Auckland
**Regional** Council
TE RAUHITANGA TAIAO

State of the Environment Monitoring

# Groundwater Quality Data Report 1998-2005

December 2007 Technical Publication 352

Auckland Regional Council
Technical Publication No. 352, December 2007
ISSN 1175-205X
ISBN -13: 978-1-877483-07-3
**www.arc.govt.nz**

# State of the Environment Monitoring: Groundwater Quality Data Report 1998-2005

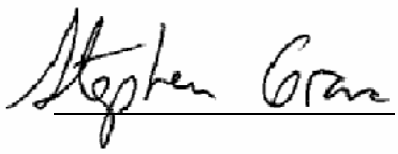
Environmental Research

Monitoring and Research Group

# Contents



Peer reviewed by:

Stephen Crane  Date: 24 December 2007

Approved for release by:

Grant Barnes  Date: 24 December 2007

# Acknowledgements

This report was prepared by the Monitoring and Research Group at the Auckland Regional Council. ARC staff from the Environmental Services team, principally Ross Winterburn, is thanked for his diligent sample collection and data management. Kylie Park is also thanked for her diligent assistance with the data analysis and report preparation. Chris Daughney from GNS is thanked for his helpful discussions and assistance with the statistical analysis of the water quality data. Stephen Crane is thanked for his careful review of this report.

**Recommended Citation:**

Auckland Regional Council (2007). State of the Environment Monitoring: Groundwater Quality Data Report 1998-2005. ARC Technical Publication 352. Auckland. 86 Pages.

# 1 Background

The Auckland region contains a large number of both sedimentary and volcanic aquifer systems storing significant groundwater resources important for town, irrigation, geothermal, domestic and stock water supplies, as well as providing essential baseflow to Auckland's rivers and streams, supportive of their surface water quality and ecosystems.

Natural groundwater quality is principally related to the geology of the aquifer (through rock-water interaction) and the degree of confinement of the aquifer. Groundwater quality can also be affected by land-use activities either within the groundwater recharge zone or directly from land activities overlying unconfined or semi-confined aquifer systems, i.e. anthropogenic contamination.

The geology of the Auckland region principally comprises Triassic to Early Cretaceous basement 'greywacke' rocks overlain by a succession of Tertiary (Late Eocene to Early Miocene) marine sediments, covered by a thin sequence of Pliocene to Holocene terrestrial and shallow marine sediments found mainly in coastal and lowland areas. From Early Miocene to Holocene intermittent volcanic activity formed much of the Waitakere Ranges, Great Barrier Island, Little Barrier Island, South Auckland Volcanic Field and Auckland (Isthmus) Volcanic Field (Edbrooke, 2001).

The main rock types of the Auckland region consist of the following principal aquifer types (Figure 1):

- volcanics, basalt and andesite lava flows and pyroclastics
- coastal dune sands
- alluvial sands and gravels
- shelly marine sandstones
- marine sandstones and mudstones
- marine basement greywackes

Each aquifer type contains many separate aquifer systems, e.g. the volcanic aquifer type consists of the Auckland (Isthmus) Volcanic Field, South Auckland Volcanic Field, Little Barrier Island, Waiheke Volcanics, Great Barrier Island and the Waitakere Volcanic Group aquifer systems. Within each of these separate aquifer systems are numerous individual aquifers each storing and transporting regionally significant quantities of groundwater.

Groundwater quality has been routinely monitored in the Auckland region since 1998 through the State of the Environment (SoE) Groundwater Quality Monitoring Program. This program currently monitors a number of aquifer systems within the first five principal aquifer types (excluding the basement greywackes) focusing principally on monitoring the region's high-use aquifersSome aquifers are particularly vulnerable to overlying landuse impacts especially unconfined or semi-confined aquifers, which are

relatively unprotected from any vertical migration of contaminants from overlying activities. The age of the groundwater is also important; where groundwater is old, historic landuses can still have a significant impact today (Rosen and White, 2001).

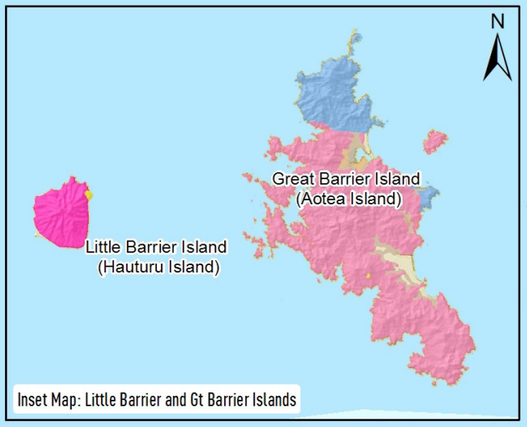
The groundwater recharge area, aquifer transmissivity, storativity and the degree of aquifer confinement from the overlying land use are important factors controlling the affect of landuse activities on groundwater quality. Any land use that discharges contaminants to ground can have a significant impact on groundwater quality. Land use activities with the potential to contaminate groundwater include any hazardous or industrial activity using, storing, transporting or disposing of hazardous substances.

