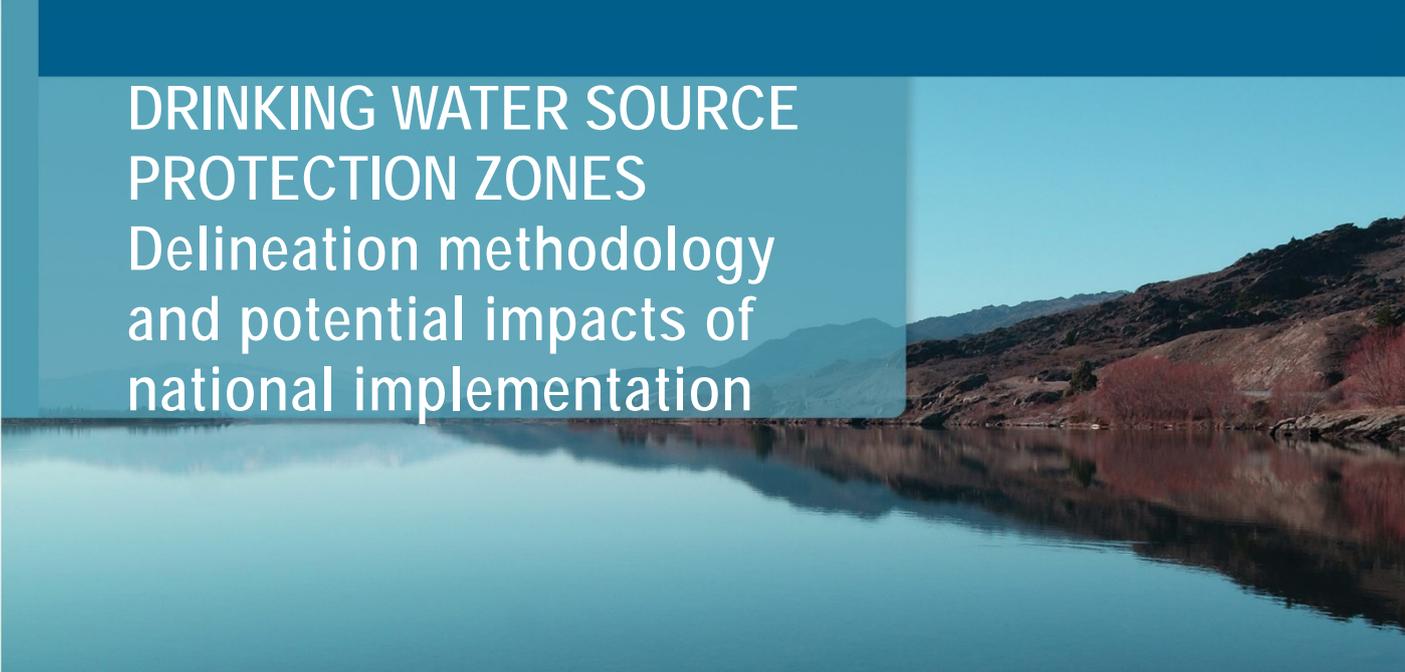


DRINKING WATER SOURCE PROTECTION ZONES Delineation methodology and potential impacts of national implementation



PREPARED FOR
Ministry for the Environment

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EXECUTIVE SUMMARY

Land areas (protection zones) have been identified that would be affected by the implementation of a nationally-consistent drinking water source protection zone delineation methodology.

For drinking water from groundwater sources, the protection zones delineate a circle around the abstraction site. The radius of the circle is determined from estimates of aquifer properties, groundwater bore properties and supply volumes. Two types of groundwater zones are provided: smaller circles representing an estimated contaminant travel time of 1 year, and larger circles representing a contaminant travel time of 50 years. The smaller circles are intended to represent the areas that present a risk from microbial contaminants. The larger circles represent the areas that present a risk from chemical contaminants.

For drinking water from surface water sites, entire upstream catchments have been delineated, as well as Intermediate Zones, set as buffers to a distance of 100 m of a stream, and 25 km upstream of a abstraction site.

The relative costs of implementation of the zones have been assessed, at a high level, based on their current land cover, and separately, on the number of discharge, land use and water take consents sites as well as the number of Hazardous Industries and Activities List (HAIL) sites within the zones. These separate assessments were adjusted, at a regional level, based on how comprehensive the related regional council planning rules are with respect to drinking water source protection zones, and with respect to how compliant the regions are with the New Zealand Drinking-water Standards.

The separate assessments led, predominantly, to the same ranking of regions in terms of relative economic impact of zone implementation.

Canterbury and Hawke's Bay are the regions that are likely to be most affected by the implementation of groundwater source protection areas though Canterbury already has planning rules that consider source protection zones, so from a regulatory perspective, some of that impact has already been borne.

Waikato and Otago are the two regions most affected by the implementation of surface water source protection zones.

A large number of spatial and summary tables have been compiled and provided as supplementary data to enable further analysis as required.

The Ministry for the Environment is seeking to understand what areas in New Zealand would potentially be affected if all drinking water supply sources were required to have source protection zones in place. In addition, the Ministry would like to know the potential costs that might be incurred by landowners and regulators in ensuring land use activities within source protection zones were appropriately managed. This information is intended to inform the Review of the National Environmental Standard for Sources of Human Drinking Water (Drinking Water NES)¹.

To this end, source protection zones around known drinking water supplies have been delineated using standard methods^{2,3}. Land cover, land use consents, discharge consents, water take consents and Hazardous Activities and Industries List (HAIL) sites within these zones have also been determined.

Two scenarios (a conservative, and a mid-level scenario) of drinking water quality risk weighting have been subjectively applied to the land cover, consent and HAIL information, enabling a total drinking water risk within each regional council to be estimated.

The relative impacts, at a regional level, were further adjusted based on a subjective assessment of how comprehensive each Regional Council's planning rules are with respect to drinking water source protection zones.

An alternative regional adjustment has been applied, based on the assessed⁴ percentage of water distribution zones in each region that were compliant with the bacterial and protozoal standards with the Drinking-water Standards for New Zealand⁵.

This report begins by describing the methods and results of delineating the source protection zones. This is followed by the land cover, consent, and HAIL data processing methodologies. An assessment of current regional council plan provisions associated with source protection zones is provided. This is followed by an assessment of the potential economic impact of implementing the source protection zones.

The report body is restricted to describing methodologies and summaries of findings. Technical details have been provided in a series of appendices, fully referenced from within the main body of the report. An appendix is also dedicated to describing the supplementary data associated with, but not included in, this report.

This report is not intended to provide a definitive assessment of potential risks to individual drinking water supplies. Detailed, site-specific information would be required for each water supply, its source waters and associated land-use, to make a definitive risk assessment.

¹ Resource Management (National Environmental Standards for Sources of Human Drinking Water) Regulations 2007. <http://www.legislation.govt.nz/regulation/public/2007/0396/latest/whole.html>

² Moreau, M, Cameron, S., Daughney, C., Gussyev, M., Tschritter, C., 2014. Envirolink Tools Project - Capture Zone Delineation - Technical Report (No. GNS Science Report 2013/57). GNS, Taupo

³ Pattle Delamore Partners Ltd, ESR Ltd, 2005. Methodology for Delineating Water Catchments (Report prepared for the Ministry for the Environment). Pattle Delamore Partners Ltd., ESR Ltd., Christchurch.

⁴ Mattingley, B., Nokes, C., 2018. Changes in New Zealand drinking-water quality since 2005 (Confidential Client Report No. FW18024). The Institute of Environmental Science and Research Limited (ESR) for the Ministry for the Environment.

⁵ Ministry of Health, 2008. Drinking-water Standards for New Zealand 2005 (Revised 2008). Wellington: Ministry of Health. <http://www.health.govt.nz/water/>

2 REGIONAL COUNCIL RULES ABOUT DRINKING WATER SOURCE PROTECTION⁶

Councils have Regional Plans to specify objectives, policies and rules to achieve the requirements of the National Environmental Standard for Sources of Human Drinking Water (Drinking Water NES)¹. The Drinking Water NES requires councils to consider effects of activities that are upstream or up-gradient of drinking water sources. Specifically, regional councils are required to:

- decline applications for discharge or water permits that are likely to result in community drinking water becoming unsafe for human consumption following existing treatment (Drinking Water NES regulations 7-8);
- be satisfied that permitted activities in regional plans will not result in community drinking water supplies being unsafe for human consumption following existing treatment (Drinking Water NES regulation 10);
- place conditions on relevant resource consents that require notification of drinking water suppliers if significant unintended events occur (e.g. spills) that may adversely affect sources of human drinking water (Drinking Water NES regulation 12).

Regulations 7, 8 and 10 of the Drinking Water NES apply to water supplies serving no fewer than 501 people for not less than 60 days per year. Regulation 12 applies to water supplies serving no fewer than 25 people for not less than 60 days per year.

Currently the Drinking Water NES does not require regional councils to establish formal source protection zones. Part of the purpose of this report is, as part of a larger review of the Drinking Water NES, to investigate the possible cost implications of including the requirement to specify source protection zones.

This section of the report provides a review of Regional Plans, and their rules concerning drinking water source protection. This is required so that, for each regional council, the relative impact of implementing source protection zones may be assessed.

A review of the planning rules from all 16 of the regional councils (some are unitary authorities) has been compiled to summarise the current approaches that each council has in place for source protection areas around drinking water supplies.

While this review has been restricted to rules in Regional Plans, we are aware that in some cases City/District Plans and Council Bylaws also include rules relating to drinking water source protection. We also note that regional council policies must also comply with the Drinking Water NES, and are used to guide decision making of consent applications. Regional council policies are not part of this review.

Councils have implemented the Drinking Water NES either via a Plan Change or through a full replacement of the Regional Plan. Some Councils have operative Regional Plans while others are at various stages of a proposed plan, from notification, through to hearing and appeal processes. When a council has an operative and a proposed plan, the rules in the proposed plan have legal effect and increasingly gain legal weight as it moves through the decision process until it becomes operative and supersedes the previous plan. Proposed plans will therefore guide resource consent decision making, and for this reason, proposed plans have also been reviewed.

The age of the Regional Plan for any particular council generally affects the level of detail in the plan regarding specific rules that target protecting water supplies. The older plans often have qualitative rules such as 'an activity is permitted provided the water quality downstream is not reduced', whereas the newer or proposed plans, or those with Plan Changes, generally have explicit consideration of

⁶ This section, and Appendix C have been externally reviewed by Sri Hall, Work Group Manager – Planning Engagement and Policy, WSP-Opus, and revised following that review.

protection zones where activities are excluded around water supplies. Several regional councils go so far as to designate specific source protection zones.

It must be kept in mind that regional councils use different terminology for similar things. Where one council uses 'community water supply', others use 'water supply', 'drinking water supply' or 'registered drinking water supply'. Likewise there are different focuses for unitary authorities in comparison to the regional councils for water supply protection as they have additional water supply, sewerage and stormwater responsibilities.

Appendix C contains summaries of how each council guides their management of water supply protection within their Regional Plans. Where possible, examples are provided of specific rules that each of the regional councils have applied to meet the Drinking Water NES requirements. These lists are not intended to be exhaustive, but a summary of the land use activities that are controlled for source protection zones. Table 1 is an overview of council rules and includes a subjective rating of how comprehensive each council's source protection zone rules are. As a guide:

- High = there are well defined protection zones and specific rules around water supplies,
- Medium = general source protection rules exist,
- Indirect = no quantitative zones defined around water supplies, but informed by water quality measures and consenting process.

Table 1. Summary of current regional council plan provisions relating to drinking water protection.

| Council | Summary of plan provisions relating to drinking water source protection | How Comprehensive | Explicit consideration of source protection zones? | Planning Documents |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|----------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| Northland | Effluent discharges 20 m separation from any water supply bore ^{1 2} . No discharge of tracers upstream of any registered drinking water supply ² . | Indirect | Partial | ¹ The Regional Plan (Soil and Water), ² Proposed Regional Plan 2017 |
| | ¹ https://www.nrc.govt.nz/resources/?url=/Resource-Library-Summary/Plans-and-Policies/Regional-plans/ ² https://www.nrc.govt.nz/contentassets/506f48db06744ab782c65e56acd19dde/proposed-regional-plan-september-2017-final-7-sept-2017.pdf | | | |
| Auckland | No quantitative areas around community water supplies, but there are designated Water Supply Management Areas that protect council owned supplies. | Medium | No | ¹ Auckland Council Regional Plan: Air, Land and Water, ² The Regional Plan: Farm Dairy Discharges |
| | ¹ https://www.aucklandcouncil.govt.nz/plans-projects-policies-reports-by-laws/our-plans-strategies/district-and-regional-plans/regional-plans/regional-plan-air-land-water/Pages/alw-plan-text.aspx ² http://www.aucklandcity.govt.nz/council/documents/regionalplans/farmdairydischarges/Auckland%20Regional%20Plan%20-%20Farm%20Dairy%20Discharges.pdf | | | |
| Waikato | No quantitative areas identified around water supplies. No offal holes within 100 m of a water supply bore. | Indirect | No | Waikato Regional Plan |
| | https://www.waikatoregion.govt.nz/council/policy-and-plans/rules-and-regulation/regional-plan/waikato-regional-plan/ | | | |
| Bay of Plenty | Qualitative rules but water supply catchments are defined and recognised in several sections of the Plan. | Medium | Partial | The Bay of Plenty Regional Natural Resources Plan |
| | http://www.gdc.govt.nz/freshwater-plan-proposed/ | | | |
| Gisborne | Qualitative and quantitative rules. No discharge upstream of a community water supply intake ^{1 2} . No discharge from pit latrines or discharge to land from deep bores closer than 1000m upflow or 150m down flow of a community drinking water supply ² . | Medium | Partial | ¹ Tairāwhiti Resource Management Plan, ² Proposed Freshwater Plan |
| | ¹ http://www.gdc.govt.nz/the-tairawhiti-plan/ ² http://www.gdc.govt.nz/freshwater-plan-proposed/ | | | |

| | | | | |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|---------|--------------------------------------------------------------------------------------------------------------------------------------------|
| Taranaki | General setback distances are specified for water supplies. Water supply buffer for discharges from septic tanks (>50m). Discharges from industry, farm effluent and piggery/poultry must be >50m of any water supply bore and >25m of surface water bodies. Seismic surveys >100m ¹ . | Medium | Partial | Regional Freshwater Plan |
| https://www.trc.govt.nz/council/plans-and-reports/strategy-policy-and-plans/regional-fresh-water-plan/ | | | | |
| Hawke's Bay | Exclusion distances not specified, qualitative approach informed by the NES. | Indirect | No | Hawke's Bay Regional Resource Management Plan |
| https://www.hbrc.govt.nz/assets/Document-Library/Plans/Regional-Resource-Management-Plan/View-RRMP/New-Volume-1.pdf | | | | |
| Manawatu-Wanganui | Specific Water Supply Zones are identified in the Water Management Zone classification which require a higher level of water quality consideration. Discharge of domestic wastewater at least 20m from any drinking water bore and surface water body ¹ . | Medium | Yes | One Plan |
| https://www.horizons.govt.nz/publications-feedback/one-plan | | | | |
| Wellington | Well-defined and specific quantitative source protection areas for surface water and groundwater sources in the Proposed Natural Resources Plan ³ . Contains specific rules about discharges in community supply protection areas. | High | Yes | ¹ Regional Freshwater Plan ² Regional Plan for Discharges to Land ³ Proposed Natural Resources Plan |
| http://www.gw.govt.nz/Regional-Freshwater-Plan/ http://www.gw.govt.nz/regional-plan-for-discharges-to-land/ http://www.gw.govt.nz/assets/Plans--Publications/Regional-Plan-Review/Proposed-Plan/Proposed-Natural-Resources-Plan-for-the-Wellington-Region-July-2015.pdf | | | | |
| Nelson | The emphasis is on protection of the city water supply sources. There are no specific rules for any other community water supplies. | Indirect | No | Nelson Resource Management Plan |
| http://nelson.govt.nz/environment/nelson-resource-management-plan/nelson-resource-management-plan-2/view-the-nrmp/download-the-nrmp-2/ | | | | |
| Tasman | No quantitative areas identified around water supplies. | Indirect | No | Tasman Resource Management Plan |

| | | | | | |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------|--------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| | | | | | http://nelson.govt.nz/environment/nelson-resource-management-plan/nelson-resource-management-plan-2/view-the-nrmp/download-the-nrmp-2/ |
| Marlborough | Specific groundwater protection zones are designated around water supplies ³ . | High | Yes | ¹ Wairau/Awatere Resource Management Plan ² Marlborough Sounds Resource Management Plan ³ Proposed Marlborough Environment Plan | https://www.marlborough.govt.nz/your-council/resource-management-policy-and-plans/wairau-awatere-resource-management-plan https://www.marlborough.govt.nz/your-council/resource-management-policy-and-plans/marlborough-sounds-resource-management-plan https://www.marlborough.govt.nz/your-council/resource-management-policy-and-plans/proposed-marlborough-environment-plan |
| West Coast | Specific rules for potable groundwater bores (generally >50m from a discharge). | Medium | Partial | Regional Land and Water Plan | http://www.wcrc.govt.nz/Documents/Resource%20Management%20Plans/Operative%20Land%20and%20Water%20Plan%20May%202014.pdf |
| Canterbury | Source protection zones are well defined, rules included in the Plan to not allow certain activities within these zones. | High | Yes | The Canterbury Land and Water Regional Plan | https://www.ecan.govt.nz/your-region/plans-strategies-and-bylaws/canterbury-land-and-water-regional-plan/ |
| Otago | Shows locations of community water supplies. Rules for buffer zones are general, for example 100m to a well used for domestic purposes. | Medium | Partial | ¹ Regional Plan:Waste For Otago ² Regional Plan: Water For Otago | https://www.orc.govt.nz/media/1516/regional-plan-waste-for-otago.pdf http://archive.orc.govt.nz/Publications-and-Reports/Regional-Policies-and-Plans/Regional-Plan-Water/#download |
| Southland | Specific source protection areas are well defined and rules specify what is not allowed in this zone ³ | High | Yes | ¹ Effluent Land Application Plan ² Water Plan ³ Proposed Southland Water and Land Plan | http://www.es.govt.nz/document-library/plans-policies-and-strategies/regional-plans/Pages/Effluent-Land-Application-Plan.aspx http://www.es.govt.nz/document-library/plans-policies-and-strategies/regional-plans/Pages/Water-Plan.aspx http://www.es.govt.nz/Document%20Library/Plans,%20policies%20and%20strategies/Regional%20plans/Southland%20Water%20and%20Land%20Plan/Proposed%20Southland%20Water%20and%20Land%20Plan%20Part%20A%20%20Decisions%20Version%20(4%20April%202018)%20PDF.pdf |

3.1 Summary

Drinking water source protection zones have been delineated for all drinking water sources that serve more than 100 people, following standard methods as described below.

For surface water sources, areas were delineated that describe a Catchment Zone (encompassing the entire catchment upstream of the abstraction point) and an Intermediate Zone (encompassing a 100 m buffered area extending 25 km upstream area). For groundwater sources, circular areas around the source sites were delineated that describe a Capture Zone (encompassing areas within a 50 year contaminant travel time) and a Protection Zone (encompassing areas within a one year contaminant travel time). The delineation methods have been selected from a range of standard methods set out for surface water³ and groundwater² source sites. The methods selected provide the highest detail possible given the data available and the need for national consistency.

For the purpose of assessing costs of source protection zone implementation in the Drinking Water NES, the groundwater Protection Zones (1 year travel time) and surface water Intermediate Zones have been selected as most relevant, and are the primary focus of this report. The supplementary data provided covers all zone types,

3.2 Identification and Classification of Drinking Water Source Sites

Source site data were obtained from the New Zealand drinking water register⁷ as of 1st July 2017.

Source sites were discarded if they lacked location information, if their locations were outside the New Zealand mainland or if they were rainwater collection sites. Figure 1 displays where the sites are located.

These data were saved as an ESRI point shapefile called DrinkingWaterSources (see Appendix A) and supplied as supplementary data.

The source sites were limited to those that supplied at least 100 people, and then classified into groundwater and surface water supplies. This was based on the source site identifier ("source code"), and description ("stDescription") fields for each site in the register. Later analysis considers an additional subset of these data of just those sites that supply at least 500 people, to align with the current Drinking Water NES regulations.

Source sites were classified as groundwater if their source code had a "G" prefix, or if they had a description of: "Well (unconfined)"; "Well (confined)"; "Spring" or "Ground Other type".

Source sites were classified as surface water if they had an "S" prefix of their source code, or if they had a description of: "Stream or River (direct)", "Impounding reservoir (off-river)", "Lake", "Stream or River (indirect)", "Water race (direct)" or "Water race (indirect)". This method of classification ensured that surface water taken via infiltration galleries was classified as a surface water take rather than a groundwater take.

These data were saved to two separate ESRI point shape files called DrinkingWaterSurfaceWaterSources and DrinkingWaterGroundwaterSources (Appendix A), and supplied as supplementary data.

⁷ <http://www.drinkingwater.esr.cri.nz/general/waterdatabase.asp>

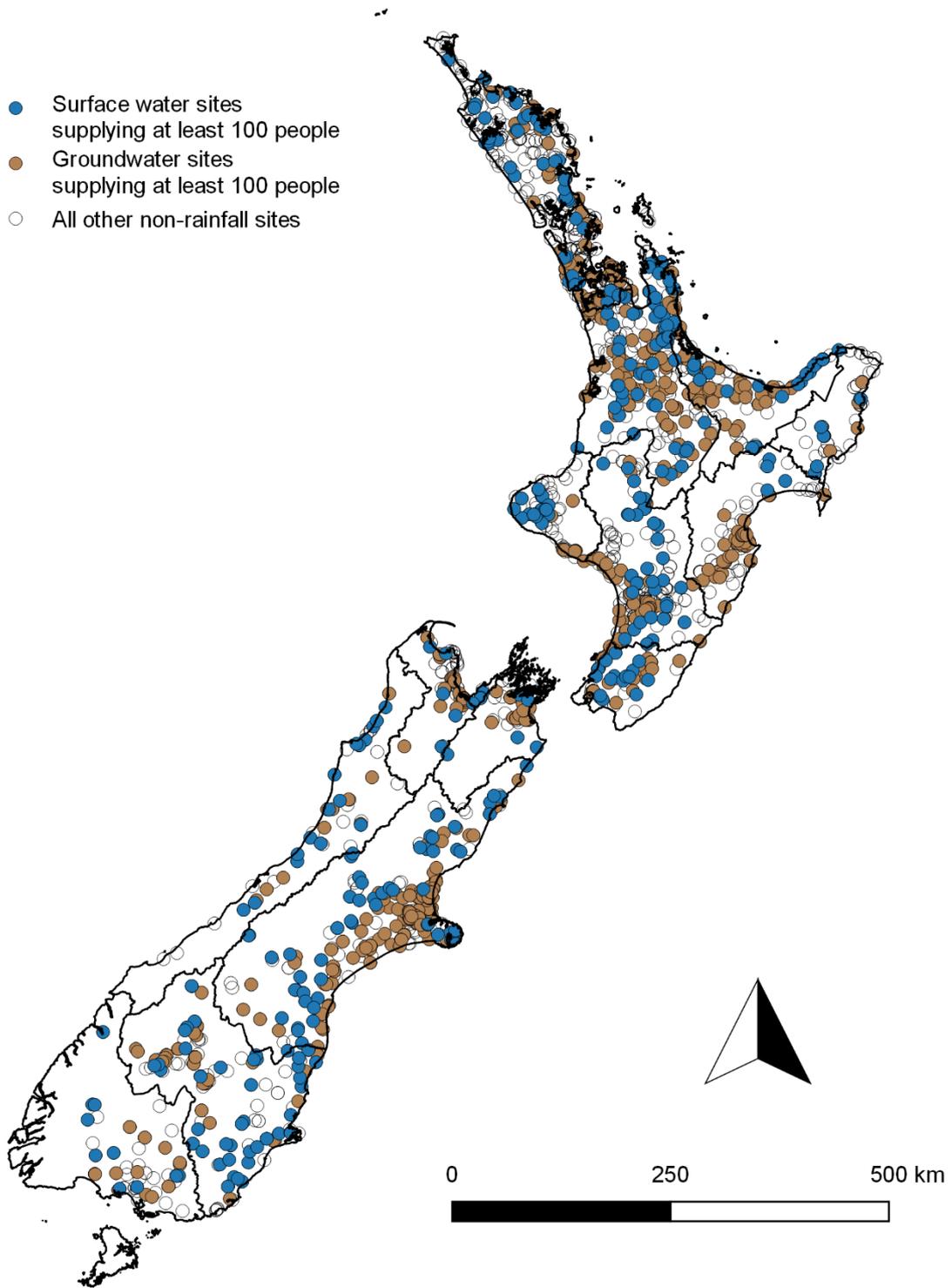


Figure 1. Drinking water source sites.

