Sensitivity: General

Raglan Wastewater Consent

Groundwater Risks Assessment

Prepared for Watercare Services Ltd
Prepared by Beca Limited

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Contents

Appendices

Revision History

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Executive Summary

Watercare operates the Raglan Wastewater Treatment Plant (WWTP) on behalf Waikato District Council (WDC). In response to long-standing community and Whāingaroa hapū concerns regarding the curent discharge into Raglan Harbour, Watercare is propoing the discharge of MABR/MBR and UV treated wastewater to land through a coastal gully system located in Wainui Reserve. Whilst the discharge is primarily to a gully which is an overland flow path (OLFP), investigations have been undertaken (and presented here) to assess the potential for the treated wastewater to infiltrate into the ground and groundwater.

Site investigations include a deep fully cored borehole to identify the soil and rock profile in the elevated coastal cliffs; groundwater level monitoring in two purpose installed piezometers; hand augers with one off groundwater level measurements, in-situ permeability testing and double ring infiltrometers to assess the nature, extent and permeability of shallow soils, laboratory grain size analysis and geomorphic mapping. This information has been used to develop a conceptualised hydrogeological model of the gully, which was further validated with hydraulic modelling of surface flows.

The upper gully is characterised by wetland features, seepage zones, and other hydrological indicators of persistent surface and near-surface water retention that have developed on fine grained volcanic ash. The volcanic soils are of low permeability, restricting flow and infiltration; further confirmed by the lack of notable rainfall response in piezometers. The upper part of the gully is predominantly an overland flow path i.e. most rainfall leaves the system as run-off with limited soil infiltration occurring.

At the bottom of the gully, sand dunes overlap the lower permeability volcanic ashes. The permeability of field testing in the sands is higher, allowing for some increased rainfall infiltration compared to the rest of the gully, although there is also discharge from the deeper regional groundwater level resulting in a shallow groundwater surface in the sands.

Infiltration of treated wastewater within the upper and middle sections of the gully is unlikely due to the low permeability and shallow groundwater depth which promotes runoff rather than infiltration.

At the lower end of the gully, where it meets the sand dunes, infiltration potential is higher due to increased permeability of the sand. However, overall, the risk of potential impacts on groundwater is considered to be low, noting that the conceptual model described above indicates little infiltration to groundwater and surface hydraulic modelling suggests the flow conditions (water depth, velocity, erosive power etc) for the peak wastewater stream are not materially different to the current 100 yr ARI event.

Any infiltration which does occur in the sand dunes would ultimately report to the regional groundwater surface which discharges to the coast. There is some potential for increased or more visible flow across the beach, particularly during dry weather. Elsewhere, any increased seepage may not be readily distinguished from existing seepage or high flows after rainfall events

Quantitative groundwater monitoring is not considered necessary given the overall low potential for groundwater infiltration anywhere except the sand dunes. Regardless, some visual monitoring (mapping and / or drone imagery) is recommended to confirm the low risk profile presented here or to allow for an adaptive management plan to be implemented commensurate with any actual effects.

1 Introduction

1.1 Project Description

Watercare operates the Raglan Wastewater Treatment Plant (WWTP) on behalf Waikato District Council (WDC). The Raglan WWTP currently discharges treated wastewater via a marine outfall into the Raglan Harbour. Due to instances of non-compliances with its current consent, the Raglan WWTP is currently undergoing substantial upgrades to a Membrane Aerated Biofilm Reactor (MABR)/Membrane Bioreactor (MBR) treatment process which will be a step change in the level of treatment and provide a very high quality treated wastewater.

In response to long-standing community and Whāingaroa hapū concerns regarding the discharge into Raglan Harbour, investigations into alternative discharge environments have been undertaken over a number of years and a Best Practicable Option (BPO) has emerged. The BPO includes the discharge of MABR/MBR and UV treated wastewater to land through a coastal gully system located in Wainui Reserve, with contingency discharges discharging to the existing outfall in the Raglan Harbour..

Whilst the discharge is primarily to a gully which is an overland flow path (OLFP), there is some potential for the additional water volume in the gully to either result in direct surface erosion (addressed in the Hydraulic Assessment of Overland Flow Path Report, dated 16th April 2025), or, for the water to infiltrate into the ground. Should the latter occur, then this could result in increased seepage into the gully with potential implications for slope stability.

As part of the consenting process for this new discharge, Beca has been commissioned to conduct a groundwater risk assessment with a particular focus on the potential for discharged treated wastewater to infiltrate into the groundwater system. This assessment is designed to support the resource consent application and will focus on evaluating and where practical, avoiding, remediating or mitigating potential groundwater impacts.

1.2 Purpose and Scope of this Report

This report provides an assessment of the potential groundwater effects and risks associated with the discharge of wastewater to the gully. The key matters addressed at this report are as follows:

- Identifying and describing the existing geological and groundwater context of the Project area.
- Recommending measures to avoid, remedy or mitigate potential effects on groundwater where appropriate.
- Presenting an overall conclusion on the level of actual and potential groundwater effects of the Project after the recommended measures are implemented.

2 Project Site Overview

The proposed discharge site is into a gully located in Wainui Reserve, located at 316 Wainui Road, approximately 3 km southwest of Raglan (Figure 1).

Figure 1. Project site area.

The upper part of the site is currently in pasture, and slopes gently towards the gully area, which faces to the west and alternates steep with flat areas that drain to the coast.

Slip scarps and evidence of past instability have been noted on site and are discussed in more detail in Section 3.3.

Survey information available from LINZ for the site appears to be slightly inaccurate with contours not matching site features in some areas.

The site area is around 3.45Ha in area.

3 Geological Setting

3.1 Regional and Mapped Geology

The published geological map *(Waterhouse, B. C. and White, P. J., 1994)* for the area shows the site to be underlain by the Okete Volcanic Formation (Figure 2) comprising weathered volcanic material (olivine basalt lava, scoria and tuff) in the form of mud, silt, sand and gravel. This was observed on site overlain by more recent volcanic ash and tephra. Additionally, active dune sands have been mapped along the coastal margin, representing dynamic sedimentary processes that continue to shape the landscape.

The underlying strata transitions to the Karioi Volcanic Formation, characterized by basaltic andesite, tuff, and volcanic breccia. These formations reflect distinct volcanic events from a historically active period (Heron, 2020).

According to nearby borehole data and stratigraphic sequencing, the Okete Volcanic Formation is underlain by calcareous sandstone and sandy limestone of the Aotea Formation, followed by calcareous sandstone and siltstone of the Te Akatea Formation, both of which belong to the Te Kuti Group (Edbrooke, 2005). These formations are commonly exposed along the northern coastline of Raglan Harbour and less frequently along the Opotoru embayment coastline (Heron, 2020).

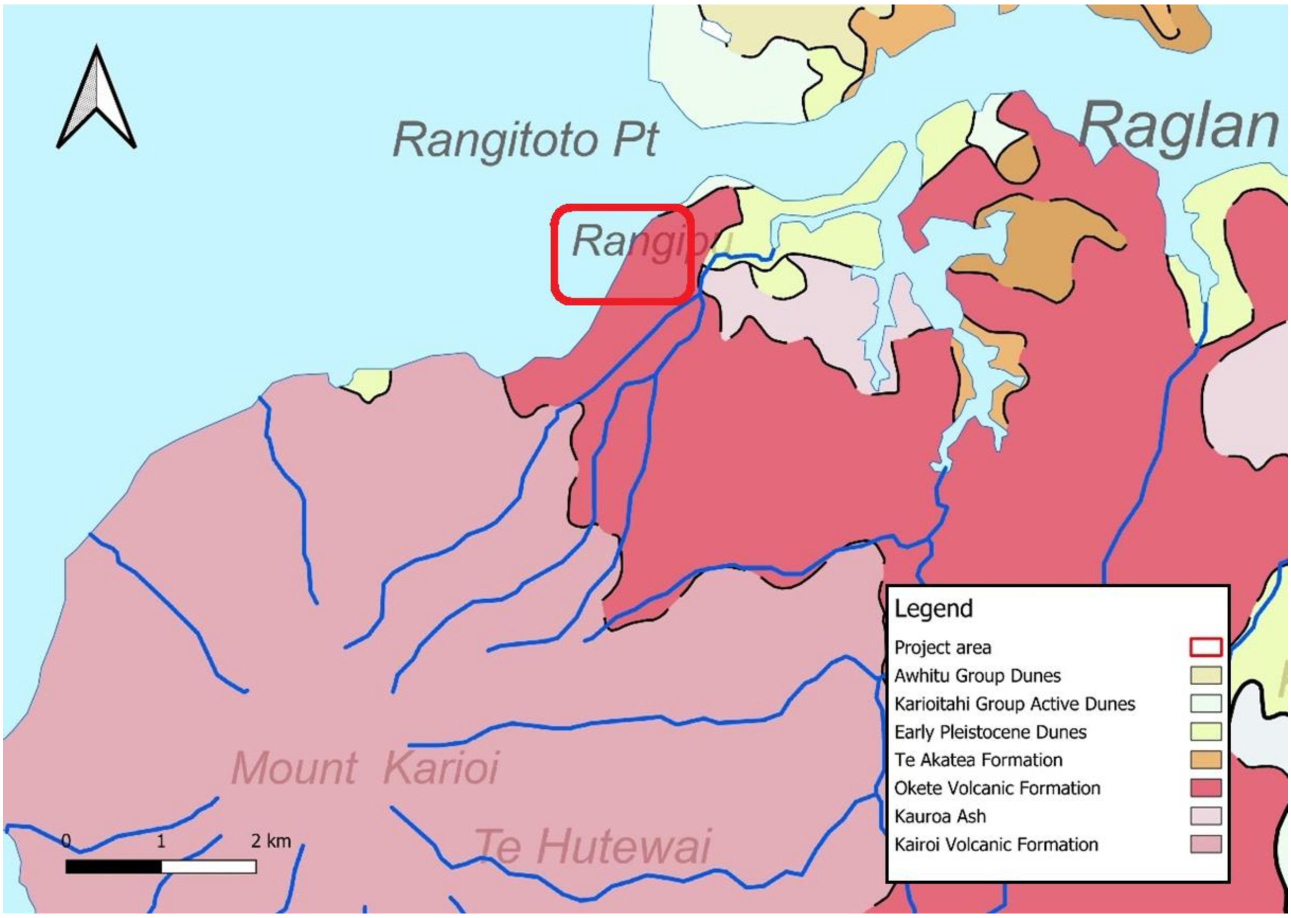

Figure 2 Published geology of the project area (Geological Map of New Zealand, 1:250,000 scale (GNS Science, 2020)).

3.2 Site Investigations

3.2.1 Initial Investigation (November 2024)

An initial phase of ground investigations was conducted between 11 to 15 November 2024 to characterise the ground and groundwater conditions. This phase included the drilling of two boreholes, one fully cored to a depth of 45 meters below ground level (bgl) for assessing the soil profile, and a wash-drilled borehole to 16.5 meters depth immediately adjacent. The boreholes were located at the top of the gully for installation of piezometers. Four hand augers were undertaken within the gully. Geological and geomorphological mapping was also conducted during this phase to further assess site conditions.

Seven soil samples were collected from the hand augers for grain size analysis (particle size distribution).

Falling head permeability tests were performed during drilling in borehole BH2, and were also attempted in the hand augers; however, only two of the falling head tests in the hand augers were successful, as the remaining holes collapsed during the test.

3.2.2 Secondary Investigations (March 2025)

A subsequent phase of investigations took place between 6 to 7 March 2025. The second phase of investigations was to allow for additional testing in the dune sands. This round consisted of six hand augers, four falling head permeability tests in the hand augers, and three double-ring infiltrometer tests to better assess the potential for incidental infiltration and seepage in the dune sands. Additionally, nine soil samples—both surface and subsurface—were collected for grain size analysis.

The geotechnical investigation locations are displayed on Figure 3 and in Appendix A and the investigation logs are included in Appendix B.

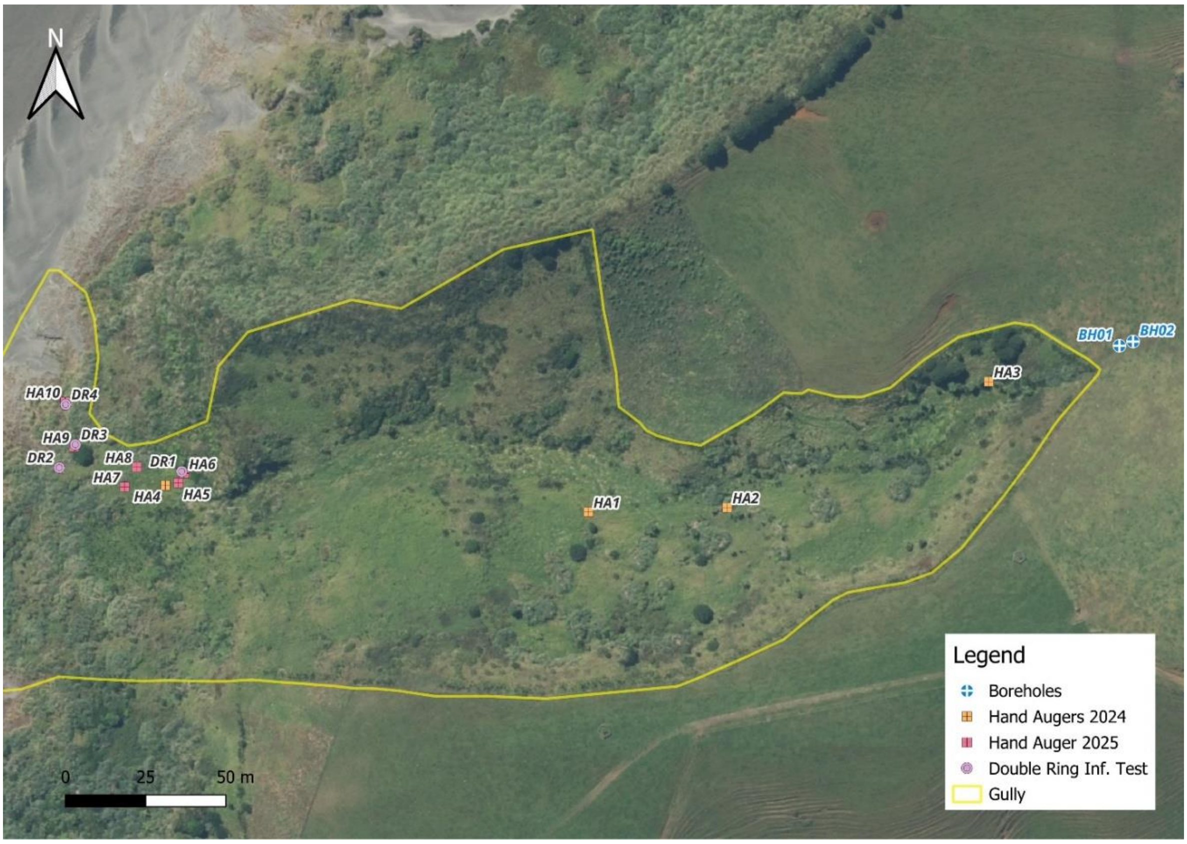

Figure 3. Location of the investigations.

3.3 Local Geology

Based on site investigations and the observations from the geological mapping, the project area consists of surface layers of silty and clayey ashes from the Kauroa Formation (ash), underlain by alternating deposits of clayey silt and fine to medium sand with a fine matrix, characteristic of the Karioi Formation.

Borehole log data has been combined with the site mapping to develop a conceptual cross section of the gully (Figure 4, next page). The gully contains a sequence of volcanic ash deposits (pink in Figure 4), ranging from silty clays to silty fine sands. In its lower section near the shoreline, these deposits are overlain by a dune system (yellow on Figure 4) composed of fine sands with a silty matrix. Additionally, windblown sands (very thin green layer on Figure 4 section) are present along the valley slopes in the middle section, contributing to variability in sediment composition of the gully.

Distinct breccia layers (gravelly, brown in Figure 4 section) were encountered in the borehole from 19.4-21.3 mRL and from 5.0-9.0 mRL. The upper layer correlates with similar geology exposed in the gully, and seepage at the gully exposure correlates to the groundwater level recorded in the deepest piezometer (BH01). This is inferred to be representative of deeper regional groundwater flow towards the coast.

The soils in the middle and upper sections were logged as predominantly “fines” (i.e. silt and clay sized particles) likely to be of low permeability, which restricts infiltration. This conclusion is supported by permeability tests conducted in hand auger bores HA02 and HA03, and presence of wetland features identified in site mapping (Figure 4.

Along the gully, flat boggy areas were observed, transitioning into densely vegetated zones where surface water was not visibly present but could be inferred. Seepage zones were predominantly identified downslope, particularly after each terrace, where an ephemeral stream displayed both flowing and stagnant water. The highest seepage volumes occurred in the lower sections, whereas in the upper areas, water tended to accumulate, forming ponded zones due to the limited drainage capacity of the soil.

These observations indicate minimal infiltration, with water percolating briefly before resurfacing, likely controlled by an underlying lower-permeability stratums that restricts deeper infiltration and sustains surface saturation.

The near surface groundwater level in HA03 correlates to the shallow seepage mapped on Figure 4 and also to the groundwater level recorded in the shallow piezometer (BH02) at the top of the gully, and is inferred to be a perched groundwater level.

Recent shallow slip scarps were observed on the southern slope of the gully, indicating minor slumping and sloughing of the shallow layers. Additionally, hummocky ground was mapped in this area. To the west of the gully, a distinct linear scarp was identified, accompanied by significant groundwater seepage.

At the terminal section of the gully, where the sand dunes deposits overlie the volcanic substrates, scour zones were present, suggesting naturally occurring active erosional processes that contribute to the formation of a preferential flow path.

