# PRIVATE WATER SUPPLIES – WHERE ARE THEY AND WHAT ARE THE RISKS?

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## ABSTRACT (500 WORDS MAXIMUM)

Christchurch City Council (Council) has been working to identify, assess and prioritise the needs and risks of communities served by private water supplies. A two-pronged approach was adopted, using GIS mapping and onsite investigations to address the many unknowns and knowledge gaps in this area.

This paper presents the results of Council investigations which brought together GIS mapping outcomes with "ground truthing" at specific sites to build a picture of the drinking water needs of communities not serviced by Council, to define risks related to this and to set the baseline for further work.

While water supply in urban reticulation networks is relatively simple, the situation can be more complex in rural areas such as Banks Peninsula. Banks Peninsula lies southeast of Christchurch and comprises more than a dozen bays with small towns and settlements. Drinking water networks in these bays are mostly not connected, meaning that each community receives a different level of service. Diamond Harbour, for example, receives drinking water from the Council's reticulated network, while Purau, a nearby settlement, does not.

A GIS mapping tool was used to identify possible private water suppliers within the Christchurch District. In the modern era a plethora of data is available. The GIS mapping made use of datasets from multiple sources and included the generation of spatial data layers to mechanise the identification of private water suppliers. As a further step, a risk assessment algorithm was developed to produce risk heat maps that greatly assisted understanding the comparative water supply risks faced by discrete clusters of properties. The risk assessment was used to prioritise individual communities for further assessment.

The mapping tool is dynamic and allows Council to identify possible private water suppliers and systems on an ongoing basis, as and when datasets are updated. The tool also allows Council to manually identify and record private water supplies and systems, to maintain institutional knowledge and to supplement the algorithm's findings.

A needs assessment case study was completed for one of the higher risk un-serviced communities identified - Koukourārata Marae and local Port Levy community - and generated a comprehensive list of water supply service options. These were compared using multi-criteria analysis to determine the suitability of the various options. The outcome assisted Council in its initial planning for servicing the community.

Readiness assessments were undertaken for existing private water suppliers that were willing to participate. This provided useful baseline information on the compliance status of private water supplies in Christchurch.

Overall, the work has proven a useful starting point, has identified key data gaps and themes, and has provided direction for working towards compliance with the Local Government Act requirement (as amended by the Water Services Act) to perform a needs assessment.

**KEYWORDS**

**Private drinking water supplies, needs assessment, GIS mapping**

**PRESENTER PROFILE**

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# INTRODUCTION

Identifying private water supplies is an issue being faced around the country. There is a lack of certainty on the number of private suppliers that exist and the potential risks to consumers connected to private supplies. In Christchurch, this is no different, however Christchurch City Council (Council) has been working towards meeting its drinking water assessment mandates in terms of the Local Government Act 2002, as amended by the Water Services Act 2021 (**the Act**). The Act includes specific requirements for an assessment of drinking water services that will be required every 3 years. This includes identifying communities with private water supplies that serve more than one household, and assessing whether this level of service is acceptable.

Council and Beca worked together on tackling the issue in the Christchurch district. A GIS-based approach was adopted on the basis that large amounts of existing data can be brought together quickly and efficiently to inform the analysis and to identify key data gaps. The GIS mapping was undertaken in two steps as follows:

1. Identify communities serviced by private water supplies

2. Assess comparative supplier risks (and assist with prioritisation for action)

Following the identification and risk assessments, it became clear that the needs assessment requires more than data analysis. On the ground ‘truthing’ was completed for registered private water suppliers, willing to participate in order to fill in the gaps and assess risks on an individual supplier basis. The focus of these assessments was to determine the ‘readiness to comply’ of the suppliers.

In parallel, a case study community needs assessment was undertaken for an un-serviced coastal settlement in Christchurch’s Banks Peninsula. This involved identifying water supply risks to the community and potential solutions involving increasing the level of service. The steps of this needs assessment can be replicated for other communities.

This paper details the methodology employed and the outcomes of this work, which was undertaken between 2021-2022. It is hoped that the learnings will assist other councils and authorities with their identification of communities with private water supplies.

