COLORECTAL CANCER RISK AND NITRATE CONTAMINATION IN NEW ZEALAND DRINKING WATER

by

J. S. RICHARDS

A research dissertation submitted in partial fulfilment
of the requirements for the award of the degree of
Master of Science
of Loughborough University

JUNE 2020

Supervisor: Dr. T. Radu

Water, Engineering and Development Centre
School of Architecture, Building and Civil Engineering
Loughborough University

Acknowledgments

This dissertation would not have been possible without the significant contribution from the drinking water suppliers who provided nitrate data and supply information for their water supplies.

Thank you also to the Regional Councils for providing nitrate data and information on the use of bores for domestic consumption.

Thank you to ESR for the provision of the P2 Programme database with historical nitrate data and for providing general information and advice throughout the project.

Thank you to the Ministry of Health for assistance in contacting private drinking water suppliers.

Thank you to my employer Fluent Infrastructure Solutions Ltd who have provided me the time and resources to complete this dissertation.

Thank you to my supervisor and thank you to the Nitrates in Water Research Group for your support, guidance and encouragement throughout the project and for the loan of the Nico Trios nitrate analyser.

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Abstract

Exposure to nitrate in drinking water has been associated with an increased risk of colorectal cancer at nitrate levels far lower than the Maximum Acceptable Value of 50 mg/L. This project aimed to review nitrate concentrations in New Zealand drinking water and undertake a preliminary assessment of their potential effect on colorectal cancer rates.

Nitrate data was collected from water suppliers for more than 3.9 million people (~84% of the population) and exposure was extrapolated for an additional 600,000 people. Based on international dose-response estimates, 7 - 17% of the population are exposed to potentially harmful nitrate levels and 0.6 – 5.6% of colorectal cancer cases may be attributable. Exposure to nitrate in drinking water is likely to be a significant risk factor for colorectal cancer in New Zealand.

These preliminary results warrant further study in New Zealand and warrant taking practical, precautionary steps to reduce nitrate levels in drinking water.

Key Words: Nitrate, Drinking Water, Colorectal Cancer, New Zealand

Executive Summary

1. Introduction

New Zealand has some of the highest colorectal cancer rates in the world (Ferlay et al., 2018). Recent studies in Europe and the United States have provided evidence for an association between nitrate levels in drinking water and colorectal cancer (e.g. Espejo-Herrera et al., 2016, Schullehner et al., 2018). This association has been found to occur at nitrate levels far lower than 50 mg/L which is the current World Health Organisation (WHO) Guideline Value (WHO, 2016) and the 'Maximum Acceptable Value' (MAV) in the Drinking-water Standards for New Zealand 2005 (revised 2018) (DWSNZ) (MoH, 2018).

New Zealand drinking water suppliers are not required to routinely monitor or report on nitrate levels if levels have been previously found to be below 25 mg/L (50% of the MAV) (MoH, 2018) and there is no national repository of data that can be reliably used to estimate exposure to nitrate in drinking water for the population. This situation means that there is limited understanding of the scale of the potential public health risk posed by nitrate levels in drinking water. It is not clear whether the high colorectal cancer rates in New Zealand can be partially attributed to exposure to elevated nitrate levels in drinking water or whether incidences of colorectal cancer could be reduced through management of nitrate loads to drinking water sources or nitrate reduction at the treatment plant level.

The aim of this project is to review nitrate concentrations in New Zealand drinking water and their potential effect on colorectal cancer rates in the country.

The objectives of the project are to:

1. Review literature linking nitrate with colorectal cancer
2. Review nitrate sources in drinking water in New Zealand and suitable removal technologies
3. Develop a preliminary database of nitrate concentrations in New Zealand drinking water
4. Undertake a preliminary characterisation of population exposure to nitrate in New Zealand drinking water over time and place
5. Develop an initial estimate of the potential population burden of colorectal cancer attributed to nitrate exposure from drinking water

2. Methodology

Nitrate data was requested from registered[1] drinking suppliers in early 2020. Nitrate data was collected from a total of 78 registered water suppliers covering 382 registered water supplies

[1] Registered on the *Register of Drinking-water Suppliers for New Zealand (Part One: Networked Supplies serving more than 25 or more people)* (ESR, 2019)

and 450 zones that supply to approximately 3,970,000 people, or approximately 84% of the 2018 New Zealand population (based on Stats NZ, 2020). The data was collected from District Council and private (non-District Council) registered water suppliers. Drinking water samples were collected and analysed for nitrate levels in the Southland District for all registered water supplies in Southland that did not have available nitrate data (two supplies) and from 20 unregistered water supplies.

The nitrate database was developed using the data collected from registered drinking water suppliers and the results from the sampling in Southland. Supply information was included based on information provided by the suppliers and publicly available information from ESR (2020a). The nitrate levels used in the database were an estimate of current exposure based on an average of results from 2018 – 2020 for each supply.

Nitrate data was also obtained from Regional Councils for a total of 371 bores around New Zealand previously identified as being for domestic, community, restaurant/eatery or school supplies. These bores are estimated to serve approximately 2,600 people. This data was included in the study to provide information on nitrate levels in drinking water for people who are not served by a registered drinking water supply, such as people in rural areas. These results were not included in the nitrate database due to uncertainty around whether the water sources are still used for drinking water.

The largest group of people without any available nitrate data was identified to be the ~603,000 people who are not served by registered drinking water supplies. It was estimated that 75% of these people may be served by a groundwater or surface water source and 25% may be served by rainwater sources, based on water sources used by supplies in Part 3[2] and Part 4[3] of the Register (ESR, 2019a). Nitrate exposure for these people was estimated based on extrapolating the data collected for unregistered water supplies in Southland and from the data provided by Regional Councils.

Historical nitrate data was extracted from the Priority 2 (P2) Programme historical database (ESR, 2019b). This sampling programme aimed to identify water supplies with determinands at concentrations greater than 50% of the MAV. This database includes nitrate sample results from 576 registered supplies, sampled between 1996 and 2003 as part of the P2 Programme. The historical nitrate data covers a total of 1,304,701 people (approximately 35% of the 2001 New Zealand population (Stats NZ, 2020a)).

[2] Part 3 of the Register covers *Networked Supplies that serve less than 25 people*
[3] Part 4 of the Register covers *Specified Self-Suppliers*

3. Results and Discussion

Epidemiological studies investigating the link between exposure to nitrate in drinking water and colorectal cancer were identified through a methodical literature review. Three recent studies were identified that provide dose-response relationships most relevant to the New Zealand population; Espejo-Herrera et al. (2016), Schullehner et al. (2018) and the results from the meta-analysis by Temkin et al. (2019). These studies found that an increased risk of colorectal cancer was associated with exposure to nitrate in drinking water at concentrations as low as 3.87 mg/L (Schullehner et al., 2018) to 7.1 mg/L (Espejo-Herrera et al., 2016). Exposure to nitrate above these levels was considered to be 'potentially harmful'. Based on these results and for the purposes of this study, nitrate concentrations in drinking water greater than 5 mg/L were considered to be 'elevated'. This is 10% of the current MAV of 50 mg/L.

The main source of nitrate in New Zealand drinking water is from pastoral agriculture and in particular from intensive pastoral dairy farming (Elliott et al., 2005, MFE and Stats NZ, 2020). Nitrogen applied to pasture as fertiliser is taken up by the pasture, consumed by grazing animals and returned to the soil in animal urine patches. The nitrogen content of the urine patches typically exceeds the plant's requirements and can leach into the groundwater (Pakrou and Dillon, 2004). Other sources of nitrate contamination include horticulture, human wastewater and other point sources of contamination that may be important at the local scale. (McLay et al., 2001, MFE and Stats NZ, 2019).

Nitrate levels in New Zealand drinking water were found to range from less than detection (<0.01 mg/L) to 41.8 mg/L. More than 60% of the New Zealand population were found to be exposed to less than 2 mg/L. A total of 8.2% of the population were found to be exposed to more than 5 mg/L and 2.2% were found to be exposed to more than 10mg/L. A total of 4,459 people (0.1% of the population) were found to be exposed to more than 25 mg/L (50% of the MAV).

Exposure to nitrate in drinking water varied across the 20 District Health Boards (DHBs). The DHBs with the largest number of people exposed to more than 5 mg/L were Canterbury (72,314 people) and Southern (71,703 people). Canterbury DHB also had the largest number of people exposed to more than 10 mg/L (48,898), more than 15 mg/L (31,475) and more than 25 mg/L (3,215). Waikato DHB had the highest number of people with unknown exposure levels (117,624 people).

Clusters of drinking water supplies with elevated nitrate levels identified in the south of Canterbury, the south of Southland, Waikato and Northland appear to be associated with areas of high cattle density. The elevated nitrate concentrations in Nelson-Marlborough were more likely attributed to intensive horticulture and nitrate levels in Taranaki were typically low

despite the very high cattle density in the region. This finding indicated the importance of other landuse activities and local site-specific factors on nitrate levels in drinking water.

The proportion of people (out of those with available nitrate data) exposed to elevated levels of nitrate in drinking water varied considerably by the size category[4] (ESR, 2019) of the registered drinking water supplies. The percentage of people within a supply category exposed to greater than 10, 15 and 25 mg/L was highest in the smallest supply categories (Neighbourhood and Small) and lowest in the largest supply categories (Medium and Large). Data coverage also increased with increasing supply size, ranging from 18% for neighbourhood supplies to 100% for Large supplies.

The extrapolation for those served by unregistered supplies resulted in an estimated 19,990 people exposed to greater than 50 mg/L and an estimated 81,590 exposed to 25 – 50 mg/L. This extrapolation indicated that although there are only approximately 603,000 people served by unregistered supplies (compared to approximately 4,096,000 served by registered supplies), the total number exposed to > 50 mg/L, 25 – 50 mg/L and 10-15 mg/L may be significantly higher for those served by unregistered supplies compared to those served by registered supplies. The extrapolation also indicated that a significantly higher percentage (up to 14.4%) of the population is likely to be exposed to greater than 5 mg/L than found by the nitrate database (8.2%).

Based on changes in nitrate levels in 238 individual supplies that had nitrate data available in both the current database and the historic database (ESR, 2019b), it is clear that there has been an increase in nitrate levels over the past two decades in a greater number of supplies and for a greater number of people than there has been a decrease. This was found for a change of more than 1mg/L, more than 2mg/L and more than 5 mg/L. This finding indicates that exposure to nitrate in drinking water has increased over the past two decades. This is a significant finding and was anticipated given rapid expansion in the dairy industry and associated increase in fertiliser application over a similar period.

The number of New Zealanders currently exposed to potentially harmful levels of nitrate in drinking water may range from approximately 320,000, based on Espejo-Herrera et al. (2016) to more than 515,000, based on Schullehner et al. (2018). This is equivalent to 6.7 – 10.8% of the population (based on the nitrate database and excluding the extrapolation for unregistered supplies). These preliminary results indicate that between 0.6% and 3.2% of colorectal cancer cases in New Zealand may be attributable to exposure to nitrate in drinking water, equivalent to approximately 19 – 103 cases, based on the number of new registrations in 2016 (3219) and the dose-response relationships published by Espejo-Herrera et al. (2016) and Schullehner et al. (2018). Inclusion of extrapolated exposure estimates for the approximately

[4] Neighbourhood: 25 - 100 people, Small (101 – 500 people), Minor (501 – 5,000 people), Medium (5,001 – 10,000), Large (>10,001 people)

603,00 people served by unregistered supplies would increase the estimated number of people exposed to potentially harmful levels of nitrate in drinking water to between 569,000 and 804,000 (12.1 – 17.1% of the 2018 New Zealand population). The inclusion of these exposure estimates would increase the Population Attributable Fraction (PAF) to between 1.75, based on Temkin et al. (2019) to 5.6%, based on Espejo-Herrera et al. (2016) and would increase the estimated number of attributable cases to between 56 and 180 cases per year. These PAFs are within the range estimated for the United States (1-8%) by Temkin et al. (2019).

The most effective method of reducing nitrate levels in drinking water is to reduce nitrate loads to groundwater through land use changes and improvements to land management practices, in particular in pastoral agriculture. Due to the lag times associated, other approaches are likely to be required. For supplies of less than 50 people where an alternative source is not available, it is likely that point of use treatment in each dwelling would be the most cost-effective approach to reducing nitrate levels. For larger supplies, it is likely that the most cost-effective approaches would be prioritising use of an existing lower-nitrate source, blending or development of a new lower-nitrate source. Where an alternative lower nitrate source is not available, the most appropriate advanced treatment option would need to be identified on a site-specific basis.

4. Conclusions and Recommendations

Based on the preliminary results of this study, exposure to nitrate in drinking water could potentially be a significant contributing risk factor for colorectal cancer cases in New Zealand. The results indicate that the risk posed by exposure to nitrate in drinking water is likely to be of similar significance to the established risk factors of high consumption of red meat, physical inactivity, high consumption of processed meat and smoking, and likely to be less significant than heavy alcohol consumption or obesity.

The results of this study are significant and strongly suggest that further research into nitrate levels in New Zealand drinking water is warranted, along with further research into the dose response relationship between exposure to nitrate in drinking water and colorectal cancer in New Zealand. It is recommended that Taumata Arowai review the evidence for an association between nitrate in drinking water and colorectal cancer, and if this evidence continues to increase, consider establishing a MAV for nitrate in drinking water based on chronic health effects. This could be based on the one-in-one-hundred thousand cancer risk level.

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Glossary of Terms

Determinand: A constituent or property of a sampled of water that is determined or estimated (as defined in MoH (2018))

District Councils: Territorial Authorities whose responsibility includes provision of local infrastructure (including water supply) in their district. There are a total of 67 District Councils in New Zealand (including the Chatham Islands District Council which was not included in this study).

District Health Boards: Responsible for providing or funding health services in their District. There are a total of 20 District Health Boards in New Zealand.

Drinking water supplier: a person who supplies drinking water

Hazard Ratio: see Risk Ratio

Meta-analysis: A technique that combines the results of a number of epidemiological studies into a single estimate, based on a weighted average of the individual study results. (e.g. Webb, Bain and Page, 2017)

Priority 2 Determinands: Determinands of public health significance that are present at concentrations that exceed 50 percent of the Maximum Acceptable Value in a specific supply or distribution zone (MoH, 2018)

Population Attributable Fraction (PAF): the proportion of disease in a population that can be attributed to a specific exposure (e.g. Webb, Bain and Page, 2017).

Private drinking water supplier: For the purposes of this study, drinking water suppliers that are not District Councils are considered to be private suppliers. This includes Government agencies such as Department of Conservation and the New Zealand Defence Force, private developers and community organisations.

Regional Councils: Responsible for the integrated management of the natural resources of their Region, including managing the effects of using freshwater and the land. There are a total of 11 Regional Councils in New Zealand.

Register: The Register of Drinking-water Suppliers for New Zealand (ESR, 2020), including:

- Part One: Register of Suppliers serving greater than 25 people
- Part Two: Register of Water Carriers
- Part Three: Register of Networked Suppliers serving fewer than 25 people
- Part Four: Register of Specified Self-Suppliers

Registered Supplier: Drinking water suppliers who have registered on the Register. All drinking water suppliers who supply drinking water beyond their own property are required to register (however sometimes suppliers to less than 25 are not registered.)

Risk Ratio: The risk of disease in one group divided by the risk of disease in a reference group (e.g. Webb, Bain and Page, 2017).

Self-supplier: A person who owns a drinking-water supply used exclusively to supply water to a property owned by that person

Taumata Arowai: A standalone Crown entity that will be responsible for the regulation of drinking water in New Zealand, currently in the establishment phase and expected to become fully operational in mid-2021.

Unregistered Supplier: For the purposes of this study, Unregistered Suppliers includes all self-suppliers and drinking water suppliers that have not registered in Part One of the Register. This typically includes suppliers who supply to less than 25 people.

Abbreviations

CI: Confidence Interval

DWSNZ: Drinking-water Standards for New Zealand 2005 (revised 2018)

ESR: Institute of Environmental Science and Research

DHB: District Health Board

HR: Hazard Ratio

IARC: International Agency on Cancer Research

MAV: Maximum Acceptable Value

MoH: Ministry of Health

P2: Priority 2

PAF: Population Attributable Fraction

RR: Risk Ratio

WHO: World Health Organisation

1. Introduction

New Zealand has some of the highest colorectal cancer rates in the world (Ferlay et al., 2018). New Zealand also has a recently intensified dairy industry which has contributed to elevated nitrate loads in New Zealand waterways (MFE and Stats NZ, 2019). Recent studies in Europe and the United States have provided evidence for an association between nitrate levels in drinking water and colorectal cancer, particularly in certain population sub-groups, such as those with high red meat intake and low vitamin C intake (e.g. Espejo-Herrera et al., 2016; Schullehner et al., 2018). This association has been found to occur at nitrate levels far lower than 50 mg/L which is the current World Health Organisation (WHO) Guideline Value (WHO, 2016) and the 'Maximum Acceptable Value' (MAV) in the Drinking-water Standards for New Zealand 2005 (revised 2018) (DWSNZ) (MoH, 2018).

New Zealand drinking water suppliers are not required to routinely monitor or report on nitrate levels below 25 mg/L (50% of the MAV) (MoH, 2018) and there is no national repository of data that can be reliably used to estimate exposure to nitrate in drinking water for the population. This situation means that there is limited understanding of the scale of the potential public health risk posed by nitrate levels in drinking water. It is not clear whether the high colorectal cancer rates in New Zealand can be partially attributed to exposure to elevated nitrate levels in drinking water or whether incidences of colorectal cancer could be reduced through better management of nitrate loads to drinking water sources or nitrate reduction at the treatment plant level.

This topic has been selected due to recent media attention in New Zealand on potential links between nitrate and colorectal cancer, the Author's previous experience managing elevated nitrates in remote community water supplies in Australia and due to the recent establishment of the Nitrates in Water Research Group (refer Section 1.3).

1.1 Project Aim and Objectives

The aim of this project is to:

Review nitrate concentrations in New Zealand drinking water and their potential effect on colorectal cancer rates in the country

This aim is supported by a number of objectives and research questions. The aim, objectives and research questions are presented in **Table 1** below.

Table 1: Project aim, objectives and research questions

Aim: Review nitrate concentrations in New Zealand drinking water and their potential effect on colorectal cancer rates in the country				
Objective 1: Review literature linking nitrate with colorectal cancer	**Objective 2:** Review nitrate sources in drinking water in New Zealand and suitable removal technologies	**Objective 3:** Develop a preliminary database of nitrate concentrations in New Zealand drinking water	**Objective 4:** Undertake a preliminary characterisation of population exposure to nitrate in New Zealand drinking water over time and place	**Objective 5:** Develop an initial estimate of the potential population burden of colorectal cancer attributed to nitrate exposure from drinking water
Research Question 1.1: What is the potential link between exposure to nitrate in drinking water and colorectal cancer? **Research Question 1.2:** What concentrations of nitrate in drinking water have been found to be associated with increased risk of colorectal cancer in previous studies? **Research Question 1.3:** What are the current international estimates for the dose-response relationship for nitrate exposure from drinking water and colorectal cancer?	**Research Question 2.1:** What is the main source of nitrate in New Zealand drinking water? **Research Question 2.2:** What are the most suitable nitrate removal technologies for New Zealand drinking water supplies?	**Research Question 3.1:** Are the supplies for which there is no available nitrate data and unregistered supplies likely to have significantly different concentrations than the supplies for which there is available data? **Research Question 3.2:** How many people may be exposed to nitrate levels in drinking water above the level found to be associated with increased risk of colorectal cancer?	**Research Question 4.1:** How do nitrate concentrations in drinking water vary around the Country? **Research Question 4.2:** Have nitrate concentrations in New Zealand drinking water increased over the past two decades?	**Research Question 5.1:** How many cases of colorectal cancer in New Zealand may be potentially attributable to exposure to nitrate in drinking water? **Research Question 5.2:** Is the risk factor of exposure to nitrate in drinking water significant compared to other known colorectal cancer risk factors in New Zealand?

1.2 Contribution to Science

This project contributes to science and public health by developing the first estimate of the number of cases of colorectal cancer potentially attributable to nitrate in drinking water in New Zealand. The results are important due to the high rates of colorectal cancer in New Zealand and due to the modifiable nature of the risk factor of exposure to elevated nitrate in drinking water. This project also contributes to science by developing the first preliminary database of nation-wide nitrate concentrations in drinking water. The nitrate data collected for supplies that previously lacked data and the extrapolated nitrate levels for unregistered drinking water supplies is also an important contribution. The results of this preliminary study will also contribute to a future epidemiological study, further described in Section 1.3 below.

1.3 Nitrates in Water Research Group

The Nitrates in Water Research Group was established in mid-2019 with the aim of contributing to the international body of scientific research on the human health impacts of nitrate in drinking water through an epidemiological study in New Zealand. Due to the current lack of available data on drinking water nitrate concentrations in New Zealand, the present study is required to provide the drinking water nitrate data for the epidemiological study. The findings of the present study will also help define the scope of the future epidemiological study. The Group does not currently have any external funding. The Group is directed by Prof. Michael Baker and currently consists of epidemiologists, freshwater ecologists, environmental health researchers and the author. The Nitrates in Water Research Group members are:

- **Prof Michael Baker:** Epidemiologist, University of Otago, Wellington
- **Ass Prof Simon Hales**: Environmental Epidemiologist, University of Otago, Wellington
- **Dr Mike Joy**: Freshwater Ecologist, Victoria University, Wellington
- **Edward Randal**: Research Fellow, University of Otago, Wellington
- **Prof Alistair Woodward**: Epidemiologist, University of Auckland
- **Dr Timothy Chambers:** Senior Research Fellow, University of Otago, Wellington
- **Jayne Richards:** Water Engineer and Masters Student, Loughborough University

1.4 Note on Units of Measurement

Nitrate concentrations in drinking water are typically reported in mg/L as either NO_3 (the nitrate ion) or NO_3-N (the nitrogen component of the nitrate ion). This study refers to the concentration of the nitrate ion (NO_3) in accordance with the units used in the DWSNZ (MoH, 2018). Studies from the United States typically report in NO_3-N, and laboratories in New Zealand can report using either units. Nitrate concentrations from studies reported as NO_3-N have been converted to NO_3 for consistency in this study, by multiplying the NO_3-N concentration by 4.4267.

1.5 Structure of Document

The main body of this document is divided into four separate chapters. These are:

- Literature Review
- Methodology
- Results and Discussion
- Conclusions and Recommendations

Each chapter is divided into key headings and sub-headings and references are provided at the end of the document.

2. Literature Review

2.1 Colorectal Cancer in New Zealand

Colorectal cancer, encompassing both colon and rectal cancers, is the third most prevalent cancer worldwide, with an estimated 1,849,518 incidences in 2018 (Ferlay et al., 2018). Based on age standardized data, it has an estimated global incidence rate of 19.7 per 100,000 people. There were an estimated 880,792 mortalities from colorectal cancer in 2018, making it the second highest contributor to cancer deaths worldwide (Ferlay et al., 2018).

Colorectal cancer is New Zealand's third most prevalent cancer (after prostate and breast cancers), with 3,219 registrations of colorectal cancer recorded in 2016 (MoH, 2019). Based on 2016 data, the age standardised incident rate is 41.9 per 100,000 for the population as a whole, 31.1 for females and 46.1 for males (MoH, 2019). These rates are significantly higher than the global average and are amongst the highest in the world (Ferlay et al., 2018).

The New Zealand Cancer Registry has records extending back to 1948 (MoH, 2019). Colorectal Cancer registrations in New Zealand (as an age standardised rate per 100,000) steadily increased between the late 1940's and mid-1990's, with a peak of 57.3 in 1994. Rates have declined gradually since the mid 1990's to the 2016 rate of 41.9 (MoH, 2019). Similar trends have been detected in a number of other developed countries after they have reached a very high level of development and the decline is considered to be partially attributable to the implementation of colorectal cancer screening programs and possibly also changes in diet (Fidler et al., 2017).

Colorectal cancer is a significant contributor to cancer deaths in New Zealand. Data extracted from the New Zealand Cancer Registry (MoH, 2018a) indicates that 15.4% (60,172) of total registered cancer deaths between 1948 and 2015 were attributable to colorectal cancer. Mortality numbers from colorectal cancer in New Zealand are predicted to increase over the next 15 years, due to the increasing population while mortality rates (expressed per 100,000) are projected to decrease due to improvements in screening and management (Araghi et al., 2019).

Colorectal cancer rates vary significantly throughout the country, with the highest incident rates in South Canterbury, Southern, Taranaki and Nelson/Marlborough District Health Boards (DHBs) (HQSC, 2019) (based on 2009 – 2013 data).

2.2 Risk Factors for Colorectal Cancer

Risk factors for colorectal cancer include modifiable and non-modifiable risk factors. Known non-modifiable risk factors for development of colorectal cancer include age, personal history of polyps, family history of colorectal cancer and inflammatory bowel disease (Shah et al., 2012). Known modifiable risk factors include obesity, physical inactivity, consumption of red

meat, consumption of processed meat, alcohol consumption and smoking (Richardson et al., 2016).

The proportion of disease in a population that could be prevented if the modifiable risk factor (or exposure) was eliminated/reduced can be estimated using population attributable fractions (PAFs) (Webb, Bain and Page, 2017). PAFs provide an indication of the relative importance of modifiable risk factors in a population and the maximum possible impact of primary preventative strategies. Due to the high rates of colorectal cancer in New Zealand, even small changes in the prevalence of risk factors could result in a significant reduction in registrations (Richardson et al., 2016).

PAFs have recently been estimated for known modifiable colorectal cancer risk factors in New Zealand by Richardson et al. (2016). Crude (rather than age-standardised) prevalence estimates of each risk factor were identified based on the results of population-based health and nutrition surveys. Relative Risks (refer paragraph below) were calculated based on the results of well-designed systematic reviews, intervention studies or cohort studies.

PAFs were calculated based on the following:

$$PAF = \frac{Pe(RR-1)}{Pe(RR-1)+1}\ x\ 100\%$$

$$Where\ Pe = the\ prevalence\ of\ exposure\ to\ the\ risk\ factor$$

$$RR = the\ relative\ risk$$

The results of Richardson et al. (2016) are summarised in **Table 2** below.

The concept of relative risk is commonly used in epidemiology to measure associations between exposure and disease. Common measures of relative risk include Hazard Ratios (HRs), Odd Ratios and Relative Risk Ratios (RRs) and these are calculated based on the risk of disease in one group divided by the risk of disease in a reference group (e.g. Webb, Bain and Page, 2017). These ratios can be assumed to be equivalent for a rare event, such as cancer. A RR greater than one indicates a positive association between exposure to the risk factor and the risk of disease while a RR of less than one indicates a negative association (Webb, Bain and Page, 2017). As an example, a RR of 1.15 indicates a 15% increased risk of disease associated with exposure, compared to no exposure, while a RR of 3.0 indicates three times the risk. RRs are typically described with 95% confidence intervals (CIs). A RR with a 95% CI above 1.0 (e.g. 1.15 (1.07-1.19) indicates a statistically significant positive association while a RR with a 95% CI below 1.0 (e.g. 0.93 (0.88-0.98) indicates a statistically significant negative association. A RR with a 95% CI that crosses 1.0 (e.g. 1.15 (0.92-1.20) indicates that the association is not statistically significant.

Table 2: Estimated Population Attributable Fractions for colorectal cancer risk factors in New Zealand (based on Richardson et al. 2016)

Risk Factors	RR (95% CI)	Prevalence of Risk Factor in New Zealand	PAF in New Zealand (95% CI)	Estimated Reduction in Registrations if Risk Factor Eliminated*
Heavy alcohol consumption	1.44 (1.25 – 1.65)	16.1% of adults have hazardous drinking pattern	6.6% (3.6 – 9.6)	212
High consumption of red meat	1.35 (1.21 – 1.51)	14.4% eat red meat more than 5 times per week	4.8% (2.6 – 7.0)	154
Obesity	1.33 (1.25 – 1.42)	29.9% obese (BMI ≥ 30)	9.0% (6.7 – 11.2)	289
Physical Inactivity	1.32 (1.23-1.39)	14.3% adults physically inactive (<30 mins physical activity / week)	4.4% (2.6 – 7.0)	141
High consumption of processed meat	1.31 (1.13 – 1.51)	8.6% eat processed meat more than 5 times per week	2.6% (0.9 – 4.3)	83
Smoking	1.15 (1.00 – 1.32)	17.2% (smoke at least once per month)	2.5% (0.0 – 5.2)	80

** Extrapolated by the Author based on the number of registrations of colorectal cancer in New Zealand in 2016 (3,219) (MoH, 2019)*

Obesity and alcohol consumption were found to be the most significant modifiable lifestyle risk factors for colorectal cancer in New Zealand (Richardson et al., 2016). Exposure to elevated nitrate in drinking water was not taken into consideration as a modifiable risk factor by Richardson et al. (2016), most likely because there was inconclusive evidence and a limited number of studies at the time of publishing.

The PAFs estimated by Richardson et al. (2016) demonstrate the importance of consideration of both the relative risk and the prevalence of a risk factor when considering the potential population burden of the risk factor. Whilst there is published literature on the relative risk of colorectal cancer associated with exposure to nitrate in drinking water from international studies, there is no data on the prevalence of levels of exposure in New Zealand.

2.3 Ingested Nitrate: A Probable Carcinogen

In 2006, expert scientists in an international working group from the International Agency on Cancer Research (IARC) concluded that "*ingested nitrate or nitrite under conditions that result in endogenous nitrosation is probably carcinogenic to humans (group 2A)"* (IARC, 2010). The IARC is part of the WHO and is widely considered to be the authority on carcinogenic

substances, through the Monograph Programme. The process of endogenous nitrosation is summarised in **Figure 1** and further described below.

Ingested nitrate can be reduced to nitrite by the action of bacteria in the mouth (WHO, 2016). Nitrite can react with nitrostable compounds in the acidic conditions of a healthy human stomach to produce N-nitroso compounds, many of which are probable human carcinogens. The N-nitroso compounds produced in the stomach can act as carcinogens in the colon and rectum. This process is called endogenous (i.e. internal) nitrosation. Endogenous conversion of nitrate to nitrite has been previously estimated to be approximately 5-7% of ingested nitrate for normal individuals and 20% for those with a high rate of conversion (FAO and WHO, 1995 cited in Thomson, Nokes and Cressey, 2007).

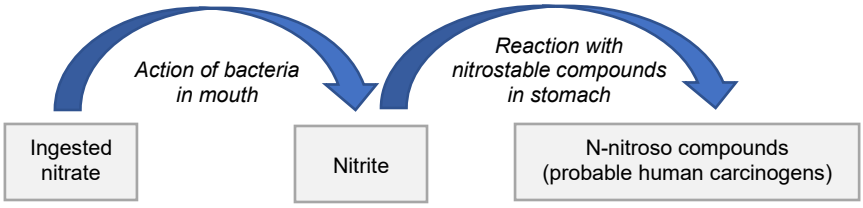


Figure 1: Summary of endogenous nitrosation

Vegetables are the highest source of ingested nitrate through diet in New Zealand (Thomson, Nokes and Cressey, 2007). Nitrate concentrations in New Zealand vegetables are similar to those reported in international studies and were highest in lettuce, watercress, celery, spinach, silver beet and beetroot (Thomson, Nokes and Cressey, 2007). Vegetables are also a strong source of vitamin C and other antioxidants that have been found to inhibit the process of endogenous nitrosation (Grosse et al., 2006). Therefore the formation of N-nitroso compounds from nitrate ingested in vegetables may be inhibited by the concurrent ingestion of vitamin C and other antioxidants in the vegetables (Grosse et al., 2006).

Nitrate in drinking water is typically ingested without concurrent ingestion of vitamin C and antioxidants and may therefore result in greater formation of the probably carcinogenic N-nitroso compounds compared to ingestion of nitrate through vegetable consumption. The first human trials investigating the association of consumption of nitrate in drinking water and the formation of N-nitroso compounds were undertaken as a pilot study in 2019 (van Breda et al. 2019). Although the participant size was small, the results of the study showed that ingestion of nitrate in drinking water can have a significant contribution to the endogenous formation of N-nitroso compounds (Van Breda et al. 2019). These results are in accordance with the results of earlier observational studies (e.g. Van Maanen et al. 1996).

2.4 Nitrate in Drinking Water and Colorectal Cancer

The WHO drinking water guideline value for nitrate of 50 mg/L (as nitrate ion) was established to protect bottle-fed infants from the acute condition Methaemoglinaemia, or ‘blue baby’

syndrome (WHO, 2016). This potentially fatal condition can occur when nitrite, endogenously converted from the consumed nitrate, interacts with haemoglobin, reducing the efficiency at which oxygen is transported by blood. The New Zealand MAV for short-term exposure to nitrate of 50 mg/L is based on the WHO guideline value (MoH, 2018).

A guideline value based on chronic (long term) health effects has never been established for nitrate in drinking water by the WHO or Ministry of Health (MoH) due to insufficient evidence of associations with chronic effects (MoH, 2017). Studies into the chronic effects of consumption of water with elevated nitrate levels have assessed associations with various cancers and birth defects and have yielded various and sometimes inconsistent results (Ward et al., 2005, Ward et al., 2018).The strongest potential association appears to be with colorectal cancer and there is increasing evidence to support this association (Ward et al., 2018, Temkin et al., 2019).

Two recent epidemiological studies in Denmark (Schullehner et al., 2018) and Spain and Italy (Espejo-Herrera et al., 2016) with different study designs contribute significantly to the body of evidence supporting this association, due to the large populations studied, the resulting statistical power and the detailed exposure assessments undertaken. Both studies assigned participants with average annual nitrate exposure levels using residential history and data from water suppliers and found increased risk of colorectal cancer with increased long-term exposure to nitrate in drinking water at levels significantly below current guidelines.

In the Schullehner et al. (2018) nation-wide, longitudinal study across the Danish population, annual average drinking water nitrate concentrations were assigned to each individual in the study, based on residential history and nitrate data from public and private water supplies over a 15-year exposure period. This 15-year exposure period was selected because it was assumed to be representative of the relationship between exposure and outcome. Schullehner et al. (2018) found a statistically significant increased risk of colorectal cancer for individuals exposed to average drinking water nitrate concentrations between 3.87 mg/L and 9.25 mg/L and an even higher risk for individuals exposed to greater than 9.25 mg/L. Refer **Table 3** below for HRs and 95% CIs. A linear dose response relationship was suggested. The study did not account for known colorectal cancer risk factors such as diet (including red meat intake), alcohol intake, smoking and physical inactivity although the analysis was adjusted for the highest level of education gained as a proxy for these risk factors. The authors suggested the need to lower the drinking water standard for nitrate for protection of public health.

Espejo-Herrera et al.'s 2016 study included individuals aged 20 to 85 years, diagnosed with colorectal cancer within 11 provinces in Spain and Italy between 2008 and 2011 along with hospital-based and population-based controls living within the hospital catchment area. Nitrate levels were assigned to each individual from the age of 18 until 2 years before the study, based on participant's residential history, nitrate data collected from municipal and non-

municipal supplies and the participant's reported daily water intake. Published nitrate content of commonly consumed food products were used with participant's reported food intake to estimate dietary nitrate intake. Information from participants on other known colorectal cancer risk factors (such as physical activity levels, smoking) was included in the study. Espejo-Herrera at al. (2016) found the effects of exposure to ingested nitrate differed depending on whether the exposure source was drinking water, vegetables or animal products. Long-term exposure to nitrate in drinking water was associated with increased colorectal cancer risk at levels substantially below current drinking water standards, particularly when coupled with high red meat intake.

Seven epidemiological studies that assessed the association between drinking water and colorectal cancer were identified and the results of these studies are summarised in **Table 3** below. Some studies report results for colon cancer and rectal cancer separately and these are noted in **Table 3** below. Three additional studies were identified but were excluded from the summary table. Studies that assessed colorectal cancer mortality rates (rather than incidence rates) (e.g. Chiu et al., 2010, Yang, Wu and Chang, 2007) have been excluded as there are additional factors that affect mortality after the initial incidence. Ecological studies (e.g. Gulis, Czompolyopva and Carhan, 2002) have also been excluded due to their inability to account for confounding factors.

The results of these seven studies are varied, but the majority suggest a positive association between ingestion of elevated nitrate in drinking water and colorectal cancer at levels significantly below New Zealand's MAV of 50 mg/L. Statistically significant associations have been identified for nitrate concentrations as low as 1.59 mg/L (Weyer et al., 2001). The results indicate that the association may be stronger for colon cancer than rectal cancer and is likely to be stronger for subgroups including those with high red meat consumption and those with low vitamin C intake. The inconsistencies in the results of these seven studies highlight the need for further research including epidemiological studies outside of Europe and the United States and further studies on sub-groups such as men, those with low-vitamin C intake and those with high red meat intake. Studies have been focused on populations in the United States (four out of the seven studies), in particular in Iowa (three studies) and on females (three studies).

A recent meta-analysis of relevant published literature (Temkin et al., 2019) suggested a statistically significant positive linear association of 4% increase in risk of colorectal cancer per 4.43 mg/L increase in exposure to the nitrate ion (RR=1.04, 95% CI: 1.01 – 1.07). Temkin et al. (2019) also estimated a one-in-one-million cancer risk level per year of 0.62 mg/L (95% CI: 0.35 – 2.79). This level was estimated to be the concentration that corresponds to one additional case of nitrate-attributable colorectal cancer cases per year. Regulatory agencies often consider a lifetime one-in-one-million cancer risk as the acceptable risk level for public

exposure to carcinogenic chemicals (Temkin et al., 2019), although a lifetime one-in-100,000 risk is typically used for genotoxic carcinogens in New Zealand drinking water (MoH, 2017). Further epidemiological studies are required to confirm the dose-response relationship and the one-in-one-million (or one-in-100,000) cancer risk level for a lifetime exposure.

Table 3: Summary of Identified Epidemiological Studies Investigating Nitrate in Drinking Water and Association with Colorectal Cancer

Authors, (Year of Publication) Study Location	Study Design and Study Population	Exposure and Incidence Description	Exposure Intervals for key findings	HR (95% CI) and cancer site (if considered separately)	Other Effects / Adjustments	Comment
Weyer et al. (2001) Iowa, United States	Prospective cohort study 16,541 women on public water supplies, aged 58-69 years in 1986	Average nitrate concentration in public water supplies, 1955 – 1988. Cancer incidence between 1986 and 1998	<1.59 mg/L	Reference case	Adjusted for age, education, smoking, physical activity, body mass index, waist-to-hip ratio, intakes of vitamins C and E, dietary nitrate, fruits and vegetables.	Statistically significant positive relationship for exposure between 1.59 and 4.43 mg/L and 4.44 – 10.89 mg/L and colon cancer. Not statistically significant for exposure above 10.89 mg/L.
			1.59 - 4.43 mg/L	1.54 (1.09-2.17) colon		
			4.44 -10.89 mg/L	1.58 (1.13-2.23) colon		
			>10.89 mg/L	1.01 (0.70-1.48)* colon		
De Roos et al. (2003) Iowa, United States	Population-based case-control 714 cases and 1,124 controls aged 40 - 85, with nitrate data for > 70% of the time period.	Average nitrate concentration in public water supplies, 1960 – 1987 Cancer incidence between 1986 and 1989	< 4.43 mg/L	Reference case	Considered below median vitamin C intake and above median red-meat intake	Strong associations for exposure above 22.13 mg/L with colon cancer for below median vitamin C intake or above median red-meat intake (but not with rectum cancer)
			4.44 - 22.13 mg/L	Not statistically significant		
			>22.13 mg/L and > 10 years exposure with low vitamin C	2.0 (1.2-3.3) colon		
			>22.13 mg/L and > 10 years exposure with high red meat	2.2 (1.4-3.6) colon		

Authors, (Year of Publication) Study Location	Study Design and Study Population	Exposure and Incidence Description	Exposure Intervals for key findings	HR (95% CI) and cancer site (if considered separately)	Other Effects / Adjustments	Comment
McElroy et al. (2008) Wisconsin, United States	Population-based case-control study, women only 475 cases and 1447 controls, aged 20-74 years	Women in rural areas with private water supplies, based on modelled nitrate levels, extrapolated from water quality data from 1994	< 2.21 mg/L	Reference case	None	Strong positive association for exposure above 44.27 mg/L
			> 44.27 mg/L	2.91 (1.52-5.56) (Proximal colon cancer only)		
Espejo-Herrera et al. (2016) Spain and Italy	Multi-centred Case-control study 1,869 cases and 3,530 controls Aged 20 to 85 years	Nitrate levels in drinking water and average daily water consumption, 30 years to 2 years before the interview. Average water intake 1.4 L/day (cases), 1.3 L/day (controls).	≤ 5 mg/day	Reference case	Adjusted for sex, age, education, body mass index, physical activity, non-steroidal anti-inflammatories use, family history of colorectal cancer energy intake.	Strong positive associations above 10mg/day (equivalent to ~7.1 mg/L)
			> 10 mg/day	1.49 (1.24-1.78)		
			> 10 mg/day, men with high red meat intake	1.71 (1.30-2.26)		
			> 10 mg/day	1.52 (1.24-1.86) colon		
Fathmawati et al. (2017) Yogyakarta, Indonesia	Hospital-based Case-Control Study 75 cases, 75 controls	Single nitrate samples for each source collected 2016, residents for minimum 3 years, hospital patients 2014-2016.	≤ 50 mg/L	Reference case	Adjusted for protein intake, smoking history, age, family history of cancer and diabetes	Low numbers in study, however > 25% samples > 50 mg/L.
			> 50 mg/L	2.82 (1.08-7.40)		
			> 50 mg/L and > 10 years at water source	4.31 (1.32-14.10)		

Authors, (Year of Publication) Study Location	Study Design and Study Population	Exposure and Incidence Description	Exposure Intervals for key findings	HR (95% CI) and cancer site (if considered separately)	Other Effects / Adjustments	Comment
Schullehner et al. (2018) Denmark	Population based cohort study using Danish records 1.7 million people, 35 years to 69 years of age, with nitrate data for > 75% of the period	1978-2011, 15 year exposure period Annual nitrate results allocated to each household	< 1.27 mg/L	Reference case	Adjusted for age, sex, year of birth and previous cancer diagnosis. Adjusting for highest level of education achieved did not change significance of results.	High quality of data. Dose-response trend suggested for colorectal cancer, colon cancer alone and rectum cancer alone.
			1.27 - 2.33 mg/	1.06 (0.97 – 1.16)*		
			2.33 - 3.87 mg/L	1.03 (0.94 – 1.13)*		
			3.87 - 9.25 mg/L	1.11 (1.02 – 1.20)		
			≥ 9.25 mg/L	1.15 (1.07 – 1.24)		
Jones et al. (2019) Iowa, United States	Cohort study 15,532 post-menopausal women in Iowa who reported using the same public water source for more than 10 years.	Estimated annual average nitrate for each public water supply between 1955-1988. Used incident colon and rectum cancers diagnosed between 1986 and 2010 from the State Health Registry	< 1.59 mg/L	Reference case	Adjusted for age, physical activity, smoking status and disinfection by products.	Found no association between average nitrate concentration in public water supply and colorectal cancer risk in the study population.
			1.59-3.54 mg/L	1.13 (0.88-1.45)* colon 0.48 (0.28-0.84)* rectum		
			3.55- 5.98 mg/L	1.32 (1.03-1.69) colon 0.86 (0.53, 1.38)* rectum		
			5.99 - 15.54 mg/L	0.98 (0.76-1.27)* colon 0.94 (0.60, 1.48)* rectum		
			>15.54 mg/L	0.97 (0.75-1.26)* colon 0.64 (0.38, 1.07)* rectum		

** Denotes results that are not statistically significant*

2.5 Nitrate Contamination in New Zealand Waterways

Nitrate leached into waterways is one of the primary pollutants of concern in New Zealand due to both environmental and human health impacts (MFE and Stats NZ, 2019). Nitrate is highly soluble in water and nitrate in the soil that is not taken up by plants is readily leached to the groundwater, where it can be subsequently transported to surface water systems. Due to often slow groundwater movement rates, the environmental and human health impacts of current land use practices may not fully arise for years or decades into the future (MFE and Stats NZ, 2019).

The largest source of dissolved nitrogen in New Zealand waterways is estimated to be from pastoral farming areas and specifically from intensive dairy farming (Elliott et al., 2005, MFE and Stats NZ, 2020). Pasture is the most extensive land cover type in New Zealand, covering approximately 40% of the land area (MFE and Stats NZ, 2019). Nitrogen, in the form of fertilizer is added to pasture to provide more forage for the animals and to enable higher stocking rates. Direct leaching of nitrate from fertilizer application is typically small unless the fertilizer application is poorly timed, such as a few days before a high rainfall event (Vogeler, Lucci and Shephard, 2015). Fertilizer application to pasture also results in increased nitrogen content of the fodder and increased nitrogen intake for the animals and a subsequent increased return of nitrogen to the land via animal urine patches (Vogeler, Lucci and Shephard, 2015). The uneven distribution of the highly concentrated urine patches around a paddock results in patches of excess soil nitrogen that cannot be taken up by plants and are leached into the groundwater (Pakrou and Dillon, 2004). This indirect leaching of nitrate from urine patches is the largest source of nitrate contamination from pastoral farming (Parfitt et al., 2012, Romera et al., 2012, Vogeler, Lucci and Shephard, 2015).

Nitrate leaching is typically higher for intensive dairying than for mixed sheep and beef (Elliott et al., 2005, McLay et al., 2001). Dairy farming was estimated to contribute approximately 37% of the nitrogen load to New Zealand's coastal waters in 2005 (Elliott et al., 2005), when the land area used for dairy farming was significantly smaller than it is today. There has been a significant shift in recent decades from sheep and beef farming to dairy farming in New Zealand and the number of dairy cattle increased by 70% (from 3.8 million to 6.5 million) between 1994 and 2000 (MFE and Stats NZ, 2020). This rapid expansion and intensification of the dairy industry in New Zealand has been associated with a significant increase in nitrogen fertilisers applied to the land (of the order of a 250% increase) and an increase in nitrate load leached to groundwater (MFE, 2019, MFE and Stats NZ, 2019).

Other sources of nitrate contamination in New Zealand include human wastewater, market gardens, forestry activities, effluent disposal systems, stock feeding yards (McLay et al., 2001, MFE and Stats NZ, 2019). On a national scale the contribution of point sources to nitrogen loads to the coast is minor (approximately 3% of the total load) but point sources can result in

elevated groundwater nitrate concentrations on a local scale (McLay et al., 2001). Site specific factors such as local climate, hydrogeology, soil management also affect groundwater nitrate concentrations at the local scale in New Zealand (McLay et al., 2001).