Examples of land uses which may potentially contaminate groundwater are most commonly associated with urban areas and include ports, airports, railways, roads, services particularly wastewater networks and pipelines, urban stormwater runoff, construction excavations and airbourne pollutants from industrial air discharges and vehicle emissions. In rural areas, the more dominant land uses which can affect the groundwater quality include farming (farm dumps, pesticide and fertiliser application and irrigation, farm animal wastes, sheep dips), horticultural activities and septic tanks and cesspits discharges (Fetter, 1992).

Landfills, storage/treatment/burial pits or ponds, land application of municipal and industrial wastewater, material stockpiles, graveyards, above and underground storage tanks can be associated with both urban and rural areas (Fetter, 1992). Quarrying of the region's basalt, andesite, greywacke and conglomerate resources can also have a direct affect on the groundwater quality of the underlying aquifers (Kermode, 1992).

The groundwater quality data from the SoE Groundwater Monitoring Program is summarised and reported annually, and contributes to the determination of the relative state of freshwater resources in the Auckland region and for informing water quality guidelines, standards and indicators. Analysis of groundwater quality trends is reported separately, typically at 5-yearly intervals; the first of these is the Groundwater Quality State and Trends in the Auckland Region 1998- 2004 report TP353 produced for the ARC by Institute of Geological and Nuclear Sciences (Daughney, 2007a).

# Auckland Region Geology & Groundwater Bore Location Map




Quintals Road Bore 13
Waiwera Thermal
Chenery Road Production
Aquatic Park, Parakai
Rimmer Road
Waitakere Road
Waitakere Road #2
Watson Avenue, Sandringham
Central Park Industrial Estate
Tiwai Road
Mt Richmond Domain
Amelia Earhart Avenue
Lambie Drive, Puhinui
Burnside Road
Bullens Road
Seagrove Road
Fielding Road - Volcanic
Fielding Road - Sands
Ostrich Farm Road #1
Ostrich Farm Road #2
Rifle Range Road - Shallow
Rifle Range Road - Deep
B.P. Bombay
Douglas Road

## Legend

- Boreholes
- Thermal Boreholes

**Geology**

**Holocene Sediments**
- Alluvial Sediments
- Dune Sands

**Pleistocene Sediments**
- Alluvial Sediments
- Dune Sands

**Kaawa Formation**
- Shelly and Carbonaceous

**Waitemata Group**
- Sandstone, Mudstone

**Te Kuiti Group**
- Sandstone, Mudstone, Coal measures

**Northland Allcation**
- Mudstone, Limestone, Minor Volcanics

**Basement**
- Greywackes

**Great Barrier Is. Volcanics**
- Volcanics

**Waiheke Island**
- Volcanics

**Little Barrier Is. Volcanics**
- Volcanics

**South Auckland & Auckland Volcanics**
- Basalt
- Scoria
- Tuff

**Waitakere Group Volcanics**
- Volcanics
- Volcaniclastic

Kilometers
0 2.5 5 10 15 20 25

Map Produced by GIS Information Services Auckland Regional Council

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# 2 Programme Objectives

The primary purpose of the groundwater monitoring programme is to provide state of the environment information as required under section 35 of the Resource Management Act, 1991. The information collected is important as it contributes to our understanding of how aquifer systems operate and how adjacent land uses may compromise the long-term sustainability of our region's groundwater resources.

This groundwater quality programme also forms part of the "Healthy Ecosystems" component of the ARC's Long Term Community Consultation Plan 2006-16. Specific objectives include managing and minimising the effects of present and future urban and rural development, growth, and intensification across the region. The water quality parameters provide information on the condition of the region's groundwater, and feedback on management actions. This is necessary to confirm that ARC's management strategies are effective in sustaining aquifer functions and uses of groundwater. By achieving this outcome we are working towards achieving the ARC mission:

- "Working in partnership with our regional community to achieve social, economic, cultural and environmental wellbeing".