3.3 Surface Water Catchments and Intermediate Zones

Drinking water protection zones for the surface water sites (Figure 2) were prepared following the methods described in “Methodology for Delineating Water Catchments”³. In particular, two types of zones were prepared for each site:

1. The entire upstream catchment.
2. An Intermediate Zone that extends 25 km upstream and buffered 100 m landward allowing for attenuation and dispersion within the flowing water, with additional attenuation in the saturated and unsaturated zones underlying the buffer strip. The 25 km is the equivalent of 7 hours travel time for a flow of less than 1 m/s.

The River Environment Classification V2.4 (RECV2.4)⁸ digital river network was used to determine the upstream catchments. The REC reach closest to the drinking water source site was originally selected as the lowest reach of the catchments to be delineated. Where location information was imprecise, or source sites were adjacent to multiple reaches, the nearest reach was sometimes not the correct one. A table of source site to REC reach ID's was manually created in order to override the automatically selected nearest reach. This override table is provided in Appendix E (Table 15). Where the upstream catchments intersected lakes, as defined by the Land Information New Zealand (LINZ) 1:250,000 lake data⁹, the lake area was added to the catchment.

To account for rivers with wide beds (e.g. braided rivers), the 100 m buffering for the Intermediate Zones was from the edge of the riverbed areas as defined within the Fundamental Soils Layer (FSL)¹⁰.

The surface water protection zones were saved to two ESRI polygon shape files called SurfaceWaterSourceProtectionZones-EntireCatchments and SurfaceWaterSourceProtectionZones-IntermediateZones (Appendix A), and supplied as supplementary data.

In addition, the REC V2 river reaches that were used in creating the surface water protection zones have been saved as ESRI line shape files. Each river reach has two attributes, the REC reach ID, and the Drinking Water Register Source Code. Where a river reach is associated with multiple drinking water sources, it is provided multiple times. These files are called SurfaceWaterSourceCatchmentsRECR reaches and SurfaceWaterSourceIntermediateZoneRECR reaches (Appendix A), and supplied as supplementary data.

⁸ Snelder, T., Biggs, B., Weatherhead, M., 2010. New Zealand river environment classification user guide, 2nd ed. Ministry for the Environment, Wellington.

https://www.niwa.co.nz/static/web/nzRec2_v4.gdb.zip

⁹ <https://data.linz.govt.nz/layer/50168-nz-lake-polygons-topo-1250k/>

¹⁰ <https://data.mfe.govt.nz/layer/52766-fundamental-soil-layers-new-zealand-soil-classification/>

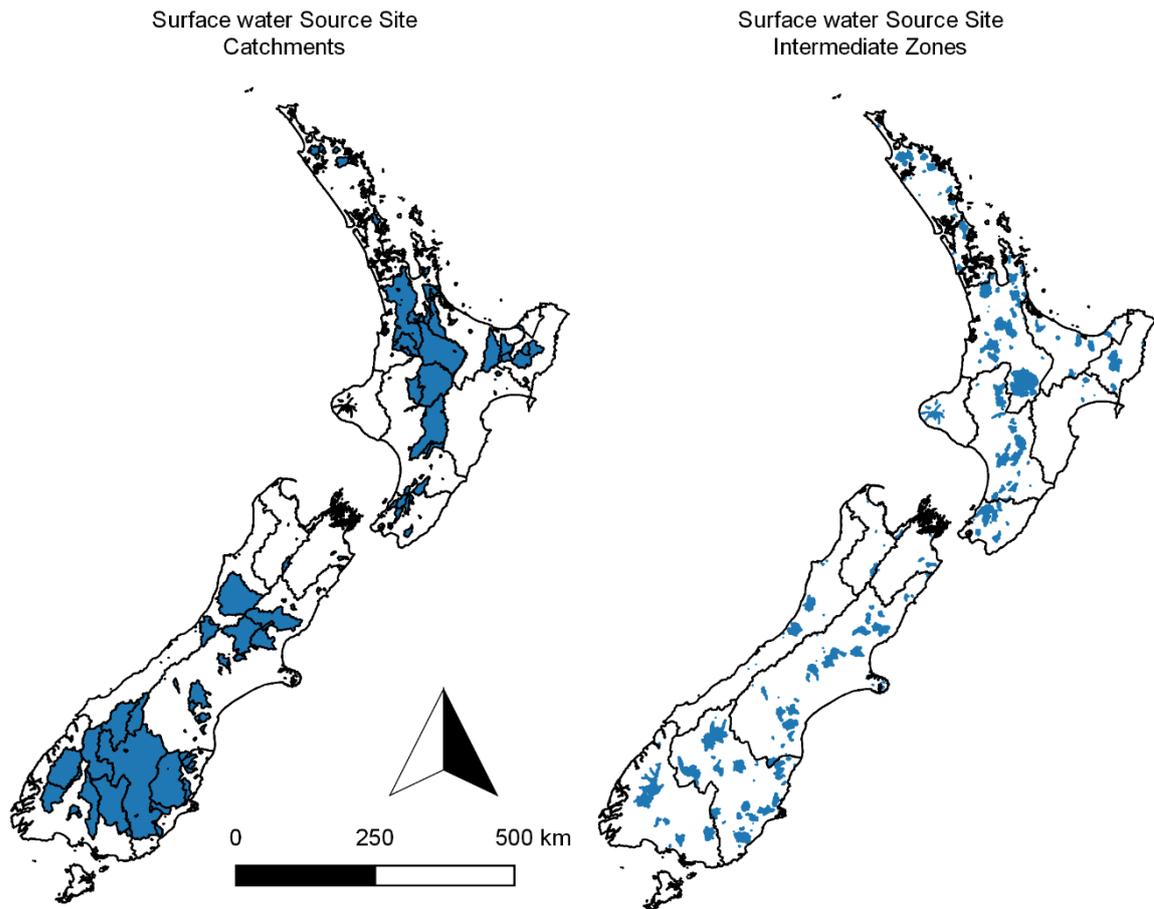


Figure 2. Surface water protection zones for drinking water source sites supplying more than 100 people.

3.4 Groundwater Protection Zones

Groundwater protection zones (Figure 3) were prepared following the methods described in “Capture Zone Delineation”³. In particular, the “Calculated Fixed Radius” was used to prepare two types of zones for each site:

1. Capture Zone (50 year travel time)
2. Protection Zone (1 year travel time)

The radius of the zones for sources in confined aquifers was calculated using:

$$r = \sqrt{\frac{Qt}{\pi nb}} \quad (1)$$

For sources in unconfined aquifers, the Capture Zone radius used Equation (2), while the Protection Zone used the smaller radius calculated from Equation (1), and Equation (2).

$$r = \sqrt{\frac{Q}{\pi \times \text{recharge}}} \quad (2)$$

As described in the groundwater source protection zone delineation guidelines², this avoids the conceptual discontinuity of the Protection Zone being smaller than the Capture Zone.

In Equations (1) and (2), Q is the abstraction rate from the source [L^3/T], t is travel time [T], n is the effective porosity¹¹ of the aquifer, b is the screen length [L], and *recharge* is the rate that water from the land surface enters the groundwater [L/T].

The travel time (t) was set to 50 years or 1 years for the Capture Zone and Protection Zone respectively.

Screen lengths (b) were set to 3 m unless the source sites were described as “Wells (confined)”, in which case the screen length was set to 6 m. These lengths were selected as they are conservative, but not uncommon lengths.

Effective porosity (n) was set based on assigning recommended values from Moreau *et al* (2014)² to the aquifer lithologies given in the Aquifer Map of New Zealand¹². The lithology-to-effective porosity lookup table is provided in Appendix E (Table 16). Source sites that were not within the mapped aquifers were allocated a default effective porosity of 0.0032 (the most conservative value provided by Moreau *et al.*, (2014).

The abstraction rate assigned to a source was based on the population served by the associated plant. If a source was the only one associated with a plant, then the rate of abstraction was set to the population served by the plant multiplied by 260 litres per day (the average New Zealand domestic water usage¹³). If a source went to a plant with multiple sources, then each source was allocated the population served by the plant divided by one less than its number of sources (to allow for redundancy in the supply network). The source abstraction rate was then estimated as the population served by the source multiplied by 260 litres per day. For sources associated with a plant that had multiple, mixed groundwater and surface water sources, then the abstraction rate was set to the lesser of 260 litres per person per day or 200 m³day⁻¹.

Aquifer recharge was estimated at 30% of the mean annual rainfall¹⁴, based on a review of default recharge estimation methodologies throughout New Zealand¹⁵.

The assumptions made in applying the protection zone radii calculations, and the sensitivity of the radii to each of the equations parameters have been assessed in Appendix B. The findings indicate that the assumptions are not unreasonable for a national assessment, and that of the various parameters, the effective porosity has the largest effect on zone radii. The groundwater delineation guidelines² provide an effective porosity for alluvial gravels of 0.0032 based on work carried out in Canterbury¹⁶. It is assumed for this study that this value is valid for all gravels.

There may be differences between the zones defined by Regional Councils, and the results of this work. There are two main reasons for this. Firstly, there are differences between the data contained in the Drinking Water Register and Regional Council data regarding the location of drinking water abstraction points that may affect the location of the zones defined in the national-scale assessment. Secondly, this approach was a broad-scale national assessment, using a relatively simple approach that was practical to apply on a national scale. Individual regional councils may employ different methods for delineating source protection zones, and the shape and size of their zones may differ from the zones used for the purpose of this national-scale assessment.

¹¹ Effective porosity (also called transport porosity) is the portion of the aquifer void space that water flows and contaminants flow through. Note that this is different to the total porosity.

¹² Moreau, M., Bekele, M., 2015. Groundwater component of the Water Physical Stock Account (WPSA) (GNS Consultancy Report No. 2014/290). GNS.

¹³ Water New Zealand, Undated. National Performance Review 2016-2017 Volume 1: National Overview. Water New Zealand, Wellington.

¹⁴ <https://data.mfe.govt.nz/layer/89420-average-annual-rainfall-2016/>

¹⁵ Waikato: <https://www.waikatoregion.govt.nz/environmental-information/environmental-indicators/groundwater/flow5a-report/flow-5a-techinfo/>

Canterbury: Aitchison-Earl, P., Scott, D., Sanders, R., 2004. Groundwater Allocation Limits: Guidelines for the Canterbury Region (No. U04/02). Environment Canterbury, Christchurch.

Southland: Hughes, B., Wilson, K., Rissmann, C., Rodway, E., 2016. Physiographics of Southland: Development and application of a classification system for managing land use effects on water quality in Southland (Technical Report No. NO 2016/11). Environment Southland.

¹⁶ Dann, R., Bidwell, V., Thomas, S., Wöhling, T., Close, M., 2010. Modeling of Nonequilibrium Bromide Transport through Alluvial Gravel Vadose Zones. *Vadose Zone Journal* 9, 731–746. <https://doi.org/10.2136/vzj2009.0127>

These data were saved to two separate ESRI polygon shapefiles called GroundwaterCaptureZones and GroundwaterProtectionZones (Appendix A) and supplied as supplementary data.

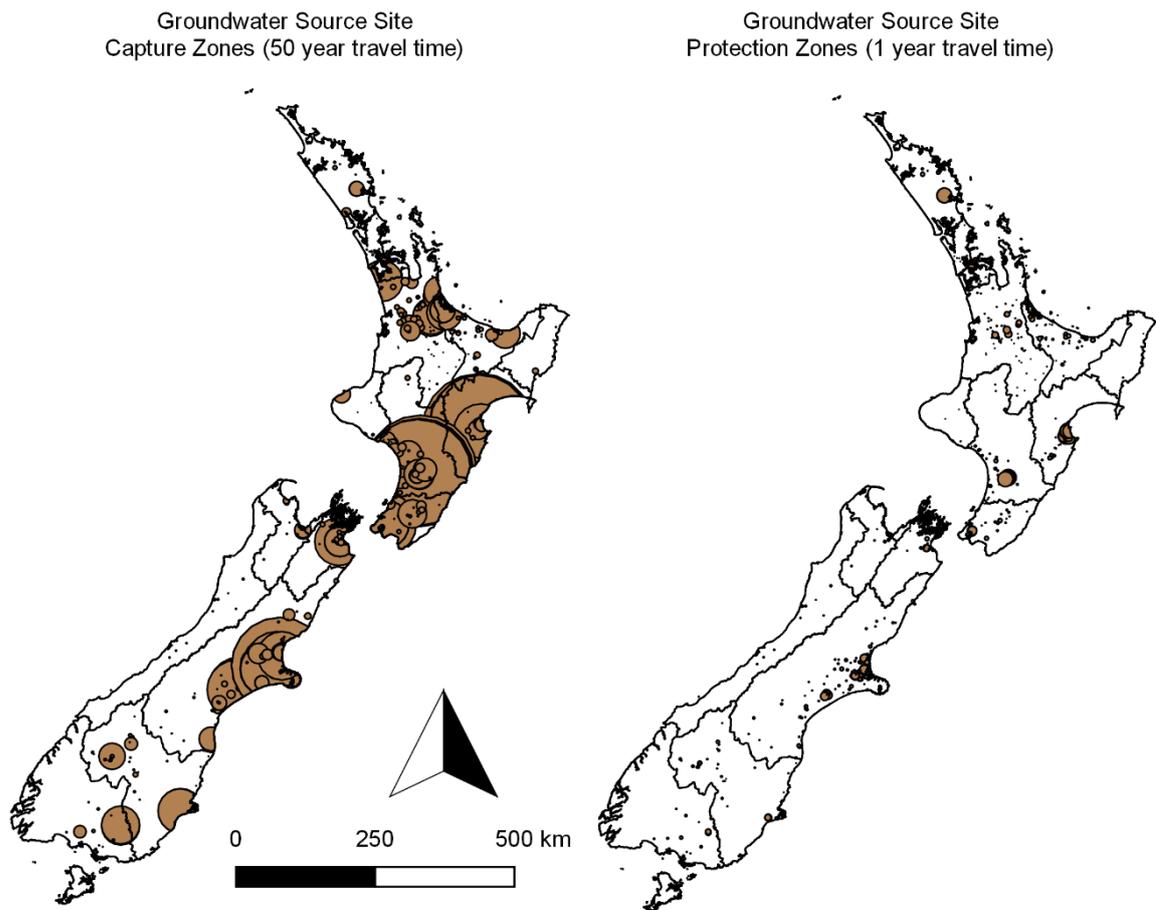


Figure 3. Surface water and ground water protection zones for drinking water source sites supplying more than 100 people.

4.1 Summary

Canterbury has nearly twice as much land area (178,000 ha) assigned to Groundwater Protection Zones (1 year travel time) as any other region, constituting nearly 30% of the national total (665,000 ha). This is likely to be a result of the high number of high-yielding groundwater sites with low effective porosity that supply most communities across Canterbury.

Waikato and Otago have the greatest areas in surface water Intermediate Zones (160,000 ha) with 700,000 ha nationally.

The land cover of groundwater source protection zones (1 year travel time) is dominated by high-producing grassland (59% nationally). Regionally, the exceptions are Auckland, where built areas dominate; Marlborough, where orchards and vineyard cover the most area; Gisborne, where croplands dominate and the West Coast where areas assessed as low risk to drinking water quality (see Table 3) are the main land cover.

For surface water intermediate zones, the primary land cover has low risk to drinking water quality (57%). Regionally, the exceptions are Northland, Auckland, Gisborne, Manawatu-Wanganui, and Taranaki, which are all dominated by high-producing grassland. Canterbury is evenly divided between low-risk land cover and high-producing grassland.

4.2 Regionalised Zones

One of the purposes of this study was to understand impacts of implementation of source protection zones at a regional level. To enable this, within each region, the individual source site zones were combined. This was repeated for each zone type, e.g. for the groundwater Protection Zones and Capture Zones, the surface water Intermediate Zones and catchments. An additional subset of each of the regionalised zone types was generated whereby only those sites that supplied more than 500 people were combined. The 500 person limit aligns with the current threshold in the Drinking Water NES. This resulted in eight different zone types. These data were saved to eight separate ESRI polygon shapefiles described in Table 2, listed in Appendix A, and supplied as supplementary data.

Table 2. Various protection zone types prepared as regionalised summaries.

| Zone type | Plant population minimum size | ESRI Spatial data name |
|----------------------------------|-------------------------------|------------------------|
| Surface Water Catchments | 100 | RegionalisedSWC |
| Surface Water Intermediate Zones | 100 | RegionalisedSWIZ |
| Surface Water Catchments | 500 | RegionalisedSWCGT500 |
| Surface Water Intermediate Zones | 500 | RegionalisedSWIZGT500 |
| Groundwater Capture Zone | 100 | RegionalisedGWCZ |
| Groundwater Protection Zone | 100 | RegionalisedGWPZ |

| | | |
|-----------------------------|-----|-----------------------|
| Groundwater Capture Zone | 500 | RegionalisedGWCZGT500 |
| Groundwater Protection Zone | 500 | RegionalisedGWPZGT500 |

4.3 Land Cover data

Land cover information was sourced from the Land Cover Database Version 4 (LCDBV4)¹⁷. The land cover classes were reclassified so that those that were considered to be of low risk to drinking water quality were combined into a single class called “low risk” (Table 3). This reduced the land cover from 33 classes down to 13.

Table 3. LCDBV4 classes re-classed as low risk to drinking water quality.

| LCDBV4 Class No. | LCDBV4 Class Name | Low Risk? | LCDBV4 Class No. | LCDBV4 Class Name | Low Risk? |
|------------------|----------------------|-----------|------------------|------------------------|-----------|
| 1 | Built up | | 44 | Depleted Grassland | |
| 2 | Urban Park | | 45 | Herbaceous Freshwater | ✓ |
| 5 | Transport Inf | | 46 | Herbaceous Saline | ✓ |
| 6 | Mines & Dumps | | 47 | Flaxland | ✓ |
| 10 | Sand & Gravel | ✓ | 50 | Fernland | ✓ |
| 12 | Landslide | ✓ | 51 | Gorse & Broom | ✓ |
| 14 | Snow & Ice | ✓ | 52 | Manuka & Kanuka | ✓ |
| 15 | Alpine Grass | ✓ | 54 | Broadleaved Indig | ✓ |
| 16 | Gravel & Rock | ✓ | 55 | Sub Alpine Shrubland | ✓ |
| 20 | Lake & Pond | ✓ | 56 | Mixed Exotic Shrubland | ✓ |
| 21 | River | ✓ | 58 | Grey Scrub | ✓ |
| 22 | Estuarine | ✓ | 64 | Forest Harvested | |
| 30 | Cropland | | 68 | Deciduous Hardwood | |
| 33 | Orchard & Vineyard | | 69 | Indigenous Forest | ✓ |
| 40 | High Producing Grass | | 70 | Mangrove | ✓ |
| 41 | Low Producing Grass | | 71 | Exotic Forest | |
| 43 | Tussock Grassland | ✓ | | | |

For each of the eight source protection zone types, the total in-zone area of each of these land classes within each regional council area¹⁸ was found. This information was then summarised by regional council area.

By way of an example, Figure 4 displays the break-down and area of the different land cover classes within groundwater Protection Zones (1 year travel time), and surface water Intermediate Zones for drinking water sources that supply at least 100 people. The distribution of land cover types was nearly

¹⁷ <https://data.mfe.govt.nz/layer/52764-land-cover-database-v4-0-class-orders/>

¹⁸ <https://datafinder.stats.govt.nz/layer/92204-regional-council-2018-generalised/>

identical for the sites that supplied at least 500 people, although the amount of overall area was reduced as these are a subset of the zones that supply at least 100 people.

Land cover of the eight different zone types has been saved to ESRI polygon shapefiles described in Table 2, listed in Appendix A, and supplied as supplementary data.

The land cover break-down for all the different types of protection zones is provided in the supplementary data as an excel spreadsheet called SourceProtectionZoneLandCoverSummaryTables (Appendix A).

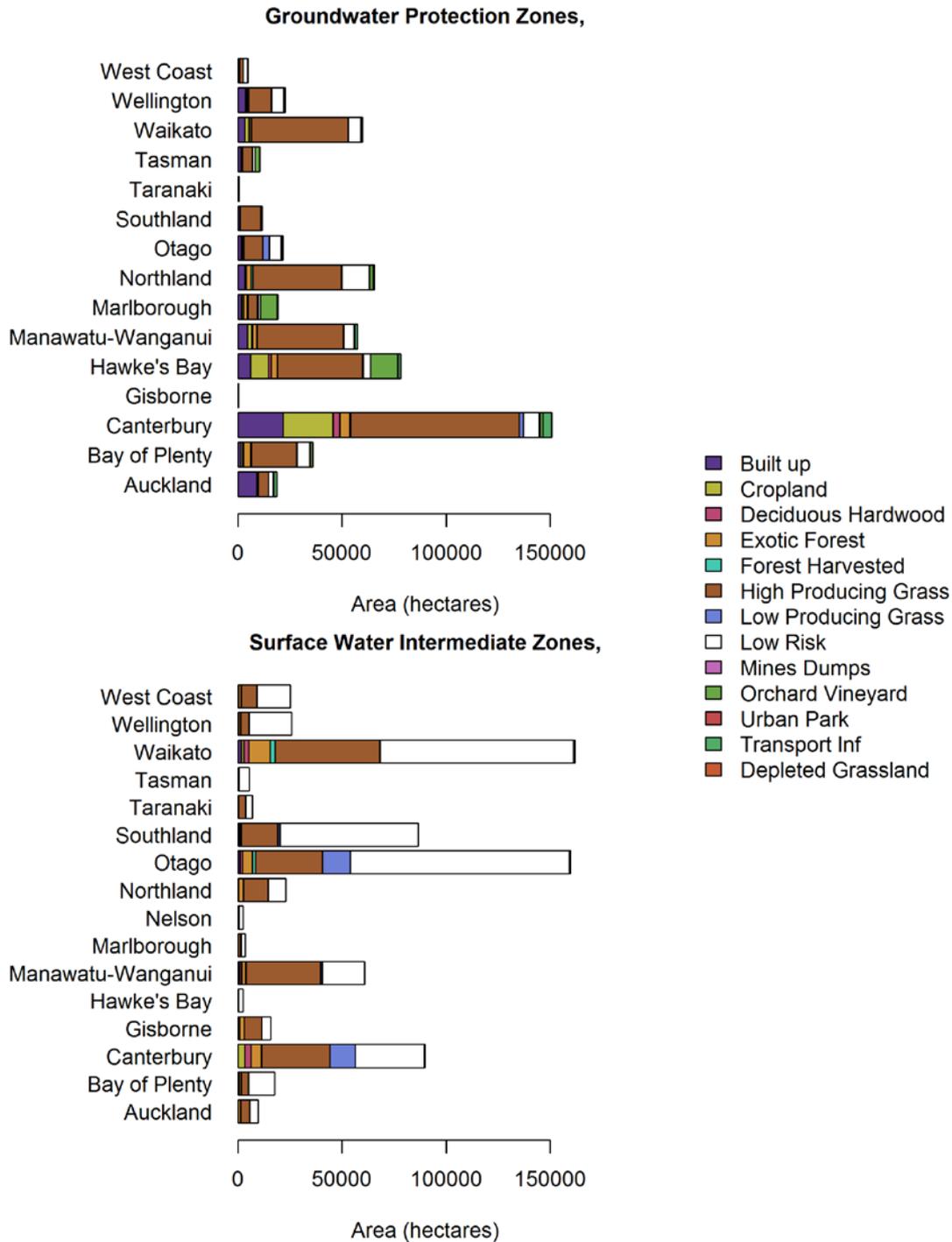


Figure 4. Drinking water source zone land cover for each region for groundwater protection zones and surface water Intermediate zones for source sites that supply at least 100 people.

4.4 Discharge Consents, Land Use Consents, Water Take Consents and HAIL Sites

Consented activities and Hazardous Activities and Industries List (HAIL) sites potentially pose risks to drinking water quality if they were in source protection zones. For example, some discharge consents are for contaminants, some land use consents are for activities associated with bacteria, some water takes are associated with land uses that present a risk, or may, through reducing stream flow rates, affect the concentration of contaminants, while some HAIL sites may leach chemicals. Quantifying the number of these sites within source protection zones in each region is a first step in quantifying the risk that they may pose, and the cost of limiting that risk.

Resource consent data and Hazardous Activities and Industries List (HAIL) data were obtained from online databases or directly from Regional Councils. Where possible the data were filtered to only include those data that were currently valid and that related to water quality. For example air discharge consents were generally discarded, and HAIL sites that had a "Status" of having been verified as non-HAIL, remediated, or entered in error, were removed. Water take consent data were obtained from the online MfE database¹⁹. Any sites without location information, or that plotted off the New Zealand coast, were discarded.

These data were saved to four separate ESRI point shapefiles called DischargeConsents, LandUseConsents, WaterTakeConsents, and HAIL (Appendix A), and are supplied as supplementary data.

The number of sites (broken down into site types) within each regionalised zone type (as in Table 3) was found. The water take consent data was further broken down into sub-categories (i.e. Industrial, Irrigation, Hydro, Drinking and Other). For other Resource Consent types the classification was not consistent across regions, and further work would be required to create consistent sub-categories. These data were saved as an excel spreadsheet called SourceProtectionZoneConsentSummaryTables (Appendix A), and supplied as supplementary data.