The Ministry for the Environment's recently announced Action for Healthy Waterways Package (MFE, 2020) identifies the significant need to reduce nitrogen leaching to New Zealand waterways. Supporting documentation for the Package identifies that nitrogen leaching must be reduced through long-term land use changes (e.g. where intensive agriculture has been established on free draining soils) and also through improved agricultural practices, such as reduction in fertiliser application rates, improved timing of fertiliser application and reduced stocking rates (MFE, 2020a). The Package introduces a nitrogen fertiliser 'cap' of 190 kg N/ha/yr as a short-term measure to reduce the highest fertiliser application rates in pastoral farming New Zealand (MFE, 2020). The Package acknowledges that land use changes and the associated reductions in nitrogen leaching are long term changes that will take a generation (MFE, 2020).

2.6 Nitrate in New Zealand Drinking Water

Drinking water sources in New Zealand are typically groundwater or surface water sources. MoH has commissioned occasional investigations into nitrate levels in drinking water, the most recent in 2018 (ESR, 2018). The 2018 survey was undertaken to provide MoH with up to date information due to land-use changes possibly influencing nitrate concentrations in drinking water. A total of 215 samples from water supplies in dairying areas in Southland, Canterbury and Waikato that supply more than 500 people and are sourced from groundwater were included in the study. The study found that nitrate concentrations exceeded 25 mg/L (50% of the MAV) in three source waters but in none of the distribution zones. These results highlight the fact that water sources with differing nitrate concentrations may supply a single distribution zone.

There are four water supplies where nitrate is assigned as a Priority 2 (P2) determinand (due to the concentration historically exceeding 25 mg/L or 50% of the MAV), requiring monitoring at the treatment plant. These supplies are Ashburton, Darfield, Rolleston (in the Canterbury District) and Lower Waitaki (Otago District) and together they supply water to approximately 37,800 people (ESR, 2019), or approximately 0.8% of the 2018 New Zealand population (Stats NZ, 2020). There are an additional 12 distribution zones where nitrate is assigned as a P2 determinand, requiring monitoring in the distribution (reticulation) zone. These zones supply water to approximately 17,400 (~0.4% of 2018 population) and include the Bombay Zone (Auckland), Richmond and Waimea Industrial (Nelson), Burnham Camp, Dromore, Dunsandel and Sherwood Estate, Edendale, Sandy Knolls, Fairton, Hinds and Poyntz Road (Canterbury) and Pleasant Point and Rangitata Huts (South Canterbury) (ESR, 2019).

Nitrate levels in groundwater in some areas of Canterbury have been identified to be at or above the MAV of 50 mg/L, posing a risk of Methaemoglinaemia, or 'blue baby' syndrome to bottle-fed infants in areas that are not serviced by a registered drinking water supply (CPH, 2016, ECAN, 2020). High risk areas with groundwater nitrate levels regularly above 50 mg/L have been identified in the lower Waitaki Valley, Ashburton, Seadown and Clandeboye areas (ECAN, 2020). Community and Public Health (part of the Canterbury DHB) recommend that self-suppliers, or people who are not served by a registered drinking water supply test their water source for nitrate if the source is from a moderate (unknown risk) or high risk area (CPH, 2016). Groundwater nitrate concentrations exceeding the MAV have also been identified in Southland, Nelson-Marlborough, Taranaki, Waikato, Mid-Central and Counties-Manukau Regions (Stats NZ, 2020b) however the risk of Methaemoglinaemia to babies in areas not served by registered supplies does not appear to be as clearly publicised as in Canterbury.

2.7 Drinking Water Quality Regulation in New Zealand

Drinking water quality in New Zealand is regulated under the Health (Drinking Water Amendment Act) 2007 (2019) by the Ministry of Health. This Act requires suppliers of drinking water to more than 25 people to register on the Register of New Zealand Drinking Water Suppliers. There are currently 677 registered drinking water supplies, serving approximately 4,095,200 people (ESR, 2020a) or ~87% of the 2018 population (Stats NZ, 2020). Registered drinking water suppliers include District Councils and private (non-District Council) organisations (e.g. community water groups, developers, New Zealand Defence Force etc).

A new water regulator, Taumata Arowai is currently being established in New Zealand. The establishment of Taumata Arowai is a result of the recent Government Inquiry and Three Waters Review following a campylobacter outbreak in Havelock North (DIA, 2020). The outbreak resulted in illness for approximately 5,500 people and deaths of up to four people and raised concern about the effectiveness of the current regulatory regime and capability and sustainability of water service providers (DIA, 2020). Taumata Arowai is scheduled to take responsibility for drinking water regulation in mid-2021.

2.8 Drinking Water Quality Data Availability in New Zealand

The collation of drinking water quality data on a national scale can be difficult and time consuming in New Zealand. This is due to a number of factors, including:

- The implementation of a risk-based approach to monitoring of chemical determinands of health concern in the mid-1990s, rather than a 'blanket monitoring' approach, resulting in low levels of monitoring for chemical determinands (including nitrate). The 'Priority 2 Chemical Determinand Identification Programme (the P2 Programme) ran

between 1995 and 2004 and used historical information and details from questionnaires to identify supplies where P2 determinands may be present at potentially health significant concentrations (Davies, Nokes and Ritchie, 2001). The P2 Program assessed more than 850 water supplies serving more than three million people. If a P2 determinand was found to be less than 50% of the MAV ongoing monitoring was not deemed to be required. P2 determinands are typically only assigned to supplies serving greater than 500 people (Nokes, 2020).

- Reporting requirements do not require actual concentrations to be reported. Suppliers are only required to report on the number of samples collected in a reporting period and the number of samples exceeding 50% of MAV, rather than the actual concentration of the chemical determinand (Nokes, 2019).
- The change of databases used to store national drinking water quality data on multiple occasions since the mid-1990s. The currently used Drinking Water Online database is not publicly available and there are a very small number of people with access to the entire database (Nokes, 2019). It is understood that the database would only include nitrate concentrations for supplies where nitrate is assigned as a P2 determinand.
- Contact details for suppliers are not provided in the publicly available version of the Register and contact details may be difficult to obtain due to privacy restrictions (Nokes, 2019).
- There are a large number of registered drinking water supplies in New Zealand supplying a relatively small total population. As of April 2019, there were 403 suppliers, responsible for 677 networked supplies (that serve more than 25 people), serving a total of 4,059,171 people (MoH, 2019).
- A relatively large proportion of the population (~603,500 people (ESR, 2020a) or ~13% of the 2018 population (Stats NZ, 2020)) is not served by a Registered drinking water supplier. These people are likely to be served by either very small networked supplies or are classified as ‘self-supplied’.

This situation is very different to other countries such as Denmark, where historic drinking water nitrate data is readily available (Schullehner et al., 2018).

2.9 Reduction of Nitrate Levels in Drinking Water

The most logical way to reduce nitrate concentrations in drinking water is to reduce nitrate inputs into New Zealand water sources. Given long timeframes associated with land-use change (MFE, 2020) and the often long lag-times before reductions in leaching rates result in

changes to nitrate concentrations at the water source (due to groundwater travel time), it is important to identify options to reduce nitrate concentrations at the water supply level.

Non-treatment-based options to reduce nitrate concentrations in a drinking water supply include the use or development of an alternative, low-nitrate water source (e.g. a deeper well) and blending the water with a lower nitrate-level water. Alternative low-nitrate sources are not always available or economic to develop and elevated nitrate levels have been identified in groundwater at depths of greater than 100m in some areas of Canterbury (ECAN, 2002, Rutter and Rutter, 2019) Therefore use or development of an alternative low nitrate source is not always feasible.

Blending of water sources can occur through either through a controlled process at the treatment plant (WSDOH, 2018), or through managed aquifer recharge at the source. Managed aquifer recharge is currently being trialled at a small number of sites in the Ashburton District with the aim of protecting drinking water supplies, enhancing groundwater quality, improving baseflows to spring-fed streams and rivers and improving groundwater levels (ECAN, 2019). The trials have involved conveying low-nitrate water from the alpine-fed Rangitata River to constructed infiltration basins which allow the low-nitrate water to recharge the groundwater system. High nitrate levels in the groundwater are diluted through the recharge process (ECAN, 2019). It is understood the process is under consideration as an option to reduce nitrate levels in some drinking water supplies in the Ashburton District in the south of Canterbury and in Hawkes Bay.

The most common water treatment processes used to reduce nitrate levels in drinking water are reverse osmosis, ion exchange, electrodialysis reversal and biological denitrification (WHO, 2016). Nitrate cannot be removed through conventional treatment processes such as filtration or coagulation. There are many factors to be considered when selecting an appropriate treatment technology, such as the influent water quality, potential for scaling or fouling, ability to dispose of waste streams generated, rejection rates, cleaning requirements, complexity of operation, power demand, treated water nitrate level required and post treatment requirements (WSDOH, 2018). Recent research on nitrate removal from drinking water has focused on hybrid treatment systems or combinations of the four most common advanced treatment systems (e.g. Bergquist et al., 2016, Epszstein et al., 2015, Ebrahimi and Roberts, 2013).

The reverse osmosis process involves forcing water across a semi-permeable membrane, leaving ionic species such as nitrate behind (Kapoor and Viraraghavan, 1997). Reject water rates can be as high as 90% in low pressure systems, generating a significant waste stream that requires disposal (WSDOH, 2018). High pressure systems (>70m head) can reduce reject rates to around 15% but require considerable energy to operate (WSDOH, 2018). Reverse osmosis membranes are subject to fouling and therefore typically require pre-

treatment and periodic acid or caustic cleans (WSDOH, 2018). The reverse osmosis process is not selective for nitrate and reduces the total mineral content of the water, requiring post treatment remineralisation (Kapoor and Viraraghavan, 1997).

Ion exchange involves passing the water through an anion exchange resin where the nitrate ions are exchanged for chloride ions (Kapoor and Viraraghavan, 1997). When the resin's exchange capacity is exhausted it is regenerated by backwashing with a sodium chloride or other salt-based solution. This requires a supply of salt, the cost of which is often a significant proportion of the operational and maintenance costs of ion exchange plants and produces a waste stream high in sodium chloride and nitrate that requires disposal (Kapoor and Viraraghavan, 1997). The resin degrades over time and may need to be replaced every few years (WSDOH, 2018). Post treatment pH reduction may be required to reduce the corrosivity of the treated water (WSDOH, 2018).

The electrodialysis process selectively transfers ions through a semi-permeable membrane via electrochemical separation (Kapoor and Viraraghavan, 1997). An electrical current transfers the ions from a less concentrated to a more concentrated solution and in electrodialysis reversal plants, the polarity of the electrodes are frequently reversed to reduce the risk of scaling (Kapoor and Viraraghavan, 1997). Electrodialysis plants typically requires less pre-treatment than reverse osmosis but still require periodic membrane cleaning and produce a concentrated waste brine stream (WSDOH, 2018).

Biological denitrification process uses bacteria to convert nitrate to nitrogen gas through the dentrification process. The process can be either fixed film (where the organisms attach to the surface of an inert media) or suspended growth (Mohseni-Bandpi, Elliott and Zazouli, 2013). An organic carbon source, such as methanol, ethanol or acetic acid is typically required for cell growth and post treatment is required to remove residual organic carbon and biomass (Mohseni-Bandpi, Elliott and Zazouli, 2013). Biological denitrification plants generate a much smaller volume waste stream than other nitrate treatment plants and do not generate concentrated brines (WSDOH, 2018). Biological denitrification plants typically have a lower power demand than other nitrate treatment plants but do require a lengthy start-up period for new systems (WSDOH, 2018).

Domestic nitrate treatment systems have been used by self-suppliers in New Zealand in areas where nitrate levels have exceeded the MAV and where there is community awareness around the associated health concerns (Kelly, 2020). More than 500 domestic nitrate removal units are estimated to be in use in the Canterbury area (based on Kelly, 2020). Domestic nitrate removal systems are typically small under-sink reverse osmosis units that only treat water that will be consumed for drinking or food preparation (provided via a separate faucet at the kitchen sink). Although reject water percentages can be very high (greater than 75%) the small volumes of water required to be treated per day generally keep the reject water volumes

similarly low. The manufacturer's typically state nitrate reduction levels of approximately 85% and the units are generally certified against international standards. The units are cost effective, at approximately NZ$700 - NZ$1,500 per unit (~$450 - $1,000 USD) (Kelly, 2020 and Taylor, 2020). Operating costs are also low as they rely on water pressure (~30m head) rather than power to operate. Pre-filtration cartridges are typically changed out bi-annually while the membranes are generally changed every 2-3 years, at a cost of approximately $200 unit (~$130 USD) per membrane (Kelly, 2020).

The Drinking-water Standards for New Zealand (MoH, 2018) do not specifically permit point-of use treatment systems and the Health (Drinking water) Amendment Act (2019) requires water suppliers to provide water in compliance with the Drinking Water Standards for New Zealand to the point of connection. Therefore point-of-use or domestic treatment systems are rarely used by water suppliers in New Zealand.

3. Methodology

3.1 Review of Literature Linking Nitrate with Colorectal Cancer

3.1.1 Review of potential link between exposure to nitrate in drinking water and colorectal cancer

Colorectal cancer rates in New Zealand were identified through a search of MoH publications using the search term “colorectal cancer” and through a review of publicly available information in the Atlas of Healthcare Variation (HQSC, 2019). Published literature on risk factors for colorectal cancer in New Zealand were identified through a query of the Web of Science and PubMed databases using the search terms “Çolorectal cancer and risk factors and New Zealand” and a combination of these terms.

The Web of Science and PubMed databases were queried to identify relevant published literature on the potential link between exposure to nitrate in drinking water and colorectal cancer using the search terms ‘drinking water and nitrate and colorectal cancer’ and a combination of these terms. Relevant documents published by the WHO and its subsidiary agencies were also reviewed, including the background document for development of WHO guidelines for drinking water quality (WHO, 2016) and the Monograph on the Evaluation of Carcinogenic Risks to Humans for Ingested Nitrate and Nitrite (IARC, 2010).

3.1.2 Identification of nitrate concentrations associated with an increased risk of colorectal cancer and associated dose-response relationship

The results of the identified published literature investigating the potential link between exposure to nitrate in drinking water and colorectal cancer were summarised in a table. Studies were excluded if they were ecologic in design or if they assessed mortality rates rather than incidence rates. Nitrate concentrations in the literature published as NO_3-N were multiplied by 4.4267 to convert them to NO_3.

Results relevant to the present study of the New Zealand population were identified through exclusion of results only relevant to certain population sub-groups (e.g. women only, or populations with low vitamin C intake), exclusion of results that were not statistically significant and exclusion of results considered to have poor study design. The results of a recently published meta-analysis that pooled the results of published studies was also considered to be relevant. Nitrate concentrations associated with an increased risk of colorectal cancer and the associated dose-response relationship were then identified from the remaining relevant results.

3.2 Review of Nitrate Sources in New Zealand Drinking Water and Suitable Removal Technologies

3.2.1 Identification of the main source of nitrate in drinking water in New Zealand

Academic literature on the source of nitrate in New Zealand water ways was identified through a query of the Web of Science database using the search term ‘nitrate and source and New Zealand and water’ or a combination of these terms. Information was also obtained from publicly available national ‘state of the environment’ reports published by government agencies.

3.2.2 Identification of suitable nitrate removal technologies

Published academic literature was identified through a query of the Web of Science database using the search term ‘nitrate and removal and drinking water” or a combination of these terms. Publicly available guidance documents from international health departments were also reviewed. Two New Zealand domestic water treatment suppliers were identified and interviewed over the telephone to discuss options for self-suppliers.

3.3 Nitrate Data Collection

3.3.1 District Council water suppliers

Requests for nitrate data and supply information were sent to publicly available email addresses to the 66 District Councils in New Zealand in January 2020. A one-page summary of the project was provided to the District Councils with the data request. Copies of the data request sent to District Councils and the project summary sheet are provided in the Appendices.

The majority of the District Councils treated the data request as an Official Information Request under the Local Government Official Information and Meetings Act 1987, which requires the District Council to provide an official response within a 20-working day timeframe. Follow up email requests were sent during February and March 2020 to District Councils who did not respond to the original request, along with follow up phone calls.

Nitrate data was obtained directly from the District Council websites for Selwyn District Council (2019), Tauranga City Council (2019), Hamilton City Council (2019) and WaterCare (2019) (for Auckland Council).

3.3.2 Private water suppliers

Due to privacy restrictions, contact details for private drinking water suppliers are not publicly available and could not be provided by the MoH for the study. The MoH Drinking Water Team has incomplete records for contact details for private drinking water suppliers and only located contact details for a total of 119 private drinking water suppliers (out of a total of 319). The MoH Drinking Water Team Leader emailed the 119 Private drinking water suppliers in January

2020, requesting permission for the Nitrates in Water Research Group to use their contact details to contact them to request nitrate data and supply information for the study. A similar data request to that sent to the District Councils was sent to private suppliers who agreed to be contacted for the study, along with the project summary sheet. A copy of the data request sent to private suppliers is included in the Appendices.

3.3.3 Regional Councils

Nitrate data for water sources used for domestic or community supply was requested from Regional Councils during March 2020 with the aim of obtaining information on nitrate levels in drinking water for people served by unregistered drinking water supplies. Regional Councils were also requested to provide any available estimates on the water sources used by self-suppliers in the Region (i.e. the percentage that rely on rainwater compared to the percentage that rely on groundwater or surface water). This query was also sent to ESR, MoH, and Water New Zealand (the national water industry representative body) and was passed on to the Taumata Arowai Establishment Unit. A copy of the data request sent to Regional Councils is included in the Appendices.

3.3.4 Water sampling

Water samples were collected and analysed for nitrate from 22 supplies in the Southland District in December 2020, including two registered supplies with no available nitrate data and 20 unregistered or self-supplies. The unregistered water supplies were selected based on a review of aerial imagery of Southland using Google Maps to identify areas with more than five houses that are not supplied by a registered drinking water supply. These areas were selected as they were considered to be the most likely areas to have unregistered networked community water supplies. Information on the water supplies sampled were obtained from discussions with local residents or from observations during the sampling. The unregistered supplies are estimated to serve a total of 302 people and include cafes, hotels, roadhouses, stores and private dwellings The Southland District was selected for nitrate testing due to its high colorectal cancer rates, the intensive dairy industry in parts of the District and due to ease of access for the Author.

Water samples were collected in 200mm plastic sample bottles and stored at less than 4 degrees celsius and for less than 24 hours prior to analysis. The nitrate-Nitrogen concentration was analysed by the Author using a TriOS Nico nitrate meter. The TriOS Nico nitrate meter uses a UV photometer for the determination of nitrate by absorption, taking into account turbidity and organic substances (TriOS, 2018). Water samples were analysed in a ‘VALtub’’ connected to the sensor (refer **Figure 2**). The VALtub and sensor were rinsed with deionised water, dried with paper towel and then twice rinsed with the sample prior to analysis. Each sample was analysed at least twice and the result taken as the average of the readings. The TriOS Nico nitrate meter provides the nitrate concentration in NO_3-N and was

converted to NO_3 by multiplying by 4.4267. A total of seven duplicate samples (~30% of samples) were sent to the WaterCare Services Invercargill laboratory for analysis. The Watercare Services Invercargill laboratory is a MoH recognised laboratory (MoH, 2020).

Figure 2: TriOS Nico nitrate meter with VALtub connected to sensor (sample bottle also shown - with red lid)

Sampling of approximately 100 unregistered water supplies in the Southland District was planned to be undertaken during February 2020 but was delayed due to severe flooding and a State of Emergency being declared in the District in early February. The sampling was re-scheduled to March 2020 but could not be undertaken due to travel restrictions associated with the COVID-19 pandemic. Sampling was also planned to be undertaken in the Canterbury District during March 2020, however this was not possible due to travel restrictions associated with the COVID-19 pandemic.

3.3.5 Historical nitrate data

A copy of the P2 Programme historical database was provided by ESR (ESR, 2019b). This database includes nitrate sample results from 576 registered drinking water supplies, sampled between 1996 and 2003 as part of the P2 Programme. The database includes the supply owner name, supply name, supply code, population served, Public Health Unit, sample date and nitrate concentration.

3.3.6 Other nitrate data

Access to nitrate data stored in the MoH Drinking Water Online database and its predecessor, the Water Information New Zealand database was requested from MoH however access could not be granted due to privacy restrictions.

3.4 Calculation of Nitrate Levels in Drinking Water

3.4.1 Calculation of current nitrate level

The current nitrate concentration for each registered water supply was calculated based on the average of 2018-2020 results using the nitrate data collected. The sample date was listed as the most recent sample date. Where a supplier did not have any results from the 2018 – 2020 period, the most recent result was used in the database. Nitrate samples from the reticulation or water treatment plant were used in preference to raw source water samples, where available. Where a water supply is supplied from multiple water sources with differing nitrate levels and no reticulation or water treatment plant results were available, the nitrate level for the supply was calculated as a weighted average based on the proportional contribution of each source. If the proportional contribution of each source could not be provided by the supplier it was assumed that each source with available nitrate data contributed evenly. Nitrate data for water sources listed as 'not in use' or 'offline' by the water supplier were not included in the calculation. If different supply zones in a water supply were supplied by different water sources, separate nitrate concentrations were calculated for each zone and the zones were entered into the database as separate entries.

If a nitrate result was less than detection it was listed as 50 percent of the detection level. Nitrate data provided as Dissolved Inorganic Nitrogen or Total Dissolved Nitrogen were assumed to be equivalent to NO_3-N.

3.4.2 Calculation of historical nitrate level

Historical nitrate concentrations were calculated for each water supply in the nitrate database that also had available data in the P2 Programme historical database from ESR (ESR, 2019b). The historical nitrate level was calculated as an average of results for the supply from 1996- 2000, to ensure that the historical level represents data from at least 20 years ago. The sample date was listed as the most recent sample date.

3.4.3 Calculation of nitrate levels for unregistered supplies

Exposure to nitrate in drinking water for those served by unregistered supplies was estimated based on the nitrate data collected from sampling unregistered supplies in Southland and from the data provided from the Regional Councils. Data was only included from water sources recorded as being for domestic, school, eatery or community supply. Water sources were estimated to serve three people if they were identified as bring for domestic supply and 25 people if they were identified as being for school, restaurant, or community supply. The nitrate levels for the water sources in the Regional Council supplied data were calculated based on the average of the 2018 to 2020 results for each source. The nitrate levels for the unregistered water supplies sampled in Southland were calculated based on the average of the results of the analyses for each supply.

3.5 Development of Nitrate Database

The nitrate database was developed in Microsoft Excel using the data collected from suppliers. The following information was manually entered for each water supply with available nitrate data:

- Supply Owner Name
- Supply Owner Type (District Council / Private)
- Supply Name (including Zone name, if relevant)
- Supply Code (or zone code, if relevant)
- Number of people served by the supply or the zone
- Source Name
- Source Code
- GPS coordinates for supply (location identified using Google Maps)
- District Health Board (checked using the Stats NZ District Health Board 2015 GIS map (Stats NZ, 2017))
- Public Health Unit
- Any nitrate removal processes used
- Current nitrate concentration (mg/L NO_3-N) (for data provided as NO_3-N)
- Current nitrate concentration (mg/L NO_3)
- Date of most recent nitrate sample
- Historical nitrate concentration (mg/L NO_3-N) (for data provided as NO_3-N), if available
- Historical nitrate concentration (mg/L NO_3), if available
- Date of historical nitrate sample, if available
- Historical population (1999 data), from P2 Programme historical database, if available
- Data source
- Contact details for the person who provided the information
- Whether the current nitrate level is calculated from multiple samples (Yes / No)
- Whether the current nitrate level is the average of multiple water sources (Yes / No)
- Whether monthly nitrate sampling is undertaken (Yes / No)
- Comments

The supply information included in the database was based on information provided by the supplier or from ESR (2020a), where the information was not provided by the supplier. If a supply population was listed as less than 50 people (but not specified) the supply was assigned a population of 25 people.

3.6 Assessment of Exposure to Nitrate Levels in Drinking Water

3.6.1 Assessment of exposure to nitrate in drinking water across New Zealand

Nitrate concentration bands were selected to categorise exposure levels across the New Zealand population, with consideration of the MAV in New Zealand (50 mg/L) and 50% of the MAV (25 mg/L). The range of each nitrate concentration band increases with increasing nitrate concentration due to the smaller numbers of people exposed to higher concentrations. The nitrate concentration bands selected were:

- < 1 mg/L
- 1 – 2 mg/L
- 2 – 5 mg/L
- 5 – 10 mg/L
- 10 - 15 mg/L
- 15 - 25 mg/L
- 25 - 50 mg/L
- > 50 mg/L

The number of people exposed to each concentration band was calculated using the current nitrate level and population for each water supply in the nitrate database in Microsoft Excel. The percentage of the population exposed to each concentration band and the number of people without data were calculated using the most recent (2018) New Zealand census population data (Stats NZ, 2020) and the total population served by registered supplies from the Drinking Water Register for New Zealand (April 2020) (ESR, 2020a) (excluding bulk water supply numbers). The total DHB population was also obtained from the 2018 New Zealand census population data (Stats NZ, 2020) to enable comparison of exposure between DHBs.

3.6.2 Assessment of spatial variation of nitrate levels in drinking water

Maps of nitrate levels in drinking water supplies were created using QGIS version 3.10 ‘A Coruña’ (QGIS, 2020) and a vector file of New Zealand DHB boundaries sourced from Creative Commons Attribution 3.0 New Zealand (2012), in the *EPSG:2193 – NZGD2000 / New Zealand Transverse Mercator 2000* coordinate reference system. The coordinates and current nitrate concentrations for drinking water supplies in the nitrate database were imported as comma separated values.

The location of elevated nitrate levels in drinking water supplies were mapped with a vector file of cattle density sourced from Creative Commons Attribution 3.0 New Zealand (2012) to compare nitrate levels in drinking water to areas of high cattle density. The Koordinates and Land Information New Zealand databases were queried for a vector file of fertiliser application rates however a file with sufficient detail could not be located.

The maps created were used as the basis of a qualitative assessment of the spatial distribution of nitrate levels in drinking water. Shape files of distribution zone boundaries provided by some suppliers were not used in the maps as they were not available for all supplies.

3.6.3 Comparison of exposure within supply categories

The number of people exposed to each nitrate concentration band were plotted for each water supply size category[5] used in the Register (ESR, 2019) to compare nitrate levels between the different supply size categories.

3.6.4 Estimation of exposure for those served by unregistered supplies

The data collected from sampling unregistered supplies in Southland and the data supplied by the Regional Councils were extrapolated to estimate exposure for the total number of people served by unregistered supplies. The extrapolation was based on an estimate of the percentage of people supplied by unregistered groundwater and surface water supplies compared to unregistered rainwater supplies. The results of the extrapolation were used to compare estimated exposure for the population supplied by unregistered supplies to the exposure for those served by registered drinking water supplies. This extrapolation is a limitation of this project and is further discussed in Section 4.10.

3.6.5 Changes in exposure to nitrate levels in drinking water over time

Seasonal variation of nitrate levels in drinking water was assessed by plotting monthly nitrate levels from six registered supplies where monthly sampling is undertaken and calculating the range of nitrate levels in these six supplies.

The total number of people and the percentage of the population exposed to each nitrate concentration band was compared between the current database P2 Programme historical database to assess differences in exposure characteristics. The 2001 census data (Stats NZ, 2020a) was used to calculate the percentages of the population exposed for the historical data. Changes in nitrate concentrations within individual supplies were also calculated to assess changes in exposure over the past 20 years. The changes were calculated based on the current nitrate level minus the historical nitrate level for supplies which had nitrate data in both databases. The changes were classified based on the size of the increase or decrease in nitrate concentration and the number of supplies and population exposed to the changes were plotted in Microsoft Excel.

[5] Neighbourhood: 25 - 100 people, Small (101 – 500 people), Minor (501 – 5,000 people), Medium (5,001 – 10,000), Large (>10,001 people)

3.7 Initial Estimate of Potential Population Burden of Colorectal Cancer Colorectal Attributable to Nitrate Exposure from Drinking Water

3.7.1 Number of people exposed to potentially harmful levels of nitrate in drinking water

The number of people currently exposed to nitrate concentrations above those associated with an increased risk of colorectal cancer (identified in Section 3.1.2 above) were extracted from the nitrate database. The number of people estimated to be exposed to potentially harmful levels from unregistered supplies were extracted from the extrapolated data for unregistered supplies. The number of people exposed to potentially harmful levels of nitrate in drinking water were extracted from the P2 Programme historical database for comparison.

3.7.2 Assessment of number of colorectal cancer cases potentially attributable to exposure to elevated nitrate in drinking water

The Population Attributable Fractions (PAFs) for exposure to nitrate in drinking water as a risk factor for colorectal cancer in New Zealand were estimated using the PAF calculation described in Section 2.2, based on the number of people exposed to potentially harmful levels extracted from the nitrate database and the risk ratios from the identified relevant studies. The estimated number of potentially attributable cases was also calculated based on the estimated PAFs and the number of colorectal cancer registrations in New Zealand in 2016 (MoH, 2019).

The estimated PAFs calculated for exposure to nitrate in drinking were compared to the PAFs for colorectal risk factors calculated by Richardson et al. (2016) to gain an understanding of the potential relative significance of exposure to nitrate in drinking water compared to the other known risk factors.

3.7.3 Exposure to elevated nitrate levels and colorectal cancer incidence rate within DHBs

Correlations between the percentage of the DHB population exposed to nitrate levels greater than 5 mg/L and 25 mg/L (based on the nitrate database) and colorectal cancer incidence rates within each DHB (HQSC, 2019) were investigated for the purpose of hypothesis generation.

4. Results and Discussion

4.1 Nitrate concentrations associated with an increased risk of colorectal cancer

For the purpose of this preliminary study, the results from published studies most relevant to the New Zealand population are considered to be:

- Espejo-Herrera et al. (2016);
- Schullehner et al. (2018); and
- Temkin et al. (2019) (a meta-analysis).

The results from Weyer et al. (2001), De Roos et al. (2003) and McElroy et al. (2008) are applicable to population sub-groups and therefore beyond the scope of this preliminary study. The results from Fathmawati et al. (2017) are based on a small sample population and are based on higher nitrate concentrations than typically found in registered water supplies in New Zealand. The results from Jones et al. (2019) were not statistically significant and therefore not applicable for the purpose of this study. These excluded studies (with the exception of Jones et al. (2019)) were all included in the Temkin et al. (2019) meta-analysis and have therefore been indirectly considered for the New Zealand population in this study.

The studies relevant to the New Zealand population found that an increased risk of colorectal cancer was associated with exposure to nitrate in drinking water at concentrations as low as 3.87 mg/L (Schullehner et al., 2018), 4.43 mg/L (Temkin et al., 2019) and 7.1 mg/L (Espejo-Herrera et al., 2016). Exposure above these concentrations is considered to be 'potentially harmful' for the purpose of this study.

The associated dose response relationships are estimated to be:

- A 49% increase in risk with exposure greater than 7.1 mg/L (Espejo-Herrera et al., 2016).
- An 11% increase in risk with exposure to 3.87 mg/L – 9.25 mg/L and a 15% increase in risk associated with exposure to more than 9.25 mg/L (Schullehner et al., 2018).
- A 4% increase in risk with every 4.43 mg/L increase in nitrate concentration above 4.43 mg/L (Temkin et al., 2019).

Based on these results and for the purposes of this study, nitrate concentrations in drinking water of greater than 5 mg/L are considered to be 'elevated'.

4.2 Nitrate Data Collected and Nitrate Database

4.2.1 Database of nitrate levels in drinking water

Nitrate data was collected for a total of 3,969,964 people for inclusion in the nitrate database. This is equivalent to approximately 84% of the New Zealand population. The data included in the nitrate database includes:

- Data from District Council registered supplies

- Data from private registered supplies
- Data from sampling in Southland (registered and unregistered supplies)
- Data collected for three additional unregistered supplies (two operated by District Councils and one private)

The data collected is summarised in **Table 4** below. An abbreviated version of the nitrate database is provided in the Appendices with supply names removed for privacy.

Table 4: Summary of data collected for the nitrate database

	Number in nitrate database	Total Number in Register*	Percentage covered by the nitrate database
District Council Suppliers	60	66	90.9%
Private Suppliers	18	319	5.6%
Suppliers Total	78	403	19.4%
Registered Supplies	382	677	56.4%
People served by registered supplies	3,969,562	4,096,189	96.9%
People served by unregistered supplies**	402	603,566	0.1%

	Total number of people in nitrate database	Total New Zealand Population***	Percentage of population covered by the nitrate database
	3,969,964	4,699,755	84%

** Register of drinking Water Suppliers for New Zealand of Drinking Water Suppliers for New Zealand (ESR, 2020a)*

*** The total number of people served by unregistered supplies (603,566) was estimated by subtracting the number of people served by registered drinking water supplies from the 2018 New Zealand population.*

**** Based on 2018 census data (Stats NZ, 2020)*

The nitrate database developed in this study covers a large percentage of the New Zealand population (84%) (and 97% of people served by registered supplies) and provides an excellent indication of current exposure to nitrate in drinking water. The low percentage of registered suppliers covered in the database (19.4%), despite the high percentage of people served by registered supplies (97%) highlights the very high number of small water supplies in New Zealand, where 3% of people are served by more than 80% of the suppliers.

Data was available for 60 out of the 66 District Councils but was not available for all of the supplies operated by these Councils. There was a low response rate from private suppliers and the database only includes data from ~6% of the private suppliers. A total of 18 of the 382 registered supplies had multiple zones supplied by different water sources (with different nitrate levels). These zones were treated as separate entries in the database and resulted in an additional 68 entries (resulting in a total of 450 registered supply zones in the database).

The nitrate data was typically provided as either laboratory results sheets from individual sampling events (PDFs) or excel spread sheets listing nitrate results and sampling dates. The laboratories used analytical methods approved for nitrate analysis in the Drinking Water Guidelines for New Zealand (MoH, 2017, refer Volume 3, Part 2.1, page 264). Examples of the data received are provided in the Appendices. Nitrate data was more frequently available from individual raw water samples than from treated reticulation samples and the current level was calculated as a weighted average of data from multiple water sources for 160 of the supplies in the database. A total of 266 supplies had more than one recent nitrate result available from the 2018 – 2020 period and monthly sampling was occurring in a total of 33 water supplies.

Nitrate levels in New Zealand drinking water supplies were found to range from less than detection (<0.01 mg/L) to 41.8 mg/L. The nitrate levels in drinking water supplies in the nitrate database are analysed and discussed in Sections 4.3 - 4.9. Further comments on the nitrate database are provided in Section 4.2.4.

4.2.2 Nitrate data collected from sampling in Southland

Nitrate concentrations in the supplies sampled in Southland ranged from 0.00 mg/L in Monowai (water sourced from a National Park) to 33.7 mg/L in Riversdale. More than 50% of the supplies had nitrate concentrations greater than 5 mg/L and four supplies had nitrate concentrations greater than 25 mg/L (50% of the MAV). The laboratory duplicates were all within +/- 0.3 mg/L NO_3 and were therefore considered to correlate very well with the field results. The results from the sampling in Southland are provided in **Table 5** below.

Table 5: Results from sampling in Southland

Location	Water Source	Sample Date	NO_3-N (mg/L)	NO_3 (mg/L)	Lab Duplicate (mg/L NO_3-N)
Monowai	Lake Monowai	16/12/19	0.00	0.00	
Manapouri	Southland District Council registered supply	16/12/19	0.004	0.02	
Pukerau	Clutha District Council rural supply	14/12/19	0.051	0.23	0.03
Waikawa	Rainwater Supply	15/12/19	0.076	0.34	
Tokanui School	Private Bore	14/12/19	0.15	0.66	
Nightcaps	Southland District Council registered supply	16/12/19	0.15	0.66	0.14
Te Anau East	Private Bore	16/12/19	0.3	1.33	
Dipton	Town Supply (private)	16/12/19	0.32	1.42	0.38
Garston 1	Private Bore	14/12/19	0.64	2.83	
Garston 2	Unknown	14/12/19	1.17	5.18	
Quarry Hills	Private Farm Bore	15/12/19	1.61	7.13	1.3
Lochiel School	Private Bore	16/12/19	1.7	7.53	

Location	Water Source	Sample Date	NO_3-N (mg/L)	NO_3 (mg/L)	Lab Duplicate (mg/L NO_3-N)
Dipton West School	Private Bore	16/12/19	2.01	8.90	2.1
Athol	Private Bore	14/12/19	2.22	9.83	
Waikaia	Private Bore	14/12/19	2.36	10.45	
5 Rivers	Private Bore	14/12/19	3.53	15.63	
Woodlands	Private Bore	15/12/19	3.79	16.78	
Tokanui	Private Bore	15/12/19	4.01	17.75	
Morton Mains	Private Bore	15/12/19	5.8	25.67	6.0
Mandeville	Private Supply	14/12/19	6.55	28.99	
Riversdale 1	Private Bore	14/12/19	7.11	31.47	7.1
Riversdale 2	Private Bore	14/12/19	7.61	33.69	

The majority of the locations sampled were not supplied by a community supply and instead each dwelling had an individual water supply. In the coastal areas of Southland, residents reported that salt-water intrusion prevents the use of groundwater for potable water supply and the residents rely on rainwater. The residents reported purchasing water from a water tanker during periods of drought. In inland areas of Southland, residents reported either using rainwater supplemented with groundwater during periods of drought or using groundwater as their primary water source.

Nitrate has recently been identified to be the contaminant in groundwater that poses the highest risk to human health in the Southland District (NIWA, 2019). The results of the sampling in Southland identified nitrate levels exceeding 50% of the MAV in 20% of the unregistered water supplies sampled and support the findings of NIWA (2019). The town of Riversdale has a population of almost 400 people (Stats NZ, 2020c) but does not have a reticulated water supply. The nitrate results from drinking water samples in Riversdale are greater than 50% of the MAV and should be regularly monitored due to the potential risk of Methaemoglinaemia for bottle-fed infants should the levels exceed the MAV (as per MoH 2018), however the Author could not find any indication that monitoring is occurring. The Southland District Council is considering extending the Lumsden-Balfour reticulated water supply scheme to Riversdale (SDC, 2018). It is recommended that this is prioritised to reduce the health risks associated with nitrate levels at greater than 50% of the MAV in Riversdale. It is also recommended that Taumata Arowai work with Regional Councils to ensure that the risk of Methaemoglinaemia is adequately managed in areas where groundwater nitrate concentrations are at or around 50 mg/L in areas other than Canterbury (where the risk appears to be well publicised).

The nitrate data collected by the Author for the supplies in Southland is an important contribution of the study as nitrate levels in these supplies were previously unknown and also

because the results are based on actual drinking water samples, rather than environmental monitoring data.

4.2.3 Nitrate data collected for unregistered water supplies – Regional Councils

Nitrate data was obtained from Regional Councils for a total of 371 bores tagged as being for domestic, community, restaurant/eatery or school supplies, including 244 from Environment Canterbury, 84 from Environment Southland, 19 from Taranaki Regional Council, 17 from Otago Regional Council, five from Bay of Plenty Regional Council and two from Northland Regional Council. The five other Regional Councils either did not have any available data or did not respond to the request for information. These bores are estimated to serve approximately 2,593 people. Nitrate levels ranged from less than detection to 115mg/L (more than twice the MAV) in a bore in Canterbury and are further discussed in Sections 4.5 and 4.6.

The nitrate data from the Regional Councils has not been included in the nitrate database as it is considered to be less reliable than the data collected from water suppliers or the data collected by the Author in Southland, due to uncertainty of whether the water sources are still used for drinking water. These results have instead been included separately in the study to assist with estimation of nitrate exposure to those served by unregistered drinking water supplies. A summary of the data collected from Regional Councils is provided in the Appendices.

4.2.4 Comments on nitrate database

The nitrate database is an important contribution of the study as it is the first-time nitrate data has been collated on a national scale, covering all levels of nitrate in drinking water in New Zealand. Despite the low coverage of private supplies, nitrate data was much more readily available than anticipated and the coverage of registered supplies (97% of people served) is considered to be excellent.

The availability of nitrate data indicates that registered suppliers (in particular District Councils) are undertaking more than the minimum sampling required for compliance with the DWSNZ (MoH, 2018). Based on this finding it is recommended that Taumata Arowai consider reviewing the minimum sampling frequency for determinands that are not classified as 2a, 2b or 2c in the next revision of the DWSNZ (MoH, 2018).

The lack of response to participate in the study from Private registered suppliers and lack of available data from these supplies highlights potential differences in service levels provided by private suppliers compared to District Council suppliers, who may have greater resources and greater expertise in water quality management. Contacting private suppliers was difficult due to privacy restrictions and incomplete records held by MoH. It is recommended that Taumata Arowai consider stronger regulation-of and support-to private registered suppliers and improvements to management of contact details for Private registered suppliers. It is further

recommended that electronic contact details for all water suppliers in New Zealand should be publicly available.

The lack of a central repository of water quality data from New Zealand drinking water supplies meant that considerable time and effort was required to collate the nitrate database (more than three months). It is recommended that Taumata Arowai consider improvements to water quality data reporting and storage on a national level.

4.3 Preliminary characterisation of population exposure to nitrate in drinking water

4.3.1 Exposure to nitrate in New Zealand drinking water

Based on the nitrate database developed, more than 60% of the New Zealand population were found to be exposed to less than 2 mg/L. A total of 8.2% of the population were found to be exposed to more than 5 mg/L and 2.2% were found to be exposed to more than 10mg/L. A total of 4,459 people (0.1% of the population) were found to be exposed to more than 25 mg/L (greater than 50% of the MAV). The number of people in New Zealand exposed to each nitrate concentration range is shown in **Table 6** and **Figure 3** below. The number of people for whom there is no available nitrate data in the database are also shown, divided into those served by registered supplies and those served by unregistered supplies (based on the 2018 census population).

Table 6: New Zealand population exposure to nitrate levels in drinking water (based on nitrate database)

Nitrate Exposure Range (mg/L)	No. People Exposed	% of People in Database	% of NZ Population*
<1.0	1,266,608	31.9%	27.0%
2.0	1,581,404	39.8%	33.6%
2.0 – 5.0	734,019	18.5%	15.6%
5.0 – 10.0	283,297	7.1%	6.0%
10.0 – 15.0	24,827	0.6%	0.5%
15.0 – 25.0	75,350	1.9%	1.6%
25.0 – 50.0	4,459	0.1%	0.1%
>50.0	-	0.0%	0.0%
No data (registered supplies)	126,627	N/A	2.7%
No data (unregistered supplies)	603,164	N/A	12.8%

** Based on Stats NZ (2020)*

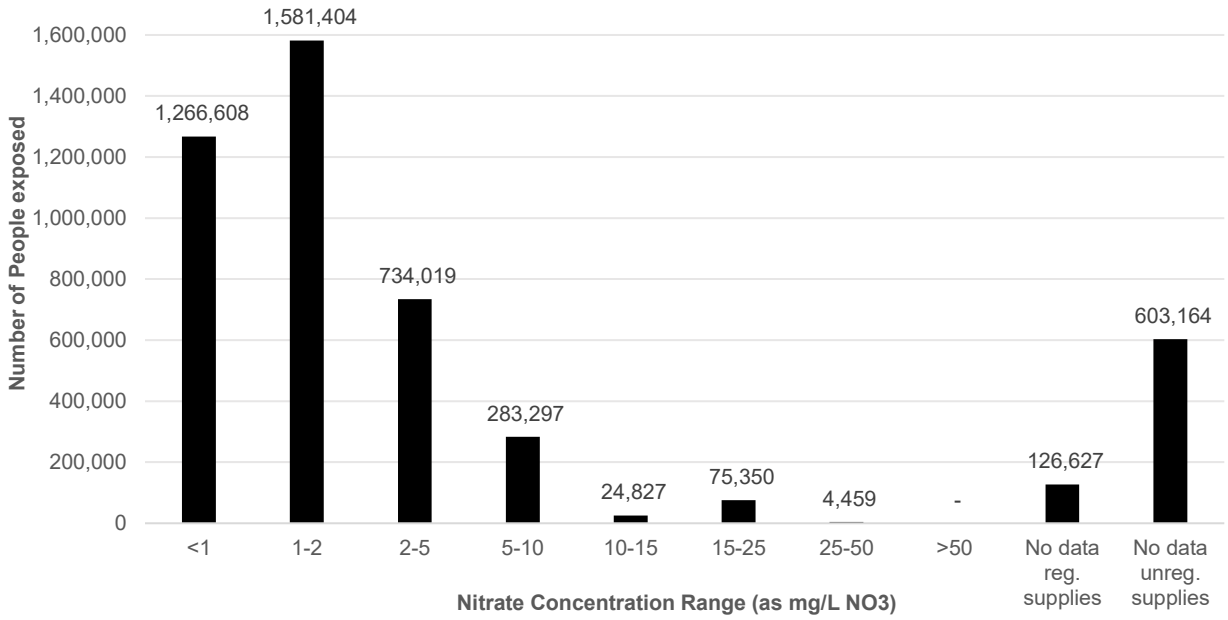


Figure 3: Nitrate levels in New Zealand drinking water (based on nitrate database)

The number of people found to have a current nitrate exposure greater than 25mg/L (50% of the MAV) (4,459 people) is less than the number of people supplied by supplies where nitrate is a P2 determinand at the treatment plant (37,800) or in a distribution zone (17,400) (ESR, 2019). This indicates the success of the additional monitoring and management required if a P2 determinand is assigned and suggests that suppliers have taken steps to reduce nitrate levels to below 50% of the MAV.

Three water supplies were found to have nitrate levels above 50% of the MAV but do not currently have nitrate assigned as a P2 determinand. This is likely to be because the supplies serve less than 500 people (based on Nokes, 2020) and is further discussed in Section **4.5**.

4.3.2 Distribution of exposure to nitrate in drinking water – by District Health Board

Exposure to nitrate in drinking water varied across the 20 DHBs as shown in **Figure 4** and **Figure 5** below. Waitemata DHB has the largest number of people exposed to less than 1 mg/L (350,083 people). The DHBs with the largest number of people exposed to more than 2 mg/L were Canterbury (254,699 people) and the Waikato (229,965 people). The DHBs with the largest number of people exposed to more than 5 mg/L were Canterbury (72,314 people) and Southern (71,703 people). Canterbury DHB also had the largest number of people exposed to more than 10 mg/L (48,898), more than 15 mg/L (31,475) and more than 25 mg/L (3,215). Nelson-Marlborough DHB, Waikato DHB and Southern DHB also had high numbers of people exposed to more than 15 mg/L (16,490, 14,749 and 11,884 respectively). Waikato had the highest number of people with unknown exposure levels (117,624 people). These results are shown in **Figure 4** below.