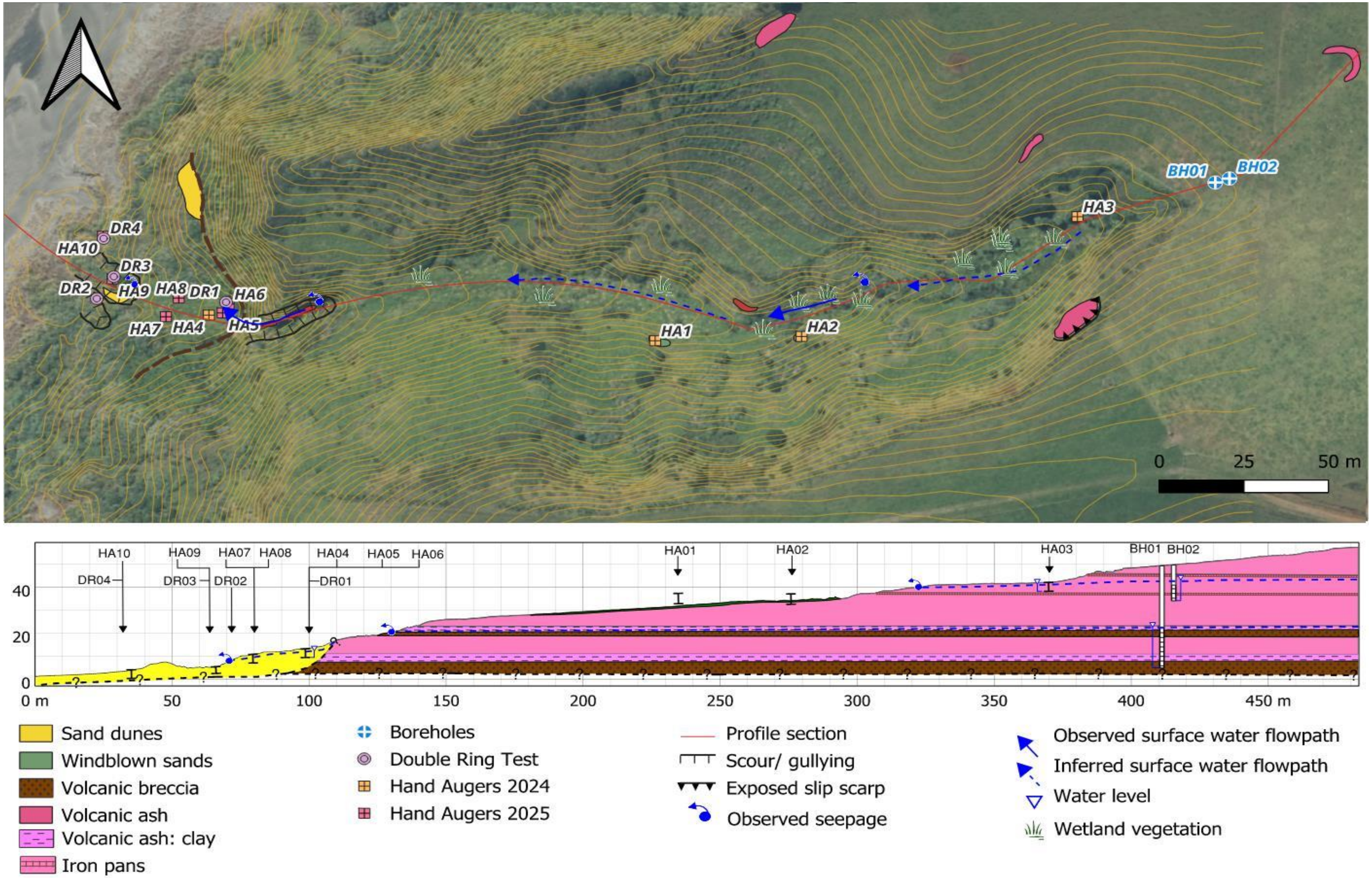

Figure 4. Geological – geomorphological map and cross-section..

4 Hydrogeology Setting

4.1 Regional Hydrogeology

The volcanic deposits of basalt and scoria within the Okete and Karioi Volcanic Formations are recognized aquifers in the region. Most regional studies focus on deeper groundwater; there is much less published information on the shallower layers such as those expected in the gully. Generally groundwater is considered to flow radially from the summit of Mount Kariori, but at this site would expect flow to be discharging to the west-north-west towards the coast.

4.2 Groundwater levels

The two boreholes were completed as piezometers, with BH01 targeting the deeper (regional) groundwater level and BH02 targeting shallower soil layers to confirm if there are perched groundwater levels in the elevated coastline. Both were equipped with a level logger to continuously monitor groundwater data. Measurements were recorded from 29 November 2024 to 6 March 2025, with manual readings taken on 28 November 2024, 17 January 2025, and 6 March 2025.

The level logger in BH01 malfunctioned and ceased recording on 6 December 2024. It was replaced on 16 January 2025, resulting in a gap in the data for this particular piezometer:

Water levels and rainfall data is summarized in Figure 5.

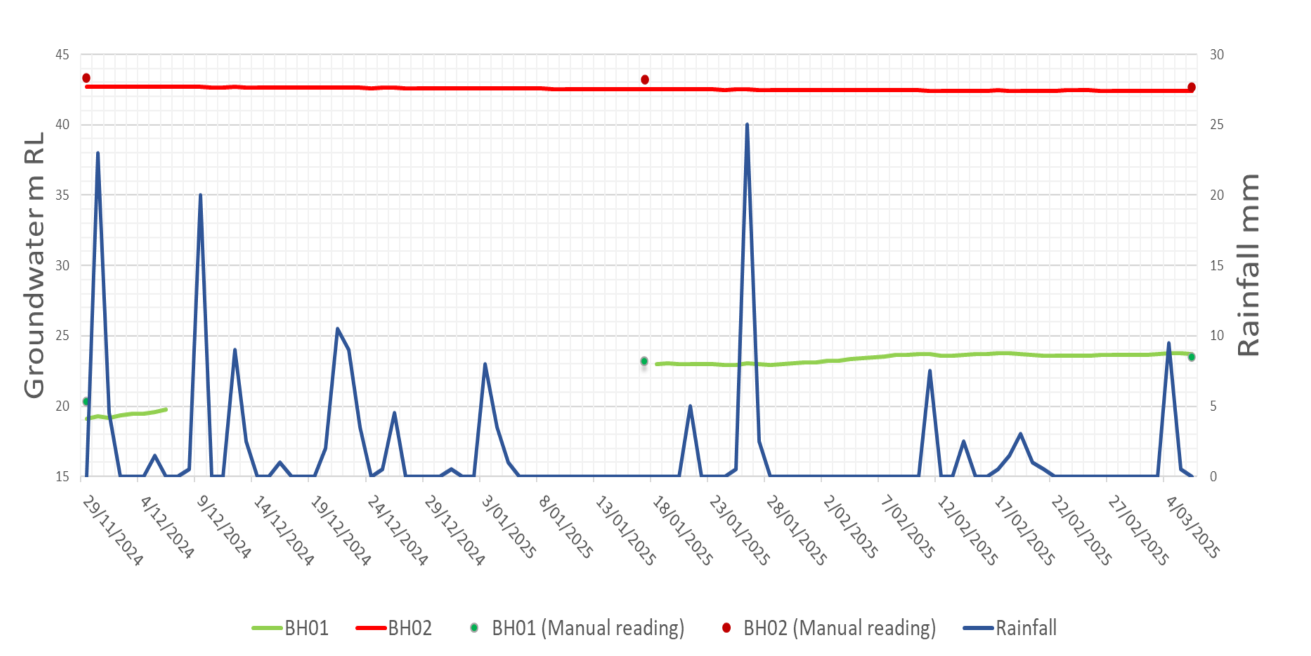

Figure 5. Water levels in piezometers BH01 and BH02 with rainfall for the same period of time.

Groundwater was also encountered at shallow depths in most, but not all hand augers:

Table 1. Depth to groundwater in the investigations.

Hand auger	Groundwater depth (m BGL)
HA1	Not encountered
HA2	Not encountered
HA3	0.3
HA4	0.2

Hand auger	Groundwater depth (m BGL)
HA5	0.2
HA6	0.2
HA7	1.4
HA8	0.5
HA9	1.0
HA10	Not encountered

Based on the data from a brief monitoring period, observations from the piezometers installed at the upper margin of the gully reveal the presence of two distinct groundwater tables: a deeper regional groundwater level at 24 mRL and a shallower perched groundwater level at 43 mRL.

Groundwater was detected at relatively shallow depths in most hand-augered boreholes, with the exception of HA1, which was drilled on the gully slope, HA2, positioned at the midsection of the gully, and HA10, located beyond the gully at its boundary with the beach. As shown on Figure 4, when plotted on a cross section, the one-off measured groundwater levels in hand augers in the upper gully do correlate to the perched level in BH02, and one-off measured groundwater levels in HA04 in the lower gully, as well as mapped seepage correlate to the deeper regional groundwater level in BH01,

Moreover, as shown in the graphs, rainfall events do not appear to have an immediate impact on groundwater levels, suggesting a delayed or limited response of the aquifer system to precipitation. This is consistent with the observation of high “fines” content and the expected low permeability of the soils i.e. most rainfall runs off the surface rather than infiltrating in any significant quantum.

The gully's geological structure consists of a stratified sequence of volcanic ash deposits, incorporating materials ranging from silty clays to silty fine sands, all exhibiting low permeability. This geological composition facilitates the development of waterlogged zones where the groundwater table remains near the surface, and what limited quick flow which does occur then emerges at locations where the phreatic level intersects the topography (refer to Figure 4).

4.3 Particle Size Distribution Analysis

Soil samples across the sites taken at shallow depths, between the surface and down to 1.5 m were sent to the laboratory for particle size distribution analyses:

Table 2. Samples analysed for particle size distribution.

Sample	Investigation	Depth (m BGL)	Date taken	Lithology
1	HA2	0.5	14/11/2024	Silty SAND
2		1.5	14/11/2024	Silty SAND
3	HA3	0.0	14/11/2024	Clayey SILT
4		0.5	14/11/2024	Clayey SILT
5		1.0	14/11/2024	Clayey SILT
6	HA4	0.0	14/11/2024	Silty SAND
7		0.75	14/11/2024	Silty SAND
8	HA5	0.5	05/03/2025	Clayey SILT
9	DR1	Surface	05/03/2025	Clayey SILT
10	HA6	0.5	05/03/2025	Clayey SILT
11	HA7	0.2	05/03/2025	Clayey SILT

Sample	Investigation	Depth (m BGL)	Date taken	Lithology
12		1	05/03/2025	Clayey SILT
13	HA8	0.5	05/03/2025	Silty SAND
14		1.2	05/03/2025	Silty SAND
15	DR2	Surface	06/03/2025	Silty SAND
16	HA10	Surface	06/03/2025	SAND

The laboratory particle size distribution reports are attached as Appendix C. The particle size distribution curves are shown in Figure 6.

According to the Wentworth (1922) grain size classification chart, the grain size distribution curves indicate that the soil is predominantly **silty fine sand**, while samples HA3 (0.5–1.0) and HA3 (1.0–1.5) consist of **clayey silt.**

The "fines" component—defined as particles smaller than 0.06 mm, including silt and clay—ranges from 2% in the HA10 sample to as much as 70% in samples HA3 (0.5–1.0) and HA3 (1.0–1.5). On average, fines make up approximately 15% of the other samples. Based on our experience and testing on aggregates, an increase in the fine component from 5% to 10% even in a soil otherwise described as a sand can significantly reduce soil permeability.

4.4 Estimation of Permeability based on PSD Analysis

The estimation of soil permeability using analytical methods is made possible by determining specific granulometric diameters, particularly d10 and d20. Two widely recognized approaches are the Hazen Method (1911), which uses the finer d10 diameter and a coefficient based on grain uniformity, and the Kasenow Method (2002), which relies on the less restrictive d20 diameter.

The permeability estimations are shown in Table 3. The methodology of both methods can be found in Appendix D.

It is noted that grain size correlations such as these have limitations for estimating permeability, especially in fine-grained soils or for sands with a long 'fines tail" (i.e. high proportion of silts and clays which as noted above will significantly influence hydraulic behaviour. Factors like density changes, void ratio variations, and clay content affect permeability in ways that grain size alone cannot capture. While these correlations work well for coarse-grained materials, they often fail to account for the complex interactions in fine particles, leading to inaccurate assessments.

Since permeability depends on more than just particle size, relying solely on grain size correlations can be misleading. Fine-grained soils have unique properties that influence water movement, which standard analyses may not reflect.

Field testing provides more accurate results by measuring permeability under natural conditions, ensuring reliable data for engineering applications. Both types of testing are provided below for wider comparison.

More generally, when comparing the PSD curves to the permeability estimations it can be seen that the finest of the samples (HA05 0.5-0.6m, DR1 0-0.1 m, HA07 1.0-1.1 and HA03 0-0.5m) do yield the lowest permeability values (10^{-6} to 10^{-9} m/s); however, the remaining values are high (typically 10-5 m/s) for soils with 5 -10 % fines. Additionally, even between Hazen and Kasenow there can be large variability for the same soil highlighting the importance of the factors identified above.

Class	1	2	3	4	5	6	7	8	9	10	11	12
K (cm / seg)	3	0,7	0,1	0,05	$9 \cdot 10^{-3}$	$5 \cdot 10^{-3}$	$2 \cdot 10^{-3}$	$7 \cdot 10^{-4}$	$7 \cdot 10^{-5}$	$1 \cdot 10^{-5}$	$< 1 \cdot 10^{-5}$	$<< 1 \cdot 10^{-5}$
K (m / day)	2.600	600	86	43	8	4,3	1,7	0,6	0,06	0,008	< 0,008	<< 0,008

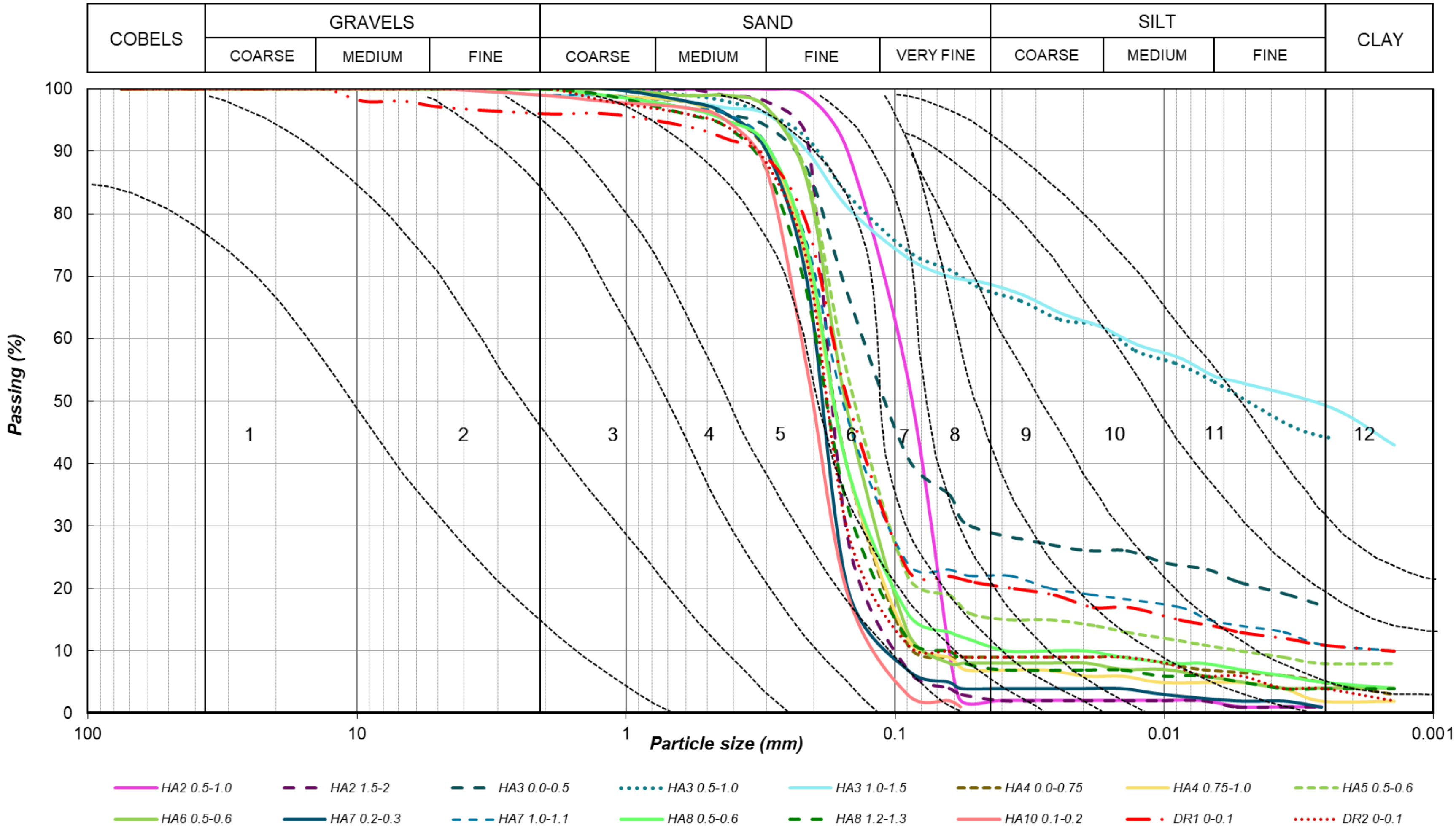

Figure 6. Particle size distribution curves.

