Groundwater Quality and Quantity Annual Report 2023

Prepared to meet the Requirements of CRC231955

Christchurch City Council

June 2024

Christchurch City Council

Internal Document Review

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Contents

List of Tables

List of Figures

1 Introduction

Christchurch City Council (the Council) is required to review annual groundwater monitoring data from various sites within the territorial boundary of the Council. A combination of the Council's hydrometric network data currently managed by NIWA (NIWA, 2023), and a selective Council's water supply wells results have been reviewed.

This work pertains to the groundwater aspect of the Comprehensive Stormwater Network Discharge Consent (CSNDC), CRC231955, issued by ECan to the Council on 20 December 2019. The work has been completed in accordance with the Christchurch City Council's Environmental Monitoring Programme (EMP).

1.1 Background

The CSNDC serves as a global consent enabling the Council to discharge water and contaminants to land and water from the stormwater network. A portion of this consent (conditions 49 – 55) requires the preparation and implementation of the EMP produced by the Council. The EMP serves to assess the effects of stormwater discharges from the Council stormwater network on the receiving environment. The purpose of the EMP is "to (1) measure whether stormwater discharges are causing adverse effects on groundwater quality and quantity, (2) determine compliance with the conditions of consent, and (3) inform stormwater mitigation."

Schedule 9 of the CSNDC sets the receiving environment objectives and attribute levels for groundwater and springs.

1.2 Objective

Section 3.4 of the EMP details the Council's annual groundwater reporting requirements. The objective of this report is to address the requirements specified in the EMP as follows:

- Groundwater level patterns in CCC water level monitoring wells;
- Groundwater quality patterns for copper, lead and zinc in ECan monitoring wells;
- *E. coli* detections in CCC water supply wells;
- Groundwater quality patterns for copper, lead and zinc from CCC water supply wells;
- Any information from spring monitoring that could be attributed to stormwater impacts on groundwater;
- Statistical analyses of change for *E. coli* (daily data from pumping stations) and electrical conductivity (quarterly data at ECan monitoring wells; used as an indicator of changes in metals levels) shall be undertaken using Time Trends or other robust analysis, using a statistical level of significance of 5% (i.e. $p \leq 0.05$);
    - A minimum of three years is required before trends analysis can be undertaken (NIWA, 2014);

- Trends analysis shall be conducted on data since the beginning of the dataset.

- Any groundwater related issues that affect the performance of stormwater management systems; and
- An assessment as to whether the Receiving Environment Objectives and Attribute Target Levels specified in Schedule 9 (Groundwater and Springs) of the consent conditions are being met at each site for copper, lead and zinc.

2 Limitations of the Report

In the past, the Council did not have a routine monitoring program focused on sampling from specific wells. It is important for the Council to establish a consistent plan for monitoring the shallower aquifers (aquifer 1 and aquifer 2). A well-defined monitoring strategy can provide information on the quality of data and help identify any potential issues or areas for improvement.

The Council is working on revising the groundwater chapter of the existing Environmental Monitoring Plan (EMP). Once the new version of the EMP groundwater chapter is finalised, the Council will have a clearer direction on the specific data quality requirements to focus on. With a finalised EMP, the Council can determine the key parameters and metrics that need to be monitored in both aquifers. This will enable the Council to establish precise guidelines for data collection, analysis, and ongoing monitoring.

This report is presented as an Interim report, and it summarises a collective analysis of data from selective wells at different times of the year. While having specific well data from shallower aquifers would provide a more detailed understanding of the quality of the drinking water, at this interim period, the summary based on the existing data sources can still offer insights into the overall quality of drinking water at the source.

This report doesn't cover a trend analysis of change in electrical conductivity, copper, zinc and *E.coli*, due to inconsistent and insufficient data set from dedicated sampling points from the past three years.

The new sampling requirements at the source of the water supply are influenced by the introduction of the new Drinking Water Quality Assurance Rules 2021 (DWQAR) prepared by Taumata Arowai in accordance with section 49 of the Water Services Act 2021. The new rules require the Council to monitor source water[12] with the following frequency (DWQAR - Table

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[1] *Samples may be collected either at the source abstraction point or at the treatment plant before any form of treatment, if water is from a single source. If multiple sources are used, samples must be collected from each source at points before any mixing of source water occurs.*

[2] *Where multiple bores access the same aquifer, one bore can be sampled to provide results that are representative of a number of bores if the water supplier can demonstrate that the bore that is sampled is representative of the bores that are not sampled. The representative nature of the sampled bore must be re-established every five years or after significant seismic activity.*

16):

- *E. coli* and total coliforms: 2 times per month
- Copper and lead: annually

There is no requirement to sample Zinc at the source.