Mid-Central, Tairawhiti and Waitemata DHBs had the highest percentages of the DHB population exposed to less than 1 mg/L (all greater than 60%). South-Canterbury DHB had the highest percentage of the DHB population exposed to greater than 2mg/L (64.7%) and the highest percentage of the DHB population exposed to >5 mg/L (51.5%). Exposure to greater than 5 mg/L was also high in the Hawke's Bay DHB (39.1%) and the Northland DHB (34%). Exposure to nitrate levels greater than 10mg/L and greater than 15mg/L as a percentage of the DHB population was highest in Nelson-Marlborough (11.1% for > 10 mg/L and 10.9% for > 15 mg/L) and in Canterbury (9.1% for > 10 mg/L and 5.8% for > 15 mg/L). The percentages of people with unknown exposure levels were high in Northland, West Coast, Waiarapa, Tairawhiti, and Nelson-Marlborough, each with unknown exposure levels for more than 30% of the DHB population (with the highest in Northland at 44%). These results are shown below.

The spatial variability and regional differences are further discussed in Section **4.4** below.

Figure 4: Exposure to nitrate levels (mg/L NO_3) by District Health Board (based on nitrate database and population data from Stats NZ (2020))

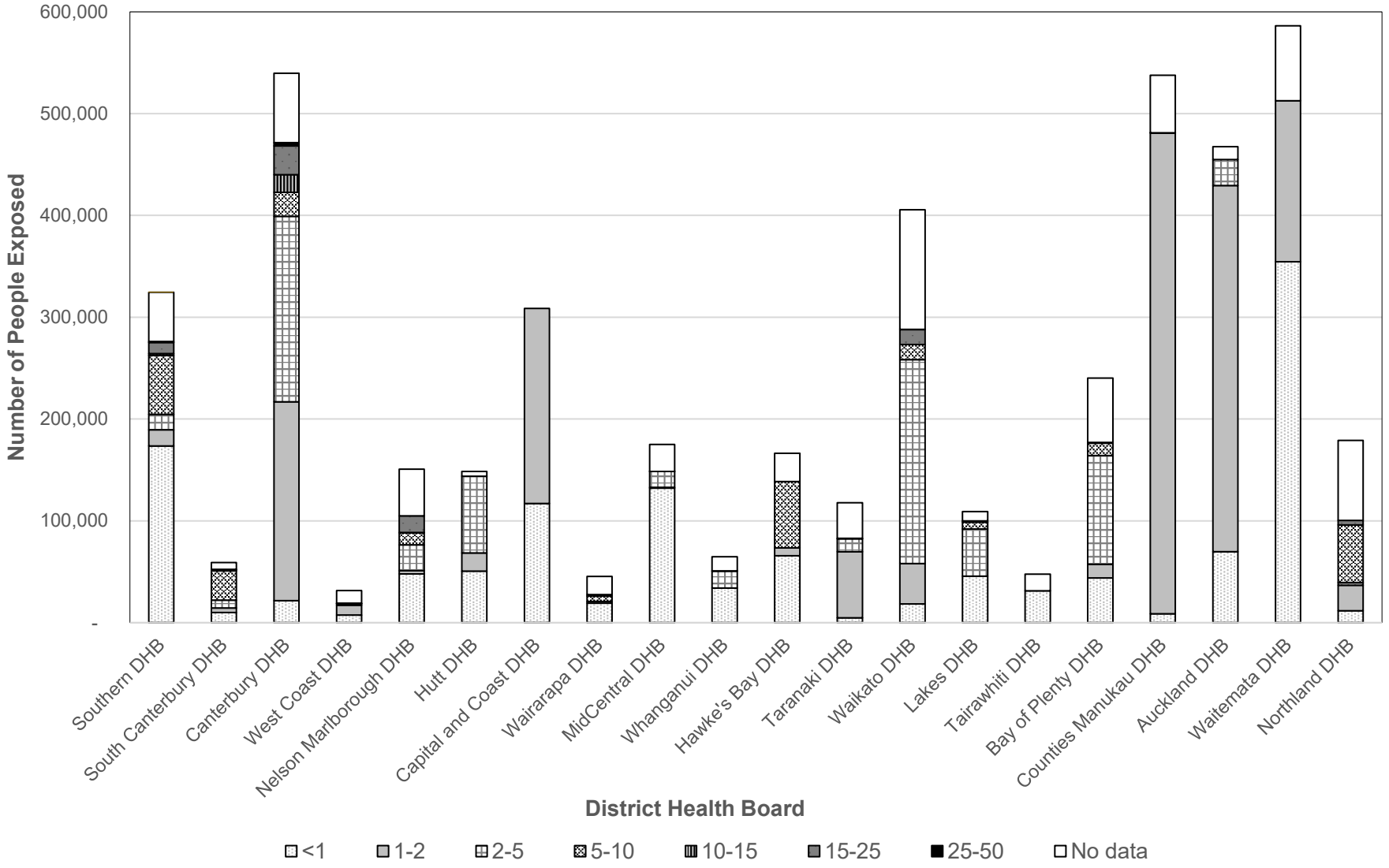
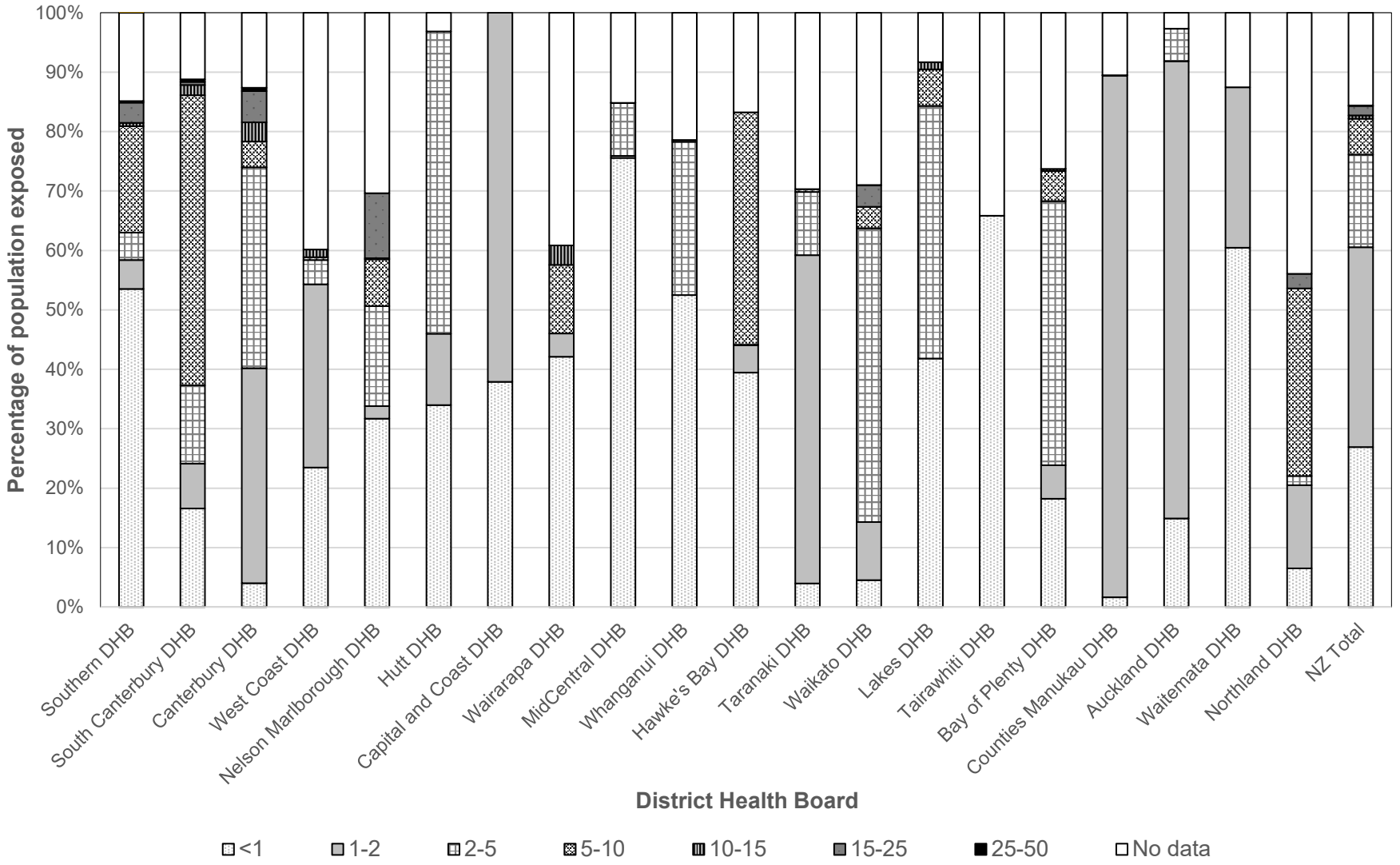


Figure 5: Percentage of DHB populations exposed nitrate concentration bands (mg/L NO_3) (based on nitrate database and Stats NZ (2020))

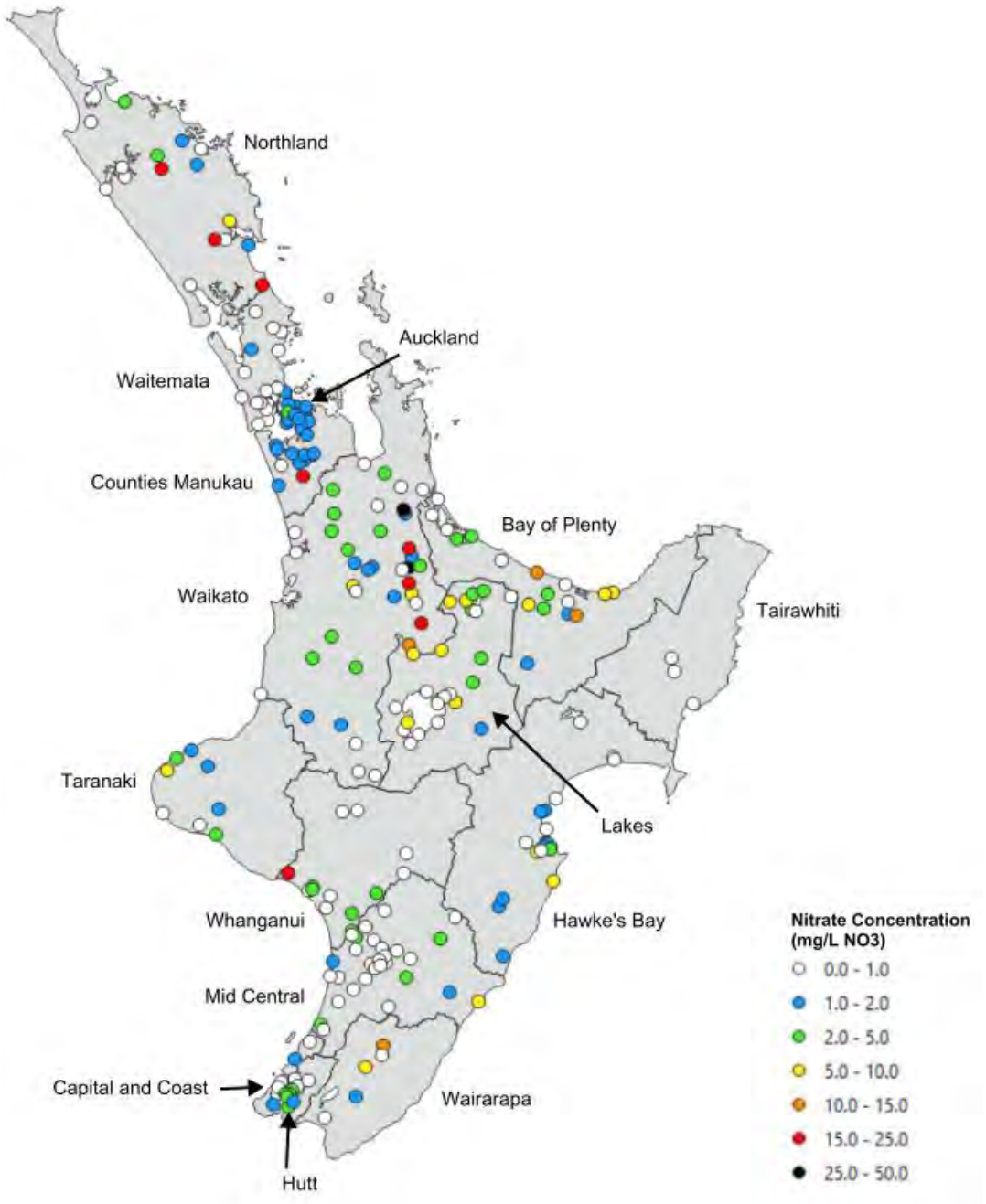


4.4 Spatial variability of nitrate levels in drinking water

4.4.1 Spatial distribution of nitrate concentrations in drinking water

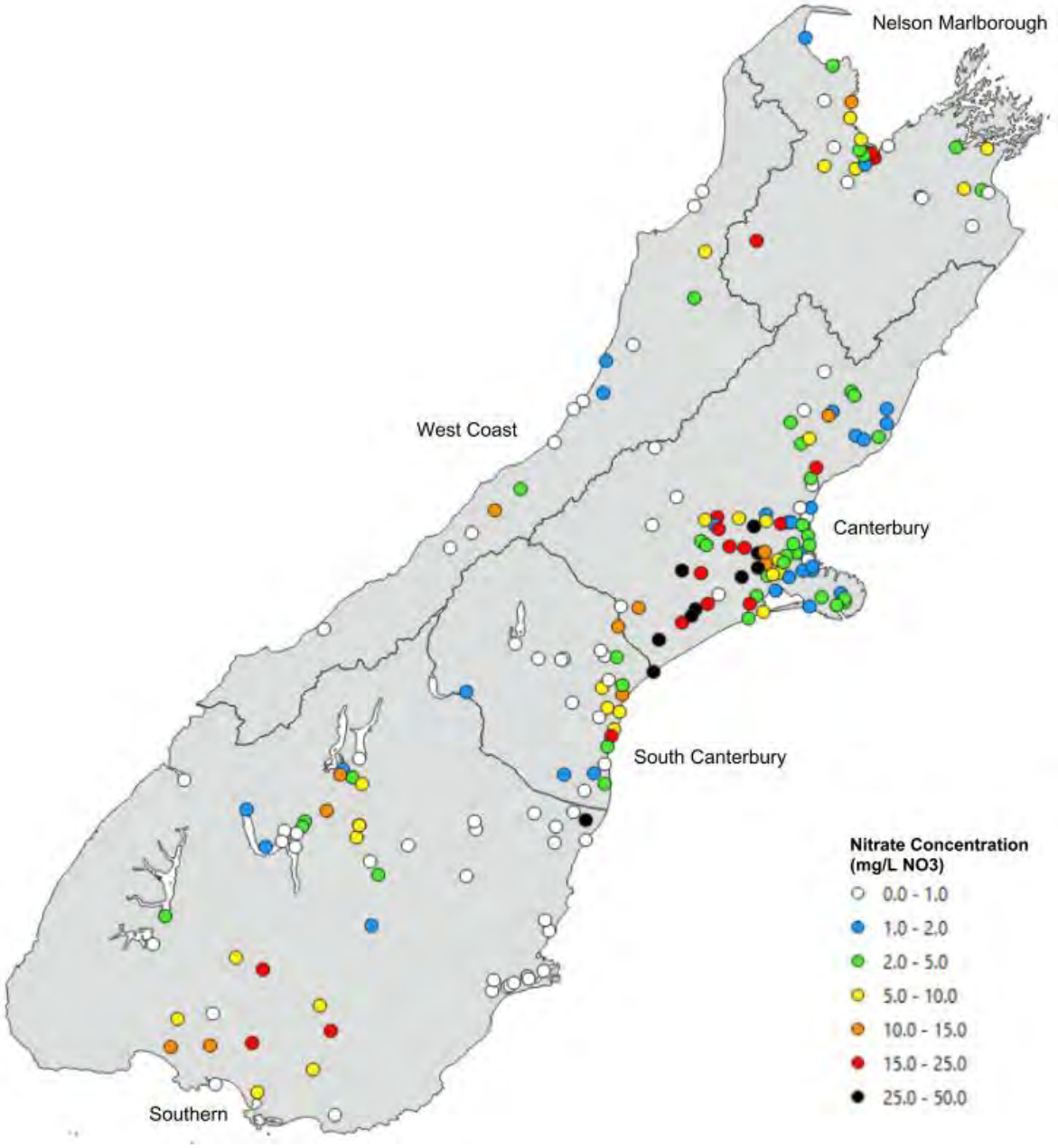
Nitrate levels in drinking water were found to have significant variation across New Zealand and within each DHB. Some supplies in close proximity to each other were found to have significantly different nitrate levels. **Figure 6** and **Figure 7** below display the location and nitrate concentration band of all registered water supplies in the nitrate database in New Zealand's North and South islands. The location of each DHB is also shown and labelled in these figures.

Figure 6: Nitrate levels in registered drinking water supplies, North Island



Map based on data from nitrate database and Creative Commons 3.0 New Zealand (2012)

Figure 7: Nitrate levels in registered drinking water supplies, South Island



Map based on data from nitrate database and Creative Commons 3.0 New Zealand (2012)

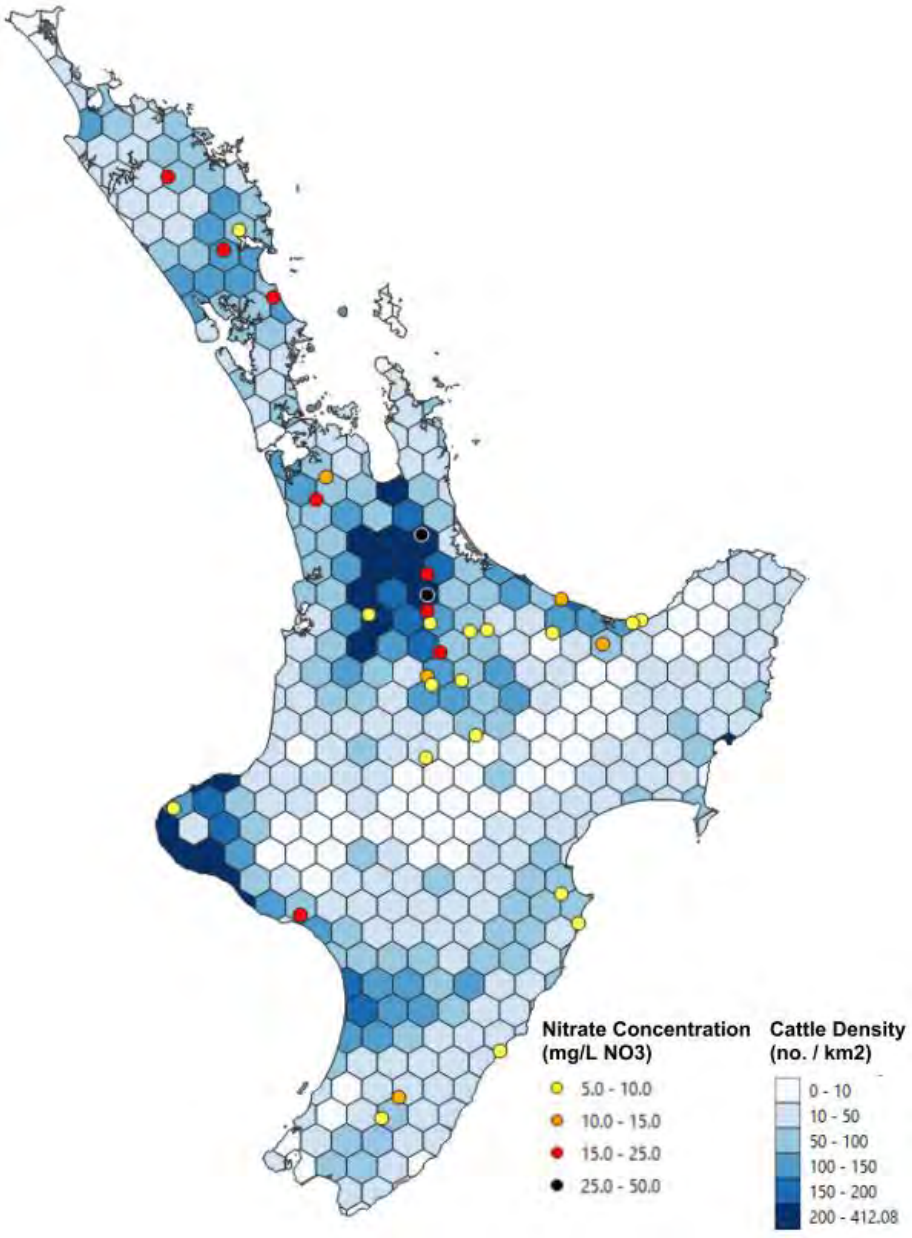
These maps clearly indicate clusters of drinking water supplies with elevated nitrate levels in the south of Canterbury, the south of Southland, Nelson Marlborough, Waikato and Northland. The maps also indicate clusters of drinking water supplies with low nitrate levels, such as in the Auckland, Waitemata, Counties Manukau, Tairawhiti, Hawke's Bay, Mid Central, Capital and Coast and Hutt District Health Boards.

4.4.2 Cattle density and spatial distribution of elevated nitrate levels in drinking water

The clusters of drinking water supplies with elevated nitrate levels (>5mg/L) in the south of Canterbury, the south of Southland, Waikato and Northland appear to be associated with

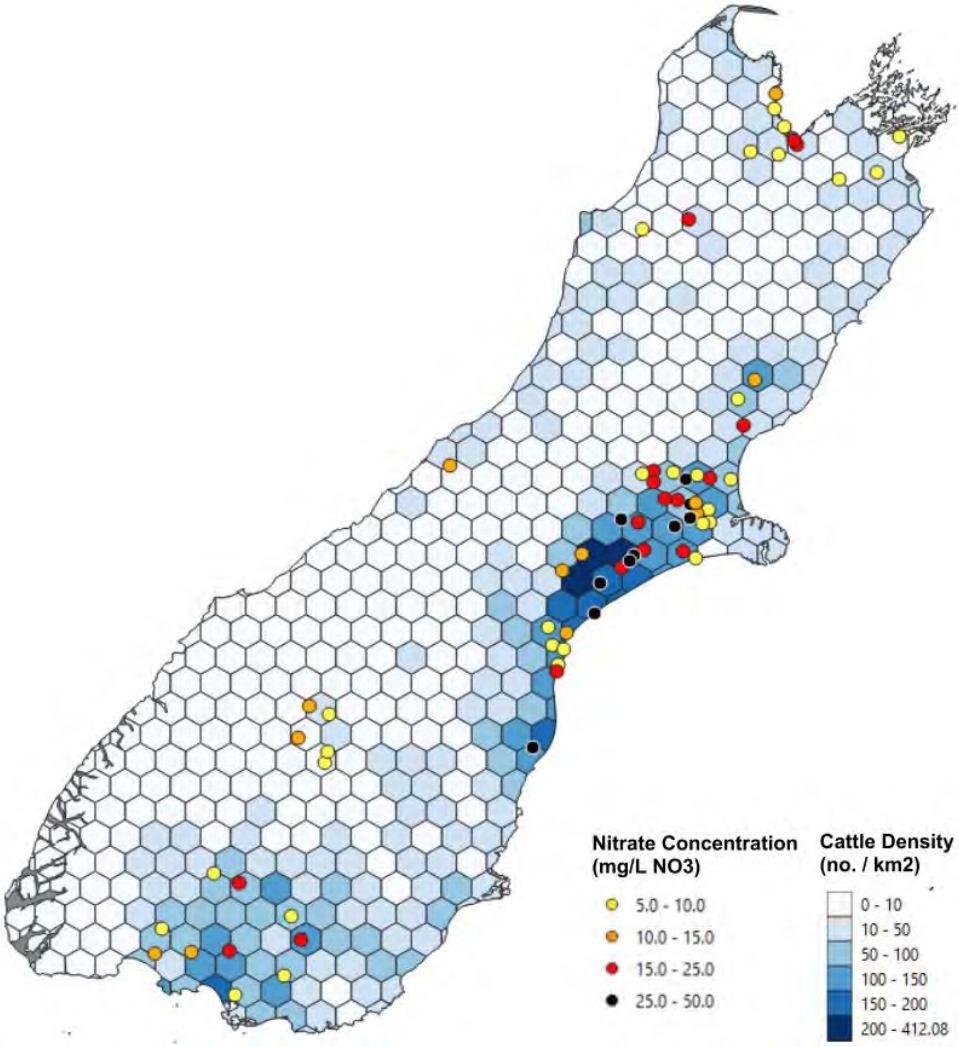
areas of high cattle density (refer **Figure 8** and **Figure 9** below). The elevated nitrate concentrations in Nelson-Marlborough did not appear to be associated with high cattle density nitrate levels in Taranaki were typically low despite the very high cattle density in the region. These findings are further described below. Drinking water supplies with nitrate levels of less than 5 mg/L are not shown in **Figure 8** or **Figure 9**.

Figure 8: Cattle density and elevated nitrate levels in registered drinking water supplies, North Island



Map based on data from nitrate database and Creative Commons 4.0 International (2019)

Figure 9: Cattle density and elevated nitrate levels in registered drinking water supplies, South Island



Map based on data from nitrate database and Creative Commons 4.0 International (2019)

The identification of clusters of water supplies with elevated nitrate concentrations in areas with high cattle density such as South Canterbury, Canterbury, Southland, Nelson Marlborough, Northland and parts of the Waikato were an anticipated result of the study due to well documented high nitrate leaching from areas with intensive cattle in New Zealand (e.g. Parfitt et al., 2012, Romera et al., 2012). The typically low nitrate levels in drinking water supplies located in Taranaki and the western Waikato which also have very high cattle intensity was not anticipated and are further discussed below.

All water supplies in the nitrate database in the Taranaki District are supplied from surface water sources, with the exception of one groundwater fed supply. Previous groundwater quality investigations in the Taranaki District have found nitrate levels in excess of 25 mg/L in 17% of groundwater monitoring sites, and levels in excess of 12.5 mg/L in 44% of sites (Taranaki Regional Council, 2017). Therefore it is possible that surface water sources used for

drinking water supply in the Taranaki District are less susceptible to elevated nitrate levels due to nitrate leaching than groundwater sources in the District, potentially due to the flushing effects of high rainfall and stream flow. Nitrate concentrations have been found to be lower in surface waters than groundwaters in other areas of New Zealand with extensive nitrate contamination in groundwater (NIWA, 2019)

Surface water sources are also the dominant water source in the Waikato District and supplies fed by surface water sources in the District were found to have less than 5mg/L nitrate concentration. Supplies with nitrate levels greater than 5 mg/L in the Waikato District were supplied by groundwater sources (or a mixture of groundwater and surface water sources). It is possible that water suppliers in these areas have endeavoured to use sources with low nitrate levels (such as deep bores). Data availability was also relatively low in both of these Districts, at around 70% of the population. It is therefore possible that exposure to elevated nitrate levels in drinking water in these regions is higher than identified through this study.

The high nitrate levels in water supplies that are not associated with high cattle density (such as in the Nelson-Marlborough Region) are likely associated with other land uses such as market gardening, other types of agriculture or other point sources of contamination. These findings highlight the potential inaccuracies in extrapolating nitrate levels in drinking water sources based solely on environmental monitoring data or regional land use data and the need to consider local site specific factors and point sources of contamination (e.g. McLay et al., 2001).

Comparison of nitrate levels in drinking water with fertiliser application rates was attempted however no publicly available datasets with sufficient granularity beyond the regional level could be identified. Comparison of nitrate levels with fertiliser application rates is recommended during the next phase of the study.

4.5 Variation in nitrate levels by water supply size category

The proportion of people exposed to the highest nitrate concentration bands varied considerably by the water supply size category (based on the size categories in ESR, 2019). The percentage of people exposed to greater than 10, 15 and 25 mg/L was highest in the smallest supply categories (Neighbourhood and Small) and lowest in the largest supply categories (Medium and Large). In the smallest supply categories, 21% of people with data (Neighbourhood) and 16% (Small) were exposed to greater than 10 mg/L, compared to 5% (Medium) and 1% (Large) in the largest supply categories. Similarly, 14% of people with data (Neighbourhood) and 5% (Small) were exposed to greater than 25 mg/L, compared to zero people exposed in the Medium and Large supply categories. The total number of people supplied by each category increases with increasing supply size (with the exception of Minor and Medium), ranging from 10,851 in the Neighbourhood category to 3,434,362 in the Large

category. These results are presented in **Figure 10** and **Table 7** below. Data coverage also increased with increasing supply size, ranging from 18% for neighbourhood supplies to 100% for Large supplies, as shown in **Table 7**.

The data collected from Regional Councils for unregistered supplies (and considered to be less reliable, refer Section **4.6**) and the data collected in Southland has been included in the unregistered supply category in **Figure 10** and **Table 7** to provide a comparison of potential exposure levels between unregistered and registered supplies. An estimated 114 people (or 5% of the people with available nitrate data in this category) may be exposed nitrate levels greater than 50 mg/L, while 580 people (22%) may be exposed to greater than 25 mg/L.

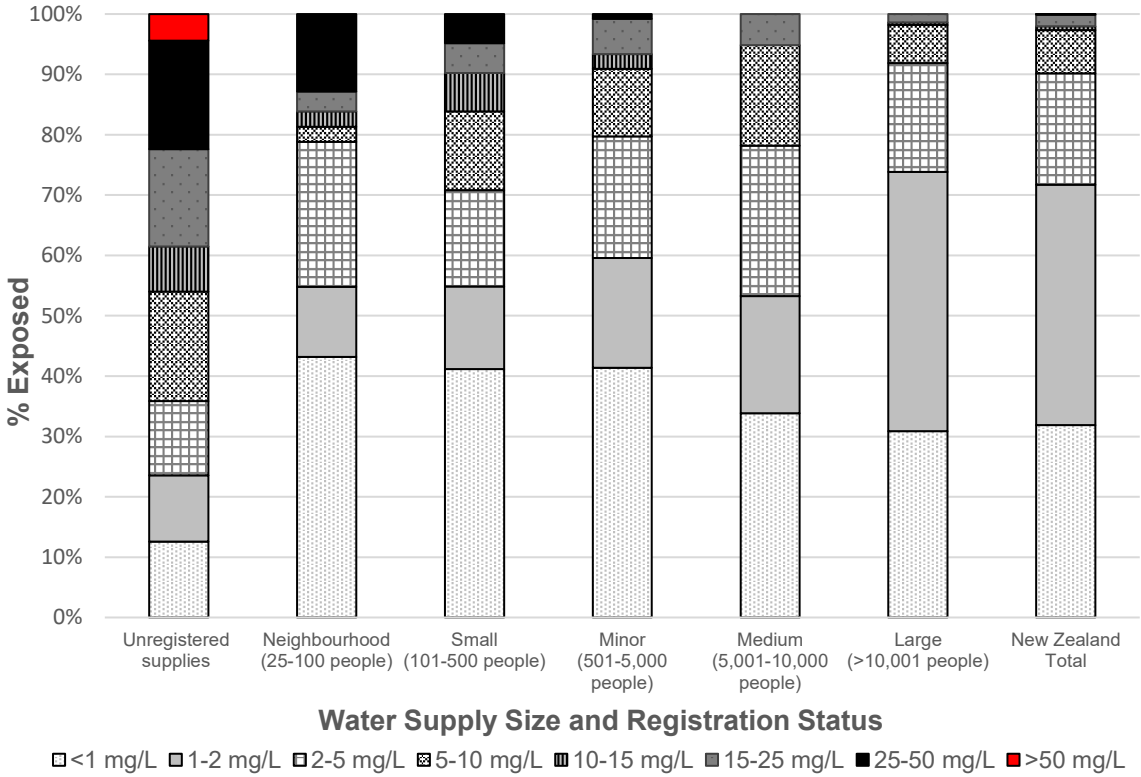


Figure 10: Nitrate levels in New Zealand drinking water by supply size and registration status (based on nitrate database, data from Regional Councils and data collected in Southland)

The results clearly indicate that people served by unregistered supplies and the smallest categories of registered drinking water supplies are more likely to be exposed to higher nitrate levels in drinking water than those supplied by the largest supply categories. This is an important finding given that data coverage in the nitrate database is also lowest for the smallest supply categories and unregistered supplies. It is recommended that additional data collection or sampling of Neighbourhood, Small and unregistered supplies is undertaken during the next phase of the study.

Table 7: Nitrate levels in New Zealand drinking water by water supply size category (based on nitrate database, data from Regional Councils and data collected in Southland)

	Drinking water supply category and size (number of people)					
Nitrate exposure range (mg/L)	**Unregistered (N/A)**	**Neighbourhood (25-100)**	**Small (101-500)**	**Minor (501–5,000)**	**Medium (5,001-10,000)**	**Large (>10,000)**
<1.0	326	859	14,017	125,663	53,529	1,072,437
2.0	285	230	4,665	55,249	30,679	1,490,553
2.0 – 5.0	319	478	5,438	61,256	39,360	627,412
5.0 – 10.0	471	50	4,434	33,982	26,351	218,421
10.0 – 15.0	193	50	2,171	7,556	-	15,047
15.0 – 25.0	419	66	1,685	17,612	8,134	47,800
25.0 – 50.0	466	255	1,645	2,478	-	-
>50.0	114	-	-	-	-	-
Total no. with data	2,593	1,988	34,055	303,796	158,053	3,471,670*
No data	600,973	8,863	23,187	73,664	21,203	-
Population in Register	603,566	10,851	57,242	377,460	179,256	3,434,362
% data coverage	0.4%	18%	59%	80%	88%	100%

** Based on population data provided by water suppliers the number of people served by large supplies is higher than the number in 2019 Register (ESR, 2019). Some of these supplies would have been classified as Medium supplies in ESR (2019).*

Based on current MoH policy, P2 determinands are typically only assigned to water supplies with greater than 500 people (Nokes, 2020). This policy would exclude registered supplies with the greatest risk of elevated nitrate levels from the monthly monitoring and management requirements that would be required if nitrate was assigned as a P2 determinand. It is recommended that Taumata Arowai consider assigning nitrate as a P2 determinand in supplies with less than 500 people where nitrate levels exceed 50% of the MAV.

The finding that the highest risk of exposure is in the smallest supplies highlights the need to ensure that registered drinking water suppliers have adequate resources and expertise to safely manage Neighbourhood and Small water supplies. This finding also highlights the opportunity for suppliers to identify innovative approaches to improve water quality for small supplies without significantly increasing operational costs. One such innovative approach was recently implemented by Waitaki District Council, where the water supplies for a number of small communities (serving approximately 1,300 people) south of Oamaru City were amalgamated through the installation of a pipeline to convey treated water from Oamaru City to the small communities. This approach has resulted in significantly improved drinking water quality for these supplies (Roy, 2019).

4.6 Estimate of exposure for those without data

People served by unregistered supplies are the largest group of people without available nitrate data. No estimate could be obtained from Regional Councils, MoH, ESR or Water New Zealand for the proportion of people served by unregistered supplies who rely on rainwater, compared to those who use groundwater or surface water for their drinking water. Water sources used for unregistered supplies are likely to vary around New Zealand depending on rainfall and availability and quality of groundwater and it is likely that many people served by unregistered supplies would use a mixture of water sources (i.e. rainwater supplemented with groundwater during periods of low rainfall). ESR maintains separate registers of Networked Supplies that serve less than 25 people and 'specified self-suppliers' (these are not included in the main part of the Register) (ESR 2019a, refer parts 3 and 4). These registers cover more than 1,016 supplies and an estimated 153,102 people and the water source for each supply is classified as either rainwater, surface water or groundwater. In the absence of any available national estimate, extrapolation of the water sources used by people on these registers is considered to provide the most robust estimate for water sources used by the approximately 601,000 people served by unregistered supplies.

A total of 75% of the people in Parts 3 and 4 of the Register are supplied by a groundwater or surface water source, with the remaining 25% served by rainwater. Extrapolating these percentages to the people served by unregistered supplies without any available nitrate data would result in an estimated 451,403 people supplied by groundwater or surface water sources and 149,570 people supplied by rainwater. Extrapolating exposure levels based on Regional Council data and the results of the sampling in Southland would result in the additional number of people in each nitrate concentration band shown in **Table 8** below. Based on the results of the sampling in Southland, those served by rainwater supplies are assumed to be exposed to negligible levels of nitrate (<1 mg/L).

Table 8: Estimated exposure for those with no data, served by unregistered supplies (based on data from Regional Councils, data collected in Southland and population data from Stats NZ (2020))

Nitrate Exposure Range (mg/L)	Extrapolated no. of people* exposed served by unregistered supplies	No. people exposed (from nitrate database)	Total	% of 2018 NZ Population
<1.0	206,648	1,266,608	1,473,256	31.3%
1.0 - 2.0	49,899	1,581,404	1,631,303	34.7%
2.0 – 5.0	55,852	734,019	789,871	16.8%
5.0 – 10.0	82,465	283,297	365,762	7.8%
10.0 – 15.0	33,791	24,827	58,618	1.2%
15.0 – 25.0	73,361	75,350	148,711	3.2%
25.0 – 50.0	81,590	4,459	86,049	1.8%
>50.0	19,960	-	19,960	0.4%
Total	**603,566**	**3,969,964**	**4,573,530**	**97.3%**

** Includes 2,593 people with data from Regional Councils and sampling in Southland*

This extrapolation indicates that although there are only approximately 603,000 people served by unregistered supplies (compared to approximately 4,096,200 served by registered supplies), the total number of people served by unregistered supplies exposed to > 50 mg/L, 25 – 50 mg/L and 10-15 mg/L may be higher than the total number of people exposed who are supplied by registered supplies. This extrapolation also indicates that a significantly higher percentage of the population (up to 14.4%) is likely to be exposed to greater than 5 mg/L than found by the nitrate database (8.2%).

It is important to note that the Regional Council data may overestimate exposure to elevated nitrate levels in unregistered drinking water supplies due to the following reasons:

- The ‘use’ of a bore is advised at the time of consent (environmental approval) to use the water and is not updated if the use changes after the consent is issued.
- The Regional Council results are raw water results and there may be treatment to remove nitrate (e.g. household undersink reverse osmosis units)
- Regional Council monitoring programmes often aim to target areas of poor water quality
- Does not consider use of multiple sources (i.e. rainwater tank supplemented by a groundwater supply during periods of drought)

For these reasons the Regional Council Data was not included in the nitrate database. Nonetheless, this extrapolation indicates the potential for significant exposure to elevated nitrate levels in drinking water from unregistered supplies across New Zealand and warrants further investigation in the next phase of this study.

The data for unregistered supplies is heavily biased to data from Canterbury and to a lesser extent Southland, with more than 60% of the data available for unregistered supplies coming from Environment Canterbury and 20% from Environment Southland. The extrapolation was repeated without any of the data from Environment Canterbury to assess this potential bias. This resulted in an even higher percentage of the population (up to 14.5%) estimated to be exposed to greater than 5 mg/L and the same percentage of the population (up to 2.2%) estimated to be exposed to greater than 25 mg/L. The extrapolation was also repeated without data from either Environment Canterbury or Environment Southland and results were similar, with an estimated 13.2% of the population exposed to greater than 5 mg/L and the 2.2% estimated to be exposed to greater than 25 mg/L. These results indicate that the extrapolation is not strongly influenced by the over-representation of data from Environment Canterbury (or to a lesser from Environment Southland) and is considered to provide a reasonable, yet preliminary indication of potential exposure for approximately 603,000 people who are not served by a registered drinking water supply.

This is the first known attempt to estimate water source types used by those served by unregistered water supplies in New Zealand and the first known attempt to assess exposure

to nitrate in drinking water for people who are not supplied by registered drinking water suppliers. People served by unregistered supplies are likely to have the highest risk of exposure to elevated nitrate levels in drinking water. This is significant and it is recommended that Taumata Arowai consider establishing monitoring programs for unregistered water supplies and consider regulation of unregistered supplies. It is also recommended that there is greater sharing of drinking water quality data collected by Regional Councils for environmental monitoring or resource consenting purposes with the drinking water regulator. It is further recommended that people served by unregistered supplies monitor nitrate levels in their water supplies.

4.7 Changes in nitrate levels in drinking water over time

4.7.1 Seasonal Variation

Monthly nitrate results for six registered drinking water supplies are shown in **Figure 11** below. These supplies were selected from the 33 supplies with monthly data to show the range of temporal variation identified, to show temporal variation from supplies with different nitrate levels and to show temporal variation from different Districts in New Zealand. **Figure 11** demonstrates that seasonal variation of nitrate levels in New Zealand drinking water can range from minor fluctuations (e.g. Havelock, Dromore) to significant seasonal changes (e.g. Seadown). The variation in nitrate concentrations over the 2018 – 2019 period within the supplies (calculated by subtracting the lowest result from the highest result within each of the six supplies) ranged from 1.3 mg/L (Havelock) to 11.0 mg/L (Seadown).

Significant temporal variability in nitrate concentrations of drinking water supply source waters has previously been reported by ESR (2018) and is supported by the findings of this study. The extent of the variation is likely to be associated with soil type, nitrate contamination source, drinking water source (e.g. depth of bore) and proximity to point contamination sources. Significant seasonal changes may potentially be associated with high rainfall events and specific activities at point sources of nitrate contamination.

Clear seasonal trends in groundwater nitrate concentrations have previously been reported in Canterbury, with higher concentrations in winter or spring and lower concentrations in autumn (ECAN, 2002). The seasonal fluctuations were attributed to greater rainfall and lower evaporation and plant activity rates during winter, resulting in greater soil moisture content and nitrate leaching to groundwater compared to in summer and autumn when moisture content was lower (ECAN, 2002). The temporal variation of the six supplies shown in **Figure 11** do not appear to follow this trend and it is likely that there are other factors influencing the variation. The impact of seasonal variation is a minor limitation in this study and is further discussed in Section **4.10.5**.

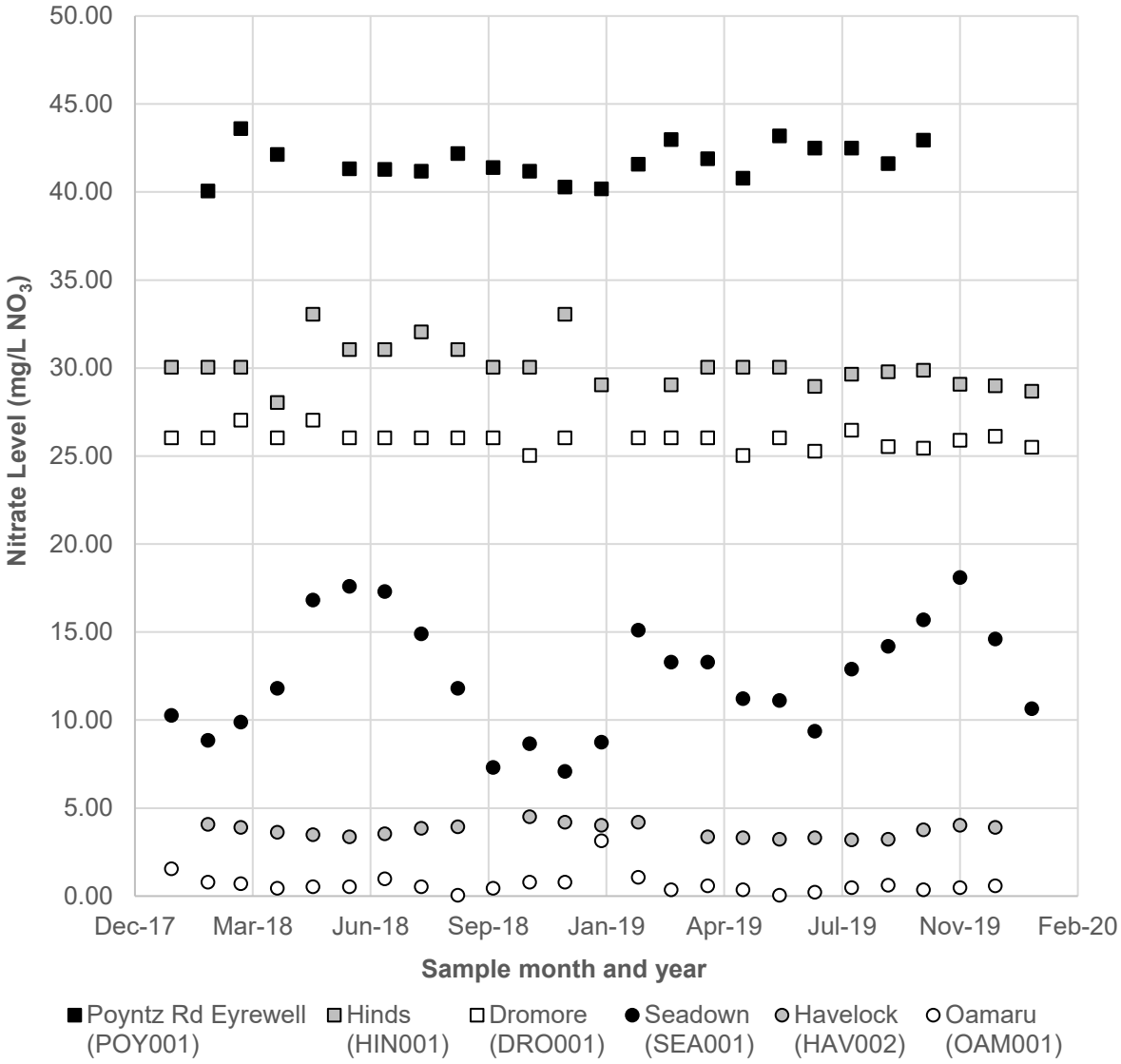


Figure 11: Temporal variation in nitrate levels from five drinking water supplies

4.7.2 Changes over the past two decades

Data from the P2 Programme historical database indicates that more than 10% of the 2001 New Zealand population were exposed to greater than 10 mg/L of nitrate in drinking water (refer **Table 9** and **Figure 12** below). This is significantly higher than the percentage of the population exposed to greater than 10 mg/L in the current database (2.2%, refer **Table 6**). The total number of people exposed to greater than 10 mg/L was also higher in the historical database (374,130) than the current database (104,636). The number of people exposed to 10-15 mg/L in the historical database (276,492, **Table 9**) is more than 10 times the number in the current database (24,827, **Table 6**) while the number exposed to 15-25 mg/L is similar in both databases. The number of people exposed to 25 - 50 mg/L in the historic database (22,450, **Table 9**) is more than five times the number in the current database (4,459, **Table 6**) and there were 900 people exposed to greater than 50 mg/L in the historical database

(compared to zero in the current database). The relatively high exposure to greater than 10mg/L in the historical database was found despite the low level of data coverage (35% of 2001 population).