Table 3. Permeability estimations based on Kasenow and Hazen

PERMEABILITY ESTIMATION					
ID	Depth (m)	Kasenow (d20)		Hazen (d10 – d60)	
		K (m/day)	K (m/s)	K (m/day)	K (m/s)
HA2	0.5-1.0	3	4 x 10^{-5}	6 x 10^{-1}	7 x 10^{-6}
HA2	1.5-2	90	1 x 10^{-4}	3	4 x 10^{-5}
HA3	0.0-0.5	4 x 10^{-4}	5 x 10^{-9}	2 x 10^{-1}	2 x 10^{-6}
HA3	0.5-1.0	-	-	-	-
HA3	1.0-1.5	-	-	-	-
HA4	0.0-0.75	6	7 x 10^{-5}	2	2 x 10^{-5}
HA4	0.75-1.0	6	6 x 10^{-5}	2	2 x 10^{-5}
HA4	0.0-0.75	6	7 x 10^{-5}	2	2 x 10^{-5}
HA4	0.75-1.0	6	6 x 10^{-5}	2	2 x 10^{-5}
HA5	0.5-0.6	9 x 10^{-3}	1. x 10^{-7}	5 x 10^{-1}	6 x 10^{-6}
DR1	0-0.1	7 x 10^{-4}	8 x 10^{-9}	1 x 10^{-1}	2 x 10^{-6}
HA6	0.5-0.6	6	6 x 10^{-5}	2	3 x 10^{-5}
HA7	0.2-0.3	9	1 x 10^{-4}	4	5 x 10^{-5}
HA7	1.0-1.1	7 x 10^{-4}	8 x 10^{-9}	7 x 10^{-2}	9 x 10^{-7}
HA8	0.5-0.6	1	1 x 10^{-5}	2	2 x 10^{-5}
HA8	1.2-1.3	3	3 x 10^{-5}	2	3 x 10^{-5}
DR2	0-0.1	3	3 x 10^{-5}	2	3 x 10^{-5}
HA10	0.1-0.2	10	1 x 10^{-4}	5	5 x 10^{-5}

4.5 Permeability Testing

The field permeability analyses were undertaken to provide an understanding of the capacity of the soils within the gully to accept and transmit the treated wastewater discharge. A total of eleven hydraulic tests were conducted: two falling head tests in BH02 during drilling, eight falling head test in hand augers, and four double ring infiltrometer tests.

For the falling head test, the static water level was recorded when encountered and then a volume of water was added to the hand augers or borehole. After adding a volume of water, water levels were recorded manually or with a level logger until the water level had fully recovered, or until there was no recovery. Results from the falling head tests are presented in Appendix E.

The initial rapid water level loss is driven by the hydraulic conductivity of dry soil. Initially, water infiltrates the soil rapidly due to capillary action and the presence of large macropores, which allow quick movement, as well as the large driving head. As saturation increases and the head decreases, the infiltration rate stabilizes, dictated by the soil's hydraulic conductivity and intrinsic permeability. The later time loss rate data is therefore considered more suitable for assessing the permeability of the soils and is presented in Table.

It can be seen generally that when compared to the PSD analysis the permeabilities are typically 1-2 orders of magnitude smaller (as expected noting the previous commentary), and in our view more representative of in-situ (mass) flow conditions. The high values reported for BH02 are from tests during drilling, not in the completed piezometer and were undertaken above the water table; it is possible that the high values are indicating loss of flow around the casing / poor casing seal, rather than genuine loss into the ground.

Table 4. Estimation of the conductivity from the falling head tests.

ID	Depth tested (mBGL)	Lithology	Depth to Groundwater (m)	Hydraulic Conductivity (m/d)	Hydraulic Conductivity (m/s)
BH02	0-1.0	Clayey SILT	**Not encountered**	3.49	4×10^{-5}
BH02	4.0-5.0	Silty CLAY	**Not encountered**	1.40	2×10^{-5}
HA1	0-3.0	SAND/ SILT	**Not encountered**	**Non conclusive**	**Non conclusive***
HA2	0-2.0	Silty SAND	**Not encountered**	0.04	5×10^{-7}
HA3	0-1.8	Clayey SILT	0.3	0.08	1×10^{-6}
HA4	0-2.0	Silty SAND	0.2	**Non conclusive**	**Non conclusive***
HA6	0-1.5	Clayey SILT	0.2	0.07	8×10^{-7}
HA7	0-1.5	Clayey SILT	1.4	0.07	9×10^{-7}
HA8	0-1.5	Silty SAND	0.5	0.36	4×10^{-6}
HA9	0-1.5	Silty SAND	1.0	0.11	1×10^{-6}

* HA01 and HA04 hole collapsed during test.

The double ring infiltrometer (DRI) test directly measures the vertical infiltration rate of a site. DRI tests were conducted in small (15 cm inner, 30 cm outer) rings; these were chosen given the lack of accessibility for bringing in the larger volumes of water that would be required to support testing in larger diameter rings. Prior to installing the double ring apparatus, each site was prepared by removing overburden. The rings were driven into the ground until a good seal was achieved. The rings were embedded 5 cm into the ground.

The test comprises partially filling the inner and outer rings with water to approximately the top and maintaining the water at a constant level by topping the water back up at specific time intervals of 2.5 or 5 minutes, depending on the conditions. At each interval, the decrease in water level within both rings was measured and recorded, tracking any variations. This procedure continued until a stabilized rate of decline was observed across at least five consecutive readings or for a minimum duration of one hour. Table 5 provides a summary of the DRI raw test results, and the test analyses are presented in Appendix F.

Table 5. DRI field results.

Test	Test depth (m BGL)	Raw Field Infiltration Rate (mm/h)	Raw Field Infiltration Rate (m/s)	Lithology
DR1	0.1	1	2×10^{-7}	Clayey SILT
DR2	0.2	54	2×10^{-5}	Silty SAND
DR3	0.1	108	3×10^{-5}	Silty SAND
DR4	0.25	804	2×10^{-4}	SAND

While the DRI tests approached a steady-state condition, they did not fully reach it. As a result, the findings may not accurately reflect long-term saturated conditions i.e. current field rates may be an overestimation.

It is important to note that the different test methods are not directly comparable. The DRI measures vertical infiltration rate, while the falling head tests in hand augers provides an indication of horizontal hydraulic conductivity. Both of these methods test bulk / mass behaviour albeit on a smaller scale then a pumping test, whilst the grain size correlations provide an even smaller scale test that will not account for heterogeneity or anisotropy in the soil layers. However, when considered together, they provide collective insight into the likely hydraulic behaviour of a site (further discussed in the next section).

5 Hydrogeological Conceptualisation

The hydrogeological condition of the ground conditions in and around the gully has been conceptualised based on the site investigation data and interpreted results.

The project area is shaped by a sequence of volcanic ash deposits, consisting of materials that range from silty clays to fine silty sands. In its lower section near the shoreline, these deposits are topped by a dune system composed of fine sands within a silty matrix. Additionally, windblown sands along the valley slopes in the middle section contribute to variations in sediment composition and surface stability throughout the gully.

Within the upper gully:

- Site mapping identified wetland features, seepage zones, and other hydrological indicators of persistent surface and near-surface water retention.
- This is consistent with the laboratory grain size analysis and field permeability tests, which show that the soils in the upper and middle section of the gully have a very low permeability, restricting flow and infiltration.
- Shallow water levels were also encountered in the hand augers in the area, which are perched relative to the deeper groundwater level.
- The shallow perched groundwater levels, in combination with the low permeability and lack of notable rainfall infiltration in the piezometer explain the presence of wetland features i.e. most rainfall leaves the system as run-off not infiltration.

At the bottom of the gully, where it meets the sand dunes:

- The permeability from field testing is notably higher consistent with the presence of coarser, more porous materials in this area.
- This allows for increased rainfall infiltration compared to the rest of the gully, as well as discharge from the deeper regional groundwater level resulting in a shallow groundwater surface in the sands.

The above hydrogeological conceptualization is also supported by the hydraulic modelling undertaken for the assessment of hydraulic impacts on the existing OLFP in the gully. Specifically, baseline hydraulic modelling indicates shallow water ponding and low flow velocities in the areas mapped as “wetlands” on Figure 4. Conversely, the hydraulic modelling indicates higher flow velocities in the areas mapped as having visible surface flow on Figure 4.

6 Assessment of Potential Effects on Groundwater

Site specific testing and the conceptual model presented above suggests that infiltration of treated wastewater is unlikely to occur in the upper gully, due to the predominance of silts and clays, as well as shallow groundwater levels. Consequently, the majority of the discharged flow is expected to remain at or near the surface, promoting surface runoff rather than facilitating percolation into deeper geological layers. This is consistent with the hydraulic modelling outlined in the Hydraulic Assessment of Overland Flow Path.

The potential for infiltration of treated wastewater is slightly greater in the lower parts of the gully due to the presence of coarser grained sands, albeit that the overall likelihood / volume remains low given that this area has shallow groundwater levels (i.e., the ground is already nearly fully saturated and so would not be expected to absorb much additional volume).

The potential for effects on the existing OLFP / surface water flows, as well as erosional risk are outlined in that same report the Hydraulic Assessment of Overland Flow Path. The gully will be replanted with wetland species (raupo) to buffer and slow flows through the gully system.

In the event that some infiltration does occur in the lower gully area, infiltrated water may re-emerge in the lowest sections of the gully or as a visible flow path across the beach (in dry weather). As the hydraulic modelling indicates that the flow characteristics of the peak wastewater flow is not materially different to the current 100 yr ARI rain event, the risk that discharge would exacerbate existing internal erosion / localized instability of the dunes is considered low, and regardless overall stability of the cliffs is not expected to be impacted.

Any treated wastewater which does infiltrate, will ultimately be discharged at the coast, i.e. no freshwater receptors or groundwater users.

Overall, any potential effects on groundwater are expected to be low.

7 Recommendations for Monitoring

Given the overall low impact on groundwater levels, specific quantitative groundwater monitoring is not considered to be of value for ongoing residual risk assessment or decision making.

The Hydraulic Assessment of Overland Flow Path has recommended a gully monitoring regime, with annual monitoring for the first couple of years to confirm that discharge has not exacerbated erosion, or to trigger implementation of appropriate remedial or mitigation measures if it does.

This would be a pragmatic approach to assessing the residual groundwater risk also e.g. mapping of seepage features to confirm they are not new, exacerbated or resulting in localised erosion. This could be done as a manual mapping exercise (for seepage features), supported by high resolution drone imagery to allow a direct comparison over time.

This would allow an adaptive management approach to be implemented with remedial or mitigation measures that are directly proportionate to any actual effects that occurs.

8 Summary

The project site is located in a west-facing gully, characterized by alternating steep and flat areas that drains as an overland flow path (OLFP) toward the coast.

Site specific testing, laboratory testing and geological mapping have been used to conceptualize the hydrogeology of the gully site, which correlates well to hydraulic modeling of surface water flow conditions which form the OLFP. The gully is comprised of predominantly fine grained materials, with associated low infiltration rates that have promoted development of wetlands within the upper gully. Coarser grained, higher permeability sands are located closer to beach level.

Infiltration within the upper and middle sections of the gully is unlikely due to the low permeability and shallow groundwater depth. At the lower end of the gully, where it meets the sand dunes, infiltration potential is higher due to increased permeability of the sand.

Overall, the risk of potential impacts on groundwater is considered to be low, noting that the conceptual model described above indicates little infiltration to groundwater and surface hydraulic modelling suggests the flow conditions (water depth, velocity, erosive power etc) for the peak wastewater stream are not materially different to the current 100 yr ARI event. Any infiltration which does occur would ultimately discharge to the coast and so there is some potential for increased / visible flow across the beach during dry weather.

Regardless, some visual monitoring (mapping and / or drone imagery) is recommended to confirm the low risk profile presented here or to allow for an adaptive management plan to be implemented commensurate with any actual effects.

9 Applicability Statement

This report has been prepared by Beca Group Limited (**Beca**) on the specific instructions of Watercare Services Limited (**Client**). It is solely for our Client's use for the purpose for which it is intended in accordance with the agreed scope of work. Any use or reliance by any person contrary to the above, to which Beca has not given its prior written consent, is at that person's own risk.

Should you be in any doubt as to the applicability of this report and/or its recommendations for the proposed development as described herein, and/or encounter materials on site that differ from those described herein, it is essential that you discuss these issues with the authors before proceeding with any work based on this document.

This report should be read in full, having regard to all stated assumptions, limitations and disclaimers. No part of this report shall be taken out of context and, to the maximum extent permitted by law, no responsibility is accepted by Beca for the use of any part of this report in any context, or for any purpose, other than that stated herein

10 References

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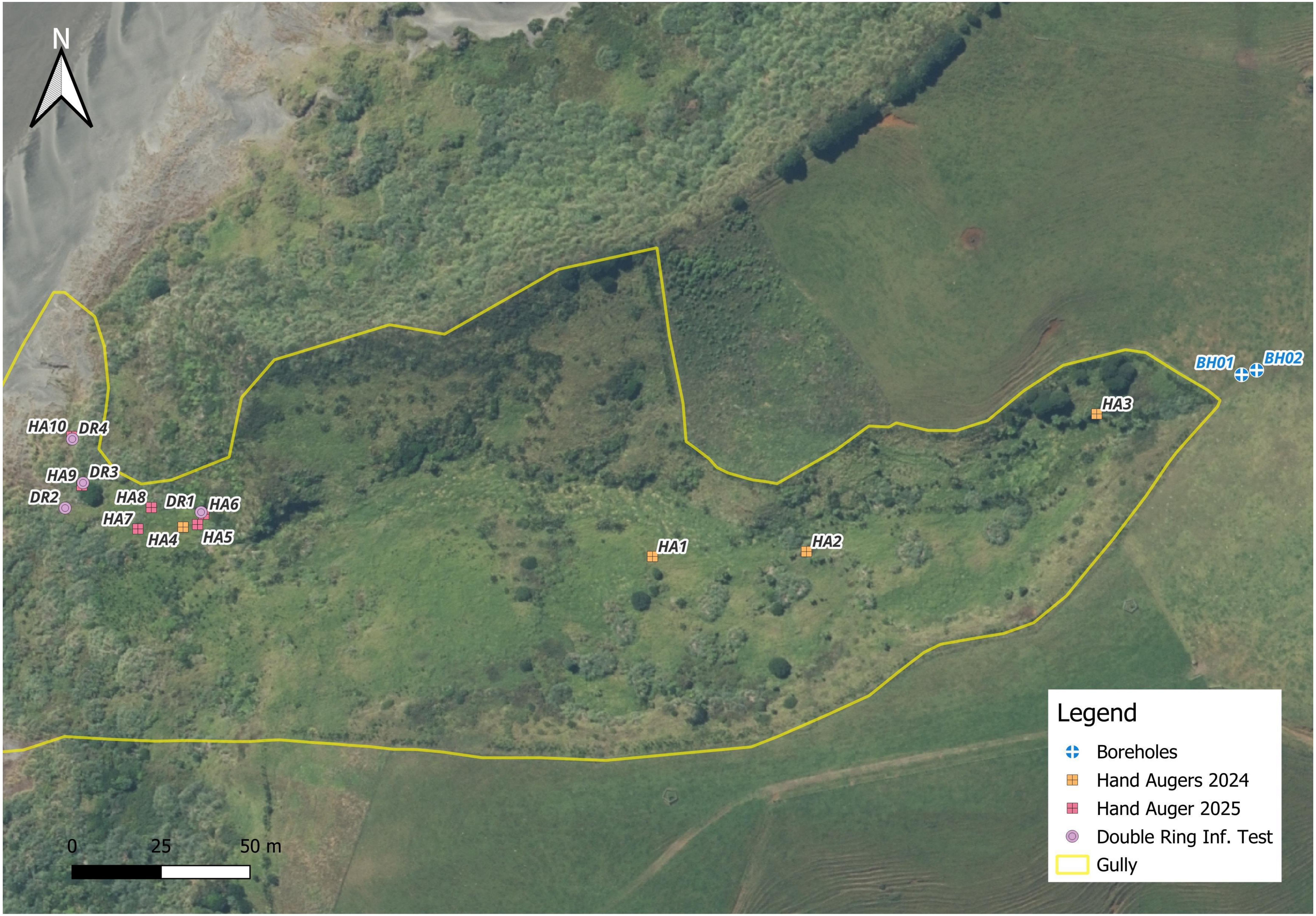
A

Appendix A – Investigation locations site plan



N
BH01
BH02
HA3
HA10
DR4
HA9
DR3
DR2
HA8
DR1
HA6
HA7
HA4
HA5
HA1
HA2
0
25
50 m
Legend
Boreholes
Hand Augers 2024
Hand Auger 2025
Double Ring Inf. Test
Gully

B

Appendix B – Investigations Logs

Beca — Geotechnical Log Key Sheet

SOIL AND ROCK DESCRIPTIONS

Soil and Rock Descriptions are in general accordance with the NZ Geotechnical Society (NZGS), 2005.
Hand-held Vane Shear Strength measurements are in general accordance with the NZGS, 2001.

METHODS

BH	Machine Borehole
CPT	Cone Penetration Test
DCP	Dynamic Cone Penetration
HA	Hand Auger
SPT	Standard Penetration Test
IVAN	In-situ Vane Test
MA	Machine Auger
OB	Open Barrel
SNC	Sonic Core Drilling
TP	Test Pit/Trench
TT	Triple Tube
PT	Thin-walled Open Drive Tube
VE	Vacuum Excavation
W	Wash Boring

WEATHERING

CW	Completely Weathered
HW	Highly Weathered
MW	Moderately Weathered
SW	Slightly Weathered
UW	Unweathered

SAMPLES

B	Bulk Disturbed Sample
C	Core Sample
D	Small Disturbed Sample
U	Thin-wall Open Drive (Push) Tube Sample

WATER

▼ Groundwater Level (GWL)

IN-SITU TESTS

Shear Vane

Su	In-situ peak undrained shear strength and remoulded undrained shear strength
UTP	Unable to Penetrate
CB	Pilcon-type vane tested in Core Barrel
DH	Pilcon-type vane tested in-situ (downhole)
GV	Geonor vane, tested in-situ
IcV	Icone vane, tested in-situ

Standard Penetration Test (SPT)

N	SPTn Sampler (Split-spoon)
Nc	SPTn Solid Cone
HB	SPT Hammer Bouncing

TERMINOLOGY

RL	Reduced Level
RQD	Rock Quality Designation

GRAPHIC LOG (1 or a combination of the following)

Clay	Silt	Sandstone (SST)	Conglomerate	Fine Igneous
Gravel	Sand	Siltstone (ZST)	Limestone	Coarse Igneous
Shells	Organic Material	Mudstone	Foliated Metamorphic	Ignimbrite
Cobbles / Boulders	Wood	Interbedded SST & ZST	Asphalt	No Core

MONITORING INSTALLATION

Backfill Material

Sand	Grout	Bentonite
Gravel	Cement Mixes	

Standpipe

Plain

Slotted

Vibrating Wire

ORGANIC SOILS

Von Post Degree of Humification

H1	Completely unconverted and mud-free peat, when pressed gives clear water and plant structure is visible.
H2	Partially unconverted and mud-free peat, when pressed gives almost clear water and plant structure is visible.
H3	Very slightly decomposed or very slightly muddy peat, when pressed gives marked muddy water, no peat substance passes through the fingers and plant structure is less visible.
H4	Slightly decomposed or slightly muddy peat, when pressed gives muddy water and plant structure is less visible.
H5	Moderately decomposed or very muddy peat with growth structure evident but slightly obliterated.
H6	Moderately decomposed or very muddy peat with indistinct growth structure.
H7	Fairly well decomposed or very muddy peat but the growth structure can just be seen.
H8	Well decomposed or very muddy peat with very indistinct growth structure.
H9	Practically decomposed or mud-like peat in which almost no growth structure is evident.
H10	Completely decomposed or mud peat where no growth structure can be seen, entire substance passes through the fingers when pressed.