The main objectives of this programme are to:

- Determine the temporal and spatial variability of selected water quality parameters within the principal aquifer types throughout the region
- Provide a baseline of groundwater quality information from which the presence, direction and magnitude of trends can be determined
- Identify any impacts of different land-use activities affecting the more vulnerable aquifers in the region.

Further broader objectives include:

- Identification of the present and potential impacts of development activities
- Collection of baseline data for calibration of short-term surveys of similar areas
- Evaluation of groundwater quality with respect to pollution incidents
- Assessment of the effectiveness of land use planning policies intended to protect groundwater quality
- Ensuring that existing environmental controls are adequate to avoid unacceptable adverse environmental impacts

At the conception of this programme, the initial intent was not to seek areas of actively changing groundwater chemistry i.e. groundwater contamination, rather it was to monitor long-term water quality of "typical" groundwater within a particular aquifer and to determine long-term water quality trends. Such relatively unimpacted baseline data may then be used to assess the impact of landuse practices on groundwater quality.

Where an aquifer is considered to be primarily unaffected by landuse practices, the SoE groundwater data can be particularly useful in establishing background groundwater quality for the area so that minimum groundwater remediation targets can be set. Establishing the degree of aquifer vulnerability is therefore essential to this end.

## 2.1 Report Content

This report provides 7 years of summary groundwater quality data from January 1998 to December 2005, collected from 24 bores located throughout five of the six principal aquifer types of the Auckland region (excluding the basement greywackes). The report includes:

- Sampling bore information and water level data (Section 3, Table 1).
- Summary water quality parameter statistics tabulated by bore, grouped by principal aquifer type (Section 3, Tables 2-7).

Previous reports (i.e Crowcroft and Bowden, 2002; Scoble, 1997; Scoble, 2000) can be obtained by contacting the Auckland Regional Council (09) 366 2000; in electronic format from the ARC's website: www.arc.govt.nz/publications or email: info@arc.govt.nz

## 2.2 Programme Design

The SoE groundwater quality monitoring sites were selected based on areas of high groundwater use and intensive landuse, the integrity of any existing bores, long term bore accessibility, and to provide aquifer representativeness and a good geographic spread across the region's aquifers. Figure 1 shows the location of the selected sampling sites across the Auckland region and Table 1 (Section 3) lists the bore names, principal aquifer types, aquifer confinement and landuses. Full monitoring site details are provided in Appendix 1.

The principal aquifer types currently monitored are:

- Auckland (Isthmus) Volcanic Field - basalts – high use & vulnerable
- South Auckland Volcanic Field - basalts – high use & vulnerable
- Pleistocene Sediments - alluvial sands and gravels & coastal dune sands - vulnerable
- Kaawa Formation - shelly sandstones – high use
- Waitemata Group - sandstones and mudstones – high use & vulnerable in shallow aquifer systems
- Parakai Geothermal System - Waitemata Group – high use
- Waiwera Geothermal System - Waitemata Group – high use

The only principal aquifer type currently not monitored is the basement greywackes.

Waitemata Group sandstones comprise the most widespread water bearing rock type in the region, although these sediments are variable throughout the region. For this reason, the monitoring programme includes eight Waitemata monitoring bores.

Some stratified geological formations form aquifers of sufficient thickness such that groundwater in the upper and lower parts of the aquifer may have different quality (e.g. Waitemata Sandstones). It is therefore necessary to take samples from both the upper and lower parts of these aquifers.

The sampling bores used have thorough bore construction and lithological details to ensure that the bore penetrates only the target aquifer and that the overlying aquifers are excluded. The bores chosen are believed to be representative of their particular aquifer.

The SoE Groundwater Quality Monitoring Programme operates on a 5-year schedule. The sampling methodology has been developed to ensure consistency in sampling across the sites and throughout the duration of the programme.

The optimum frequency for monitoring was determined as quarterly, to achieve a sample size that provides a statistically significant detection of trends and also to include some seasonal variation over a long time frame. However, due to the slow groundwater flow within the less permeable sandstone aquifers, annual sampling was considered to be the most appropriate use of resources. The sampling schedule for these aquifers was therefore designed as annual with one year of seasonal quarterly monitoring of each sandstone aquifer bore once during the first 5-years of the program. The 2005-2009 sampling plan and sampling frequency is summarised in Appendix 2.

The anticipated minimum timeframe for this programme was 10 years. This was to provide a statistically significant data set for trend analysis in the sandstone aquifers, with more data obtained for the other aquifers sampled quarterly and bi-annually each year.