Table 9: Historical nitrate levels in New Zealand drinking water (1996 – 2003)

NO3 Concentration Range (mg/L)	No. People Exposed (1996 – 2003)*	% People in Database	% of 2001 NZ Population**
<1.0	581,978	45%	16%
1.0 2.0	112,656	9%	3%
2.0 5.0	151,680	12%	4%
5.0 - 10.0	84,257	6%	2%
10.0 - 15.0	276,492	21%	7%
15.0 - 25.0	74,288	6%	2%
25.0 - 50.0	22,450	2%	1%
> 50.0	900	0.1%	0.02%
Total with data	1,304,701	N/A	35%
No data	2,432,576	N/A	65%

** Extracted from ESR (2019b)*
*** Based on Stats NZ (2020a)*

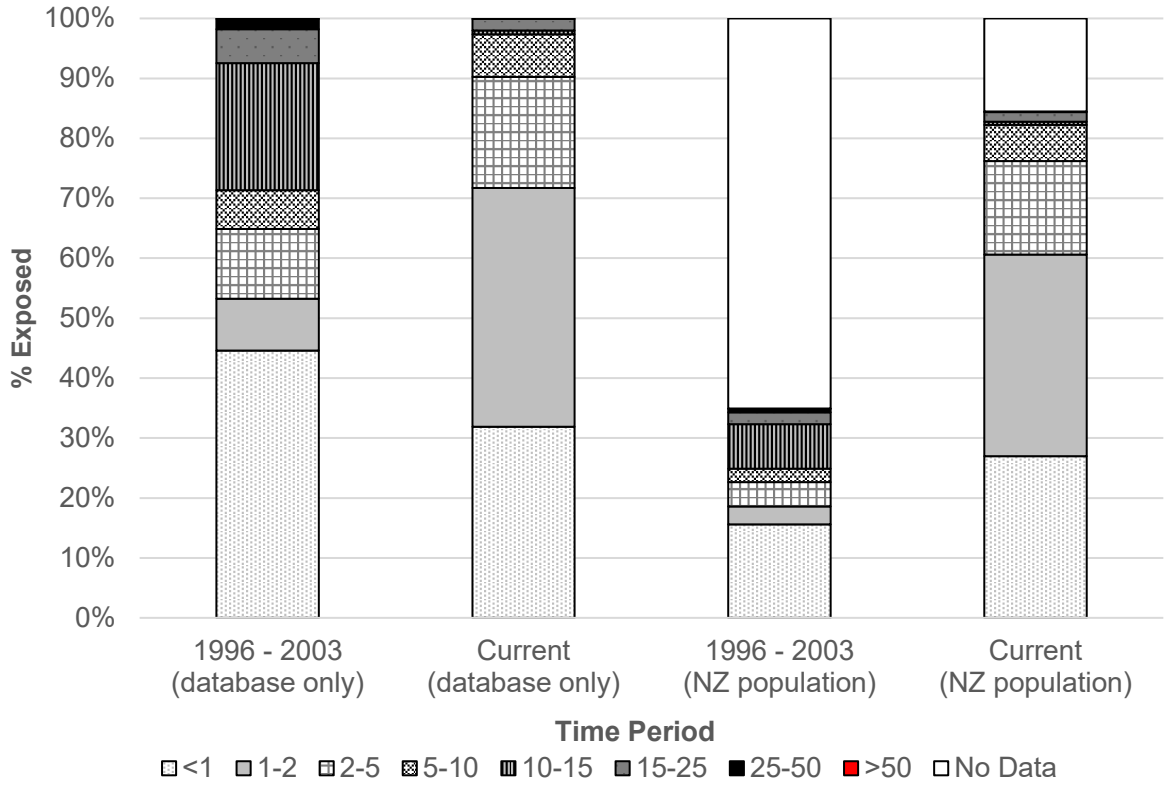


Figure 12: Current and historical exposure to nitrate levels, as a percentage of those in each database and as a percentage of the New Zealand population (2001 and 2018) (based on nitrate database and ESR (2019b))

It is possible that the higher exposure in the P2 Programme historical database compared to the current database is due to the historical database being the result of a targeted sampling program and due to the differences in data coverage of different supply categories in the two

databases. The purpose of the P2 Programme was to specifically identify supplies with greater than 25 mg/L nitrate and therefore sampling was targeted towards these supplies (Davies, Nokes and Ritchie, 2001).

The P2 Programme historical database covers a greater number of people in the two smallest registered supply categories than the current database, as shown in **Table 10** below and these supply categories have been identified to have the greatest levels of elevated nitrates out of all the registered supply categories (refer Section 4.5). It is therefore possible that the exposures for people served by Small and Neighbourhood supplies in the P2 Programme historical database more closely reflect actual current exposures for these people than the data from the nitrate database. There are slightly higher numbers of people in the Minor and Medium supply categories in the current database compared to the P2 Programme historical database, and significantly higher numbers in the Large category in the current database. As a result of these differences it is difficult to draw conclusions from a comparison of exposures between the two databases. Instead, consideration of changes in nitrate levels within individual supplies is likely to be more meaningful.

Table 10: Number of people in each supply category, P2 Programme historical database compared to current database (based on nitrate database and ESR (2019b))

	Drinking water supply category and size (number of people)				
Database	**Neighbourhood (25-100)**	**Small (101-500)**	**Minor (501–5,000)**	**Medium (5,001-10,000)**	**Large (>10,000)**
P2 Programme historical database	5,620	75,953	278,025	129,544	815,559
Current database	1,988	34,055	303,796	158,053	3,471,670

A total of 238 supplies had nitrate data available in both the current nitrate database and the P2 Programme historic database. Of these supplies, a significant (>5 mg/L) increase in nitrate level was identified for a total of 26 supplies (currently serving a total of 127,890 people) and an increase of between 2 and 5 mg/L was identified in a further 25 supplies (currently serving a total of 129,564 people). An increase of greater than 1 mg/L was identified in a total of 79 supplies, currently serving a total of 599,810 people. These numbers are significantly higher than the number of supplies where nitrate levels decreased by more than 1 mg/L over the same time period (35 supplies currently serving 233,956 people). Nitrate levels did not change by more than 1 mg/L in a total of 124 supplies currently serving a total of 864,889 people. These results are shown in **Figure 13** below.

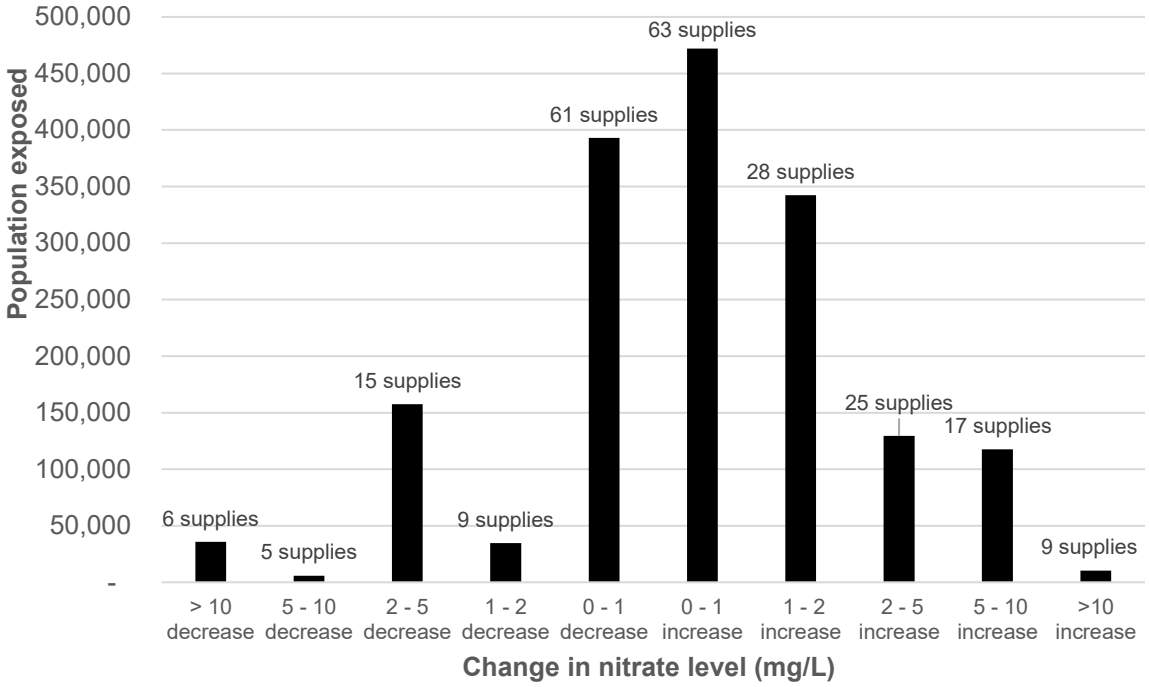


Figure 13: Change in nitrate levels in 238 drinking water supplies over the past-two decades (based on nitrate database and ESR (2019b))

Based on changes in nitrate levels in individual supplies (**Figure 13**), it is clear that there has been an increase in nitrate levels over the past two decades in a greater number of supplies and for a greater number of people than there has been a decrease. This is true for a change of more than 1mg/L, more than 2mg/L and more than 5 mg/L. This finding indicates that exposure to nitrate in drinking water has increased over the past two decades. This is a significant finding and was anticipated given the rapid expansion of the dairy industry and a 250% increase in fertiliser application over a similar period (MFE and Stats NZ, 2019). The finding is similar to findings from national state of the environment reports, such as (MFE and Stats NZ, 2020) where nitrate concentrations in groundwater were reported to have an increasing trend in around 38% of sites monitored for over the past decade.

4.8 Nitrate treatment in New Zealand Drinking water supplies

Advanced water treatment to reduce nitrate levels in drinking water was only found to be occurring in one registered supply. The supply is privately operated and serves 200 people in the Counties Manukau District. The water source for the supply is a bore with nitrate levels of around 51.8 mg/L. The supplier advised that an ion exchange treatment plant was installed during early 2019, reducing nitrate levels to approximately 12 mg/L. The nitrate level of 12 mg/L was recorded in the nitrate database for this supply (rather than 51.8 mg/L) because the ion exchange unit was installed prior to the commencement of this study (July 2019).

Blending of water sources to reduce nitrate levels was found to be occurring in the Richmond supply (RIC001), operated by Tasman District Council. This supply serves approximately

16,000 people and is located in the Nelson- Marlborough Region. The water for the supply is sourced from wells in the Richmond Borefield, Waimea Borefield and the Appleby Well. Nitrate levels have historically been high in this supply (at times >50 mg/L) and since 2015 blending of the water sources has been controlled to achieve the current nitrate level of approximately 22 mg/L.

A new water source has recently been developed to supply a privately operated supply in Canterbury that has historically had nitrate concentrations above 50% of the MAV. The supply serves approximately 1,700 people and had an average nitrate concentration of 39.2 mg/L, based on monthly samples taken over the 2018 – 2020 period. In early 2020 a new deep bore with significantly lower nitrate levels was commissioned to replace the high-nitrate well. The commissioning of the new bore occurred during the period of this study and therefore the average of the 2018-2020 results was recorded in the database (39.2 mg/L). Nitrate treatment or water source management to reduce nitrate levels was not identified in any other water supplies in this study.

These results indicate that there is limited local New Zealand experience in advanced water treatment processes for nitrate removal from drinking water. Drinking water suppliers seeking to reduce nitrate levels would need to undertake a site-specific options assessment to identify the most appropriate approach. It is likely that the most cost-effective approaches would be prioritising use of an existing lower-nitrate source, blending or development of a new lower-nitrate source. Where an alternative lower nitrate source is not available, advanced water treatment will likely be required and the most appropriate treatment option will be dependent on a number of factors, such as the influent water quality, ability to dispose of waste water streams, power demand, chemical cleaning requirements, operational costs and complexity of operation.

For supplies of less than 50 people, it is likely that point of use treatment in each dwelling would often be the most cost-effective approach to reducing nitrate levels, unless there is a readily available alternative source of lower nitrate water (refer cost estimates in Appendices). For Neighbourhood and Small supplies where an alternative water source is not available, point of use treatment may still be competitive with advanced water treatment costs and would need to be assessed on a site-specific basis. Point of use treatment is not specifically permitted under the current Drinking Water Standards (MoH, 2018) and it is recommended that Taumata Arowai consider reviewing options to permit point of use treatment in the next revision of the DWSNZ (MoH, 2018). Point of use treatment would likely prove to be more economic for self-suppliers than development of a new low-nitrate water source (refer cost estimates in Appendices).

4.9 Preliminary estimate of population burden of colorectal cancer attributable to nitrate in drinking water

4.9.1 Exposure to nitrate levels in drinking water associated with increased risk of colorectal cancer

Based on the results of the nitrate database and the results of relevant international studies, the number of New Zealanders currently exposed to potentially harmful levels of nitrate in drinking water may range from approximately 317,000, based on Espejo-Herrera et al. (2016) to more than 505,000, based on Schullehner et al. (2018). This is equivalent to 6.7 – 10.8% of the population. Based on the calculation of the Population Attributable Fractions (PAFs) (refer Section 2.2), these preliminary results indicate that between 0.6% and 3.2% of colorectal cases in New Zealand may be attributable to exposure to nitrate in drinking water. This is equivalent to approximately 19 – 103 cases, based on the number of new registrations in 2016, 3219 (MoH, 2019). These results assume that the people without any available nitrate data (a total of 729,791 people or 16% of the population) are not exposed to potentially harmful levels of nitrate in drinking water (as only the data from the nitrate database is used). These estimates are shown in **Table 11** below.

Table 11: Number of people estimated to be exposed to potentially harmful levels of nitrate in drinking water and estimated PAFs for colorectal cancer (based on current exposures in the nitrate database)

Study	Exposure Range (mg/L NO3)	HR	No. people exposed	% of 2018 population	PAF (%)	Estimated no. cases attributable
Espejo-Hererra et al., 2016	≥7.1	1.49	317,213	6.75%	3.20	103.1
	Total	**-**	**317,213**	**6.7%**	**3.20**	**103.1**
Schullehner et al., 2018	3.87 - 9.25	1.11	390,221	8.30%	0.91	29.1
	≥ 9.25	1.15	115,206	2.45%	0.37	11.8
	Total	**-**	**505,427**	**10.8%**	**1.28**	**40.9**
Temkin et al., 2019*	4.43 - 8.85	1.04	283,131	6.02%	0.24	7.7
	8.85 - 13.28	1.08	21,088	0.45%	0.04	1.2
	13.28 - 17.71	1.12	47,019	1.00%	0.12	3.9
	17.71 - 22.13	1.16	31,215	0.66%	0.11	3.4
	22.13 - 26.56	1.20	13,523	0.29%	0.06	1.9
	26.56 - 30.98	1.24	1,683	0.04%	0.01	0.3
	30.98 - 35.41	1.28	238	0.01%	0.00	0.0
	35.41 - 39.84	1.32	2,000	0.04%	0.01	0.4
	39.84 - 44.27	1.36	265	0.01%	0.00	0.1
	Total		**400,162**	**8.5%**	**0.59**	**18.8**

** The exposure ranges and HRs have been extrapolated from Temkin et al. (2019) based on the estimated 4% increase in risk for every 1 mg/L NO_3-N (or 4.43 mg/L NO_3)*

Applying the same exposure ranges and Hazard Ratios to the historical data from the P2 Programme database results in an estimate of 431,226 – 498,099 people (9.2 – 10.6% of the 2018 population) exposed to potentially harmful levels of nitrate in drinking water, higher estimates for the PAF (1.1 – 4.3%) and higher estimates for the number of attributable cases

(36 to 139) compared to the results from the current nitrate database (refer **Table 12**). This analysis is built on the assumption that all people in the historic nitrate database exposed between 1996 and 2003 are still alive today and is therefore a preliminary estimate for hypothesis generation only. Given the much higher coverage of nitrate data from Neighbourhood and Small water supplies in the P2 Programme database compared to the current database and the higher nitrate exposures in these categories (refer Section **4.5**), the estimate of the PAF range using the historical data may present a more accurate representation of the actual PAF range.

Table 12: Number of people estimated to be exposed to potentially harmful levels of nitrate in drinking water and estimated PAFs for colorectal cancer (based on historical exposures in the P2 Programme Database, ESR (2019b))

Study	Exposure Range (mg/L NO3)	HR	No. people exposed	% of 2018 population	PAF (%)	Estimated no. cases attributable
Espejo-Hererra et al., 2016	≥7.1	1.49	431,226	9.2%	4.30	138.5
	Total	**-**	**431,226**	**9.2%**	**4.30**	**138.5**
Schullehner et al., 2018	3.87 - 9.25	1.11	119,134	2.5%	0.28	9.0
	≥ 9.25	1.15	378,965	8.1%	1.20	38.5
	Total	**-**	**498,099**	**10.6%**	**1.47**	**47.4**
Temkin et al., 2019*	4.43 - 8.85	1.04	50,996	1.09%	0.04	1.4
	8.85 - 13.28	1.08	144,963	3.08%	0.25	7.9
	13.28 - 17.71	1.12	201,517	4.29%	0.51	16.5
	17.71 - 22.13	1.16	44,463	0.95%	0.15	4.9
	22.13 - 26.56	1.20	3,668	0.08%	0.02	0.5
	26.56 - 30.98	1.24	5,870	0.12%	0.03	1.0
	30.98 - 35.41	1.28	3,415	0.07%	0.02	0.7
	35.41 - 39.84	1.32	100	0.00%	0.00	0.0
	39.84 - 44.27	1.36	13,065	0.28%	0.10	3.2
	Total	**-**	**468,057**	**9.96%**	**1.12**	**36.0**

** The exposure ranges and HRs have been extrapolated from Temkin et al. (2019) based on the estimated 4% increase in risk for every 1 mg/L NO_3-N (or 4.43 mg/L NO_3)*

Inclusion of exposure estimates for approximately 600,000 people on unregistered supplies with no available data (extrapolated from Regional Council data in Section 4.6 above) would increase the estimated number of people potentially exposed to harmful levels of nitrate in drinking water to between 568,810 and 804,122 (12.1 – 17.1 % of the New Zealand population) (refer **Table 13** below). The inclusion of these exposure estimates would increase the estimated PAF to between 1.75 (based on Temkin et al., 2019) and 5.6% (based on Espejo-Herrera et al., 2016) and would increase the estimated number of attributable cases to between 56 and 180 cases per year (refer **Table 13**). As described in Section **4.2.3** the Regional Council data and extrapolated exposure estimate for people served by unregistered supplies is considered to have lower reliability and is therefore a preliminary estimate for hypothesis generation only.

Table 13: Number of people estimated to be exposed to potentially harmful levels of nitrate in drinking water and estimated PAFs for colorectal cancer, including exposure estimate for people served by unregistered supplies (based on nitrate database and unregistered supply data)

Study	Exposure Range (mg/L NO3)	HR	No. people exposed (unregistered supplies)	Total no. people exposed	% of 2018 population	PAF (%)	Est. no. cases attributable
Espejo-Hererra et al., 2016	≥7.1	1.49	250,160	568,810	12.1%	5.60	180.2
	Total	**-**	**250,160**	**568,810**	**12.1%**	**5.60**	**180.2**
Schullehner et al., 2018	3.87 - 9.25	1.11	78,164	468,834	10.0%	1.09	34.9
	≥ 9.25	1.15	218,825	335,288	7.1%	1.06	34.1
	Total	**-**	**296,989**	**804,122**	**17.1%**	**2.14**	**69.0**
Temkin et al., 2019	4.43 - 8.85	1.04	61,452	344,936	7.34%	0.29	9.4
	8.85 - 13.28	1.08	52,051	73,438	1.56%	0.12	4.0
	13.28 - 17.71	1.12	30,987	78,184	1.66%	0.20	6.4
	17.71 - 22.13	1.16	31,684	63,081	1.34%	0.21	6.9
	22.13 - 26.56	1.20	24,546	38,210	0.81%	0.16	5.2
	26.56 - 30.98	1.24	21,935	23,744	0.51%	0.12	3.9
	30.98 - 35.41	1.28	15,319	15,645	0.33%	0.09	3.0
	35.41 - 39.84	1.32	15,319	17,407	0.37%	0.12	3.8
	39.84 - 44.27	1.36	10,619	10,945	0.23%	0.08	2.7
	44.27 - 48.70	1.40	6,789	6,828	0.15%	0.06	1.9
	48.70 - 53.12	1.44	3,134	3,152	0.07%	0.03	0.9
	53.12 - 57.55	1.48	2,611	2,626	0.06%	0.03	0.9
	57.55 - 61.98	1.52	3,656	3,677	0.08%	0.04	1.3
	61.98 - 66.41	1.56	2,089	2,101	0.04%	0.03	0.8
	66.41 - 70.83	1.60	2,611	2,626	0.06%	0.03	1.1
	70.83 - 75.26	1.64	-	-	0.00%	0.00	0.0
	75.26 - 79.69	1.68	1,045	1,051	0.02%	0.02	0.5
	79.69 - 84.11	1.72	2,089	2,101	0.04%	0.03	1.0
	84.11 - 88.54	1.76	1,045	1,051	0.02%	0.02	0.5
	88.54 - 92.97	1.80	522	525	0.01%	0.01	0.3
	92.97 - 97.39	1.84	522	525	0.01%	0.01	0.3
	97.39 - 101.82	1.88	522	525	0.01%	0.01	0.3
	101.82 - 106.25	1.92	-	-	0.00%	0.00	0.0
	106.25 - 110.68	1.96	522	525	0.01%	0.01	0.3
	110.68 - 115.10	2.00	1,045	1,051	0.02%	0.02	0.7
	Total		**292,115**	**693,955**	**14.8%**	**1.75**	**56.3**

The results of this study indicate that between 6.7% and 17% of the population are exposed to potentially harmful levels of nitrate in drinking water. The estimate of 6.7% excludes estimated exposure for unregistered supplies and is based on the results of Espejo-Herrera et al. 2016 while the estimate of 17% includes the extrapolation of exposure for those on unregistered supplies and is based on the results of Schullehner et al. (2018). The differences in the dose response relationships published in the literature and uncertainty of exposure for those supplied by unregistered supplies has resulted in the relatively wide range of 6.7 – 17% for this estimate. The epidemiological study proposed as the next phase of this project will contribute to the international body of research on the health impacts of nitrate levels in drinking water and attempt to provide greater certainty on the dose response relationship in New Zealand. The study will also provide an improved estimate of exposure for those supplied by unregistered supplies.

Comparison with published international estimates indicates that the percentage of the population exposed to potentially harmful levels of nitrate in drinking water may be lower in New Zealand compared to Europe and the United States. This study has found that 0.1% of the New Zealand population (or 2.2 % including the extrapolated exposure for those served by unregistered supplies) is exposed to greater than 25 mg/L nitrate in drinking water, compared to an estimated 6.5% of the population of 12 European Union member states (Van Grinsven, Rabl and De Kok, 2010). Similarly, this study has found that 8.2% of the New Zealand population (or 14.4% including the extrapolated exposure for those served by unregistered supplies) is exposed to greater than 4.43 mg/L nitrate in drinking water, compared to 28.9% in the United States (extrapolated from Temkin et al., 2019). Both the United States and European studies included data for private wells (extrapolated through different methods). Intensive agricultural activities have been practiced for much longer in Europe and the United States than in New Zealand, and therefore nitrate contamination would be expected to be lower in New Zealand. The estimated percentage of colorectal cancer incidences potentially attributable to exposure to nitrate in drinking water in New Zealand (1.75 – 5.6%, including extrapolated exposure for those served by unregistered supplies) is within the published range estimated for the United States (1-8%) (Temkin et al., 2019).

This study has developed the first estimate of the potential contribution of exposure to nitrate levels in drinking water to colorectal cancer cases in New Zealand. Although the results are preliminary, they indicate that exposure to nitrate in drinking water is likely to be a significant contributing factor to colorectal cancer cases in New Zealand. Exposure to nitrate in drinking water may have a similar significance to the established risk factors of high consumption of red meat, physical inactivity, high consumption of processed meat and smoking, that have estimated PAFs between 2.5 and 4.8% in New Zealand (refer **Table 2**). The established risk factors of heavy alcohol consumption and obesity are likely to be more significant risk factors

than exposure to nitrate in drinking water due to the high Hazard Ratios and high prevalence rates of these risk factors (refer **Table 2**).

The preliminary results of this study strongly suggest that further research into nitrate levels in New Zealand drinking water is warranted, along with further research into the epidemiology of exposure to nitrate in drinking water in New Zealand. It is recommended that Taumata Arowai consider the body of evidence for the association between nitrate in drinking water and colorectal cancer and if the evidence continues to increase, consider establishing a chronic MAV for nitrate based on an accepted one-in-one-hundred thousand cancer risk.

The results warrant application of the precautionary principal and suggests that practical steps should be taken to reduce exposure to elevated nitrate levels in drinking water. This would include improved management of nitrate contamination sources and investigation practical steps that could be taken to reduce elevated nitrate levels in drinking water supplies. Practical steps may include using available water sources with lower nitrate levels, blending sources to reduce nitrate levels or installation of nitrate treatment processes. This is recommended for both registered suppliers and unregistered suppliers. This finding also supports the implementation of drinking water source protection zones and land management rules that seek to reduce nitrate leaching to waterways.

4.9.2 Comparison of elevated nitrate levels to Colorectal Cancer incidence rates

The location of registered water supplies with elevated nitrate concentrations (greater than 5 mg/L) and the 2009 – 2013 age-adjusted colorectal cancer incidence rates by DHB as show in **Figure 14**. High rates of colorectal cancer in the Southern, South Canterbury, Canterbury and the Nelson Marlborough DHBs coincide with clusters of elevated nitrate levels in drinking water. The high rates of colorectal cancer in the West Coast, Waiarapa, Taranaki and Waitemata DHBs do not appear to coincide with elevated nitrate levels in registered drinking water supplies based on the available data, indicating the strong influence of other risk factors.

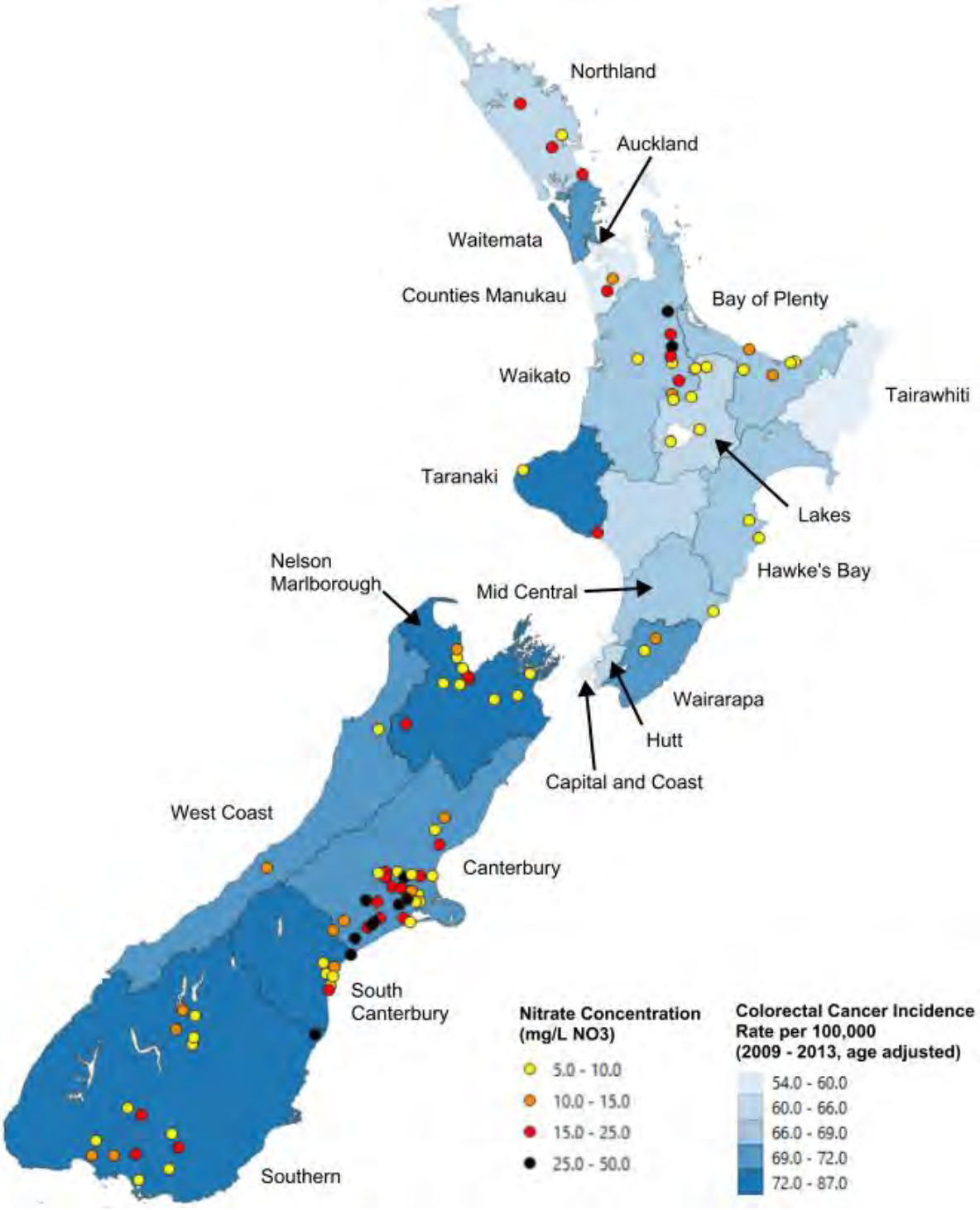


Figure 14: Elevated nitrate levels in registered drinking water supplies and colorectal cancer incidence rates within each District Health Board

Map based on data from nitrate database, 2009 – 2013 age adjusted colorectal cancer rates per DHB (HQSC, 2019) and Creative Commons 4.0 International (2019)

The percentage of people within each DHB exposed to greater than 5 mg/L nitrate in drinking water was moderately positively correlated with colorectal cancer incidence rates ($R^2 = 0.48$)

(refer **Figure 15**). The correlation between exposure to greater than 25 mg/L and colorectal cancer incidence rates was also positive, although weaker, with an R^2 of 0.32. These correlations are briefly discussed after **Figure 16**.

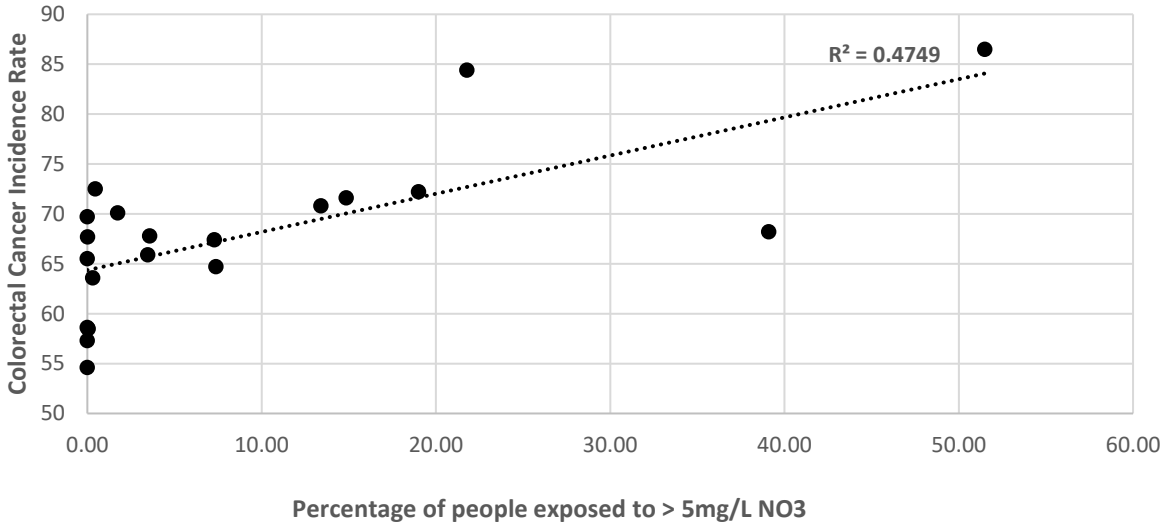


Figure 15: Correlation between percentage of exposed to greater than 5mg/L nitrate in drinking water and DHB colorectal cancer incidence rates (based on nitrate database and HQSC (2019))

Figure 16 (a-c) shows the percentage of the population within each DHB exposed to greater than 5 mg/L and greater than 25 mg/L nitrate in drinking water and the colorectal cancer incidence rates within each DHB. **Figure 16** (a.) indicates that the high percentages of people exposed to greater than 5 mg/L nitrate in drinking water in the South-Canterbury, Southern, Nelson-Marlborough, Waiarapa and Canterbury DHBs coincides with high incidence rates of colorectal cancer within these DHBs. Similarly, **Figure 16** (b.) indicates that the high percentages of people exposed to greater than 25 mg/L nitrate in drinking water in the South-Canterbury, Southern and Canterbury DHBs coincides with the high incidence rates of colorectal cancer within these DHBs. **Figure 16** (c.) indicates that all DHBs with an age adjusted colorectal cancer incidence rate of less than 68 per 100,000 have less than 10% of the DHB population exposed to greater than 5 mg/L and less than 0.03% of the DHB population exposed to greater than 5 mg/L. DHBs with an age adjusted colorectal cancer incidence rate of greater than 68 per 100,000 typically have more than 10% of the DHB population exposed to greater than 5 mg/L (with the exception of Waitemata, West Coast and Taranaki).

Figure 16 (a-c) is based on data from the nitrate database (estimated exposure for unregistered supplies is not included) and the colorectal cancer rates from HQSC (2019).

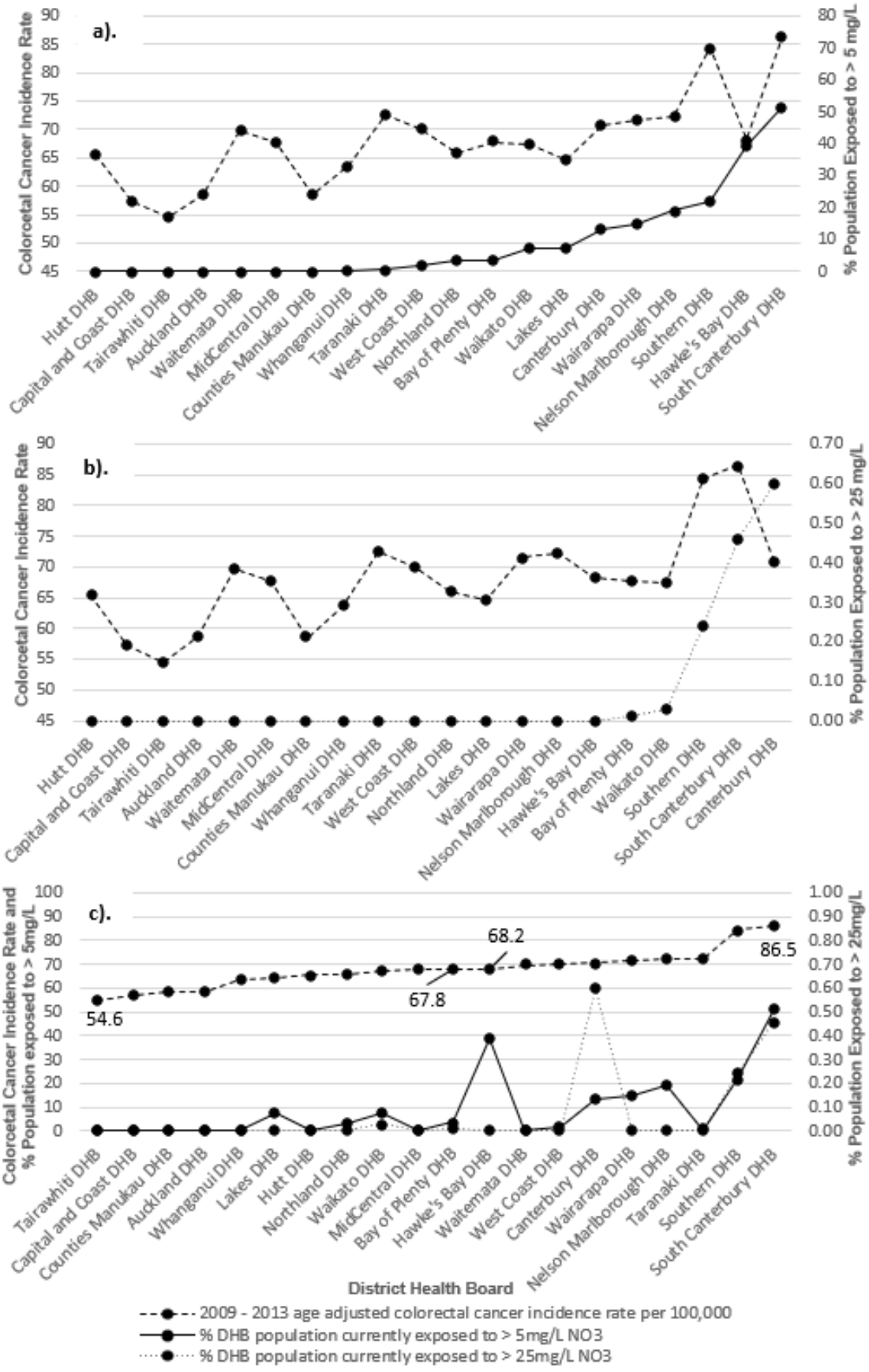


Figure 16: DHB colorectal cancer incidence rates and percentage of people within each DHB exposed to nitrate levels greater than 5mg/L (a.), 25 mg/L (b.) and both levels (c.)

These correlations, although only weak to moderate, are higher than anticipated in the context of epidemiology and the association between exposure and disease. This may indicate the influence of other risk factors or confounding factors in DHBs where there is high exposure to nitrate in drinking water. Alternatively, this may indicate that the dose-response relationship between exposure to nitrate in drinking water and colorectal cancer rates in New Zealand is higher than reported in the literature in other countries.

4.10 Study Strengths and Weaknesses

Despite being a preliminary investigation, there are a number of strengths associated with this study. These strengths include:

- High nitrate data coverage for the New Zealand population in the nitrate database (84%).
- High nitrate data coverage for the population served by registered water supplies in the nitrate database (97%).
- Estimated nitrate levels in drinking water for approximately 600,000 people not served by a registered supply have been considered.
- Nitrate data collected from multiple different sources.
- Nitrate levels in the nitrate database are estimated from multiple results from 2018-2020 where possible, rather than based on a single result.
- Results of multiple, peer-reviewed international studies have been applied, including the results of a recent meta-analysis (Temkin et al., 2019).
- The comparison of current nitrate levels to nitrate levels from approximately twenty years ago within individual supplies.
- Robust evidence of elevated nitrate levels in unregistered water supplies based on the results of the Author's sampling in Southland.
- Ability to identify the location and map all of the registered supplies included in the study.
- The data collected provides a robust basis for the follow-on epidemiological study.

Due to the preliminary nature of the study there are a number of associated weaknesses. The most significant weaknesses are considered to be uncertainties in the dose-response relationship, not considering length of exposure, not considering co-founding factors and lack of data for unregistered and small and private registered supplies. The identified weaknesses are discussed below.

4.10.1 Uncertainty in dose-response relationship

Although there is increasing evidence for the association between nitrate in drinking water and colorectal cancer there are still uncertainties around the dose-response relationship. This study is based on the implicit assumption that the dose response relationships published in

the academic literature by Schullehner et al., (2018) and Espejo-Herrera et al., (2016) are applicable to the New Zealand population. This highlights the importance of the future epidemiological study in New Zealand. The use of the dose response calculated in the meta-analysis by Temkin et al., (2019) attempts to address some of this uncertainty. The impact of the uncertainty of the dose-response relationship on the results of this study is considered to be significant and for this reason the results are preliminary only.

4.10.2 Length of exposure not considered

Exposure to elevated nitrate in drinking water has been associated with an increased risk of colorectal cancer after a relatively long exposure period, typically 10 – 30 years (e.g. Espejo-Herrera et al., 2016, Schullehner et al., 2018, De Roos et al., 2003). Due to the preliminary nature of this study, exposure has been restricted to current (2018-2020) exposure (with consideration of exposure from approximately twenty years ago for comparison purposes) and has not considered length of exposure at the individual level. Nitrate levels have increased over the past twenty years in more supplies than have decreased (refer **Figure 13**) and therefore the results of this study may overestimate actual individual exposure over multiple decades. The impact of this on the results is considered to be moderate and highlights the importance of considering the results as preliminary only.

It is recommended that the length of exposure to nitrate in drinking water is considered at the individual level during the next phase of the study. It is recommended that study participants are recruited from areas with long term records of nitrate levels in drinking water. Supplies with more than 15 years of annual nitrate data collected in this study are Invercargill city, Pleasant Point, Pareora, Ashburton, Greymouth, Marlborough District Council Supplies (Picton, Havelock, Renwick, Riverlands, Wairau Valley), Nelson, Palmerston North, Richmond, Burham and Ruawai.

4.10.3 Co-founding factors for colorectal cancer not considered

This study has not considered co-founding factors for colorectal cancer such as consumption of red and processed meat, physical inactivity, obesity and smoking. This study has also not considered vitamin C or antioxidant intake which have been found to inhibit the formation of N-nitroso compounds through endogenous nitrosation. Consideration of co-founding factors was considered to be beyond the scope of this preliminary study. The impact of this is considered to be moderate and again highlights the importance of considering the results as preliminary only. It is recommended that co-founders are considered during the next phase of the study through consideration of risk factors at the individual level.

It is also possible that nitrate could be a proxy for other carcinogenic agricultural pollutants such as pesticides. It is recommended that this is considered during the next phase of the study.

4.10.4 Under-representation of unregistered, private, Neighbourhood and Small supplies

The data coverage of unregistered supplies, private registered supplies and supplies from the smallest registered supply categories (Neighbourhood and Small) is very low and presents a significant gap in the nitrate database. This is a weakness of the study, particularly because the people supplied by unregistered and the smallest registered supply categories are likely to have the highest risk of exposure to potentially harmful nitrate levels in drinking water. The extrapolation of data collected for unregistered supplies attempts to address this weakness although it is acknowledged that the Regional Council data is of lower reliability than the data collected by the Author in Southland or the data in the nitrate database. Targeted sampling of unregistered, Neighbourhood, Small and private supplies is recommended during the next phase of the study to improve data coverage for these groups.

4.10.5 Seasonal Variation

Seasonal variation of nitrate levels in New Zealand drinking water can range from minor fluctuations (e.g. Havelock, Dromore) to significant seasonal changes (e.g. Seadown) as identified in **Figure 11**. The extent of the variation may be associated with site specific factors such as soil type, nitrate source and drinking water source (e.g. depth of bore). Significant seasonal changes may potentially be associated with high rainfall events, proximity to point contamination sources and specific activities at point sources of nitrate contamination. The impact of seasonal variation on the results in this database is likely to be highest for supplies with only a single data point from a single point in time, as averages were taken for supplies with multiple data points. The overall impact of seasonal variation on the results of the study is considered to be minor. Such seasonal variation is not the focus of the present investigation but is important to be aware of when interpreting the results.

4.10.6 Average nitrate concentrations for water supplies fed from multiple sources

Nitrate results were far more readily available for raw source waters than for treated water or reticulation samples. Some water supplies are fed by multiple sources and in many cases the proportional contribution of each source is either not known or may vary over time. The contribution of each source was proportioned based on information from suppliers on indicative proportions for the contribution of each source. Where this information could not be provided each source that had available data was assumed to contribute equally. This assumption will have the highest impact for supplies with multiple sources that have differing nitrate levels. The overall impact of seasonal variation on the results of the study is considered to be minor.

4.10.7 Population Discrepancies

The population used for supplies in the database was based on the estimated number of people served by each supply provided by the suppliers. In some cases, the population

provided was different to the population served by the supply listed in the Register. The total number of people served by registered supplies was based on the 2020 Register (ESR, 2020a), whereas the population for New Zealand and each DHB was based on the 2018 census data. This discrepancy in population data is important to note but is not considered to have a significant impact on the results of the study.

4.10.8 No consideration of consumption of multiple sources or bottled water

This study has not considered consumption from multiple water sources or consumption of bottled water. It is possible that the water supply may be different for an individual's place of work compared to their home. This is beyond the scope of the current study but is recommended to be considered in the next phase of the study.

Annual consumption of bottled water in New Zealand is estimated to be around 135 million litres per year (MFE, 2018). Bottled water sales from supermarkets have been found to be higher in the summer months which may indicate opportunistic consumption of bottled water rather than regular consumption (MFE, 2018). Assuming a daily water consumption of 1.5 L/person/day (based on Thomson, Nokes and Cressey, 2007) and the annual volume of 135 million litres, up to 247,000 New Zealanders may consume bottled water (~5% of the population). This indicates that the results of this study may over-estimate exposure to elevated nitrate levels in drinking water in New Zealand. Due to the low levels of bottled water consumption and likelihood of opportunistic consumption the overall impact on the results of the study are considered to be minor. It is recommended that consumption of bottled water is considered at the individual level during the next phase of the study.

4.10.9 No consideration of different dose-response relationships for different types of colorectal cancers

Differences in the dose response relationships for nitrate in drinking water and different categories of colorectal cancer have been identified in epidemiological studies in the literature (refer **Table 3**). Consideration of different categories of colorectal cancer is beyond the scope of the present study but is recommended for consideration in the next phase of the study.

4.10.10 Potential errors in unit conversions

Suppliers were requested to advise whether nitrate data was provided as NO_3 or NO_3-N. Where there was uncertainty or suspicion of incorrect units, further attempts were made to clarify the units, such as requesting the laboratory results sheets. It is possible however that incorrect units were used for a small number of supplies. Some nitrate data was only available as Total Nitrogen (TN), or Total Dissolved Nitrogen (TDN). In these cases, all nitrogen was assumed to be NO_3-N, as nitrate is typically the dominant form of nitrogen in drinking water. However, it is possible that this assumption has resulted in small errors in results for some supplies. The overall impact of these potential error sources is considered to be minor.

4.10.11 Manual development of nitrate database

The nitrate database was manually developed as an independent database requiring significant manual data entry. The database would have been improved if it was based on the existing supply data from the Register of Drinking-water Suppliers for New Zealand (ESR, 2019), however a publicly available version of the Register with the relevant supply information was not identified at the start of the study.

5. Conclusions and Recommendations

5.1 Reflection on research process and achievement

The aim of this study was to review nitrate concentrations in New Zealand drinking water and their potential effect on colorectal cancer rates in the country.

This aim has been successfully achieved. The objectives and research questions for this project have also been achieved. A brief summary of how each objective and research question has been met is provided below.

5.1.1 Objective 1: Review literature linking nitrate with colorectal cancer

This objective was successfully achieved and is addressed by through research questions 1.1, 1.2. and 1.3.

Research Question 1.1: What is the potential link between exposure to nitrate in drinking water and colorectal cancer?

This question was successfully addressed in Section **2.3**. Ingested nitrate or nitrite under conditions that result in endogenous nitrosation has been classified as *probably carcinogenic to humans* by the International Agency on Cancer Research (IARC, 2010). Endogenous nitrosation is the process where nitrite reacts with nitrostable compounds in the acidic conditions of a healthy human stomach to produce N-nitroso compounds (IARC, 2010). Nitrate ingested in drinking water can be reduced to nitrite by the action of bacteria in the mouth (WHO, 2016). The N-nitroso compounds produced in the stomach can act as carcinogens in the colon and rectum.