Machine Borehole Log

Project:	Raglan Wastewater Consent	**Project number:**	4703642
Site location:	316 Wainui Rd. Raglan.	**Client:**	Watercare Waikato

Location:	Paddock above gully and 200m south of trig point.	**Coordinate system:**	NZTM2000	**Vertical datum:**	NZVD 2016
		Northing:	5813570.6	**Ground level (mRL):**	50.00
		Easting:	1761706.6	**Location method:**	Waikato RC GIS

Column headings: Installations | Drilling (GWL, Fluid Return, Recovery, Method, Casing, RQD) | In Situ Tests (Su (kPa), SPT) | Samples | Depth (m) | RL (m) | Graphic Log | Soil/ Rock Description | Geological Unit

Depth (m)	RL (m)	Soil/ Rock Description	Geological Unit
0.0 – 0.6	50.0 – 49.4	Firm, clayey organic SILT, some fine to medium sand, trace fine gravel; dark brownish grey; dry, high plasticity. Organics: Fibrous. Gravel, sub-angular to subrounded, moderately weathered, pumice. [Topsoil]	Kauroa Ash Formation
0.6 – 3.0	49.4 – 47.0	Stiff, clayey SILT, some fine sand, trace fine gravel; dark reddish brown; moist, high plasticity. Sand: sub-angular. Gravel, sub-angular to subrounded, moderately weathered pumice. [Volcanic Ash]	Kauroa Ash Formation
3.0 – 5.35	47.0 – 44.65	Firm, silty CLAY, minor fine sand; light brown; moist, high plasticity.	Kauroa Ash Formation
5.35 – 7.5	44.65 – 42.5	Very stiff, fine sandy SILT, some clay; light brown; moist, low plasticity. *5.60 - 5.65m: 15 cm Fe-Mn band. Black.* *7.40 - 7.50m: 10 cm Fe-Mn band. Black.*	Karioi Volcanic Formation
7.5 – 8.1	42.5 – 41.9	7.5-8.1: no recovery.	Karioi Volcanic Formation
8.1 – 10.0	41.9 – 40.0	Very stiff, fine sandy SILT, some clay; light reddish brown; moist, low plasticity.	Karioi Volcanic Formation

Drilling:

Depth (m)	Recovery	Method
0.0 – 1.5	100%	HA
1.5 – 3.0	93%	TT
3.0 – 4.5	93%	TT
4.5 – 6.0	100%	TT
6.0 – 7.5	100%	TT
7.5 – 9.0	60%	TT
9.0 – 10.0	100%	TT

Casing: 123 mm

Date started:	11/11/2024	**Date end:**	13/11/2024	**Comments:**
Logged by:	JC	**Drilled by:**	McMillan Drilling Ltd	GW at 6.44 m bgl on 12/11 at 07:30am at 10.5 m depth and 3m casing.
Vane ID:	N/A	**Equipment:**	N102	GW at 15.39 on 13/11 at 07:40am at 39 m bgl and 3m casing.
Vane type:	N/A	**Method:**	TT/HA	GW at 28.39 on 14/11 at 08:30am on completed piezometer.
Vane width:	N/A	**Inclination:**	90°	GW at 29.10 on 14/11 at 05:30pm on piezometer after development.
SPT No:	N/A	**Diameter:**	96mm	GW at 29.60 on 15/11 at 07:30am on piezometer.
SPT efficiency:	N/A	**Fluid type:**	Polymer/Water	Strength/stiffness inferred from SPT tests completed in BH02 offset 5m from BH01

For Explanation of Symbols and Abbreviations See Key Sheet

Project:	Raglan Wastewater Consent			**Project number:**	4703642
Site location:	316 Wainui Rd. Raglan.			**Client:**	Watercare Waikato
Location:	Paddock above gully and 200m south of trig point.	**Coordinate system:**	NZTM2000	**Vertical datum:**	NZVD 2016
		Northing:	5813570.6	**Ground level (mRL):**	50.00
		Easting:	1761706.6	**Location method:**	Waikato RC GIS

Depth (m)	RL (m)	Recovery	Method	Soil/ Rock Description	Geological Unit
10.0–11.9	40.0–38.1	100% (to 10.5); 100%	TT	Very stiff, fine sandy SILT, some clay; light reddish brown; moist, low plasticity.	Kariori Volcanic Formation
11.9–13.5	38.1–36.5	100%	TT	Medium dense, silty fine SAND, trace clay; light greyish brown; moist, low plasticity.	Kariori Volcanic Formation
13.5–14.7	36.5–35.3	20%	TT	13.5-14.7m: no recovery.	Kariori Volcanic Formation
14.7–15.0	35.3–35.0	20%	TT	Medium dense, silty fine SAND, minor clay, some fine gravel; dark orangish brown; moist, low plasticity. *14.70 - 14.85m: 15 cm Fe-Mn band. Dark reddish brown.*	Kariori Volcanic Formation
15.0–16.4	35.0–33.6	7%	TT	15.0-16.4m: no recovery.	Kariori Volcanic Formation
16.4–17.1	33.6–32.9	93%	TT	Medium dense, silty fine SAND, minor clay, some fine gravel; dark orangish brown; moist, low plasticity fines, matrix supported. Sand: sub-angular. Gravel: sub-angular to subrounded, highly weathered, volcanics. *16.50 - 16.90m: Dark orangish brown*	Kariori Volcanic Formation
17.1–20.0	32.9–30.0	93%; 90%; 90%	TT	Medium dense, silty fine to medium SAND, some fine gravel; dark brown; moist, low plasticity fines. Sand: sub-angular. Gravel: sub-angular to subrounded, highly weathered, Fe-Mn cobbles.	Kariori Volcanic Formation

GWL marker at approx. 15.35 m.

Date started:	11/11/2024	**Date end:**	13/11/2024
Logged by:	JC	**Drilled by:**	McMillan Drilling Ltd
Vane ID:	N/A	**Equipment:**	N102
Vane type:	N/A	**Method:**	TT/HA
Vane width:	N/A	**Inclination:**	90°
SPT No:	N/A	**Diameter:**	96mm
SPT efficiency:	N/A	**Fluid type:**	Polymer/Water

Comments:
GW at 6.44 m bgl on 12/11 at 07:30am at 10.5 m depth and 3m casing.
GW at 15.39 on 13/11 at 07:40am at 39 m bgl and 3m casing.
GW at 28.39 on 14/11 at 08:30am on completed piezometer.
GW at 29.10 on 14/11 at 05:30pm on piezometer after development.
GW at 29.60 on 15/11 at 07:30am on piezometer.
Strength/stiffness inferred from SPT tests completed in BH02 offset 5m from BH01

Beca Machine Borehole Log

Project:	Raglan Wastewater Consent			**Project number:**	4703642
Site location:	316 Wainui Rd. Raglan.			**Client:**	Watercare Waikato
Location:	Paddock above gully and 200m south of trig point.	**Coordinate system:**	NZTM2000	**Vertical datum:**	NZVD 2016
		Northing:	5813570.6	**Ground level (mRL):**	50.00
		Easting:	1761706.6	**Location method:**	Waikato RC GIS

Depth (m)	RL (m)	Recovery	Method	Soil/ Rock Description	Geological Unit
20.00 – 25.50		90% (to 21.0), 93% (21.0–22.5), 100% (22.5–24.0), 100% (24.0–25.5)	TT	Medium dense, silty fine to medium SAND, some fine gravel; dark brown; moist, low plasticity fines. Sand: sub-angular. Gravel: sub-angular to subrounded, highly weathered, Fe-Mn cobbles. *25.00 - 25.50m: Very Stiff*	Karioi Volcanic Formation
25.50 – 27.00		87% (25.5–27.0)	TT	Medium dense, silty fine SAND; dark brown; moist, low plasticity, *25.80m: light yellowish brown;*	Karioi Volcanic Formation
27.00 – 28.70		97% (27.0–28.5)	TT	Stiff, fine sandy CLAY; light brown; moist, high plasticity. *27.45 - 27.55m: light yellowish brown;*	Karioi Volcanic Formation
28.70 – 30.00		100% (28.5–30.0)	TT	Silty fine GRAVEL, minor clay, some fine to coarse sand; dark brown mottled black, white, grey and yellow; moist, high plasticity fines. Gravel: sub-angular to subrounded, highly weathered basalt. Sand: sub-angular, highly weathered basalt, pumice. [Completely weathered volcanic breccia]	Karioi Volcanic Formation

Depth scale: 20.5, 21.0, 21.5, 22.0, 22.5, 23.0, 23.5, 24.0, 24.5, 25.0, 25.5, 26.0, 26.5, 27.0, 27.5, 28.0, 28.5, 29.0, 29.5
RL scale: 29.5, 29.0, 28.5, 28.0, 27.5, 27.0, 26.5, 26.0, 25.5, 25.0, 24.5, 24.0, 23.5, 23.0, 22.5, 22.0, 21.5, 21.0, 20.5

Date started:	11/11/2024	**Date end:**	13/11/2024	**Comments:**
Logged by:	JC	**Drilled by:**	McMillan Drilling Ltd	GW at 6.44 m bgl on 12/11 at 07:30am at 10.5 m depth and 3m casing.
Vane ID:	N/A	**Equipment:**	N102	GW at 15.39 on 13/11 at 07:40am at 39 m bgl and 3m casing.
Vane type:	N/A	**Method:**	TT/HA	GW at 28.39 on 14/11 at 08:30am on completed piezometer.
Vane width:	N/A	**Inclination:**	90°	GW at 29.10 on 14/11 at 05:30pm on piezometer after development.
SPT No:	N/A	**Diameter:**	96mm	GW at 29.60 on 15/11 at 07:30am on piezometer.
SPT efficiency:	N/A	**Fluid type:**	Polymer/Water	Strength/stiffness inferred from SPT tests completed in BH02 offset 5m from BH01

For Explanation of Symbols and Abbreviations See Key Sheet

Project:	Raglan Wastewater Consent			**Project number:**	4703642
Site location:	316 Wainui Rd. Raglan.			**Client:**	Watercare Waikato
Location:	Paddock above gully and 200m south of trig point.	**Coordinate system:**	NZTM2000	**Vertical datum:**	NZVD 2016
		Northing:	5813570.6	**Ground level (mRL):**	50.00
		Easting:	1761706.6	**Location method:**	Waikato RC GIS

Installations	GWL	Fluid Return	Recovery	Method	Casing	RQD	Su (kPa)	SPT	Samples	Depth (m)	RL (m)	Graphic Log	Soil/ Rock Description	Geological Unit
													Silty fine GRAVEL, minor clay, some fine to coarse sand; dark brown mottled black, white, grey and yellow; moist, high plasticity fines. Gravel: sub-angular to subrounded, highly weathered basalt. Sand: sub-angular, highly weathered basalt, pumice. [Completely weathered volcanic breccia]	Kariori Volcanic Formation
			100%	TT						30.5	19.5		Medium dense, silty fine to medium SAND, trace clay; light reddish brown; moist, low plasticity. Sand: sub-angular to sub-rounded, highly weathered, pumice. *31.00 - 31.70m: 5-10 cm layers of interbeds*	
										31.0	19.0			
										31.5	18.5			
			100%	TT						32.0	18.0			
										32.5	17.5			
										33.0	17.0			
			100%	TT						33.5	16.5			
										34.0	16.0			
										34.5	15.5			
			100%	TT						35.0	15.0			
										35.5	14.5			
										36.0	14.0			
			100%	TT						36.5	13.5			
										37.0	13.0			
										37.5	12.5		Very stiff, clayey SILT, trace fine sand; light orangish brown with white layers, moist, high plasticity.	
			100%	TT						38.0	12.0		Very stiff, silty CLAY; dark grey; moist, high plasticity.	
										38.5	11.5			
										39.0	11.0			
			100%	TT						39.5	10.5			

Date started:	11/11/2024	**Date end:**	13/11/2024	**Comments:**
Logged by:	JC	**Drilled by:**	McMillan Drilling Ltd	GW at 6.44 m bgl on 12/11 at 07:30am at 10.5 m depth and 3m casing.
Vane ID:	N/A	**Equipment:**	N102	GW at 15.39 on 13/11 at 07:40am at 39 m bgl and 3m casing.
Vane type:	N/A	**Method:**	TT/HA	GW at 28.39 on 14/11 at 08:30am on completed piezometer.
Vane width:	N/A	**Inclination:**	90°	GW at 29.10 on 14/11 at 05:30pm on piezometer after development.
SPT No:	N/A	**Diameter:**	96mm	GW at 29.60 on 15/11 at 07:30am on piezometer.
SPT efficiency:	N/A	**Fluid type:**	Polymer/Water	Strength/stiffness inferred from SPT tests completed in BH02 offset 5m from BH01

Beca — Machine Borehole Log

Borehole ID: BH01

Project:	Raglan Wastewater Consent	**Project number:**	4703642
Site location:	316 Wainui Rd. Raglan.	**Client:**	Watercare Waikato

Location:	Paddock above gully and 200m south of trig point.	**Coordinate system:**	NZTM2000	**Vertical datum:**	NZVD 2016
		Northing:	5813570.6	**Ground level (mRL):**	50.00
		Easting:	1761706.6	**Location method:**	Waikato RC GIS

Depth (m)	RL (m)	Drilling: Recovery	Drilling: Method	Soil/ Rock Description	Geological Unit
40.0–40.5	10.0–9.5	100%	TT	Very stiff, silty CLAY; dark grey; moist, high plasticity.	
				Hard, silty CLAY; light bluish grey; moist, high plasticity,	
40.5–41.0	9.5–9.0	100%	TT	Hard, clayey SILT, some fine sand; light streaked brown, moist, high plasticity.	
41.0–45.0	9.0–5.0	100% / 100% / 100%	TT	Extremely to very weak, moderately weathered, light brownish grey to dark brown BRECCIA. Gravels: fine to coarse, sub-angular, slightly weathered andesite.	Karioi Volcanic Formation
45.0	5.0			45.00m - End of Borehole, Hole terminated at target depth.	

Column headings: Installations; Drilling (GWL, Fluid Return, Recovery, Method, Casing, RQD); In Situ Tests (Su (kPa), SPT); Samples; Depth (m); RL (m); Graphic Log; Soil/ Rock Description; Geological Unit.

Depth scale: 40.5, 41.0, 41.5, 42.0, 42.5, 43.0, 43.5, 44.0, 44.5, 45.0, 45.5, 46.0, 46.5, 47.0, 47.5, 48.0, 48.5, 49.0, 49.5

RL scale: 9.5, 9.0, 8.5, 8.0, 7.5, 7.0, 6.5, 6.0, 5.5, 5.0, 4.5, 4.0, 3.5, 3.0, 2.5, 2.0, 1.5, 1.0, 0.5

Date started:	11/11/2024	**Date end:**	13/11/2024
Logged by:	JC	**Drilled by:**	McMillan Drilling Ltd
Vane ID:	N/A	**Equipment:**	N102
Vane type:	N/A	**Method:**	TT/HA
Vane width:	N/A	**Inclination:**	90°
SPT No:	N/A	**Diameter:**	96mm
SPT efficiency:	N/A	**Fluid type:**	Polymer/Water

Comments:
GW at 6.44 m bgl on 12/11 at 07:30am at 10.5 m depth and 3m casing.
GW at 15.39 on 13/11 at 07:40am at 39 m bgl and 3m casing.
GW at 28.39 on 14/11 at 08:30am on completed piezometer.
GW at 29.10 on 14/11 at 05:30pm on piezometer after development.
GW at 29.60 on 15/11 at 07:30am on piezometer.
Strength/stiffness inferred from SPT tests completed in BH02 offset 5m from BH01

For Explanation of Symbols and Abbreviations See Key Sheet

Beca	Photo Log	Location ID:	BH01
			Sheet 1 of 7

Project:	Raglan Wastewater Consent		**Project number:**	4703642	
Site location:	316 Wainui Rd. Raglan.		**Client Name:**	Watercare Waikato	
Location:	Paddock above gully and 200m south of trig point.	**Coordinate system:** NZTM2000		**Vertical datum:**	NZVD 2016
		Northing: 5813570.6		**Ground level (mRL):**	50.00
		Easting: 1761706.6		**Location method:**	Waikato RC GIS

Core Box 01 - 0.00mbgl to 3.50mbgl

Core Box 02 - 3.50mbgl to 6.65mbgl

Photo Log

Location ID: BH01

Project:	Raglan Wastewater Consent		**Project number:**	4703642	
Site location:	316 Wainui Rd. Raglan.		**Client Name:**	Watercare Waikato	
Location:	Paddock above gully and 200m south of trig point.	**Coordinate system:** NZTM2000		**Vertical datum:**	NZVD 2016
		Northing: 5813570.6		**Ground level (mRL):**	50.00
		Easting: 1761706.6		**Location method:**	Waikato RC GIS

Core Box 03 - 6.65mbgl to 10.50mbgl

Core Box 04 - 10.50mbgl to 14.70mbgl

Photo Log

Location ID: BH01

Project:	Raglan Wastewater Consent		**Project number:**	4703642	
Site location:	316 Wainui Rd. Raglan.		**Client Name:**	Watercare Waikato	
Location:	Paddock above gully and 200m south of trig point.	**Coordinate system:** NZTM2000		**Vertical datum:**	NZVD 2016
		Northing: 5813570.6		**Ground level (mRL):**	50.00
		Easting: 1761706.6		**Location method:**	Waikato RC GIS