Additional sampling for other groundwater quality programmes is also undertaken within the standard sampling timetable. At present, six ARC SoE bores are being sampled quarterly for the Institute of Geological and Nuclear Sciences (GNS) National Groundwater Monitoring Programme (see Appendix 2). Additionally, groundwater samples are also taken from the South Auckland Volcanics in Pukekohe for input to the Institute of Environmental Science and Research Ltd (ESR) National Pesticide Programme from the Rifle Range Rd – Shallow bore, plus two groundwater springs and a privately owned farm irrigation bore.

## 2.3 Water Quality Parameters

The aim of sampling groundwater for the SoE Groundwater Quality Programme is to obtain a representative sample of aquifer water chemistry. Groundwater samples are analysed in the field for temperature, pH, electrical conductivity, and dissolved oxygen

(DO). Samples are then analysed at the laboratory for pH, suspended solids (SS), turbidity and total dissolved solids (TDS) and for a full list of inorganic parameters, major cations and anions, nutrients and selected heavy metals to achieve as complete an ion balance as possible. A full list of the water quality parameters analysed is provided in Appendix 3. Note, synthetic organics are not currently a part of the SoE Groundwater Quality Monitoring Programme.

## 2.4 Programmme Changes

The water quality parameters analysed were expanded to include dissolved major and minor cations and anions, aluminum and hexavalent chromium in April 2004, to enable comparison with selected water quality guidelines and to enable the charge balance error (CBE) to be calculated to show that the data is within the less than 5% acceptable limit. At this time, the laboratory used to analyse the groundwater samples was also changed from Watercare Services to RJ Hill Laboratory. Duplicate samples were sent to both laboratories for the April and July 2004 monitoring rounds to ensure consistency of the data set.

A review of the groundwater sampling frequency and water quality parameters analysed was undertaken in June 2005 in conjunction with a review of the SoE Groundwater Quality Monitoring Programme by GNS (Daughney, 2007a). The new sampling plan for 2005-2009 is provided in Appendix 2. This review identified the bores which displayed no significant seasonal variation, for which quarterly seasonal monitoring was consequently ceased.

Additionally, the water quality parameters were expanded to include field pH and DO, and laboratory phosphate, faecal coliforms and E-coli to provide indicators of potential anthropogenic or landuse impact. The water quality parameter list provided in Appendix 3 shows the changes to the sampling frequency with the parameters grouped into quarterly, bi-annual and annual monitoring.

## 2.5 Water Quality Guidelines

New Zealand does not have specific groundwater quality guidelines. Therefore, Drinking-water Standards for New Zealand (MoH, 2005) are used to assess the state of groundwater used as drinking water supply. ANZECC (2000) are used to assess the environmental health of the groundwater and any potential risk to the environment. This is based on the fact that groundwater discharges as baseflow into the region's streams and eventually into the marine environment. Theses two guidelines are currently deemed most appropriate to assess the state of the region's groundwater resources and are in accordance with the Proposed Auckland Regional Plan: Air, Land and Water Plan (ARC, 2002).

## 2.6 Quality Control, Data Storage and Analysis

To ensure that sampling is producing reproducible results, a quality assurance and quality control (QA/QC) system is used. This involves the analysis of two duplicate samples from each quarterly sampling round. These samples are collected from randomly selected bores and sent for analysis with no identification other than the sampling date and a unique number.

The laboratories used for the routine analysis of samples from the SoE Groundwater Quality Programme have been both Laboratory Services Ltd, a subsidiary of Watercare Services Ltd., Mangere and R J Hill Laboratory, Hamilton. Both these laboratories are ISO and IANZ accredited and have their own rigorous internal QA/QC systems.

Quality control measures are undertaken in accordance with Auckland Regional Council's internal standards, consistent with AS/NZS ISO 9001:2000, including procedures for the collection, transport and storage of samples, and methods for data verification and quality assurance to ensure consistency across the monitoring programme. All field and laboratory data is stored in the ARC's water quality archiving database (HYDSTRA).

The data analysis and calculation of summary statistics median, inter quartile range (IQR) and median absolute deviation (MAD) has been performed using the '2007 National Groundwater Monitoring Programme Calculator' (Daughney, 2007b), which is a GNS spreadsheet developed for automatic processing of the water quality data using a log-normal probability regression technique (Helsel and Cohn, 1988). This statistical analysis approach was adopted since the groundwater quality data contains a high proportion of non-detect results (results below instrument sensitivity and reported with 'less than' values) and in some cases more than one detection limit. Log-normal probability regression techniques have been shown to be more robust and more accurate for multiple censored (non-detect) data than other more standard methods of statistical calculation (Helsel and Hirsch, 1992).