Research Question 1.2: What concentrations of nitrate in drinking water have been found to be associated with increased risk of colorectal cancer in previous studies?

This question was successfully addressed in Sections **2.4** and **4.1**. Exposure to nitrate levels as low as 3.87 mg/L (Schullehner et al., 2018), 7.1 mg/L (Espejo-Herrera et al., 2016) and 4.43 mg/L (based on the meta-analysis by Temkin et al., 2019) have been associated with an increased risk of colorectal cancer. These levels are approximately 10% of the MAV (50 mg/L).

Research Question 1.3: What are the current international estimates for the dose-response relationship for nitrate exposure from drinking water and colorectal cancer?

This question was successfully addressed in Section **2.4**. Current relevant international estimates were identified to be:

- A 4% increase in risk with every 4.43 mg/L increase in nitrate concentration above 4.43 mg/L (Temkin et al., 2019)
- A 49% increase in risk with exposure greater than 7.1 mg/L (Espejo-Herrera et al., 2016)

- An 11% increase in risk with exposure to 3.87 mg/L – 9.25 mg/L and a 15% increase in risk associated with exposure to more than 9.25 mg/L (Schullehner et al., 2018)

While there is increasing evidence for this association, uncertainties remain around the dose response relationship and the applicability of international estimates to the New Zealand population. Further research is required to improve certainty on the association.

5.1.2 Objective 2: Review nitrate sources in drinking water in NZ and suitable removal technologies

This objective was successfully achieved and is addressed by the following two research questions.

Research Question 2.1: What is the main source of nitrate in New Zealand drinking water?

This question was successfully addressed in Section **2.5**. The main source of nitrate in New Zealand drinking water is from pastoral agriculture and in particular from intensive pastoral dairy farming. Other sources of nitrate contamination include horticulture, human wastewater and other point sources of contamination that may be important at the local scale.

Research Question 2.3: What are the most suitable nitrate removal technologies for New Zealand drinking water supplies?

This question was successfully addressed in Sections **2.9** and **4.8**. For supplies of less than 50 people where an alternative source is not available, it is likely that point of use treatment in each dwelling may be the most cost-effective approach to reducing nitrate levels. For larger supplies, it is likely that the most cost-effective approaches would be prioritising use of an existing lower-nitrate source, blending or development of a new lower-nitrate source. Where an alternative lower nitrate source is not available, the most appropriate advanced treatment option would need to be identified on a site-specific basis.

5.1.3 Objective 3: Develop a preliminary database of nitrate concentrations in NZ drinking water

The nitrate database water was successfully developed and is provided in the Appendices.

Research Question 3.1: Are the supplies for which there is no available nitrate data and unregistered supplies likely to have significantly different concentrations than the supplies for which there is available data?

This question was successfully addressed in Section **4.6**. The largest group of people without available nitrate data are the 603,000 people served by unregistered supplies. The results strongly indicate that these people are likely to have higher exposure to nitrate in drinking water than those supplied by registered water supplies. Small and Neighbourhood supplies were also found to have the lowest nitrate data availability and the highest exposure to elevated nitrate levels amongst registered supplies.

Research Question 3.2: How many people may be exposed to nitrate levels in drinking water above the level found to be associated with increased risk of colorectal cancer?

This question was successfully addressed in Section **4.9.1**. Based on the results of the study between 320,000 and 804,000 people (approximately 6.7 – 17.1% of the population) may be exposed to potentially harmful levels of nitrate in drinking water. This is a significant finding and warrants further research and application of the precautionary principal.

5.1.4 Objective 4: Undertake a preliminary characterisation of population exposure to nitrate in New Zealand drinking water over time and place

This objective was successfully achieved and is addressed by the results of research questions 4.1 and 4.2.

Research Question 4.1: How do nitrate concentrations in drinking water vary around the Country?

This question was successfully addressed in Section **4.4**. Maps were developed to visually present the spatial variability in nitrate concentrations in drinking water. These maps clearly indicate clusters of drinking water supplies with elevated nitrate levels in the south of Canterbury, the south of Southland, Nelson Marlborough, Waikato and Northland. Elevated nitrate levels in water supplies in the south of Canterbury, the south of Southland, Waikato and Northland appear to be associated with areas of high cattle density.

Research Question 4.2: Have nitrate concentrations in New Zealand drinking water increased over the past two decades?

This question was successfully addressed in Section **4.7.2**. Based on changes in nitrate levels in individual supplies it is clear that there has been an increase in nitrate levels over the past two decades in a greater number of supplies and for a greater number of people than there has been a decrease. This finding indicates that exposure to nitrate in drinking water has increased over the past two decades.

5.1.5 Objective 5: Develop an initial estimate of the potential population burden of colorectal cancer attributed to nitrate exposure from drinking water

This objective was successfully achieved and is addressed by the following two research questions.

Research Question 5.1: How many cases of colorectal cancer in New Zealand may be potentially attributable to exposure to nitrate in drinking water?

This question was successfully addressed in Section **4.9.1**. The preliminary results from this study indicate that between 0.6% and 3.2% of colorectal cancer cases in New Zealand may be attributable, equivalent to approximately 19 – 103 cases per year. This estimate increases

to 1.7% - 5.6% of colorectal cancer cases and 56 – 180 cases per year if the exposure estimates for those served by unregistered supplies are included.

Research Question 5.2: Is the risk factor of exposure to nitrate in drinking water significant compared to other known colorectal cancer risk factors in New Zealand?

This question was successfully addressed in Section **4.9.1**. The results of this preliminary study indicate that exposure to nitrate in drinking water is likely to be a significant risk factor for colorectal cancer in New Zealand and may be of similar significance to the risks of consuming red meat, consuming processed meat, physical inactivity and smoking in the New Zealand population. This is a significant finding and strongly suggests that further research into nitrate levels in New Zealand drinking water is warranted, along with further research into the epidemiology of exposure to nitrate in drinking water in New Zealand.

5.2 Recommendations

5.2.1 Recommendations for next phase of study

The key recommendations for the next phase of this study are:

- Undertake targeted sampling of unregistered, Neighbourhood, Small and private supplies to improve data coverage for these groups. These groups of people have been identified to have the lowest availability of nitrate data and also the highest risk of exposure to elevated nitrate concentrations.
- Consider the length of exposure to nitrate in drinking water. Supplies with more than 15 years of annual nitrate data collected in this study are Invercargill City, Pleasant Point, Pareora, Ashburton, Greymouth, Marlborough District Council Supplies (Picton, Havelock, Renwick, Riverlands, Wairau Valley), Nelson, Palmerston North, Richmond, Burham and Ruawai. Study participants could potentially be recruited from these areas with long term records of nitrate levels in drinking water.
- Consider co-founding risk factors such smoking, obesity, consumption of red and processed meat, physical inactivity, vitamin-C consumption at the individual level.
- Consider consumption of bottled water is considered at the individual level.
- Consider dose response relationships associated with different types of colorectal cancer (e.g. colon, rectal).
- Consider other carcinogenic agricultural contaminants that may be found in groundwaters with high nitrate levels.

5.2.2 Recommendations for Taumata Arowai

The key recommendations for Taumata Arowai are:

- Consider the body of evidence for the association between nitrate in drinking water and colorectal cancer. If the evidence continues to increase, consider establishing a chronic MAV for nitrate based on an accepted one-in-one-hundred thousand cancer risk.
- Consider improvements to water quality data reporting and data storage on a national level. The lack of a central repository for water quality data means that considerable time and effort is required to gain an understanding of drinking water quality.
- Consider reviewing the requirements for minimum sampling frequency for chemical compliance for determinands not classified as 2a, 2b or 2c in the next revision of the DWSNZ (MoH, 2018).
- Consider stronger regulation-of and support-to private registered suppliers. The lack of response to participate in the study from private registered suppliers and lack of available data from these supplies highlights potential differences in service levels provided by private suppliers compared to District Council suppliers.
- Improve management of contact details for private registered suppliers.
- Work with registered drinking water suppliers to ensure that they have adequate resources and expertise to safely manage Neighbourhood and Small water supplies.
- Consider establishing water quality monitoring programs for unregistered water supplies.
- Consider regulation of unregistered supplies to improve public health outcomes.
- Consider establishing greater sharing of drinking water quality data collected by Regional Councils for environmental monitoring or resource consenting purposes.
- Work closely with Regional Councils to ensure that the risk of Methaemoglinaemia is adequately managed in areas where groundwater nitrate concentrations are at or around 50 mg/L in areas other than Canterbury.
- Work with Ministry for the Environment and Regional Councils on the implementation of land management rules that seek to reduce nitrate leaching to waterways.
- Support water suppliers to take precautionary, practical steps to reduce nitrate levels in drinking water.
- Consider reviewing options to permit point of use treatment in the next revision of the DWSNZ (MoH, 2018).
- Consider assigning nitrate as a P2 determinand in supplies with less than 500 people where nitrate levels exceed 50% of the MAV.

5.2.3 Recommendations for drinking water suppliers

The following recommendations are for water suppliers:

- Water suppliers without any available nitrate data should test their water supplies for nitrate.
- Self-suppliers and those supplied by unregistered supplies should test the nitrate level in their water supply and seek advice from their DHB.
- Apply the precautionary principle and consider investigating practical steps that could be taken to reduce elevated nitrate levels in drinking water supplies. Precautionary, practical steps may include using available water sources with lower nitrate levels, blending sources to reduce nitrate levels or installation of nitrate treatment processes.
- Identify innovative approaches to improve water quality for Neighbourhood and Small supplies without significantly increasing operational costs.

5.3 Conclusion

This study provides the first ever attempt to characterise exposure to nitrate in drinking water across the New Zealand population. It also provides the first known attempt to assess exposure to nitrate in drinking water for people who are not supplied by registered drinking water suppliers. This study provides the first estimate of the potential contribution of exposure to nitrate in drinking water to colorectal cancer rates in New Zealand.

Based on the results of this study, 320,000 to 800,000 people may be exposed to potentially harmful levels of nitrate in drinking water, equivalent to 6.7 – 17.1% of the New Zealand population. Exposure to nitrate in drinking water is estimated to be attributable for 0.6 – 5.6% of colorectal cancer incidences in New Zealand. The results of this study indicate that nitrate in drinking water is likely to be a significant contributing factor to colorectal cancer rates in New Zealand and may be as significant as the established risk factors of consumption of red meat, consumption of processed meat, lack of physical activity and smoking. Nitrate in drinking water is unlikely to be as significant as the risk factors of obesity or heavy alcohol consumption.

Although the results of this study are preliminary only, they are significant and they strongly suggest that further research into nitrate levels in New Zealand drinking water is warranted, along with further research into the epidemiology of exposure to nitrate in drinking water and association with colorectal cancer risk.

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APPENDIX A

Copy of data request sent to District Councils

Investigation of Colorectal cancer risk and nitrate contamination in New Zealand drinking water

Drinking Water Suppliers - Data Request

1. Data Request

To assist in the study the following data is requested from water suppliers in New Zealand:

1. A list of the water supplies operated by the supplier, including:
    - Supply name
    - Number of people served by the supply
    - Supply Code
    - Source name(s)
    - Source code(s)
    - GPS coordinates of the source(s) (please advise coordinate system)
    - Any water treatment process in place that removes nitrate
    - Distribution Zone names and codes (if applicable)
    - Number of people served by each zone (if applicable)

2. Any available nitrate data from the water supplies operated by the supplier.
    - Please include any historical data
    - Please include date and location of sampling
    - Please confirm unit of measurement for nitrate data (i.e. NO_3-N mg/L or NO_3 mg/L)

3. Digital file of supply boundaries including:
    - Digital file (eg. Shape file) of supply boundary
    - Digital file (eg. Shape file) of Distribution Zone Boundaries (if applicable)
    - Please advise coordinate system for digital files

Please provide the data to: nitratesinwater@otago.ac.nz. Please provide the data by **10 February 2020.**

2. Data Storage and Use

- The data will be used in the investigation of Colorectal cancer risk and nitrate contamination in New Zealand drinking water.
- The data will be stored securely by the University of Otago.
- The data will only be accessed by researchers involved in the study from the University of Otago, Victoria University Wellington, the University of Auckland and Loughborough University.
- A copy of the results of the study will be provided to Drinking Water Suppliers for information.
- The data sources will be acknowledged in any papers published.
- The data provided on each water supply may be used for future epidemiological studies by the University of Otago, Victoria University Wellington and the University of Auckland.

3. Queries

Please address any queries to: nitratesinwater@otago.ac.nz or alternatively please phone Jayne Richards on 03 974 4586 or mobile 027 456 9945.

Your assistance in this study is greatly appreciated.

APPENDIX B

Copy of data request sent to private suppliers

Dear water supplier,

The health importance of exposure to nitrate in drinking water is currently being assessed by a team of New Zealand researchers. The outcomes of this research will have implications for protecting public health, drinking water quality management and land use practices in New Zealand. A summary of the project is attached.

This email requests permission for the researchers in the Nitrates Study Group to use your contact details (provided during supply registration) to write to you to request any available nitrate data from your supply and to use data stored within the Drinking-water database. If you are happy to give your permission, please e-mail Jayne Richards directly nitratesinwater@otago.ac.nz advising you are happy for your contact details to be used for the purpose of this project. Thank you for your time and consideration of this request.

I look forward to hearing back from you at your earliest convenience.

Ngā mihi,

Jayne Richards
MSc Student
Nitrates Study Group
M: 027 456 9945 | E: nitratesinwater@otago.ac.nz

Department of Public Health | Te Tari Hauora Tūmatanui
University of Otago, Wellington | Te Whare Wānanga o Otāgo ki Te Whanga-Nui-a-Tara

Nga mihi

Karen Beirne
Team Leader
Drinking Water
Public Health
Population Health and Prevention
Ministry of Health
DDI: 04 816 4487
Fax: 04 495 4401

http://www.health.govt.nz
mailto:Karen.Beirne@health.govt.nz

APPENDIX C

Copy of data request sent to Regional Councils

Investigation of Colorectal cancer risk and nitrate contamination in New Zealand drinking water

Regional Councils - Data Request

Data on nitrate levels in water sources used for domestic or community water supplies is kindly requested from Regional Councils in New Zealand. Please note we have already received nitrate data from District Councils for their registered drinking water supplies (where available). Limited data has been obtained for supplies not operated by District Councils or for self-suppliers (those not served by a registered drinking water supply). The purpose of this data request is to improve our understanding of nitrate levels in drinking water for those not served by a registered drinking water supply.

Data Request

1. Please provide any available nitrate data for bores or surface water sources used for domestic or community water supply. Please include:
    - Any historical nitrate data
    - Date of sampling
    - Confirmation of measurement for nitrate data (i.e. NO_3-N mg/L or NO_3 mg/L)
    - Bore number / surface water code
    - GPS coordinates of the water source location (please advise coordinate system)
    - Use of bore / surface water source (i.e. domestic / community supply)
    - Supply name (if available)
    - Bore depth (if available)
    - Number of people served by the supply (if available)
    - If the data is from an environmental monitoring program, please provide a brief explanation of how individual bores were selected to be included in the monitoring program. This will help us understand how representative the results are for self-suppliers in the region.

2. Please also provide any available estimates or information on the water sources used by self-suppliers (those people not served by a registered drinking water supply) in your region. We are particularly interested in estimates of the percentage of self-suppliers relying on rainwater compared to those relying on bore water or surface water sources in each region.

Please provide the data to: nitratesinwater@otago.ac.nz. Please provide the data by **3 April 2020**.

Data Storage and Use

- The data will be used in the investigation of Colorectal cancer risk and nitrate contamination in New Zealand drinking water.
- The data will be stored securely by the University of Otago.
- The data will only be accessed by researchers involved in the study from the University of Otago, Victoria University Wellington, the University of Auckland and Loughborough University.
- A copy of the results of the study will be provided to Regional Councils for information.
- The data sources will be acknowledged in any papers published.
- The data provided on each water supply may be used for future epidemiological studies by the University of Otago, Victoria University Wellington and the University of Auckland.

Queries

Please address any queries to: nitratesinwater@otago.ac.nz or alternatively please phone Jayne Richards on 03 974 4586 or mobile 027 456 9945.

Your assistance in this study is greatly appreciated.

APPENDIX D

Project Summary Sheet sent with all data requests

Investigation of colorectal cancer risk and nitrate contamination of New Zealand drinking water: Project Summary

Introduction

There is increasing evidence linking exposure to nitrate in drinking water to multiple negative health outcomes, including colorectal cancer, thyroid disease, and neural tube defects. In many studies, the risk of the adverse health outcome was found to occur at drinking water nitrate levels significantly lower than New Zealand's 'Maximum Acceptable Value' of 50 mg/L (Drinking-water Standards for New Zealand 2005 (revised 2018)). The evidence for negative health outcomes is strongest for colorectal cancer.

The scale of the potential public health risk posed by current nitrate levels in drinking water in New Zealand is uncertain. A major limitation is the lack of a publicly available repository of data that can be used to provide a valid estimate of nitrate exposure levels across the population.

A research group has recently been established to assess the health importance of nitrate contamination of drinking water to human health in New Zealand. The outcomes of this research will have implications for protecting public health, drinking water quality management, and land use practices in New Zealand.

First Project

The first project to be undertaken by the research group will focus on developing a preliminary national database of nitrate levels in New Zealand drinking water. These data will be used to provide an initial assessment of the potential population burden of colorectal cancer attributable to this sources of nitrate exposure.

The objectives of the first project are to:

- Review literature linking nitrate exposure with colorectal cancer
- Review nitrate sources in drinking water in NZ
- Develop a preliminary national database of nitrate concentrations in NZ drinking water
- Undertake a preliminary characterisation of population exposure to nitrates in NZ drinking water over time and place
- Develop an initial estimate of the potential population burden of colorectal cancer attributed to nitrate exposure from drinking water

Data will be collected from drinking-water suppliers and the Ministry of Health during late 2019. The data will be collated and analysed during early 2020 with project completion in late 2020.

The data collected from this project will feed into future work to be undertaken by the research group.

Key Contacts:

The key researchers involved in the first project are:

- Prof Michael Baker: Research Group Leader, Epidemiologist, University of Otago, Wellington
- Dr Mike Joy: Freshwater Ecologist, Institute for Governance and Policy Studies, Victoria University, Wellington
- Jayne Richards: MSc Student, Loughborough University / Senior Environmental Engineer, Fluent Infrastructure Solutions, Queenstown
- Ass Prof Simon Hales: Environmental Epidemiologist, University of Otago, Wellington
- Ed Randal: Environmental Health Researcher, University of Otago, Wellington
- Prof Alistair Woodward: Epidemiologist, University of Auckland, Auckland

APPENDIX E

Nitrate Database

							Current Nitrate Data							Historic Nitrate Data (ESR, 2019b)			
No.	District Health Board	Public Health Unit	Supply Owner	Supply Population	Northing	Easting	Current NO3-N (mg/L)	Current NO3 (mg/L)	Date of most recent sample	Data Source	Multiple samples 2018 2019?	Average of multiple sources?	Monthly Sampling?	Historic nitrate level (NO3-N mg/L)	Historic nitrate level (NO3 mg/L)	Date of most recent historic sample	Historic Supply Population
1	Counties Manukau DHB	Auckland DHB	Private Supplier	200	-37.192921	174.981425	2.80	**12.4**	4/12/2019	Supplier	No	No	No	No data	No data	No data	No data
2	Southern DHB	Public Health South	Private Supplier	1,100	-45.077825	168.744336	0.04	**0.2**	3/10/2019	Supplier	No	No	No	No data	No data	No data	No data
3	Southern DHB	Public Health South	Private Supplier	850	-44.671725	167.926058	0.01	**0.0**	23/11/2014	Supplier	No	No	No	No data	No data	No data	No data
4	West Coast DHB	Community and Public	Private Supplier	219	-41.605653	171.87868	0.03	**0.1**	4/08/2015	Supplier	No	No	No	No data	No data	No data	No data
5	Southern DHB	Public Health South	Southland District Council	180	-45.983273	167.760131	1.50	**6.6**	19/07/2019	Supplier	Yes	No	No	No data	No data	No data	No data
6	Southern DHB	Public Health South	Southland District Council	1,152	-46.311965	168.784898	2.20	**9.7**	9/10/2019	Supplier	Yes	No	No	No data	No data	No data	No data
7	Southern DHB	Public Health South	Southland District Council	1,061	-45.739528	168.441696	3.60	**15.9**	9/10/2019	Supplier	Yes	No	No	0.49	2.2	11/03/1999	187
8	Southern DHB	Public Health South	Southland District Council	201	-45.669946	168.239052	1.40	**6.2**	9/10/2019	Supplier	Yes	No	No	0.65	2.9	14/05/1997	274
9	Southern DHB	Public Health South	Southland District Council	798	-46.143102	167.9974	2.80	**12.4**	9/10/2019	Supplier	Yes	No	No	1.45	6.4	9/03/1999	729
10	Southern DHB	Public Health South	Southland District Council	1,506	-46.363889	168.018283	0.02	**0.1**	19/07/2019	Supplier	Yes	No	No	0.4	1.8	16/03/1998	1,656
11	Southern DHB	Public Health South	Southland District Council	2,628	-45.414444	167.71794	1.00	**4.4**	9/10/2019	Supplier	Yes	No	No	0.92	4.1	25/03/1999	1,857
12	Southern DHB	Public Health South	Southland District Council	561	-46.135063	167.689005	3.20	**14.2**	9/10/2019	Supplier	Yes	No	No	No data	No data	No data	No data
13	Southern DHB	Public Health South	Southland District Council	2,436	-46.142411	168.32475	4.00	**17.7**	9/10/2019	Supplier	Yes	No	No	5.6	24.8	19/03/1998	2,100
14	Southern DHB	Public Health South	Southland District Council	228	-45.566714	167.608778	0.00	**0.0**	16/12/2019	Author	No	No	No	0.005	0.02	14/05/1997	240
15	Southern DHB	Public Health South	Southland District Council	667	-45.971444	168.030851	0.14	**0.6**	16/12/2019	Author	No	No	No	0.113	0.50	9/03/1999	821
16	Southern DHB	Public Health South	Invercargill City Council	47,000	-46.417905	168.347313	1.67	**7.4**	7/10/2019	Supplier	Yes	No	Yes	1.05	4.65	4/06/1997	No data
17	Taranaki DHB	Taranaki DHB	New Plymouth District Council	59,072	-39.057848	174.071849	0.26	**1.2**	1/05/2019	Supplier	No	No	No	0.15	0.66	30/03/1998	35,700
18	Taranaki DHB	Taranaki DHB	New Plymouth District Council	3,983	-39.155858	174.206121	0.36	**1.6**	1/05/2019	Supplier	No	No	No	0.125	0.55	30/03/1998	3,500
19	Taranaki DHB	Taranaki DHB	New Plymouth District Council	1,625	-39.114671	173.953544	0.72	**3.2**	1/05/2019	Supplier	No	No	No	No data	No data	No data	No data
20	Taranaki DHB	Taranaki DHB	New Plymouth District Council	530	-39.190996	173.88001	1.15	**5.1**	1/05/2019	Supplier	No	No	No	0.985	4.36	11/04/2000	600
21	Canterbury DHB	Community and Public	Waimakariri District Council	330	-43.31064	172.382904	0.36	**1.6**	2/10/2019	Supplier	No	Yes	No	0.2	0.89	12/02/1997	350
22	Canterbury DHB	Community and Public	Waimakariri District Council	105	-43.3557161	172.5421989	0.33	**1.5**	17/12/2019	Supplier	No	No	No	No data	No data	No data	No data
23	Canterbury DHB	Community and Public	Waimakariri District Council	12,630	-43.377723	172.658023	1.37	**6.1**	18/12/2019	Supplier	Yes	Yes	No	0.7	3.10	27/03/1998	8,600
24	Canterbury DHB	Community and Public	Waimakariri District Council	2,353	-43.368737	172.487213	3.54	**15.7**	19/12/2019	Supplier	No	No	No	4.2	18.59	1/10/1996	650
25	Canterbury DHB	Community and Public	Waimakariri District Council	280	-43.3621109	172.5680554	0.40	**1.8**	17/10/2019	Supplier	No	No	No	7.2	31.87	1/10/1996	200
26	Canterbury DHB	Community and Public	Waimakariri District Council	828	-43.3266226	172.0184878	4.11	**18.2**	19/09/2019	Supplier	No	Yes	No	No data	No data	No data	No data
27	Canterbury DHB	Community and Public	Waimakariri District Council	2,993	-43.3346964	172.1829782	1.87	**8.3**	23/09/2019	Supplier	No	Yes	No	0.075	0.33	27/03/1998	No data
28	Canterbury DHB	Community and Public	Waimakariri District Council	7,325	-43.3272493	172.6884017	0.05	**0.2**	8/10/2019	Supplier	No	Yes	No	0.0375	0.17	10/11/1997	1,200
29	Canterbury DHB	Community and Public	Waimakariri District Council	215	-43.3805032	172.285321	9.44	**41.8**	2/12/2019	Supplier	Yes	No	Yes	No data	No data	No data	No data
30	Canterbury DHB	Community and Public	Waimakariri District Council	17,880	-43.3772781	172.6508654	0.63	**2.8**	17/09/2019	Supplier	No	Yes	No	0.25	1.11	27/03/1998	No data
31	Canterbury DHB	Community and Public	Waimakariri District Council	1,150	-43.280654	172.710319	0.42	**1.9**	22/10/2019	Supplier	No	No	No	0.335	1.48	19/05/1999	600
32	Canterbury DHB	Community and Public	Waimakariri District Council	613	-43.3540546	172.3806103	1.80	**8.0**	16/12/2019	Supplier	No	Yes	No	No data	No data	No data	No data
33	South Canterbury DHB	Community and Public	Timaru District Council	4,550	-44.086447	171.151502	-	**0.4**	25/09/2019	Supplier	Yes	Yes	No	0.117	0.52	7/05/1998	4,500
34	South Canterbury DHB	Community and Public	Timaru District Council	2,121	-44.091408	171.243882	-	**2.1**	9/01/2020	Supplier	Yes	No	No	0.2	0.89	28/08/1998	2,121
35	South Canterbury DHB	Community and Public	Timaru District Council	312	-44.371057	171.165207	-	**5.2**	9/01/2020	Supplier	Yes	No	No	No data	No data	No data	No data
36	South Canterbury DHB	Community and Public	Timaru District Council	25	-44.423021	171.104439	-	**0.5**	25/09/2018	Supplier	No	No	No	No data	No data	No data	No data
37	South Canterbury DHB	Community and Public	Timaru District Council	450	-44.487874	171.2099	-	**6.7**	18/07/2019	Supplier	Yes	No	No	0.68	3.01	1/03/2000	480
38	South Canterbury DHB	Community and Public	Timaru District Council	130	-43.920321	171.262556	-	**13.1**	9/01/2019	Supplier	Yes	No	No	3.95	17.49	10/03/1997	130
39	South Canterbury DHB	Community and Public	Timaru District Council	1,200	-44.260541	171.12874	-	**8.2**	9/01/2020	Supplier	Yes	No	No	0.25	1.11	28/04/1998	1,200
40	South Canterbury DHB	Community and Public	Timaru District Council	50	-44.180568	171.517553	-	**40.3**	9/01/2020	Supplier	Yes	No	Yes	3	13.28	10/03/1997	400
41	South Canterbury DHB	Community and Public	Timaru District Council	895	-44.297731	171.275695	-	**12.4**	9/01/2020	Supplier	Yes	No	Yes	1.65	7.30	24/08/1999	No data
42	South Canterbury DHB	Community and Public	Timaru District Council	280	-44.530547	171.190504	-	**21.0**	8/01/2019	Supplier	Yes	No	No	0.1275	0.56	1/03/2000	240
43	South Canterbury DHB	Community and Public	Timaru District Council	1,650	-44.051312	171.120376	-	**0.8**	25/09/2018	Supplier	No	No	No	0.1125	0.50	3/08/1999	No data
44	South Canterbury DHB	Community and Public	Timaru District Council	4,620	-44.245782	171.277916	-	**2.4**	9/01/2019	Supplier	Yes	Yes	No	0.575	2.55	28/04/1998	3,984
45	South Canterbury DHB	Community and Public	Timaru District Council	26,832	-44.397042	171.25503	-	**5.2**	9/01/2020	Supplier	Yes	No	No	0.15	0.66	26/02/1997	26,832
46	West Coast DHB	Community and Public	Grey District Council	280	-42.366602	171.413039	0.04	**0.2**	18/03/2019	Supplier	Yes	No	No	No data	No data	No data	No data
47	West Coast DHB	Community and Public	Grey District Council	9,410	-42.450787	171.209802	0.27	**1.2**	18/03/2019	Supplier	Yes	No	No	0.2	0.89	26/03/1998	5,676
48	Canterbury DHB	Community and Public	Christchurch City Council	1,350	-43.803882	172.967998	0.62	**2.7**	19/07/2017	Supplier	No	No	No	0.45	1.99	21/06/1996	350
49	Canterbury DHB	Community and Public	Christchurch City Council	150	-43.825607	172.706431	0.45	**2.0**	25/05/2017	Supplier	No	No	No	No data	No data	No data	No data
50	Canterbury DHB	Community and Public	Christchurch City Council	1,600	-43.430755	172.69585	1.05	**4.6**	19/09/2017	Supplier	No	No	No	No data	No data	No data	No data
51	Canterbury DHB	Community and Public	Christchurch City Council	185,000	-43.531079	172.6366	0.24	**1.1**	10/12/2019	Supplier	Yes	Yes	No	No data	No data	No data	No data
52	Canterbury DHB	Community and Public	Christchurch City Council	16,000	-43.48197	172.703948	0.68	**3.0**	1/06/2017	Supplier	Yes	Yes	No	No data	No data	No data	No data
53	Canterbury DHB	Community and Public	Christchurch City Council	10,000	-43.529904	172.597941	0.93	**4.1**	24/05/2017	Supplier	Yes	Yes	No	0.65	2.88	14/10/1999	7,000
54	Canterbury DHB	Community and Public	Christchurch City Council	2,500	-43.569748	172.69247	0.21	**0.9**	10/12/2019	Supplier	Yes	Yes	No	0.15	0.66	18/02/1997	3,000
55	Canterbury DHB	Community and Public	Christchurch City Council	42,000	-43.543231	172.530848	0.60	**2.7**	26/10/2018	Supplier	Yes	Yes	No	0.6	2.66	28/02/1997	30,000
56	Canterbury DHB	Community and Public	Christchurch City Council	250	-43.750286	172.933128	0.45	**2.0**	10/07/2015	Supplier	No	No	No	No data	No data	No data	No data
57	Canterbury DHB	Community and Public	Christchurch City Council	240	-43.773879	172.788816	1.13	**5.0**	26/04/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
58	Canterbury DHB	Community and Public	Christchurch City Council	1,200	-43.629071	172.724986	0.24	**1.1**	10/12/2019	Supplier	Yes	Yes	No	No data	No data	No data	No data
59	Canterbury DHB	Community and Public	Christchurch City Council	750	-43.623207	172.648217	0.24	**1.1**	10/12/2019	Supplier	Yes	Yes	No	No data	No data	No data	No data
60	Canterbury DHB	Community and Public	Christchurch City Council	2,500	-43.603279	172.719337	0.24	**1.1**	10/12/2019	Supplier	Yes	Yes	No	No data	No data	No data	No data
61	Canterbury DHB	Community and Public	Christchurch City Council	80,000	-43.47733	172.583448	0.56	**2.5**	26/11/2019	Supplier	Yes	Yes	Yes	1.15	5.09	28/02/1997	70,000
62	Canterbury DHB	Community and Public	Christchurch City Council	150	-43.78307	172.968557	0.62	**2.7**	19/07/2017	Supplier	No	No	No	No data	No data	No data	No data
63	Canterbury DHB	Community and Public	Christchurch City Council	200	-43.817177	172.903616	0.91	**4.0**	23/10/2018	Supplier	No	No	No	No data	No data	No data	No data

							Current Nitrate Data							Historic Nitrate Data (ESR, 2019b)			
No.	District Health Board	Public Health Unit	Supply Owner	Supply Population	Northing	Easting	Current NO3-N (mg/L)	Current NO3 (mg/L)	Date of most recent sample	Data Source	Multiple samples 2018 2019?	Average of multiple sources?	Monthly Sampling?	Historic nitrate level (NO3-N mg/L)	Historic nitrate level (NO3 mg/L)	Date of most recent historic sample	Historic Supply Population
64	South Canterbury DHB	Community and Public	Waimate District Council	120	-44.33691	170.897478	0.04	**0.2**	28/07/2016	Supplier	No	No	No	No data	No data	No data	No data
65	South Canterbury DHB	Community and Public	Waimate District Council	1,350	-44.681956	171.133462	0.14	**0.6**	28/07/2016	Supplier	No	No	No	0.105	0.46	1/03/2000	1,200
66	South Canterbury DHB	Community and Public	Waimate District Council	600	-44.794399	171.134311	0.56	**2.5**	27/08/2015	Supplier	No	No	No	0.75	3.32	24/02/1997	430
67	South Canterbury DHB	Community and Public	Waimate District Council	430	-44.586321	171.153968	0.83	**3.7**	14/01/2020	Supplier	Yes	No	Yes	No data	No data	No data	No data
68	South Canterbury DHB	Community and Public	Waimate District Council	141	-44.731619	170.823969	0.36	**1.6**	28/07/2016	Supplier	Yes	Yes	No	0.05	0.22	24/02/1997	150
69	South Canterbury DHB	Community and Public	Waimate District Council	360	-44.826992	170.974099	0.01	**0.0**	6/03/2019	Supplier	No	No	No	0.05	0.22	24/02/1997	450
70	South Canterbury DHB	Community and Public	Waimate District Council	3,000	-44.732776	171.048173	0.27	**1.2**	14/01/2019	Supplier	Yes	Yes	Yes	0.3	1.33	19/11/1997	3,000
71	Northland DHB	Northland DHB	Kaipara District Council	500	-36.136316	174.022648	0.00	**0.0**	19/12/2019	Regional	Yes	No	No	0.37	1.64	30/03/1999	600
72	Northland DHB	Northland DHB	Kaipara District Council	N/A	-36.126171	174.574564	4.20	**18.6**	19/04/2012	Regional	No	No	No	1.4	6.20	12/10/2000	200
73	Wairarapa DHB	Regional Public Health	Private Supplier	1,500	-40.893149	175.661243	2.50	**11.1**	2/10/2019	Regional	Yes	Yes	No	0.79	3.50	9/03/1999	600
74	South Canterbury DHB	Community and Public	Mackenzie District Council	200	-44.091672	170.846495	0.03	**0.1**	13/12/2018	Supplier	No	No	No	0.29	1.28	20/04/1999	150
75	South Canterbury DHB	Community and Public	Mackenzie District Council	30	-44.0894	170.652296	0.03	**0.1**	13/12/2018	Supplier	No	No	No	No data	No data	No data	No data
76	South Canterbury DHB	Community and Public	Mackenzie District Council	1,000	-44.097776	170.82889	0.15	**0.7**	8/10/2018	Supplier	No	No	No	0.1	0.44	7/04/1999	850
77	South Canterbury DHB	Community and Public	Mackenzie District Council	500	-44.005251	170.477756	0.03	**0.1**	11/10/2018	Supplier	No	No	No	0.05	0.22	25/09/1996	500
78	South Canterbury DHB	Community and Public	Mackenzie District Council	1,300	-44.259388	170.101319	0.38	**1.7**	4/10/2018	Supplier	No	No	No	0.06	0.27	7/04/1999	1,300
79	Nelson Marlborough	Nelson Marlborough DHB	Marlborough District Council	1,333	-41.719573	173.893664	0.01	**0.1**	5/12/2018	Supplier	No	No	No	No data	No data	No data	No data
80	Nelson Marlborough	Nelson Marlborough DHB	Marlborough District Council	24,028	-41.51357	173.959752	1.00	**4.4**	13/09/2019	Supplier	Yes	Yes	No	0.8	3.54	10/03/1997	16,500
81	Nelson Marlborough	Nelson Marlborough DHB	Marlborough District Council	618	-41.279482	173.768469	0.84	**3.7**	11/12/2019	Supplier	Yes	Yes	Yes	0.75	3.32	6/03/1997	474
82	Nelson Marlborough	Nelson Marlborough DHB	Marlborough District Council	4,185	-41.290648	174.000875	2.10	**9.3**	9/12/2019	Supplier	Yes	No	Yes	1.4	6.20	22/10/1997	3,990
83	Nelson Marlborough	Nelson Marlborough DHB	Marlborough District Council	1,884	-41.510787	173.828607	1.20	**5.3**	11/12/2019	Supplier	Yes	Yes	Yes	No data	No data	No data	No data
84	Nelson Marlborough	Nelson Marlborough DHB	Marlborough District Council	740	-41.530468	174.008217	0.00	**0.0**	18/12/2019	Supplier	Yes	Yes	Yes	No data	No data	No data	No data
85	Nelson Marlborough	Nelson Marlborough DHB	Marlborough District Council	160	-41.554036	173.522774	1.67	**7.4**	11/12/2019	Supplier	Yes	No	Yes	0.64	2.83	22/03/2000	125
86	South Canterbury DHB	Community and Public	Private Supplier	220	-43.619256	171.748286	8.19	**36.3**	18/11/2019	Supplier	Yes	No	No	6.6	29.22	21/01/1997	400
87	Southern DHB	Public Health South	Private Supplier	300	-44.882525	169.003506	2.50	**11.1**	19/09/2019	Supplier	No	No	No	No data	No data	No data	No data
88	Taranaki DHB	Taranaki DHB	Private Supplier	400	-41.563765	173.532669	0.03	**0.1**	16/01/2020	Supplier	Yes	No	No	No data	No data	No data	No data
89	Taranaki DHB	Taranaki DHB	South Taranaki District Council	1,980	-39.430534	174.299273	0.28	**1.2**	30/10/2018	Supplier	No	No	No	0.25	1.11	25/02/1998	2,200
90	Taranaki DHB	Taranaki DHB	South Taranaki District Council	10,900	-39.58856	174.280146	0.86	**3.8**	31/10/2018	Supplier	No	No	No	0.5	2.21	25/02/1998	9,500
91	Taranaki DHB	Taranaki DHB	South Taranaki District Council	1,370	-39.456813	173.853632	0.05	**0.2**	1/11/2018	Supplier	No	No	No	0.075	0.33	24/02/1998	1,500
92	Taranaki DHB	Taranaki DHB	South Taranaki District Council	2,880	-39.530899	174.144067	0.05	**0.2**	30/10/2018	Supplier	No	No	No	0.0625	0.28	8/04/1999	3,100
93	Canterbury DHB	Community and Public	Hurunui District Council	1,921	-43.154914	172.72968	0.13	**0.6**	1/11/2019	Supplier	Yes	Yes	No	0.645	2.9	20/04/1999	No data
94	Canterbury DHB	Community and Public	Hurunui District Council	699	-42.745149	172.873917	0.44	**1.9**	1/11/2019	Supplier	Yes	Yes	No	No data	No data	No data	No data
95	Canterbury DHB	Community and Public	Hurunui District Council	5,832	-43.2749478	172.6357133	0.08	**0.3**	1/11/2019	Supplier	Yes	Yes	No	0.3	1.3	27/03/1998	3,500
96	Canterbury DHB	Community and Public	Hurunui District Council	273	-42.7376574	172.6702255	0.04	**0.2**	1/11/2019	Supplier	Yes	No	No	No data	No data	No data	No data
97	Canterbury DHB	Community and Public	Hurunui District Council	42	-42.8856786	173.2160715	1.01	**4.4**	1/11/2019	Supplier	Yes	No	No	No data	No data	No data	No data
98	Canterbury DHB	Community and Public	Hurunui District Council	565	-43.1158957	172.7183496	0.50	**2.2**	1/11/2019	Supplier	Yes	No	No	No data	No data	No data	No data
99	Canterbury DHB	Community and Public	Hurunui District Council	888	-42.812909	173.273775	0.25	**1.1**	1/11/2019	Supplier	Yes	No	No	0.15	0.7	13/02/1997	240
100	Canterbury DHB	Community and Public	Hurunui District Council	366	-42.772806	172.849295	3.23	**14.3**	1/11/2019	Supplier	Yes	No	No	3.8	16.8	4/07/1996	475
101	Canterbury DHB	Community and Public	Hurunui District Council	948	-42.528376	172.821759	0.01	**0.0**	1/11/2019	Supplier	Yes	No	No	0.025	0.1	26/04/1999	1,500
102	Canterbury DHB	Community and Public	Hurunui District Council	753	-42.923451	172.640855	0.90	**4.0**	1/11/2019	Supplier	Yes	No	No	0.265	1.2	7/03/2000	750
103	Canterbury DHB	Community and Public	Hurunui District Council	129	-42.8786507	173.0493247	0.25	**1.1**	1/11/2019	Supplier	Yes	No	No	No data	No data	No data	No data
104	Canterbury DHB	Community and Public	Hurunui District Council	315	-42.8925067	172.7109061	1.67	**7.4**	1/11/2019	Supplier	Yes	No	No	No data	No data	No data	No data
105	Canterbury DHB	Community and Public	Hurunui District Council	681	-42.9008021	173.104671	0.28	**1.2**	1/11/2019	Supplier	Yes	No	No	0.465	2.1	7/03/2000	600
106	Canterbury DHB	Community and Public	Hurunui District Council	210	-42.7299003	173.2762892	0.23	**1.0**	1/11/2019	Supplier	Yes	No	No	No data	No data	No data	No data
107	Canterbury DHB	Community and Public	Hurunui District Council	84	-42.8059548	172.5675688	0.87	**3.8**	1/11/2019	Supplier	Yes	No	No	No data	No data	No data	No data
108	Canterbury DHB	Community and Public	Hurunui District Council	435	-42.6399793	173.0178375	1.03	**4.6**	1/11/2019	Supplier	Yes	No	No	No data	No data	No data	No data
109	Canterbury DHB	Community and Public	Hurunui District Council	255	-42.655399	173.041856	0.57	**2.5**	1/11/2019	Supplier	Yes	No	No	No data	No data	No data	No data
110	Canterbury DHB	Community and Public	Hurunui District Council	285	-43.054635	172.760557	3.60	**15.9**	1/11/2019	Supplier	Yes	No	No	1.4	6.2	4/07/1996	220
111	Canterbury DHB	Community and Public	Hurunui District Council	513	-44.21705	171.181556	0.13	**0.6**	1/11/2019	Supplier	Yes	No	No	No data	No data	No data	No data
112	Waikato DHB	Waikato DHB	Waikato District Council	2,149	-37.404162	175.14352	0.84	**3.7**	11/11/2019	Supplier	Yes	No	No	0.3	1.3	25/03/1998	400
113	Waikato DHB	Waikato DHB	Waikato District Council	7,435	-37.557695	175.159226	0.89	**3.9**	11/11/2019	Supplier	Yes	No	No	No data	No data	No data	No data
114	Waikato DHB	Waikato DHB	Waikato District Council	6,879	-37.667611	175.1488	0.60	**2.6**	11/11/2019	Supplier	Yes	No	No	0.3	1.3	25/03/1998	5,420
115	Waikato DHB	Waikato DHB	Waikato District Council	3,187	-37.803091	174.873031	0.16	**0.7**	22/10/2019	Supplier	Yes	No	No	0.1	0.4	24/03/1998	2,400
116	Waikato DHB	Waikato DHB	Waikato District Council	45	-37.678387	174.856043	0.04	**0.2**	3/01/2020	Supplier	Yes	No	No	No data	No data	No data	No data
117	Counties Manukau DHB	Auckland DHB	Waikato District Council	60	-37.390283	174.72772	0.33	**1.5**	4/09/2018	Supplier	Yes	No	No	No data	No data	No data	No data
118	Counties Manukau DHB	Auckland DHB	Waikato District Council	36	-37.327883	174.915057	3.83	**16.9**	4/09/2018	Supplier	Yes	No	No	No data	No data	No data	No data
119	Waikato DHB	Waikato DHB	Matamata-Piako District Council	35	-37.881583	175.759014	6.02	**26.6**	1/04/2019	Supplier	Yes	No	No	No data	No data	No data	No data
120	Waikato DHB	Waikato DHB	Matamata-Piako District Council	6,309	-37.813784	175.7727	0.33	**1.5**	7/10/2019	Supplier	Yes	No	No	0.3	1.3	6/04/1998	5,600
121	Waikato DHB	Waikato DHB	Matamata-Piako District Council	634	-37.76098	175.753372	3.50	**15.5**	7/10/2019	Supplier	Yes	No	No	No data	No data	No data	No data
122	Waikato DHB	Waikato DHB	Matamata-Piako District Council	6,603	-37.659263	175.52911	1.00	**4.4**	20/12/2019	Supplier	Yes	Yes	No	0.35	1.5	23/03/1998	No Data
123	Waikato DHB	Waikato DHB	Matamata-Piako District Council	120	-37.501229	175.494207	0.09	**0.4**	8/10/2019	Supplier	Yes	No	No	No data	No data	No data	No data
124	Waikato DHB	Waikato DHB	Matamata-Piako District Council	3,838	-37.543193	175.712155	0.42	**1.9**	7/10/2019	Supplier	Yes	No	No	0.075	0.3	23/03/1998	No Data
125	Waikato DHB	Waikato DHB	Matamata-Piako District Council	100	-37.872573	175.842611	1.01	**4.5**	9/10/2019	Supplier	Yes	No	No	No data	No data	No data	No data
126	Waikato DHB	Waikato DHB	Matamata-Piako District Council	80	-37.523939	175.703813	8.30	**36.7**	5/12/2019	Supplier	Yes	No	No	No data	No data	No data	No data