# IDENTIFYING PRIVATE SUPPLIES

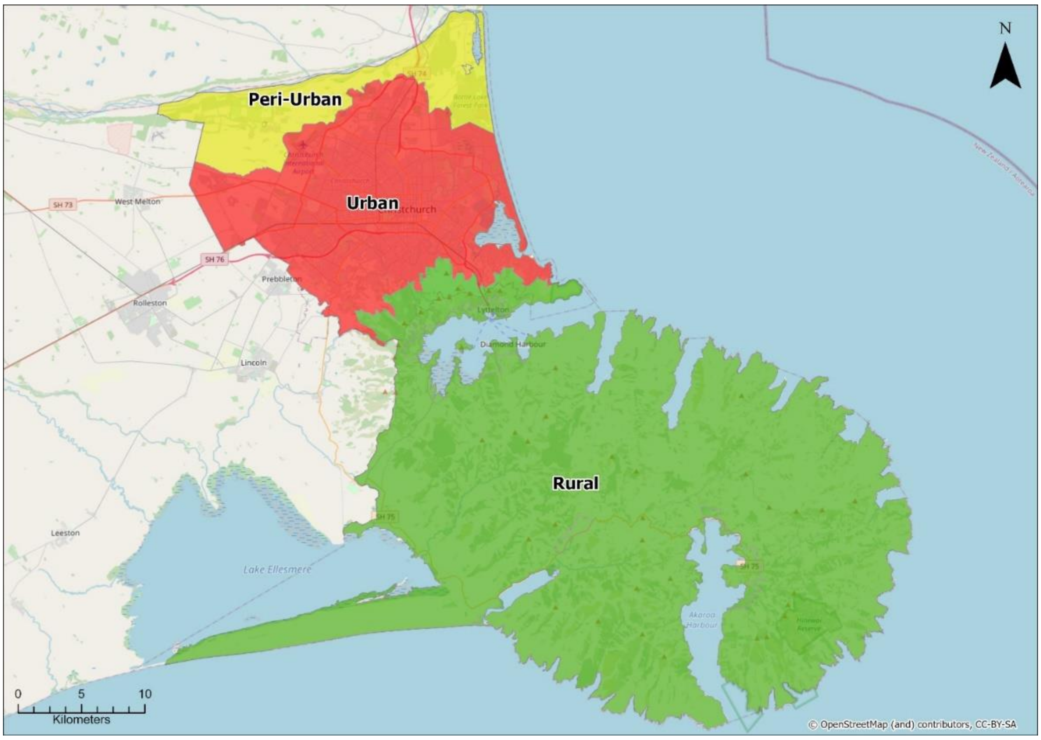
Taumata Arowai has estimated up to 75,000 private suppliers exist nationwide. However, the exact number is not known. Under Part 8 of the Water Services Act 2021, if a water supplier provides drinking water to more than one household, it is a water supplier under the Act. Using this definition, private water suppliers can vary greatly in size, from the very small (e.g. two neighbouring houses), to comparatively large (e.g., entire communities). Similar to other Councils in New Zealand, Christchurch City Council has limited knowledge or records for unregistered private suppliers. Traditionally, a letter drop would be utilised to seek to identify private suppliers. Beca and Council were aware of unsuccessful instances of this in recent times. This meant that a 'smart' approach was needed as a first step to identifying them.

GIS was used to spatially identify water suppliers. A model was developed that identified clusters of properties with no known connection to the Christchurch City water supply network (based on rating information). The model did not necessarily identify private water suppliers, but it did identify properties that had a need for water and where it was not clear how they received it.

A decision was taken early in the study to divide the district into three zones – urban, peri-urban and rural (refer Figure 1 overleaf). The reason for adopting three zones is that the method to identify private suppliers, and also to assess risk, may be slightly different in each zone, taking into account the differences in land use and also in data layers available in each respective zone (e.g., urban properties can often simply join Council's existing reticulation network, whereas remote rural properties cannot). As a result, the GIS algorithm was customised to suit each zone.

An example of this is the method used to identify occupied dwellings. In the urban zone it was defined as any building with an area greater than 40 $m^2$. Applying this method in the rural zone produced erroneous results, as many farm properties have multiple buildings larger than 40 $m^2$.

*Figure 1: Zone Boundaries in the Christchurch District*




A variety of data sets were sourced, reviewed and incorporated within the GIS model. The data sets came from a number of sources and a workshop was held between Beca, Council and ECan to assess the suitability of sources. A key feature of the GIS tool development was that it should be dynamic. Many of the data sources are frequently changed (e.g., land ownership) and it is important that Council can seamlessly re-run this analysis to identify un-serviced properties on an ongoing basis. Such a review was completed in July 2023 and will be updated regularly.

The focus of the identification was to locate supplies which Council could potentially become responsible for under the provisions of the Act as well as to assess the adequacy of drinking water access to the community. As provided for in the Act, properties owned by government entities (i.e., The Crown) were excluded. This removed public schools, prisons and most of the larger, more easily identifiable private suppliers.

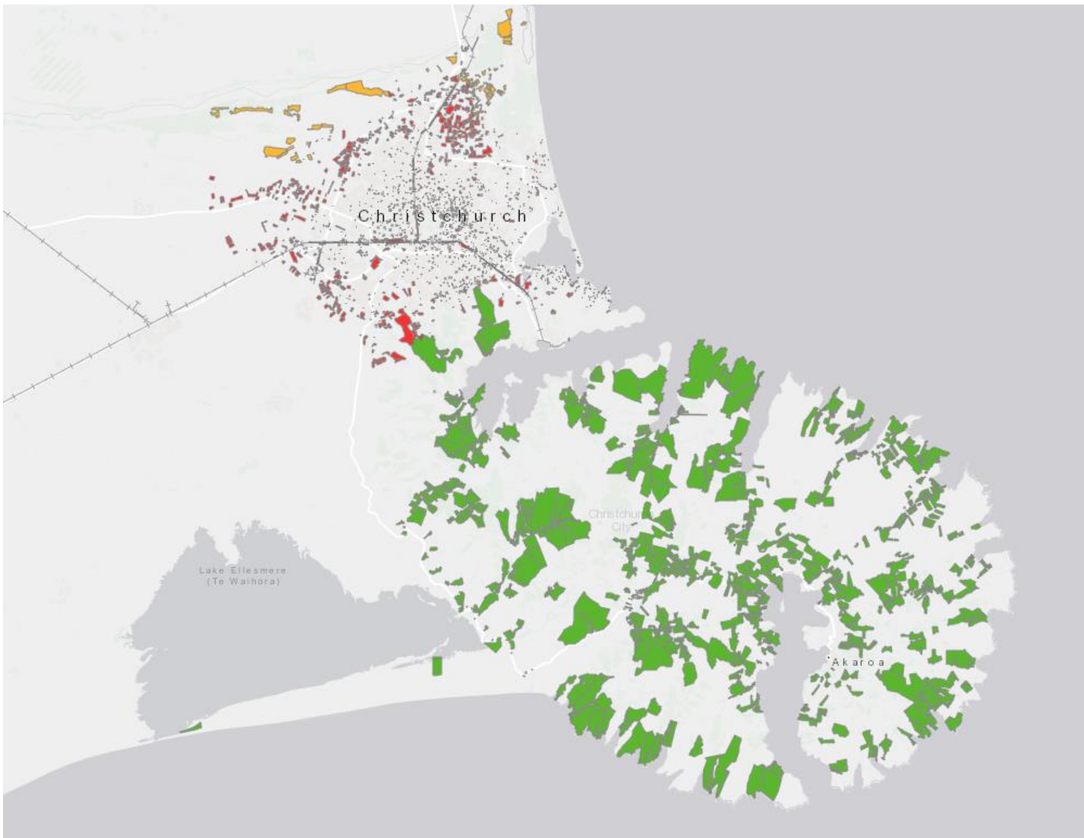
Properties that pay water supply rates to Christchurch City Council were excluded from consideration. Additionally, properties with a registered water supply bore were excluded on the assumption that the bore is supplying only the household it is sited on.