¹⁹ <https://data.mfe.govt.nz/table/53613-primary-use-and-source-of-consented-freshwater-takes-201314/data/>

5.1 Summary

The aim of this project was to assess the implications of implementing source protection zones. The relative cost of implementing source protection zones in each region was separated into two components;

1. the relative cost of changing land use (as determined from land cover) within source protection zones, to limit the effects on drinking water quality;
2. the relative cost associated with consent and HAIL sites within source protection zones, to limit their impact on drinking water quality.

Based on land cover, Canterbury is assessed as having the highest potential impact in terms of risk and mitigation cost of implementing the groundwater protection (1 year travel time) zones. Accounting for how comprehensive the planning rules are, Hawke's Bay's total risk (but not mitigation cost) is the greatest.

For implementing surface water Intermediate Zones, Waikato is assessed as having the highest potential impact under all scenarios.

Based on discharge and water take consents, Canterbury remains the region with the highest risk ranking for groundwater zones, and Waikato for surface water zones.

The potential impacts of different land cover types on drinking water quality were assessed using two approaches, a risk-based approach, and a mitigation-cost approach. A subjective risk weighting and relative cost of mitigation (per hectare) was determined for each land cover type. The total risk and cost was then found for the protection zones within each region. Two scenarios were assessed; Scenario 1: a conservative assessment, whereby land use activities were assumed to be at the riskier end of the scale, and Scenario 2: a mid-level risk, whereby land use activities were assumed to be at an average state. The risk totals for each region were then further adjusted, firstly according to how comprehensive the Regional Council rules were with regard to source protection zones and secondly according to a previous assessment²⁰ of the percentage of water distribution zones that were compliant with the bacterial and protozoal standards in the New Zealand Drinking Water Standards as of 2016-2017²⁰.

The consent/HAIL risk weightings were derived by allocating a risk weighting after consideration of available sub-categories. These weightings were combined with the number of sites within the source protection zones in a region, to establish a total risk estimate. In a similar manner to land cover, two risk weighting scenarios were applied; Scenario 1: a conservative scale, and Scenario 2: an average scale. The risk totals for each region were then further adjusted as per the land cover assessment, firstly according to how comprehensive the Regional Council rules were, and secondly according to a previous assessment²⁰ of the percentage of water distribution zones that were compliant with the Drinking-water Standards for New Zealand .

The differing criteria for defining HAIL sites and requiring land-use consents between regional councils has the potential to skew the cost assessment. For this reason, comparative assessment is focussed on the more consistent discharge and water take consents.

²⁰ Mattingley, B., Nokes, C., 2018. Changes in New Zealand drinking-water quality since 2005 (Confidential Client Report No. FW18024). The Institute of Environmental Science and Research Limited (ESR) for the Ministry for the Environment.

5.2 Land Cover

5.2.1 Land Cover Risk Weighting

This section assesses the risk to drinking water based on the land use activities within the defined source protection zones. The land cover classes have been assessed for their relative risk, per hectare, to drinking water supplies (Table 4). The risk weighting was based on a subjective expert assessment by Neal Borrie, Aqualinc's Senior Environmental Engineer. No distinction has been made between the type of drinking water source (e.g. groundwater, surface water, source size, plant treatment), or the location of the land cover with respect to the source (except that it is within the related zone). Two risk scenarios were applied; Scenario 1: Conservative and Scenario 2: Mid-level. The Conservative scenario assumes that land use activities are poor with respect to drinking water quality risks, whereas the Mid-Level scenario assumes that land use activities are average, with respect to drinking water quality. The risk weighting was prepared by initially ranking the different land covers in terms of risk to drinking water. Starting from the lowest, least risky, ranked land cover, the weighting was estimated based on how much more risky the land use associated with a land cover was likely to be compared to the land cover ranked beneath it. This converted the ranking to a relative, open ended, dimensionless weighting.

Table 4. Land cover relative drinking water risk weighting per hectare.

| Land Cover | Assumed Land Use Activity | Primary Contaminant: A = Aesthetic, B = Bacterial, C = Chemical. | Risk type: D = Diffuse, E = Event. | Scenario 1: Conservative Risk Weighting | Scenario 2: Mid-Level Risk Weighting |
|-------------------------|------------------------------------------------|---------------------------------------------------------------------------|------------------------------------------|--------------------------------------------------|-----------------------------------------------|
| Built up | Septic tanks | B, C | E | 3 | 2 |
| Cropland | Sprayed and irrigated | A, B, C | D | 7 | 1 |
| Deciduous Hardwood | Steep, erosion prone, heavily tracked | A | E | 1 | 1 |
| Exotic Forest | Steep, erosion prone, heavily tracked | A | E | 2 | 2 |
| Forest Harvested | Steep, erosion prone, heavily tracked | A | E | 4 | 3 |
| High Producing Grass | Intensive Dairy Farm, sprayed and irrigated | B,C | D | 11 | 3 |
| Low Producing Grass | Sheep and beef, not irrigated | B | D | 4 | 3 |
| Low Risk | No risk activities | | | 0 | 0 |
| Mines & Dumps | Dump | A, C | D | 22 | 10 |
| Orchard & Vineyard | Sprayed and irrigated | C | D | 9 | 4 |
| Transport Inf | High use road | A, B, C | E | 3 | 2 |
| Urban Park | Minimal irrigation | C | D | 2 | 1 |
| Depleted Grassland | Sheep and beef, low stocking rate | A,B | D | 2 | 1 |

In addition to considering the relative risk associated with each land cover type, an assessment was made of the relative cost of mitigating any drinking water risks. These relative costs were estimated by Stuart Ford, from The Agribusiness Group, an Agricultural and Resource Economist who has over 30 years' experience working in the area of the Primary Industries in New Zealand, and has extensive experience of the land management systems across the land uses to be evaluated.

The representative land use characteristics assumed when estimating the mitigation costs, for each land cover, together with the relative cost associated with Scenario 1: Conservative, and Scenario 2: Mid-Level, are shown in Table 5. In a similar manner to the risk weighting, the mitigation costs are relative, open ended, weightings on an arbitrary dimensionless scale.

Table 5. Relative mitigation cost estimates per hectare for different land covers.

| Land Cover | Scenario 1: Conservative, assumed characteristics | Scenario 2: Mid-Level, assumed characteristics | Scenario 1: Conservative Cost Weighting | Scenario 2: Mid-Level Cost Weighting |
|----------------------|-----------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|--------------------------------------|
| Built up | Individual septic tanks. Large areas of sections. | Sewerage systems. Small areas of sections. | 250 | 50 |
| Cropland | Poor practices for application of chemicals and animal control. Large areas of exposed soils left fallow. | Good practices for application of chemicals and animal control. Very quick return of paddocks to adequate cover after harvest. | 0.325 | 0.025 |
| Deciduous Hardwood | | | 0 | 0 |
| Exotic Forest | | | 0 | 0 |
| Forest Harvested | Large areas of clear felled forest not replanted. Poor practice in terms of meeting the forest harvesting guidelines. | Small areas of clear felled forest not replanted. Good practice in terms of meeting the forest harvesting guidelines. | 1 | 0.5 |
| High Producing Grass | Poor practices for application of fertilisers and animal control. | Good practices for application of fertilisers and animal control. | 0.15 | 0.05 |
| Low Producing Grass | Poor animal control. | Good animal control. | 0.5 | 0.25 |
| Low Risk | | | 0 | 0 |
| Mines&Dumps | Poor bunding of danger areas. Large areas of exposed work faces. | Good bunding of danger areas. Small areas of exposed work faces. | 20 | 5 |
| Orchard&Vineyard | Poor practices for application of chemicals. | Good practices for application of chemicals. | 1.5 | 0.5 |
| Transport Inf | Poor bunding of danger areas. Poor work practices. | Good bunding of danger areas. Good work practices. | 55 | 15 |
| Urban Park | | | 0 | 0 |
| Depleted Grassland | Large areas of exposed soil. | Small areas of exposed soil. | 0.25 | 0.05 |

For each region a total land cover risk weighting and cost was calculated. This was achieved by multiplying the land cover risk weightings and costs by the land cover areas.

The regional total risks, and total costs were then adjusted according to the subjective rating given to each regional council based on how comprehensive their drinking water source protection rules were (Table 1). A council with a “High” rating had their total weightings multiplied by 1/10 (i.e. divided by 10). A “Medium” rating, had their weightings multiplied by 2/10 (i.e. divided by 5). An “Indirect” rating had their weightings multiplied by 3/10 (i.e. divided by 3.33).

An alternative regional weighting adjustment was also applied based on the percentage of distribution zones within each region that, in 2016-17, were compliant with the bacterial and protozoal standards in the Drinking Water Standards of New Zealand²⁰.

Examples of the risk rankings for the land-cover-based, rules-adjusted Scenario 2: Mid-Level are shown in Figure 5.

Examples of the cost rankings for the land-cover-based, rules-adjusted, Scenario 2: Mid-Level are shown in Figure 6.

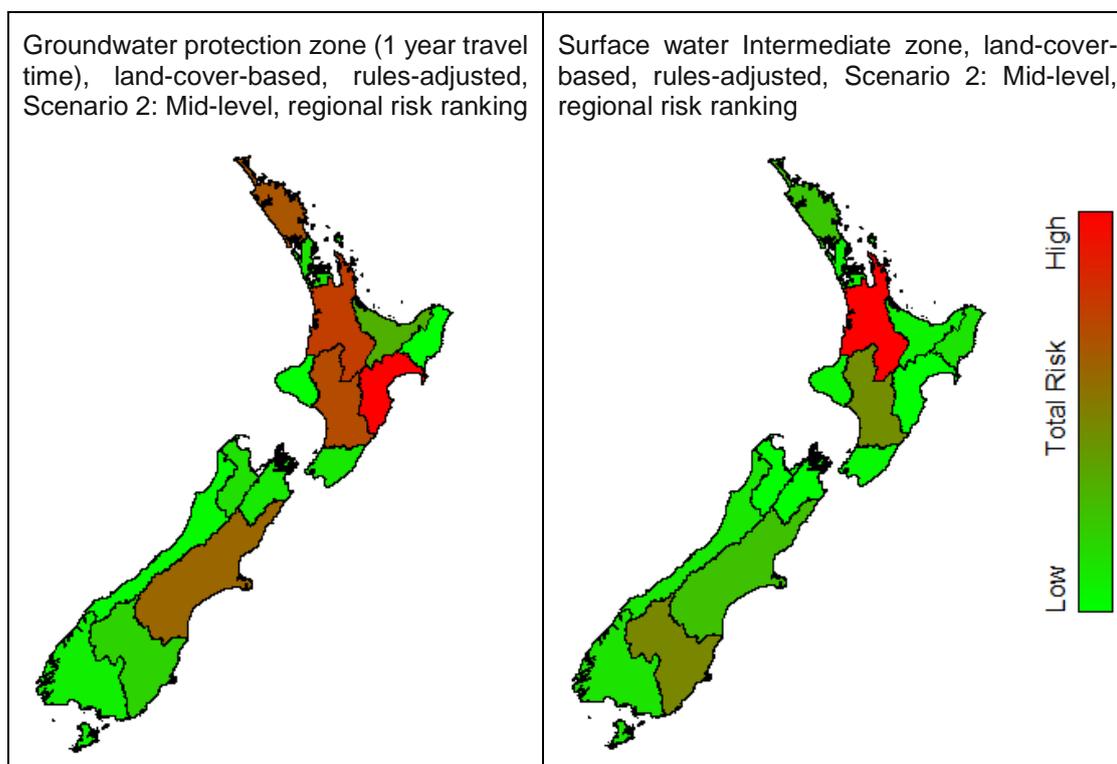


Figure 5. Total regionalised source protection zone land-cover-based drinking water risk ranking.

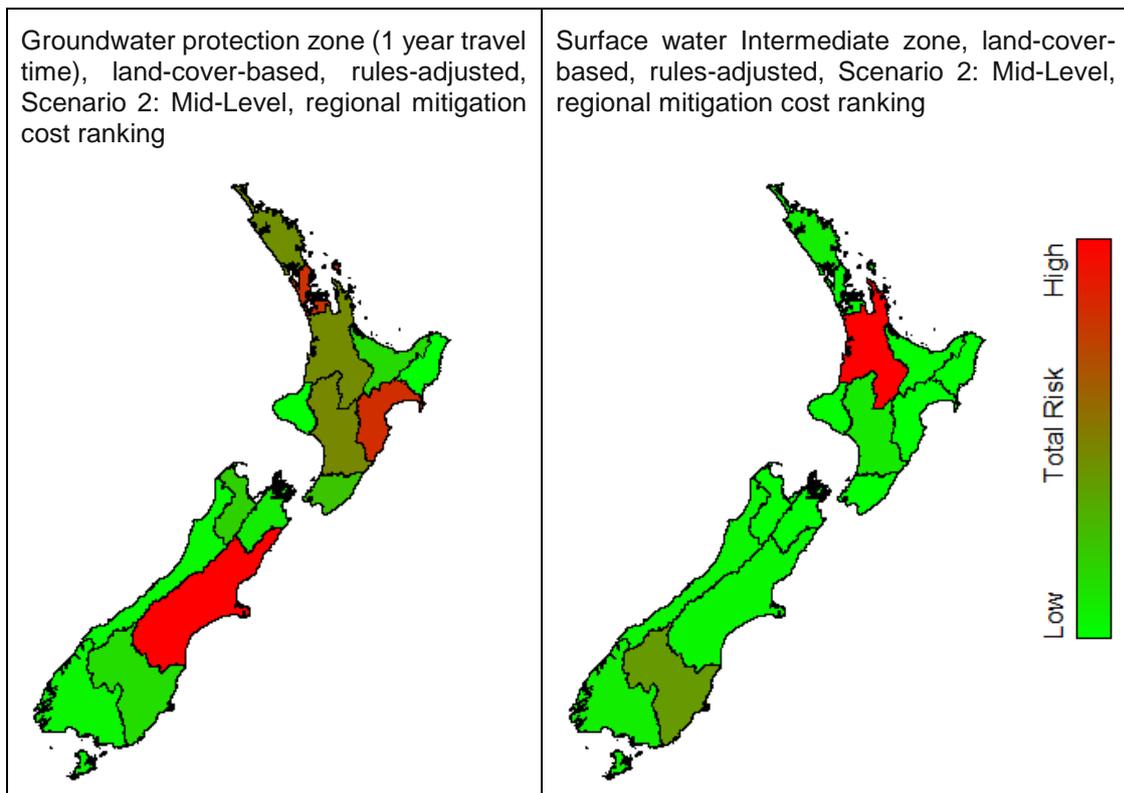


Figure 6. Total regionalised source protection zone land-cover-based drinking water mitigation cost ranking.

A selection of rankings of regions based on the land cover risk and mitigation costs for the groundwater Protection zones (1 year travel time) and surface water Intermediate zones, are provided in Table 6 and Table 7, respectively. Note that Nelson has no groundwater Protection Zones. The full suite of ranking scenario combinations are provided as supplementary data as an excel spreadsheet called RegionalSPZLandCoverCosts (Appendix A).

Table 6. Regional rankings of land cover-based risk and mitigation cost assessment for groundwater Protection Zones (1 year travel time). Regions are ranked on a linear scale from highest risk/cost (red) to lowest risk/cost (green).

| Scenario 1: Mid-Level risk ranking | Scenario 1: Mid-Level mitigation cost ranking | Council Rules Weighted Scenario 1: Mid-Level risk ranking | Council Rules Weighted Scenario 1: Mid-Level mitigation cost ranking | Council DWSNZ Compliance Weighted Scenario 1: Mid-Level risk ranking | Council DWSNZ Compliance Weighted Scenario 1: Mid-Level mitigation cost ranking |
|------------------------------------|-----------------------------------------------|-----------------------------------------------------------|----------------------------------------------------------------------|----------------------------------------------------------------------|---------------------------------------------------------------------------------|
| Canterbury | Canterbury | Hawke's Bay | Canterbury | Canterbury | Canterbury |
| Manawatu-Wanganui | Auckland | Waikato | Hawke's Bay | Hawke's Bay | Hawke's Bay |
| Hawke's Bay | Hawke's Bay | Manawatu-Wanganui | Auckland | Manawatu-Wanganui | Manawatu-Wanganui |
| Waikato | Manawatu-Wanganui | Northland | Manawatu-Wanganui | Waikato | Waikato |
| Northland | Wellington | Canterbury | Waikato | Bay of Plenty | Wellington |
| Bay of Plenty | Waikato | Bay of Plenty | Northland | Northland | Marlborough |
| Wellington | Northland | Otago | Wellington | Marlborough | Northland |
| Otago | Marlborough | Tasman | Tasman | Southland | Tasman |
| Marlborough | Bay of Plenty | Auckland | Bay of Plenty | Otago | Bay of Plenty |
| Southland | Otago | Wellington | Otago | Tasman | Otago |
| Auckland | Tasman | Marlborough | Marlborough | Wellington | Southland |
| Tasman | Southland | Southland | Southland | West Coast | Auckland |
| West Coast | West Coast | West Coast | West Coast | Auckland | West Coast |
| Gisborne | Taranaki | Gisborne | Taranaki | Gisborne | Gisborne |
| Taranaki | Gisborne | Taranaki | Gisborne | Taranaki | Taranaki |

Table 7. Regional rankings of land cover-based risk and mitigation cost assessment for surface water Intermediate Zones. Regions are ranked on a linear scale from highest risk/cost (red) to lowest risk/cost (green).

| Scenario 1: Mid-Level risk ranking | Scenario 1: Mid-Level mitigation cost ranking | Council Rules Weighted Scenario 1: Mid-Level risk ranking | Council Rules Weighted Scenario 1: Mid-Level mitigation cost ranking | Council DWSNZ Compliance Weighted Scenario 1: Mid-Level risk ranking | Council DWSNZ Compliance Weighted Scenario 1: Mid-Level mitigation cost ranking |
|------------------------------------|-----------------------------------------------|-----------------------------------------------------------|----------------------------------------------------------------------|----------------------------------------------------------------------|---------------------------------------------------------------------------------|
| Waikato | Waikato | Waikato | Waikato | Waikato | Waikato |
| Otago | Otago | Otago | Otago | Canterbury | Otago |
| Canterbury | Southland | Manawatu-Wanganui | Manawatu-Wanganui | Otago | Southland |
| Manawatu-Wanganui | Manawatu-Wanganui | Canterbury | Northland | Manawatu-Wanganui | Manawatu-Wanganui |
| Southland | Canterbury | Northland | Southland | Southland | Canterbury |
| Northland | Northland | Gisborne | West Coast | West Coast | West Coast |
| Gisborne | West Coast | Southland | Canterbury | Gisborne | Northland |
| West Coast | Auckland | West Coast | Auckland | Northland | Bay of Plenty |
| Auckland | Bay of Plenty | Auckland | Bay of Plenty | Bay of Plenty | Tasman |
| Wellington | Taranaki | Bay of Plenty | Tasman | Wellington | Gisborne |
| Bay of Plenty | Tasman | Taranaki | Taranaki | Marlborough | Marlborough |
| Taranaki | Wellington | Wellington | Gisborne | Taranaki | Wellington |
| Marlborough | Gisborne | Marlborough | Wellington | Tasman | Taranaki |
| Tasman | Marlborough | Tasman | Marlborough | Auckland | Auckland |
| Nelson | Nelson | Nelson | Nelson | Hawke's Bay | Nelson |
| Hawke's Bay | Hawke's Bay | Hawke's Bay | Hawke's Bay | Nelson | Hawke's Bay |

5.3 Water Take Consents, Land Use Consents, Discharge Consents and HAIL Sites

5.3.1 Consent/HAIL Site Risk Weighting

This section assesses the risk to drinking water based on the number and type of consented activity and HAIL sites within the defined source protection zones. The water take, land use, and discharge consents, and HAIL sites have been assessed for their relative risk, per site, to drinking water supplies. The risk weighting was based upon a subjective expert assessment. No distinction has been made between the type of drinking water source (e.g. groundwater, surface water, source size, plant treatment), or the location of the site with respect to the source (except that it is within the related zone). Where consents have been classified (e.g. Industrial, Irrigation, Hydro, Drinking and Other, for water takes), the classification has been considered in allocating the risk weightings. Except for water takes (which have previously been compiled into a national database), the classification systems varied from council to council. Where classification was limited, a conservative approach was taken to allocation of the risk weighting. All HAIL sites (after removing those with a status that indicated no risk to drinking water) were allocated the highest weighting, irrespective of sub-classification.

The categories of the water permits were nationally consistent, enabling region-independent risk weightings to be allocated (Table 8). For land use consents, discharge consents, and HAIL sites, the sub categories varied from council to council. The risk weightings for these sites are in Appendix D.

Through combining the risk weightings with the number of sites within the source protection zones, a total risk weighting was able to be determined for each region. The very large number of HAIL sites and land use consents in some regions leads to them skewing the overall risk weighting. The inability to assess either the validity of HAIL sites, or the risk they may pose to drinking water, makes their inclusion problematic. The high number of land use consents in some regions (particularly unitary authorities) is associated with building and structure consents that may have little relevance to drinking water quality. For this reason the total risk weighting without the HAIL sites, and without both the HAIL sites and the land use consents were also calculated. As with the land cover risk assessment, the weightings were adjusted according to the rating given to each regional council based on how comprehensive their drinking water source protection rules were (Table 1). A council with a “High” rating had their total weightings multiplied by 1/10 (i.e. divided by 10). A “Medium” rating, had their weightings multiplied by 2/10 (i.e. divided by 5). An “Indirect” rating had their weightings multiplied by 3/10 (i.e. divided by 3.33).

In addition, an alternative regional weighting multiplier was applied based on the percentage of distribution zones within each region that, in 2016-17, were compliant with the bacterial and protozoal standards in the Drinking Water Standards of New Zealand²⁰. The compliance measure was expressed as a percentage, so this was converted to a fraction of 1, and then the weighting was calculated as 1 minus this fraction. In this way a high compliance (e.g. 99 %) would lead to a weighting multiplier of 0.01, thereby greatly reducing the overall weighting, whereas a low compliance region (e.g. 1 %) would lead to a weighting multiplier of 0.99, thereby having little effect on the overall weighting.

The rules-adjusted total water take and discharge site mid-level risk rankings for surface water Intermediate zones and groundwater Protection zones (1 year travel time) are shown in Figure 7.

By way of comparison, a range of different rankings of the regional risk totals for the groundwater Protection zones (1 year travel time) and surface water Intermediate Zones, are provided in Table 9 and Table 10 respectively. Note that consent data was not available for Gisborne. The full suite of ranking scenario combinations are provided as supplementary data as an excel spreadsheet called RegionalSPZConsentAndHAILCosts (Appendix A).

Table 8. Water Permit relative drinking water risk weighting

| Water Permit Category | Assumed land use activity | Primary Contaminant: A = Aesthetic, B = Bacterial, C = Chemical. | Risk type: D = Diffuse, E = Event. | Scenario 1: Conservative Risk | Scenario 2: Mid-level Risk |
|-----------------------|------------------------------|------------------------------------------------------------------|------------------------------------|-------------------------------|----------------------------|
| Industrial | Chemical plant | C | D, E | 4 | 2 |
| Irrigation | High intensity dairy farming | B,C | D | 2 | 2 |
| Hydro | High rate of take | | | 1 | 0 |
| Drinking | High rate of take | | | 1 | 0 |
| Other | Worst of the above | A,B,C | | 4 | 2 |

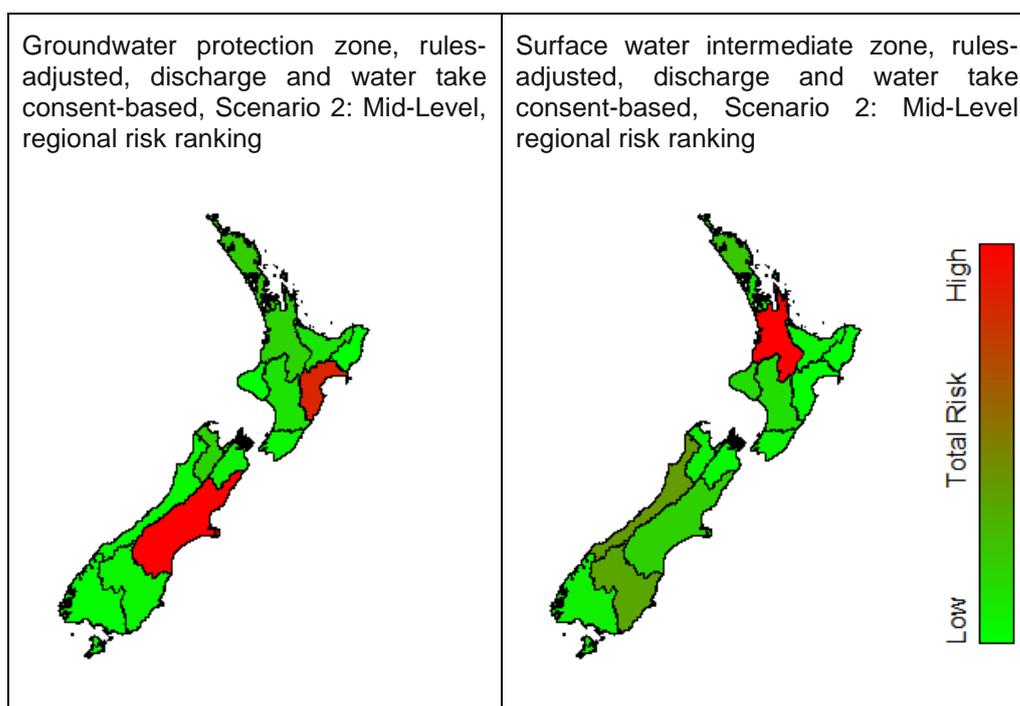


Figure 7. Region ranking for source protection zone rules adjusted, discharge and water-permit consent-based drinking water risk ranking.