Core Box 05 - 14.70mbgl to 19.30mbgl

Core Box 06 - 19.30mbgl to 22.85mbgl

Project:	Raglan Wastewater Consent		**Project number:**	4703642	
Site location:	316 Wainui Rd. Raglan.		**Client Name:**	Watercare Waikato	
Location:	Paddock above gully and 200m south of trig point.	**Coordinate system:** NZTM2000		**Vertical datum:**	NZVD 2016
		Northing: 5813570.6		**Ground level (mRL):**	50.00
		Easting: 1761706.6		**Location method:**	Waikato RC GIS

Core Box 07 - 22.85mbgl to 26.25mbgl

Core Box 08 - 26.25mbgl to 29.70mbgl

Photo Log

Location ID: **BH01**

Project:	Raglan Wastewater Consent			**Project number:**	4703642
Site location:	316 Wainui Rd. Raglan.			**Client Name:**	Watercare Waikato
Location:	Paddock above gully and 200m south of trig point.	**Coordinate system:**	NZTM2000	**Vertical datum:**	NZVD 2016
		Northing:	5813570.6	**Ground level (mRL):**	50.00
		Easting:	1761706.6	**Location method:**	Waikato RC GIS

Core Box 09 - 29.70mbgl to 32.75mbgl

Core Box 10 - 32.75mbgl to 36.00mbgl

Photo Log

Location ID:	**BH01**		Sheet 6 of 7
Project:	Raglan Wastewater Consent	**Project number:**	4703642
Site location:	316 Wainui Rd. Raglan.	**Client Name:**	Watercare Waikato

Location:	Paddock above gully and 200m south of trig point.	**Coordinate system:**	NZTM2000	**Vertical datum:**	NZVD 2016
		Northing:	5813570.6	**Ground level (mRL):**	50.00
		Easting:	1761706.6	**Location method:**	Waikato RC GIS

Core Box 11 - 36.00mbgl to 39.00mbgl

Core Box 12 - 39.00mbgl to 42.00mbgl

Photo Log

Project:	Raglan Wastewater Consent		**Project number:**	4703642	
Site location:	316 Wainui Rd. Raglan.		**Client Name:**	Watercare Waikato	
Location:	Paddock above gully and 200m south of trig point.	**Coordinate system:** NZTM2000	**Vertical datum:**	NZVD 2016	
		Northing: 5813570.6	**Ground level (mRL):**	50.00	
		Easting: 1761706.6	**Location method:**	Waikato RC GIS	

Core Box 13 - 42.00mbgl to 45.00mbgl

Beca — Machine Borehole Log

Project:	Raglan Wastewater Consent	**Project number:**	4703642
Site location:	316 Wainui Rd. Raglan.	**Client:**	Watercare Waikato
Location:	Paddock above gully and 200m south of trig point.	**Coordinate system:**	NZTM2000
		Northing:	5813574.2
		Easting:	1761710.8
		Vertical datum:	NZVD 2016
		Ground level (mRL):	50.50
		Location method:	Waikato RC GIS

Depth (m)	RL (m)	Recovery	Method	SPT	Soil/ Rock Description	Geological Unit
0.0 – 0.6	50.5 – 49.9	100%	HA		Firm, clayey organic SILT, some fine sand; dark brownish grey; dry, high plasticity. Organics: Fibrous [Topsoil]	Kauroa Ash Formation
0.6 – 1.5	49.9 – 49.0	100%	HA		Very stiff, clayey SILT, some fine sand; dark reddish brown; moist, high plasticity.	Kauroa Ash Formation
1.5 – 1.95	49.0 – 48.55	100%	SPT	1, 1, 1, 2, 1, 2 N=6		Kauroa Ash Formation
1.95 – 3.0			W			Karioi Volcanic Formation
3.0 – 3.45	47.5 – 47.05	100%	SPT	0, 0, 0, 0, 0, 0 N=0	Firm, silty CLAY, minor fine sand; light brown; moist, high plasticity.	Karioi Volcanic Formation
3.45 – 4.5			W			Karioi Volcanic Formation
4.5 – 4.95	46.0 – 45.55	100%	SPT	1, 1, 1, 1, 2, 5 N=9	Stiff, silty CLAY, minor fine sand; light brown; moist, high plasticity.	Karioi Volcanic Formation
4.95 – 6.0			W			Karioi Volcanic Formation
6.0 – 6.45	44.5 – 44.05	100%	SPT	2, 2, 3, 3, 3, 4 N=13	Very stiff, fine sandy SILT, minor clay; light brown; moist, low plasticity.	Karioi Volcanic Formation
6.45 – 7.5			W			Karioi Volcanic Formation
7.5 – 7.95	43.0 – 42.55	100%	SPT	1, 1, 2, 2, 2, 3 N=9	Very stiff, fine sandy SILT, minor clay; light reddish brown; moist, low plasticity.	Karioi Volcanic Formation
7.95 – 9.0			W			Karioi Volcanic Formation
9.0 – 9.45	41.5 – 41.05	100%	SPT	1, 1, 2, 2, 2, 3 N=9	Very stiff, fine sandy SILT, minor clay; light reddish brown; moist, low plasticity.	Karioi Volcanic Formation
9.45 – 10.0			W			Karioi Volcanic Formation

Date started:	14/11/2024	**Date end:**	14/11/2024
Logged by:	JC	**Drilled by:**	McMillan Drilling Ltd
Vane ID:	N/A	**Equipment:**	N102
Vane type:	N/A	**Method:**	W/SPT/HA
Vane width:	N/A	**Inclination:**	90°
SPT No:	N102	**Diameter:**	96mm
SPT efficiency:	94%	**Fluid type:**	Water

Comments:
GW at 6.75 m bgl on 14/11 at 05:00pm on completed piezometer after development.
GW at 6.74 m bgl on 15/11 at 07:30am on completed piezometer.
Borehole was washdrilled.

For Explanation of Symbols and Abbreviations See Key Sheet

Machine Borehole Log

Borehole ID: BH02

Project:	Raglan Wastewater Consent	**Project number:**	4703642
Site location:	316 Wainui Rd. Raglan.	**Client:**	Watercare Waikato

Location:	Paddock above gully and 200m south of trig point.	**Coordinate system:**	NZTM2000	**Vertical datum:**	NZVD 2016
		Northing:	5813574.2	**Ground level (mRL):**	50.50
		Easting:	1761710.8	**Location method:**	Waikato RC GIS

Recovery	Method	SPT	Depth (m)	RL (m)	Soil/ Rock Description	Geological Unit
	W					Kariol Volcanic Formation
100%	SPT	1, 2, 2, 3, 3, 3, N=11	10.5 – 11.0	40.0 – 39.5	Very stiff, fine sandy SILT, some clay; light reddish brown; moist, low plasticity.	
	W		11.0 – 12.0	39.5 – 38.5		
100%	SPT	2, 2, 3, 5, 5, 6, N=19	12.0 – 12.45	38.5 – 38.05	Medium dense, silty fine SAND, trace clay; light greyish brown; moist, low plasticity fines.	
	W		12.45 – 13.5			
100%	SPT	1, 2, 4, 4, 4, 5, N=17	13.5 – 13.95	37.0 – 36.55	Medium dense, silty fine SAND, trace clay; light greyish brown; moist, low plasticity fines.	
	W		13.95 – 15.0			
100%	SPT	2, 2, 4, 5, 6, 8, N=23	15.0 – 15.45	35.5 – 35.05	Medium dense, silty fine SAND, trace clay; light greyish brown; moist, low plasticity fines.	
	W		15.45 – 16.5			
			16.5	34.0	16.50m - End of Borehole, Hole terminated at target depth.	

Date started:	14/11/2024	**Date end:**	14/11/2024	**Comments:**
Logged by:	JC	**Drilled by:**	McMillan Drilling Ltd	GW at 6.75 m bgl on 14/11 at 05:00pm on completed piezometer after development.
Vane ID:	N/A	**Equipment:**	N102	GW at 6.74 m bgl on 15/11 at 07:30am on completed piezometer.
Vane type:	N/A	**Method:**	W/SPT/HA	Borehole was washdrilled.
Vane width:	N/A	**Inclination:**	90°	
SPT No:	N102	**Diameter:**	96mm	
SPT efficiency:	94%	**Fluid type:**	Water	

For Explanation of Symbols and Abbreviations See Key Sheet

Photo Log

Location ID: BH02

Project:	Raglan Wastewater Consent		**Project number:**	4703642	
Site location:	316 Wainui Rd. Raglan.		**Client Name:**	Watercare Waikato	
Location:	Paddock above gully and 200m south of trig point.	**Coordinate system:**	NZTM2000	**Vertical datum:**	NZVD 2016
		Northing:	5813574.2	**Ground level (mRL):**	50.50
		Easting:	1761710.8	**Location method:**	Waikato RC GIS

Core Box 01 - 0.00mbgl to 6.45mbgl

Core Box 02 - 6.45mbgl to 15.45mbgl

Geotechnical Log Key Sheet

SOIL AND ROCK DESCRIPTIONS

Soil and Rock Descriptions are in general accordance with the NZ Geotechnical Society (NZGS), 2005.
Hand-held Vane Shear Strength measurements are in general accordance with the NZGS, 2001.

METHODS

BH	Machine Borehole
CPT	Cone Penetration Test
DCP	Dynamic Cone Penetration
HA	Hand Auger
SPT	Standard Penetration Test
IVAN	In-situ Vane Test
MA	Machine Auger
OB	Open Barrel
SNC	Sonic Core Drilling
TP	Test Pit/Trench
TT	Triple Tube
PT	Thin-walled Open Drive Tube
VE	Vacuum Excavation
W	Wash Boring

WEATHERING

CW	Completely Weathered
HW	Highly Weathered
MW	Moderately Weathered
SW	Slightly Weathered
UW	Unweathered

SAMPLES

B	Bulk Disturbed Sample
C	Core Sample
D	Small Disturbed Sample
U	Thin-wall Open Drive (Push) Tube Sample

WATER

Groundwater Level (GWL)

IN-SITU TESTS

Shear Vane

Su	In-situ peak undrained shear strength and remoulded undrained shear strength
UTP	Unable to Penetrate
CB	Pilcon-type vane tested in Core Barrel
DH	Pilcon-type vane tested in-situ (downhole)
GV	Geonor vane, tested in-situ
IcV	Icone vane, tested in-situ

Standard Penetration Test (SPT)

N	SPTn Sampler (Split-spoon)
Nc	SPTn Solid Cone
HB	SPT Hammer Bouncing

TERMINOLOGY

RL	Reduced Level
RQD	Rock Quality Designation

GRAPHIC LOG (1 or a combination of the following)

Clay	Silt	Sandstone (SST)	Conglomerate	Fine Igneous
Gravel	Sand	Siltstone (ZST)	Limestone	Coarse Igneous
Shells	Organic Material	Mudstone	Foliated Metamorphic	Ignimbrite
Cobbles / Boulders	Wood	Interbedded SST & ZST	Asphalt	No Core

MONITORING INSTALLATION

Backfill Material

Sand	Grout	Bentonite
Gravel	Cement Mixes	

Standpipe

Plain | Slotted | Vibrating Wire

ORGANIC SOILS

Von Post Degree of Humification

H1	Completely unconverted and mud-free peat, when pressed gives clear water and plant structure is visible.
H2	Partially unconverted and mud-free peat, when pressed gives almost clear water and plant structure is visible.
H3	Very slightly decomposed or very slightly muddy peat, when pressed gives marked muddy water, no peat substance passes through the fingers and plant structure is less visible.
H4	Slightly decomposed or slightly muddy peat, when pressed gives muddy water and plant structure is less visible.
H5	Moderately decomposed or very muddy peat with growth structure evident but slightly obliterated.
H6	Moderately decomposed or very muddy peat with indistinct growth structure.
H7	Fairly well decomposed or very muddy peat but the growth structure can just be seen.
H8	Well decomposed or very muddy peat with very indistinct growth structure.
H9	Practically decomposed or mud-like peat in which almost no growth structure is evident.
H10	Completely decomposed or mud peat where no growth structure can be seen, entire substance passes through the fingers when pressed.

Hand Auger Log

Hand Auger ID: HA01

Project:	Raglan Wastewater Consent	**Project Number:**	4703642
Site Location:	316 Wainui Rd. Raglan.	**Client:**	Watercare Waikato

Location:	Centre of the gully	**Coordinate System:**	NZTM2000	**Vertical Datum:**	NZVD 2016
		Northing:	5813521.5	**Ground level (mRL):**	36.00
		Easting:	1761540.9	**Location Method:**	GPS +/- 10m

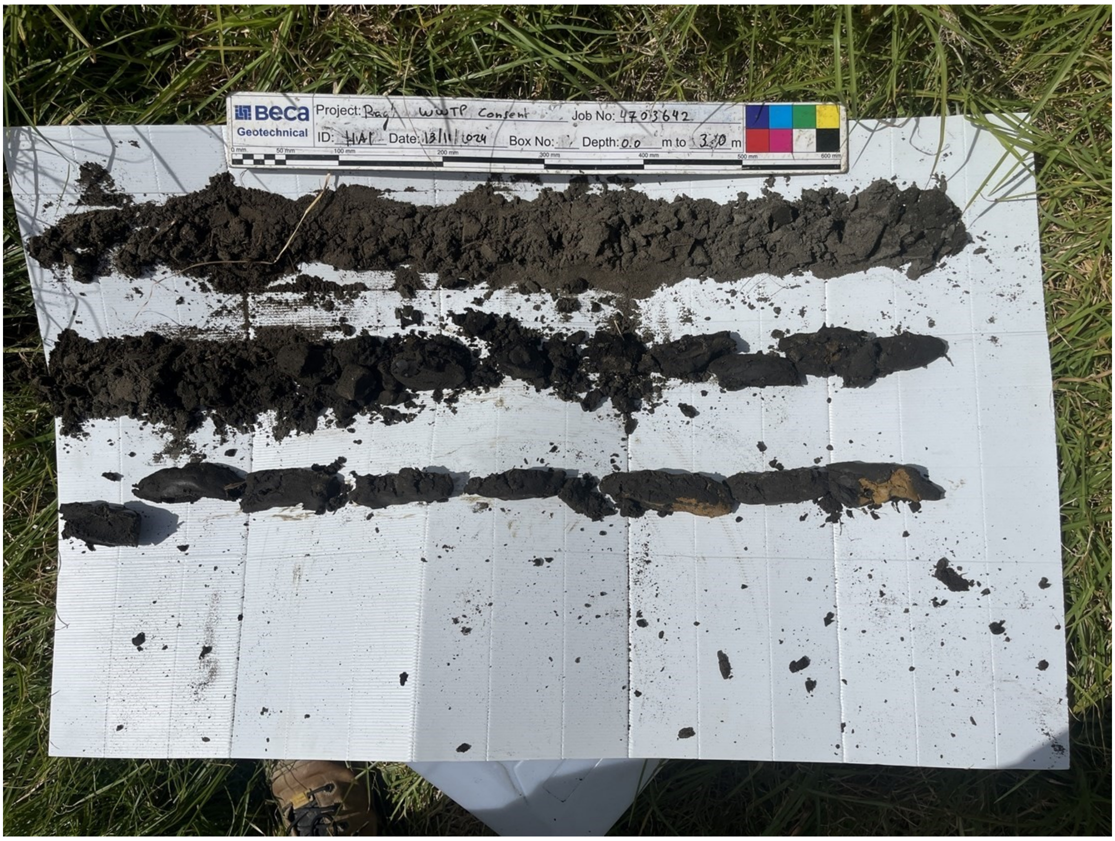
Groundwater (m)	In Situ Tests: Su (kPa)	In Situ Tests: Scala blows/50mm	Samples	Depth (m)	RL (m)	Graphic Log	Soil/ Rock Description	Geological Unit
		0 0 1 0 1 0 1 0 1 1 1 1 1 1 1 1 1 2 1 1 1 1 1 1		0.0 – 1.1	36.0 – 34.9		Loose, fine to coarse SAND, trace silt, trace organics, black; dry, non plastic. Organics: rootlets.	Holocene Windblown Deposits
		1 1 1 1 1 1		1.1 – 1.6	34.9 – 34.4		Loose, silty fine to coarse SAND, trace clay, black; moist, low plasticity fines.	Holocene Windblown Deposits
	28/14 (2.0 m); 42/20 (2.25 m); 40/17 (2.5 m); 45/17 (2.75 m); 198 (3.0 m)	2 2 2 2 2 2 2 2 2 2		1.6 – 3.0	34.4 – 33.0		Firm, SILT, minor fine to coarse sand, some clay, brown; moist, high plasticity.	KVF
				3.0	33.0		3.00m - End of hand auger, Hole terminated at target depth.	

Date Started:	13/11/2024	**Vane ID:**	Geo1249/Geo 1249	**Comments:**
Logged By:	TTW	**Vane Width:**	19mm	Hand auger terminated due to hole collapse. Groundwater not encountered. The geological unit Karioi Volcanic Formation is abbreviated to KVF.
Diameter:	50mm	**Vane Type:**	Down hole	

For Explanation of Symbols and Abbreviations See Key Sheet

Beca	# Photo Log	Location ID: **HA01** Sheet 1 of 1

Project:	Raglan Wastewater Consent			**Project number:**	4703642
Site location:	316 Wainui Rd. Raglan.			**Client Name:**	Watercare Waikato
Location:	Centre of the gully	**Coordinate system:**	NZTM2000	**Vertical datum:**	NZVD 2016
		Northing:	5813521.5	**Ground level (mRL):**	36.00
		Easting:	1761540.9	**Location method:**	GPS +/- 10m



Box 1 - 0.00mbgl to 3.00mbgl

Hand Auger Log

Hand Auger ID: HA02

Sheet 1 of 1

Project:	Raglan Wastewater Consent	**Project Number:**	4703642
Site Location:	316 Wainui Rd. Raglan.	**Client:**	Watercare Waikato

Location:	Centre of the gully	**Coordinate System:**	NZTM2000	**Vertical Datum:**	NZVD 2016
		Northing:	5813522.9	**Ground level (mRL):**	37.00
		Easting:	1761584.2	**Location Method:**	GPS +/- 10m

Groundwater (m)	In Situ Tests: Su (kPa)	In Situ Tests: Scala blows/50mm	Samples	Depth (m)	RL (m)	Graphic Log	Soil/ Rock Description	Geological Unit
		0 0 1 0 0 0 1 0 1 1 1 1 1 1 1 1 0 1 0 1 0 1 1 1 2 2 2 2 1 1 1 1 1 1 1 1 1 1 1 1		0.0 – 2.0	37.0 – 35.0	Sand	Loose, fine to coarse SAND, trace silt, trace organics, black; moist, non plastic. Organics: rootlets *1.00m: becomes wet.* *1.25 - 1.45m: becomes medium dense.* *1.40m: becomes saturated.* *1.50m: minor silt.*	Holocene Windblown Deposits
				2.0	35.0		2.00m - End of hand auger, Hole terminated at target depth.	