							Current Nitrate Data							Historic Nitrate Data (ESR, 2019b)			
No.	District Health Board	Public Health Unit	Supply Owner	Supply Population	Northing	Easting	Current NO3-N (mg/L)	Current NO3 (mg/L)	Date of most recent sample	Data Source	Multiple samples 2018 2019?	Average of multiple sources?	Monthly Sampling?	Historic nitrate level (NO3-N mg/L)	Historic nitrate level (NO3 mg/L)	Date of most recent historic sample	Historic Supply Population
127	Southern DHB	Public Health South	Queenstown Lakes District Council	4,366	-44.9373203	168.8279373	0.60	**2.7**	3/10/2018	Supplier	No	No	No	0.34	1.5	27/06/2000	1,400
128	Southern DHB	Public Health South	Queenstown Lakes District Council	1,631	-44.9856021	168.668523	0.15	**0.7**	1/10/2018	Supplier	No	No	No	0.25	1.1	12/06/1997	300
129	Southern DHB	Public Health South	Queenstown Lakes District Council	37	-44.7107136	169.2079441	0.61	**2.7**	2/10/2018	Supplier	No	No	No	No data	No data	No data	No data
130	Southern DHB	Public Health South	Queenstown Lakes District Council	1,232	-44.8576008	168.3919028	0.25	**1.1**	8/10/2018	Supplier	No	No	No	0.1	0.4	26/05/1997	200
131	Southern DHB	Public Health South	Queenstown Lakes District Council	3,767	-44.6097364	169.2614104	0.04	**0.2**	10/10/2018	Supplier	No	No	No	0.05	0.2	9/06/1997	400
132	Southern DHB	Public Health South	Queenstown Lakes District Council	1,697	-44.9668	168.8082599	1.10	**4.9**	9/10/2018	Supplier	No	No	No	1.3	5.8	26/05/1997	300
133	Southern DHB	Public Health South	Queenstown Lakes District Council	2,046	-45.0052514	168.763324	0.10	**0.4**	10/04/2018	Supplier	No	No	No	No data	No data	No data	No data
134	Southern DHB	Public Health South	Queenstown Lakes District Council	855	-44.7497893	169.2736788	1.90	**8.4**	11/10/2018	Supplier	No	No	No	No data	No data	No data	No data
135	Southern DHB	Public Health South	Queenstown Lakes District Council	25,271	-45.0414394	168.6450929	0.03	**0.1**	14/08/2018	Supplier	No	No	No	0.05	0.2	6/05/1998	8,000
136	Southern DHB	Public Health South	Queenstown Lakes District Council	13,633	-44.6623313	169.1423217	0.28	**1.2**	14/08/2018	Supplier	No	No	No	0.05	0.2	25/03/1998	2,750
137	Southern DHB	Public Health South	Queenstown Lakes District Council	150	-44.6922558	169.1118742	2.40	**10.6**	11/10/2018	Supplier	No	No	No	No data	No data	No data	No data
138	MidCentral DHB	MidCentral DHB	Tararua District Council	25	-40.594448	176.426612	1.16	**5.1**	26/06/2019	Supplier	No	No	No	No data	No data	No data	No data
139	MidCentral DHB	MidCentral DHB	Tararua District Council	6,000	-40.206001	176.099405	0.62	**2.7**	26/06/2019	Supplier	No	No	No	0.05	0.2	26/03/1998	6,000
140	MidCentral DHB	MidCentral DHB	Tararua District Council	456	-40.645633	175.703292	0.04	**0.2**	26/06/2019	Supplier	No	No	No	0.08	0.4	7/03/1999	900
141	MidCentral DHB	MidCentral DHB	Tararua District Council	200	-40.071386	176.217656	0.00	**0.0**	26/06/2019	Supplier	No	No	No	0.6	2.7	7/05/1996	200
142	MidCentral DHB	MidCentral DHB	Tararua District Council	2,700	-40.455594	175.838479	0.55	**2.4**	26/06/2019	Supplier	No	No	No	1.8	8.0	26/03/1998	2,700
143	MidCentral DHB	MidCentral DHB	Tararua District Council	200	-40.542517	176.193455	0.37	**1.6**	26/06/2019	Supplier	No	No	No	0.2	0.9	27/05/1996	200
144	MidCentral DHB	MidCentral DHB	Tararua District Council	1,500	-40.339191	175.868243	0.15	**0.7**	26/06/2019	Supplier	No	No	No	0.13	0.6	26/03/1998	1,600
145	Southern DHB	Public Health South	Dunedin City Council	1,642	-45.59567	170.670306	0.03	**0.1**	31/02/2020	Supplier	Yes	No	No	0.05	0.2	2/04/1998	1,600
146	Southern DHB	Public Health South	Dunedin City Council	450	-45.918239	170.218379	0.05	**0.2**	8/11/2019	Supplier	Yes	No	No	0.05	0.2	31/03/1998	450
147	Southern DHB	Public Health South	Dunedin City Council	37,036	-45.840581	170.493146	0.02	**0.1**	8/11/2019	Supplier	Yes	Yes	No	0.05	0.2	2/04/1998	30,841
148	Southern DHB	Public Health South	Dunedin City Council	300	-45.898173	170.336356	0.02	**0.1**	8/11/2019	Supplier	Yes	Yes	No	0.5	2.2	31/03/1998	1,100
149	Southern DHB	Public Health South	Dunedin City Council	341	-45.892034	170.35306	0.02	**0.1**	8/11/2019	Supplier	Yes	Yes	No	No data	No data	No data	No data
150	Southern DHB	Public Health South	Dunedin City Council	13,785	-45.858438	170.50031	0.02	**0.1**	8/11/2019	Supplier	Yes	Yes	No	No data	No data	No data	No data
151	Southern DHB	Public Health South	Dunedin City Council	9,535	-	-	0.02	**0.1**	8/11/2019	Supplier	Yes	Yes	No	No data	No data	No data	No data
152	Southern DHB	Public Health South	Dunedin City Council	1,124	-45.877253	170.384653	0.02	**0.1**	8/11/2019	Supplier	Yes	Yes	No	0.075	0.3	31/03/1998	3,293
153	Southern DHB	Public Health South	Dunedin City Council	10,119	-45.902592,	170.42797	0.06	**0.3**	11/11/2019	Supplier	Yes	Yes	No	0.05	0.2	22/04/1998	6,409
154	Southern DHB	Public Health South	Dunedin City Council	37,726	-	-	0.06	**0.3**	11/11/2019	Supplier	Yes	Yes	No	0.05	0.2	22/04/1998	33,728
155	Southern DHB	Public Health South	Dunedin City Council	2,469	-45.816098	170.62108	0.06	**0.3**	11/11/2019	Supplier	Yes	Yes	No	0.1	0.4	2/04/1998	No Data
156	Southern DHB	Public Health South	Dunedin City Council	750	-45.857147	170.228791	0.12	**0.5**	8/11/2019	Supplier	Yes	No	No	0.13	0.6	29/04/1999	No Data
157	Bay of Plenty DHB	Toi Te Ora DHB	Whakatane District Council	560	-38.140028	177.004677	0.28	**1.2**	1/09/2013	Supplier	No	No	No	0.855	3.8	28/07/1999	560
158	Bay of Plenty DHB	Toi Te Ora DHB	Whakatane District Council	786	-38.066077	177.004381	0.20	**0.9**	1/09/2013	Supplier	No	No	No	0.13	0.6	14/06/1999	No data
159	Bay of Plenty DHB	Toi Te Ora DHB	Whakatane District Council	160	-38.143266	177.07628	3.10	**13.7**	1/09/2013	Supplier	No	No	No	2.55	11.3	14/06/1999	200
160	Bay of Plenty DHB	Toi Te Ora DHB	Whakatane District Council	2,733	-38.87887	176.367799	0.32	**1.4**	1/09/2013	Supplier	No	No	No	1.3	5.8	24/02/1998	No Data
161	Bay of Plenty DHB	Toi Te Ora DHB	Whakatane District Council	2,841	-38.022961	176.839513	1.11	**4.9**	1/09/2013	Supplier	No	No	No	No data	No data	No data	No data
162	Bay of Plenty DHB	Toi Te Ora DHB	Whakatane District Council	690	-37.887281	176.752413	2.80	**12.4**	1/09/2013	Supplier	No	No	No	2.05	9.1	17/03/1999	800
163	Bay of Plenty DHB	Toi Te Ora DHB	Whakatane District Council	100	-38.110612	176.81589	0.67	**3.0**	1/09/2013	Supplier	No	No	No	0.405	1.8	16/02/2000	120
164	Bay of Plenty DHB	Toi Te Ora DHB	Whakatane District Council	100	-37.901386	175.699541	0.17	**0.8**	1/09/2013	Supplier	No	No	No	No data	No data	No data	No data
165	Bay of Plenty DHB	Toi Te Ora DHB	Whakatane District Council	1,912	-38.456578	176.70405	0.24	**1.1**	1/09/2013	Supplier	No	No	No	0.1	0.4	10/03/1998	3,000
166	Bay of Plenty DHB	Toi Te Ora DHB	Whakatane District Council	21,020	-37.958512	176.982238	0.03	**0.1**	1/09/2013	Supplier	No	No	No	0.15	0.7	24/02/1998	No Data
167	MidCentral DHB	Regional Public Health	Kapiti Coast District Council	6,443	-40.763808	175.14719	0.63	**2.8**	19/11/2019	Supplier	Yes	Yes	No	0.225	1.0	7/04/1998	4,700
168	MidCentral DHB	Regional Public Health	Kapiti Coast District Council	700	-40.802744	175.171246	0.14	**0.6**	19/11/2019	Supplier	Yes	No	No	0.24	1.1	24/02/1999	No Data
169	Capital and Coast DHB	Regional Public Health	Kapiti Coast District Council	41,482	-40.876047	175.065709	0.16	**0.7**	14/10/2019	Supplier	Yes	No	No	No data	No data	No data	No data
170	Capital and Coast DHB	Regional Public Health	Kapiti Coast District Council	1,599	-40.987639	174.949912	0.25	**1.1**	14/10/2019	Supplier	Yes	Yes	No	0.205	0.9	7/04/1998	No Data
171	Southern DHB	Public Health South	Central Otago District Council	6,000	-45.251475	169.37397	0.69	**3.1**	1/01/2017	Supplier	No	No	No	0.995	4.4	6/05/1999	5,000
172	Southern DHB	Public Health South	Central Otago District Council	8,000	-45.041278	169.218301	1.70	**7.5**	1/01/2014	Supplier	No	No	No	0.025	0.1	6/05/1999	No data
173	Southern DHB	Public Health South	Central Otago District Council	2,200	-45.175499	169.308271	0.08	**0.3**	1/01/2017	Supplier	No	No	No	No data	No data	No data	No data
174	Southern DHB	Public Health South	Central Otago District Council	420	-45.02208	170.137787	0.00	**0.0**	1/01/2017	Supplier	No	No	No	0.05	0.2	20/06/1996	400
175	Southern DHB	Public Health South	Central Otago District Council	400	-45.094671	169.604417	0.02	**0.1**	1/01/2017	Supplier	No	No	No	0.1	0.4	20/06/1996	350
176	Southern DHB	Public Health South	Central Otago District Council	260	-45.278992	170.051589	0.01	**0.0**	1/01/2017	Supplier	No	No	No	No data	No data	No data	No data
177	Southern DHB	Public Health South	Central Otago District Council	250	-44.973171	169.241459	0.96	**4.2**	1/01/2017	Supplier	No	No	No	No data	No data	No data	No data
178	Southern DHB	Public Health South	Central Otago District Council	950	-44.980628	170.127773	0.06	**0.3**	1/01/2017	Supplier	No	No	No	0.025	0.1	11/05/2000	No data
179	Southern DHB	Public Health South	Central Otago District Council	790	-45.530526	169.300415	0.26	**1.2**	1/01/2017	Supplier	No	No	No	0.28	1.2	21/04/1999	700
180	West Coast DHB	Community and Public	Buller District Council	951	-42.115023	171.863068	0.50	**2.2**	21/10/2019	Supplier	Yes	No	No	0.22	1.0	23/02/1999	No Data
181	West Coast DHB	Community and Public	Buller District Council	144	-41.857687	171.9494	1.61	**7.1**	14/07/2016	Supplier	Yes	No	No	No data	No data	No data	No data
182	West Coast DHB	Community and Public	Buller District Council	100	-41.524795	171.936248	0.03	**0.1**	12/05/2008	Supplier	No	No	No	No data	No data	No data	No data
183	Hawke's Bay DHB	Hawke's Bay DHB	Hastings District Council	64,764	-39.642344	176.843175	1.89	**8.4**	7/10/2019	Supplier	Yes	Yes	No	2.55	11.3	19/06/1997	11,324
184	Hawke's Bay DHB	Hawke's Bay DHB	Hastings District Council	1,900	-39.604627	176.94646	0.03	**0.1**	7/10/2019	Supplier	Yes	Yes	No	No data	No data	No data	No data
185	Hawke's Bay DHB	Hawke's Bay DHB	Hastings District Council	260	-39.815874	176.989184	1.80	**8.0**	7/10/2019	Supplier	Yes	No	No	No data	No data	No data	No data
186	Hawke's Bay DHB	Hawke's Bay DHB	Hastings District Council	198	-39.578773	176.922321	0.12	**0.5**	7/10/2019	Supplier	Yes	No	No	No data	No data	No data	No data
187	Hawke's Bay DHB	Hawke's Bay DHB	Hastings District Council	362	-39.586358	176.914098	0.26	**1.2**	7/10/2019	Supplier	Yes	No	No	No data	No data	No data	No data
188	Hawke's Bay DHB	Hawke's Bay DHB	Hastings District Council	337	-39.604019	176.894853	0.27	**1.2**	7/10/2019	Supplier	Yes	No	No	0.25	1.1	19/06/1997	337
189	Hawke's Bay DHB	Hawke's Bay DHB	Hastings District Council	750	-39.375813	176.89364	0.33	**1.5**	8/10/2019	Supplier	Yes	No	No	0.12	0.5	22/03/2000	No data

							Current Nitrate Data							Historic Nitrate Data (ESR, 2019b)			
No.	District Health Board	Public Health Unit	Supply Owner	Supply Population	Northing	Easting	Current NO3-N (mg/L)	Current NO3 (mg/L)	Date of most recent sample	Data Source	Multiple samples 2018 2019?	Average of multiple sources?	Monthly Sampling?	Historic nitrate level (NO3-N mg/L)	Historic nitrate level (NO3 mg/L)	Date of most recent historic sample	Historic Supply Population
190	Hawke's Bay DHB	Hawke's Bay DHB	Hastings District Council	126	-39.581901	176.757001	0.18	**0.8**	8/10/2019	Supplier	Yes	Yes	No	0.075	0.3	19/06/1997	126
191	Hawke's Bay DHB	Hawke's Bay DHB	Hastings District Council	12	-39.296992	176.973634	0.02	**0.1**	7/10/2019	Supplier	Yes	No	No	No data	No data	No data	No data
192	Hawke's Bay DHB	Hawke's Bay DHB	Hastings District Council	80	-39.619708	176.948239	0.76	**3.4**	7/10/2019	Supplier	Yes	No	No	No data	No data	No data	No data
193	Hawke's Bay DHB	Hawke's Bay DHB	Hastings District Council	50	-39.39136	176.868549	0.43	**1.9**	8/10/2019	Supplier	Yes	No	No	No data	No data	No data	No data
194	Hawke's Bay DHB	Hawke's Bay DHB	Hastings District Council	750	-39.629733	176.872449	0.21	**0.9**	7/10/2019	Supplier	Yes	No	No	No data	No data	No data	No data
195	MidCentral DHB	MidCentral DHB	Horowhenua District Council	17,308	-40.621822	175.286515	0.05	**0.2**	1/12/2017	Supplier	No	No	No	No data	No data	No data	No data
196	MidCentral DHB	MidCentral DHB	Horowhenua District Council	2,907	-40.474299	175.284479	0.05	**0.2**	1/12/2017	Supplier	No	No	No	No data	No data	No data	No data
197	MidCentral DHB	MidCentral DHB	Horowhenua District Council	1,805	-40.459813	175.22282	0.00	**0.0**	1/12/2017	Supplier	No	No	No	0.025	0.1	16/03/1999	No data
198	MidCentral DHB	MidCentral DHB	Horowhenua District Council	1,366	-40.547255	175.410756	0.07	**0.3**	1/12/2017	Supplier	No	No	No	0.15	0.7	23/03/1998	1,500
199	MidCentral DHB	MidCentral DHB	Horowhenua District Council	607	-40.473544	175.509675	0.12	**0.5**	1/12/2017	Supplier	No	No	No	0.115	0.5	31/05/1999	No Data
200	Bay of Plenty DHB	Toi Te Ora DHB	Western Bay of Plenty District	5,125	-37.445307	175.962299	0.16	**0.7**	11/11/2019	Supplier	Yes	Yes	No	0.1	0.4	23/04/1998	1,515
201	Bay of Plenty DHB	Toi Te Ora DHB	Western Bay of Plenty District	5,700	-37.551985	175.923123	0.07	**0.3**	11/11/2019	Supplier	Yes	Yes	No	0.075	0.3	29/04/1998	5,205
202	Bay of Plenty DHB	Toi Te Ora DHB	Western Bay of Plenty District	6,450	-37.640993	176.039297	0.16	**0.7**	4/11/2019	Supplier	Yes	Yes	No	0.25	1.1	14/06/1999	3,583
203	Bay of Plenty DHB	Toi Te Ora DHB	Western Bay of Plenty District	4,600	-37.82369	176.476483	0.01	**0.0**	21/11/2019	Supplier	Yes	No	No	7.35	32.5	1/04/1997	240
204	Bay of Plenty DHB	Toi Te Ora DHB	Western Bay of Plenty District	8,260	37.784922	176.324568	0.33	**1.5**	28/11/2019	Supplier	Yes	Yes	Yes	0.125	0.6	28/04/1998	100
205	Waikato DHB	Waikato DHB	Hauraki District Council	2,552	-37.298479	175.546701	1.06	**4.7**	13/02/2019	Supplier	Yes	No	No	No data	No data	No data	No data
206	Waikato DHB	Waikato DHB	Hauraki District Council	4,887	-37.381709	175.672545	0.01	**0.1**	13/02/2019	Supplier	Yes	No	No	0.05	0.2	9/04/1998	4,000
207	Waikato DHB	Waikato DHB	Hauraki District Council	4,927	-37.391439	175.840341	0.20	**0.9**	13/02/2019	Supplier	Yes	Yes	No	No data	No data	No data	No data
208	Waikato DHB	Waikato DHB	Hauraki District Council	2,076	-37.238667	175.38558	0.01	**0.1**	13/02/2019	Supplier	Yes	Yes	No	No data	No data	No data	No data
209	Waikato DHB	Waikato DHB	Waipa District Council	20,833	-37.891622	175.467443	0.34	**1.5**	21/01/2019	Supplier	Yes	Yes	No	No data	No data	No data	No data
210	Waikato DHB	Waikato DHB	Waipa District Council	10,665	-38.010123	175.325747	1.67	**7.4**	2/07/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
211	Waikato DHB	Waikato DHB	Waipa District Council	3,387	-37.901736	175.43388	0.34	**1.5**	21/01/2019	Supplier	No	No	No	0.1	0.4	6/11/1997	2,810
212	Waikato DHB	Waikato DHB	Waipa District Council	2,000	-38.03754	175.345127	0.16	**0.7**	7/06/2018	Supplier	Yes	Yes	No	0.1	0.4	16/03/1998	2,000
213	Waikato DHB	Waikato DHB	Waipa District Council	250	-46.565146	168.943754	0.14	**0.6**	2/07/2018	Supplier	No	Yes	No	No data	No data	No data	No data
214	Waikato DHB	Waikato DHB	Private Supplier	400	-37.865663	175.334324	0.34	**1.5**	21/01/2019	Supplier	No	No	No	3	13.3	27/11/2000	110
215	Whanganui DHB	MidCentral DHB	Rangitikei District Council	4,764	-40.069027	175.378461	0.76	**3.4**	14/06/2017	Supplier	Yes	Yes	No	0.275	1.2	25/03/1998	No data
216	Whanganui DHB	MidCentral DHB	Rangitikei District Council	1,419	-40.174528	175.384845	0.68	**3.0**	14/06/2017	Supplier	Yes	Yes	No	0.54	2.4	2/02/2000	No data
217	Whanganui DHB	MidCentral DHB	Rangitikei District Council	480	-39.936468	175.568973	0.99	**4.4**	13/06/2017	Supplier	No	No	No	No data	No data	No data	No data
218	Whanganui DHB	MidCentral DHB	Rangitikei District Council	150	-39.808271	175.791283	0.16	**0.7**	13/06/2017	Supplier	No	No	No	No data	No data	No data	No data
219	Whanganui DHB	MidCentral DHB	Rangitikei District Council	337	-40.039586	175.176446	0.01	**0.0**	12/01/2012	Supplier	No	No	No	No data	No data	No data	No data
220	Whanganui DHB	MidCentral DHB	Rangitikei District Council	1,584	-39.677905	175.798976	0.09	**0.4**	13/06/2017	Supplier	No	No	No	0.1	0.4	25/03/198	No data
221	Nelson Marlborough	Nelson Marlborough DHB	Tasman District Council	400	-41.388742	172.825015	1.80	**8.0**	1/01/2014	Supplier	No	No	No	1.8	8.0	10/04/1997	400
222	Nelson Marlborough	Nelson Marlborough DHB	Tasman District Council	1,200	-41.124235	173.009719	1.75	**7.7**	1/01/2014	Supplier	Yes	Yes	No	2.4	10.6	23/03/1999	1,200
223	Nelson Marlborough	Nelson Marlborough DHB	Tasman District Council	25	-41.028695	172.822019	0.10	**0.4**	1/01/2014	Supplier	No	No	No	No data	No data	No data	No data
224	Nelson Marlborough	Nelson Marlborough DHB	Tasman District Council	10,000	-41.343417	173.187083	5.02	**22.2**	18/11/2019	Supplier	Yes	Yes	Yes	No data	No data	No data	No data
225	Nelson Marlborough	Nelson Marlborough DHB	Tasman District Council	6,000	-41.320788	173.167818	4.78	**21.2**	18/11/2019	Supplier	Yes	Yes	Yes	No data	No data	No data	No data
226	Nelson Marlborough	Nelson Marlborough DHB	Tasman District Council	1,500	-41.405045	173.045092	2.00	**8.9**	1/01/2014	Supplier	No	No	No	2	8.9	2/04/1998	No Data
227	Nelson Marlborough	Nelson Marlborough DHB	Tasman District Council	2,730	-41.378948	173.112377	0.40	**1.8**	1/01/2014	Supplier	Yes	Yes	No	0.15	0.7	2/04/1998	2,000
228	Nelson Marlborough	Nelson Marlborough DHB	Tasman District Council	490	-41.800081	172.325477	4.30	**19.0**	1/01/2014	Supplier	No	No	No	2.33	10.3	8/04/1999	680
229	Nelson Marlborough	Nelson Marlborough DHB	Tasman District Council	450	-41.287516	172.894427	0.00	**0.0**	1/01/2014	Supplier	No	No	No	No data	No data	No data	No data
230	Nelson Marlborough	Nelson Marlborough DHB	Tasman District Council	450	-40.677609	172.682818	0.25	**1.1**	1/01/2014	Supplier	No	No	No	No data	No data	No data	No data
231	Nelson Marlborough	Nelson Marlborough DHB	Tasman District Council	200	-41.480154	172.986869	0.03	**0.1**	1/01/2014	Supplier	No	No	No	No data	No data	No data	No data
232	Nelson Marlborough	Nelson Marlborough DHB	Tasman District Council	300	-41.033347	173.019743	2.50	**11.1**	17/05/2018	Supplier	No	No	No	2.45	10.8	9/03/2000	300
233	Nelson Marlborough	Nelson Marlborough DHB	Tasman District Council	150	-40.834167	172.879862	1.00	**4.4**	1/01/2014	Supplier	No	No	No	No data	No data	No data	No data
234	Nelson Marlborough	Nelson Marlborough DHB	Tasman District Council	180	-41.32692	173.104035	0.70	**3.1**	1/01/2014	Supplier	No	No	No	2.9	12.8	10/04/1997	180
235	Nelson Marlborough	Nelson Marlborough DHB	Tasman District Council	370	-41.301844	173.074758	0.70	**3.1**	1/01/2014	Supplier	No	No	No	1.9	8.4	10/04/1997	370
236	Nelson Marlborough	Nelson Marlborough DHB	Tasman District Council	2,500	-41.237691	173.088577	1.20	**5.3**	1/01/2014	Supplier	Yes	Yes	No	1	4.4	2/04/1998	No Data
237	Canterbury DHB	Community and Public	Ashburton District Council	18,500	-43.905791	171.745202	3.43	**15.2**	10/01/2020	Supplier	Yes	Yes	Yes	2.03	9.0	2/09/1999	15,000
238	Canterbury DHB	Community and Public	Ashburton District Council	230	-43.803643	171.93592	3.95	**17.5**	15/01/2020	Supplier	Yes	No	Yes	No data	No data	No data	No data
239	Canterbury DHB	Community and Public	Ashburton District Council	90	-43.837627	171.849708	5.68	**25.1**	15/01/2020	Supplier	Yes	No	Yes	No data	No data	No data	No data
240	Canterbury DHB	Community and Public	Ashburton District Council	210	-43.869386	171.818029	7.22	**32.0**	14/01/2020	Supplier	Yes	No	Yes	6	26.6	21/02/1997	170
241	Canterbury DHB	Community and Public	Ashburton District Council	110			0.03	**0.1**	14/01/2020	Supplier	Yes	No	Yes	No data	No data	No data	No data
242	Canterbury DHB	Community and Public	Ashburton District Council	340	-44.002665	171.569878	6.65	**29.4**	14/01/2020	Supplier	Yes	No	Yes	6.2	27.4	4/12/1996	200
243	Canterbury DHB	Community and Public	Ashburton District Council	160	-43.82157	171.421579	2.39	**10.6**	17/01/2020	Supplier	Yes	No	Yes	2.275	10.1	18/10/2000	120
244	Canterbury DHB	Community and Public	Ashburton District Council	1,700	43.632772	171.647166	0.85	**3.8**	13/01/2020	Supplier	Yes	No	Yes	0.71	3.1	15/02/2000	900
245	Canterbury DHB	Community and Public	Ashburton District Council	178	-	-	0.47	**2.1**	13/01/2020	Supplier	Yes	No	Yes	No data	No data	No data	No data
246	Canterbury DHB	Community and Public	Ashburton District Council	90	-43.810519	171.280503	0.03	**0.1**	17/01/2020	Supplier	Yes	No	Yes	No data	No data	No data	No data
247	Canterbury DHB	Community and Public	Ashburton District Council	260	-43.705361	-43.705361	0.77	**3.4**	13/01/2020	Supplier	Yes	No	Yes	No data	No data	No data	No data
248	Canterbury DHB	Community and Public	Ashburton District Council	1,100	-43.755765	172.023346	0.21	**0.9**	15/01/2020	Supplier	Yes	No	Yes	0.24	1.1	17/02/2000	No data
249	Southern DHB	Public Health South	Waitaki District Council	399	-44.9424622	170.8919787	0.02	**0.1**	1/01/2020	Supplier	No	No	No	0.05	0.2	16/10/1996	160
250	Southern DHB	Public Health South	Waitaki District Council	197	-45.1115259	170.7372404	0.03	**0.1**	1/01/2020	Supplier	No	No	No	No data	No data	No data	No data
251	Southern DHB	Public Health South	Waitaki District Council	86	-45.5354132	170.6415251	0.01	**0.0**	1/01/2020	Supplier	No	No	No	No data	No data	No data	No data
252	Southern DHB	Public Health South	Waitaki District Council	573	-44.9447366	170.5889469	0.13	**0.6**	1/01/2020	Supplier	No	No	No	0.07	0.3	12/05/2000	No Data

							Current Nitrate Data							Historic Nitrate Data (ESR, 2019b)			
No.	District Health Board	Public Health Unit	Supply Owner	Supply Population	Northing	Easting	Current NO3-N (mg/L)	Current NO3 (mg/L)	Date of most recent sample	Data Source	Multiple samples 2018 2019?	Average of multiple sources?	Monthly Sampling?	Historic nitrate level (NO3-N mg/L)	Historic nitrate level (NO3 mg/L)	Date of most recent historic sample	Historic Supply Population
253	Southern DHB	Public Health South	Waitaki District Council	137	-45.0226165	170.7482487	0.01	**0.0**	1/01/2020	Supplier	No	No	No	No data	No data	No data	No data
254	Southern DHB	Public Health South	Waitaki District Council	778	-44.988944	170.979832	6.94	**30.7**	4/12/2019	Supplier	Yes	No	Yes	0.05	0.2	27/05/1996	360
255	Southern DHB	Public Health South	Waitaki District Council	15,561	-45.097565	170.970554	0.16	**0.7**	11/12/2019	Supplier	Yes	No	Yes	0.33	1.5	17/05/2000	No data
256	Capital and Coast DHB	Regional Public Health	Porirua City Council	54,830	-41.134906	174.839194	0.03	**0.1**	1/11/2019	Supplier	Yes	Yes	No	No data	No data	No data	No data
257	Capital and Coast DHB	Regional Public Health	Porirua City Council	175	-41.116881	174.95183	0.03	**0.1**	1/11/2019	Supplier	Yes	Yes	No	No data	No data	No data	No data
258	Capital and Coast DHB	Regional Public Health	Wellington City Council	4,816	-41.207241	174.808041	0.03	**0.1**	1/11/2019	Supplier	Yes	Yes	No	No data	No data	No data	No data
259	Capital and Coast DHB	Regional Public Health	Wellington City Council	15,714	-41.171539	174.824808	0.03	**0.1**	1/11/2019	Supplier	Yes	Yes	No	No data	No data	No data	No data
260	Capital and Coast DHB	Regional Public Health	Wellington City Council	190,107	-41.278458	174.776591	0.23	**1.0**	1/11/2019	Supplier	Yes	Yes	No	No data	No data	No data	No data
261	Hutt DHB	Regional Public Health	Hutt City Council	10,140	-41.174702	174.9819	0.03	**0.1**	1/11/2019	Supplier	Yes	Yes	No	No data	No data	No data	No data
262	Hutt DHB	Regional Public Health	Hutt City Council	388	-41.153829	174.978041	0.03	**0.1**	1/11/2019	Supplier	Yes	Yes	No	No data	No data	No data	No data
263	Hutt DHB	Regional Public Health	Hutt City Council	4,959	-41.291765	174.8969	0.70	**3.1**	1/11/2019	Supplier	Yes	Yes	No	No data	No data	No data	No data
264	Hutt DHB	Regional Public Health	Hutt City Council	5,421	-41.179718	174.932477	0.70	**3.1**	1/11/2019	Supplier	Yes	Yes	No	No data	No data	No data	No data
265	Hutt DHB	Regional Public Health	Hutt City Council	48,940	-41.209332	174.908518	0.70	**3.1**	1/11/2019	Supplier	Yes	Yes	No	No data	No data	No data	No data
266	Hutt DHB	Regional Public Health	Hutt City Council	7,690	-41.212747	174.880077	0.70	**3.1**	1/11/2019	Supplier	Yes	Yes	No	No data	No data	No data	No data
267	Hutt DHB	Regional Public Health	Hutt City Council	8,479	-41.227313	174.884955	0.70	**3.1**	1/11/2019	Supplier	Yes	Yes	No	0.25	1.1	10/06/1997	8,034
268	Hutt DHB	Regional Public Health	Hutt City Council	17,855	-41.262552	174.946921	0.45	**2.0**	1/11/2019	Supplier	Yes	Yes	No	No data	No data	No data	No data
269	Hutt DHB	Regional Public Health	Upper Hutt City Council	39,927	-41.12496	175.06532	0.03	**0.1**	1/11/2019	Supplier	Yes	Yes	No	No data	No data	No data	No data
270	Waikato DHB	Waikato DHB	Waitomo District Council	4,612	-38.334277	175.164332	0.54	**2.4**	27/11/2019	Supplier	Yes	No	No	0.4	1.8	30/03/1998	No data
271	Waikato DHB	Waikato DHB	Waitomo District Council	280	-38.520722	175.361668	0.56	**2.5**	2/07/2013	Supplier	Yes	Yes	No	No data	No data	No data	No data
272	Waikato DHB	Waikato DHB	Waitomo District Council	200	-38.697475	174.619555	0.03	**0.1**	29/01/2020	Supplier	Yes	No	No	No data	No data	No data	No data
273	Waikato DHB	Waikato DHB	Waitomo District Council	500	-38.466104	175.016642	1.10	**4.9**	11/03/2015	Supplier	No	No	No	1.1	4.9	14/05/1996	500
274	Waikato DHB	Waikato DHB	Ruapehu District Council	180	-39.173332	175.401812	0.00	**0.0**	7/10/2019	Supplier	No	No	No	No data	No data	No data	No data
275	Whanganui DHB	MidCentral DHB	Ruapehu District Council	1,000	-39.418532	175.39958	0.03	**0.1**	7/10/2019	Supplier	No	No	No	No data	No data	No data	No data
276	Waikato DHB	Waikato DHB	Ruapehu District Council	130	-38.842009	174.982963	0.31	**1.4**	7/10/2019	Supplier	No	No	No	No data	No data	No data	No data
277	Waikato DHB	Waikato DHB	Ruapehu District Council	170	-38.998536	175.37758	0.01	**0.0**	7/10/2019	Supplier	No	No	No	No data	No data	No data	No data
278	Whanganui DHB	MidCentral DHB	Ruapehu District Council	1,033	-39.427817	175.280981	0.13	**0.6**	7/10/2019	Supplier	No	No	No	0.1	0.4	1/04/1998	No data
279	Waikato DHB	Waikato DHB	Ruapehu District Council	4,480	-38.883678	175.2592	0.33	**1.4**	7/10/2019	Supplier	No	No	No	0.2	0.9	2/04/1998	5,200
280	Waikato DHB	Waikato DHB	Private Supplier	200	-39.200624	175.53941	0.00	**0.0**	7/10/2019	Supplier	No	No	No	No data	No data	No data	No data
281	Waikato DHB	Waikato DHB	South Waikato District Council	300	-38.070748	175.647236	0.33	**1.5**	5/09/2019	Supplier	Yes	Yes	No	No data	No data	No data	No data
282	Waikato DHB	Waikato DHB	South Waikato District Council	4,116	-38.050494	175.780428	1.99	**8.8**	5/09/2019	Supplier	Yes	Yes	No	0.4	1.8	26/03/1998	4,500
283	Waikato DHB	Waikato DHB	South Waikato District Council	13,300	-38.228181	175.867323	4.11	**18.2**	5/09/2019	Supplier	Yes	Yes	No	3.7	16.4	26/03/1998	16,000
284	Waikato DHB	Waikato DHB	South Waikato District Council	700	-37.978547	175.75751	3.40	**15.0**	5/09/2019	Supplier	Yes	No	No	2.4	10.6	30/03/1998	700
285	Waikato DHB	Waikato DHB	South Waikato District Council	50	-38.108868	175.820795	0.12	**0.5**	5/09/2019	Supplier	No	Yes	No		No data	No data	No data
286	Hawke's Bay DHB	Hawke's Bay DHB	Napier City Council	57,660	-39.491878	176.913628	0.09	**0.4**	1/01/2020	Supplier	Yes	Yes	No	0.075	0.3	19/06/1997	25,800
287	Hawke's Bay DHB	Hawke's Bay DHB	Central Hawkes Bay District	3,666	-39.995827	176.55643	0.45	**2.0**	23/04/2018	Supplier	No	No	No	0.9	4.0	23/01/1998	2,500
288	Hawke's Bay DHB	Hawke's Bay DHB	Central Hawkes Bay District	2,355	-39.941823	176.589621	0.40	**1.8**	24/04/2018	Supplier	Yes	Yes	No	0.5	2.2	23/01/1998	2,355
289	Hawke's Bay DHB	Hawke's Bay DHB	Central Hawkes Bay District	160	-40.301595	176.612228	0.26	**1.1**	15/02/2020	Supplier	Yes	No	No	No data	No data	No data	No data
290	Wairarapa DHB	Regional Public Health	South Waiarapa District Council	1,776	-41.218564	175.459507	0.39	**1.7**	12/12/2019	Supplier	Yes	Yes	No	0.2	0.9	11/12/2002	1,505
291	Wairarapa DHB	Regional Public Health	Private Supplier	80	-41.35248	175.205523	0.00	**0.0**	18/09/2019	Supplier	Yes	No	No	No data	No data	No data	No data
292	Counties Manukau DHB	Auckland DHB	Watercare Services Ltd	4,562	-37.2109	174.8884	-	**1.3**	1/01/2018	Supplier	Yes	Yes	No	7.4	32.8	20/04/1999	2,662
293	Auckland DHB	Auckland DHB	Watercare Services Ltd	280,912	-36.89367	174.8367	-	**1.3**	1/01/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
294	Counties Manukau DHB	Auckland DHB	Watercare Services Ltd	984	-36.9891	174.7788	-	**1.3**	1/01/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
295	Counties Manukau DHB	Auckland DHB	Watercare Services Ltd	997	-37.226707	174.926394	-	**1.3**	1/01/2018	Supplier	Yes	Yes	No	0.05	0.2	4/06/1997	504
296	Auckland DHB	Auckland DHB	Watercare Services Ltd	19,309	-36.851478	174.765646	-	**1.0**	1/01/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
297	Counties Manukau DHB	Auckland DHB	Watercare Services Ltd	1,434	-37.135983	174.700156	-	**1.3**	1/01/2018	Supplier	Yes	Yes	No	0.025	0.1	19/04/1999	1,152
298	Counties Manukau DHB	Auckland DHB	Watercare Services Ltd	50,129	-36.943637	174.893492	-	**1.3**	1/01/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
299	Waitemata DHB	Auckland DHB	Watercare Services Ltd	61,464	-36.910229	174.65082	-	**0.7**	1/01/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
300	Counties Manukau DHB	Auckland DHB	Watercare Services Ltd	428	-37.164514	174.713746	-	**1.3**	1/01/2018	Supplier	Yes	Yes	No	0.025	0.1	4/03/1999	250
301	Waitemata DHB	Auckland DHB	Watercare Services Ltd	35,272	-36.543609	174.704351	-	**0.7**	1/01/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
302	Waitemata DHB	Auckland DHB	Watercare Services Ltd	135,657	-36.8783	174.631166	-	**1.0**	1/01/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
303	Counties Manukau DHB	Auckland DHB	Watercare Services Ltd	7,189	-36.9778	174.9492	-	**1.3**	1/01/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
304	Auckland DHB	Auckland DHB	Watercare Services Ltd	47,845	-36.920298	174.757381	-	**1.3**	1/01/2018	Supplier	Yes	Yes	No	0.063	0.3	7/06/2000	40,000
305	Counties Manukau DHB	Auckland DHB	Watercare Services Ltd	1,255	-37.2395	174.8746	-	**1.3**	1/01/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
306	Counties Manukau DHB	Auckland DHB	Watercare Services Ltd	99,873	-36.893188	174.924324	-	**1.3**	1/01/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
307	Counties Manukau DHB	Auckland DHB	Watercare Services Ltd	16,558	-37.191	174.9245	-	**1.3**	1/01/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
308	Waitemata DHB	Auckland DHB	Watercare Services Ltd	2,344	-36.977868	174.631798	-	**0.0**	1/01/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
309	Counties Manukau DHB	Auckland DHB	Watercare Services Ltd	82,895	-36.974143	174.788996	-	**1.3**	1/01/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
310	Counties Manukau DHB	Auckland DHB	Watercare Services Ltd	77,196	-37.025799	174.893065	-	**1.3**	1/01/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
311	Auckland DHB	Auckland DHB	Watercare Services Ltd	50,413	-36.891517	174.753917	-	**1.0**	1/01/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
312	Waitemata DHB	Auckland DHB	Watercare Services Ltd	4,315	-36.852049	174.768385	-	**0.0**	1/01/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
313	Auckland DHB	Auckland DHB	Watercare Services Ltd	31,006	-36.877004	174.787849	-	**1.3**	1/01/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
314	Waitemata DHB	Auckland DHB	Watercare Services Ltd	158,345	-36.7963	174.7676	-	**1.3**	1/01/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
315	Waitemata DHB	Auckland DHB	Watercare Services Ltd	82,199	-36.7711	174.7037	-	**1.0**	1/01/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data

							Current Nitrate Data							Historic Nitrate Data (ESR, 2019b)			
No.	District Health Board	Public Health Unit	Supply Owner	Supply Population	Northing	Easting	Current NO3-N (mg/L)	Current NO3 (mg/L)	Date of most recent sample	Data Source	Multiple samples 2018 2019?	Average of multiple sources?	Monthly Sampling?	Historic nitrate level (NO3-N mg/L)	Historic nitrate level (NO3 mg/L)	Date of most recent historic sample	Historic Supply Population
316	Auckland DHB	Auckland DHB	Watercare Services Ltd	25,507	-36.923222	174.785369	-	**3.0**	1/01/2018	Supplier	Yes	Yes	No	3.95	17.5	19/01/1999	12,000
317	Waitemata DHB	Auckland DHB	Watercare Services Ltd	1,028	-36.911158	174.621737	-	**0.7**	1/01/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
318	Counties Manukau DHB	Auckland DHB	Watercare Services Ltd	14,862	-36.941875	174.839185	-	**1.3**	1/01/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
319	Counties Manukau DHB	Auckland DHB	Watercare Services Ltd	63,800	-36.962285	174.875621	-	**1.3**	1/01/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
320	Counties Manukau DHB	Auckland DHB	Watercare Services Ltd	470	-37.187433	174.828336	-	**1.3**	1/01/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
321	Waitemata DHB	Auckland DHB	Watercare Services Ltd	5,789	-36.866026	174.580245	-	**0.7**	1/01/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
322	Waitemata DHB	Auckland DHB	Watercare Services Ltd	851	-36.8709	174.5469	-	**0.7**	1/01/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
323	Waitemata DHB	Auckland DHB	Watercare Services Ltd	8,851	-36.792116	174.618724	-	**0.7**	1/01/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
324	Counties Manukau DHB	Auckland DHB	Watercare Services Ltd	609	-37.185476	174.996666	-	**2.0**	1/01/2018	Supplier	Yes	Yes	Yes	No data	No data	No data	No data
325	Counties Manukau DHB	Auckland DHB	Veolia Water, Papakura	352	-36.535739	174.502336	-	**1.6**	1/01/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
326	Waitemata DHB	Auckland DHB	Watercare Services Ltd	4,579	-36.677951	174.450388	-	**0.1**	1/01/2018	Supplier	Yes	Yes	Yes	0.0745	0.3	25/03/1998	2,200
327	Waitemata DHB	Auckland DHB	Watercare Services Ltd	597	-37.00169	174.564064	-	**0.1**	1/01/2018	Supplier	Yes	Yes	No	0.075	0.3	21/05/1997	460
328	Waitemata DHB	Auckland DHB	Watercare Services Ltd	563	-36.836397	174.429906	-	**0.7**	1/01/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
329	Counties Manukau DHB	Auckland DHB	Veolia Water, Papakura	48,513	-37.062452	174.942133	-	**1.6**	1/01/2018	Supplier	Yes	Yes	No	0.125	0.6	26/03/1998	26,800
330	Waitemata DHB	Auckland DHB	Watercare Services Ltd	4,664	-36.419824	174.727786	-	**0.0**	1/01/2018	Supplier	Yes	Yes	No	0.05	0.2	19/03/1998	4,020
331	Counties Manukau DHB	Auckland DHB	Watercare Services Ltd	8,697	-37.2615	174.7399	-	**0.0**	1/01/2018	Supplier	Yes	Yes	No	No data	No data	No data	No data
332	Waitemata DHB	Auckland DHB	Watercare Services Ltd	4,111	-36.399031	174.660381	-	**0.2**	1/01/2018	Supplier	Yes	Yes	Yes	0.36	1.6	10/11/1999	3,120
333	Waitemata DHB	Auckland DHB	Watercare Services Ltd	2,114	-36.294398	174.523853	-	**0.3**	1/01/2018	Supplier	Yes	Yes	Yes	0.78	3.5	16/06/1999	2,190
334	Waikato DHB	Waikato DHB	Hamilton City Council	169,325	-37.785562	175.27782	0.47	**2.1**	1/01/2019	Supplier	Yes	No	No	0.22	1.0	7/09/1999	117,100
335	Bay of Plenty DHB	Toi Te Ora DHB	Tauranga City Council	52,000	-37.673456	176.235255	0.46	**2.0**	4/12/2019	Supplier	Yes	Yes	No	0.57	2.5	15/06/1999	No data?
336	Bay of Plenty DHB	Toi Te Ora DHB	Tauranga City Council	51,783	-37.699517	176.117775	0.96	**4.3**	4/12/2019	Supplier	Yes	Yes	No	0.93	4.1	11/06/1999	No data?
337	Canterbury DHB	Community and Public	Selwyn District Council	350	-42.939324	171.561824	0.03	**0.1**	5/03/2019	Supplier	No	No	No	No data	No data	No data	No data
338	Canterbury DHB	Community and Public	Selwyn District Council	299	-43.210025	171.715338	0.03	**0.1**	5/03/2019	Supplier	No	No	No	No data	No data	No data	No data
339	Canterbury DHB	Community and Public	Selwyn District Council	170	-43.563892	172.469287	1.16	**5.1**	27/02/2019	Supplier	No	No	No	No data	No data	No data	No data
340	Canterbury DHB	Community and Public	Selwyn District Council	3,250	-43.489516	172.109747	5.00	**22.1**	5/03/2019	Supplier	No	No	No	0.35	1.5	31/03/1998	1,350
341	Canterbury DHB	Community and Public	Selwyn District Council	480	-43.660095	172.193398	6.50	**28.8**	26/02/2020	Supplier	No	No	No	3.8	16.8	11/10/2000	420
342	Canterbury DHB	Community and Public	Selwyn District Council	180	-43.525085	172.320736	5.70	**25.2**	26/02/2020	Supplier	No	No	No	No data	No data	No data	No data
344	Canterbury DHB	Community and Public	Selwyn District Council	50	-43.513252,	172.423924	2.70	**12.0**	5/03/2019	Supplier	No	No	No	No data	No data	No data	No data
345	Canterbury DHB	Community and Public	Selwyn District Council	1,207	-43.499895	172.214528	4.40	**19.5**	26/02/2020	Supplier	No	No	No	4.4	19.5	11/06/1996	300
346	Canterbury DHB	Community and Public	Selwyn District Council	148	-43.369096	171.532987	0.03	**0.1**	27/02/2020	Supplier	No	No	No	No data	No data	No data	No data
347	Canterbury DHB	Community and Public	Selwyn District Council	2,350	-43.761526	172.299699	0.82	**3.6**	6/03/2019	Supplier	Yes	Yes	No	0.5	2.2	3/04/1998	1,250
348	Canterbury DHB	Community and Public	Selwyn District Council	5,400	-43.640448	172.482711	1.42	**6.3**	6/03/2019	Supplier	Yes	Yes	No	0.9	4.0	4/12/1997	1,295
349	Canterbury DHB	Community and Public	Selwyn District Council	1,409	-43.461693	171.893519	0.61	**2.7**	26/02/2019	Supplier	No	No	No	No data	No data	No data	No data
350	Canterbury DHB	Community and Public	Selwyn District Council	183	-43.373943	171.990555	0.42	**1.9**	26/02/2019	Supplier	No	No	No	No data	No data	No data	No data
351	Canterbury DHB	Community and Public	Selwyn District Council	3,906	-43.581187	172.511968	0.59	**2.6**	6/03/2019	Supplier	Yes	Yes	No	0.4	1.8	8/10/1996	500
352	Canterbury DHB	Community and Public	Selwyn District Council	313	-43.886672	172.238016	0.73	**3.2**	6/03/2019	Supplier	No	No	No	No data	No data	No data	No data
353	Canterbury DHB	Community and Public	Selwyn District Council	35	-43.650543	172.385513	0.93	**4.1**	27/02/2020	Supplier	No	No	No	No data	No data	No data	No data
354	Canterbury DHB	Community and Public	Selwyn District Council	15,047	-43.59081	172.379123	3.15	**13.9**	8/03/2019	Supplier	Yes	Yes	No	0.94	4.2	5/05/1999	2,000
355	Canterbury DHB	Community and Public	Selwyn District Council	240			0.03	**0.1**	27/02/2020	Supplier	No	No	No	No data	No data	No data	No data
356	Canterbury DHB	Community and Public	Selwyn District Council	920	-43.481601	171.934257	1.00	**4.4**	27/02/2020	Supplier	No	No	No	No data	No data	No data	No data
357	Canterbury DHB	Community and Public	Selwyn District Council	585	-43.3897	172.020393	4.31	**19.1**	26/02/2019	Supplier	No	No	No	2.2	9.7	25/03/1997	384
358	Canterbury DHB	Community and Public	Selwyn District Council	992	-43.811837	172.252074	4.25	**18.8**	26/02/2019	Supplier	Yes	Yes	No	2	8.9	4/05/1999	610
359	Canterbury DHB	Community and Public	Selwyn District Council	520	-43.337183	171.926948	1.48	**6.6**	26/02/2019	Supplier	No	No	No	1.3	5.8	20/06/1996	105
360	Canterbury DHB	Community and Public	Selwyn District Council	510	-43.643281	172.426511	1.80	**8.0**	26/02/2019	Supplier	No	No	No	4.4	19.5	11/06/1996	424
361	Canterbury DHB	Community and Public	Selwyn District Council	606	-43.661563	172.548067	0.25	**1.1**	26/02/2019	Supplier	No	No	No	0.2	0.9	8/10/1996	297
362	Canterbury DHB	Community and Public	Selwyn District Council	25	-43.853633	172.357497	1.16	**5.1**	27/02/2019	Supplier	No	No	No	No data	No data	No data	No data
363	Canterbury DHB	Community and Public	Selwyn District Council	30	-43.634646	171.894178	4.13	**18.3**	6/03/2019	Supplier	No	No	No	No data	No data	No data	No data
364	Canterbury DHB	Community and Public	Selwyn District Council	80	-43.738671	172.442957	0.23	**1.0**	27/02/2019	Supplier	No	No	No	No data	No data	No data	No data
365	Canterbury DHB	Community and Public	Selwyn District Council	1,800	-43.52207	172.368677	2.27	**10.0**	26/02/2019	Supplier	Yes	Yes	No	2.2	9.7	8/10/1996	200
366	MidCentral DHB	MidCentral DHB	Manuwatu District Council	15,419	-40.226381	175.567217	0.08	**0.4**	5/07/2017	Supplier	Yes	Yes	No	0.075	0.3	21/02/1997	13,000
367	MidCentral DHB	MidCentral DHB	Manuwatu District Council	462	-40.220141	175.424129	1.06	**4.7**	5/07/2017	Supplier	No	No	No	No data	No data	No data	No data
368	MidCentral DHB	MidCentral DHB	Manuwatu District Council	163	-40.292577	175.425416	0.01	**0.0**	5/07/2017	Supplier	No	No	No	No data	No data	No data	No data
369	MidCentral DHB	MidCentral DHB	Manuwatu District Council	423	-40.371582	175.235016	0.27	**1.2**	5/07/2017	Supplier	No	No	No	No data	No data	No data	No data
370	MidCentral DHB	MidCentral DHB	Manuwatu District Council	328	-40.143389	175.494761	0.20	**0.9**	5/07/2017	Supplier	No	No	No	0.2	0.9	23/09/1996	475
371	MidCentral DHB	MidCentral DHB	Manuwatu District Council	226	-40.041539	175.637959	0.01	**0.0**	5/07/2017	Supplier	No	No	No	0.8	3.5	23/09/1996	200
372	Bay of Plenty DHB	Toi Te Ora DHB	Kawerau District Council	7,721	-38.087459	176.700746	1.31	**5.8**	1/01/2020	Supplier	Yes	Yes	No	0.4	1.8	3/03/1998	7,000
373	Southern DHB	Public Health South	Gore District Council	7,500	-46.098947	168.945928	4.22	**18.7**	29/07/2019	Supplier	Yes	Yes	No	4.5	19.9	31/03/1998	8,365
374	Southern DHB	Public Health South	Gore District Council	300	-45.960489	168.868165	2.03	**9.0**	6/01/2020	Supplier	Yes	No	No	1.05	4.6	8/04/1997	300
375	Hawke's Bay DHB	Hawke's Bay DHB	Wairoa District Council	350	-39.027251	177.41761	0.01	**0.0**	27/05/2019	Supplier	No	No	No	No data	No data	No data	No data
376	Hawke's Bay DHB	Hawke's Bay DHB	Wairoa District Council	4,300	-39.0369	177.430763	0.01	**0.0**	27/05/2019	Supplier	No	No	No	0.05	0.2	23/04/1998	4,300
377	Hawke's Bay DHB	Hawke's Bay DHB	Wairoa District Council	300	-38.811685	177.1477	0.09	**0.4**	27/05/2019	Supplier	No	No	No	No data	No data	No data	No data
378	Lakes DHB	Toi Te Ora DHB	Rotorua Lakes Council	42,500	-38.137978	176.251475	0.62	**2.7**	17/03/2015	Supplier	No	No	No	0.4	1.8	5/06/1997	42,500
379	Lakes DHB	Toi Te Ora DHB	Rotorua Lakes Council	10,330	-38.144214	176.284562	0.07	**0.3**	17/03/2015	Supplier	No	No	No	0.5	2.2	21/10/1997	8,200