Table 9. Regional rankings of consent-based risk assessment for groundwater Protection Zones (1 year travel time). Land Use Consents and HAIL sites have not been included as part of these rankings. Regions are ranked on a linear scale from highest risk/cost (red) to lowest risk/cost (green).

| Scenario 1: Conservative risk totals | Scenario 2: Mid-Level risk totals | Council Rules- adjusted Scenario 1: Conservative | Council Rules- adjusted Scenario 2: Mid-Level | Council DWSNZ Compliance- adjusted Scenario 1: Conservative | Council DWSNZ Compliance- adjusted Scenario 2: Mid-Level |
|--------------------------------------------|-----------------------------------------|-----------------------------------------------------------|--------------------------------------------------------|-------------------------------------------------------------------------|----------------------------------------------------------------------|
| Canterbury | Canterbury | Hawke's Bay | Canterbury | Hawke's Bay | Canterbury |
| Hawke's Bay | Hawke's Bay | Canterbury | Hawke's Bay | Canterbury | Hawke's Bay |
| Tasman | Auckland | Tasman | Auckland | Tasman | Auckland |
| Marlborough | Northland | Auckland | Northland | Auckland | Northland |
| Auckland | Tasman | Northland | Tasman | Northland | Tasman |
| Northland | Marlborough | Marlborough | Waikato | Marlborough | Waikato |
| Manawatu- Wanganui | Waikato | Waikato | Manawatu- Wanganui | Waikato | Manawatu- Wanganui |
| Wellington | Manawatu- Wanganui | Manawatu- Wanganui | Bay of Plenty | Manawatu- Wanganui | Bay of Plenty |
| Waikato | Bay of Plenty | Bay of Plenty | Marlborough | Bay of Plenty | Marlborough |
| Bay of Plenty | Wellington | Otago | Otago | Otago | Otago |
| Otago | Otago | Wellington | Wellington | Wellington | Wellington |
| West Coast | West Coast | West Coast | West Coast | West Coast | West Coast |
| Southland | Southland | Southland | Southland | Southland | Southland |
| Taranaki | Taranaki | Taranaki | Taranaki | Taranaki | Taranaki |
| Nelson | Nelson | Nelson | Nelson | Nelson | Nelson |

Table 10. Regional rankings of consent-based risk assessment for surface water Intermediate Zones. Land Use Consents and HAIL sites have not been included as part of these rankings. Regions are ranked on a linear scale from highest risk/cost (red) to lowest risk/cost (green).

| Scenario 1: Conservative risk totals | Scenario 2: Mid-Level risk totals | Council Rules- adjusted Scenario 1: Conservative | Council Rules- adjusted Scenario 2: Mid-Level | Council DWSNZ Compliance- adjusted Scenario 1: Conservative | Council DWSNZ Compliance- adjusted Scenario 2: Mid-Level |
|--------------------------------------------|-----------------------------------------|-----------------------------------------------------------|--------------------------------------------------------|----------------------------------------------------------------------------|----------------------------------------------------------------------|
| Waikato | Waikato | Waikato | Waikato | Waikato | Waikato |
| West Coast | Canterbury | West Coast | Northland | West Coast | Northland |
| Canterbury | West Coast | Otago | West Coast | Otago | West Coast |
| Otago | Otago | Northland | Otago | Northland | Otago |
| Northland | Northland | Canterbury | Canterbury | Canterbury | Canterbury |
| Taranaki | Taranaki | Taranaki | Taranaki | Taranaki | Taranaki |
| Manawatu- Wanganui | Manawatu- Wanganui | Manawatu- Wanganui | Manawatu- Wanganui | Manawatu- Wanganui | Manawatu- Wanganui |
| Southland | Southland | Auckland | Bay of Plenty | Auckland | Bay of Plenty |
| Wellington | Wellington | Southland | Auckland | Southland | Auckland |
| Auckland | Bay of Plenty | Tasman | Southland | Tasman | Southland |
| Marlborough | Auckland | Wellington | Wellington | Wellington | Wellington |
| Bay of Plenty | Marlborough | Bay of Plenty | Tasman | Bay of Plenty | Tasman |
| Tasman | Tasman | Marlborough | Marlborough | Marlborough | Marlborough |
| Nelson | Nelson | Nelson | Nelson | Nelson | Nelson |
| Hawke's Bay | Hawke's Bay | Hawke's Bay | Hawke's Bay | Hawke's Bay | Hawke's Bay |

5.4 Discussion

The risk assessment associated with land cover, and with the consent/HAIL sites has been kept separate as no reasonable/pragmatic approach to combining them could be found. Table 11 compares the land cover regional rankings with the consent/HAIL regional rankings for Scenario 2: Mid-level risk. The rankings are reasonably similar with the higher ranking regions remaining high irrespective of the method, and the lower risk regions remaining low. The most notable difference is between the types of source protection zones.

For land cover, the mitigation cost has also been assessed. This tests the assumption that relative mitigation costs are likely to be similar to relative risks. Table 11 indicates that, while the regional rankings are not identical, the high-risk regions generally have high-mitigation cost. The minor re-ordering of rankings based on risk and mitigation cost may be viewed as an estimate of the ranking uncertainty.

Canterbury and Hawke's Bay stand out as the regions with the greatest risk associated with groundwater protection zones. In both cases the regions are supplying to large populations from sites within, or close to urban settings. The high abstraction rates and the conservatively low value used for the effective porosity lead to large protection zones, and the urban areas lead to high risk land cover and large number of consent sites. In combination this results in high overall risks. Consideration of more detailed protection zones for these regions, and the likelihood that drinking water risk is already a consideration within these regions is likely to greatly reduce the risk rating.

Table 11. Comparison of regional rankings using land cover risk, land cover mitigation cost, consent/HAIL site risk, and source zone type. All rankings are rules adjusted, Scenario 2: Mid-level assessments. Regions are ranked on a linear scale from highest risk/cost (red) to lowest risk/cost (green).

| Groundwater Protection Zone (1 year travel time) | | | Surface water Intermediate Zone | | |
|-----------------------------------------------------|---------------------------------------------|---------------------------------------------------|----------------------------------|---------------------------------------------|---------------------------------------------------|
| Land cover derived, risk ranking | Land cover derived, mitigation cost ranking | Discharge and Water consent derived, risk ranking | Land cover derived, risk ranking | Land cover derived, mitigation cost ranking | Discharge and Water consent derived, risk ranking |
| Hawke's Bay | Canterbury | Canterbury | Waikato | Waikato | Waikato |
| Waikato | Hawke's Bay | Hawke's Bay | Otago | Otago | Northland |
| Manawatu-Wanganui | Auckland | Auckland | Manawatu-Wanganui | Manawatu-Wanganui | West Coast |
| Northland | Manawatu-Wanganui | Northland | Canterbury | Northland | Otago |
| Canterbury | Waikato | Tasman | Northland | Southland | Canterbury |
| Bay of Plenty | Northland | Waikato | Gisborne | West Coast | Taranaki |
| Otago | Wellington | Manawatu-Wanganui | Southland | Canterbury | Manawatu-Wanganui |
| Tasman | Tasman | Bay of Plenty | West Coast | Auckland | Bay of Plenty |
| Auckland | Bay of Plenty | Marlborough | Auckland | Bay of Plenty | Auckland |
| Wellington | Otago | Otago | Bay of Plenty | Tasman | Southland |
| Marlborough | Marlborough | Wellington | Taranaki | Taranaki | Wellington |
| Southland | Southland | West Coast | Wellington | Gisborne | Tasman |
| West Coast | West Coast | Southland | Marlborough | Wellington | Marlborough |
| Gisborne | Taranaki | Taranaki | Tasman | Marlborough | Nelson |
| Taranaki | Gisborne | Nelson | Nelson | Nelson | Hawke's Bay |
| | | | Hawke's Bay | Hawke's Bay | |

In terms of implementing source protection zones, the cost to the regions is associated with limiting activities in the zones, reviewing current land use and permitted activities, removing activities that are an unacceptable risk to drinking water, and amending considerations when consenting activities. Ideally, planning rules would also be amended to reflect the need to consider source protection zones. More detailed assessment of source protection zones, using methods that are more comprehensive than those used for this study, would ideally be undertaken. This would enable the specific situations of each source to be considered leading to optimal zones. An example of this is the consideration of groundwater flow direction enabling a reduction in source protection areas down-gradient of a groundwater source site. Where consented activities exist within source protection areas but had not been considered as such when the application was approved, then reassessments of the activities' risk to drinking water quality are likely to be necessary. In a similar way, a prioritisation of HAIL site verification within the source protection zones would assist with confirmation of appropriate limitation on drinking water quality risk. This would be a cost to regional councils. For the five regional councils with source protection zones already within their planning rules, these considerations may have already been met.

Owners of land within source protection areas will be affected by the need to remove drinking water risks, having reduced options for land use activities, and increased compliance costs. Such restriction in land use may reduce the potential productivity of the land, and land value, but is offset at the community level by the reduced cost of drinking water quality-related health issues.

The risk and cost-mitigation weightings were subjectively prepared using expert knowledge. It is possible that alternative weightings may be equally appropriate, or that the weightings could be refined

following feedback from interested parties. The analyses undertaken here has been set up to be largely automated, so that alternative weightings may be simply applied to test how they affect the relative risks and mitigation costs. In a similar manner the adjustment to the weightings based on how comprehensive each regional council's planning rules were, was largely subjective. Any number of alternative adjustments could be applied without difficulty.

While the focus of these analyses were on the regional costs, the same approach could be taken to any particular area or even to individual source sites.

In preparing the groundwater source protection zones, several parameters were estimated from a variety of source data. As those data are refined, so too could this analyses. An example is the estimation of effective porosity, which was based on aquifer lithologies from the national groundwater aquifer map. The current MfE Groundwater Atlas project is likely to lead to an updated aquifer map. Once complete, that could be used to reduce one of the greater uncertainties when defining the source protection areas. If the Groundwater Atlas project is also able to map groundwater flow nationally, then an improved source protection zone methodology may be able to be undertaken.

National datasets have been prepared for land use consents, discharge consents and HAIL sites. With addition of the few missing regional councils' data, quality checking and merging of the alternative sub-classifications, these data could prove to be a valuable tool for future national-scale analyses that would complement the previously-compiled national water take consents data.

Several councils already have source protection zones defined for their regions. A comparative analysis between the methods used in this report, and these councils, would enable the appropriate confidence to be given to the findings of this report. By the same token, finding out, direct from the councils that have implemented source protection zones, the cost they have incurred, would assist in converting the relative costs assessed in this report to real-world costs.

This report was made possible through the professional engagement of two external consultants.

Sri Hall, Work Group Manager – Planning Engagement and Policy, WSP-Opus provided an expert overview of the regional council planning summary.

Stuart Ford, Agricultural and Resource Economist, The Agribusiness Group, provided the expert knowledge required to estimate land cover mitigation costs.

Appendix A: Supplementary Data

This appendix lists the supplementary data associated with this report. These data have been provided independently of the report.

Table A.1: Supplementary data descriptions

| Data Name | Description | Format |
|-----------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|----------------|
| DrinkingWaterSources | Point data of New Zealand drinking water source sites | ESRI Shapefile |
| DrinkingWaterSurfaceWaterSources | Point data of New Zealand surface water drinking water source sites supplying more than 100 people | ESRI Shapefile |
| DrinkingWaterGroundwaterSources | Point data of New Zealand groundwater drinking water source sites supplying more than 100 people | ESRI Shapefile |
| SurfaceWaterSourceProtectionZones-EntireCatchments | Polygon data of catchments for surface water drinking water source sites supplying more than 100 people | ESRI Shapefile |
| SurfaceWaterSourceProtectionZones-IntermediateZones | Polygon data of Intermediate protection zones for surface water drinking water source sites supplying more than 100 people | ESRI Shapefile |
| SurfaceWaterSourceCatchmentsRECR reaches | Line data of RECV2 reaches within the surface water drinking water source catchments | ESRI Shapefile |
| SurfaceWaterSourceIntermediateZoneRECR reaches | Line data of RECV2 reaches within the surface water drinking water source Intermediate Zones | ESRI Shapefile |
| GroundwaterCaptureZones | Polygon data of 50 year travel time protection zones for groundwater drinking water source sites supplying more than 100 people | ESRI Shapefile |
| GroundwaterProtectionZones | Polygon data of 1 year travel time protection zones for groundwater drinking water source sites supplying more than 100 people | ESRI Shapefile |
| RegionalisedSWC | Polygon data of regionalised catchments for surface water drinking water source sites supplying greater than 100 people | ESRI Shapefile |
| RegionalisedSWIZ | Polygon data of regionalised Intermediate Zones for surface water drinking water source sites supplying greater than 100 people | ESRI Shapefile |
| RegionalisedSWCGT500 | Polygon data of regionalised catchments for surface water drinking water source sites supplying greater than 500 people | ESRI Shapefile |
| RegionalisedSWIZGT500 | Polygon data of regionalised Intermediate Zones for surface water drinking water source sites supplying greater than 500 people | ESRI Shapefile |
| RegionalisedGWCZ | Polygon data of regionalised Capture Zones for groundwater drinking water source sites supplying greater than 100 people | ESRI Shapefile |
| RegionalisedGWPZ | Polygon data of regionalised Protection Zones (1 year travel time) for groundwater drinking water source sites supplying greater than 100 people | ESRI Shapefile |

| Data Name | Description | Format |
|--------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| RegionalisedGWCZGT500 | Polygon data of regionalised Capture Zones for groundwater drinking water source sites supplying greater than 500 people | ESRI Shapefile |
| RegionalisedGWPZGT500 | Polygon data of regionalised Protection Zones (1 year travel time) for groundwater drinking water source sites supplying greater than 500 people | ESRI Shapefile |
| LandCoverSWC | Polygon land cover data of regionalised catchments for surface water drinking water source sites supplying greater than 100 people | ESRI Shapefile |
| LandCoverSWIZ | Polygon land cover data of regionalised Intermediate Zones for surface water drinking water source sites supplying greater than 100 people | ESRI Shapefile |
| LandCoverSWCGT500 | Polygon land cover data of regionalised catchments for surface water drinking water source sites supplying greater than 500 people | ESRI Shapefile |
| LandCoverSWIZGT500 | Polygon land cover data of regionalised Intermediate Zones for surface water drinking water source sites supplying greater than 500 people | ESRI Shapefile |
| LandCoverGWCZ | Polygon land cover data of regionalised Capture Zones for groundwater drinking water source sites supplying greater than 100 people | ESRI Shapefile |
| LandCoverGWPZ | Polygon land cover data of regionalised Protection Zones (1 year travel time) for groundwater drinking water source sites supplying greater than 100 people | ESRI Shapefile |
| LandCoverGWCZGT500 | Polygon land cover data of regionalised Capture Zones for groundwater drinking water source sites supplying greater than 500 people | ESRI Shapefile |
| LandCoverGWPZGT500 | Polygon land cover data of regionalised Protection Zones (1 year travel time) for groundwater drinking water source sites supplying greater than 500 people | ESRI Shapefile |
| SourceProtectionZoneLandCoverSummaryTables | Tables, for each type of protection zone (sheets) of total and percentage area that each land cover type (columns) makes up within each regional council (rows). | Excel Spreadsheet |
| DischargeConsents | Point data of New Zealand current discharge consent sites | ESRI Shapefile |
| LandUseConsents | Point data of New Zealand current land use consent sites | ESRI Shapefile |
| WaterTakeConsents | Point data of New Zealand 2013-2014 water take consent sites | ESRI Shapefile |
| HAIL | Point data of New Zealand current HAIL sites | ESRI Shapefile |
| SourceProtectionZoneConsentSummaryTables | Tables, for each Discharge/Landuse/Water take/HAIL site type (sheets) of total sites within each protection zone type (columns) within each regional council (rows). | Excel Spreadsheet |
| RegionalSPZConsentAndHAILCosts | Tables, for each type of protection zone (sheets) of total consent and HAIL – based risk for all scenario combinations (columns) by region (rows). | Excel Spreadsheet |

| Data Name | Description | Format |
|---------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| RegionalSPZLandCoverCosts | Tables, for each type of protection zone (sheets) of total land cover – based risk and mitigation cost for all scenario combinations (columns) by region (rows). | Excel Spreadsheet |

Appendix B: Groundwater Protection Zone Assumptions and Sensitivity Analysis

As a partial check of the data included in the Drinking Water Register, and the assumptions that have been used in the groundwater source projection zone delineation, community water supply well data was obtained from Environment Canterbury (ECan). This dataset included the source number (as used in the drinking water register), the confinement status, and the well screen details. Although rates or volumes of abstraction were not given in this dataset, we were able to link it to ECan's consent database, via the well numbers.

B.1 Confinement status

For community groundwater supplies servicing more than 100 people, the confinement status in the ECan data was compared to the Source Description field in the MoH Register. Out of 293 supplies in ECan's dataset, 225 could be matched to a source in the MoH Register. The results of the comparison are summarised in Table 12.

Table 12 Comparison of GW Source type from MoH register with ECan confinement status

| GW Source type in MoH register | Number of supplies | Confinement status in ECan data | Number of supplies |
|--------------------------------|--------------------|----------------------------------|--------------------|
| Confined | 154 | Unconfined / semiconfined | 130 |
| | | Confined / Coast confined gravel | 23 |
| | | Not determined | 1 |
| Unconfined | 47 | Unconfined / semiconfined | 34 |
| | | Confined / Coast confined gravel | 13 |
| | | Not determined | 0 |
| Unknown | 24 | Unconfined / semiconfined | 21 |
| | | Confined / Coast confined gravel | 2 |
| | | Not determined | 1 |

For sources classified in the register as "confined", 84% are listed as unconfined or semi-confined in ECan's data. The unconfined and semi-confined categories have been lumped together on the assumption that if there is doubt about the confinement status or the aquifer is known to not be fully confined, then it is conservative to assume that the aquifer is unconfined. Out of the 130 bores categorized as confined in the register but unconfined / semi-confined by ECan, 87 (67%) are semi-confined.

For sources classified in the register as "unconfined", 72% are listed by ECan as unconfined or semi-confined.

As the source protection zone delineation for this project has been based on the MoH register data in an "as-is" state, it is possible that a large number of the zones mapped using the confined bore methodology should ideally have been based on the unconfined method.

For groundwater sources classified in the register as "unknown", 88% are classified by ECan as unconfined or semi-confined. This indicates that assuming "unknown" groundwater sources to be unconfined in the zone delineation process was reasonable, as well as conservative.

B.2 Well screen length

In the groundwater source protection zone delineation process standard well screen lengths were assumed, based on expert knowledge. For bores in unconfined aquifers (based on the MoH register classification), the screen length was assumed to be 3 m, and for bores in confined aquifers the screen length was assumed to be 6 m. The basis for these assumptions was that screens are typically supplied in 3 m sections, and that bores in unconfined aquifers are likely to be shallower and therefore screened over a smaller depth.

The mean, median and mode of the screen lengths from ECan's data are summarised in Table 13, based on the source type from the MoH register.

Table 13. Screen lengths from ECan data

| GW Source type in MoH register | Mean screen length (m) | Median screen length (m) | Mode screen length (m) |
|--------------------------------|------------------------|--------------------------|------------------------|
| Confined | 6.8 | 6.0 | 6.0 |
| Unconfined | 4.1 | 4.1 | 3.0 |
| Unconfined + Unknown | 5.2 | 4.0 | 3.0 |

The values in Table 13 support the assumptions that were used in the groundwater zone delineation, and also the assumption that bores classified as “unknown” should be treated as unconfined.

As discussed above in B.1, there is some mis-match between the confinement status on the MoH register and ECan's data. This is especially the case for bores classified by MoH as confined, where the majority are classified by ECan as semi-confined. Although, from a source protection point-of-view, it would be more conservative to assume that these bores are unconfined, in terms of well construction they are more likely to be similar to confined bores. This is supported by the data in Table 13.

B.3 Abstraction volumes

For sources that could be linked to the ECan consents data (187 sources), 94% had a consented volume that was greater than the volume assumed based on source population. In some cases the consented volume is substantially higher. There are a number of reasons for this, including:

- Consent conditions not being reflected accurately in the consents database (for example where higher volumes are specified that can be taken on a limited number of days)
- Consents where the use for drinking water is combined with other uses such as firefighting and irrigation of public amenity areas.
- Global consents, where the total consented volume may relate to more than one source in the MOH register (e.g. Christchurch City).
- Operational reasons, such as pumping from a bore at a high rate to fill a tank or reservoir.
- Consented flow rates incorporating population growth projections over the timeframe of the consent.

The population-based flow assumption that has been used for delineating groundwater source protection zones is appropriate because it is more likely to reflect the actual volumes pumped.

B.4 Sensitivity to assumptions

To test the sensitivity of the groundwater source protection zone radius to the parameters used, a default set of parameters were selected, each of which were then varied systematically over a reasonable range while holding the others constant. The default parameters and the ranges of variance are summarised in Table 14.

Table 14 Parameter defaults and ranges for sensitivity testing

| Parameter and units | Default value | Lower bound | Upper bound |
|----------------------------------------|---------------|-------------|-------------|
| Abstraction rate (m ³ /day) | 400 | 200 | 5000 |
| Travel time (years) | 50 | 1 | 100 |
| Porosity (dimensionless) | 0.3 | 0.003 | 0.3 |
| Screen length (m) | 3 | 3 | 30 |

Figure 8 shows the sensitivity of the source protection zone radius to varying the abstraction rate. If the abstraction rate is higher than the assumed value, the protection zone radius will be greater. The radius is slightly more sensitive to errors in abstraction rate for smaller flow rates.

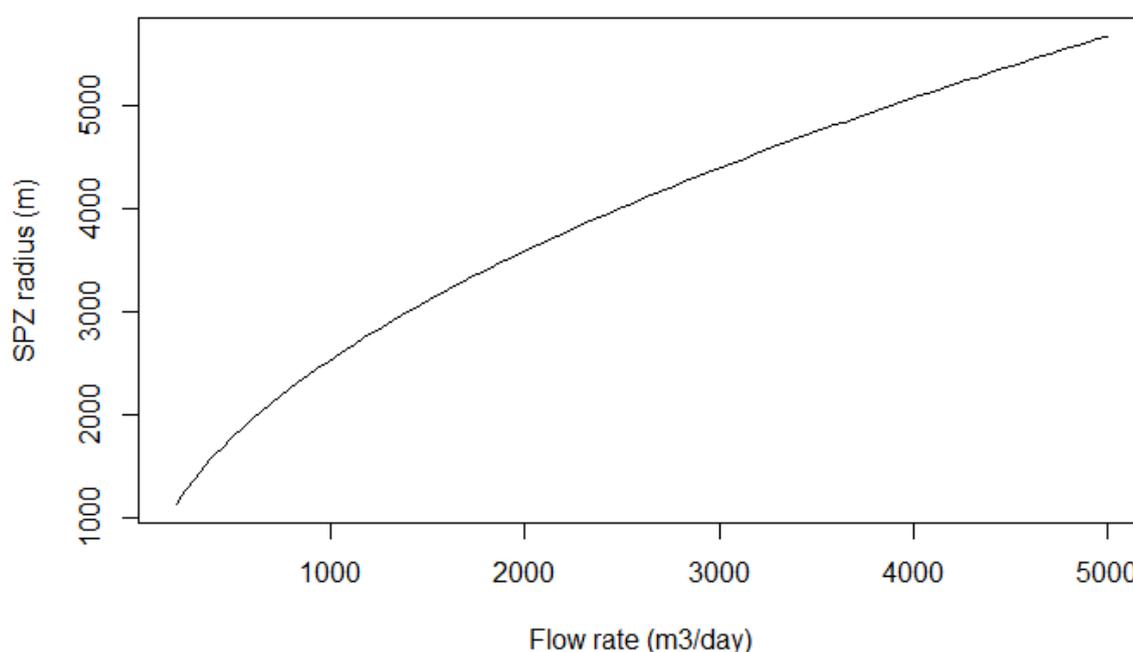


Figure 8. Sensitivity of SPZ radius to abstraction rate

Figure 9 shows the sensitivity of the source protection zone radius to varying the effective porosity, plotted on both linear and log scales. If the effective porosity is lower than the assumed value, the protection zone radius will be larger. Porosity values higher than 0.3 are unlikely for aquifer materials. Over the range of values that is traditionally used for the effective porosity of aquifer materials (approximately 0.1–0.3), the radius is relatively insensitive to changing the porosity. However, with a lower value, such as the value of 0.0032 recommended by Moreau *et al* (2014)² for alluvial gravels, the radius is very sensitive to the assumed value of porosity.