Depth scale (m): 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5

RL scale (m): 36.5, 36.0, 35.5, 35.0, 34.5, 34.0, 33.5, 33.0, 32.5

Date Started:	13/11/2024	**Vane ID:**	N/A	**Comments:**
Logged By:	TTW	**Vane Width:**	N/A	Hand auger terminated due to hole collapse. Groundwater not encountered.
Diameter:	50mm	**Vane Type:**	N/A	

For Explanation of Symbols and Abbreviations See Key Sheet

Beca

Photo Log

Location ID: HA02

Sheet 1 of 1

Project:	Raglan Wastewater Consent			**Project number:**	4703642
Site location:	316 Wainui Rd. Raglan.			**Client Name:**	Watercare Waikato
Location:	Centre of the gully	**Coordinate system:**	NZTM2000	**Vertical datum:**	NZVD 2016
		Northing:	5813522.9	**Ground level (mRL):**	37.00
		Easting:	1761584.2	**Location method:**	GPS +/- 10m

Box 1 - 0.00mbgl to 2.00mbgl

Hand Auger Log

Hand Auger ID: HA03

Project:	Raglan Wastewater Consent	**Project Number:**	4703642
Site Location:	316 Wainui Rd. Raglan.	**Client:**	Watercare Waikato
Location:	Gully head	**Coordinate System:**	NZTM2000
Vertical Datum:	NZVD 2016	**Northing:**	5813562.2
Ground level (mRL):	43.00	**Easting:**	1761665.8
Location Method:	GPS +/- 10m		

Groundwater (m)	In Situ Tests: Su (kPa)	In Situ Tests: Scala blows/50mm	Samples	Depth (m)	RL (m)	Graphic Log	Soil/ Rock Description	Geological Unit
				0.0	43.0		Stiff, SILT, trace fine to coarse sand, some clay, trace organics, dark brown; moist, high plasticity. Organics: rootlets.	Holocene Windblown Deposits
	68/17							
▼								
	68/45			0.5	42.5		*0.50m: becomes wet.*	
	71/45							
							No recovery.	
	62/45			1.0	42.0		Stiff, SILT, trace fine to coarse sand, minor clay, dark brown; wet, high plasticity.	
	51/8							
							No recovery.	
	54/20			1.5	41.5			
	79/37							
							Stiff, SILT, trace fine to coarse sand, trace clay, orange brown; moist, low plasticity.	KVF
							1.90m - End of hand auger, Hole terminated at target depth.	
	68/40			2.0	41.0			
				2.5	40.5			
				3.0	40.0			
				3.5	39.5			
				4.0	39.0			
				4.5	38.5			

Date Started:	13/11/2024	**Vane ID:**	Geo1249
Logged By:	TTW	**Vane Width:**	19mm
Diameter:	50mm	**Vane Type:**	Down hole

Comments:
Hand auger terminated due to hole collapse. Groundwater measured on completion of hand auger. The geological unit Karioi Volcanic Formation is abbreviated to KVF.

For Explanation of Symbols and Abbreviations See Key Sheet

Photo Log

Location ID: HA03

Project:	Raglan Wastewater Consent	**Project number:**	4703642
Site location:	316 Wainui Rd. Raglan.	**Client Name:**	Watercare Waikato

Location:	Gully head	**Coordinate system:**	NZTM2000	**Vertical datum:**	NZVD 2016
		Northing:	5813562.2	**Ground level (mRL):**	43.00
		Easting:	1761665.8	**Location method:**	GPS +/- 10m

Box 1 - 0.00mbgl to 1.90mbgl

Hand Auger Log

Hand Auger ID: HA04

Project:	Raglan Wastewater Consent	**Project Number:**	4703642
Site Location:	316 Wainui Rd. Raglan.	**Client:**	Watercare Waikato

Location:	Gully mouth	**Coordinate System:**	NZTM2000	**Vertical Datum:**	NZVD 2016
		Northing:	5813529.9	**Ground level (mRL):**	14.00
		Easting:	1761408.9	**Location Method:**	GPS +/- 10m

Groundwater (m)	In Situ Tests: Su (kPa)	In Situ Tests: Scala blows/50mm	Samples	Depth (m)	RL (m)	Graphic Log	Soil/ Rock Description	Geological Unit
▼ (approx. 0.15)				0.0	14.0		Soft, SILT, trace fine to coarse sand, trace clay, trace organics, black; wet, low plasticity.	Holocene Windblown Deposits
	14/8			0.2			Soft, fine to coarse sandy SILT, trace clay, trace organics, black; wet, low plasticity.	
	14/8			0.5	13.5			
	20/14			0.7			*0.70m: becomes saturated.*	
	62/48			1.0	13.0		*1.00m: becomes stiff.*	
				1.3			No recovery.	
				1.5	12.5			
				2.0	12.0		2.00m - End of hand auger, Hole terminated at target depth.	
				2.5	11.5			
				3.0	11.0			
				3.5	10.5			
				4.0	10.0			
				4.5	9.5			

Date Started:	13/11/2024	**Vane ID:**	Geo1249	**Comments:**
Logged By:	TTW	**Vane Width:**	19mm	Hand auger terminated due to hole collapse. Groundwater measured on completion of hand auger.
Diameter:	50mm	**Vane Type:**	Down hole	

For Explanation of Symbols and Abbreviations See Key Sheet

Photo Log

Location ID:	HA04	Sheet 1 of 1	
Project:	Raglan Wastewater Consent	**Project number:**	4703642
Site location:	316 Wainui Rd. Raglan.	**Client Name:**	Watercare Waikato

Location:	Gully mouth	**Coordinate system:**	NZTM2000	**Vertical datum:**	NZVD 2016
		Northing:	5813529.9	**Ground level (mRL):**	14.00
		Easting:	1761408.9	**Location method:**	GPS +/- 10m

Box 1 - 0.00mbgl to 2.00mbgl

C

Appendix C – Laboratory Tests Results

Beca Geotest
21 Pitt Street
PO Box 6345
Auckland 1141

PARTICLE SIZE DISTRIBUTION
WET SIEVE/HYDROMETER

Report No. **HYD: AKL25-00001-S01**

Issue No. 1

Client:	Watercare - Waikato
Project:	Raglan WWTP Consent
Project No:	4703642
Client Request ID:	4703642/107

ACCREDITED TESTING LABORATORY

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

Sangita Shah
Authorised Signatory
20/02/2025

Sample Details

Sample ID: AKL25-00001-S01
Sampled By: Client
Client Sample ID: HA2
Location: Raglan WWTP Consent
Depth (m): 0.5-1.0
Tested by: S.Shah/F.Perese

Date Sampled:
Date Submitted: 17/01/2025
Date Tested: 10/02/2025
Soil Description: Silty SAND

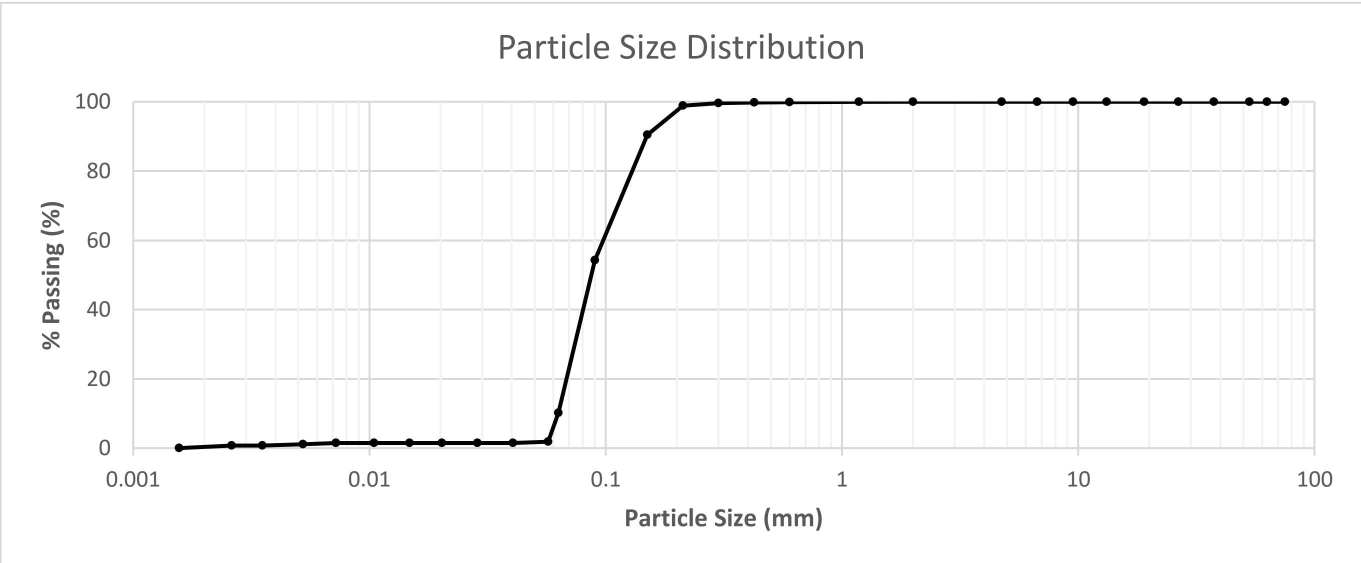
Test Results

Test Standard: NZS4402: 1986, Test 2.8.4

Dispersion: Sodium hexametaphosphate, pH = 9

Fraction Determined by Sieving			
Sieve Size mm	% Passing	Sieve Size mm	% Passing
75	100	2.00	100
63	100	1.18	100
53	100	0.600	100
37.5	100	0.425	100
26.5	100	0.300	100
19	100	0.212	99
13.2	100	0.150	90
9.5	100	0.090	54
6.7	100	0.063	10
4.75	100		

Fraction Determined by Hydrometer			
Particle Size mm	% Passing	Particle Size mm	% Passing
0.0571	2	0.0016	0
0.0405	2		
0.0286	2		
0.0202	2		
0.0148	2		
0.0104	2		
0.0072	2		
0.0052	1		
0.0035	1		
0.0026	1		



% Clay	% Silt	%Sand	% Gravel	Max. Size:
0	10	90	0	0.212mm

Beca Geotest
21 Pitt Street
PO Box 6345
Auckland 1141

PARTICLE SIZE DISTRIBUTION
WET SIEVE/HYDROMETER

Report No. **HYD: AKL25-00001-S02**

Issue No. 1

Client:	Watercare - Waikato
Project:	Raglan WWTP Consent
Project No:	4703642
Client Request ID:	4703642/107

ACCREDITED TESTING LABORATORY

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

Sangita Shah
Authorised Signatory
20/02/2025

Sample Details

Sample ID: AKL25-00001-S02
Sampled By: Client
Client Sample ID: HA2
Location: Raglan WWTP Consent
Depth (m): 1.5-2.0
Tested by: F.Perese/P.Singh

Date Sampled:
Date Submitted: 17/01/2025
Date Tested: 10/02/2025
Soil Description: Silty SAND

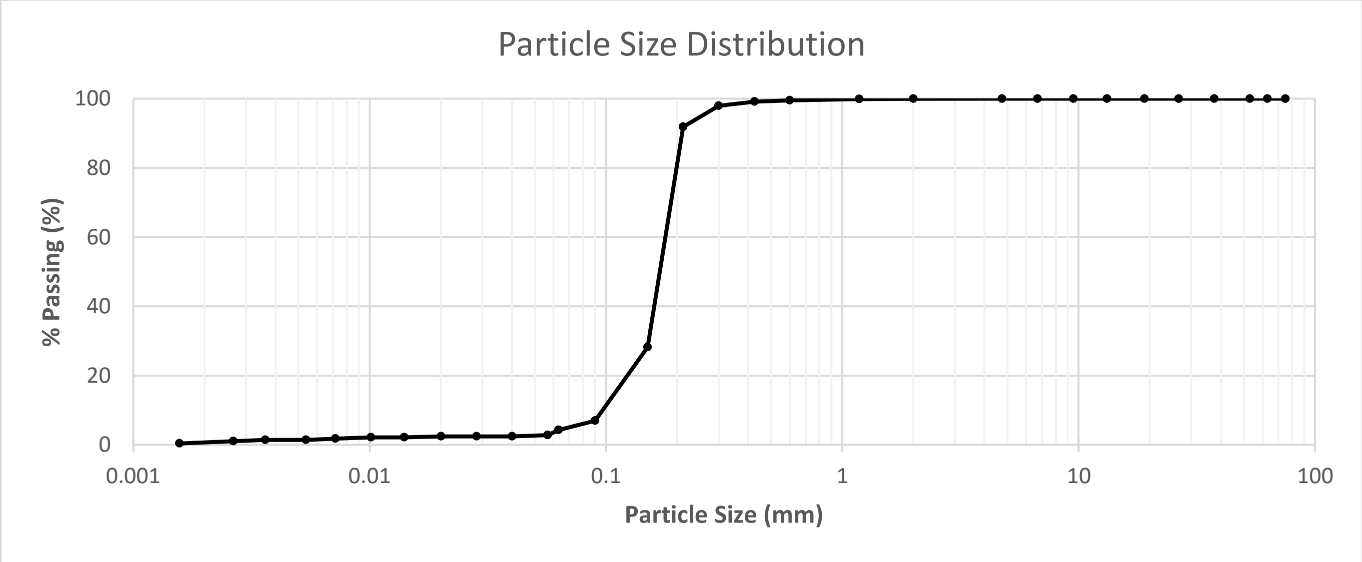
Test Results

Test Standard: NZS4402: 1986, Test 2.8.4

Dispersion: Sodium hexametaphosphate, pH = 9

Fraction Determined by Sieving			
Sieve Size mm	**% Passing**	**Sieve Size mm**	**% Passing**
75	100	2.00	100
63	100	1.18	100
53	100	0.600	100
37.5	100	0.425	99
26.5	100	0.300	98
19	100	0.212	92
13.2	100	0.150	28
9.5	100	0.090	7
6.7	100	0.063	4
4.75	100		

Fraction Determined by Hydrometer			
Particle Size mm	**% Passing**	**Particle Size mm**	**% Passing**
0.0566	3	0.0016	0
0.0401	2		
0.0284	2		
0.0201	2		
0.0140	2		
0.0101	2		
0.0072	2		
0.0054	1		
0.0036	1		
0.0026	1		



% Clay	% Silt	%Sand	% Gravel	Max. Size:
1	3	96	0	0.425mm

Beca Geotest
21 Pitt Street
PO Box 6345
Auckland 1141

PARTICLE SIZE DISTRIBUTION WET SIEVE/HYDROMETER

Report No. **HYD: AKL25-00001-S03**

Issue No. 1

Client:	Watercare - Waikato
Project:	Raglan WWTP Consent
Project No:	4703642
Client Request ID:	4703642/107

ACCREDITED IANZ TESTING LABORATORY

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

Sangita Shah
Authorised Signatory
20/02/2025

Sample Details

Sample ID: AKL25-00001-S03
Sampled By: Client
Client Sample ID: HA3
Location: Raglan WWTP Consent
Depth (m): 0.0-0.5
Tested by: P.Singh/F.Perese

Date Sampled:
Date Submitted: 17/01/2025
Date Tested: 10/02/2025
Soil Description: Clayey SILT

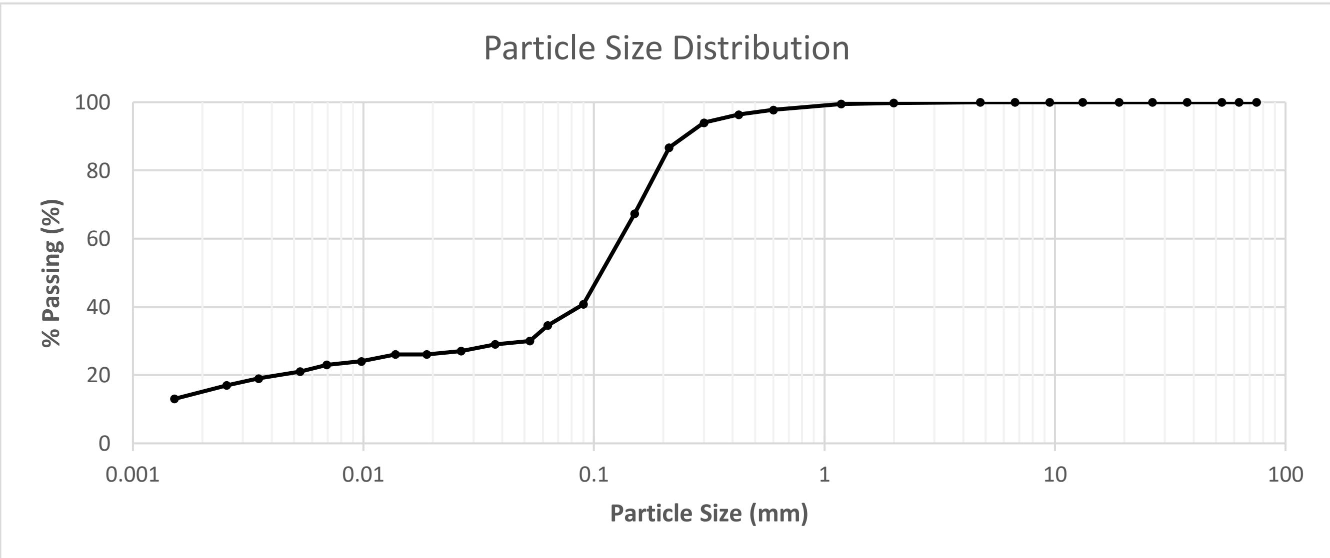
Test Results

Test Standard: NZS4402: 1986, Test 2.8.4

Dispersion: Sodium hexametaphosphate, pH = 9

Fraction Determined by Sieving			
Sieve Size mm	% Passing	Sieve Size mm	% Passing
75	100	2.00	100
63	100	1.18	100
53	100	0.600	98
37.5	100	0.425	96
26.5	100	0.300	94
19	100	0.212	87
13.2	100	0.150	67
9.5	100	0.090	41
6.7	100	0.063	35
4.75	100		