It is understood that the GIS analysis is not definitive,but merely uses available data to confirm the likely existence and location of private suppliers, allowing them to be prioritised for further action including on-the-ground checking. As ground truthing proceeds over time, the model is progressively updated.

It should also be noted that the identification methodology only looked at sites which currently have a building on them. It did not consider areas/zones which will have new populations in future (i.e., Kāinga Nohoanga zones). Nor did it include the population growth forecast.

Potential private water suppliers identified through this analysis are shown in Figure 2 (the colours of the land parcels shown relate to their zoning as delineated in Figure 1. I.e., red = urban, orange = peri-urban, green = rural).

*Figure 2: GIS Map of Potential Private Water Suppliers in Christchurch District*




The total number of potential private water suppliers identified for the rural, peri-urban, and urban areas was 1240, 119 and 1767, respectively. As with all models, the expectation was that the outputs contained a level of inaccuracy (in that not all properties identified were likely to be serviced by private supplies). However, identifying a possible water supplier is only the first step in the process. To confirm the existence of suppliers with certainty requires onsite assessments. However, to visit more than3,000 properties would be challenging. The approach to this problem was to identify comparatively higher risk zones based on a risk assessment methodology, so they could be prioritised for further work.

# RISK ASSESSMENT

A risk framework was used to quantify the risks as required by the Act in terms of adequacy of supply, and safety of supply. This helped to define whether the level of service was satisfied and allowed prioritisation of those supplies with the highest risk of not meeting service requirements.

The key assessment criteria used for water service needs are summarised in Table 1. These were defined based on:

- Beca knowledge
- Ministry of Health, Handbook for Preparing a Water Safety Plan (May 2019)
- World Health Organisation, Sanitation Safety Planning, Manual for Safe Use and Disposal of Wastewater, Greywater and Excreta (2015)
- Council feedback

*Table 1: Risk Criteria for Drinking Water Suppliers*

| Drinking Water Supplies |
| --- |
| • Catchment<br>• Source<br>• Treatment<br>• Supply<br>• Operation<br>• End Users<br>• Sustainability<br>• Resilience<br>• Future |

A GIS-based risk assessment model was developed that incorporated a range of available spatial datasets. Where relevant data was available, but not in a spatial format, spatial layers were either built, or default assumptions made about a specific risk factor for a specific area. In this respect, the model is bespoke and specific to the Christchurch district. It is important to note that only sites identified as not receiving water from Council have been assessed.

It is also important to note that the risk assessment tool is intended for initial comparative assessment of water supply risks and is not a comprehensive risk assessment tool.

Furthermore, the GIS methodology only considers whether or not the site is ‘occupied’. It does not consider the relative population associated with any individual site. The risk assessment criteria associated with population only considers density (i.e., how close individual buildings are to each other). Based on this approach, sites with elevated populations and/or water supply needs (e.g., marae, schools, etc.) were not specifically identified as higher risk. For non-residential properties, manual adjustment for population will be required.

High level GIS risk assessment analysis was undertaken to calculate a weighted risk score for each property. Table 2 outlines the spatial datasets used in the risk analysis, the criteria for each risk, the score related to each criterion and the weighting for each risk type.

Each property, except those supplied by Council, was given a score value and a corresponding weighted score value for each risk based on the criteria it falls within. The weighted scores were then summed to produce a total weighted score per property.

This analysis was also joined to the centroid of the largest building > 40m2 per property to produce a risk score heat map.

*Table 2: Weighting and Criteria for Comparative Risk Assessment*

| Risk | Description | Weighting |
|---|---|---|
| Microbial contamination | • E. coli sample data exists for the Christchurch area. These scores indicate higher E. coli presence in the Banks Peninsula area. If properties are obtaining their water from ground or streams, then E. coli represents a risk. | 5% |
| Flooding Zone | • Flood map extents for the 1 in 50-year and 1 in 200-year events were utilised to determine risk of surface flooding introducing contaminants to private water supplies. | 5% |
| Nitrate Contamination | • Nitrate sample data exists across the Christchurch region. Elevated nitrates represent a risk to ground or surface water sources. | 20% |
| Chemical Contamination | • Industrial processes are generally listed on the Listed Land Use Register (LLUR). These are spatially mapped under LLUR Activities, LLUR Sites and Discharge Consents. The proximity of a private supply to industry was used as a proxy for risk. | 10% |
| Intake depth | • The risk of contamination for deeper water sources is lower, so those properties that have shallower bores or use surface water, have a higher risk. | 20% |
| Source Vulnerability | • Greater depth to groundwater represents lower contamination risk to the source. Spatial data exists showing areas that have a depth to groundwater > 6m or are within the coastal confined gravel aquifer system. | 20% |
| Density | • Density was used as a proxy for population. This is an important aspect of risk as it determines the exposure (the more people exposed, the greater the risk). To assess density, the centroid of largest building within each parcel was utilised. High density was mapped using 50m clusters from largest building > $40m^2$ per property. And medium density was mapped using 250m clusters from largest building > $40m^2$ per property | 20% |