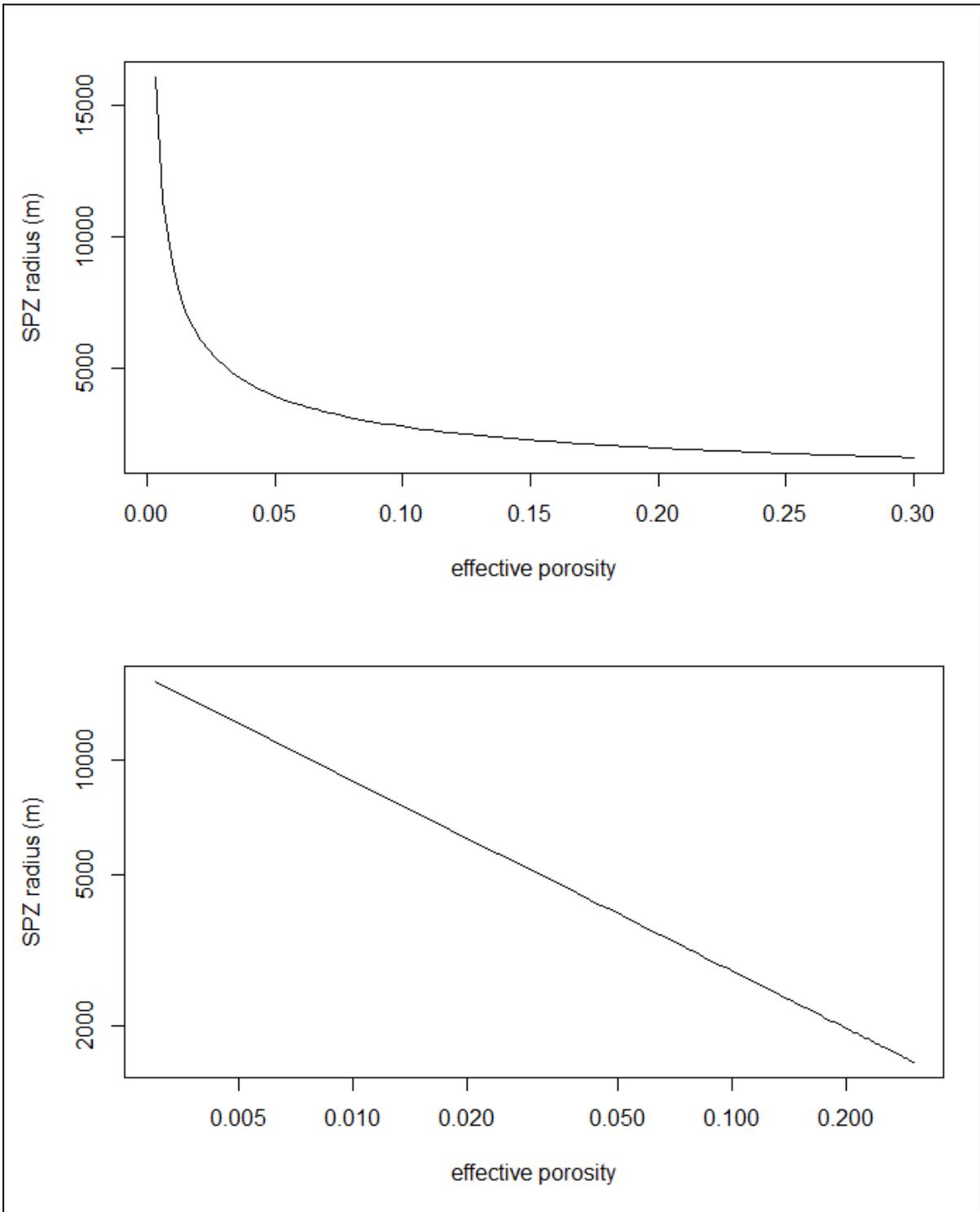


Figure 9. Sensitivity of SPZ radius to effective porosity (top: linear scales; bottom: log scales)

Figure 10 shows the sensitivity of the source protection zone radius to varying the well's screen length. Increasing the screen length results in a smaller source protection zone radius. Screen lengths less than 3 m (the assumed value for unconfined aquifers) are unlikely to occur often. In low-yielding aquifers screen lengths may be substantially longer than the assumed values (the ECan community supply dataset has several bores with screens in the 20–30 m range). The sensitivity of the protection zone radius to screen length decreases with increasing screen length.

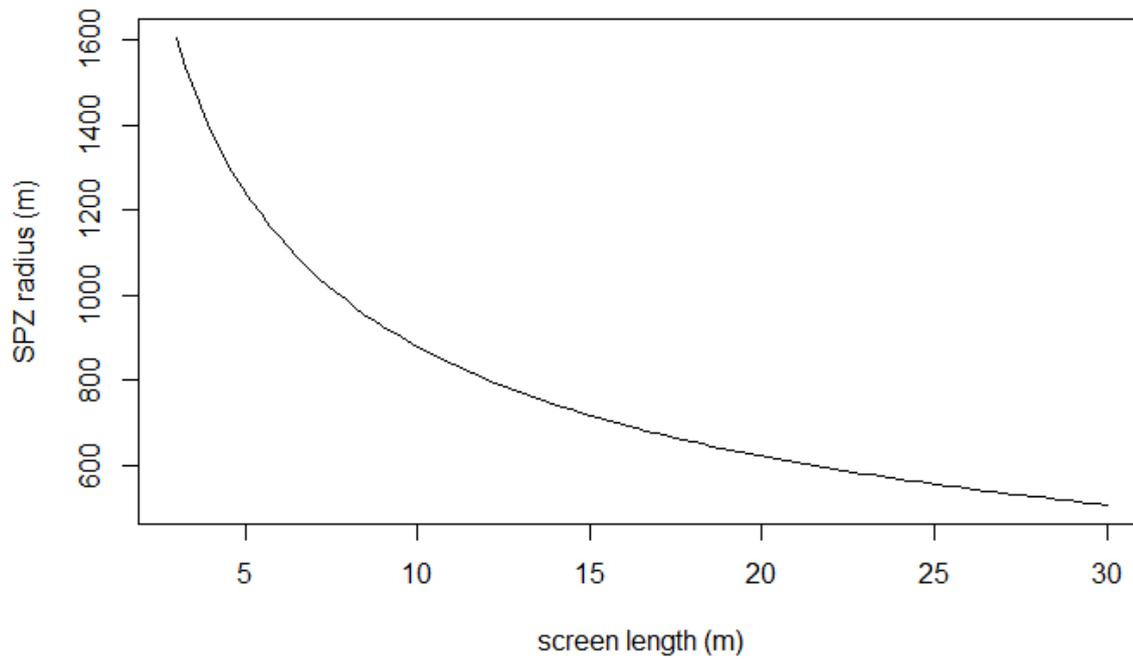


Figure 10. Sensitivity of SPZ radius to screen length

Figure 11 shows the sensitivity of the source protection zone radius to varying the travel time. The values for the travel time are recommended in Moreau *et al* (2014): 1 year for source protection zones, and 10–50 years for capture zones. Increasing the travel time that the source protection zone needs to protect against increases the radius of the protection zone. The sensitivity of the zone radius to travel time decreases as the travel time increases: in the example shown in Figure 11 the radius for 10 years is 3.2 times the radius for 1 year, but the radius for 50 years is only 2.2 times the 10 year radius.

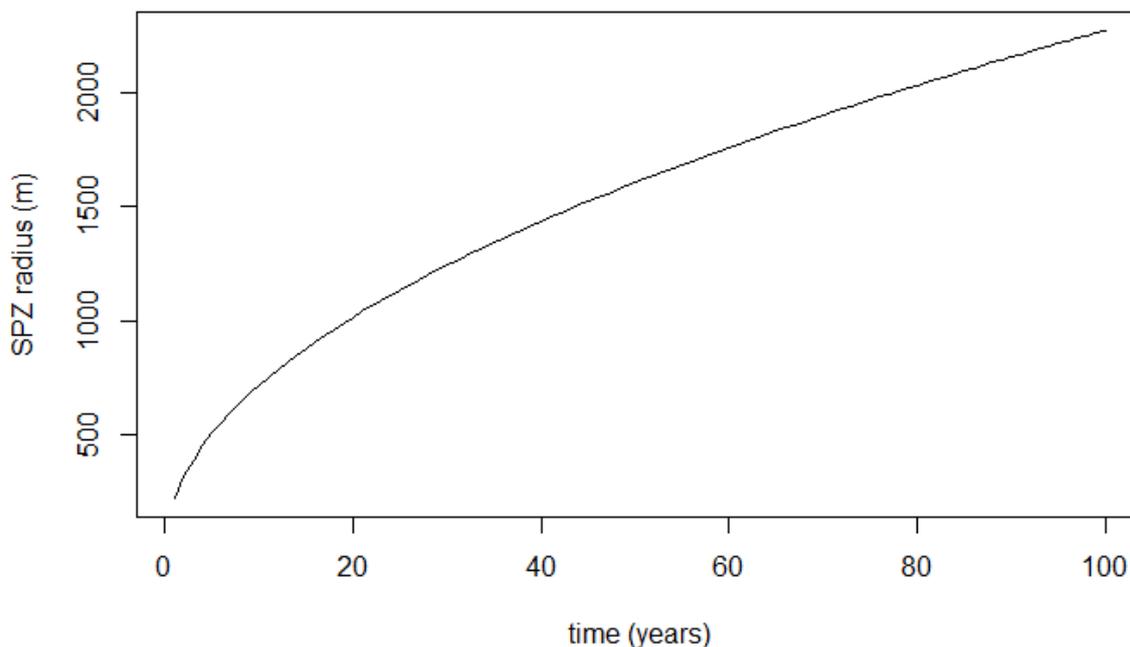


Figure 11. Sensitivity of SPZ radius to travel time

Appendix C: Regional Council Drinking Water Quality Planning Rules

This appendix provides information about each Regional Council's planning rules that are related to current drinking water supply protection. The lists of rules (blue coloured text) are not intended to be exhaustive but examples of the level of drinking water supply protection each council has deemed necessary to meet the NES requirements. We have added emphasis (bold text) to some sections of the rules to highlight their relevance.

This appendix has been externally reviewed by Sri Hall, Work Group Manager – Planning Engagement and Policy, WSP-Opus, and revised following that review.

C.1 Northland

The Northland Regional Council has a current Regional Plan²¹, and a 2017 Proposed Regional Plan²² which is currently in the early hearing stages. The Regional Soil and Water Plan is part of the Regional Plan.

Neither plan has quantitative community water supply rules, however when relevant nearby consents are sought, the impacts on the water supply would be assessed. Discharges are not permitted where it would render groundwater unsuitable for human consumption.

²¹ <https://www.nrc.govt.nz/resources/?url=/Resource-Library-Summary/Plans-and-Policies/Regional-plans/>

²² <https://www.nrc.govt.nz/contentassets/506f48db06744ab782c65e56acd19dde/proposed-regional-plan-september-2017-final-7-sept-2017.pdf>

An example of some relevant rules are included below.

Regional Water and Soil Plan

16. RULES FOR ANIMAL EFFLUENT DISCHARGES – 16.1 PERMITTED ACTIVITIES – The following discharges of animal effluent are permitted activities: The discharge of the following effluents: (i) Animal effluent; (ii) Water containing animal effluent; and/or (iii) Farm wastewater onto or into land is a permitted activity, provided that: (b) The effluent is not discharged to land within a distance of: (i) **20 metres of any river, stream, lake, Coastal Marine Area or indigenous wetland;** (iii) **20 metres from the bore head for any water supply bore;** (i) The discharge results in no more than minor contamination of groundwater and surface water beyond a 20 metre separation distance measured horizontally from the outer edge of the land application area. In no case shall the discharge result in a lowering of water quality so that the receiving water body can no longer meet the water quality purpose set out in Objective 7.4.1.

19. RULES FOR SOLID WASTE DISCHARGES – 19.1 PERMITTED ACTIVITIES – The following discharges of solid waste and associated discharges of leachate are permitted activities: 1. The discharge of contaminants onto or into land from an open or closed clean fill landfill (including industrial and trade premises) is a permitted activity, provided that: (e) **The discharge does not increase the concentrations of the following metals in any receiving waters above the following limits:** Groundwater Surface Water Total Chromium 50 mg/m³ 2 mg/m³ Total Copper 2,000 mg/m³ 2 mg/m³ Total Lead 10 mg/m³ 1 mg/m³ Total Zinc - 5 mg/m³ **or result in other contaminants entering groundwater in concentrations that would render it unsuitable for human consumption,** or surface water in concentrations that have a more than minor adverse effect on aquatic life.

23. RULES FOR DISCHARGES FROM OTHER ACTIVITIES – 23.1 PERMITTED ACTIVITIES – The following discharges of contaminants are permitted activities: 2. The discharge of contaminants onto or into land, other than discharges provided for by other rules in this Plan is a permitted activity, provided that: (c) No contaminant is discharged in circumstances which may result in that contaminant (or any other contaminant emanating as a result of natural processes from that contaminant) entering: (i) Groundwater in **concentrations that would render it unsuitable for human consumption.**

Proposed Regional Plan

C.6.3 Agricultural waste discharges C.6.3.1 Farm wastewater discharges to land – permitted activity
The discharge of farm wastewater onto or into land is a permitted activity provided: 2) there is no discharge to land or overland flow within: e) **20 metres of the head of any drinking water supply bore**

C.6.9 Other discharges of contaminants C.6.9.2 Discharge of tracers – permitted activity. The discharge of a tracer into water is a permitted activity provided: 1) **the discharge is not upstream of any abstraction point for a registered drinking water supply,** unless approved by the water supplier

C.6.8.2 Discharges from contaminated land - permitted activity. The passive discharge of contaminants from contaminated land into water, or onto or into land where it may enter water, is a permitted activity, provided; 2) the site investigation report demonstrates that the passive discharge of: a) contaminants in sensitive groundwater, at the property boundary or within 50 horizontal metres of the contaminant source (whichever is less), **does not exceed: iii) the contaminant concentrations in Drinking Water Standards for New Zealand 2005 (revised 2008), and 'Community Groundwater Supply Source Protection 2000'**

C.2 Auckland

The Auckland Council Regional Plan: Air, Land and Water (ALWP)²³ shows a focus on protection of water supply areas by designating Water Supply Management Areas, which are council-owned areas surrounding council water supply infrastructure. There is no reference to 'community water supplies' or the protection of such. There are no quantitative community water supply rules, however it is assumed the location of these are considered on a case by case basis when consent applications are sought. There is a separate document called The Regional Plan: Farm Dairy Discharges (FDD)²⁴, which addresses issues associated with dairy farm discharges. Examples of parts of these plans that relate to the exclusion areas surrounding a water supply are detailed below:

ALWP

Sewage Sludge (including Biosolids) Permitted Activities 5.5.29 In reference to the biosolids grading system detailed at section 4.3 of the Guidelines for the Safe Application of Biosolids to Land in New Zealand, (August 2003) the application of Grade Aa biosolids onto or into land is a Permitted Activity, subject to the following standards and terms: (d) **The application is not to any Water Supply Management Area(s)**; (g) The application must provide for buffer zones between the application area and neighbouring land uses or sensitive environments as follows: (ii) **20 metres from any surface water body and the coastal marine area**; (iii) **20 metres from any water supply bore**.

FDD

6.2.1.3 Washwater or dairy sludge shall not be applied onto land or injected into land in such a place or in such circumstances that it may enter: (a) a water body that is not part of the washwater treatment system, or (b) **any water supply bore**, or

6.3.1.9 Any new pond(s) constructed after the date that this Plan becomes operative shall not be located: (b) **in such a place where seepage of contaminants may enter** and potentially cause adverse effects on: (i) a water body that is not part of the washwater treatment system, or (ii) **any water supply bore**.

C.3 Waikato

The Waikato Regional Plan²⁵ is the operative plan in the region. Currently a review is taking place of this plan but there is no proposed plan yet. The plan does not have quantitative community water supply rules in respect of the control of land use activities and effects on water quality, however when consents are sought the impacts on a water supply would be assessed. There are several technical reports that show the council has been investigating protection zones, which include 'Delineation of protection (capture) zones for the Putaruru well field and the Blue Spring on the Waihou River, 2012'²⁶ and 'Community Groundwater Supply Source Protection, 2000'²⁷.

Some relevant rules from the Waikato Regional Plan include:

3.5.4.4 Permitted Activity Rule – Discharges of Water to Water – General Rule Except as expressly provided for by other rules in this Plan any discharge of water (excluding geothermal water), into water is a permitted activity subject to the following conditions:
a) There shall be **no adverse effect on water quality of the receiving water body**.

5.2.6.2 Permitted Activity Rule – Offal Holes on Production Land

²³ <https://www.aucklandcouncil.govt.nz/plans-projects-policies-reports-by-laws/our-plans-strategies/district-and-regional-plans/regional-plans/regional-plan-air-land-water/Pages/alw-plan-text.aspx>

²⁴ <http://www.aucklandcity.govt.nz/council/documents/regionalplans/farmdairydischarges/Auckland%20Regional%20Plan%20-%20Farm%20Dairy%20Discharges.pdf>

²⁵ <https://www.waikatoregion.govt.nz/council/policy-and-plans/rules-and-regulation/regional-plan/waikato-regional-plan/>

²⁶ <https://www.waikatoregion.govt.nz/services/publications/technical-reports/tr/tr201216>

²⁷ <https://www.waikatoregion.govt.nz/services/publications/technical-reports/2000/>

- b) The discharge of contaminants into or onto land as part of the operation of an offal hole when occurring outside of: is a permitted activity subject to the following conditions:
 - i) The **offal hole shall not be within 100 metres of any water supply bore or water body.**

5.3.4.6 Permitted Activity Rule – Discharges from Remediation of Contaminated Land

Any discharge arising from remediation of contaminated land is a permitted activity, subject to the following conditions:

- b) No contaminants from the remediation of the contaminated land shall be discharged into water or onto land unless discharged to a landfill authorised in Section 5.2.7.

C.4 Bay of Plenty

The Bay of Plenty Regional Natural Resources Plan (RNRP)²⁸ has policies and rules to ensure the sustainable management of land and water resources. Water quality classifications have been assigned to the rivers in the region, which can be seen in the Water Quality Classification Maps of the RNRP for each area. Rivers contributing to water supplies for council-owned sources are shown as 'Water Supply Catchments' and are referred to in the rules of the plan. Plan Change 10 looks to reduce nutrient loss within the Lake Rotorua groundwater catchment to improve water quality, so within this area farms have certain rules to follow such as N loss limits. Although this is not a specific source protection for a particular water supply, it will increase the quality for the water supplies in the catchment.

Examples of relevant Objectives and Rules from the RNRP are detailed below.

6 Water Supply Water Quality Classification – Any discharge of a contaminant or water to water in a stream or river classified as Water Supply in the Water Quality Classification Map shall not alter the quality of the water beyond the following standards and criteria after reasonable mixing of the discharge with the receiving water: (a) The discharge shall not cause the pH of the surface water to exceed 9.0 units, or fall below 6.0 units. (b) The discharge shall not cause the dissolved oxygen level to fall below 5 grams per cubic metre. (c) The water shall not be rendered unsuitable for treatment (equivalent to coagulation, filtration, disinfection or micro-filtration) for human consumption by the presence of contaminants as a result of the discharge. (d) The water shall not be tainted or contaminated so as to make it unpalatable or unsuitable for consumption by humans after treatment (equivalent to coagulation, filtration, disinfection and micro-filtration), or unsuitable for irrigation as a result of the discharge. (e) There shall be no undesirable biological growths as a result of any discharge of a contaminant into the water. (f) The discharge of contaminants (either by itself or in combination with the same, similar, or other contaminants) or water to water shall not cause: (i) The production of conspicuous oil or grease films, scums or foams, or floatable or suspended materials. (ii) Any conspicuous change in the colour or visual clarity. There shall be no greater than 20% decrease in secchi disc depth or black disk range. (iii) Any emission of objectionable odour (refer to the Operative Bay of Plenty Regional Air Plan). (iv) The rendering of fresh water unsuitable for consumption by farm animals (refer to ANZECC Guidelines for Fresh and Marine Water Quality, 200047). (v) Any significant adverse effects on aquatic life (refer to ANZECC Guidelines for Fresh and Marine Water Quality, 2000). (g) The discharge shall not cause the E. coli level to exceed 126 cfu/ml as measured by a single sample. (h) The discharge shall not contain any hazardous substance that presents a risk to human health, or which renders water untreatable to a potable quality (as defined by the Ministry of Health). (i) The natural temperature of the water shall not be changed by more than one (1) degree Celsius as a result of the discharge.

DW R20 (Rule 30) Permitted – Discharge of Stormwater to Surface Water-The discharge of stormwater to surface water, or to land where the discharge enters surface water, is a permitted activity, subject to the following conditions: (k) **Where the discharge is to a part of a receiving water body that is classified as Water Supply, the discharge shall not contain any substance that renders the water unsuitable for treatment** (equivalent to coagulation, filtration, disinfection or micro-infiltration) **for human consumption.**

²⁸ <https://www.boprc.govt.nz/plans-policies-and-resources/plans/regional-natural-resources-plan/>

DW R13 (Rule 25) Permitted – Farm Dumps – The discharge of contaminants, including leachate, to land in circumstances where the contaminant or its by-products may enter water, as part of the operation of an on-farm rubbish dump, is a permitted activity subject to the following conditions: (d) **No part of the dump site shall be located within: (i) 50 horizontal metres of any groundwater bore, stream, river, lake or wetland.**

C.5 Gisborne

The Tairāwhiti Resource Management Plan (TRMP)²⁹ is all of the Gisborne District's resource management plans combined into one. A new Proposed Freshwater Plan³⁰ is underway and some of this document is already operative and included in the TRMP. There are rules that designate quantitative setback distances of particular discharges, such as solid waste disposal and pit latrines from community water supplies. A community water supply is defined as:

A reticulated publicly or privately owned drinking water supply connecting at least two buildings on separate Certificates of Title and serving at least 1500 person days per year (for example, serving 25 people at least 60 days per year) **but excluding the Gisborne City Municipal Water Supply.**

It should be noted that the community water supplies are referred to separately to the Gisborne City Municipal Water Supply.

TRMP

Non-complying Activities 6.2.3(14) – The **point source discharge** of liquids to land or waterbodies and their margins where the discharge: b) **Is to a waterbody or to land in a way that directly enters water above a community drinking water supply intake point.**

6.2.15(1) Discharge of agrichemicals – Permitted if d) The discharge **shall not result in the deposition of noxious or dangerous levels of agrichemicals or hazardous contaminants onto waterbodies specifically managed for public water supply** purposes;

Proposed Freshwater Plan

Rule 5.1.15 Non-complying activity: The point source discharge of liquids to land or waterbodies and their margins where the discharge: b) is to a waterbody or to land in a way that directly enters water **above a community drinking water supply** intake point

Rule 5.4.3 Permitted provided: The discharge of any contaminants into or onto land in connection with solid waste disposal at farms c. The discharge shall occur no less than **100 metres from any river, surface waterbody, wetland, drain or channel, from any bore used for drinking water supply, from the coastal marine area, or from any Protection Management Area identified within the Combined Plan.**

Schedule 14: Clearances, Setbacks and Maximum Slope Gradients for Installation of Disposal Systems

2. Permitted Activity **discharges from pit latrines shall be no closer than: b. 50 metres of a bore, well or spring used for a buildings water supply, stock water or irrigation water; or c. 1000 metres up flow and 150 metres down flow of a community drinking water supply;**

5. Permitted Activity **discharges to land from deep bores shall be no closer than: c. 1000 metres up flow and 150 metres down flow of a community drinking water supply;**

²⁹ <http://www.gdc.govt.nz/the-tairawhiti-plan/>

³⁰ <http://www.gdc.govt.nz/freshwater-plan-proposed/>

C.6 Taranaki

Taranaki Regional Council uses the Regional Freshwater Plan (RFP)³¹ to manage freshwater resources in the region. Most of the discharge rules specify a buffer distance of 50 m around any bore, well or spring used for water supply and 25m of any surface water body. Examples of several rules where this distance is specified, are detailed below. It is expected that a discretionary approach is taken when considering discharge consents in the vicinity of a water supply take. Seismic surveys must be located at least 100 metres from any bore, well or spring used for water supply purposes in order to avoid the potential contamination of the water supply.