Fraction Determined by Hydrometer			
Particle Size mm	% Passing	Particle Size mm	% Passing
0.0527	30	0.0015	13
0.0373	29		
0.0266	27		
0.0188	26		
0.0138	26		
0.0098	24		
0.0069	23		
0.0053	21		
0.0035	19		
0.0025	17		



% Clay	% Silt	%Sand	% Gravel	Max. Size:
15	20	65	0	0.600mm

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PARTICLE SIZE DISTRIBUTION
WET SIEVE/HYDROMETER

Report No. **HYD: AKL25-00001-S04**

Issue No. 1

Client:	Watercare - Waikato
Project:	Raglan WWTP Consent
Project No:	4703642
Client Request ID:	4703642/107

ACCREDITED IANZ TESTING LABORATORY

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

Sangita Shah
Authorised Signatory
20/02/2025

Sample Details

Sample ID: AKL25-00001-S04
Sampled By: Client
Client Sample ID: HA3
Location: Raglan WWTP Consent
Depth (m): 0.5-1.0
Tested by: F.Perese/P.Singh

Date Sampled:
Date Submitted: 17/01/2025
Date Tested: 10/02/2025
Soil Description: Clayey SILT

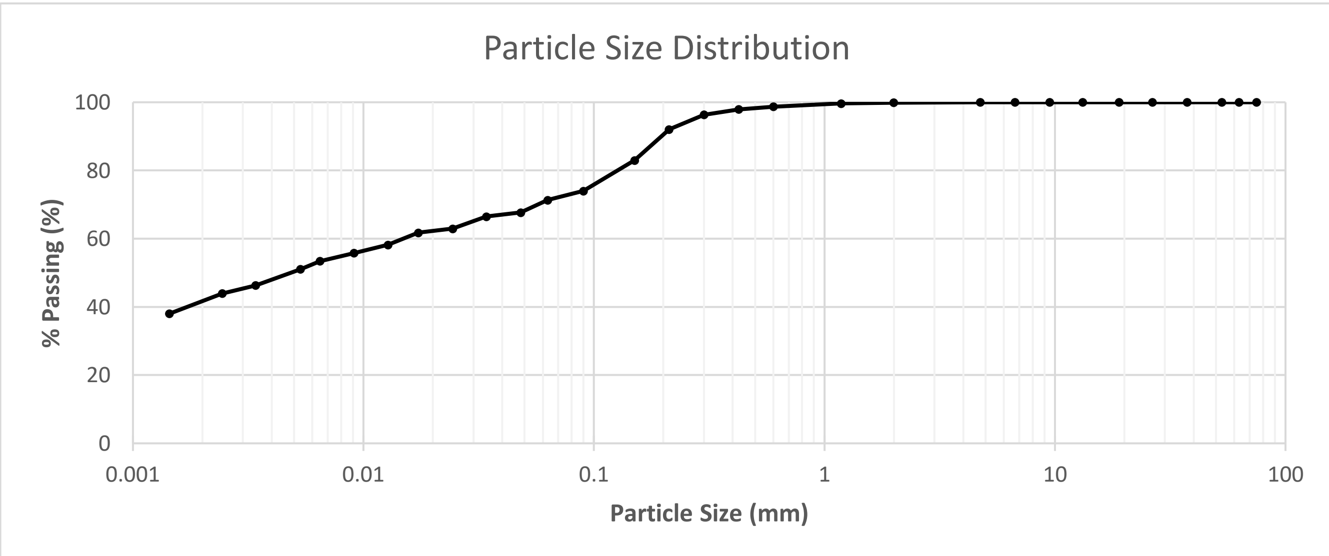
Test Results

Test Standard: NZS4402: 1986, Test 2.8.4

Dispersion: Sodium hexametaphosphate, pH = 9

Fraction Determined by Sieving			
Sieve Size mm	% Passing	Sieve Size mm	% Passing
75	100	2.00	100
63	100	1.18	100
53	100	0.600	99
37.5	100	0.425	98
26.5	100	0.300	96
19	100	0.212	92
13.2	100	0.150	83
9.5	100	0.090	74
6.7	100	0.063	71
4.75	100		

Fraction Determined by Hydrometer			
Particle Size mm	% Passing	Particle Size mm	% Passing
0.0481	68	0.0014	38
0.0341	66		
0.0244	63		
0.0173	62		
0.0128	58		
0.0091	56		
0.0065	53		
0.0053	51		
0.0034	46		
0.0024	44		



% Clay	% Silt	%Sand	% Gravel	Max. Size:
41	30	29	0	0.600mm

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Auckland 1141

PARTICLE SIZE DISTRIBUTION
WET SIEVE/HYDROMETER

Report No. HYD: AKL25-00001-S05

Issue No. 1

Client:	Watercare - Waikato
Project:	Raglan WWTP Consent
Project No:	4703642
Client Request ID:	4703642/107

ACCREDITED IANZ TESTING LABORATORY

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

Sangita Shah
Authorised Signatory
20/02/2025

Sample Details

Sample ID: AKL25-00001-S05
Sampled By: Client
Client Sample ID: HA3
Location: Raglan WWTP Consent
Depth (m): 1.0-1.5
Tested by: F.Perese/P.Singh

Date Sampled:
Date Submitted: 17/01/2025
Date Tested: 10/02/2025
Soil Description: Clayey SILT

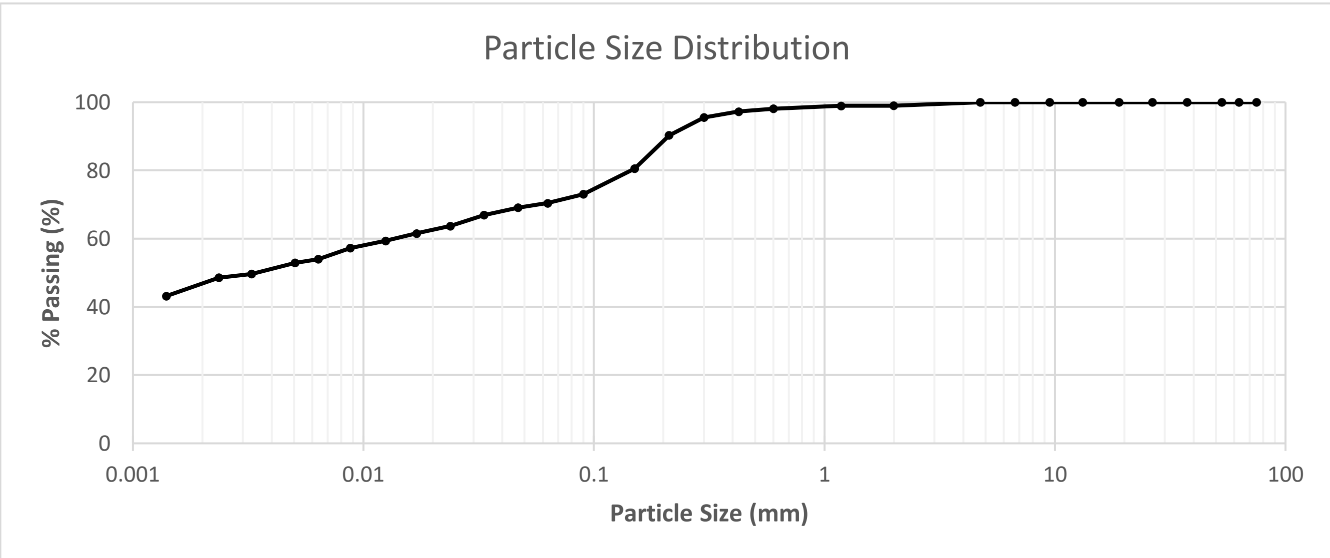
Test Results

Test Standard: NZS4402: 1986, Test 2.8.4

Dispersion: Sodium hexametaphosphate, pH = 9

Fraction Determined by Sieving			
Sieve Size mm	% Passing	Sieve Size mm	% Passing
75	100	2.00	99
63	100	1.18	99
53	100	0.600	98
37.5	100	0.425	97
26.5	100	0.300	96
19	100	0.212	90
13.2	100	0.150	81
9.5	100	0.090	73
6.7	100	0.063	70
4.75	100		

Fraction Determined by Hydrometer			
Particle Size mm	% Passing	Particle Size mm	% Passing
0.0468	69	0.0014	43
0.0334	67		
0.0239	64		
0.0170	62		
0.0125	59		
0.0088	57		
0.0064	54		
0.0051	53		
0.0033	50		
0.0024	49		



% Clay	% Silt	%Sand	% Gravel	Max. Size:
47	23	29	1	2.00mm

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Auckland 1141

PARTICLE SIZE DISTRIBUTION
WET SIEVE/HYDROMETER

Report No. **HYD: AKL25-00001-S06**

Issue No. 1

Client:	Watercare - Waikato
Project:	Raglan WWTP Consent
Project No:	4703642
Client Request ID:	4703642/107

ACCREDITED IANZ TESTING LABORATORY

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

Sangita Shah
Authorised Signatory
20/02/2025

Sample Details

Sample ID:	AKL25-00001-S06	**Date Sampled:**	
Sampled By:	Client	**Date Submitted:**	17/01/2025
Client Sample ID:	HA4	**Date Tested:**	10/02/2025
Location:	Raglan WWTP Consent	**Soil Description:**	Silty SAND
Depth (m):	0.0-0.75		
Tested by:	F.Perese		

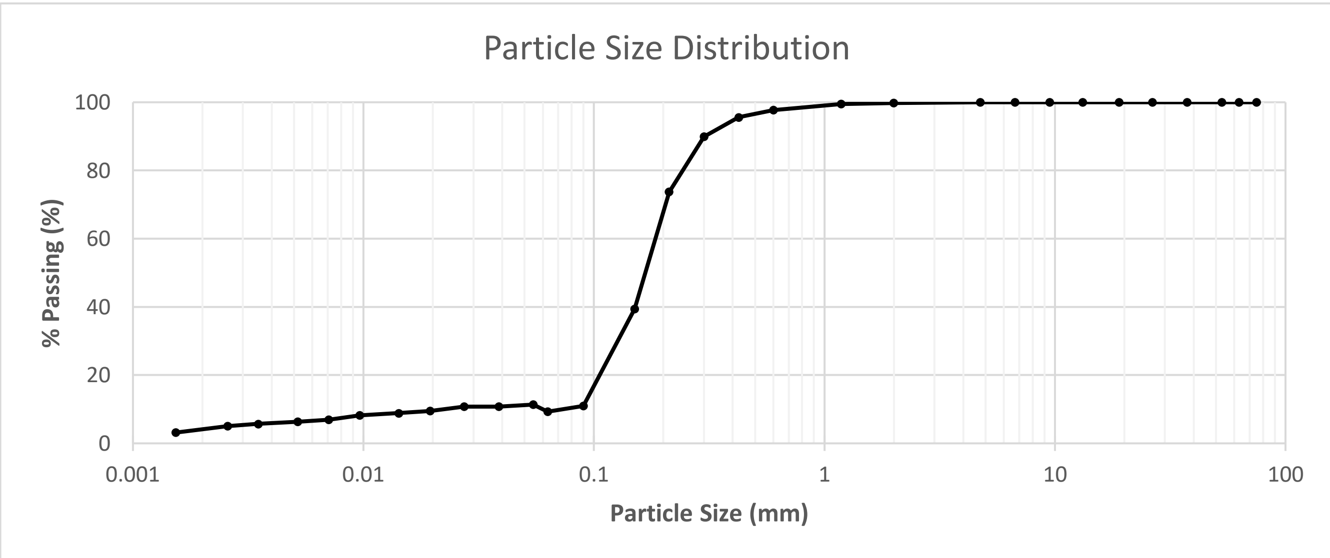
Test Results

Test Standard: NZS4402: 1986, Test 2.8.4

Dispersion: Sodium hexametaphosphate, pH = 9

Fraction Determined by Sieving			
Sieve Size mm	% Passing	Sieve Size mm	% Passing
75	100	2.00	100
63	100	1.18	99
53	100	0.600	98
37.5	100	0.425	96
26.5	100	0.300	90
19	100	0.212	74
13.2	100	0.150	39
9.5	100	0.090	11
6.7	100	0.063	9
4.75	100		

Fraction Determined by Hydrometer			
Particle Size mm	% Passing	Particle Size mm	% Passing
0.0546	11	0.0015	3
0.0387	11		
0.0274	11		
0.0195	9		
0.0142	9		
0.0096	8		
0.0071	7		
0.0052	6		
0.0035	6		
0.0026	5		



% Clay	% Silt	%Sand	% Gravel	Max. Size:
4	5	91	0	1.18mm

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PARTICLE SIZE DISTRIBUTION
WET SIEVE/HYDROMETER

Report No. **HYD: AKL25-00001-S07**

Issue No. 1

Client: Watercare - Waikato

Project: Raglan WWTP Consent

Project No: 4703642

Client Request ID: 4703642/107

ACCREDITED TESTING LABORATORY

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

Sangita Shah
Authorised Signatory
20/02/2025

Sample Details

Sample ID: AKL25-00001-S07
Sampled By: Client
Client Sample ID: HA4
Location: Raglan WWTP Consent
Depth (m): 0.75-1.0
Tested by: F.Perese/P.Singh

Date Sampled:
Date Submitted: 17/01/2025
Date Tested: 10/02/2025
Soil Description: Silty SAND

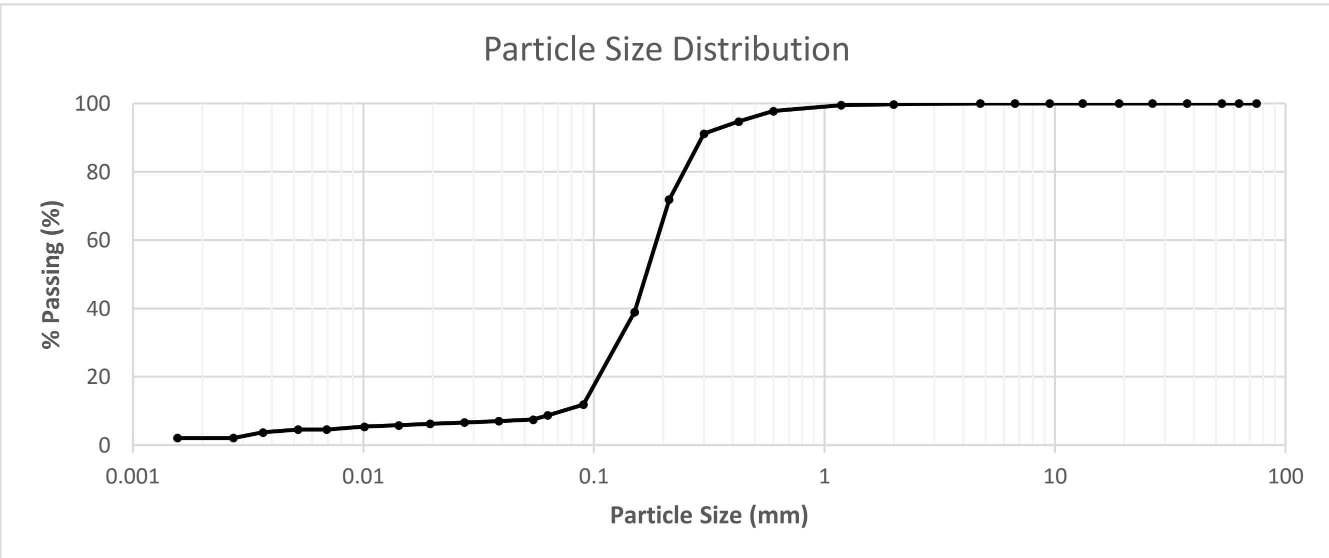
Test Results

Test Standard: NZS4402: 1986, Test 2.8.4

Dispersion: Sodium hexametaphosphate, pH = 9

Fraction Determined by Sieving			
Sieve Size mm	**% Passing**	**Sieve Size mm**	**% Passing**
75	100	2.00	100
63	100	1.18	99
53	100	0.600	98
37.5	100	0.425	95
26.5	100	0.300	91
19	100	0.212	72
13.2	100	0.150	39
9.5	100	0.090	12
6.7	100	0.063	9
4.75	100		

Fraction Determined by Hydrometer			
Particle Size mm	**% Passing**	**Particle Size mm**	**% Passing**
0.0546	7	0.0016	2
0.0387	7		
0.0274	7		
0.0195	6		
0.0142	6		
0.0101	5		
0.0069	5		
0.0052	5		
0.0037	4		
0.0027	2		



% Clay	% Silt	%Sand	% Gravel	Max. Size:
2	7	91	0	1.18mm

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Auckland 1061

PARTICLE SIZE DISTRIBUTION
WET SIEVE/HYDROMETER

Report No. **HYD: AKL25-00056-S01**

Issue No. 1

Client:	Watercare Services Ltd.
Project:	Raglan WWTP Consent
Project No:	4703642
Client Request ID:	4703642/112

ACCREDITED IANZ TESTING LABORATORY

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

Pritpal Singh
Authorised Signatory
14/04/2025

Sample Details

Sample ID:	AKL25-00056-S01	**Date Sampled:**	
Sampled By:		**Date Submitted:**	20/03/2024
Client Sample ID:	HA1	**Date Tested:**	9/04/2025
Location:	Raglan WWTP	**Soil Description:**	Clayey SILT
Depth (m):	0.5		
Tested by:	F.Perese / J.Jacobs / P.Singh		