An initial risk assessment workshop was held, with the key finding being that settlements/communities in Banks Peninsula (i.e., the rural zone) were identified as comparatively higher risk than their urban and peri-urban counterparts. This is largely due to higher densities of un-supplied networks (in the peri-urban space buildings are generally spaced further apart, and in the urban space buildings are generally serviced already) and the water source vulnerability of properties in Banks Peninsula.

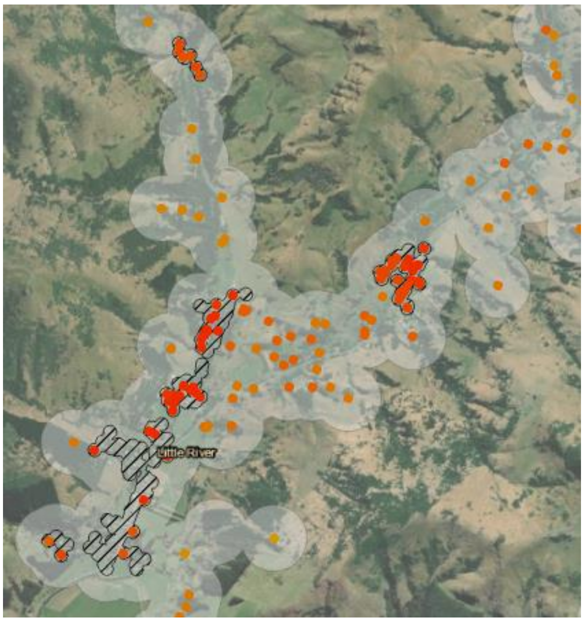
The communities identified as comparatively higher risk were:

- Little River (external to the Council supply)
- Purau
- Port Levy
- Little Akaloa
- Okains Bay
- Le Bons Bay
- Tikao Bay
- Pigeon Bay (Upper portion)
- Okuti Valley (related to Little River)
- Teddington
- Onuku

Figures 3 – 6, shown below, are snips taken from the GIS screening risk model. The dots represent un-serviced properties (with the darker red dots indicating comparatively higher risk buildings than lighter dots). Also, the lighter grey hatch indicates that adjacent buildings are within 250m of each other; and the diagonal grey hatch indicates this distance is less than 50m.

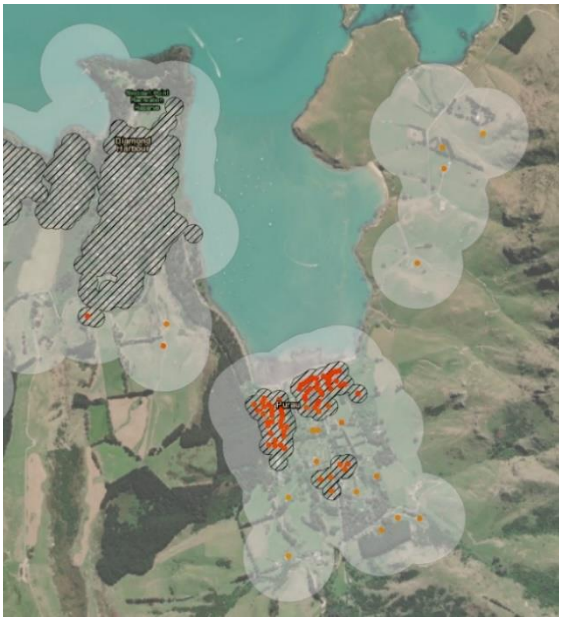
In Little River (Figure 3) it is interesting to note that while the 'core' of the community is fully serviced (shown by the black hatched area with no dots), a similar-sized population immediately surrounding Little River is not. The un-serviced area poses a risk, but also represents an opportunity to extend the existing water supply scheme to service the wider locality.

*Figure 3: GIS Map Showing Risk Assessment for Little River*



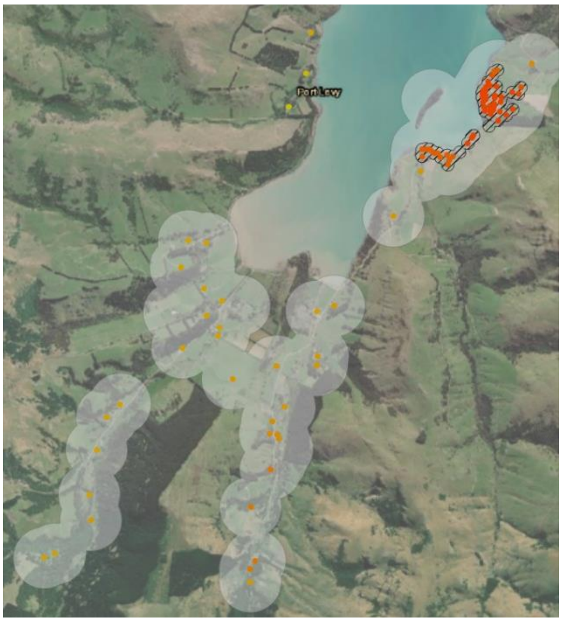

Similarly, in Purau (Figure 4) the settlement is wholly un-serviced. Adjacent to Purau is Diamond Harbour, which is almost fully serviced. Purau is sited down-gradient of Diamond Harbour, so, again, represents an opportunity to extend an existing network to improve coverage, rather than requiring that a completely new treatment scheme is implemented.