3 Scope of work

In order to meet the objectives of this report, the Council undertook the following scope of work:

- Presented a summary of all groundwater level monitoring data from the Council Hydrometric Network currently managed by NIWA from 27 sites
- *E.coli* detection in the Council water supply wells
- Research Summary on groundwater quality and quantity investigation projects

4 Methodology

4.1 Data Source: the Council Hydrometric Data

Groundwater level data was retrieved from the Council Annual Hydrometric Network Report 2023.

5 Assessment Criteria

Groundwater data for *E. coli* have been compared to the attribute target levels specified in Schedule 9 of the CSNDC, in accordance with section 3.4 of the EMP. The attribute target levels are presented in Table 1.

Table 1: Receiving Environment Objectives and Attribute Target Levels for Groundwater **(Schedule 9, CRC231955)**

Objective	Attribute	Attribute target Level
Protect drinking water quality	*Escherichia coli concentrations* in drinking water	No statistically significant increase in the concentration of *Escherichia coli* at drinking water supply wells

6 Results and Discussion

6.1 Groundwater level patterns in the Council water level monitoring sites

The Council groundwater network consists of a total of 27 sites operated by NIWA as at the end of 2023. The summary of the maximum, mean and minimum groundwater levels recorded during 2023 are presented in APPENDIX I.

All sites in the groundwater network are measured manually except for the Halswell Retention Basin (3255009), Dartford St (3246005) and Sumner (3257031) sites which are telemetered level sensors. At present the data from the telemetered sites is available up to the last hour.

Manual groundwater levels are measured on either a weekly or fortnightly basis, depending on site status requirements. An additional requirement is that following rainfall of greater than 20 mm in a 24-hour period, groundwater measurements should be delayed by 2 days.

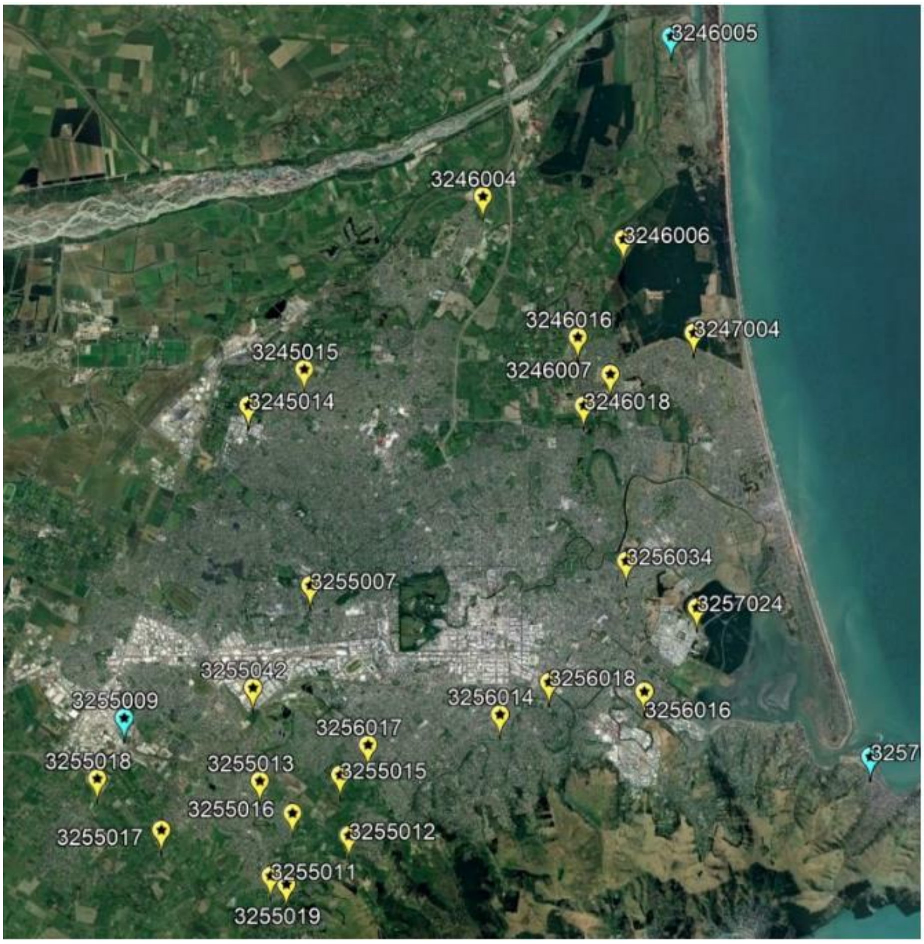

Figure 1: Location of the Council groundwater level sites during 2023. Telemetered sites are labelled with blue pins and manual sites with yellow pins.