RFP Rule Examples

Rule 22 Discharge of contaminants from **on-site domestic wastewater treatment** systems onto or into land. Permitted if: **The discharge shall not be within 50m of any bore, well or spring used for water supply;**

Rule 29 Discharge of **contaminants from industrial and trade** premises onto or into land, excluding those provided for by Rules 22, 23 and 42. Permitted if: **The discharge shall not be within 25m of a surface water body;** The discharge shall **not be within 50m of any existing bore, well or spring used for water supply;**

Rule 39 Discharge of **farm dairy effluent** onto or into land. Permitted if: Discharge shall **not occur within 50m of any bore, well or spring used for water supply** purposes; Discharge shall **not occur within 25m of any surface waterbody;**

Rule 37 **Discharge of piggery or poultry** washdown water or poultry effluent onto or into land. Permitted if: Discharge shall **not occur within 50m of any bore or well used for water supply purposes;** **Discharge shall not occur within 25m of any surface waterbody;**

Rule 46 Drilling and/or construction of a well, bore, piezometer or seismic survey into and under land. Permitted if: Any seismic survey shall be located **not less than 100m from any bore, well or spring used for water supply** purposes.

C.7 Hawkes Bay

Hawke's Bay uses the Hawke's Bay Regional Resource Management Plan³² to inform resource use in the region. Policies and rules do not specify exclusion distances around water takes but these would be considered when consent applications are made. Water Management Zones are designated to limit the leaching of nitrogen into groundwater.

Examples of policies and rules in the Hawke's Bay Regional Resource Management Plan that relate to the protection of water supplies are specified below.

POL 10 REGULATION – DISCHARGES OF AGRICHEMICALS

3.6.10 To provide for discharges of agrichemicals into air, onto land or into water, in circumstances where the following requirements are met: (i) **The discharge does not result in any spray drift being deposited on any roof or other structure used as a catchment for water supply.**

5.9.2 WATER QUALITY POLICIES

POL TT1 SURFACEWATER QUALITY LIMITS, TARGETS AND STATE INDICATORS

4. **Manage point source discharges and the use of production land upstream of any registered drinking water supply takes** to ensure compliance with the Resource Management (National

³¹ <https://www.trc.govt.nz/council/plans-and-reports/strategy-policy-and-plans/regional-fresh-water-plan/>

³² <https://www.hbrc.govt.nz/assets/Document-Library/Plans/Regional-Resource-Management-Plan/View-RRMP/New-Volume-1.pdf>

Environmental Standards for Sources of Human Drinking Water) Regulations 2007 and the Drinking-Water Standards for New Zealand (2005 Revised edition 2008).

POL TT2 GROUNDWATER QUALITY LIMITS

1. For groundwater Hawke's Bay Regional Council will: (d) **Manage point source discharges and the use of production land upstream of any registered drinking water supply takes** to ensure compliance with the Resource Management (National Environmental Standards for Sources of Human Drinking Water) Regulations 2007 and the Drinking-Water Standards for New Zealand (2005 Revised edition 2008).

C.8 Manawatu-Wanganui

Horizons (the Manawatu-Wanganui Regional Council) has the One Plan³³ that is a consolidated resource management planning document including the Regional Plan. This is a far more recent document than some councils have and, although it considers the protection of water supplies, the focus is on surface water supplies.

Surface water in the region is classified into Water Management Zones. Surface water takes and the tributaries within the catchments they are sourced from, are shown in Figure B:10, page B-73 of the One Plan and would be used as a reference for any activity that may affect the Water Supply Values, when considering consent applications. Table B10 'Water Supply Value in the Region' of the One Plan specifies the rivers and areas that are considered part of each Water Management Zone. These will often include all tributaries above the point of water take. Specific buffer zones around community water supplies are not specified.

Under the One Plan existing dairy, intensive sheep and beef, cropping and horticulture operations within "priority catchments", plus conversions elsewhere in the region will require a resource consent in terms of nutrient management to limit diffuse nutrient loss and degradation of water resources, including drinking water supplies.

Examples of rules from the One Plan that impose specific buffer distances are included below;

Rule 14-13 Existing **discharges of domestic wastewater** (e) The *discharge* must comply with the following separation distances: (i) **at least 20 m from any bore* used for drinking water supply** (ii) **at least 20 m from surface water bodies.**

Policy 15-1: Consent decision-making for *agrichemicals*

When making decisions on *resource consent* applications and setting consent *conditions* for *discharges of agrichemicals** that fail to meet either Rule 15-1 or Rule 15-2 (and which are therefore *discretionary activities*), the Regional Council will have regard to: (e) **preventing any discharge that is likely to adversely affect sensitive areas including**, but not limited to: (vii) **domestic, commercial and public water supply* catchments and intakes,**

Where: a *Public water supply* means a reticulated publicly or privately owned drinking *water* supply connecting at least two buildings and serving at least 1,500 person days per year (e.g. 25 people for at least 60 days per year) and *Drinking water* is water intended to be used for human consumption, food preparation, utensil washing, oral hygiene or personal hygiene.

³³ <https://www.horizons.govt.nz/publications-feedback/one-plan>

C.9 Wellington

Greater Wellington Regional Council uses a series of Regional Management Plan documents including the Regional Coastal Plan, Regional Freshwater Plan³⁴, Regional Soil Plan, Regional Air Quality Management Plan and a Regional Plan for Discharges to Land³⁵. They are currently in the hearing process of the new Proposed Natural Resources Plan (PNRP)³⁶ that will encompass the existing Regional Management Plans.

The Proposed Natural Resources Plan has extensive source protection consideration for both surface water and groundwater community drinking supplies and has used a similar delineation of source protection zones to those used in this report. An online geodatabase designates the location of the source protection zones for all relevant community drinking water supply points.

Surface drinking water protection areas are defined by the run time it would take water entering the stream to reach the abstraction point. Different catchments have different run times based on catchment characteristics. A 200m wide buffer is overlaid on the defined river-run extent up the catchment from the abstraction point. The surface water community drinking water supply protection areas are incorporated as maps in Chapter 13, Map 26 of the PNRP (Figure 12). A category 1 surface water body includes the water within 1000m of a surface water abstraction site used for community drinking.

Schedule M2 of this plan specifies groundwater drinking water supply abstraction points. The groundwater drinking supply protection areas are incorporated in Maps 27a, 27b, and 27c of the PNRP (Figure 13). The zones describe the area within which an activity might reasonably be expected to impact upon the quality of water at the abstraction point.

The following activities are a risk to drinking water supplies and are limited in these catchments: septic tanks/ pit toilets, wastewater, agricultural effluent, agrichemicals, pest control sprays, farm dumps and offal pits. Water abstraction for dewatering where there is risk to water quality and discharges of water are also controlled (e.g., from contaminated land).

Appendix 6 of the Freshwater Plan also identifies surface water catchments that are managed for water supply purposes, but does not identify the areas of protection in such detail as the PNRP does. This is particularly the case for the groundwater supply bores. The Regional Plan for Discharges to Land specifies several rules for 20m buffers around drinking water supplies, but there are no separate rules specified for community water supplies.

³⁴ <http://www.gw.govt.nz/Regional-Freshwater-Plan/>

³⁵ <http://www.gw.govt.nz/regional-plan-for-discharges-to-land/>

³⁶ <http://www.gw.govt.nz/assets/Plans--Publications/Regional-Plan-Review/Proposed-Plan/Proposed-Natural-Resources-Plan-for-the-Wellington-Region-July-2015.pdf>

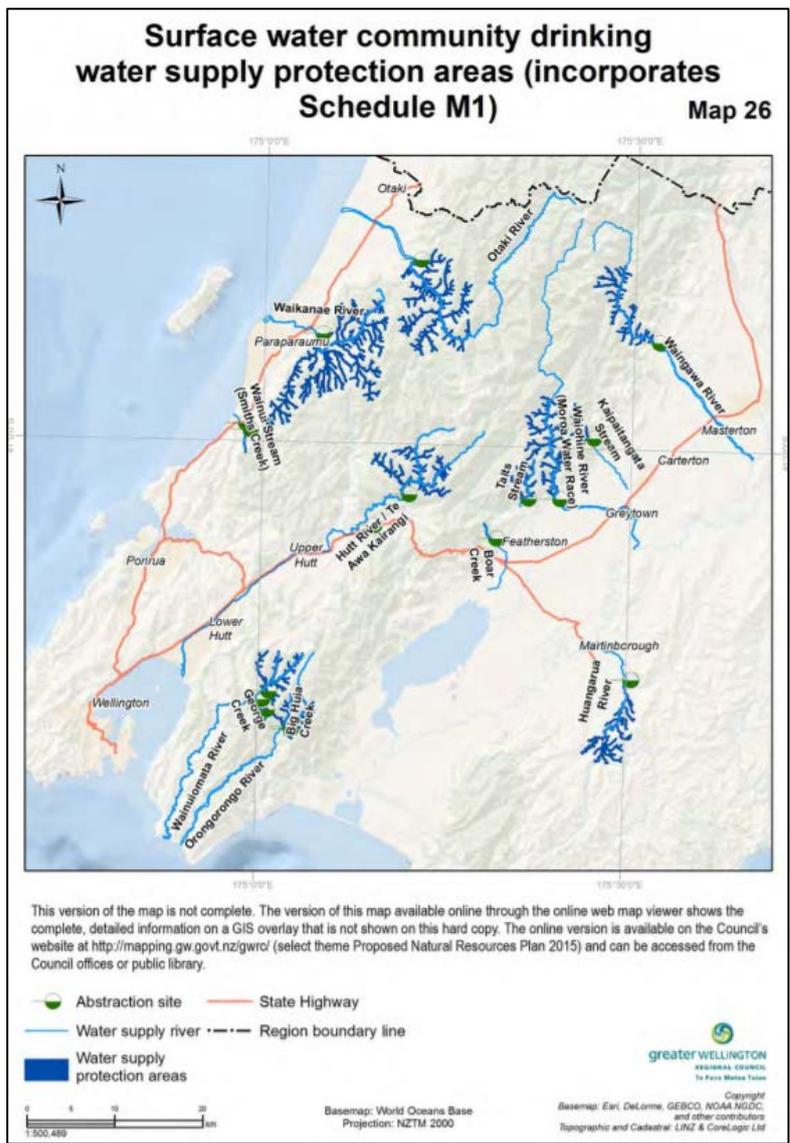
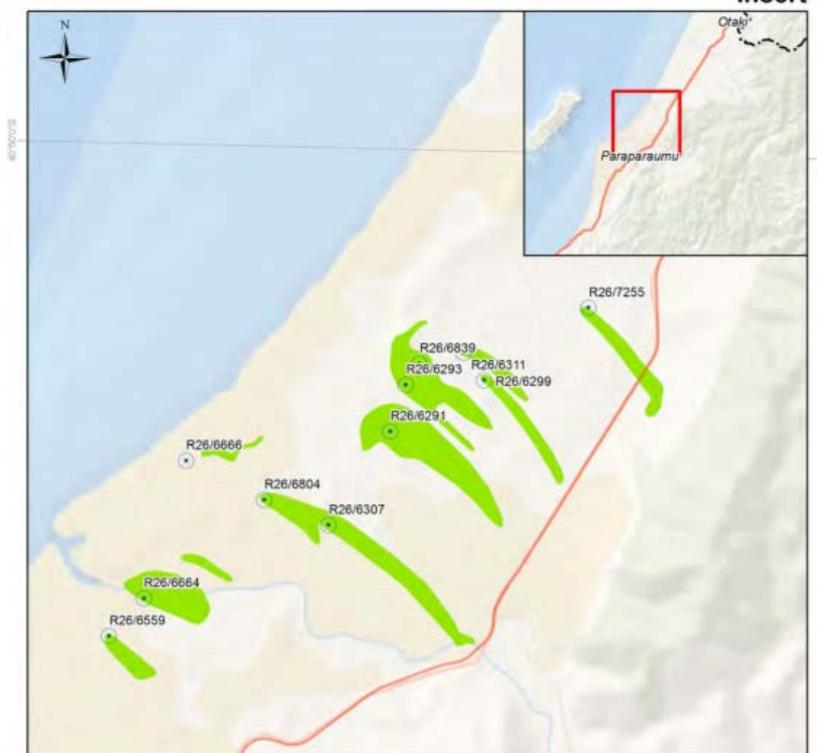


Figure 12. Example of surface water community drinking water supply protection areas, PNRP Map 26.

Groundwater community drinking water supply protection areas - Kāpiti Coast (incorporates Schedule M2)

Map 27c
Insert



This version of the map is not complete. The version of this map available online through the online web map viewer shows the complete, detailed information on a GIS overlay that is not shown on this hard copy. The online version is available on the Council's website at <http://mapping.gw.govt.nz/gwrc/> (select theme Proposed Natural Resources Plan 2015) and can be accessed from the Council offices or public library.

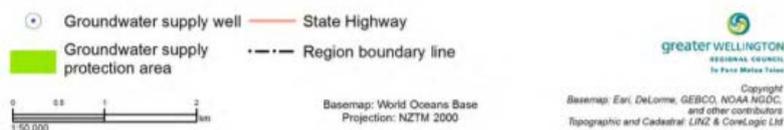


Figure 13. Example of groundwater community drinking water supply protection areas, PNRP Map 27c

Examples of rules that relate to drinking water source protection are included below.

Proposed Natural Resources Plan

Policy P69: Human drinking water supplies- The adverse effects from discharges to land and water on the quality of community drinking water supplies and group drinking water supplies shall be avoided to the extent practicable. Where adverse effects cannot be avoided, the adverse effects shall be managed having particular regard to: (a) water quality in relation to determinants, including aesthetic determinants, at the water supply abstraction point, and (b) the type and concentration of the contaminant(s) in the actual discharge, and (c) soil type, in the case of discharges to land, and (d) travel time and path of contaminants from source to water supply abstraction point, and (e) treatment, design and maintenance, and (f) the risk of accident or an unforeseen event causing significant adverse effects on water quality. This shall be done in consultation with the drinking water supply operator and in accordance with the National Environmental Standards for Sources of Human Drinking Water 2007.

Rule R36: Agrichemicals – The discharge of agrichemicals into air or onto or into land where it may enter water is a permitted activity, provided the following conditions are met: For all applications

excluding residential areas and hand-held/knapsack applications: (e) **there is no discharge into water or within a community drinking water supply protection area.**

Rule R46: Dye or salt tracer – The discharge of dye or salt tracer, excluding radioisotope tracers, into water or onto or into land where it may enter water is a permitted activity, provided the following conditions are met: (a) **the discharge is not into a water body within a community drinking water supply protection area** as shown on Map 26, Map 27a, Map 27b or Map 27c.

Rule R76: Discharge of contaminants to land – New or upgraded on-site wastewater systems **within community drinking water supply protection areas are controlled activities.**

Rule R92: Refuse, silage, compost – **All discharges to land within community drinking water supply protection areas are restricted discretionary activities.**

Rule R71: Pit latrine – The discharge of domestic wastewater onto or into land and the associated discharge of odour from a new pit latrine is a permitted activity, provided that the following conditions are met: (a) **the pit latrine is not located: (ii) within a community drinking water supply protection area** as shown on Map 26, Map 27a, Map 27b or Map 27c.

Rule R75: New or upgraded on-site wastewater systems – The discharge of domestic wastewater onto or into land and the associated discharge of odour from a new or upgraded on-site domestic wastewater treatment and discharge system is a permitted activity provided the following conditions are met: (e) **the discharge is not located within: (iv) a community drinking water supply protection area** as shown on Map 26, Map 27a, Map 27b or Map 27c.

Rule R77: Application of Aa biosolids to land – The discharge of Aa grade biosolids onto or into land and the associated discharge of odour is a permitted activity, provided the following conditions are met: (e) **the discharge is not located within a community drinking water supply protection area** as shown on Map 26, Map 27a, Map 27b, or Map 27c.

Rule R78: Application of biosolids (Ab, Ba, or Bb) to land – The discharge of Ab, Ba or Bb grade biosolids onto or into land and the associated discharge of odour is a restricted discretionary activity, provided the following conditions are met: (a) **the discharge is not located within a community drinking water supply protection area** as shown on Map 26, Map 27a, Map 27b, or Map 27c, and

Rule R79: Discharge of treated wastewater – The discharge of treated wastewater onto or into land, and the associated discharge of odour is a controlled activity, provided the following conditions are met: (a) **the discharge is not located within a community drinking water supply protection area** as shown on Map 26, Map 27a, Map 27b, or Map 27c, and

Rule R83: Discharge of collected animal effluent onto or into land – The discharge of collected animal effluent, including sludge, onto or into land and the associated discharge of odour from: (a) dairy farms, (b) piggeries, (c) poultry farms, (d) other premises involving the concentration of animals in a confined area is a controlled activity, provided the following conditions are met: (e) **the discharge is not located within: (iii) a community drinking water supply protection area** as shown on Map 26, Map 27a, Map 27b or Map 27c, and

Rule R89: Farm refuse dumps – The discharge of contaminants onto or into land, and the associated discharge of odour, from a new farm refuse dump is a permitted activity, provided the following conditions are met: (d) the farm refuse dump is **not located within: (iii) a community drinking water supply protection area** as shown on Map 26, Map 27a, Map 27b, or Map 27c, and

Rule 92: All discharges to land within community drinking water supply protection areas – **The discharge of a contaminant onto or into land that occurs within a community drinking water supply protection area, and is not permitted under Rules R71, R75, R77, R78 or R89 is a restricted discretionary activity** provided the following conditions are met:

Rule R146: Geotechnical investigation bores – The use of land and the associated diversion and discharge of water or contaminants for the drilling, construction or alteration of a geotechnical investigation bore is a permitted activity, provided the following conditions are met: (a) **the bore is not located within a community drinking water supply protection area** shown on Map 26, Map 27a, Map 27b, or Map 27c, and

Regional Freshwater Plan

Policy 5.2.5 To **manage water quality for water supply purposes** in those water bodies, or parts of water bodies, identified in Appendix 6 (subject to Policy 5.2.10).

Explanation. This policy sets out the areas where water quality will be managed for water supply purposes. These water bodies are identified in Appendix 6. The relevant guidelines to consider when deciding whether a discharge is able to satisfy this policy are given in section A8.6 of Appendix 8.

Regional Discharge to Land Plan

Buffer distances from rivers and watercourses have been included so that this Plan is not inconsistent with the Regional Freshwater Plan. The Regional Freshwater Plan directs that catchments identified in Appendix 6 of that Plan are managed for the purpose of water supply. Other rivers are managed for contact recreation.

Rule 9 Refuse disposal and composting

The discharge of any contaminants into or onto land in connection with: (1) refuse disposal at farm (including factory farms) landfills or domestic (residential) waste disposal sites; and (2) farm composting operations (including factory farms) and domestic composting operations;

is a Permitted Activity provided (c) the **discharge shall occur no less than 20 m from any surface water body, from any bore used for drinking water supply**, or from the coastal marine area;

Rule 11 Offal pits and silage

The discharge of contaminants into or onto land in connection with: (1) the disposal of offal on production land or at a factory farm; (2) the storage of silage;

is a Permitted Activity provided (a) the discharge shall occur **no less than 20 m from any surface water body, from any bore used for drinking water supply** or from the coastal marine area;

Rule 13 Agricultural effluent

The discharge of collected agricultural effluent, except composted agricultural effluent, into or onto land from: (1) dairy sheds; (2) piggeries; (3) poultry farms; or (4) other premises, involving the concentration of livestock in a confined area, from which effluent is collected and discharged;

is a Controlled Activity and shall comply with the standards and terms below. (b) the discharge shall occur **no less than 20 metres** from the neighbouring property boundary, **any surface water body**, farm drain, water supply race, **any bore**, or the coastal marine area;

Rule 19 Water treatment plant wastes

The discharge from water treatment plants into or onto land of: (1) supernatant and other waste water; (2) coagulant wastes and admixtures containing coagulant wastes mixed with soil, aggregates, or other naturally occurring materials;

is a Controlled Activity, and shall comply with the standards and terms below. (a) the discharge shall occur **no less than 20 metres from any surface water body, from any bore used for drinking water** supply, irrigation or stock water or from the coastal marine area;

C.10 Nelson

The Nelson Resource Management plan (NRMP)³⁷ is split into 4 volumes, made up of 'General', 'Zones', 'Appendices', and 'Planning Maps'. Nelson City Council takes water from the Maitai and Roding rivers to supply drinking water, and these catchments are owned and managed by the Council to protect the quality of the city's water supplies. In the rest of the region there is currently only 1 community water supply not council owned.

There are no specified distances of source protection zones around community water supplies in the NRMP and the adverse effects of the potential discharge in any catchment of a water take would be

³⁷ <http://nelson.govt.nz/environment/nelson-resource-management-plan/nelson-resource-management-plan-2/view-the-nrmp/download-the-nrmp-2/>

assessed through the resource consent application process. The relevant rules that relate to drinking water source protection in the NRMP are included below.

Zone RU1.2 is the rural zone area surrounding Nelson, which contains the **two water supply sources**. RU1.2.i Providing that activities do not conflict with the overall objectives and policies for the Zone, they will generally be permitted. This philosophy means that while there will be no lists of activities which will generally be provided for in the Zone, any activity which can be demonstrated to comply with the permitted standards of the zone can proceed.

The key discharge rules for the freshwater receiving environments are included within Appendix 28 'Freshwater'. This includes rule FWr.25 as set out below. Any other discretionary activity resource consent application can be considered against its impact on community water supplies if this is relevant.

FWr.25 General discharges to land where it may enter water

FWr.25.1

a) Discharge of water from swimming pools, and b) discharge of swimming pool filter backwash water where discharge to the sewerage system is not practicable, and c) discharge of dead animals, offal and household organic waste to offal pits in the Rural Zone, and d) discharge of grey water or sediment-laden water to land is permitted if:

i) the discharge does not result in surface ponding or runoff of any contaminant into a surface water body, and ii) there is no direct discharge of any contaminant into any surface water body, and iii) the **discharge is not within 25m of a surface water body** or within any Flood Overlay, and iv) the discharge is not within 50m of any bore, well, or spring used for water supply, and v) the discharge is not noxious, dangerous, offensive or objectionable to such an extent that it has or is likely to have a significant adverse effect on the environment, and vi) the water is contained on the site so that there are no adverse effects on adjoining properties. e) The discharge of water from a sediment treatment pond or impoundment area onto land where it may enter a surface water body is permitted if:

i) there is no point source discharge of any contaminant into any water body, and ii) the water is not discharged onto adjoining properties f) Discharge of point source stormwater to land is permitted if:

i) **the discharge is not within 25m of a surface water body**, and ii) **the discharge is not within 50m of any bore, well or spring used for water supply**, and iii) the discharge is not noxious, dangerous, offensive or objectionable to such an extent that it has, or is likely to have, an adverse effect on the environment, and iv) the water is not discharged onto adjoining properties. g)

Discharges into the Council's stormwater infrastructure are permitted if they comply with:

i) the conditions in the NCC Stormwater Bylaw 2006, and ii) section 9.3 of the NCC Land Development Manual 2010, and iii) all other stormwater management requirements in the plan.

C.11 Tasman

The Tasman Resource Management Plan (TRMP)³⁸ is the Tasman District Council's combined district and regional plan. It seems that the Tasman District Council primarily uses the NES to inform water supply and resource consent application decisions as there are no specific references to water supply protection zones. However, community water supply security is a significant issue for Tasman District Council and the values of various catchments are outlined in Chapter 30 Taking, Using, Damming and Diverting Water and this includes highlighting the water supply values. There are surface water protection zones covering large areas. Specific rules within Chapter 31 Water Take, Diversion or Use protect the supply and allocation of community supplies. Chapter 36 Contaminant Discharge Rules contain a number of provisions which require setbacks from water bodies and from bores for domestic water supply purposes. It also sets out rules ensuring there is no increase in sediments or pathogenic organisms in groundwater bores used for potable water supply purposes.

An example of a rule in the TRMP that relates to community water supplies is included below.

Section 36.6.2.2 Controlled Activities (Discharge of Pesticides) (d) 'The pesticide is not discharged onto any urban or **community water supply catchment area**, or roof, or other water collection structure'. Where 'community water supply' means a reticulated water supply of potable water to a

³⁸ <http://www.tasman.govt.nz/policy/plans/tasman-resource-management-plan/>

number of water users primarily for domestic household supply and may include industrial and commercial uses.

C.12 Marlborough

Marlborough has two separate operational Regional Plans; Marlborough Sounds Resource Management Plan³⁹ and Wairau/Awatere Resource Management Plan⁴⁰. The Proposed Marlborough Environment Plan (PMEP)⁴¹ is currently in the hearing process and is a combination of the operational plans.

The Wairau/Awatere Resource Management Plan, and the Marlborough Sounds Resource Management Plan, do not specify rules for community water supplies. The PMEP identifies areas of groundwater protection are required above sensitive aquifers that supply drinking water. Figure 14 shows several defined groundwater protection areas around water supply bores. There is no specific source protection areas for surface water supplies.