*Figure 4: GIS Map Showing Risk Assessment for Purau*



The situation at Port Levy (which includes the Koukourārata marae) is somewhat different. Neither the marae nor the Port Levy community are serviced by Council and there are significant challenges in the provision of potable water. Figure 5 shows properties that are disparate (yellow dots in middle top of image), medium proximity (orange dots within grey hatch), and close proximity (red dots in diagonal hatch). This communicates the impact of proximity on risk (i.e. number of people at risk per hectare).

*Figure 5: GIS Map Showing Risk Assessment for Koukourārata / Port Levy*




The areas identified as comparatively higher risk are all located on Banks Peninsula. Council supplemented the risk assessment through the use of their knowledge of permanent populations with information about seasonal influx which boosts the population significantly in holiday periods. This generates peak populations that can be significantly higher than the permanent population (for example, Okains Bay has a 500-person campground which is heavily used over the summer period; Koukourārata has a marae which also has a large visitor population for specific cultural events). This information is represented graphically in Figure 6 below.

*Figure 6: Graph Summarising Populations and Household Density for Banks Peninsula Communities*

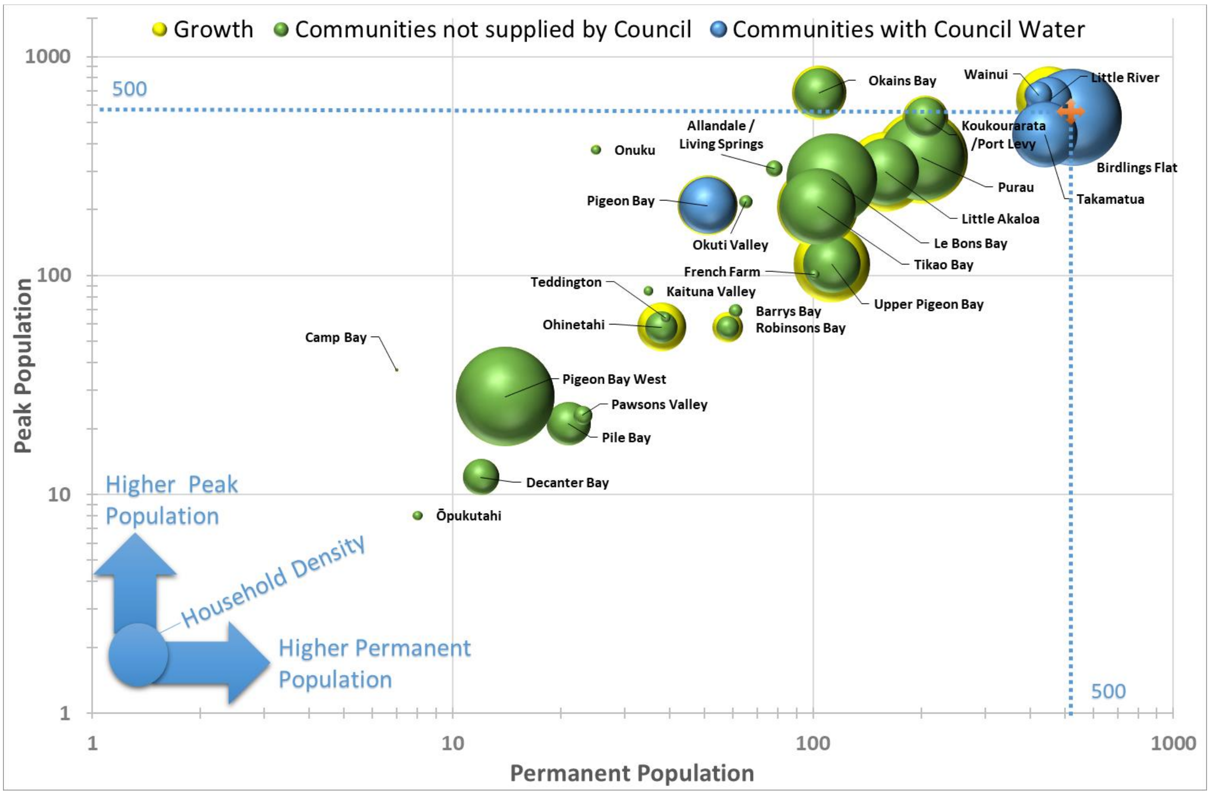



Figure 6 shows that a number of the larger communities (e.g., Birdlings Flat and Little River) are already supplied with water by Council. It also shows a number of communities with low permanent populations but much higher populations for short periods in the summer (e.g., Okains Bay, where the peak population is ~600 and the permanent is ~100). This approach enabled Council to prioritise the provision of water to these communities. Council has projects in place to provide a drinking water supply system for Okains Bay and Port Levy (including Koukourārata).

Future growth, and the resilience of communities (especially coastal communities) is a key consideration when planning water supply. With coastal inundation, and other risks being present, councils will need to consider whether the investment in water supply for un-served communities will be appropriate in 50 or more years' time.