6.2 *E. coli* detections in the Council Water supply wells

In total, there were 321 *E. coli* samples taken from 15 water supply wells that are in either aquifer 1 or aquifer 2, in the 2023 calendar year. There were no exceedances recorded.

6.3 Copper, Zinc and Lead in the Council Water supply wells

The new Drinking Water Quality Assurance Rules 2021(DWQAR) prepared by Taumata Arowai in accordance with section 49 of the Water Services Act 2021 require the Council to monitor source water with the following frequency. The new requirement does not require the Council to monitor Zinc from a source water.

- *E. coli* and total coliforms: 2 times per month
- Copper and lead: annually

7 Related research and ongoing groundwater investigation projects

During 2022 -2024, the Council has been working on various groundwater research and monitoring projects related to assessing and managing risks to the safety of drinking water. Sections **Error! Reference source not found.** and 7.2 highlights the summary of some of the projects that the Council undertook in groundwater space.

7.1 Shallow Groundwater Levels under Christchurch

The Council has engaged Aqualinc Ltd to undertake data analysis to support the preparation of notices to be placed on Land Information Memoranda (LIMs) across the city that identify potential risks from shallow groundwater. The data analysis work aims to assess whether or not the new high-resolution data has changed the statistics, and whether or not the additional monitoring points adequately fill gaps for areas with no previous monitoring.

There are four groups of groundwater level data that have been considered as part of this study:

- Long-term data collected manually by both Councils at fortnightly or monthly intervals comprising:
- 55 bores regularly monitored; and
- A further 23 bores were monitored by the Council as part of their Eastman Te Kura site study (with data available from 2016 to present).
- Old data from 782 bores collected manually by EQC at monthly intervals from 2011/12 to late 2016; New data collected from 160 original EQC bores

instrumented with transducers that record data automatically from late 2016 to the present (these bores have both manual data prior to late 2016 and new high-resolution data thereafter); and new data collected from 84 new monitoring bores with transducers that record high-resolution data automatically from late 2016 to present (these have no manual data prior to 2016).

Discussion and recommendations

The high-resolution data collected since 2016 provides a unique insight into the behaviour of shallow groundwater over this period. This has been a period with some extreme rainfall events, as well as two years of low groundwater recharge. The response of the APP network has been variable: the majority of bores show raised groundwater levels relative to the preceding 2011 to 2016 period, some show little change, and some have lowered. Overall, the changes are generally relatively small (< ~0.3 m) though even this small change may cause some issues in areas with very shallow groundwater. The inclusion of the new (post-2016) data (while using the old data in areas with no post-2016 data) has enabled the generation of new surfaces. The changes from the original 2016 surface to the new one have resulted in some areas that have expanded and other areas that have been reduced. However, the value of the additional spatial data has been limited as many of the new piezometers are located close to existing bores. The addition of the Eastman Te Kura data has provided more confidence in the interpolation in this area, where there previously had been little information. The greatest confidence is provided in the areas that are close to measurement sites and also areas where the original and new surfaces are close in terms of groundwater level for each. The additional temporal data has resulted in an interpolated surface with differences in the depth to shallow groundwater that is noticeable in some areas, but with little difference in other areas. Spatially, the new data provides some additional control, but not substantially. The network was originally installed for land damage assessment post-earthquakes. It was not designed for defining depth to shallow groundwater across the city, and the spatial distribution of bores is not ideal for this purpose. Regardless, the data sets are far more advanced than what is typical in across other cities in New Zealand and are a valuable source of information for informing shallow groundwater risk. Further observations are as follows:

- The operation of the APP network were continuously maintained over the last few years when record-high groundwater levels have been experienced in some areas. There is now greater confidence in the measured high groundwater levels which are likely to be good predictors of future highs (including potential sea level rise which has been accommodated in the sea level rise scenario).
- The high-resolution temporal data captures the dynamic response of groundwater levels to high-intensity, short duration, rainfall events. This cannot be captured by individual manual measurements. As manual field measurements usually occur during fair weather, the response from wet weather events is usually missed.