The statistical data calculated using the Helsel and Cohn (1988) method begins to become less reliable when more than 70% of the data set contains non-detects and/or when the Pearson correlation coefficient (r), which describes the strength of the regression, is less than 0.8. The statistical summary data (Tables 2-7) therefore shows any data, where any such lower reliability occurs, in italics. Note that calculation of the median does not rely on the lognormal regression method until more than 50% of the data are non-detects, therefore the median is only italicised when the r-value is less than 0.8 and the data set contains more than 50% non-detects.

Outliers were defined as being values greater than four times the MAD and were excluded from the calculation of the parameters of distribution (MAD and IQR). The number of samples (Count) and percentage of data less than detection limit (% Results Censored) reported also excludes any outliers. Note, however, that the minimum and maximum values reported include the entire dataset, including outliers.

## 2.7 Reports

The reporting of the SoE groundwater quality programme data was initially scheduled for a five yearly term with the first principal report due in January 2003. The first groundwater quality data summary report 'Auckland Region Long Term Baseline Groundwater Chemistry Programme, 3yr Data Summary Report' was however published in 2001 (Vujnovich, 2001) and a 'Groundwater Quality State and Trends in the Auckland Region 1998-2004 report TP353' was produced for the ARC by Institute of Geological and Nuclear Sciences (Daughney, 2007a).

This Groundwater Quality Data Report 1998-2005 is the second data summary report but is the first of a series of annual data reports commencing from 2005 onwards. The second trends and analysis report is scheduled to be produced in 2009.

The SoE Groundwater Quality Monitoring Programme is reviewed approximately every 5 years. Past reviews were reported in 2004 (Daughney, 2007a) and the next review is scheduled for 2008/09.

The data contained in this report will also be used to populate relevant environmental indicators anticipated as a web-based reporting initiative currently in the early planning stages. When live, this information can be accessed at the ARC's website www.arc.govt.nz.

# 3 Results

The groundwater quality aquifer and bore information and full statistical summary results are presented in the following seven tables:

- Table1 contains the aquifer and bore physical characteristics,
- Tables 2-7 contains the groundwater quality data summaries, tabulated by bore and grouped by principal aquifer type, as listed in Table 1.