							Current Nitrate Data							Historic Nitrate Data (ESR, 2019b)			
No.	District Health Board	Public Health Unit	Supply Owner	Supply Population	Northing	Easting	Current NO3-N (mg/L)	Current NO3 (mg/L)	Date of most recent sample	Data Source	Multiple samples 2018 2019?	Average of multiple sources?	Monthly Sampling?	Historic nitrate level (NO3-N mg/L)	Historic nitrate level (NO3 mg/L)	Date of most recent historic sample	Historic Supply Population
380	Lakes DHB	Toi Te Ora DHB	Rotorua Lakes Council	4,826	-38.080915	176.212512	1.58	**7.0**	18/03/2015	Supplier	No	No	No	1.25	5.5	12/03/1998	3,800
381	Lakes DHB	Toi Te Ora DHB	Rotorua Lakes Council	1,700	-38.033216	176.263405	0.76	**3.4**	18/03/2015	Supplier	No	No	No	0.6125	2.7	20/04/1999	1,250
382	Lakes DHB	Toi Te Ora DHB	Rotorua Lakes Council	868	-38.093945	176.080046	1.15	**5.1**	17/03/2015	Supplier	No	No	No	1.6	7.1	12/03/1998	550
383	Lakes DHB	Toi Te Ora DHB	Rotorua Lakes Council	880	-38.021015	176.348728	0.65	**2.9**	17/03/2015	Supplier	No	No	No	0.41	1.8	20/04/1999	920
384	Lakes DHB	Toi Te Ora DHB	Rotorua Lakes Council	340	-38.048768	176.560879	0.15	**0.7**	17/03/2015	Supplier	No	No	No	0.05	0.2	5/06/1997	400
385	Lakes DHB	Toi Te Ora DHB	Rotorua Lakes Council	1,060	-38.435995	176.340758	0.66	**2.9**	18/03/2015	Supplier	No	No	No	0.615	2.7	20/04/1999	No data?
386	Wairarapa DHB	Regional Public Health	Carteron District Council	5,230	-41.027264	175.52535	2.16	**9.6**	17/05/2019	Supplier	No	Yes	No	0.05	0.2	11/12/1997	4,200
387	MidCentral DHB	MidCentral DHB	Palmerston North City Council	350	-40.383653	175.543221	0.01	**0.0**	17/09/2019	Supplier	Yes	No	No	0.05	0.2	18/07/1996	240
388	MidCentral DHB	MidCentral DHB	Palmerston North City Council	493	-40.281649	175.629891	0.00	**0.0**	17/09/2019	Supplier	Yes	No	No	0.1	0.4	24/06/1996	450
389	MidCentral DHB	MidCentral DHB	Palmerston North City Council	2,800	-40.294659	175.753485	0.01	**0.0**	17/09/2019	Supplier	Yes	No	No	No data	No data	No data	No data
390	MidCentral DHB	MidCentral DHB	Palmerston North City Council	3,563	-40.367327	175.663513	0.05	**0.2**	17/09/2019	Supplier	Yes	No	No	No data	No data	No data	No data
391	MidCentral DHB	MidCentral DHB	Palmerston North City Council	450	-40.36506	175.617848	0.05	**0.2**	17/09/2019	Supplier	Yes	Yes	No	No data	No data	No data	No data
392	MidCentral DHB	MidCentral DHB	Palmerston North City Council	11,859	-40.328898	175.650967	0.02	**0.1**	17/09/2019	Supplier	Yes	Yes	No	No data	No data	No data	No data
393	MidCentral DHB	MidCentral DHB	Palmerston North City Council	56,412	-40.356063	175.610982	0.01	**0.0**	17/09/2019	Supplier	Yes	Yes	No	No Data	No Data	No Data	No Data
394	Northland DHB	Northland DHB	Far North District Council	4,200	-35.406103	173.802866	3.80	**16.8**	18/06/2018	Supplier	No	Yes	No	1.25	5.5	18/03/1998	4,000
395	Northland DHB	Northland DHB	Far North District Council	5,400	-35.117221	173.267425	0.05	**0.2**	26/07/2018	Supplier	No	Yes	No	0.05	0.2	23/04/1998	5,000
396	Northland DHB	Northland DHB	Far North District Council	3,500	-35.379891	174.065254	0.28	**1.2**	26/06/2018	Supplier	No	No	No	0.05	0.2	2/03/1998	1,500
397	Northland DHB	Northland DHB	Far North District Council	6,700	-35.227699	173.948741	0.30	**1.3**	18/04/2018	Supplier	Yes	Yes	No	0.075	0.3	19/03/1998	2,500
398	Northland DHB	Northland DHB	Far North District Council	800	-35.320164	173.770668	0.85	**3.7**	27/09/2018	Supplier	Yes	Yes	No	0.2	0.9	3/03/1997	500
399	Northland DHB	Northland DHB	Far North District Council	180	-35.454784	173.523504	0.04	**0.2**	24/05/2018	Supplier	No	No	No	No Data	No Data	No Data	No Data
400	Northland DHB	Northland DHB	Far North District Council	600	-35.40223	173.504116	0.04	**0.2**	24/05/2018	Supplier	No	No	No	No Data	No Data	No Data	No Data
401	Northland DHB	Northland DHB	Far North District Council	900	-35.5379	173.383299	0.07	**0.3**	30/07/2018	Supplier	No	Yes	No	No Data	No Data	No Data	No Data
402	Northland DHB	Northland DHB	Far North District Council	4,000	-35.280511	174.090673	0.20	**0.9**	7/03/2018	Supplier	No	No	No	0.2125	0.9	9/02/1999	2,000
403	Nelson Marlborough	Nelson Marlborough DHB	Nelson City Council	45,000	-41.273421	173.283966	0.07	**0.3**	10/06/2019	Supplier	Yes	Yes	No	No Data	No Data	No Data	No Data
404	West Coast DHB	Community and Public	Westland District Council	105	-42.673742	171.033469	0.13	**0.6**	31/07/2014	Supplier	No	No	No	No Data	No Data	No Data	No Data
405	West Coast DHB	Community and Public	Westland District Council	252	-43.464548	170.017803	0.08	**0.4**	12/11/2014	Supplier	No	No	No	No Data	No Data	No Data	No Data
406	West Coast DHB	Community and Public	Westland District Council	2,611	-43.387282	170.183367	0.11	**0.5**	8/05/2019	Supplier	No	No	No	No Data	No Data	No Data	No Data
407	West Coast DHB	Community and Public	Westland District Council	110	-43.881116	169.042441	0.06	**0.3**	12/11/2014	Supplier	No	No	No	No Data	No Data	No Data	No Data
408	West Coast DHB	Community and Public	Westland District Council	348	-43.148218	170.551496	0.60	**2.7**	7/02/2019	Supplier	No	No	No	No Data	No Data	No Data	No Data
409	West Coast DHB	Community and Public	Westland District Council	3,447	-42.715638	170.968105	0.05	**0.2**	14/03/2019	Supplier	No	Yes	No	No Data	No Data	No Data	No Data
410	West Coast DHB	Community and Public	Westland District Council	318	-42.631117	171.186872	0.34	**1.5**	31/07/2014	Supplier	No	No	No	No Data	No Data	No Data	No Data
411	West Coast DHB	Community and Public	Westland District Council	291	-42.897614	170.815814	0.07	**0.3**	6/08/2014	Supplier	No	No	No	No Data	No Data	No Data	No Data
412	West Coast DHB	Community and Public	Westland District Council	405	-43.261975	170.361054	2.70	**12.0**	29/01/2015	Supplier	No	No	No	No Data	No Data	No Data	No Data
413	Wairarapa DHB	Regional Public Health	Masterton District Council	19,000	-40.949771	175.661716	0.01	**0.1**	1/01/2019	Supplier	Yes	No	No	0.05	0.2	15/07/1997	19,000
414	MidCentral DHB	MidCentral DHB	Private Supplier	3,500	-40.402943	175.582914	0.00	**0.0**	1/05/2018	Supplier	Yes	Yes	No	No Data	No Data	No Data	No Data
415	MidCentral DHB	MidCentral DHB	Private Supplier	800	-40.198924	175.389204	0.03	**0.1**	28/09/2019	Supplier	Yes	Yes	No	0.025	0.1	8/05/2000	1,000
416	Canterbury DHB	Community and Public	Private Supplier	1,700	-43.612622	172.312654	8.85	**39.2**	7/01/2020	Supplier	Yes	Yes	No	No Data	No Data	No Data	No Data
417	Southern DHB	Public Health South	Private Supplier	260	-44.974686	169.244246	1.20	**5.3**	15/01/2020	Supplier	No	No	No	No Data	No Data	No Data	No Data
418	Southern DHB	Public Health South	Private Supplier	90	-45.068405	168.522099	0.45	**2.0**	19/02/2020	Supplier	No	No	No	No Data	No Data	No Data	No Data
419	MidCentral DHB	MidCentral DHB	Private Supplier	9,000	-40.386214	175.618781	0.00	**0.0**	14/11/2019	Supplier	Yes	Yes	No	No Data	No Data	No Data	No Data
420	Northland DHB	Northland DHB	Private Supplier	2,000	-34.988788	173.518752		**4.8**	1/11/2019	Supplier	Yes	Yes	No	No Data	No Data	No Data	No Data
421	Whanganui DHB	MidCentral DHB	Whanganui District Council	5,000	-39.901501	175.064382	0.51	**2.3**	2/11/2016	Supplier	No	No	No	No Data	No Data	No Data	No Data
422	Whanganui DHB	MidCentral DHB	Whanganui District Council	29,450	-39.933067	175.028639	0.10	**0.4**	2/11/2016	Supplier	No	Yes	No	0.15	0.7	11/02/1997	39,417
423	Whanganui DHB	MidCentral DHB	Whanganui District Council	5,000	-39.91719	175.063237	0.46	**2.0**	2/11/2016	Supplier	No	Yes	No	No Data	No Data	No Data	No Data
424	Whanganui DHB	MidCentral DHB	Whanganui District Council	350	-39.959616	175.201037	0.08	**0.4**	27/06/2011	Supplier	No	No	No	1	4.4	28/05/1996	350
425	Whanganui DHB	MidCentral DHB	Whanganui District Council	200	-39.821071	174.862218	4.00	**17.7**	26/07/2004	Supplier	No	No	No	1.4	6.2	28/05/1996	120
426	Tairawhiti DHB	Tairawhiti DHB	Gisborne City Council	30,600	-38.664092	178.022772	0.04	**0.2**	30/01/2020	Supplier	Yes	Yes	No	0.05	0.2	28/05/1997	30,000
427	Tairawhiti DHB	Tairawhiti DHB	Gisborne City Council	491	-38.468922	177.864336	0.12	**0.5**	22/01/2020	Supplier	Yes	No	No	0.025	0.1	2/03/2000	No Data
428	Tairawhiti DHB	Tairawhiti DHB	Gisborne City Council	200	-38.38252	177.83364	0.02	**0.1**	22/01/2020	Supplier	Yes	No	No	No Data	No Data	No Data	No Data
429	Lakes DHB	Toi Te Ora DHB	Taupo District Council	2,381	-38.704467	176.030445	0.01	**0.0**	2/07/2019	Supplier	Yes	No	No	0.025	0.1	13/05/1999	No Data
430	Lakes DHB	Toi Te Ora DHB	Taupo District Council	134	-38.392122	176.030493	1.38	**6.1**	4/07/2019	Supplier	Yes	No	No	0.55	2.4	5/06/1997	120
431	Lakes DHB	Toi Te Ora DHB	Taupo District Council	152	-38.719504	176.152651	1.51	**6.7**	4/07/2019	Supplier	Yes	No	No	0.7	3.1	4/06/1997	180
432	Lakes DHB	Toi Te Ora DHB	Taupo District Council	200	-38.6686	176.104418	0.01	**0.0**	2/07/2019	Supplier	Yes	No	No	1.75	7.7	4/06/1997	200
433	Lakes DHB	Toi Te Ora DHB	Taupo District Council	174	-38.853187	176.012509	0.06	**0.3**	2/07/2019	Supplier	Yes	No	No	0.05	0.2	9/06/1997	320
434	Lakes DHB	Toi Te Ora DHB	Taupo District Council	1,696	-38.662852	175.919571	0.03	**0.1**	2/07/2019	Supplier	Yes	No	No	0.05	0.2	5/06/1997	433
435	Lakes DHB	Toi Te Ora DHB	Taupo District Council	1,312	-38.370187	175.778121	2.45	**10.8**	4/07/2019	Supplier	Yes	No	No	1.5	6.6	26/11/1997	1,540
436	Lakes DHB	Toi Te Ora DHB	Taupo District Council	739	-38.932435	175.872652	0.01	**0.0**	5/07/2019	Supplier	Yes	No	No	0.05	0.2	6/04/1998	1,350
437	Lakes DHB	Toi Te Ora DHB	Taupo District Council	1,883	-38.90786	175.753855	0.01	**0.0**	5/07/2019	Supplier	Yes	No	No	0.05	0.2	2/04/1998	2,600
438	Lakes DHB	Toi Te Ora DHB	Taupo District Council	197	-38.592318	176.282351	0.87	**3.8**	5/07/2019	Supplier	Yes	No	No	No Data	No Data	No Data	No Data
439	Lakes DHB	Toi Te Ora DHB	Taupo District Council	23,810	-38.689338	176.068842	0.00	**0.0**	2/07/2019	Supplier	Yes	No	No	0.025	0.1	8/06/1999	No Data
440	Lakes DHB	Toi Te Ora DHB	Taupo District Council	327	-37.989725	177.349222	1.42	**6.3**	5/06/2019	Supplier	Yes	No	No	0.7	3.1	5/06/1997	220
441	Lakes DHB	Toi Te Ora DHB	Taupo District Council	3,938	-38.99003	175.808131	0.20	**0.9**	2/07/2019	Supplier	Yes	No	No	No Data	No Data	No Data	No Data
442	Lakes DHB	Toi Te Ora DHB	Taupo District Council	37	-38.762664	175.685619	0.10	**0.4**	2/07/2019	Supplier	Yes	No	No	No Data	No Data	No Data	No Data

							Current Nitrate Data							Historic Nitrate Data (ESR, 2019b)			
No.	District Health Board	Public Health Unit	Supply Owner	Supply Population	Northing	Easting	Current NO3-N (mg/L)	Current NO3 (mg/L)	Date of most recent sample	Data Source	Multiple samples 2018 2019?	Average of multiple sources?	Monthly Sampling?	Historic nitrate level (NO3-N mg/L)	Historic nitrate level (NO3 mg/L)	Date of most recent historic sample	Historic Supply Population
443	Lakes DHB	Toi Te Ora DHB	Taupo District Council	116	-38.424343	175.805869	1.91	**8.5**	4/07/2019	Supplier	Yes	No	No	1.4	6.2	5/07/1997	180
444	Lakes DHB	Toi Te Ora DHB	Taupo District Council	87	-38.734613	176.00899	0.01	**0.0**	5/07/2019	Supplier	Yes	No	No	0.05	0.2	9/06/1997	120
445	Lakes DHB	Toi Te Ora DHB	Taupo District Council	313	-38.859699	175.778681	1.82	**8.1**	2/07/2019	Supplier	Yes	No	No	2.3	10.2	18/06/1997	420
446	Northland DHB	Northland DHB	Whangarei District Council	56,530	-35.725019	174.322691	1.87	**8.3**	6/11/2019	Supplier	Yes	Yes	No	0.4	1.8	13/02/1997	48,000
447	Northland DHB	Northland DHB	Whangarei District Council	14,800	-35.880301	174.467078	0.31	**1.4**	12/11/2019	Supplier	Yes	Yes	No	0.15	0.7	23/02/1998	5,900
448	Northland DHB	Northland DHB	Whangarei District Council	92	-35.845889	174.289112	0.18	**0.8**	1/11/2019	Supplier	No	No	No	No Data	No Data	No Data	No Data
449	Northland DHB	Northland DHB	Whangarei District Council	200	-35.843978	174.204136	3.75	**16.6**	13/11/2019	Supplier	Yes	Yes	No	No Data	No Data	No Data	No Data
450	Bay of Plenty DHB	Toi Te Ora DHB	Opotiki District Council	4,530	-38.004231	177.28714	1.41	**6.2**	2/09/2010	Regional	No	Yes	No	No data	No data	No data	No data
451	Bay of Plenty DHB	Toi Te Ora DHB	Whakatane District Council	25	-37.856529	176.662288	6.10	**27.0**	1/09/2013	Supplier	No	No	No	No data	No data	No data	No data
452	Hawke's Bay DHB	Hawke's Bay DHB	Central Hawkes Bay District	50	-39.945406	176.928042	0.77	**3.4**	31/10/2019	Supplier	Yes	No	No	No data	No data	No data	No data
453	Southern DHB	Public Health South	Private Supplier	25	-45.043686	168.596185	0.03	**0.1**	23/10/2018	Supplier	No	No	No	No Data	No Data	No Data	No Data

APPENDIX F

Examples of nitrate data received from drinking water suppliers

1. *Example laboratory sheets from Westland District Council*
2. *Example data available online from Selwyn District Council*
3. *Example results summary received from Ashburton District Council*

Hill Laboratories
TRIED, TESTED AND TRUSTED

R J Hill Laboratories Limited
28 Duke Street Frankton 3204
Private Bag 3205
Hamilton 3240 New Zealand

T 0508 HILL LAB (44 555 22)
T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

Certificate of Analysis

Client:	Westland District Council	**Lab No:**	2142735	SPv1
Contact:	P Cannell	**Date Received:**	15-Mar-2019	
	C/- Westland District Council	**Date Reported:**	26-Mar-2019	
	Private Bag 704	**Quote No:**	95129	
	Hokitika 7842	**Order No:**	107788	
		Client Reference:	Hoki P2	
		Submitted By:	P Cannell	

Sample Type: Drinking Water for DWSNZ Compliance

		Sample Name:	HOK001HO - 140319 14-Mar-2019 12:00 pm				
		Lab Number:	2142735.1				
Individual Tests							
Total Antimony	g/m³		< 0.00021	-	-	-	-
Total Arsenic	g/m³		< 0.0011	-	-	-	-
Total Barium	g/m³		< 0.0053	-	-	-	-
Total Cadmium	g/m³		< 0.000053	-	-	-	-
Total Chromium	g/m³		0.00071	-	-	-	-
Total Copper	g/m³		0.21	-	-	-	-
Total Lead	g/m³		0.00022	-	-	-	-
Total Manganese	g/m³		0.00082	-	-	-	-
Total Mercury	g/m³		< 0.00008	-	-	-	-
Total Nickel	g/m³		< 0.00053	-	-	-	-
Total Selenium	g/m³		< 0.0011	-	-	-	-
Chlorate	g/m³		< 0.005	-	-	-	-
Nitrite-N	g/m³		< 0.002	-	-	-	-
Nitrate-N	g/m³		0.051	-	-	-	-
Nitrate-N + Nitrite-N	g/m³		0.052	-	-	-	-
Nitrate	g/m³		0.2	-	-	-	-
Halogenated Volatile Disinfection By-Products in Water - GCMS							
Bromochloroacetonitrile	g/m³		< 0.0002	-	-	-	-
Bromodichloromethane	g/m³		0.0032	-	-	-	-
Bromoform (tribromomethane)	g/m³		< 0.00007	-	-	-	-
Carbon tetrachloride	g/m³		< 0.0007	-	-	-	-
Chloroform (Trichloromethane)	g/m³		0.032	-	-	-	-
Chloropicrin	g/m³		< 0.0003	-	-	-	-
1,2-Dibromo-3-chloropropane	g/m³		< 0.0003	-	-	-	-
Dibromoacetonitrile	g/m³		< 0.0003	-	-	-	-
Dibromochloromethane	g/m³		0.00014	-	-	-	-
1,2-Dibromoethane (ethylene dibromide, EDB)	g/m³		< 0.0003	-	-	-	-
1,1-Dichloro-2-propanone	g/m³		0.0007	-	-	-	-
Dichloroacetonitrile	g/m³		0.0011	-	-	-	-
Tetrachloroethene (tetrachloroethylene)	g/m³		< 0.0007	-	-	-	-
1,1,1-Trichloro-2-propanone	g/m³		0.0028	-	-	-	-
Trichloroacetonitrile	g/m³		< 0.0003	-	-	-	-
1,1,1-Trichloroethane	g/m³		< 0.0002	-	-	-	-
Trichloroethene (trichloroethylene)	g/m³		< 0.0004	-	-	-	-
Total Trihalomethanes (THM)	g/m³		0.035	-	-	-	-
Chloroform:MAV ratio			0.081	-	-	-	-

2019 Chemical tests results	Sample Name:	MAV & GUIDELINE VALUES (*)	Arthurs Pass Source - School Terrace S00577 05-Mar-2019 12:14 pm	Castle Hill Source S00579 05-Mar-2019 11:03 am	Dalethorpe Source - Dalethorpe Road S00827 05-Mar-2019 9:57 am	Darfield Source - SH 73 Bore 1 G01961 05-Mar-2019 9:08 am	Jowers Road Source - Jowers Road G00671 05-Mar-2019 3:18 pm	West Melton Source - Elizabeth Allen G01957 05-Mar-2019 2:42 pm	Acheron Source - Acheron Station S00580 27-Feb-2019 1:52 pm	Claremont Source - Devine Drive G01673 27-Feb-2019 8:07 am	Lake Coleridge Source - Treatment Shed S00578 27-Feb-2019 1:16 pm	Raven Drive Source - Raven Drive G01314 27-Feb-2019 9:25 am	Taumutu Source - Taumutu Village G00680 27-Feb-2019 11:00 am	Upper Selwyn Huts Source - Main Bore G01315 27-Feb-2019 9:55 am
	Lab Number:		2136152.1	2136152.2	2136152.3	2136152.4	2136152.5	2136152.6	2132538.1	2132538.2	2132538.3	2132538.4	2132538.5	2132538.6
Total Arsenic	**g/m3**	**0.01**	< 0.0011	< 0.0011	< 0.0011	< 0.0011	< 0.0011	< 0.0011	< 0.0011	< 0.0011	< 0.0011	< 0.0011	< 0.0011	< 0.0011
Total Cadmium	**g/m3**	**0.004**	< 0.000053	< 0.000053	< 0.000053	< 0.000053	< 0.000053	< 0.000053	< 0.000053	< 0.000053	< 0.000053	< 0.000053	< 0.000053	< 0.000053
Total Chromium	**g/m3**	**0.05**	0.00067	< 0.00053	0.00064	0.00086	0.00088	0.0007	0.00094	0.00113	0.00119	0.00108	0.00097	0.00063
Total Lead	**g/m3**	**0.01**	0.00021	< 0.00011	0.00022	0.00017	< 0.00011	< 0.00011	0.00017	< 0.00011	0.00034	0.00024	< 0.00011	< 0.00011
Total Nickel	**g/m3**	**0.08**	< 0.00053	< 0.00053	0.0035	< 0.00053	< 0.00053	< 0.00053	< 0.00053	< 0.00053	< 0.00053	< 0.00053	< 0.00053	< 0.00053
pH	**pH Units**	**7.0 - 8.5**	7.8	7.4	7.1	7.7	7.5	7.6	7.7	7.7	7.6	7.9	7.7	7.9
Total Alkalinity	**g/m3 as CaCO3**	**n/v**	47	26	39	46	57	43	35	38	27	57	36	77
Free Carbon Dioxide	**g/m3 at 25°C**	**n/v**	1.4	1.9	6.2	1.9	3.6	2.4	1.4	1.4	1.3	1.5	1.3	1.8
Total Hardness	**g/m3 as CaCO3**	**<200**	50	26	37	56	69	52	33	40	26	52	38	64
Electrical Conductivity (EC)	**mS/m**	**n/v**	11.2	6.2	9.9	16.2	17	13.3	7.3	10.6	6.1	14.9	10.5	18
Electrical Conductivity (EC)	**µS/cm**	**n/v**	112	62	99	162	170	133	73	106	61	149	105	180
Approx Total Dissolved Salts	**g/m3**	**<1000**	75	42	66	109	114	89	49	71	41	100	70	121
Total Boron	**g/m3**	**1.4**	< 0.0053	0.0138	0.048	0.023	0.022	0.023	0.0077	0.0197	0.0188	0.022	0.0192	0.02
Total Calcium	**g/m3**	**n/v**	18.8	8.8	9.7	19.2	23	17.3	11.3	13.7	9.2	17.1	11.7	19.5
Total Copper	**g/m3**	**2**	< 0.00053	< 0.00053	0.00164	0.00192	0.00119	< 0.00053	0.00078	< 0.00053	0.00119	0.00054	< 0.00053	< 0.00053
Total Iron	**g/m3**	**<0.2**	< 0.021	< 0.021	< 0.021	< 0.021	< 0.021	< 0.021	< 0.021	< 0.021	< 0.021	0.056	< 0.021	< 0.021
Total Magnesium	**g/m3**	**n/v**	0.76	0.93	3	1.98	2.9	2.2	1.27	1.33	0.71	2.3	2	3.7
Total Manganese	**g/m3**	**0.4**	0.00072	< 0.00053	< 0.00053	< 0.00053	< 0.00053	< 0.00053	0.00096	< 0.00053	0.00075	0.00112	< 0.00053	< 0.00053
Total Potassium	**g/m3**	**n/v**	0.4	0.36	0.51	0.9	1.01	0.92	0.24	0.77	0.4	0.86	0.85	0.98
Total Sodium	**g/m3**	**<200**	2.3	2.9	6.1	9.7	6.6	5.9	1.9	5.5	2	9.3	5.8	12.2
Total Zinc	**g/m3**	**<1.5**	0.028	0.0113	0.0015	0.0092	0.0032	0.0039	0.0022	0.0125	0.0067	0.023	0.0012	0.0028
Chloride	**g/m3**	**<250**	< 0.5	< 0.5	4.7	7.9	6.6	4.2	0.8	4.1	0.6	8.2	5	7.8
Nitrate-N	**g/m3**	**11.3**	< 0.05	< 0.05	0.42	5	2.7	2.2	< 0.05	1.16	< 0.05	0.93	1.16	0.23
Sulphate	**g/m3**	**<250**	7.8	3.6	2.2	1	6.4	5.8	2.1	3.1	3.8	1.7	1.9	2.2

Supply Name	Mt Somers	
Population Served	260	
Supply Code	MTS001	
Source Names	Woolshed Creek	Acland Bore
Source Codes	S00219	G02190
GPS coordinates of source	NZTM 1466722.03 easting	NZTM 166839.68 easting
	5162060.44 northing	5162028.03 northing
Treatment Plant Names	Mt Somers Plant	
Treatment Plant Codes	TP00329	
Treatment for Nitrate	No	
Distribution Zone Name	Mt Somers	
Distribution Zone Code	MTS001MS	
Multiple Zone	No	

Notes Acland Bore is an emergency source that is only used during dry summers when water levels in Woolshed Creek get to low

Nitrate Sampling Results by location

Oldest to most recent
All results are Nitrate-N

Source Samples Woolshed Creek		Source Samples Acland Bore		Treatment Plant Samples Mt Somers Plant		Distribution Zone Samples MTS001MS	
Date & Time	Nitrate-N (mg/L)	Date & Time	Nitrate-N (mg/L)	Date & Time	Nitrate-N (mg/L)	Date & Time	Nitrate-N (mg/L)
7/01/2015	0.819	14/09/2017	0.88	3/12/2012	0.882	14/09/2012	0.900
14/01/2016	0.450	18/01/2018	0.67	3/01/2013	0.995		
12/01/2017	0.560	7/01/2019	0.67	7/05/2013	0.452		
11/01/2018	0.440	9/01/2020	0.69	6/06/2013	0.679		
7/01/2019	1.010			2/09/2013	0.948		
22/07/2019	0.940			2/10/2013	0.681		
31/07/2019	0.780			6/11/2013	1.011		
14/08/2019	0.900			10/12/2013	0.778		
19/08/2019	1.030			9/01/2014	0.588		
26/08/2019	1.020			4/02/2014	0.670		
5/09/2019	1.020			6/03/2014	0.744		
19/09/2019	0.650			7/04/2014	0.622		
26/09/2019	0.840			30/04/2014	0.593		
2/10/2019	0.580			3/06/2014	0.939		
14/10/2019	0.360			14/07/2014	1.143		
21/10/2019	0.510			7/08/2014	0.900		
6/01/2020	0.700			18/09/2014	0.916		
				9/10/2014	0.882		
				27/11/2014	0.808		
				11/12/2014	1.011		
				15/01/2015	0.853		
				26/02/2015	0.686		
				30/03/2015	0.326		
				21/04/2015	0.328		
				21/05/2015	0.489		
				18/06/2015	0.493		
				10/08/2015	0.514		
				10/09/2015	0.740		
				15/10/2015	0.679		
				9/11/2015	0.520		
				10/12/2015	0.654		
				18/01/2016	0.294		
				11/02/2016	0.317		
				14/03/2016	0.724		
				18/04/2016	0.452		
				16/05/2016	0.724		
				13/06/2016	0.339		
				7/07/2016	0.498		
				1/08/2016	0.588		
				15/09/2016	0.656		
				4/10/2016	0.563		
				9/11/2016	0.344		
				1/12/2016	0.631		
				4/01/2017	0.581		
				7/02/2017	0.631		
				6/03/2017	0.753		
				3/04/2017	0.360		
				1/05/2017	0.756		
				8/06/2017	0.710		
				3/07/2017	0.633		
				8/08/2017	0.980		
				7/09/2017	0.634		
				5/10/2017	0.774		
				2/11/2017	0.925		
				7/12/2017	1.093		
				18/01/2018	0.360		
				15/02/2018	0.491		
				5/03/2018	0.658		
				16/04/2018	0.679		
				7/05/2018	0.588		
				5/06/2018	1.154		
				5/07/2018	1.176		
				1/08/2018	1.131		
				6/09/2018	0.588		
				11/10/2018	0.792		
				12/11/2018	0.385		
				17/12/2018	0.602		
				23/01/2019	1.199		
				19/02/2019	1.244		
				21/03/2019	0.905		
				15/04/2019	0.430		
				13/05/2019	0.679		
				20/06/2019	0.656		
				4/07/2019	0.920		
				5/08/2019	0.820		
				9/09/2019	0.740		
				7/10/2019	0.560		
				11/11/2019	0.840		
				2/12/2019	0.840		
				13/01/2020	0.860		

APPENDIX G

Nitrate data from Regional Councils

No.	Public Health Unit	Bore or Supply Name	Estimated Population Served	Source Type	Northing	Easting	Current nitrate level (NO3-N mg/L)	Current nitrate level (NO3 mg/L)	Date of most recent sample	Data Source
1	Public Health South	**E45/0110**	3	Private Bore	1230494	4884830	0.00	**0.00**	28/11/2018	Environment Southland
2	Public Health South	**E45/0034**	3	Private Bore	1239005	4886808	0.00	**0.01**	17/09/2019	Environment Southland
3	Public Health South	**E46/0384**	25	Private Bore	1254123	4851601	0.00	**0.01**	29/08/2019	Environment Southland
4	Public Health South	**E45/0775**	3	Private Bore	1241070	4895161	0.01	**0.04**	31/07/2018	Environment Southland
5	Public Health South	**F46/1156**	3	Private Bore	1267618	4859852	0.01	**0.04**	21/11/2018	Environment Southland
6	Public Health South	**F47/0337**	3	Private Bore	1267161	4842475	0.01	**0.04**	1/04/2019	Environment Southland
7	Public Health South	**D45/0276**	3	Private Bore	1189059	4890403	0.02	**0.07**	18/06/2019	Environment Southland
8	Public Health South	**E46/1356**	3	Private Bore	1240668	4852649	0.02	**0.09**	9/02/2018	Environment Southland
9	Public Health South	**F44/0468**	3	Private Bore	1294121	4909689	0.04	**0.18**	23/01/2018	Environment Southland
10	Public Health South	**F46/1112**	3	Private Bore	1288896	4861239	0.10	**0.44**	6/03/2018	Environment Southland
11	Public Health South	**E44/0485**	3	Private Bore	1238712	4912176	0.13	**0.60**	27/11/2018	Environment Southland
12	Public Health South	**F46/0941**	3	Private Bore	1276035	4869698	0.14	**0.64**	25/05/2018	Environment Southland
13	Public Health South	**F46/1099**	3	Private Bore	1267654	4872039	0.15	**0.66**	19/01/2018	Environment Southland
14	Public Health South	**E47/0343**	3	Private Bore	1247726	4836695	0.16	**0.71**	19/02/2019	Environment Southland
15	Public Health South	**E46/1434**	3	Private Bore	1233872	4859814	0.18	**0.80**	9/01/2019	Environment Southland
16	Public Health South	**F43/0042**	3	Private Bore	1283070	4938957	0.25	**1.11**	7/02/2018	Environment Southland
17	Public Health South	**F44/0496**	3	Private Bore	1262431	4925582	0.31	**1.37**	15/05/2019	Environment Southland
18	Public Health South	**D43/0159**	3	Private Bore	1193727	4957301	0.35	**1.55**	7/05/2018	Environment Southland
19	Public Health South	**F46/1149**	3	Private Bore	1263086	4866292	0.41	**1.81**	22/02/2019	Environment Southland
20	Public Health South	**E48/0001**	25	Private Bore	1228863	4794498	0.63	**2.79**	27/09/2018	Environment Southland
21	Public Health South	**D43/0067**	25	Private Bore	1181785	4943864	0.78	**3.44**	19/09/2019	Environment Southland
22	Public Health South	**E46/1316**	3	Private Bore	1248042	4852680	0.78	**3.45**	28/06/2018	Environment Southland
23	Public Health South	**E48/0013**	25	Private Bore	1228878	4794461	1.00	**4.43**	8/02/2019	Environment Southland
24	Public Health South	**F45/0555**	25	Private Bore	1286378	4888564	1.25	**5.53**	30/07/2018	Environment Southland
25	Public Health South	**E48/0011**	25	Private Bore	1228916	4794520	1.27	**5.62**	7/02/2019	Environment Southland
26	Public Health South	**F45/0806**	25	Private Bore	1286450	4888564	1.40	**6.18**	2/10/2019	Environment Southland
27	Public Health South	**E48/0004**	3	Private Bore	1229027	4794478	1.41	**6.24**	7/02/2019	Environment Southland
28	Public Health South	**E48/0012**	3	Private Bore	1228963	4794498	1.56	**6.91**	7/02/2019	Environment Southland
29	Public Health South	**F44/0114**	3	Private Bore	1270296	4910537	1.65	**7.28**	16/11/2018	Environment Southland
30	Public Health South	**E46/0094**	3	Private Bore	1228599	4862361	1.76	**7.81**	18/09/2019	Environment Southland
31	Public Health South	**D45/0467**	25	Private Bore	1213443	4878959	1.83	**8.10**	17/05/2019	Environment Southland
32	Public Health South	**F44/0093**	3	Private Bore	1273394	4920859	1.90	**8.41**	14/11/2018	Environment Southland
33	Public Health South	**F45/0398**	25	Private Bore	1286408	4888536	2.00	**8.85**	8/01/2019	Environment Southland
34	Public Health South	**E48/0014**	25	Private Bore	1228663	4794497	2.15	**9.52**	8/02/2019	Environment Southland
35	Public Health South	**F45/0350**	3	Private Bore	1274536	4900153	2.15	**9.52**	16/09/2019	Environment Southland
36	Public Health South	**E46/1457**	3	Private Bore	1235572	4851275	2.16	**9.56**	26/04/2019	Environment Southland
37	Public Health South	**E48/0015**	3	Private Bore	1228945	4794274	2.40	**10.62**	27/09/2018	Environment Southland
38	Public Health South	**D46/0025**	3	Private Bore	1219672	4860213	2.44	**10.80**	2/11/2018	Environment Southland
39	Public Health South	**E46/0311**	3	Private Bore	1258160	4857576	2.54	**11.24**	14/11/2018	Environment Southland
40	Public Health South	**D43/0004**	25	Private Bore	1201474	4943792	2.57	**11.36**	18/09/2019	Environment Southland
41	Public Health South	**D45/0468**	25	Private Bore	1213439	4878955	2.58	**11.42**	16/05/2019	Environment Southland
42	Public Health South	**E48/0019**	25	Private Bore	1228867	4794653	2.60	**11.51**	27/09/2018	Environment Southland

No.	Public Health Unit	Bore or Supply Name	Estimated Population Served	Source Type	Northing	Easting	Current nitrate level (NO3-N mg/L)	Current nitrate level (NO3 mg/L)	Date of most recent sample	Data Source
43	Public Health South	**E45/0782**	3	Private Bore	1230162	4878795	2.63	**11.64**	5/09/2018	Environment Southland
44	Public Health South	**E44/0655**	3	Private Bore	1231377	4933682	2.82	**12.48**	19/01/2018	Environment Southland
45	Public Health South	**E45/0622**	3	Private Bore	1225067	4888309	3.24	**14.34**	28/11/2018	Environment Southland
46	Public Health South	**E45/0790**	3	Private Bore	1235076	4881282	3.24	**14.34**	14/12/2018	Environment Southland
47	Public Health South	**E46/1444**	3	Private Bore	1226007	4858910	3.29	**14.56**	22/01/2019	Environment Southland
48	Public Health South	**E46/1374**	3	Private Bore	1240287	4856534	3.78	**16.73**	7/03/2018	Environment Southland
49	Public Health South	**E43/0026**	3	Private Bore	1254275	4950935	3.83	**16.95**	19/03/2019	Environment Southland
50	Public Health South	**D46/0261**	3	Private Bore	1209938	4860071	4.13	**18.28**	29/01/2019	Environment Southland
51	Public Health South	**F44/0022**	3	Private Bore	1275535	4910333	4.30	**19.03**	6/04/2018	Environment Southland
52	Public Health South	**F45/0168**	3	Private Bore	1286764	4890718	4.60	**20.36**	18/09/2019	Environment Southland
53	Public Health South	**E46/0867**	3	Private Bore	1239977	4857616	4.83	**21.40**	19/09/2019	Environment Southland
54	Public Health South	**E46/0093**	25	Private Bore	1225514	4877667	4.90	**21.69**	3/10/2018	Environment Southland
55	Public Health South	**E46/1463**	3	Private Bore	1250338	4856696	5.16	**22.84**	28/05/2019	Environment Southland
56	Public Health South	**F45/0463**	25	Private Bore	1285995	4890305	5.35	**23.68**	17/12/2018	Environment Southland
57	Public Health South	**E46/1341**	3	Private Bore	1251216	4864649	5.45	**24.13**	16/01/2018	Environment Southland
58	Public Health South	**E46/0097**	25	Private Bore	1245466	4856832	5.45	**24.13**	20/06/2019	Environment Southland
59	Public Health South	**D43/0065**	3	Private Bore	1207190	4947103	5.55	**24.57**	23/11/2018	Environment Southland
60	Public Health South	**F46/0184**	3	Private Bore	1278799	4862676	5.74	**25.42**	18/09/2019	Environment Southland
61	Public Health South	**F45/0811**	3	Private Bore	1272927	4904651	5.75	**25.45**	25/02/2019	Environment Southland
62	Public Health South	**F45/0795**	25	Private Bore	1285986	4890367	5.90	**26.12**	16/09/2019	Environment Southland
63	Public Health South	**E44/0008**	3	Private Bore	1259779	4912629	5.95	**26.34**	17/09/2019	Environment Southland
64	Public Health South	**E46/0099**	3	Private Bore	1240259	4868382	6.06	**26.84**	18/09/2019	Environment Southland
65	Public Health South	**F44/0484**	25	Private Bore	1276884	4928237	6.10	**27.00**	2/10/2018	Environment Southland
66	Public Health South	**D43/0064**	3	Private Bore	1206567	4946155	6.70	**29.66**	23/11/2018	Environment Southland
67	Public Health South	**D43/0158**	3	Private Bore	1196265	4958245	7.07	**31.30**	4/05/2018	Environment Southland
68	Public Health South	**E44/0007**	3	Private Bore	1244871	4919019	7.31	**32.38**	17/09/2019	Environment Southland
69	Public Health South	**F46/1159**	3	Private Bore	1275160	4855670	7.53	**33.33**	19/06/2019	Environment Southland
70	Public Health South	**F46/1127**	3	Private Bore	1261733	4862460	7.89	**34.93**	20/04/2018	Environment Southland
71	Public Health South	**E45/0241**	3	Private Bore	1222673	4886991	8.30	**36.74**	28/11/2018	Environment Southland
72	Public Health South	**E46/0092**	3	Private Bore	1221489	4873831	8.39	**37.12**	18/09/2019	Environment Southland
73	Public Health South	**F45/0792**	25	Private Bore	1269403	4908102	8.80	**38.95**	2/10/2018	Environment Southland
74	Public Health South	**E44/0173**	3	Private Bore	1242480	4935713	8.95	**39.62**	21/06/2018	Environment Southland
75	Public Health South	**E45/0055**	3	Private Bore	1235952	4881332	8.95	**39.62**	19/09/2018	Environment Southland
76	Public Health South	**E45/0329**	3	Private Bore	1221241	4905077	9.30	**41.17**	26/11/2018	Environment Southland
77	Public Health South	**F45/0167**	3	Private Bore	1272258	4903815	10.64	**47.11**	18/09/2019	Environment Southland
78	Public Health South	**E44/0014**	3	Private Bore	1235036	4934607	11.00	**48.69**	20/11/2018	Environment Southland
79	Public Health South	**F44/0018**	3	Private Bore	1268651	4924011	11.98	**53.01**	17/09/2019	Environment Southland
80	Public Health South	**E46/1005**	3	Private Bore	1258034	4861071	13.70	**60.65**	13/04/2018	Environment Southland
81	Public Health South	**E44/0036**	3	Private Bore	1254572	4911057	14.76	**65.34**	17/09/2019	Environment Southland
82	Public Health South	**E45/0011**	3	Private Bore	1231050	4879090	15.12	**66.92**	18/09/2019	Environment Southland
83	Public Health South	**F44/0139**	3	Private Bore	1268956	4920903	15.63	**69.17**	17/09/2019	Environment Southland
84	Public Health South	**F45/0343**	3	Private Bore	1281957	4899138	22.00	**97.39**	7/11/2018	Environment Southland