- Visual inspection of the time series indicates that, by and large, very high groundwater levels occur for short durations (from hours to a day or two) before receding, but near-high groundwater levels remain for longer. Short duration peaks typically occur when there is heavy rain, so from a landowner's perspective, it is not obvious that groundwater might be contributing to surface flooding. Groundwater flooding would then only come to the forefront when flooding remains, well after the event has passed and conditions would be expected to be dry. This has occurred in some areas such as Flockton Basin, Woolston, parts of Halswell, and Brighton (which is exacerbated by tidal effects). Sustained high groundwater levels are of concern for property owners (for example due to damage to vegetation and the effects of rising damp).
- There is greater confidence in the likelihood of shallow groundwater in areas with nearby measurements compared to areas further away from measurement sites. Given this, LIM notices could be grouped into two categories, such as:
    - Shallow groundwater is likely at times (for shallow areas near measurement points); and
    - Shallow groundwater is possible at times (for shallow areas away from measurement points).
- The larger spatial changes in the interpolated surfaces tend to occur where a measurement point 'came online' (i.e. a new bore was monitored) or 'went offline' (i.e. a bore ceased to be measured). The cessation of monitoring has mainly occurred due to the conversion from manually dipped bores in many bores to the use of transducers on fewer bores. There will also be some cases where there has been damage to the bore (say from roading, infrastructure or land development works), but also occasionally due to failure of the down-hole logger. This is expected to continue into the future (as the logger's age), and so it is recommended that the monitoring of as many bores as possible is maintained to reduce the future influence of these valuable data sources disappearing. However, if the Council wish to rationalise the network (to reduce ongoing costs and/or redistribute the available transducers), then removing bores from areas where multiple bores are clustered together and where hydraulic responses are similar is recommended. Such locations may include:
    - Bishopdale (between Harewood and Sawyers Arms roads): currently 5 bores in close proximity (APP bores 101, 114, 116, 211 and 212), all of which have similar hydraulic responses – could remove two or three bores.
    - Avondale (between Orrick Crescent and Anzac Drive): currently 3 bores in close proximity (APP bores 35, 47, 78), two of which have similar hydraulic responses (47 and 78) – could remove one bore.
    - North New Brighton (near corner of Beach Road and Bower Avenue): currently 3 bores in close proximity (APP bores 4, 54 and 172), two of which have similar hydraulic responses (4 and 54) – could remove one bore.

- Woolston (Riley Crescent): currently 3 bores in close proximity (APP bores 5, 55 and 80), two of which have similar hydraulic responses (5 and 80) – could remove one bore.
- Beckenham (southern end of Colombo Street): currently 3 bores in close proximity (APP bores 109, 130 and 226), two of which have similar hydraulic responses (130 and 226) – could remove one bore. In addition, a similarity assessment has identified pairs of bores (located in close proximity to each other) that have similar hydrographs where one bore could be dropped. These are listed in Appendix E.

The interval that groundwater levels are logged could be reduced from 15 minutes to 1 hour. This will extend the length of time before loggers become full, thereby reducing the frequency (and therefore costs) of collecting this data from approximately once every 9 months to once every 3 years. However, this needs to be balanced with the knowledge that the loggers are starting to age, and therefore there is a higher chance of logger failure (and therefore lost data) between data collection rounds. Annual collection rounds is recommended.

There will be areas where CCC might strategically want to place transducers (for example in areas prone to groundwater flooding or in long term manually-monitored bores). Many of the original EQC bores are still in existence and may be usable. If groundwater level data is to be used operationally, then it will be necessary to telemeter the data. Options have been explored to assess the viability of doing this, and purchase/subscription options have been identified (and previously provide to CCC). If the purpose of monitoring is to obtain background information in areas that have no current monitoring, then downhole transducers and periodic downloads are a viable option. Areas with no current monitoring include:

- The CBD area (which in particular has historically reported issues with shallow groundwater) and a wider area from west to east across the middle of the city;
- North of Papanui;
- Marshlands; and
- Coastal areas in general.

Point measurements of groundwater levels are limited in their ability to fully capture the spatial variability of high groundwater level risk, but the automated network provides excellent temporal resolution. Conversely, geophysical methods have the ability to capture the state of the groundwater system over large areas, but only at the time of measurement. Therefore, the combination of the APP network with strategic geophysical testing could provide CCC with a sound spatial and temporal coverage of responses to further reduce the uncertainty associated with the assessment of shallow groundwater risk.