# TECHNICAL ASSESSMENTS OF KNOWN NETWORKS

As has been noted earlier, it became clear that GIS analysis could only do so much. To confirm the status of private suppliers at specific sites requires "on the ground truthing". For registered suppliers that were willing to participate, the following methodology was employed:

- Contact was made with the supplier
- The supplier's source, treatment and distribution were summarised
- Technical assessments for these networks/communities were undertaken (typically with an in-person site visit) to determine the readiness to comply with Taumata Arowai quality assurance rules

The scope of these assessment was limited to the quality of the supplied water only. The adequacy of supply quantity was not considered.

The 'state of supply' framework was prepared based on the Draft Quality Assurance Rules (QA Rules) dated 26th October 2021. This document informs suppliers of the requirements for demonstrating compliance. Currently, unregistered suppliers have no obligation to register with Taumata Arowai. Unregistered suppliers (except water carriers) need to be registered by November 2025 and have seven years to provide a drinking water safety plan under the Water Services Act 2021. A supplier of water does however have a duty to provide safe drinking water under the Act, whether they are registered or not.

A number of communities considered likely to be privately supplied, were contacted as part of this assessment. There were varying levels of willingness to take part in this assessment. Of those that did participate, all were aware of the Water Services Act and the upcoming regulatory changes.

The suppliers that were visited and assessed ranged from institutions and clubs (e.g., golf clubs) to parks and marae. These supplies were from urban, peri-urban and rural communities.

None of the assessed supplies were compliant. One supplier was part-way through completing upgrades which would make it compliant. The majority of the non-compliances were related to sampling and monitoring, as opposed to treatment. Two of the private suppliers indicated they were strongly opposed to chlorination.

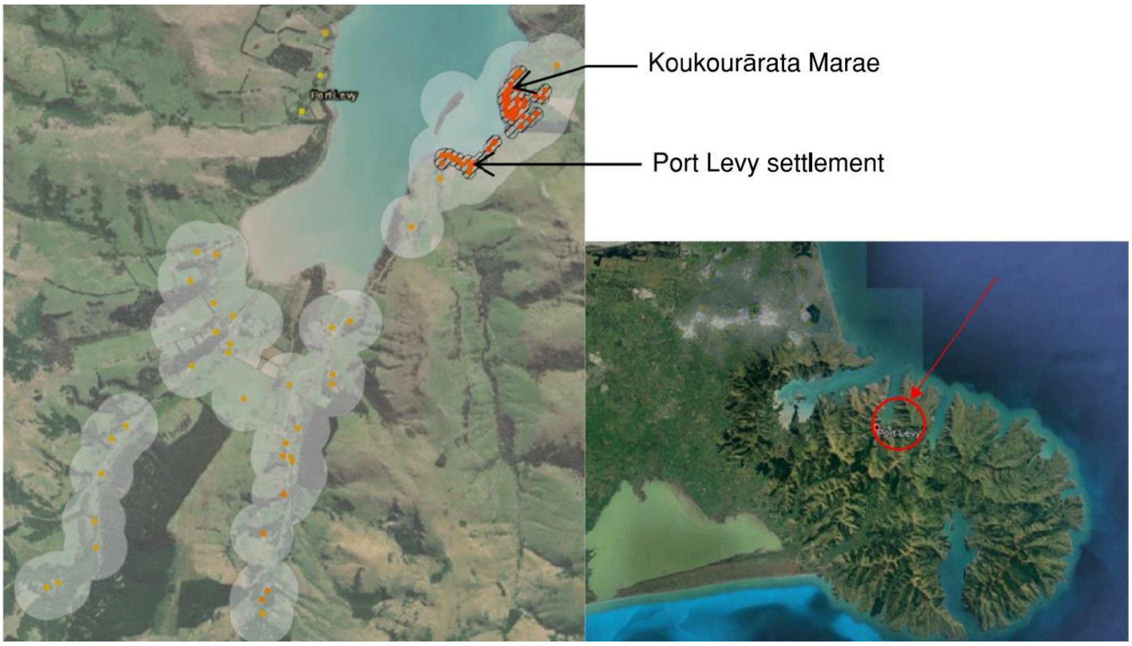
Though only covering a small sample, the technical assessments of known, and potentially higher risk, networks provides some observations that provide direction for further on-site investigations. It is notable that even the registered suppliers (who, presumably, are more likely to follow compliance guidelines) are currently unready to comply. And it suggests there is much work required to bring the unknown and un-registered supplies to a state of compliance.

# CASE STUDY AT KOUKOURĀRATA

The GIS identification and risk assessment identified communities that are at risk due to a lack of compliant water supply. A case study was completed for a community that was identified as comparatively higher risk. The purpose of this assessment was to identify options for the community to access a safe drinking water supply.

The case study assessment was undertaken for Koukourārata Marae (Tūtehuarewa) and the local Port Levy community. Fast tracking this water supply level of service assessment meant that the assessment can be set up as a template for others to be completed at a later stage. The assessment involves developing water service options for the Koukourārata Marae and the Port Levy coastal settlement (Figure 7).

*Figure 7: GIS Risk Map of Koukourārata and Port Levy*




The scope of this issues and options assessment was to identify the existing condition of the water services, to identify constraints and to recommend improvement options for Koukourārata Marae and the community coastal settlement. The regulatory requirements for the work are set out in The Act and Section 125 of the Local Government 2002 (2020 amendment).

The Koukourārata Marae and Port Levy community harvest rainwater from roofs as a primary source of drinking water. Above-ground drinking water storage tanks are used to meet demand throughout the year. These are topped up in some areas of the community using stream water, from an informal stream take, during dry spells (six households on Pa Road are known to Council but there may be others). This is permitted without the need for a resource consent under section 14(3)(b) of the Resource Management Act 1991 (RMA).