No.	Public Health Unit	Bore or Supply Name	Estimated Population Served	Source Type	Northing	Easting	Current nitrate level (NO3-N mg/L)	Current nitrate level (NO3 mg/L)	Date of most recent sample	Data Source
85	Community and Public Health	**J39/0009**	3	Private Bore	1458276	5072000	0.04	**0.17**	1/01/2018	Environment Canterbury
86	Community and Public Health	**K39/0033**	3	Private Bore	1460397	5087160	11.04	**48.85**	1/01/2018	Environment Canterbury
87	Community and Public Health	**M35/0132**	3	Private Bore	1555684	5199400	4.20	**18.57**	1/01/2018	Environment Canterbury
88	Community and Public Health	**J40/0011**	25	Private Bore	1451546	5045689	0.59	**2.61**	1/01/2018	Environment Canterbury
89	Community and Public Health	**J40/0106**	3	Private Bore	1452766	5029656	5.35	**23.68**	1/01/2018	Environment Canterbury
90	Community and Public Health	**J37/0033**	3	Private Bore	1424588	5121222	3.24	**14.34**	1/01/2018	Environment Canterbury
91	Community and Public Health	**N33/0200**	3	Private Bore	1595024	5266855	18.90	**83.66**	1/01/2018	Environment Canterbury
92	Community and Public Health	**N33/0205**	3	Private Bore	1590933	5265269	8.58	**37.98**	1/01/2018	Environment Canterbury
93	Community and Public Health	**BU24/0002**	3	Private Bore	1581037	5291074	3.77	**16.69**	1/01/2018	Environment Canterbury
94	Community and Public Health	**BX22/0115**	3	Private Bore	1517950	5177027	2.20	**9.74**	1/01/2018	Environment Canterbury
95	Community and Public Health	**BX22/0140**	3	Private Bore	1519059	5178738	0.98	**4.32**	1/01/2018	Environment Canterbury
96	Community and Public Health	**BX23/0854**	3	Private Bore	1548795	5168040	8.80	**38.95**	1/01/2018	Environment Canterbury
97	Community and Public Health	**BY20/0136**	3	Private Bore	1491492	5132196	7.30	**32.31**	1/01/2018	Environment Canterbury
98	Community and Public Health	**BY21/0167**	3	Private Bore	1495154	5134505	10.20	**45.15**	1/01/2018	Environment Canterbury
99	Community and Public Health	**BY21/0199**	3	Private Bore	1495059	5135861	18.20	**80.57**	1/01/2018	Environment Canterbury
100	Community and Public Health	**BY21/0228**	3	Private Bore	1494682	5122198	2.58	**11.42**	1/01/2018	Environment Canterbury
101	Community and Public Health	**BY21/0247**	3	Private Bore	1492353	5132895	7.40	**32.76**	1/01/2018	Environment Canterbury
102	Community and Public Health	**BY21/0306**	3	Private Bore	1494139	5139786	9.50	**42.05**	1/01/2018	Environment Canterbury
103	Community and Public Health	**BY22/0031**	3	Private Bore	1539081	5149879	8.62	**38.16**	1/01/2018	Environment Canterbury
104	Community and Public Health	**BY22/0045**	3	Private Bore	1537575	5145563	0.66	**2.90**	1/01/2018	Environment Canterbury
105	Community and Public Health	**BZ19/0238**	3	Private Bore	1462424	5093133	7.70	**34.09**	1/01/2018	Environment Canterbury
106	Community and Public Health	**BZ19/0240**	3	Private Bore	1461978	5091858	10.20	**45.15**	1/01/2018	Environment Canterbury
107	Community and Public Health	**CA19/0055**	3	Private Bore	1448509	5046561	0.35	**1.55**	1/01/2018	Environment Canterbury
108	Community and Public Health	**J38/0821**	3	Private Bore	1453443	5092999	0.00	**0.02**	1/01/2018	Environment Canterbury
109	Community and Public Health	**J38/0889**	3	Private Bore	1459822	5093954	0.20	**0.89**	1/01/2018	Environment Canterbury
110	Community and Public Health	**J39/0259**	3	Private Bore	1459386	5080404	0.05	**0.21**	1/01/2018	Environment Canterbury
111	Community and Public Health	**J39/0261**	3	Private Bore	1458495	5080102	3.80	**16.82**	1/01/2018	Environment Canterbury
112	Community and Public Health	**J39/0532**	3	Private Bore	1456247	5067982	0.15	**0.65**	1/01/2018	Environment Canterbury
113	Community and Public Health	**J40/0019**	3	Private Bore	1443630	5048785	0.03	**0.11**	1/01/2018	Environment Canterbury
114	Community and Public Health	**J40/1056**	3	Private Bore	1449816	5053306	5.71	**25.29**	1/01/2018	Environment Canterbury
115	Community and Public Health	**K36/0489**	3	Private Bore	1496322	5154884	8.55	**37.85**	1/01/2018	Environment Canterbury
116	Community and Public Health	**K37/0702**	3	Private Bore	1498545	5132239	0.06	**0.28**	1/01/2018	Environment Canterbury
117	Community and Public Health	**K37/1014**	3	Private Bore	1497246	5136987	4.30	**19.03**	1/01/2018	Environment Canterbury
118	Community and Public Health	**K37/1767**	3	Private Bore	1495841	5133469	15.70	**69.50**	1/01/2018	Environment Canterbury
119	Community and Public Health	**K37/1789**	3	Private Bore	1495156	5134510	21.00	**92.96**	1/01/2018	Environment Canterbury
120	Community and Public Health	**K37/1862**	3	Private Bore	1498353	5134836	4.50	**19.92**	1/01/2018	Environment Canterbury
121	Community and Public Health	**K37/2603**	3	Private Bore	1491330	5138244	10.91	**48.31**	1/01/2018	Environment Canterbury
122	Community and Public Health	**K37/2977**	3	Private Bore	1495273	5139067	3.00	**13.28**	1/01/2018	Environment Canterbury
123	Community and Public Health	**K37/3114**	3	Private Bore	1496720	5134695	5.80	**25.67**	1/01/2018	Environment Canterbury
124	Community and Public Health	**K37/3146**	3	Private Bore	1493416	5135266	10.01	**44.32**	1/01/2018	Environment Canterbury
125	Community and Public Health	**K38/2316**	3	Private Bore	1460781	5096432	2.27	**10.05**	1/01/2018	Environment Canterbury
126	Community and Public Health	**K38/2358**	3	Private Bore	1461996	5092320	7.20	**31.87**	1/01/2018	Environment Canterbury

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127	Community and Public Health	**L35/0878**	3	Private Bore	1503327	5181312	0.13	**0.58**	1/01/2018	Environment Canterbury
128	Community and Public Health	**L36/2094**	3	Private Bore	1534521	5176087	6.55	**28.99**	1/01/2018	Environment Canterbury
129	Community and Public Health	**L36/2122**	3	Private Bore	1521606	5167679	6.50	**28.77**	1/01/2018	Environment Canterbury
130	Community and Public Health	**L37/0685**	3	Private Bore	1501182	5143413	7.45	**32.98**	1/01/2018	Environment Canterbury
131	Community and Public Health	**M35/10179**	3	Private Bore	1562631	5197652	4.20	**18.59**	1/01/2018	Environment Canterbury
132	Community and Public Health	**M35/11936**	3	Private Bore	1544849	5194211	5.47	**24.20**	1/01/2018	Environment Canterbury
133	Community and Public Health	**M35/5440**	3	Private Bore	1558066	5193939	8.10	**35.86**	1/01/2018	Environment Canterbury
134	Community and Public Health	**M35/5509**	3	Private Bore	1548149	5180841	3.67	**16.25**	1/01/2018	Environment Canterbury
135	Community and Public Health	**M35/5869**	3	Private Bore	1547924	5203527	8.31	**36.80**	1/01/2018	Environment Canterbury
136	Community and Public Health	**M35/5918**	3	Private Bore	1550925	5181231	3.40	**15.05**	1/01/2018	Environment Canterbury
137	Community and Public Health	**M35/7878**	3	Private Bore	1563134	5205945	0.26	**1.13**	1/01/2018	Environment Canterbury
138	Community and Public Health	**M36/1448**	3	Private Bore	1564948	5158375	0.03	**0.11**	1/01/2018	Environment Canterbury
139	Community and Public Health	**M36/7734**	3	Private Bore	1545139	5162652	6.50	**28.77**	1/01/2018	Environment Canterbury
140	Community and Public Health	**M37/0499**	3	Private Bore	1544710	5145706	8.10	**35.86**	1/01/2018	Environment Canterbury
141	Community and Public Health	**N33/0204**	3	Private Bore	1594816	5264006	0.16	**0.69**	1/01/2018	Environment Canterbury
142	Community and Public Health	**N33/0206**	3	Private Bore	1585384	5266258	18.74	**82.97**	1/01/2018	Environment Canterbury
143	Community and Public Health	**O31/0107**	3	Private Bore	1652274	5308600	1.07	**4.75**	1/01/2018	Environment Canterbury
144	Community and Public Health	**O31/0196**	3	Private Bore	1650231	5306265	1.65	**7.30**	1/01/2018	Environment Canterbury
145	Community and Public Health	**O33/0078**	3	Private Bore	1622980	5268139	0.71	**3.12**	1/01/2018	Environment Canterbury
146	Community and Public Health	**M35/6295**	3	Private Bore	1554238	5204568	8.60	**38.07**	1/01/2018	Environment Canterbury
147	Community and Public Health	**J39/0716**	3	Private Bore	1441923	5063517	0.03	**0.11**	1/01/2018	Environment Canterbury
148	Community and Public Health	**J40/0620**	3	Private Bore	1432336	5030214	0.23	**1.02**	1/01/2018	Environment Canterbury
149	Community and Public Health	**J40/0995**	3	Private Bore	1453750	5056050	0.14	**0.62**	1/01/2018	Environment Canterbury
150	Community and Public Health	**L36/1131**	3	Private Bore	1515982	5168291	5.10	**22.58**	1/01/2018	Environment Canterbury
151	Community and Public Health	**J39/0555**	3	Private Bore	1452825	5063160	0.03	**0.11**	1/01/2018	Environment Canterbury
152	Community and Public Health	**J40/1110**	3	Private Bore	1448158	5058015	6.89	**30.48**	1/01/2018	Environment Canterbury
153	Community and Public Health	**K37/0216**	3	Private Bore	1480276	5139769	9.90	**43.82**	1/01/2018	Environment Canterbury
154	Community and Public Health	**K38/0148**	3	Private Bore	1471276	5117427	2.45	**10.83**	1/01/2018	Environment Canterbury
155	Community and Public Health	**K38/2200**	3	Private Bore	1488931	5112579	9.70	**42.94**	1/01/2018	Environment Canterbury
156	Community and Public Health	**BV24/0028**	3	Private Bore	1586549	5245029	0.02	**0.07**	1/01/2018	Environment Canterbury
157	Community and Public Health	**BV24/0069**	3	Private Bore	1565144	5243521	0.02	**0.09**	1/01/2018	Environment Canterbury
158	Community and Public Health	**BY21/0307**	3	Private Bore	1493211	5138792	26.00	**115.09**	1/01/2018	Environment Canterbury
159	Community and Public Health	**BZ19/0223**	3	Private Bore	1463900	5091997	18.50	**81.89**	1/01/2018	Environment Canterbury
160	Community and Public Health	**BZ19/0239**	3	Private Bore	1462461	5091184	8.70	**38.51**	1/01/2018	Environment Canterbury
161	Community and Public Health	**H39/0048**	3	Private Bore	1362035	5069389	0.92	**4.05**	1/01/2018	Environment Canterbury
162	Community and Public Health	**I39/0007**	3	Private Bore	1381604	5085171	2.02	**8.92**	1/01/2018	Environment Canterbury
163	Community and Public Health	**I40/0666**	3	Private Bore	1402803	5037774	1.26	**5.58**	1/01/2018	Environment Canterbury
164	Community and Public Health	**J37/0045**	3	Private Bore	1456148	5122812	3.79	**16.77**	1/01/2018	Environment Canterbury
165	Community and Public Health	**J37/0087**	3	Private Bore	1424127	5120960	3.73	**16.51**	1/01/2018	Environment Canterbury
166	Community and Public Health	**J38/0004**	3	Private Bore	1457420	5114105	1.32	**5.82**	1/01/2018	Environment Canterbury
167	Community and Public Health	**J38/0045**	3	Private Bore	1455871	5092875	5.45	**24.13**	1/01/2018	Environment Canterbury
168	Community and Public Health	**J38/0139**	3	Private Bore	1459973	5090318	7.70	**34.09**	1/01/2018	Environment Canterbury

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169	Community and Public Health	**J38/0259**	3	Private Bore	1455147	5094790	2.20	**9.74**	1/01/2018	Environment Canterbury
170	Community and Public Health	**J39/0562**	3	Private Bore	1458860	5088140	9.10	**40.28**	1/01/2018	Environment Canterbury
171	Community and Public Health	**J40/0081**	3	Private Bore	1449213	5050430	2.50	**11.07**	1/01/2018	Environment Canterbury
172	Community and Public Health	**K36/0033**	3	Private Bore	1478422	5160947	8.40	**37.18**	1/01/2018	Environment Canterbury
173	Community and Public Health	**K36/0088**	3	Private Bore	1483898	5170779	4.65	**20.58**	1/01/2018	Environment Canterbury
174	Community and Public Health	**K36/0119**	3	Private Bore	1487199	5156520	2.10	**9.30**	1/01/2018	Environment Canterbury
175	Community and Public Health	**K37/0156**	3	Private Bore	1490715	5132241	12.00	**53.12**	1/01/2018	Environment Canterbury
176	Community and Public Health	**K37/0243**	3	Private Bore	1479791	5126353	13.75	**60.87**	1/01/2018	Environment Canterbury
177	Community and Public Health	**K37/0493**	3	Private Bore	1465029	5130877	11.05	**48.92**	1/01/2018	Environment Canterbury
178	Community and Public Health	**K37/0697**	3	Private Bore	1496077	5134842	9.20	**40.73**	1/01/2018	Environment Canterbury
179	Community and Public Health	**K37/1661**	3	Private Bore	1493496	5136758	25.00	**110.67**	1/01/2018	Environment Canterbury
180	Community and Public Health	**K37/1939**	3	Private Bore	1494579	5133172	6.70	**29.66**	1/01/2018	Environment Canterbury
181	Community and Public Health	**K37/2166**	3	Private Bore	1494357	5135955	22.25	**98.49**	1/01/2018	Environment Canterbury
182	Community and Public Health	**K37/2301**	3	Private Bore	1492142	5140821	17.10	**75.70**	1/01/2018	Environment Canterbury
183	Community and Public Health	**K37/2314**	3	Private Bore	1494533	5123037	10.44	**46.21**	1/01/2018	Environment Canterbury
184	Community and Public Health	**K37/2387**	3	Private Bore	1492360	5132904	7.40	**32.76**	1/01/2018	Environment Canterbury
185	Community and Public Health	**K38/0144**	3	Private Bore	1470521	5114227	4.24	**18.76**	1/01/2018	Environment Canterbury
186	Community and Public Health	**K38/0407**	3	Private Bore	1462715	5105296	1.33	**5.87**	1/01/2018	Environment Canterbury
187	Community and Public Health	**K38/0408**	3	Private Bore	1462286	5113441	0.56	**2.46**	1/01/2018	Environment Canterbury
188	Community and Public Health	**K38/0427**	3	Private Bore	1462439	5093529	5.70	**25.23**	1/01/2018	Environment Canterbury
189	Community and Public Health	**K38/0436**	3	Private Bore	1461897	5091990	12.60	**55.78**	1/01/2018	Environment Canterbury
190	Community and Public Health	**K38/0437**	3	Private Bore	1461901	5091183	7.10	**31.43**	1/01/2018	Environment Canterbury
191	Community and Public Health	**K38/1861**	3	Private Bore	1464107	5092969	4.30	**19.03**	1/01/2018	Environment Canterbury
192	Community and Public Health	**K38/2210**	3	Private Bore	1460568	5093424	8.73	**38.64**	1/01/2018	Environment Canterbury
193	Community and Public Health	**K39/0006**	3	Private Bore	1460449	5088079	3.17	**14.02**	1/01/2018	Environment Canterbury
194	Community and Public Health	**L35/0086**	3	Private Bore	1538162	5190241	7.74	**34.25**	1/01/2018	Environment Canterbury
195	Community and Public Health	**L35/0194**	3	Private Bore	1535595	5188271	0.38	**1.68**	1/01/2018	Environment Canterbury
196	Community and Public Health	**L35/0205**	3	Private Bore	1520408	5180579	6.55	**28.99**	1/01/2018	Environment Canterbury
197	Community and Public Health	**L35/0349**	3	Private Bore	1536992	5204470	1.15	**5.09**	1/01/2018	Environment Canterbury
198	Community and Public Health	**L35/0596**	3	Private Bore	1523183	5192126	6.64	**29.38**	1/01/2018	Environment Canterbury
199	Community and Public Health	**L35/1195**	3	Private Bore	1523076	5205649	0.46	**2.05**	1/01/2018	Environment Canterbury
200	Community and Public Health	**L36/0200**	3	Private Bore	1531877	5157736	14.16	**62.69**	1/01/2018	Environment Canterbury
201	Community and Public Health	**L36/0584**	3	Private Bore	1524424	5175995	9.83	**43.49**	1/01/2018	Environment Canterbury
202	Community and Public Health	**L36/0933**	3	Private Bore	1508839	5149125	12.73	**56.37**	1/01/2018	Environment Canterbury
203	Community and Public Health	**L37/0130**	3	Private Bore	1507130	5128819	7.66	**33.92**	1/01/2018	Environment Canterbury
204	Community and Public Health	**L37/0556**	3	Private Bore	1525123	5147951	6.37	**28.18**	1/01/2018	Environment Canterbury
205	Community and Public Health	**L37/0876**	3	Private Bore	1502475	5138553	13.17	**58.28**	1/01/2018	Environment Canterbury
206	Community and Public Health	**L37/0914**	3	Private Bore	1501879	5139781	8.86	**39.20**	1/01/2018	Environment Canterbury
207	Community and Public Health	**L37/0932**	3	Private Bore	1502409	5138573	15.73	**69.65**	1/01/2018	Environment Canterbury
208	Community and Public Health	**L37/0964**	3	Private Bore	1502416	5138517	12.47	**55.19**	1/01/2018	Environment Canterbury
209	Community and Public Health	**L37/1453**	3	Private Bore	1502356	5138784	8.43	**37.33**	1/01/2018	Environment Canterbury
210	Community and Public Health	**M33/0203**	3	Private Bore	1573631	5252964	4.93	**21.84**	1/01/2018	Environment Canterbury

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211	Community and Public Health	**M34/0758**	3	Private Bore	1577455	5224640	0.04	**0.17**	1/01/2018	Environment Canterbury
212	Community and Public Health	**M35/0698**	3	Private Bore	1567272	5195352	5.35	**23.68**	1/01/2018	Environment Canterbury
213	Community and Public Health	**M35/4795**	3	Private Bore	1565595	5198869	6.80	**30.10**	1/01/2018	Environment Canterbury
214	Community and Public Health	**M35/4875**	3	Private Bore	1564208	5185862	0.29	**1.30**	1/01/2018	Environment Canterbury
215	Community and Public Health	**M35/5604**	3	Private Bore	1571219	5201589	3.53	**15.60**	1/01/2018	Environment Canterbury
216	Community and Public Health	**M35/6385**	3	Private Bore	1545395	5194454	7.25	**32.09**	1/01/2018	Environment Canterbury
217	Community and Public Health	**M35/6639**	3	Private Bore	1559515	5203643	5.80	**25.67**	1/01/2018	Environment Canterbury
218	Community and Public Health	**M35/6656**	3	Private Bore	1566016	5186986	0.32	**1.39**	1/01/2018	Environment Canterbury
219	Community and Public Health	**M35/6935**	3	Private Bore	1550410	5185931	0.30	**1.33**	1/01/2018	Environment Canterbury
220	Community and Public Health	**M35/9064**	3	Private Bore	1559886	5182179	2.31	**10.21**	1/01/2018	Environment Canterbury
221	Community and Public Health	**M36/0473**	3	Private Bore	1549581	5157039	0.53	**2.35**	1/01/2018	Environment Canterbury
222	Community and Public Health	**M36/1504**	3	Private Bore	1565409	5157727	0.03	**0.11**	1/01/2018	Environment Canterbury
223	Community and Public Health	**M36/20713**	3	Private Bore	1552915	5160026	5.05	**22.35**	1/01/2018	Environment Canterbury
224	Community and Public Health	**M36/2285**	3	Private Bore	1555911	5169768	5.91	**26.18**	1/01/2018	Environment Canterbury
225	Community and Public Health	**M36/2437**	3	Private Bore	1564915	5177392	1.04	**4.60**	1/01/2018	Environment Canterbury
226	Community and Public Health	**M36/2679**	3	Private Bore	1562271	5165660	0.55	**2.41**	1/01/2018	Environment Canterbury
227	Community and Public Health	**M36/3712**	3	Private Bore	1560151	5163112	0.48	**2.12**	1/01/2018	Environment Canterbury
228	Community and Public Health	**M36/3791**	3	Private Bore	1554459	5170917	1.42	**6.29**	1/01/2018	Environment Canterbury
229	Community and Public Health	**M36/4126**	3	Private Bore	1549150	5177595	5.84	**25.85**	1/01/2018	Environment Canterbury
230	Community and Public Health	**M36/5128**	3	Private Bore	1545915	5156027	0.35	**1.55**	1/01/2018	Environment Canterbury
231	Community and Public Health	**M36/5248**	3	Private Bore	1552688	5173901	7.85	**34.75**	1/01/2018	Environment Canterbury
232	Community and Public Health	**M36/5255**	3	Private Bore	1558098	5170216	3.45	**15.27**	1/01/2018	Environment Canterbury
233	Community and Public Health	**M36/8187**	3	Private Bore	1544679	5172403	9.65	**42.72**	1/01/2018	Environment Canterbury
234	Community and Public Health	**M37/0130**	3	Private Bore	1542548	5142159	1.28	**5.64**	1/01/2018	Environment Canterbury
235	Community and Public Health	**N32/0088**	3	Private Bore	1586340	5290112	0.03	**0.12**	1/01/2018	Environment Canterbury
236	Community and Public Health	**N32/0140**	3	Private Bore	1595653	5272932	6.96	**30.80**	1/01/2018	Environment Canterbury
237	Community and Public Health	**N32/0204**	3	Private Bore	1584226	5288630	3.11	**13.75**	1/01/2018	Environment Canterbury
238	Community and Public Health	**O31/0106**	3	Private Bore	1648797	5302524	1.82	**8.06**	1/01/2018	Environment Canterbury
239	Community and Public Health	**O31/0139**	3	Private Bore	1648832	5302669	1.04	**4.60**	1/01/2018	Environment Canterbury
240	Community and Public Health	**O31/0280**	3	Private Bore	1650619	5303441	3.30	**14.61**	1/01/2018	Environment Canterbury
241	Community and Public Health	**BW24/0274**	3	Private Bore	1571948	5192875	1.21	**5.36**	1/01/2018	Environment Canterbury
242	Community and Public Health	**BX23/0270**	3	Private Bore	1558443	5186126	0.26	**1.13**	1/01/2018	Environment Canterbury
243	Community and Public Health	**K39/0258**	3	Private Bore	1461570	5087880	1.27	**5.63**	1/01/2018	Environment Canterbury
244	Community and Public Health	**N34/0109**	3	Private Bore	1581860	5234131	10.05	**44.49**	1/01/2018	Environment Canterbury
245	Community and Public Health	**J40/0118**	3	Private Bore	1453470	5032886	5.30	**23.46**	1/01/2018	Environment Canterbury
246	Community and Public Health	**H38/0004**	3	Private Bore	1365955	5097816	0.29	**1.27**	1/01/2018	Environment Canterbury
247	Community and Public Health	**J37/0012**	3	Private Bore	1459329	5128412	4.60	**20.36**	1/01/2018	Environment Canterbury
248	Community and Public Health	**J37/0073**	3	Private Bore	1426119	5130605	13.39	**59.25**	1/01/2018	Environment Canterbury
249	Community and Public Health	**J38/0255**	3	Private Bore	1459846	5090506	3.40	**15.05**	1/01/2018	Environment Canterbury
250	Community and Public Health	**J39/0378**	3	Private Bore	1450190	5067377	0.43	**1.90**	1/01/2018	Environment Canterbury
251	Community and Public Health	**J40/0217**	3	Private Bore	1450813	5040433	2.99	**13.21**	1/01/2018	Environment Canterbury
252	Community and Public Health	**J40/0286**	3	Private Bore	1452780	5043889	4.48	**19.81**	1/01/2018	Environment Canterbury

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253	Community and Public Health	**J40/0469**	3	Private Bore	1448612	5039583	1.75	**7.75**	1/01/2018	Environment Canterbury
254	Community and Public Health	**K36/0118**	3	Private Bore	1471952	5150764	7.61	**33.70**	1/01/2018	Environment Canterbury
255	Community and Public Health	**K37/0234**	3	Private Bore	1475190	5122524	12.78	**56.55**	1/01/2018	Environment Canterbury
256	Community and Public Health	**K37/0266**	3	Private Bore	1481245	5135924	3.85	**17.04**	1/01/2018	Environment Canterbury
257	Community and Public Health	**K37/0468**	3	Private Bore	1493524	5130663	15.50	**68.61**	1/01/2018	Environment Canterbury
258	Community and Public Health	**K38/0240**	3	Private Bore	1467814	5100145	3.71	**16.43**	1/01/2018	Environment Canterbury
259	Community and Public Health	**K38/0404**	3	Private Bore	1470046	5107633	8.55	**37.85**	1/01/2018	Environment Canterbury
260	Community and Public Health	**K38/0412**	3	Private Bore	1485553	5114383	10.65	**47.14**	1/01/2018	Environment Canterbury
261	Community and Public Health	**L36/0003**	3	Private Bore	1512823	5176555	13.13	**58.12**	1/01/2018	Environment Canterbury
262	Community and Public Health	**L37/0349**	3	Private Bore	1515118	5141990	19.50	**86.32**	1/01/2018	Environment Canterbury
263	Community and Public Health	**N33/0249**	3	Private Bore	1619012	5268152	0.99	**4.38**	1/01/2018	Environment Canterbury
264	Community and Public Health	**BY21/0125**	3	Private Bore	1496415	5130988	13.10	**57.99**	1/01/2018	Environment Canterbury
265	Community and Public Health	**M36/2857**	25	Private Bore	1556886	5167427	1.58	**6.99**	1/01/2018	Environment Canterbury
266	Community and Public Health	**L37/1031**	25	Private Bore	1534744	5138653	0.44	**1.95**	1/01/2018	Environment Canterbury
267	Community and Public Health	**J37/0013**	3	Private Bore	1423093	5121684	9.67	**42.81**	1/01/2018	Environment Canterbury
268	Community and Public Health	**J37/0031**	3	Private Bore	1425948	5121623	2.37	**10.47**	1/01/2018	Environment Canterbury
269	Community and Public Health	**J40/0053**	3	Private Bore	1450063	5033235	10.70	**47.37**	1/01/2018	Environment Canterbury
270	Community and Public Health	**K37/0130**	3	Private Bore	1464057	5122433	4.90	**21.69**	1/01/2018	Environment Canterbury
271	Community and Public Health	**K38/0105**	3	Private Bore	1472213	5100961	0.19	**0.82**	1/01/2018	Environment Canterbury
272	Community and Public Health	**M35/4757**	3	Private Bore	1542882	5205029	6.70	**29.66**	1/01/2018	Environment Canterbury
273	Community and Public Health	**J40/0085**	3	Private Bore	1452437	5052699	0.30	**1.33**	1/01/2018	Environment Canterbury
274	Community and Public Health	**J40/0816**	3	Private Bore	1446326	5048342	5.11	**22.61**	1/01/2018	Environment Canterbury
275	Community and Public Health	**K37/0968**	3	Private Bore	1495997	5133118	15.00	**66.40**	1/01/2018	Environment Canterbury
276	Community and Public Health	**K37/1747**	3	Private Bore	1489166	5140074	10.01	**44.33**	1/01/2018	Environment Canterbury
277	Community and Public Health	**K37/1806**	3	Private Bore	1496895	5134491	2.50	**11.07**	1/01/2018	Environment Canterbury
278	Community and Public Health	**K37/1972**	3	Private Bore	1495404	5138566	17.40	**77.02**	1/01/2018	Environment Canterbury
279	Community and Public Health	**K37/2303**	3	Private Bore	1491834	5131904	9.85	**43.60**	1/01/2018	Environment Canterbury
280	Community and Public Health	**K37/2324**	3	Private Bore	1492332	5137558	11.81	**52.29**	1/01/2018	Environment Canterbury
281	Community and Public Health	**K37/2347**	3	Private Bore	1495587	5135587	14.85	**65.74**	1/01/2018	Environment Canterbury
282	Community and Public Health	**K37/2369**	3	Private Bore	1494218	5133736	19.40	**85.88**	1/01/2018	Environment Canterbury
283	Community and Public Health	**K37/2479**	3	Private Bore	1464680	5142796	8.05	**35.63**	1/01/2018	Environment Canterbury
284	Community and Public Health	**K38/1671**	3	Private Bore	1461737	5092080	12.40	**54.89**	1/01/2018	Environment Canterbury
285	Community and Public Health	**K38/1807**	3	Private Bore	1487038	5113678	9.90	**43.82**	1/01/2018	Environment Canterbury
286	Community and Public Health	**L36/0319**	3	Private Bore	1526191	5165444	6.45	**28.55**	1/01/2018	Environment Canterbury
287	Community and Public Health	**M35/11059**	3	Private Bore	1550203	5183766	2.30	**10.18**	1/01/2018	Environment Canterbury
288	Community and Public Health	**M35/5119**	3	Private Bore	1554539	5183216	2.87	**12.72**	1/01/2018	Environment Canterbury
289	Community and Public Health	**I40/0543**	3	Private Bore	1407816	5033791	0.55	**2.43**	1/01/2018	Environment Canterbury
290	Community and Public Health	**J38/0012**	3	Private Bore	1458498	5089362	7.60	**33.64**	1/01/2018	Environment Canterbury
291	Community and Public Health	**K37/0336**	3	Private Bore	1497782	5135904	3.90	**17.26**	1/01/2018	Environment Canterbury
292	Community and Public Health	**K37/0751**	3	Private Bore	1492138	5135242	6.95	**30.77**	1/01/2018	Environment Canterbury
293	Community and Public Health	**K37/0961**	3	Private Bore	1494476	5138459	14.00	**61.97**	1/01/2018	Environment Canterbury
294	Community and Public Health	**L36/0948**	3	Private Bore	1502391	5149893	7.40	**32.76**	1/01/2018	Environment Canterbury

No.	Public Health Unit	Bore or Supply Name	Estimated Population Served	Source Type	Northing	Easting	Current nitrate level (NO3-N mg/L)	Current nitrate level (NO3 mg/L)	Date of most recent sample	Data Source
295	Community and Public Health	**L37/0020**	3	Private Bore	1516055	5135434	10.85	**48.03**	1/01/2018	Environment Canterbury
296	Community and Public Health	**L37/0403**	3	Private Bore	1501169	5140524	8.15	**36.08**	1/01/2018	Environment Canterbury
297	Community and Public Health	**L37/1438**	3	Private Bore	1502016	5138198	6.10	**27.00**	1/01/2018	Environment Canterbury
298	Community and Public Health	**M34/0688**	3	Private Bore	1576234	5230074	3.17	**14.01**	1/01/2018	Environment Canterbury
299	Community and Public Health	**M34/5557**	3	Private Bore	1550195	5213075	8.21	**36.35**	1/01/2018	Environment Canterbury
300	Community and Public Health	**M35/0925**	3	Private Bore	1542314	5185673	0.75	**3.30**	1/01/2018	Environment Canterbury
301	Community and Public Health	**M35/6946**	3	Private Bore	1554138	5187471	0.17	**0.76**	1/01/2018	Environment Canterbury
302	Community and Public Health	**M35/7065**	3	Private Bore	1558966	5192860	10.01	**44.32**	1/01/2018	Environment Canterbury
303	Community and Public Health	**M36/4788**	3	Private Bore	1561024	5169020	3.80	**16.82**	1/01/2018	Environment Canterbury
304	Community and Public Health	**O31/0219**	25	Private Bore	1652653	5304335	0.54	**2.37**	1/01/2018	Environment Canterbury
305	Community and Public Health	**BW24/0051**	25	Private Bore	1579966	5215622	0.03	**0.11**	1/01/2018	Environment Canterbury
306	Community and Public Health	**L35/0191**	25	Private Bore	1536265	5183932	4.55	**20.14**	1/01/2018	Environment Canterbury
307	Community and Public Health	**L36/0362**	25	Private Bore	1521013	5155414	0.72	**3.19**	1/01/2018	Environment Canterbury
308	Community and Public Health	**L36/0725**	25	Private Bore	1534252	5164175	3.95	**17.49**	1/01/2018	Environment Canterbury
309	Community and Public Health	**L36/1313**	25	Private Bore	1510766	5168162	4.30	**19.03**	1/01/2018	Environment Canterbury
310	Community and Public Health	**M35/10632**	25	Private Bore	1570028	5190029	1.74	**7.71**	1/01/2018	Environment Canterbury
311	Community and Public Health	**M36/0698**	25	Private Bore	1540043	5148573	4.45	**19.70**	1/01/2018	Environment Canterbury
312	Community and Public Health	**N32/0108**	25	Private Bore	1617948	5269243	0.31	**1.35**	1/01/2018	Environment Canterbury
313	Community and Public Health	**N33/0103**	25	Private Bore	1586541	5262464	4.75	**21.03**	1/01/2018	Environment Canterbury
314	Community and Public Health	**O31/0228**	25	Private Bore	1648494	5302513	0.33	**1.46**	1/01/2018	Environment Canterbury
315	Community and Public Health	**L35/0850**	25	Private Bore	1533763	5201707	2.15	**9.52**	1/01/2018	Environment Canterbury
316	Community and Public Health	**M35/0217**	25	Private Bore	1566498	5206103	0.39	**1.73**	1/01/2018	Environment Canterbury
317	Community and Public Health	**M35/0474**	25	Private Bore	1576445	5207631	0.38	**1.67**	1/01/2018	Environment Canterbury
318	Community and Public Health	**M35/0834**	25	Private Bore	1571627	5196648	1.62	**7.17**	1/01/2018	Environment Canterbury
319	Community and Public Health	**M35/1653**	25	Private Bore	1564295	5185981	2.80	**12.39**	1/01/2018	Environment Canterbury
320	Community and Public Health	**M35/1860**	25	Private Bore	1564183	5179350	0.67	**2.94**	1/01/2018	Environment Canterbury
321	Community and Public Health	**M35/1864**	25	Private Bore	1561619	5178526	1.35	**5.96**	1/01/2018	Environment Canterbury
322	Community and Public Health	**M35/2325**	25	Private Bore	1570116	5181183	0.18	**0.80**	1/01/2018	Environment Canterbury
323	Community and Public Health	**M35/5251**	25	Private Bore	1569561	5186447	0.30	**1.31**	1/01/2018	Environment Canterbury
324	Community and Public Health	**M35/6040**	25	Private Bore	1563443	5181714	0.26	**1.16**	1/01/2018	Environment Canterbury
325	Community and Public Health	**M35/9594**	25	Private Bore	1577276	5207527	0.29	**1.28**	1/01/2018	Environment Canterbury
326	Community and Public Health	**M36/1045**	25	Private Bore	1574424	5178232	1.36	**6.00**	1/01/2018	Environment Canterbury
327	Community and Public Health	**M36/1225**	25	Private Bore	1568860	5176422	3.80	**16.82**	1/01/2018	Environment Canterbury
328	Community and Public Health	**J39/0135**	25	Private Bore	1457060	5072829	1.58	**6.97**	1/01/2018	Environment Canterbury
329	Northland DHB	**Campground**	25	Private Bore	-35.346191	174.353472	9.41	**41.66**	24/02/2020	Northland Regional Council
330	Northland DHB	**Holiday Park**	25	Private Bore	-36.130757	174.585092	0.00	**0.01**	10/12/2019	Northland Regional Council
331	Public Health South	**J41/0586**	3	Private Bore	1444337	5022050	6.71	**29.71**	6/11/2019	Otago Regional Council
332	Public Health South	**I44/0821**	3	Private Bore	1396005	4918936	5.53	**24.46**	4/11/2019	Otago Regional Council
333	Public Health South	**G43/0009**	3	Private Bore	1317340	4939479	4.91	**21.73**	3/03/2020	Otago Regional Council
334	Public Health South	**G41/0254**	3	Private Bore	1330621	5002692	4.14	**18.35**	3/03/2020	Otago Regional Council
335	Public Health South	**F40/0045**	3	Private Bore	1295873	5040204	2.89	**12.78**	4/12/2019	Otago Regional Council
336	Public Health South	**G42/0290**	3	Private Bore	1318086	4988261	2.29	**10.13**	3/03/2020	Otago Regional Council

No.	Public Health Unit	Bore or Supply Name	Estimated Population Served	Source Type	Northing	Easting	Current nitrate level (NO3-N mg/L)	Current nitrate level (NO3 mg/L)	Date of most recent sample	Data Source
337	Public Health South	**G41/0211**	3	Private Bore	1313189	5027110	1.24	**5.49**	4/12/2019	Otago Regional Council
338	Public Health South	**H43/0132**	3	Private Bore	1375349	4957813	1.21	**5.37**	3/12/2019	Otago Regional Council
339	Public Health South	**G42/0123**	3	Private Bore	1316486	4987258	1.02	**4.53**	3/03/2020	Otago Regional Council
340	Public Health South	**G40/0175**	3	Private Bore	1316490	5029567	0.97	**4.30**	4/12/2019	Otago Regional Council
341	Public Health South	**J43/0006**	3	Private Bore	1421848	4962170	0.84	**3.71**	2/09/2019	Otago Regional Council
342	Public Health South	**J41/0442**	3	Private Bore	1435789	5022981	0.62	**2.74**	6/11/2019	Otago Regional Council
343	Public Health South	**F40/0025**	3	Private Bore	1294354	5042603	0.50	**2.19**	4/12/2019	Otago Regional Council
344	Public Health South	**F41/0162**	3	Private Bore	1299511	5011543	0.38	**1.67**	2/09/2019	Otago Regional Council
345	Public Health South	**F42/0113**	3	Private Bore	1264458	4971085	0.36	**1.58**	26/11/2019	Otago Regional Council
346	Public Health South	**F41/0104**	3	Private Bore	1267639	5008496	0.30	**1.35**	26/11/2019	Otago Regional Council
347	Public Health South	**I44/0495**	3	Private Bore	1392260	4918203	0.11	**0.47**	4/11/2019	Otago Regional Council
348	Taranaki DHB	**GND1080**	3	Private Bore	1717976	5664745	0.13	**0.58**	1/01/2018	Taranaki Regional Council
349	Taranaki DHB	**GND1718**	3	Private Bore	1721048	5680386	0.81	**3.57**	1/01/2018	Taranaki Regional Council
350	Taranaki DHB	**GND1075**	3	Private Bore	1713523	5645279	1.08	**4.78**	1/01/2018	Taranaki Regional Council
351	Taranaki DHB	**GND0834**	3	Private Bore	1706701	5617616	1.33	**5.88**	1/01/2018	Taranaki Regional Council
352	Taranaki DHB	**GND1098**	3	Private Bore	1666598	5652560	2.02	**8.92**	1/01/2018	Taranaki Regional Council
353	Taranaki DHB	**GND2099**	3	Private Bore	1680855	5626126	2.03	**8.98**	1/01/2018	Taranaki Regional Council
354	Taranaki DHB	**GND2505**	3	Private Bore	1723994	5644058	2.11	**9.32**	1/01/2018	Taranaki Regional Council
355	Taranaki DHB	**GND1091**	3	Private Bore	1707330	5675479	2.15	**9.51**	1/01/2018	Taranaki Regional Council
356	Taranaki DHB	**GND0849**	3	Private Bore	1709130	5636145	3.69	**16.33**	1/01/2018	Taranaki Regional Council
357	Taranaki DHB	**GND1194**	3	Private Bore	1724486	5608758	2.34	**10.35**	1/01/2018	Taranaki Regional Council
358	Taranaki DHB	**GND0514**	3	Private Bore	1724029	5684247	4.74	**20.97**	1/01/2018	Taranaki Regional Council
359	Taranaki DHB	**GND0827**	3	Private Bore	1701591	5618033	2.66	**11.79**	1/01/2018	Taranaki Regional Council
360	Taranaki DHB	**GND0826**	3	Private Bore	1712142	5630866	7.90	**34.97**	1/01/2018	Taranaki Regional Council
361	Taranaki DHB	**GND1103**	3	Private Bore	1676675	5647886	2.77	**12.25**	1/01/2018	Taranaki Regional Council
362	Taranaki DHB	**GND0829**	3	Private Bore	1728941	5597650	9.87	**43.67**	1/01/2018	Taranaki Regional Council
363	Taranaki DHB	**GND000093**	3	Private Bore	1683491	5638807	2.87	**12.70**	1/01/2018	Taranaki Regional Council
364	Taranaki DHB	**GND1105**	3	Private Bore	1703856	5629095	11.22	**49.68**	1/01/2018	Taranaki Regional Council
365	Taranaki DHB	**GND0866**	3	Private Bore	1724829	5615319	3.50	**15.49**	1/01/2018	Taranaki Regional Council
366	Taranaki DHB	**GND1112**	3	Private Bore	1702153	5621304	25.54	**113.08**	1/01/2018	Taranaki Regional Council
367	Toi Te Ora DHB	**10757**	3	Private Bore	-	-	0.05	**0.22**	16/10/2005	Bay of Plenty Regional Council
368	Toi Te Ora DHB	**11174**	3	Private Bore	-	-	0.05	**0.22**	17/02/2010	Bay of Plenty Regional Council
369	Toi Te Ora DHB	**11810**	3	Private Bore	-	-	0.08	**0.35**	29/08/2014	Bay of Plenty Regional Council
370	Toi Te Ora DHB	**12104**	3	Private Bore	-	-	0.21	**0.93**	28/05/2014	Bay of Plenty Regional Council
371	Toi Te Ora DHB	**12107**	3	Private Bore	-	-	0.18	**0.80**	16/09/2014	Bay of Plenty Regional Council

APPENDIX H

Indicative cost estimates of nitrate reduction options for Neighbourhood and unregistered supplies

Preliminary Cost Estimate Point of use treatment - single dwelling (unregistered water supply)				
Element	**Description**	**Quantity**	**Rate**	**Cost**
Capital Costs				
Undersink RO unit	*Assume $2,000 / unit for supply and installation*	**1**	**2,000**	***$ 2,000***
Total Estimated Capital Cost:				**2,000**
Annual Operational Costs				
Maintenance	*Assume average of $300/ unit / year for annual servicing and maintenance. Asssume pump already in place and negligible increase in power demand*	**1**	**300**	***$ 300***
Total Estimated Annual Operational Costs				**$ 300**
NPV of Operating Costs (20 yr @ 8%)				**$ 2,900**
Preliminary Estimate NPV Capital plus Operating Costs ($NZ)				**$ 4,900**
Preliminary Estimate NPV Capital plus Operating Costs ($US)				**$ 3,200**

Preliminary Cost Estimate Point of use treatment - water supply of 50 people (assume 3 people per dwelling, total of 17 dwellings)				
Element	**Description**	**Quantity**	**Rate**	**Cost**
Capital Costs				
Undersink RO units	*Assume $2,000 / unit for supply and installation*	**17**	**2,000**	***$ 34,000***
Total Estimated Capital Cost:				**34,000**
Annual Operational Costs				
Maintenance	*Assume average of $300/ unit / year for annual servicing and maintenance. Assume existing adequate pressure*	**17**	**300**	***$ 5,100***
Total Estimated Annual Operational Costs				**$ 5,100**
NPV of Operating Costs (20 yr @ 8%)				**$ 50,100**
Preliminary Estimate NPV Capital plus Operating Costs ($NZ)				**$ 84,100**
Preliminary Estimate NPV Capital plus Operating Costs ($US)				**$ 54,900**

Preliminary Cost Estimate Point of use treatment - water supply of 100 people (assume 3 people per dwelling, total of 33 dwellings)				
Element	**Description**	**Quantity**	**Rate**	**Cost**
Capital Costs				
Undersink RO units	*Assume $2,000 / unit for supply and installation*	**33**	**2,000**	***$ 66,000***
Total Estimated Capital Cost:				**66,000**
Annual Operational Costs				
Maintenance	*Assume average of $300/ unit / year for annual servicing and maintenance. Assume existing adequate pressure*	**33**	**300**	***$ 9,900***
Total Estimated Annual Operational Costs				**$ 9,900**
NPV of Operating Costs (20 yr @ 8%)				**$ 97,200**
Preliminary Estimate NPV Capital plus Operating Costs ($NZ)				**$ 163,200**
Preliminary Estimate NPV Capital plus Operating Costs ($US)				**$ 106,600**

Preliminary Cost Estimate New 50m deep bore				
Element	**Description**	**Quantity**	**Rate**	**Cost**
Capital Costs				
Construction of new bore	*Assume 50m deep, 150 dia bore*	**1**	**15,000**	***$ 15,000***
Pump, riser, controls	*(Assume rising main existing)*	**1**	**25,000**	***$ 25,000***
Bore headworks	*Including enclosure, valves, fittings etc*	**1**	**30,000**	***$ 30,000***
Total Estimated Capital Cost:				**70,000**
Annual Operational Costs				
Maintenance	*Assume average monthly maintenance @ $300/month. Assume power costs same as previous source*	**12**	**300**	***$ 3,600***
Total Estimated Annual Operational Costs				**$ 3,600**
NPV of Operating Costs (20 yr @ 8%)				**$ 35,300**
Preliminary Estimate NPV Capital plus Operating Costs ($NZ)				**$ 105,300**
Preliminary Estimate NPV Capital plus Operating Costs ($US)				**$ 68,800**