7.2 Anticipate Baseflow and Water Balance Changes Resulting from the stormwater management plan for the Avon River catchment

The Council has engaged PDP Ltd to assess the effects of the diversion of stormwater on baseflow in waterways and springs and details of monitoring that will be undertaken of any waterways and springs that could be affected by stormwater management changes anticipated within the life of the SMP. The report also assesses the potential change to the overall water balance for the SM area arising from the change in pervious area and the stormwater management systems proposed. The portion of the report also provides an update to the report 'Groundwater Quantity Assessment for Avon Catchment (PDP, 2013)' and focus on the potential changes to the water balance in the Avon River as a result of areas that are re zoned under the district plan.

The analyses undertaken in this report indicate that, the change in pervious area and stormwater management systems proposed results in a very small (equating to negligible) increase in groundwater recharge for the Avon River Catchment.

8 Conclusions

An annual summary of the 2023 groundwater results and highlights of groundwater research projects have been presented. This report doesn't cover Zn, Cu and Pb sampling results at source for the calendar year 2023 due to the introduction of new drinking water rules at the end of 2022. This report doesn't include a trend analysis of *E.coli*, due to inconsistent and insufficient data set from dedicated sampling points for the three years to be able to conduct a trend analysis.

This report serves as an interim report until the finalisation of the Environmental Management Plan (Chapter Three- currently under review). In addition, the summary of the groundwater- related research presented in this report will contribute valuable insights into the status of groundwater quality and provide crucial support to the revised EMP. It is anticipated that the comprehensive analysis and findings from the different groundwater related research projects outlined in this report will contribute significantly to the ongoing efforts in ensuring effective groundwater management and protection.

9 Recommendations

- Historical trend analyses are produced for the Council water level data.
- Development of the sampling plan once the revision of EMP chapter is complete.

10 References

- Christchurch City Council (August 2020). Environmental Monitoring Programme for Comprehensive Stormwater Network Discharge Consent for Ōtautahi/ Christchurch City and Te Pātaka o Rākaihautū/Banks Peninsula
- Environment Canterbury (20 December 2019). Resource Consent CRC190445, A DISCHARGE PERMIT (S15): to discharge water and contaminants to land and water from the stormwater network.
- Ministry of Health (2005, revised 2018). Drinking-water Standards for New Zealand. 19 December 2018.
- NIWA (2022). Christchurch City Council hydrometric network annual report: 1 January to 31 December 2021. April 2022.
- Weir. J, Rutter. H, Dudley Ward. N, Hatley, G. (2024). Shallow Groundwater Levels Under Christchurch - APP Network Data Analysis Update. Christchurch City Council. Aqualinc Research Ltd.

Appendix A Groundwater site statistics summary 2023 comparison with full record

Table 1: Groundwater site statistics summary 2023 comparison with full record.