Risk assessments were undertaken for the existing infrastructure arrangements at the Koukourārata Marae and in the wider Port Levy community. These are summarised below in Table 3:

*Table 3: Summary of Water Supply Systems and Risks*

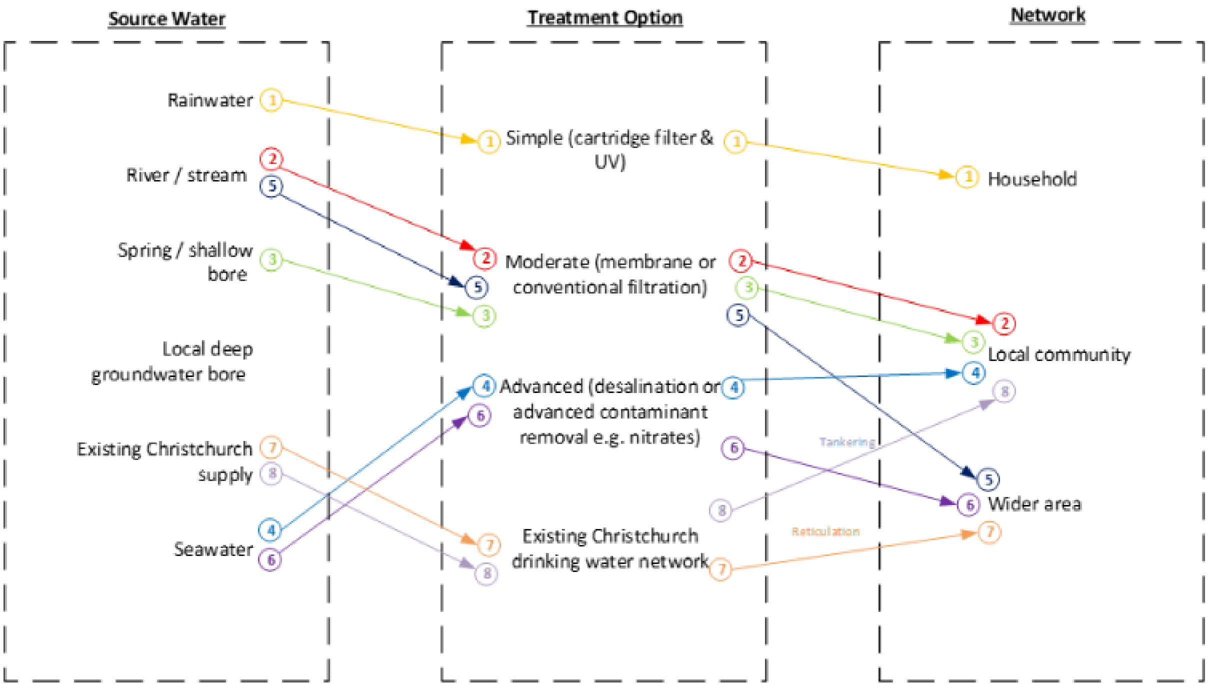
| Community / Supply | Existing System | Water Quantity / Adequacy risks | Water Quality Risks |
|---|---|---|---|
| Koukourārata Marae | Supply via rainwater harvesting and tankering. Treatment via cartridge filter + UV | Overall 'High' Risk<br>• No ability to cope with growth.<br>• Risk of natural hazards (particularly droughts) affecting supply adequacy.<br>• Risk of reduced rainfall due to climate change reducing the supply adequacy. | Overall 'Medium' Risk<br>• Disinfection residual may be insufficient (Site investigation required to confirm).<br>• Acceptability of water quality to the community.<br>• Population growth will increase the exposure risk.<br>• High peak visitor population increases the exposure risk. |
| Port Levy community | Rainwater harvesting with varying levels of treatment for each property. Informal stream take during dry spells. | Overall 'Medium' Risk<br>• Risk of natural hazards (particularly droughts) affecting supply.<br>• Risk of reduced rainfall due to climate change reducing the supply adequacy. | Overall 'Medium' Risk<br>• Disinfection residual may be insufficient (or non-existent).<br>• Monitoring regime for water quality.<br>• High visitor population during peak periods. |

While the risk to safety of the water supply for both the marae and wider community was assessed as 'Medium', it is worth noting that the marae has higher risks mainly due to higher population. However, those risks are better managed by way of better treatment processes, which means the residual risks are similar for the marae and wider community.

## LONG LIST OPTIONS

A long list of water service options was developed to address the needs. The drinking water supply level of service long list contains eight options as schematically presented in Figure 8 overleaf.

*Figure 8: Long List Option Flow Chart for Koukourārata Water Supply Options*




The eight options range from simple (e.g., households continuing to collect rainwater) to complex (desalination). They also range from smaller scale (local community supplied by stream takes) to much larger (centralised supply covering the majority of Banks Peninsula).