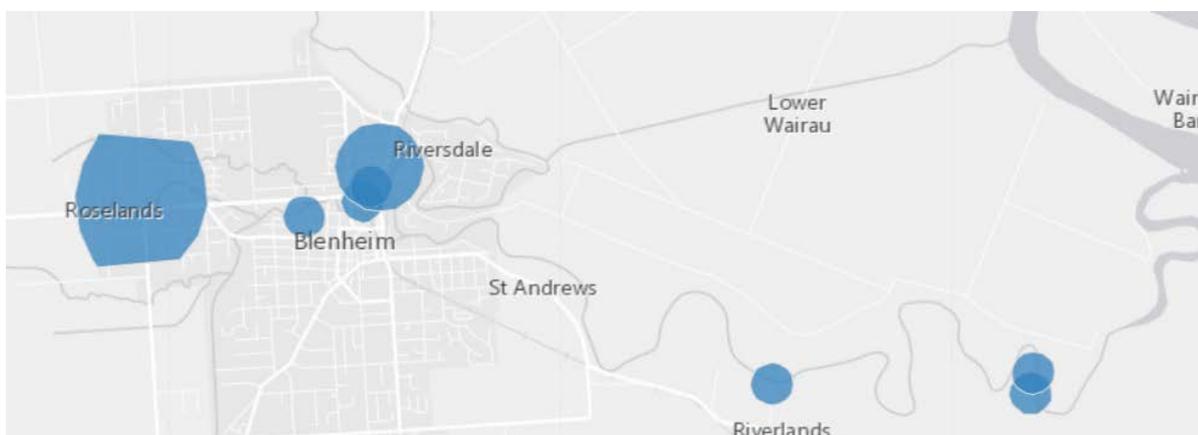


Figure 14. Several Groundwater Protection Areas⁴² in Marlborough

The following text from the PMEP explains the rationale behind identifying groundwater protection zones. Groundwater is the source of drinking water for most of Marlborough's towns and small settlements. This policy establishes controls on activities that could result in groundwater becoming unsafe for consumption as a result of the leaching of contaminants into groundwater. The vulnerability of aquifers to leachate contamination is determined by the depth of the aquifer and the permeability of the overlying soil. Any **area of land above an aquifer considered to be high risk** has been mapped in the MEP as a **Groundwater Protection Area**. Within this area, change of land use to activities likely to generate leachate should, where practicable, be avoided. Where it is not considered possible to do so, provision must be made to contain the leachate generated. The groundwater beneath existing land uses will also be monitored. Where land use in the area is observed to be adversely affecting groundwater quality, actions may be required to avoid the effect in the future. The discharge of contaminants and excavation within groundwater protection areas will also be regulated to avoid any adverse effect on groundwater quality. Collectively, the controls implemented through this policy will assist to protect the health and wellbeing of communities that rely on groundwater as a source of drinking water.

³⁹ <https://www.marlborough.govt.nz/your-council/resource-management-policy-and-plans/marlborough-sounds-resource-management-plan>

⁴⁰ <https://www.marlborough.govt.nz/your-council/resource-management-policy-and-plans/wairau-awatere-resource-management-plan>

⁴¹ <https://www.marlborough.govt.nz/your-council/resource-management-policy-and-plans/proposed-marlborough-environment-plan>

⁴² <https://data-marlborough.opendata.arcgis.com/datasets/mep-groundwater-protection-areas?geometry=173.85%2C-41.534%2C174.111%2C-41.489>

Examples of rules relevant to source protection are provided below.

PMEP

3.3.30. Discharge of human effluent into or onto land. 3.3.30.6. The discharge must not occur within a Groundwater Protection Area. 3.3.30.7. The discharge must **not occur within 50m of a bore** unless the bore intercepts the confined layer of Riverlands FMU or the confined layer of the Wairau Aquifer FMU.

3.3.31. Disposal of farm rubbish into a pit. 3.3.31.4. The farm rubbish pit must **not be located within:** (a) **50m of a bore** unless the bore intercepts the confined layer of Riverlands FMU or the confined layer of the Wairau Aquifer FMU; (b) **20m of a river**, lake, Significant Wetland, drainage channel or Drainage Channel Network;

15.M.15 Groundwater Protection Areas. Identify land in the vicinity of community drinking water supply bores as Groundwater Protection Areas. The spatial extent of the area will be determined by the vulnerability of the underlying groundwater to leachate contamination.

C.13 West Coast

The Regional Land and Water Plan⁴³ is the document the West Coast uses to inform resource management decisions in the region.

Schedule 7B of the RLWP provides a list of water bodies that community water supplies are taken from at the time of printing. Potential impacts of activities on these takes will be taken into account when considering applications for resource consents as specified in the rules of the plan.

The rule examples below from the Regional Land and Water Plan indicate rules for any drinking water bore, but not specifically for community water supplies.

3.3 Policies 3.3.1 In the management of any activity involving water to give priority to avoiding, in preference to remedying or mitigating: (1) Adverse effects on: (b) **Water supply values identified in Schedule 7B.**

Rule 63. Discharge of stormwater from reticulated systems The discharge of stormwater from any reticulated stormwater system to water is a permitted activity if all of the following conditions are met: (e) Beyond a mixing zone of 12 times the width of the receiving water body, or 200 metres, whichever is the lesser, the discharge does not give rise to the following effects: i) The production of any conspicuous oil or grease films, scums or foams, or floatable or suspended materials; or ii) Any conspicuous change in the colour or visual clarity; or iii) Any emission of objectionable odour; or iv) The rendering of fresh water unsuitable for consumption by farm animals; or v) Any significant adverse effects on aquatic life; or vi) **Adverse effects on any take of water for human consumption.**

Rule 72. Silage and silage wrap – The discharge of any contaminants into or onto land in connection with the storage of silage is a permitted activity, provided that all of the following conditions are met: C) Silage storage areas shall be located **not less than 50 metres from any potable groundwater bore or well.**

Rule 73. Solid waste and ofal pits – The discharge of any contaminants into or onto land in connection with the disposal of solid waste, including ofal, on production land is a permitted activity, provided that all of the following conditions are met: (g) **Ofal pits shall be located not less than 50 metres from any potable groundwater bore or well.**

Rule 75. Land application of agricultural effluent – (a) No agricultural effluent is discharged within: i) **50 metres of any well or bore used for potable water supply and there are no adverse effects on any take of water for human consumption;**

⁴³<http://www.wcrc.govt.nz/Documents/Resource%20Management%20Plans/Operative%20Land%20and%20Water%20Plan%20May%202014.pdf>

Rule 76. Feed lots and wintering pads – The discharge of contaminants into or onto land at or from any feed lot, stand-off pad or wintering pad is a permitted activity provided that all of the following conditions are met: a) The discharge is not within: ii) **50 metres of any bore or well used for potable water supply or stock water supply, and there are no adverse effects on any take of water for human consumption.**

Rule 79. On-site discharge of sewage effluent.– (b) The discharge is not within: iii) 100 metres of any bore or well used for potable water supply, where the discharge is from a soak pit and there are no adverse effects on any take of water for human consumption; or iv) **50 metres of any bore or well used for potable water supply** where the discharge is from other treatment systems;

Rule 80. Discharge from pit toilets – The discharge of any sewage into or onto land, other than septage, from pit toilets or long-drop toilets is a permitted activity, provided that all of the following conditions are met: (b) The toilet is not sited within: ii) **50 metres horizontally of any bore or well used for potable water supply, and there are no adverse effects on any take of water for human consumption;**

C.14 Canterbury

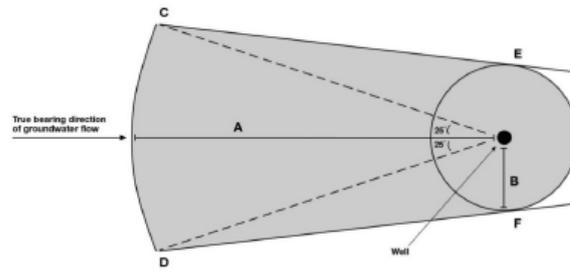
The Canterbury Land and Water Regional Plan⁴⁴ includes in depth consideration of source protection zones.

Provisional source protection areas around groundwater community drinking sources are based on the screen depth and aquifer type and range from an area of 100-2000 m up-gradient and 100-400 m downgradient of the bore (Figure 15).

Surface water source protection zones cover an area of 50 m either side of the river bed, 1000 m upstream and 100 m downstream. The groundwater and surface water protection areas are mapped in the Environment Canterbury GIS database Canterbury Maps. In some cases, such as when a new bore is constructed or if the level of protection is not deemed adequate, site specific information is used to determine the SPZ, such as: topography, geography, geology, well depth, construction, pumping rates, aquifer type, surface water flow rate, types of actual and potential contaminants, the level of treatment, and the potential risk to water quality.

⁴⁴ <https://www.ecan.govt.nz/your-region/plans-strategies-and-bylaws/canterbury-land-and-water-regional-plan/>

Figure S1A Method for calculating the area of a provisional Group or Community Drinking-water Protection Zone.



The area of the protection zone is determined by selecting from the table below depending on the screen depth (or well depth if no screen depth is recorded) and aquifer type.

Table S1A - Protection Areas

| Screen Depth (or well depth if no screen depth is recorded) | Aquifer Type | Protection distances (m) | |
|----------------------------------------------------------------------|-----------------------------------|---------------------------------|-----|
| | | Upgradient from the bore (A) | |
| <10 m | All | 2,000 | 200 |
| 10-<30 m | Unconfined or semi confined | 1,000 | 200 |
| | Confined | 100 | 100 |
| | Coastal Confined Gravel Aquifer 1 | 400 | 400 |
| 30 – 70 m | Unconfined or semi confined | 500 | 200 |
| | Confined | 100 | 100 |
| | Coastal Confined Gravel Aquifer 1 | 400 | 400 |
| > 70 m | Unconfined or semi confined | 100 | 100 |
| | Confined | 100 | 100 |
| | Coastal Confined Gravel Aquifer 1 | 400 | 400 |

Existing surface water community drinking-water supplies, including galleries, are protected from discharges for the following distances, across the full width of the bed, and within a lateral distance of 50 m from the bed:

- Upstream on a river 1,000 m
- Downstream on a river 100 m
- On a lake 500 m radius from the point of take

Schedule 1(a) – Community Drinking Water Supply Sites

1. Kimbell Rural Supply
2. Burkes Pass
3. Pukaki Airport

Figure 15. Schedule 1 of the Canterbury Land and Water Regional Plan showing parameters that determine source protection zones around community drinking water supplies.

The activities limited within the source protection zone include those that may affect water quality. Examples are included in the rules below.

Policy 4.23 *The Canterbury Land and Water Regional Plan* states that ‘**Any water source used for drinking-water supply is protected from any discharge of contaminants that may have any actual or potential adverse effect on the quality of the drinking-water supply including its taste, clarity and smell and community drinking water supplies are protected so that they align with the CWMS drinking-water targets and meet the drinking-water standards for New Zealand**’.

A community drinking water supply is defined as the sites recorded in the drinking water registry that provide >25 people with drinking water for >60 days of a calendar year together with sites listed in Schedule 1(a).

Rule 5.7 The discharge of wastewater from an existing on-site wastewater treatment system onto or into land in circumstances where a contaminant may enter water is a permitted activity, provided the following conditions are met:

5. The discharge is not onto or into land: (d) within 20 m of any surface waterbody or the Coastal Marine Area; or (e) within 50 m of a bore used for water abstraction; or (f) **within a Community Drinking-water Protection Zone** as set out in Schedule 1 of this Plan.

5.14 The discharge of untreated human excrement via a pit toilet onto or into land in circumstances where a contaminant may enter water is a permitted activity, provided the following conditions are met: 4. The pit toilet is not: (a) within 20 m of any surface waterbody, a bore used for water abstraction or the Coastal Marine Area; or (b) within a Community Drinking-water Protection Zone as set out in Schedule 1.

Most other discharge rules are similar to rule 5.7, which exclude discharges within the Community Drinking-water Protection Zones.

C.15 Otago

The Otago Regional Council regulatory documents that relate to rules surrounding water protection are the Regional Plan: Water for Otago⁴⁵, and the Regional Plan: Waste for Otago⁴⁶. These plans specify that there is to be no discharge of contaminants that will affect the quality of the water.

There are several groundwater protection zones designated, depending on the risk of leaching. It is understood that many activities involving discharge to land/water are not permitted in these areas. For example: Regional Plan: Water For Otago 9.4.20 To require that all practical alternative locations for the storage of hazardous substances have been considered before such storage occurs over Zone A of any Groundwater Protection Zone identified on the C series maps.

Schedule 1B of the Regional Plan: Water for Otago lists the community water supplies, and their locations are detailed in Maps A1-A16.

The following rules are in place for discharges near wells used for domestic purposes, so would be an absolute minimum requirement for a community water supply.

Regional Plan: Waste for Otago

7.6.8 Farm landfills (permitted activity) 1 The discharge of any contaminant into or onto land; 2 The discharge of any contaminant or water into water; or 3 The discharge of any contaminant to air, when occurring as the result of a farm landfill is a permitted activity provided that: (c) It is not dug within **100 metres**, horizontally, of a well used to provide water for **domestic purposes** or drinking water for livestock; (d) Leachate from the landfill does not enter any water body.

If this same rule is met it is considered a permitted activity for 7.6.10 Greenwaste Landfills, 7.6.12 Composting, 7.6.14 Discharges from Silage Production. 7.6.5 Offal pits on production land or factory farm

7.6.6 Offal pits on industrial or trade premises, excluding factory farms (controlled activity) 1 The discharge of any contaminant into or onto land; 2 The discharge of any contaminant or water into water; or 3 The discharge of any contaminant to air, when occurring as the result of an offal pit on industrial or trade premises (excluding factory farms) is a controlled activity, provided that: (b) It is not constructed within **100 metres**, horizontally, of a well used to provide water for **domestic purposes** or drinking water for livestock;

The Central Otago District Council Water Supply Bylaw 2008 (<http://www.codc.govt.nz/SiteCollectionDocuments/Bylaws/Other%20Council%20Bylaws/Water%20Supply%20Bylaw.pdf>) specifies rules for council water supplies and is assigned into catchments of controlled, restricted or open status. Controlled and restricted catchments are restricted or require permits for specific activities such as hunting, shooting and fishing.

⁴⁵<http://archive.orc.govt.nz/Publications-and-Reports/Regional-Policies-and-Plans/Regional-Plan-Water/#download>

⁴⁶ <https://www.orc.govt.nz/media/1516/regional-plan-waste-for-otago.pdf>

C.16 Southland

The operative Southland Regional Council plans that relate to this review are the Regional Water Plan⁴⁷ and the Effluent Land Application Plan⁴⁸. The Proposed Southland Land and Water Plan (PSLWP)⁴⁹ is in the final stages of appeals before becoming operative in 2019.

The Proposed Southland Land and Water Plan indicates that discharges cannot occur within the microbial health protection zone area (defined in Appendix J of the PSLWP) of a drinking water supply site, or if no such zone is identified then 250 m of the abstraction point of a drinking water supply. Discharges include but are not limited to pest control poisons, wastewater, septic systems, agricultural effluent/dips, silage storage/leachate, farm landfills, offal pits, and cemeteries.

The operative Regional Water Plan and Effluent Land Application Plan uses less specific terminology than the PSLWP. Generally a 100m exclusion zone is required for discharges from water abstraction sites, but a greater distance may be required in particular circumstances such as for a registered drinking water supply. The PSLWP is more detailed and defines the source protection zones much clearer than the operative plans.

Rules that relate to source protection zones, are detailed below.

PSLWP

Rule 9 – Discharge of agrichemicals onto or into surface water

(a) The discharge of agrichemicals and any associated wetting, antifoaming and anti-drifting agent and marker dyes into or onto surface water is a permitted activity provided the following conditions are met:

(vii) the discharge is **not into water within** natural state waters, a mātaītai reserve or taiāpure, or within the **microbial health protection zone of a surface water drinking water supply site identified in Appendix J**, or where no such zone is identified, **within 250 metres upstream of the abstraction point of a surface water drinking water supply site** identified in Appendix J; and The following rules in the PSLWP are very similar to Rule 9 (a) (vii) regarding source protection zones.

Rule 11 – Discharge of vertebrate pest control poisons

Rule 26 – Discharges from on-site wastewater systems,

Rule 27 – Discharges from pit toilets

Rule 29 – Discharges of aerobically composted human excreta

Rule 35 – Discharge of agricultural effluent to land

Rule 35A – Feed pads/lots

Rule 36 – Horticulture wash-water

Rule 37 – Agricultural dips

Rule 40 – Silage storage

Rule 41 – Silage leachate

Rule 43 – Farm landfills

Rule 48 – Cemeteries

Effluent Land Application Plan

Resource Consent conditions are dependent upon the scale and potential for adverse effects. Consents issued for the discharge of agricultural effluent onto or into land may be subject to the following types of conditions, as well as any other conditions deemed necessary due to site specific factors: b. **buffer distances**. These distances will typically be applied around the following: iii. water abstraction point.

⁴⁷ <http://www.es.govt.nz/document-library/plans-policies-and-strategies/regional-plans/Pages/Effluent-Land-Application-Plan.aspx>

⁴⁸ <http://www.es.govt.nz/document-library/plans-policies-and-strategies/regional-plans/Pages/Water-Plan.aspx>

⁴⁹ [http://www.es.govt.nz/Document%20Library/Plans,%20policies%20and%20strategies/Regional%20plans/Southland%20Water%20and%20Land%20Plan/Proposed%20Southland%20Water%20and%20Land%20Plan%20Part%20A%20Decisions%20Version%20\(4%20April%202018\)%20PDF.pdf](http://www.es.govt.nz/Document%20Library/Plans,%20policies%20and%20strategies/Regional%20plans/Southland%20Water%20and%20Land%20Plan/Proposed%20Southland%20Water%20and%20Land%20Plan%20Part%20A%20Decisions%20Version%20(4%20April%202018)%20PDF.pdf)

Rule 5.1.2 The following activities are permitted activities: 1. The discharge onto or into land from a new foul water drainage system; and 2. The discharge onto or into land from a replacement of an existing foul water drainage system; provided that the following criteria are met f. the soakage field dosage pipes are not within: iii **50 metres of any existing potable water abstraction point**;

Rule 5.3.1 The discharge of sludge onto or into land from individual foul water drainage systems or agricultural effluent treatment systems are permitted activities, provided that the following criteria are met: f. the discharge is not within: ii. **100 metres from any potable water abstraction point**. The same 100m buffer is applicable for effluent discharge rules 5.4.1, 5.4.2, 5.4.5, 5.4.6, and 5.5.2.

Regional Water Plan

Rule 16C – Discharge of whey from industrial or trade premises

The Council will restrict its discretion to the following matters: (iii) the **separation distance** of the discharge from surface waterbodies, artificial watercourses, subsurface drains, the coastal marine area, residential dwellings, property boundaries and drinking water sources;

Rule 49 – Agricultural effluent ponds

The Council will restrict its discretion to the following matters: 2. the **separation distance** of the agricultural effluent pond from surface water bodies, artificial watercourses, installed subsurface drains, groundwater, bores, registered drinking water supplies, the coastal marine area, trees, stop banks, residential dwellings, places of assembly, urban areas, property boundaries and historic heritage;

The explanation from Rule 49 states that:

A buffer distance of 100 metres from water abstraction points is considered an appropriate default given the potential viral and bacterial risks agricultural effluent ponds pose.

However, it is recognised that it may not be possible or necessary to comply with the buffer distances in the rule in all situations. Similarly, in **some situations greater buffer distances may be needed**.

For example, **a buffer distance greater than 100 metres may be required from a water abstraction point for a registered drinking-water supply**.

Appendix D: Regional Council Discharge, Land use and HAIL site risk weightings

This appendix sets out the Scenario 1: Conservative and Scenario 2: Mid-Level drinking water risk weightings for the consent and HAIL sites, accounting for the various Regional Council's sub-categories.

| Northland | Discharge Consents | | | | | | | Land Use Consents | | | | | | | | | HAIL Sites | | |
|--------------------------|--------------------|------------|------------|-------------|--------------|----------------|-------|-------------------|------------|------------|----------------------|---------|----------------------|-------------|--------|------------------|-------------|-------|---|
| Sub-Categories | Sewage | Industrial | Stormwater | Solid Waste | Animal Waste | Water to Water | Other | Structure | Earthworks | Extraction | TLA Land Use Consent | Culvert | Vegetation clearance | River Works | Bridge | Deposit Material | Reclamation | Other | |
| Scenario 1: Conservative | 6 | 6 | 2 | 6 | 6 | 4 | 4 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 6 |
| Scenario 2: Mid-level | 4 | 3 | 1 | 3 | 3 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 3 |

| Auckland | Water takes | | | | | Discharge Consents | | | | | | | | | | | | | | | Land Use Consents | HAIL Sites | | | | | | | | | |
|--------------------------|-------------|------------|-------|-------|----------|--------------------|------------|---|--------------|--------------------------|-------|---------------------|----------------------------|------------------------|------------------------------|--------------------|-------|------------|---|--------------------|-------------------|----------------------|------------------------|---|--------------------|---------------------------------------|-------------------|-----------------------------|-------------------------|-----------------------|----------|
| Sub-Categories | Industrial | Irrigation | Other | Hydro | Drinking | Contaminated Site | Stormwater | | Animal Waste | Comprehensive Stormwater | Dairy | Drill or Alter Bore | Earthworks Non-Residential | Earthworks Residential | Industrial or Trade Activity | Landfill Discharge | Other | Wastewater | | Vegetation Removal | Dam | Divert - Groundwater | Divert - Surface water | | Contaminated Sites | P-lab and Hazardous Substances issues | Hydrocarbon - Oil | Hydrocarbon - Fuel / Diesel | Hydrocarbon - Waste Oil | Hydrocarbon - Solvent | Historic |
| Scenario 1: Conservative | 4 | 2 | 4 | 1 | 1 | 6 | 2 | 2 | 4 | 2 | 4 | 1 | 1 | 1 | 4 | 6 | 4 | 4 | 2 | 1 | 2 | 1 | 1 | 2 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Scenario 2: Mid-level | 2 | 2 | 2 | 0 | 0 | 3 | 1 | 2 | 3 | 1 | 3 | 0 | 0 | 0 | 0 | 3 | 2 | 3 | 2 | 0 | 0 | 0 | 0 | 2 | 3 | 0 | 3 | 3 | 3 | 3 | 3 |

| Waikato | Discharge Consents | | | | | | | | | | | | Land Use Consents | | | | | | | | | | HAIL Sites | | | | |
|--------------------------|------------------------------|-------------------------------|--------------------------------|--------------|---------------|-----------------------|--------------------|-------------------|----------------|---------------|----------------|--------------------|-------------------|--------------------|--------------------|--------------|------------------|----------------|-------------------|-----------------|-----------------|-------------------|-------------|-------------|-----------------|---|---|
| Sub-Categories | Discharge to land (Inactive) | Discharge to water (Inactive) | Farm animal effluent onto land | Land - other | Land - sewage | Land - sewage (Taupo) | Land - solid waste | Land - stormwater | Water - animal | Water - other | Water - sewage | Water - stormwater | Land - well | Land - disturbance | Land - use (Taupo) | Land - other | Land - structure | Land - deposit | Land - vegetation | Whitebait stand | Bed - structure | Bed - disturbance | Bed - other | Bed - metal | Bed - whitebait | | |
| Scenario 1: Conservative | 4 | 4 | 4 | 4 | 6 | 6 | 6 | 2 | 6 | 4 | 6 | 2 | 1 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 6 |
| Scenario 2: Mid-level | 0 | 0 | 3 | 3 | 3 | 3 | 3 | 1 | 3 | 2 | 3 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 3 | |

| Bay of Plenty | Water takes | | | | | Discharge Consents | | | | | Land Use Consents | | HAIL Sites |
|--------------------------|-------------|------------|-------|-------|----------|--------------------|------------|------|------|-------|-------------------|-----------------|------------|
| | Industrial | Irrigation | Other | Hydro | Drinking | Dairy | Geothermal | Land | OSET | Water | Land Use | Land Use - Beds | |
| Sub-Categories | | | | | | | | | | | | | |
| Scenario 1: Conservative | 4 | 2 | 4 | 1 | 1 | 4 | 2 | 4 | 6 | 4 | 2 | 2 | 6 |
| Scenario 2: Mid-level | 2 | 2 | 2 | 0 | 0 | 2 | 1 | 2 | 3 | 2 | 1 | 1 | 3 |

| Gisborne | Discharge Consents | Land Use Consents | HAIL Sites |
|--------------------------|--------------------|-------------------|------------|
| Scenario 1: Conservative | 4 | 2 | 6 |
| Scenario 2: Mid-level | 2 | 1 | 3 |

| Tarankai | Discharge Consents | | | | | | | | | | | | | | | Land Use Consents | | | | | | | | | | | HAIL Sites | | | | | | | | | | |
|--------------------------|---------------------|------------|-----------------------------|-----------------|---------------------|-------------|--------------------|-------------------|---------------------------|-------------------------|---------------------|----------------------|-----------------|------------------|--------------|--------------------|----------------|----------|--------------------|-----------------------------|---------------------|---------|--------------------|--------------|----------------------|-------------------|------------|--------------------|-------------------------------------|-------------|-----------------------|------------------|------------------------|----------------------|---------------|--------------------------------|--|
| | Land - animal waste | Land - DWI | Land - Hydraulic Fracturing | Land - Industry | Land - Land Farming | Land - Misc | Land - solid waste | Land - stormwater | Land/Water - Animal Waste | Land/Water Animal Waste | Land/Water Industry | Water - Animal Waste | Water - cooling | Water - Industry | Water - Misc | Water - Stormwater | Water to Water | Dam/Weir | Structure - Bridge | Structure - Erosion Control | Structure - Culvert | Disturb | Structure - Intake | Bore Install | Structure - Pipeline | Structure - Other | | Structure - Outlet | Structure - Ford/Low Level Crossing | Reclamation | Structure - Boat Ramp | Realign Waterway | Vegetation Disturbance | Vegetation clearance | Pipe Waterway | Structure - Wharf/Marine/Jetty | |
| Sub-Categories | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Scenario 1: Conservative | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 6 | 6 | 4 | 6 | 2 | 4 | 4 | 2 | 4 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | |
| Scenario 2: Mid-level | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 1 | 3 | 3 | 2 | 3 | 0 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | |

| Hawke's Bay | Discharge Consents | | Land Use Consents | | | | | | | | | HAIL Sites | |
|--------------------------|---------------------|----------------------|-------------------|------------|------------|-------------|-------------|--------------------|--------------------|--------------------------|----------|------------|-------------------|
| | Discharge onto land | Discharge into water | Miscellaneous | Excavation | Depositing | Reclamation | Aquaculture | Roading & Tracking | Vegetation Removal | Land Use Intensification | Planting | | Soil Conservation |
| Sub-Categories | | | | | | | | | | | | | |
| Scenario 1: Conservative | 4 | 6 | 4 | 2 | 2 | 2 | 4 | 1 | 1 | 4 | 1 | 1 | 6 |
| Scenario 2: Mid-level | 2 | 3 | 2 | 1 | 1 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 3 |

| Manawatu-Wanganui | Discharge Consents | | | Land Use Consents | | | | | | | | | | | | | HAIL Sites | |
|--------------------------|--------------------|-------|-----|-----------------------------|-----------------------------------|------------------------|-------------------------------------------|-----------------------------------------------------------------|---------------------------|------------------------|-------------------------------|--------------------------------------------|-------------------------------|-----------------------------------------|------------------------------------|-----------------------------------|-----------------------------------|---|
| Sub-Categories | Land | Water | Air | Flood Protection Earthworks | Earthworks & Vegetation Clearance | Clearfelling (Logging) | Effluent Discharge Structure Construction | Railway Road Widening & Culvert Extension Associated Earthworks | Recontouring & Earthworks | Dairy Farming Land Use | Outfall Structure Development | Culvert Construction Associated Earthworks | Earthworks & Soil Disturbance | Hill Country Protection Area Earthworks | Residential Development Earthworks | Turbine Construction & Earthworks | Vegetation Clearance & Earthworks | |
| Scenario 1: Conservative | 4 | 6 | 0 | 1 | 1 | 2 | 4 | 1 | 1 | 4 | 4 | 1 | 2 | 1 | 1 | 1 | 1 | 6 |
| Scenario 2: Mid-level | 2 | 3 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |

| Wellington | Discharge Consents | | | | | | | | | | | | | Land Use Consents | | | | | | | | | | HAIL Sites | | | | | | |
|--------------------------|---------------------------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------|------------------------|-------------------------|-------------------------------|--------------------------------|---------------------------------|----------------------------------|-----------------------|-------------------------|--------------------------|------------------|------------------------|-------------------------|-------------|----------------------|--------------|-------------------|--------------|---------------------|--------------------------|-----------------------------------|------------------------------|----------------|-------------------------------|--------------|---|
| Sub-Categories | DP - ANIMAL WASTE TO LAND | DP - CONTAMINATED SITE DISG TO LAND | DP - CONTAMINATED STORMWATER TO LAN | DP - CONTAMINATED STORMWATER TO WAT | DP - DATA MIGRATION DISCHARGE | DP - DISCHARGE TO LAND | DP - DISCHARGE TO WATER | DP - INDUSTRIAL WASTE TO LAND | DP - INDUSTRIAL WASTE TO WATER | DP - LANDFILL DISCHARGE TO LAND | DP - LEACHATE DISCHARGE TO WATER | DP - SEWAGE / SLUDGES | DP - STORMWATER TO LAND | DP - STORMWATER TO WATER | LUC - STREAMWORK | LUC - SOIL DISTURBANCE | LUC - GENERAL STRUCTURE | LUC - BORES | LUC - RIVER CROSSING | LUC - PIPING | LUC - RECLAMATION | LUC - BRIDGE | LUC - DAM STRUCTURE | LUC - ROADING / TRACKING | LUC - HAZARD MITIGATION STRUCTURE | LUC - VEGETATION DISTURBANCE | LUC - CULTVERT | LUC - DATA MIGRATION LAND USE | LUC - QUARRY | |
| Scenario 1: Conservative | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4 | 6 | 6 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 1 | 2 | 2 | 6 |
| Scenario 2: Mid-level | 2 | 3 | 3 | 3 | 0 | 2 | 3 | 2 | 3 | 2 | 3 | 3 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 3 |

| Nelson | Discharge Consents | | Land Use Consents | HAIL Sites | | | | | |
|--------------------------|--------------------|-------------------|-------------------|-------------|--------|----------|------------|---------|-------------|
| Sub-Categories | Discharge to Water | Discharge to Land | | UNSPECIFIED | TIMBER | LANDFILL | GLASSHOUSE | ORCHARD | ORCHARDPOST |
| Scenario 1: Conservative | 6 | 4 | 2 | 6 | 6 | 6 | 6 | 6 | 6 |
| Scenario 2: Mid-level | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 |

| Tasman | Discharge Consents | | Land Use Consents | | | | | | | | | | | | | | | HAIL Sites | | | |
|--------------------------|--------------------|------|---------------------|------------------------|----------------------------------|---------------------|----------------------------------|----------|--------------------------------------|------------------------------|-----------------|------------------------------------|---------------------------------|----------------------|-------------------------------|-------------------------------|----------------------------|------------|------------------------------------------|--------------------------|---|
| | Water | Land | Land Use - Excavate | Land Use - Disturbance | District: Land Use Discretionary | Land Use Controlled | District: Land Use Non-complying | Land Use | Land Use: Non Notified Non-complying | Land Use - Gravel Extraction | Land Use - Bore | Land Use: Restricted Discretionary | Land Use - Hazardous Facilities | Land Use/Designation | Land Use/Subdn: Non-complying | Land Use/Subdn: Discretionary | Land Use/Subdn: Controlled | | Land Use/Subdn: Restricted Discretionary | Existing Use Certificate | |
| Sub-Categories | | | | | | | | | | | | | | | | | | | | | |
| Scenario 1: Conservative | 6 | 4 | 2 | 2 | 4 | 4 | 4 | 2 | 4 | 1 | 1 | 4 | 6 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 6 |
| Scenario 2: Mid-level | 4 | 2 | 0 | 0 | 1 | 1 | 1 | 1 | 2 | 1 | 0 | 2 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 |

| Marlborough | Discharge Consents | | Land Use Consents | HAIL Sites |
|--------------------------|--------------------|-------------------|-------------------|------------|
| | Discharge to Water | Discharge to Land | Land Use | |
| Sub-Categories | | | | |
| Scenario 1: Conservative | 6 | 4 | 2 | 6 |
| Scenario 2: Mid-level | 3 | 2 | 1 | 3 |

| West Coast | Discharge Consents | | | | | | | | | | Land Use Consents | | | | | | | | | | HAIL Sites | | | | | |
|--------------------------|------------------------------|----------------------|-------------------------------------|----------------------|----------------------------------------|------------|------------------------|---------------------------|------------|-----------------------|-------------------------------------------------|-----------------------------------------|-------------------|------------------------------------|--------------------------------|-------------------------------|-----------------------------|----------------------------------|-----------------|-----------------------------|------------------------------------|----------------------|------------|-------------------------|-------------------|---|
| Sub-Categories | Agricultural Spray discharge | Contaminants to Land | Contaminants to Coastal Marine Area | Contaminants to Land | Contaminants to Water (other than CMA) | Dairy Shed | Septic Tank (Inactive) | Septic Tank Informational | Stormwater | Stormwater (Inactive) | Tracking/Logging/Land Clearing/Land Disturbance | Works in or on Beds of Rivers and Lakes | Gravel Extraction | Construct or Alter Bore (Inactive) | Gold Mining Licence (Inactive) | Coal - Underground (Inactive) | Coal - Ancillary (Inactive) | Gravel Mining Licence (Inactive) | Rock (Inactive) | Coal - Open Cast (Inactive) | Construction/Structures (Inactive) | Vegetation Clearance | Earthworks | Disturbance of riverbed | Rural Zone Mining | |
| Scenario 1: Conservative | 4 | 4 | 0 | 4 | 6 | 4 | 6 | 6 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 2 | 2 | 6 |
| Scenario 2: Mid-level | 2 | 2 | 0 | 2 | 3 | 3 | 3 | 3 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 3 |

| Canterbury | Discharge Consents | | | | | | | | | | | | | | Land Use Consents | HAIL Sites | | | |
|--------------------------|--------------------|----------------|-----------------------|------------------------|----------|--------------------|-------------------|------------|------------------|-------------------|---------------------|---------------------|---------------|------------------|--------------------|--------------|-----------------------|------------------------|---|
| | Human Effluent | Dairy Effluent | Stormwater Industrial | Stormwater Residential | Leachate | Contaminated Water | De-watering Water | Farm Waste | P Process Solids | Passive Discharge | Liquid Agrichemical | Swimming Pool Water | Cooling Water | Dust Suppressant | Solid Agrichemical | Water Tracer | Land Use Consent (s9) | Land Use Consent (s13) | |
| Scenario 1: Conservative | 6 | 4 | 4 | 2 | 4 | 6 | 2 | 4 | 4 | 4 | 6 | 2 | 1 | 2 | 6 | 4 | 2 | 2 | 6 |
| Scenario 2: Mid-level | 4 | 3 | 1 | 1 | 2 | 3 | 0 | 2 | 2 | 0 | 3 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 3 |

| Otago | Discharge Consents | | Land Use Consents | | | | | | HAIL Sites |
|--------------------------|--------------------|--------------------|-------------------|-------------|-----------|-------------|-----------------------|------------|------------|
| Sub-Categories | Discharge to land | Discharge to water | | Disturbance | Structure | Reclamation | Defence Against Water | Deposition | |
| Scenario 1: Conservative | 4 | 6 | 2 | 2 | 1 | 2 | 1 | 4 | 6 |
| Scenario 2: Mid-level | 2 | 3 | 1 | 0 | 0 | 0 | 0 | 2 | 3 |

| Southland | Discharge Consents | | | Land Use Consents | | | | | | | | | | | | | HAIL Sites | | |
|--------------------------|--------------------|----------|-------------------------------|-------------------|-------------|-----------------|---------------|------------------|------|------------------|------------------|---------|---------------------|------------------------------|----------------------|----------------|--------------------------|---------------------------|---|
| Sub-Categories | To Land | To Water | Discharge - Contaminated Land | To Land | Planting LU | Disturb/Reclaim | Structure Use | Dairy conversion | Bore | Land Use (Other) | Effluent Storage | Burning | Expanded Dairy Farm | Structure/Disturb (Crossing) | Establish Dairy Farm | New Dairy Farm | Intensive Winter Grazing | Structure/Disturb (Other) | |
| Scenario 1: Conservative | 4 | 6 | 6 | 2 | 1 | 2 | 1 | 4 | 1 | 2 | 4 | 2 | 4 | 1 | 4 | 4 | 4 | 2 | 6 |
| Scenario 2: Mid-level | 2 | 3 | 3 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 3 | 0 | 3 | 0 | 3 | 3 | 3 | 0 | 3 |

Appendix E: Additional Tables of Information

This appendix includes auxiliary tables of information, not otherwise provided, that were either used in the data processing, or show the full range of output, as opposed to a selection shown in the main body of the report. In each case, these tables are referred to from the relevant sections of the main report.

Table 15. Source site-to-REC reach relationships, manually prepared to override automated nearest reach selection.

| SourceID | RECR reach Reassignment | SourceID | RECR reach Reassignment |
|----------|-------------------------|----------|-------------------------|
| S00211 | 1006570 | S01069 | 12088008 |
| S00258 | 1019570 | S00809 | 13050753 |
| S01021 | 1021060 | S00642 | 13076138 |
| S00046 | 3006920 | S00517 | 13076498 |
| S00067 | 3009450 | S00443 | 13076696 |
| S00073 | 3013010 | S00444 | 13093343 |
| S00071 | 3013470 | S01059 | 13093755 |
| S00076 | 3013470 | S01059 | 13093755 |
| S00076 | 3013470 | S00883 | 13113930 |
| S00070 | 3014980 | S00124 | 13114128 |
| S00078 | 3055883 | S01012 | 13116174 |
| S00029 | 3070207 | S00470 | 13116174 |
| S00008 | 3070276 | S00223 | 13130091 |
| S00009 | 3071503 | S00778 | 13140222 |
| S00103 | 3091203 | S00314 | 13171665 |
| S00133 | 3096340 | S00127 | 14192860 |
| S00006 | 3136016 | S00986 | 14196496 |
| S00001 | 3136016 | S00987 | 14196496 |
| S00002 | 3137108 | S00958 | 14211689 |
| S00367 | 3146024 | S00062 | 14223217 |
| S00281 | 3147091 | S00061 | 14223217 |
| S00629 | 4001750 | S00947 | 14223217 |
| S00503 | 4069238 | S00330 | 14232989 |
| S00191 | 4081415 | S00160 | 14239709 |
| S00801 | 4086856 | S00156 | 14261605 |
| S00106 | 5148866 | S00999 | 14266810 |
| S00034 | 7189858 | S00145 | 14276626 |
| S00037 | 7206881 | S00175 | 14283888 |
| S00040 | 7223587 | S00178 | 14289502 |
| S00252 | 7228935 | S00176 | 14309582 |
| S00083 | 7241157 | S00057 | 15256111 |
| S00386 | 9258768 | S00300 | 15266039 |
| S00631 | 9259361 | S01064 | 15305441 |
| S00400 | 12038457 | | |

Table 16. Look-up table between mapped aquifer lithologies¹² and the “Aquifer Type” classification and related effective porosity as listed in Moreau et al (2014)².

| Litho_Geol-Unique | Aquifer Type | Effective Porosity | Comment |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|--------------------|---------------------------------------------------------------------------------------|
| Fractured basalt lavas | Karstic and fractured rock (e.g. basalt and schist) | 0.1 | |
| Gravel, sand and clay forming alluvial fans | Alluvial gravel | 0.0032 | |
| Sandstone interbedded with mudstone | Sandstone and non-karstic limestone | 0.1 | |
| Late Pleistocene glacial outwash | Alluvial gravel | 0.0032 | |
| Quaternary gravel aquifers; postglacial riverbed gravels | Alluvial gravel | 0.0032 | |
| Quaternary fluvial gravels | Alluvial gravel | 0.0032 | |
| Quaternary gravels | Alluvial gravel | 0.0032 | |
| Late Quaternary glacial gravel deposits; Kowai Formation; heterogeneous fluvial deposits | Alluvial gravel | 0.0032 | |
| Quaternary gravels and sands | Alluvial gravel | 0.0032 | |
| Late Quaternary glacial and interglacial gravel sequences; alluvial deposits | Alluvial gravel | 0.0032 | |
| Late glacial to postglacial gravels (including Cannington Gravel) | Alluvial gravel | 0.0032 | |
| Quaternary deposits (river alluvial gravel, fan alluvial gravel) | Alluvial gravel | 0.0032 | |
| Quaternary sediments (river gravels and sands); and gravel-dominated sediments (Kowai Formation, which includes the Cannington Gravel) | Alluvial gravel | 0.0032 | |
| Basalt with scoria overlying sandstone/mudstone; Taheke basalt overlying greywacke/interbedded sandstone and mudstone and Taheke basalt overlying sandstone/mudstone | Alluvial gravel | 0.0032 | Alluvial gravel seems more appropriate for Rakaia-Ashburton than what GNS have mapped |
| A sequence of clay bound gravel and sand aquifers | Alluvial gravel | 0.0032 | Ashburton–Rangitata. Gravels seems more appropriate than sand |
| Basalt overlying cretaceous siltstone | Karstic and fractured rock (e.g. basalt and schist) | 0.1 | |
| Gravels, unconsolidated outwash moraine and glacial till | Alluvial gravel | 0.0032 | |
| Basalt overlying micaceous sandstone | Sandstone and non-karstic limestone | 0.1 | |

| Litho_Geol-Unique | Aquifer Type | Effective Porosity | Comment |
|-------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|--------------------|---------|
| Alluvial deposits (sand, silt and some clay); silty colluvium | Alluvial gravel | 0.0032 | |
| Alluvial deposits; Cenozoic basalt | Alluvial gravel | 0.0032 | |
| Cenozoic basalt | Karstic and fractured rock (e.g. basalt and schist) | 0.1 | |
| Basalt with scoria overlying sandstone/mudstone | Sandstone and non-karstic limestone | 0.1 | |
| Quaternary moraine, tills and outwash gravels | Alluvial gravel | 0.0032 | |
| Tertiary and Quaternary sediments including sands, gravels and recent alluvium | Alluvial gravel | 0.0032 | |
| Gravels overlying Waipapa Group greywacke | Alluvial gravel | 0.0032 | |
| Floodplain alluvium, sandy gravels | Alluvial gravel | 0.0032 | |
| Marine terrace deposits including basal marine sands with conglomerates that grades up to terrestrial sediments; sandstone and shelly limestone | Sandstone and non-karstic limestone | 0.1 | |
| Alluvial flats, river deposits; glacial outwash and till; unconsolidated sediments | Alluvial gravel | 0.0032 | |
| Moraine, till and recent outwash gravels | Alluvial gravel | 0.0032 | |
| Jurassic greywacke | Sandstone and non-karstic limestone | 0.1 | |
| Clay sandy gravels | Alluvial gravel | 0.0032 | |
| Fractured volcanic tuff; basal quartz conglomerate | Karstic and fractured rock (e.g. basalt and schist) | 0.1 | |
| Multi-layered glacial and interglacial gravel and sand aquifers | Alluvial gravel | 0.0032 | |
| Proglacial lake sediments | Alluvial (coarse) sand | 0.2 | |
| Sandy gravel glacial outwash deposits | Alluvial gravel | 0.0032 | |
| Cretaceous sandstone | Sandstone and non-karstic limestone | 0.1 | |
| Sand feldspathic with some quartz | Alluvial (coarse) sand | 0.2 | |
| Recent alluvium | Alluvial gravel | 0.0032 | |
| Quaternary alluvial sand and gravel | Alluvial gravel | 0.0032 | |
| Indurated sandstone (greywacke), with subsidiary argillite, chert, mudstone and marble | Sandstone and non-karstic limestone | 0.1 | |

| Litho_Geol-Unique | Aquifer Type | Effective Porosity | Comment |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|--------------------|---------|
| Aeolian sand tombolo wedged between basement rocks (argillite and greywacke) | Coastal sand | 0.2 | |
| Holocene alluvial sand and gravel | Alluvial gravel | 0.0032 | |
| Quaternary sand, shell and/or gravel | Alluvial gravel | 0.0032 | |
| Quaternary fluvial gravels, which are interbedded with alluvial and marine silt and clay; paleo-beach gravel, coastal sand and alluvium | Alluvial gravel | 0.0032 | |
| Predominantly sands/alluvial mud and gravel. | Alluvial gravel | 0.0032 | |
| Alluvial sediments (series of silts, sand, gravels and intercalated volcanic ashes) with fine silty basal layer | Alluvial gravel | 0.0032 | |
| Alluvial sediments (silts, sand, gravels and intercalated volcanic ashes); pumiceous sand | Alluvial gravel | 0.0032 | |
| Alternating sequence of sandstone and mudstone (Waitemata Group) | Sandstone and non-karstic limestone | 0.1 | |
| Basaltic lava flows, scoria cones and tuff rings (South Auckland Volcanics); Pumiceous shell and sandy shell beds, fine to medium sandstone with scattered pebbles and some gravels (Kaawa Formation) | Karstic and fractured rock (e.g. basalt and schist) | 0.1 | |
| Basaltic cones and associated flow deposits and tuff rings | Karstic and fractured rock (e.g. basalt and schist) | 0.1 | |
| Paleo-dune system (sand) | Coastal sand | 0.2 | |
| Quaternary sediments composed of alluvium and coastal dunes (Tauranga Group) | Alluvial gravel | 0.0032 | |
| Unconsolidated alluvial sediments with alternating sequences of clay, peat, sand/pumice, and gravel | Alluvial gravel | 0.0032 | |
| Alluvial gravel | Alluvial gravel | 0.0032 | |
| Matahina ignimbrite | Karstic and fractured rock (e.g. basalt and schist) | 0.1 | |
| Ignimbrites | Karstic and fractured rock (e.g. basalt and schist) | 0.1 | |
| Ignimbrites; Taupo sand | Karstic and fractured rock (e.g. basalt and schist) | 0.1 | |
| Alluvial terrace gravel | Alluvial gravel | 0.0032 | |

| Litho_Geol-Unique | Aquifer Type | Effective Porosity | Comment |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|--------------------|-----------------------------------------------------------------|
| Arthur marble aquifer, Takaka limestone and Takaka valley gravels | Alluvial gravel | 0.0032 | water supply bores most likely to be in the gravels |
| Motutere Gravel Formation and its reworked materials | Alluvial gravel | 0.0032 | |
| Alluvial gravel; thin fan gravel deposit; clean river gravel | Alluvial gravel | 0.0032 | |
| Highly permeable alluvial sediments; alluvial gravel | Alluvial gravel | 0.0032 | |
| Alluvial sediments | Alluvial gravel | 0.0032 | |
| Lower alluvial terraces of the Buller River and its tributaries | Alluvial gravel | 0.0032 | |
| Unconfined recent alluvial gravel outwash | Alluvial gravel | 0.0032 | |
| Alluvial terraces | Alluvial gravel | 0.0032 | |
| Alternating sequence of sandstone and mudstone; greywacke | Sandstone and non-karstic limestone | 0.1 | |
| Mamaku ignimbrite | Karstic and fractured rock (e.g. basalt and schist) | 0.1 | |
| Fractured volcanics (andesite and rhyolite); coastal sand aquifers | Coastal sand | 0.2 | Assume bores are in the coastal sands rather than the volcanics |
| Gravel fan deposits | Alluvial gravel | 0.0032 | |
| Alluvial sediments with fine silty basal layer | Alluvial gravel | 0.0032 | |
| Lava, pyroclastic and lahar deposits | Karstic and fractured rock (e.g. basalt and schist) | 0.1 | |
| Sandstone, conglomeratic shell and mudstone | Sandstone and non-karstic limestone | 0.1 | |
| Terraces comprising dominantly sandy, shelly marine sediments (Marine Terrace); alternating sequence of Tertiary concretionary, shelly, blue grey sandstone, and siltstone (Whenakura Formation) | Sandstone and non-karstic limestone | 0.1 | |
| Unconsolidated sandy gravel sediments | Alluvial gravel | 0.0032 | |
| Tertiary Taru Formation and quartz conglomerate; Quaternary fan gravel, alluvium, loess | Alluvial gravel | 0.0032 | |
| Unconsolidated Pleistocene outwash gravels, moraine and glacial till | Alluvial gravel | 0.0032 | |
| Quaternary outwash gravels, moraine and glacial till | Alluvial gravel | 0.0032 | |

| Litho_Geol-Unique | Aquifer Type | Effective Porosity | Comment |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|--------------------|---------|
| Alluvial gravel deposits; thick sandstone units; coastal barrier beach deposits; sandy limestone | Alluvial gravel | 0.0032 | |
| Unconsolidated sand and gravel | Alluvial gravel | 0.0032 | |
| Interbedded sands and limestones | Sandstone and non-karstic limestone | 0.1 | |
| Dune sand and gravels | Coastal sand | 0.2 | |
| Reworked sand and gravels | Alluvial gravel | 0.0032 | |
| Alluvial deposits separated by thin deposits of fine-grained marine sediments | Alluvial gravel | 0.0032 | |
| Shallow unconfined alluvial sand | Alluvial (coarse) sand | 0.2 | |
| Quaternary terrestrial and marine sediments (sand and gravel) | Alluvial gravel | 0.0032 | |
| Glacial and Quaternary alluvial gravels | Alluvial gravel | 0.0032 | |
| Greywacke | Sandstone and non-karstic limestone | 0.1 | |
| Predominantly quartz and feldspar sands, overlying limestone/sandstone/mudstone | Alluvial (coarse) sand | 0.2 | |
| Undifferentiated alluvium (alternating mud, clay, silt, peat, sand and gravels associated with various phases of shallow marine and terrestrial fluvial activity in a deltaic setting) | Alluvial gravel | 0.0032 | |
| Basalt flow with underlying sedimentary rocks; consolidated unweathered sands with some quartz | Karstic and fractured rock (e.g. basalt and schist) | 0.1 | |
| Waipapa Group greywacke and argillite basement rocks, overlain by undifferentiated Quaternary sand along the low lying coastal fringe | Coastal sand | 0.2 | |