## Table 1: Groundwater Bore Physical Data

| Site No. | Bore Name | Aquifer Type | Aquifer Confinement | Land Use | Bore ToC Elevation (masl) | Bore Standup (magl) | Depth BoH (mbtoc) | Screened/Open Hole Interval (mbtoc) | Static Water Level (mbtoc) | Static Water Level (masl) |
|---|---|---|---|---|---|---|---|---|---|---|
| 10 | Central Park Industrial Estate | Auckland Volcanics - Basalt, Scoria & Tuff | Unconfined | Business Estate | 23.23 | N/A | 22.67 | 12.96-22 | 5.16 | 18.07 |
| 11 | Tiwai Rd | Auckland Volcanics - Basalt, Scoria & Tuff | Unconfined | Urban / Residential | 70.16 | N/A | 58.53 | 46.53-58.53 | 54.3 | 15.86 |
| 12 | Watson Ave, Sandringham | Auckland Volcanics - Basalt, Scoria & Tuff | Unconfined | Residential | 40.05 | -0.11 | 39 | 32.5-38.5 | 12 | 28.05 |
| 13 | Mount Richmond Domain | Auckland Volcanics - Basalt, Scoria & Tuff | Unconfined | Recreational Park | N/A | N/A | 42.6 | 29.04-36.51 | 17.1 | N/A |
| 15 | Fielding Rd – Volcanic | South Auckland Volcanics - Basalt, Scoria & Tuff | Unconfined | Agricultural / Grazing | 19.99 | 0.55 | 46.7 | 16.3-46.7 (open hole) | 5.26 | 14.73 |
| 16 | B.P. Bombay | South Auckland Volcanics - Basalt, Scoria & Tuff | Unconfined | Commercial | N/A | 0.33 | 79.43 | 62-79.43 (open hole) | 7.29 | N/A |
| 17 | Rifle Range Rd – Shallow | South Auckland Volcanics - Basalt, Scoria & Tuff | Unconfined | Horticulture | 72.56 | 0.48 | 42 | 30-42 | 16 | 56.56 |
| 18 | Rifle Range Rd – Deep | South Auckland Volcanics - Basalt, Scoria & Tuff | Semi-Confined | Horticulture | 72.58 | 0.46 | 90 | 78-90 | 26.6 | 45.98 |
| 14 | Fielding Rd – Sands | Pleistocene Sediments - Alluvial Sediments | Semi-Confined | Agricultural / Grazing | 19.72 | 0.74 | 64 | 57-64 | 11.3 | 8.42 |
| 22 | Amelia Earhart Ave | Pleistocene Sediments - Alluvial Sediments | Confined | Business Estate | 11.87 | 0.43 | 50.6 | 42.6-48.6 | 8.85 | 3.02 |
| 4 | Rimmer Rd | Pleistocene Sediments - Dune Sands | Confined | Agricultural / Grazing | 33.74 | 0.36 | 63.5 | 49.5-61.5 | 29 | 4.74 |
| 8 | Ostrich Farm Rd Observation # 2 | Kaawa Formation - Shelly & Carbonaceous Sandstones | Confined | Agricultural / Grazing | 27.42 | N/A | 47.6 | 46-47 | 3.69 | 23.73 |
| 9 | Ostrich Farm Rd Observation # 1 | Kaawa Formation - Shelly & Carbonaceous Sandstones | Confined | Agricultural / Grazing | 23.11 | 0.41 | 84 | 68-84 | 2.29 | 20.82 |
| 19 | Douglas Rd Shell Bed | Kaawa Formation - Shelly & Carbonaceous Sandstones | Confined | Horticulture | 109.02 | N/A | 268.2 | 254-268 | 68 | 41.02 |
| 1 | Quintals Rd Bore 13 | Waitemata Group - Sandstones & Mudstones | Confined | Agricultural / Grazing | 12.82 | 0.21 | 129.6 | 94-129.6 (open hole) | 4.46 | 8.36 |
| 5 | Chenery Rd Production | Waitemata Group - Sandstones & Mudstones | Confined | Urban / Residential | 37.33 | 1.06 | 500 | 151-500 (open hole) | 35.8 | 1.53 |
| 6 | Waitakere Rd | Waitemata Group - Sandstones & Mudstones | Semi-Confined | Horticulture | 22.63 | 0.05 | 15.04 | 10-15.04 | 1.25 | 21.38 |
| 7 | Waitakere Rd # 2 | Waitemata Group - Sandstones & Mudstones | Confined | Horticulture | 33.18 | 0.32 | 150 | 78-150 (open hole) | 18.2 | 14.98 |
| 20 | Bullens Rd | Waitemata Group - Sandstones & Mudstones | Confined | Horticulture | 34.66 | N/A | 75 | 38.9-75 (open hole) | 12.8 | 21.86 |
| 21 | Burnsides Rd | Waitemata Group - Sandstones & Mudstones | Confined | Agricultural / Grazing | 30.52 | 1.46 | 169 | 154.2-169 (open hole) | 2.72 | 27.80 |
| 23 | Lambie Drive, Puhinui | Waitemata Group - Sandstones & Mudstones | Confined | Commercial | 18.66 | N/A | 200 | 60-200 (open hole) | -4.5 | 23.16 |
| 24 | Seagrove Rd Observation | Waitemata Group - Sandstones & Mudstones | Confined | Agricultural / Grazing | 28.18 | 0.49 | 201 | 97.8-201 (open hole) | 18.1 | 10.08 |
| 2 | Waiwera Thermal | Geothermal Waitemata Group - Sandstones & Mudstones | Confined | Commercial | 3.24 | 0.42 | 407 | 150-407 (open hole) | N/A | N/A |
| 3 | Aquatic Park, Parakai | Geothermal Waitemata Group - Sandstones & Mudstones | Confined | Commercial | N/A | 1.36 (tap) | N/A | N/A | N/A | N/A |

**Key:**

| | |
|---|---|
| BoH = bottom of hole | (masl) = metres above sea level |
| ToC = top of casing | (mbtoc) = metres below top of casing |
| N/A = Not available | (magl) = metres above ground level |