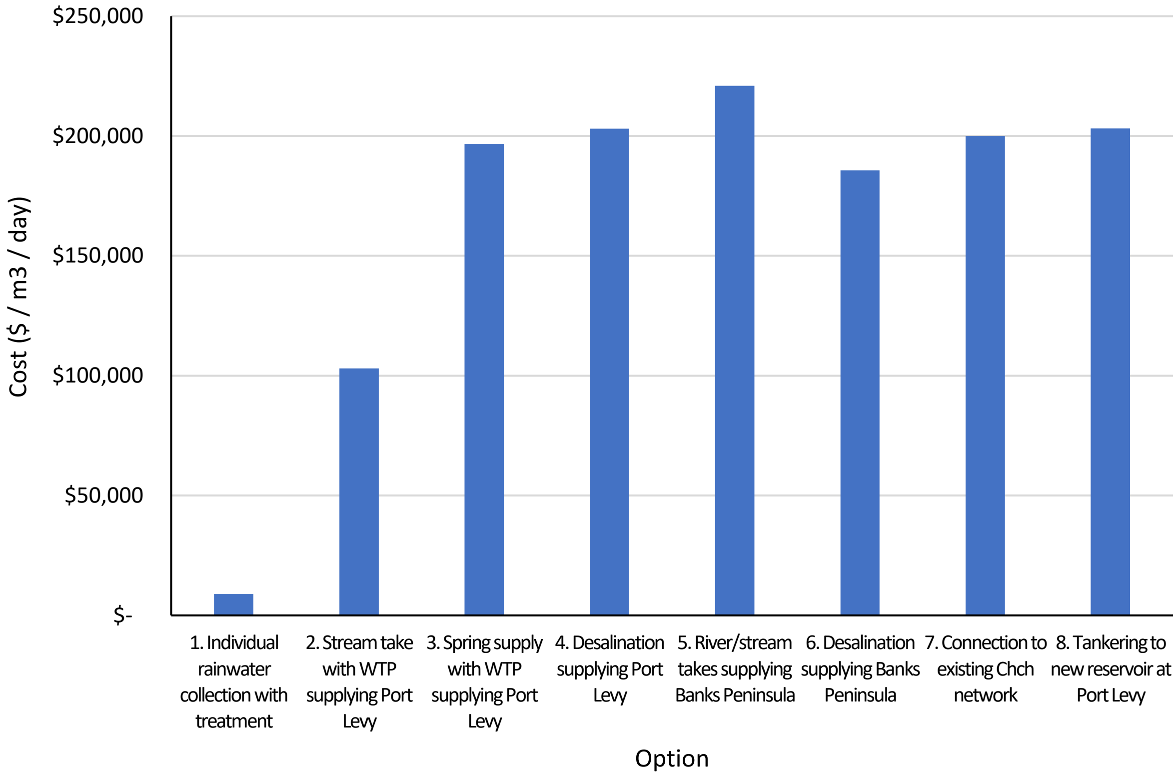
While Figure 8 shows options identified specifically for the Koukourārata Marae and local community, the format is intended to be applicable for other sites across Christchurch District. A number of options were excluded through the long listing process due to expected shortcomings. Options excluded include:

- Sourcing water from a local deep bore, which is unlikely to be available in the Port Levy area (due to unsuitable hydrogeological setting)
- Tankering drinking water from Christchurch to supply the wider Banks Peninsula. This was determined to require too many vehicle movements to be practical, and untenable due to high costs and carbon emissions.
- Wastewater reuse was discounted as there would be insufficient water supply to generate enough wastewater for reuse. Costs may also be prohibitive and recycling wastewater may be culturally unacceptable

A high-level pre-concept cost estimate (CAPEX) was undertaken for each of the long list options. To enable comparison between options, a $/m3/d value was assigned.

Comparison of costs on a per $m^3$ treated drinking water per day basis are shown in Figure 9 overleaf. It is important to note that for options 5, 6 and 7, water is supplied to population clusters, and dwelling within 250m of pipeline routes, only. I.e., water is not supplied to every dwelling on Banks Peninsula. The rationale for this approach is that supplying every dwelling across the entire peninsula would be prohibitively expensive. It is intended that individual remote dwellings will continue to self-supply.

*Figure 9: Comparative Cost Estimates for Water Supply Options at Koukourārata*




The cost information presented above shows that, in the case of Banks Peninsula, larger, centralised systems would not be more cost-effective than smaller, local options. Key reasons for this are adverse topography and long distances between communities, combined with the small scale of each community.

## CONCLUSIONS

Identifying private water suppliers as a first step to perform the needs assessment required in the Act is an issue being faced around the country. There is a lack of clarity on how many private suppliers exist and the number of people serviced by private suppliers. GIS is a useful tool to identify private suppliers with a key advantage that database information can be progressively updated with information gathered on the ground in order to improve confidence and accuracy over time.

GIS can also be used to characterise community water supply risks and to prioritise further actions, providing that sufficient data is available in digital spatial format, or that can be put into such a format.

The GIS tool identified over 3000 properties within Christchurch district that potentially access private water supplies (excluding self-supplied properties). Within that number, clear priorities based on public health risk have been established. A number of communities without access to a drinking water supply, are located near serviced areas. These communities represent "easy wins" as they can be serviced by expanding current reticulation schemes.

Other higher risk and un-serviced communities are located in remote areas where there are no easy, low cost solutions. A case study of Port Levy on Banks Peninsula (which incudes a local marae) found that building a local treatment scheme that uses local abstracted water would be more cost-effective than supplying water from further afield (i.e., by developing extensive potable supply networks supplied from a centralised water treatment facility). Influencing factors include adverse topography, long distances between communities, and the absence of an adequate, centrally-located water source.

Some assessments of registered private suppliers were also conducted to test readiness to comply with the Act. None of the private suppliers assessed were found to be ready to comply. These results suggest there is much work ahead to reach a consistent state of access and drinking water compliance across Christchurch District.

## ACKNOWLEDGEMENTS

The authors wish to acknowledge Christchurch City Council, who has initiated this work and provided technical assistance and funding.