Station details			Full record			1-January-2023 to 31-December-2023		
Number	Name	Start of record	Minimum (m)	Maximum (m)	Mean (m)	Minimum (m)	Maximum (m)	Mean (m)
3245014	Roydvale Ave	06-Oct-77	26.195	29.795	27.589	27.045	28.545	27.575
3245015	Fairford St (opp Oldwood)	19-Dec-88	24.975	26.525	25.784	25.345	26.010	25.723
3246004	PS62, Tyrone Street	05-Jun-84	11.745	14.935	13.753	14.115	14.865	14.493
3246005	Dartford St, Brooklands	21-Jul-81	8.498	10.873	9.642	9.582	10.563	9.772
3246006	Lower Styx Track Burwood Forest	11-Mar-91	10.400	12.775	11.065	11.080	11.715	*11.269
3246007	Mairehau Rd, near Greenhaven	07-Mar-97	10.040	11.450	10.927	10.670	11.190	10.882
3246016	Marshland Domain	07-Mar-97	10.590	13.134	12.364	12.130	12.720	12.345
3246018	QEII Drive (away) #2 Drain	24-May-99	10.750	12.214	11.108	11.064	11.314	11.175
3247004	No.134 Inwoods Road	12-Nov-84	11.320	12.990	12.248	12.344	12.605	12.461
3255007	Kirkwood Intermediate School	06-Jan-67	20.350	22.395	21.463	20.865	21.890	21.518
3255009	Halswell Ret.Basin, Halswell Jnt	11-Oct-77	23.701	29.585	*25.435	25.393	26.707	25.899
3255011	Cashmere/Kennedys Road	11-Sep-00	19.825	21.610	20.638	20.210	21.275	20.853
3255012	Cashmere Road	11-Sep-00	15.665	19.360	17.873	17.605	19.085	18.556
3255013	Halswell Road PS	05-Jun-84	20.390	22.970	21.753	21.040	22.210	21.331
3255015	Hendersons Road	11-Sep-00	14.985	18.310	17.260	16.695	18.190	17.689
3255016	Milns/Sparks Road	13-Apr-92	18.700	20.940	19.564	19.440	20.125	19.770
3255017	Whincops Road	13-Apr-92	22.135	23.210	22.666	22.780	23.030	22.901
3255018	Hodgens Road	13-Apr-92	24.265	26.775	24.752	25.030	25.775	25.387
3255019	Quarry Carpark No.2	16-Jun-98	18.320	22.710	19.522	18.670	19.360	*19.004
3255042	Wigram Road near Haytons	10-Dec-13	23.836	25.156	24.505	24.346	24.936	24.709
3256014	Fisher Ave/Norwood Street	20-Apr-92	13.050	15.250	14.365	13.780	14.910	14.496
3256016	Gould Crescent, Woolston	07-Aug-78	8.145	10.145	9.452	9.145	9.615	9.383
3256017	PS42, Sparks Road	07-Jul-69	15.860	18.850	17.383	16.615	18.285	17.741
3256018	PS20, Locarno Street	03-Jun-59	11.095	12.695	11.930	11.495	12.040	*11.673
3256034	PS1, Woodham Road	03-Jun-59	7.635	12.380	11.104	11.175	11.480	11.318
3257024	Ruru Road, Bexley	10-Mar-86	12.520	13.835	13.152	13.460	13.715	13.617
3257031	Cnr Wakefield and Nayland, Sumner	08-Aug-19	10.471	11.013	10.618	10.506	10.951	10.664

* Indicates gap percentage of 2.5% exceeded

Appendix B List of Council's wells in aquifers (aquifer 1 and aquifer 2)

List of all the proposed drinking water wells (Aquifer 1 and Aquifer 2) for long-term monitoring.

well_no	ccc_name	depth	aquifer	well_type_	well_sta_1	locality
M36/2828	MAIN PUMPS WELL-02	29	Aquifer 1	Bore or Well	Active (exist, present)	BECKENHAM
BX24/0627	PRESTONS WELL-04	80	Aquifer 2	Bore or Well	Active (exist, present)	Marshland, Christchurch
M36/1356	MAIN PUMPS WELL-03	28	Aquifer 1	Bore or Well	Active (exist, present)	BECKENHAM
M35/7291	BROOKLANDS WELL-02	83	Aquifer 2	Bore or Well	Active (exist, present)	BROOKLANDS
M35/7215	ASTON WELL-02	106	Aquifer 2	Bore or Well	Active (exist, present)	NORTH SHORE
M36/4591	MAIN PUMPS WELL-01	29	Aquifer 1	Bore or Well	Active (exist, present)	BECKENHAM
M36/3060	DUNBARS WELL-04	52	Aquifer 2	Bore or Well	Active (exist, present)	OAKLANDS
M36/1195	MAIN PUMPS WELL-05	29	Aquifer 1	Bore or Well	Active (exist, present)	BECKENHAM
M36/4052	DUNBARS WELL-02	54	Aquifer 2	Bore or Well	Active (exist, present)	OAKLANDS
M36/0985	MAIN PUMPS WELL-06	29	Aquifer 1	Bore or Well	Active (exist, present)	BECKENHAM
M35/8898	PICTON WELL-03	61	Aquifer 2	Bore or Well	Active (exist, present)	Riccarton
M36/1363	MAIN PUMPS WELL-04	29	Aquifer 1	Bore or Well	Active (exist, present)	BECKENHAM
M36/4053	DUNBARS WELL-01	54	Aquifer 2	Bore or Well	Active (exist, present)	OAKLANDS
M36/4333	DUNBARS WELL-03	53	Aquifer 2	Bore or Well	Active (exist, present)	HALSWELL
M35/3128	PARKLANDS WELL-02	93	Aquifer 2	Bore or Well	Active (exist, present)	NEW BRIGHTON
M35/7746	PARKLANDS WELL-03	94	Aquifer 2	Bore or Well	Active (exist, present)	PARKLANDS
M35/7180	BROOKLANDS WELL-01	82	Aquifer 2	Bore or Well	Active (exist, present)	BROOKLANDS