## Table 2: Groundwater Quality Data Summary – Auckland (Isthmus) Volcanics

Auckland Volcanics - Basalt, Scoria & Tuff

| Central Park Industrial Estate | | Count | % Results Censored | Median | IQR | MAD | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|
| General Field Parameters | Temperature (ºC) | 19 | 0 | 17.6 | 0.2 | 0.1 | 17.0 | 20.1 |
| | Dissolved oxygen (g.m$^{-3}$) | 15 | 0 | 4.30 | 2.89 | 1.74 | 1.92 | 6.77 |
| | Dissolved oxygen (% sat) | 15 | 0 | 45.1 | 30.1 | 18.2 | 20.3 | 70.8 |
| | Conductivity at 25ºC (µS.cm$^{-2}$) | 19 | 0 | 221 | 61.9 | 27.7 | 151 | 290 |
| General Lab Parameters | pH (pH unit) | 30 | 0 | 6.9 | 0.5 | 0.2 | 6.5 | 7.6 |
| | Turbidity (NTU) | 25 | 0 | 1.4 | 0.7 | 0.4 | 0.5 | 9.6 |
| | Suspended solid g.m$^{-3}$ | 26 | 19 | 0.5 | *0.5* | *0.3* | <0.5 | 6.6 |
| | Total dissolved solid g.m$^{-3}$ | 29 | 0 | 152 | 30 | 16 | 98 | 246 |
| Alkalinity | Total as CaCO3 g.m$^{-3}$ | 30 | 0 | 47.0 | 11.2 | 5.9 | 33.5 | 59.2 |
| | Bicarbonate g.m$^{-3}$ | 30 | 0 | 58.4 | 13.6 | 6.5 | 40.9 | 72.2 |
| | Carbonate g.m$^{-3}$ | 30 | 100 | *<1* | *ND* | *ND* | <1 | <1 |
| | Hydroxide g.m$^{-3}$ | 30 | 100 | *<1* | *ND* | *ND* | <1 | <1 |
| Hardness | Total as CaCO3 g.m$^{-3}$ | 29 | 0 | 66.5 | 9.7 | 5.0 | 41.6 | 81.0 |
| | Calcium as CaCO3 g.m$^{-3}$ | 29 | 0 | 30.0 | 5.5 | 3.3 | 19.0 | 37.0 |
| | Magnesium as CaCO3 g.m$^{-3}$ | 28 | 0 | 35.6 | 4.3 | 2.7 | 22.6 | 44.0 |
| Nutrients | Nitrate-N (tot.) g.m$^{-3}$ | 29 | 0 | 4.020 | 0.642 | 0.440 | 2.248 | 6.950 |
| | Nitrite-N (tot.) g.m$^{-3}$ | 26 | 100 | *<0.002* | *ND* | *ND* | <0.002 | 0.007 |
| | Nitrate/Nitrite g.m$^{-3}$ | 29 | 0 | 4.020 | 0.642 | 0.440 | 2.248 | 6.950 |
| | Ammoniacal-N (tot.) g.m$^{-3}$ | 17 | 100 | *<0.01* | *ND* | *ND* | <0.01 | 0.150 |
| | Phosphorous (tot.) g.m$^{-3}$ | 22 | 0 | 0.07 | 0.01 | 0.00 | 0.06 | 0.13 |
| | Phosphorous (diss.) g.m$^{-3}$ | 26 | 0 | 0.07 | 0.01 | 0.01 | <0.01 | 0.11 |
| | Phosphate (tot.) g.m$^{-3}$ | 0 | 100 | *ND* | *ND* | *ND* | ND | ND |
| Microbiology | Faecal Coliforms (cfu/100ml) | 1 | 0 | 190 | ND | ND | 190 | 190 |
| | Eschrichia Coli (cfu/100ml) | 1 | 0 | 190 | ND | ND | 190 | 190 |
| Silicate | Silica as SiO2 g.m$^{-3}$ | 29 | 0 | 18.0 | 1.4 | 0.7 | 15.2 | 21.3 |
| Major Cations & Anions | Calcium (tot.) g.m$^{-3}$ | 25 | 0 | 11.4 | 2.2 | 1.1 | 7.6 | 13.6 |
| | Calcium (diss.) g.m$^{-3}$ | 6 | 0 | 13.3 | 0.6 | 0.4 | 9.6 | 14.8 |
| | Magnesium (tot.) g.m$^{-3}$ | 24 | 0 | 8.6 | 1.4 | 0.7 | 5.5 | 10.5 |
| | Magnesium (diss.) g.m$^{-3}$ | 8 | 0 | 9.2 | 1.4 | 0.9 | 8.0 | 10.7 |
| | Sodium (tot.) g.m$^{-3}$ | 25 | 0 | 18.1 | 4.5 | 2.4 | 12.9 | 23.9 |
| | Sodium (diss.) g.m$^{-3}$ | 8 | 0 | 19.7 | 5.5 | 2.9 | 16.1 | 24.0 |
| | Potassium (tot.) g.m$^{-3}$ | 25 | 0 | 2.7 | 0.9 | 0.5 | 1.4 | 3.9 |
| | Potassium (diss.) g.m$^{-3}$ | 8 | 0 | 3.1 | 1.1 | 0.6 | 2.3 | 4.5 |
| | Chloride (tot.) g.m$^{-3}$ | 30 | 0 | 17.0 | 4.0 | 2.0 | 10.5 | 24.6 |
| | Sulphate (tot.) g.m$^{-3}$ | 30 | 0 | 24.0 | 6.8 | 3.5 | 14.3 | 34.7 |
| Minor Cations & Anions | Aluminium (diss.) g.m$^{-3}$ | 10 | 40 | 0.005 | 0.006 | 0.002 | <0.003 | ND |
| | Arsenic (tot.) g.m$^{-3}$ | 18 | 100 | *<0.0005* | *ND* | *ND* | <0.0005 | 0.0007 |
| | Arsenic (diss.) g.m$^{-3}$ | 6 | 100 | *<0.001* | *ND* | *ND* | <0.0005 | <0.001 |
| | Boron (tot.) g.m$^{-3}$ | 24 | 0 | 0.080 | 0.017 | 0.010 | 0.020 | 0.100 |
| | Boron (diss.) g.m$^{-3}$ | 5 | 0 | 0.090 | 0.014 | 0.008 | 0.074 | 0.098 |
| | Chromium (tot.) g.m$^{-3}$ | 13 | 100 | *<0.005* | *ND* | *ND* | <0.0005 | 0.008 |
| | Chromium (diss.) g.m$^{-3}$ | 8 | 25 | 0.0006 | 0.0003 | 0.0002 | <0.0005 | 0.001 |
| | Chromium (Hexavalent) g.m$^{-3}$ | 5 | 100 | *<0.001* | *ND* | *ND* | <0.001 | <0.001 |
| | Copper (tot.) g.m$^{-3}$ | 22 | 64 | 0.002 | 0.001 | 0 | ND | ND |
| | Copper (diss.) g.m$^{-3}$ | 6 | 0 | 0.002 | 0.001 | 0.001 | 0.001 | 0.004 |
| | Fluoride (tot.) g.m$^{-3}$ | 29 | 0 | 0.090 | 0.030 | 0.020 | 0.040 | 0.130 |
| | Iron (tot.) g.m$^{-3}$ | 28 | 0 | 0.169 | 0.154 | 0.062 | 0.080 | 1.250 |
| | Iron (diss.) g.m$^{-3}$ | 28 | 18 | 0.009 | 0.012 | 0.005 | <0.005 | 0.057 |
| | Lithium (tot.) g.m$^{-3}$ | 14 | 79 | *0.0005* | *0* | *0* | ND | 0.0010 |
| | Lithium (diss.) g.m$^{-3}$ | 5 | 0 | 0.0005 | 0.0001 | 0.0001 | 0.0004 | 0.0008 |
| | Manganese (tot.) g.m$^{-3}$ | 26 | 8 | 0.003 | 0.003 | 0.001 | <0.001 | 0.037 |
| | Manganese (diss.) g.m$^{-3}$ | 27 | 19 | 0.002 | 0.003 | 0.001 | <0.001 | 0.021 |
| | Nickel (tot.) g.m$^{-3}$ | 13 | 100 | *<0.005* | *ND* | *ND* | <0.0005 | 0.010 |
| | Nickel (diss.) g.m$^{-3}$ | 4 | 0 | 0.001 | 0.0001 | 0.0001 | 0.001 | 0.001 |
| | Lead (tot.) g.m$^{-3}$ | 16 | 100 | *<0.02* | *ND* | *ND* | <0.0001 | ND |
| | Lead (diss.) g.m$^{-3}$ | 6 | 100 | *<0.0001* | *ND* | *ND* | <0.0001 | <0.0001 |
| | Zinc (tot.) g.m$^{-3}$ | 22 | 0 | 0.015 | 0.003 | 0.002 | 0.009 | 0.044 |
| | Zinc (diss.) g.m$^{-3}$ | 4 | 0 | 0.021 | 0.002 | 0.001 | 0.009 | 0.032 |
| Ion Balance | Total Anion (mEquiv/L) | 30 | 0 | 2.0 | 0.5 | 0.2 | 1.4 | 2.7 |
| | Total Cation (mEquiv/L) | 30 | 0 | 2.1 | 0.4 | 0.2 | 1.5 | 2.6 |
| | Charge Bal. Error (% mEquiv/L) | 30 | 0 | 3.5 | 2.8 | 1.5 | 0.3 | 7.6 |

For an explanation of table formatting, see end of Table 7.