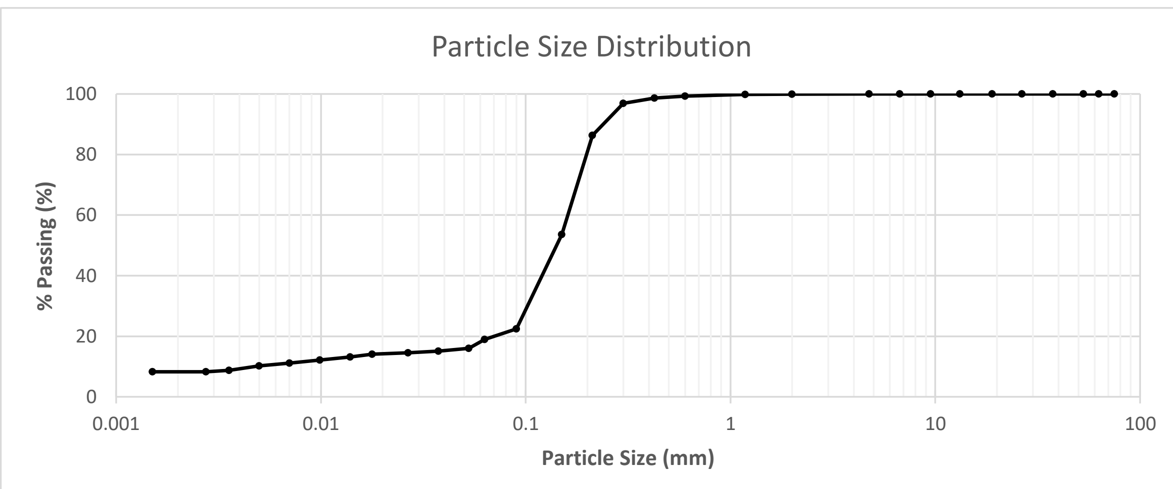
Test Results

Test Standard: NZS4402: 1986, Test 2.8.4

Dispersion: Sodium hexametaphosphate, pH = 9

Fraction Determined by Sieving			
Sieve Size mm	% Passing	Sieve Size mm	% Passing
75	100	2.00	100
63	100	1.18	100
53	100	0.600	99
37.5	100	0.425	99
26.5	100	0.300	97
19	100	0.212	86
13.2	100	0.150	54
9.5	100	0.090	22
6.7	100	0.063	19
4.75	100		

Fraction Determined by Hydrometer			
Particle Size mm	% Passing	Particle Size mm	% Passing
0.0528	16	0.0015	8
0.0376	15		
0.0266	15		
0.0178	14		
0.0139	13		
0.0099	12		
0.0070	11		
0.0050	10		
0.0036	9		
0.0027	8		



% Clay	% Silt	%Sand	% Gravel	Max. Size:
8	11	81	0	0.600mm

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PARTICLE SIZE DISTRIBUTION WET SIEVE/HYDROMETER

Report No. **HYD: AKL25-00056-S02**

Issue No. 1

Client:	Watercare Services Ltd.
Project:	Raglan WWTP Consent
Project No:	4703642
Client Request ID:	4703642/112

ACCREDITED IANZ TESTING LABORATORY

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

Pritpal Singh
Authorised Signatory
14/04/2025

Sample Details

Sample ID:	AKL25-00056-S02	**Date Sampled:**	
Sampled By:		**Date Submitted:**	20/03/2024
Client Sample ID:	DR1	**Date Tested:**	10/04/2025
Location:	Raglan WWTP	**Soil Description:**	Clayey SILT
Depth (m):	0		
Tested by:	P.Singh / F.Perese		

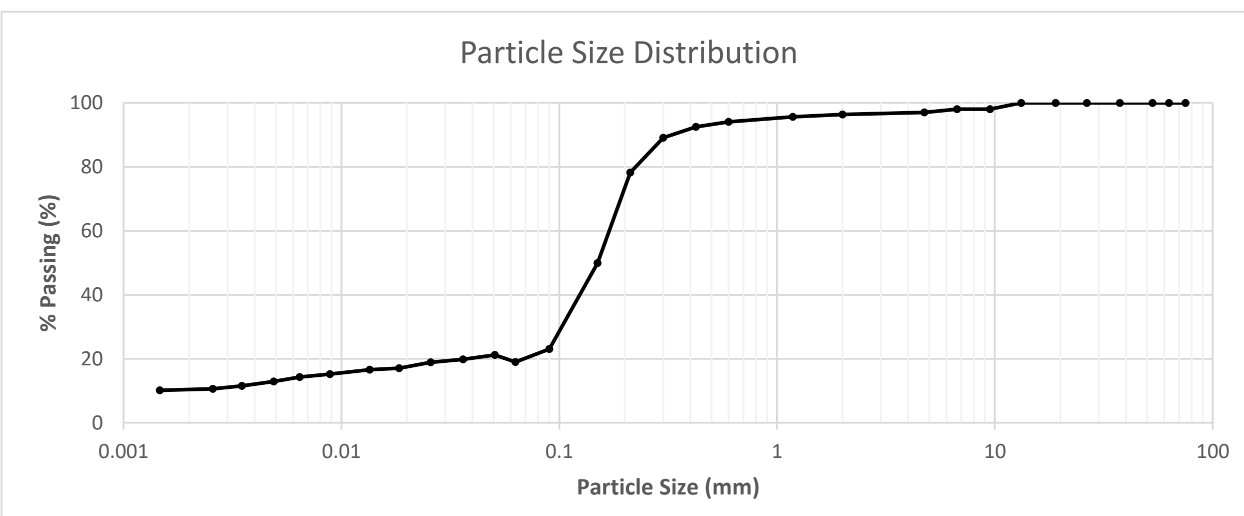
Test Results

Test Standard: NZS4402: 1986, Test 2.8.4

Dispersion: Sodium hexametaphosphate, pH = 9

Fraction Determined by Sieving			
Sieve Size mm	% Passing	Sieve Size mm	% Passing
75	100	2.00	96
63	100	1.18	96
53	100	0.600	94
37.5	100	0.425	92
26.5	100	0.300	89
19	100	0.212	78
13.2	100	0.150	50
9.5	98	0.090	23
6.7	98	0.063	19
4.75	97		

Fraction Determined by Hydrometer			
Particle Size mm	% Passing	Particle Size mm	% Passing
0.0506	21	0.0015	10
0.0361	20		
0.0257	19		
0.0184	17		
0.0135	17		
0.0089	15		
0.0064	14		
0.0049	13		
0.0035	12		
0.0026	11		



% Clay	% Silt	%Sand	% Gravel	Max. Size:
10	9	77	4	9.5mm

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Auckland 1061

PARTICLE SIZE DISTRIBUTION
WET SIEVE/HYDROMETER

Report No. **HYD: AKL25-00056-S03**

Issue No. 1

Client:	Watercare Services Ltd.
Project:	Raglan WWTP Consent
Project No:	4703642
Client Request ID:	4703642/112

ACCREDITED TESTING LABORATORY

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

Pritpal Singh
Authorised Signatory
14/04/2025

Sample Details

Sample ID:	AKL25-00056-S03	**Date Sampled:**	
Sampled By:		**Date Submitted:**	20/03/2024
Client Sample ID:	HA2	**Date Tested:**	9/04/2025
Location:	Raglan WWTP	**Soil Description:**	Clayey SILT
Depth (m):	0.5		
Tested by:	F.Perese / J.Jacobs / P.Singh		

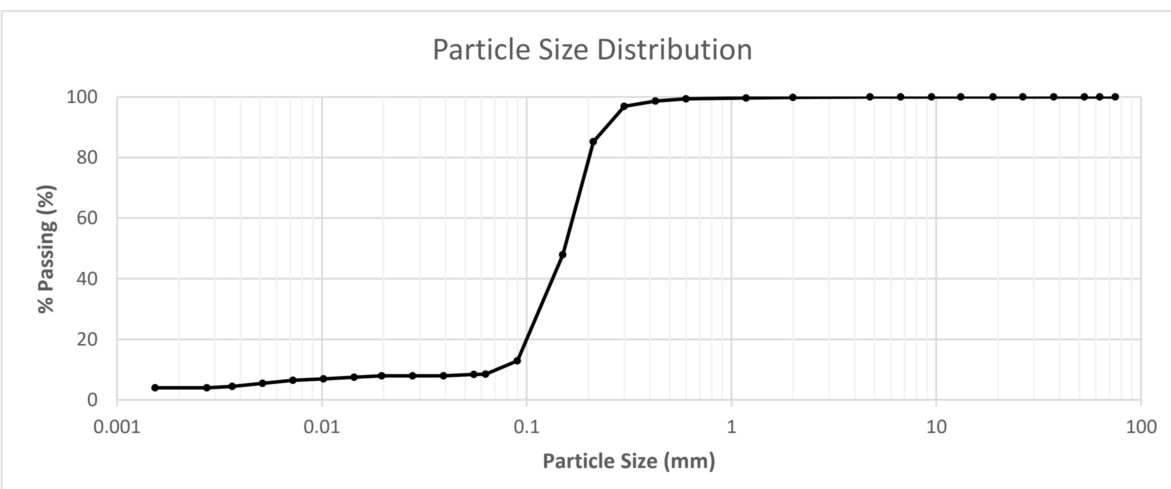
Test Results

Test Standard: NZS4402: 1986, Test 2.8.4

Dispersion: Sodium hexametaphosphate, pH = 9

Fraction Determined by Sieving			
Sieve Size mm	% Passing	Sieve Size mm	% Passing
75	100	2.00	100
63	100	1.18	100
53	100	0.600	99
37.5	100	0.425	99
26.5	100	0.300	97
19	100	0.212	85
13.2	100	0.150	48
9.5	100	0.090	13
6.7	100	0.063	8
4.75	100		

Fraction Determined by Hydrometer			
Particle Size mm	% Passing	Particle Size mm	% Passing
0.0554	8	0.0015	4
0.0393	8		
0.0278	8		
0.0196	8		
0.0144	7		
0.0102	7		
0.0072	6		
0.0051	5		
0.0037	4		
0.0028	4		



% Clay	% Silt	%Sand	% Gravel	Max. Size:
4	4	92	0	0.600mm

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Onehunga
Auckland 1061

PARTICLE SIZE DISTRIBUTION
WET SIEVE/HYDROMETER

Report No. **HYD: AKL25-00056-S04**

Issue No. 1

Client: Watercare Services Ltd.

Project: Raglan WWTP Consent

Project No: 4703642

Client Request ID: 4703642/112

ACCREDITED IANZ TESTING LABORATORY

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

Pritpal Singh
Authorised Signatory
14/04/2025

Sample Details

Sample ID: AKL25-00056-S04
Sampled By:
Client Sample ID: HA3
Location: Raglan WWTP
Depth (m): 0.2
Tested by: P.Singh / F.Perese / J.Jacobs

Date Sampled:
Date Submitted: 20/03/2024
Date Tested: 10/04/2025
Soil Description: Clayey SILT

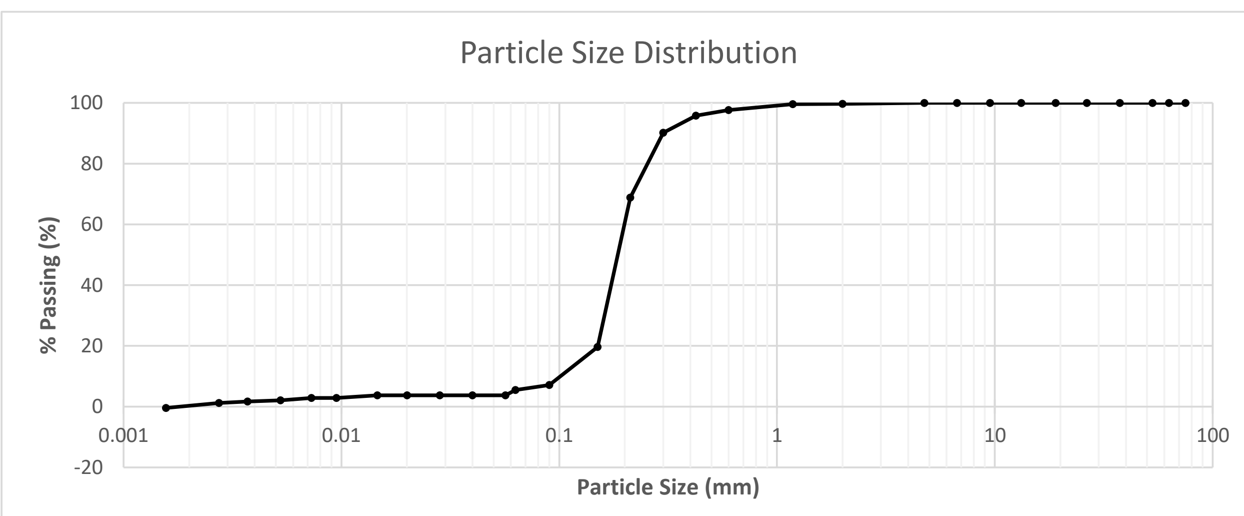
Test Results

Test Standard: NZS4402: 1986, Test 2.8.4

Dispersion: Sodium hexametaphosphate, pH = 9

Fraction Determined by Sieving			
Sieve Size mm	% Passing	Sieve Size mm	% Passing
75	100	2.00	100
63	100	1.18	100
53	100	0.600	98
37.5	100	0.425	96
26.5	100	0.300	90
19	100	0.212	69
13.2	100	0.150	20
9.5	100	0.090	7
6.7	100	0.063	5
4.75	100		

Fraction Determined by Hydrometer			
Particle Size mm	% Passing	Particle Size mm	% Passing
0.0566	4	0.0016	0
0.0400	4		
0.0283	4		
0.0200	4		
0.0146	4		
0.0095	3		
0.0073	3		
0.0053	2		
0.0037	2		
0.0027	1		



% Clay	% Silt	%Sand	% Gravel	Max. Size:
0	5	95	0	0.600mm

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PARTICLE SIZE DISTRIBUTION
WET SIEVE/HYDROMETER

Report No. **HYD: AKL25-00056-S05**

Issue No. 1

Client:	Watercare Services Ltd.
Project:	Raglan WWTP Consent
Project No:	4703642
Client Request ID:	4703642/112

ACCREDITED TESTING LABORATORY

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

Pritpal Singh
Authorised Signatory
14/04/2025

Sample Details

Sample ID: AKL25-00056-S05
Sampled By:
Client Sample ID: HA3
Location: Raglan WWTP
Depth (m): 1
Tested by: P.Singh / F.Perese / J.Jacobs

Date Sampled:
Date Submitted: 20/03/2024
Date Tested: 10/04/2025
Soil Description: Clayey SILT

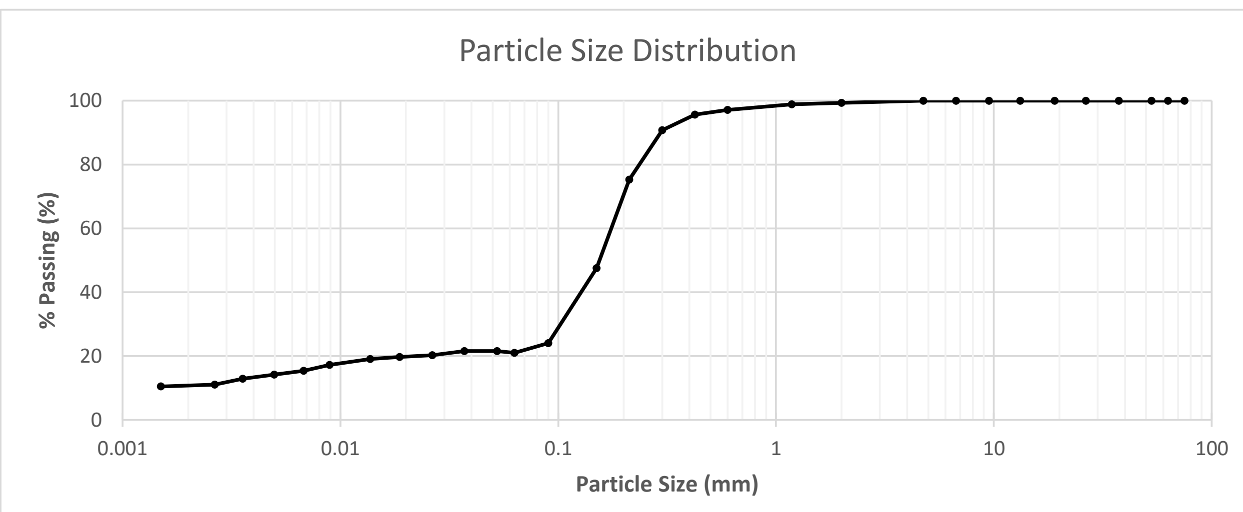
Test Results

Test Standard: NZS4402: 1986, Test 2.8.4

Dispersion: Sodium hexametaphosphate, pH = 9

Fraction Determined by Sieving			
Sieve Size mm	% Passing	Sieve Size mm	% Passing
75	100	2.00	99
63	100	1.18	99
53	100	0.600	97
37.5	100	0.425	96
26.5	100	0.300	91
19	100	0.212	75
13.2	100	0.150	47
9.5	100	0.090	24
6.7	100	0.063	21
4.75	100		

Fraction Determined by Hydrometer			
Particle Size mm	% Passing	Particle Size mm	% Passing
0.0525	22	0.0015	10
0.0371	22		
0.0264	20		
0.0187	20		
0.0137	19		
0.0089	17		
0.0068	15		
0.0050	14		
0.0036	13		
0.0027	11		



% Clay	% Silt	%Sand	% Gravel	Max. Size:
11	10	78	1	2.00mm

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PARTICLE SIZE DISTRIBUTION WET SIEVE/HYDROMETER

Report No. **HYD: AKL25-00056-S06**

Issue No. 1

Client:	Watercare Services Ltd.
Project:	Raglan WWTP Consent
Project No:	4703642
Client Request ID:	4703642/112

ACCREDITED IANZ TESTING LABORATORY

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

Pritpal Singh
Authorised Signatory
14/04/2025

Sample Details

Sample ID: AKL25-00056-S06
Sampled By:
Client Sample ID: HA4
Location: Raglan WWTP
Depth (m): 0.5
Tested by: P.Singh / F.Perese / J.Jacobs

Date Sampled:
Date Submitted: 20/03/2024
Date Tested: 10/04/2025
Soil Description: Silty SAND

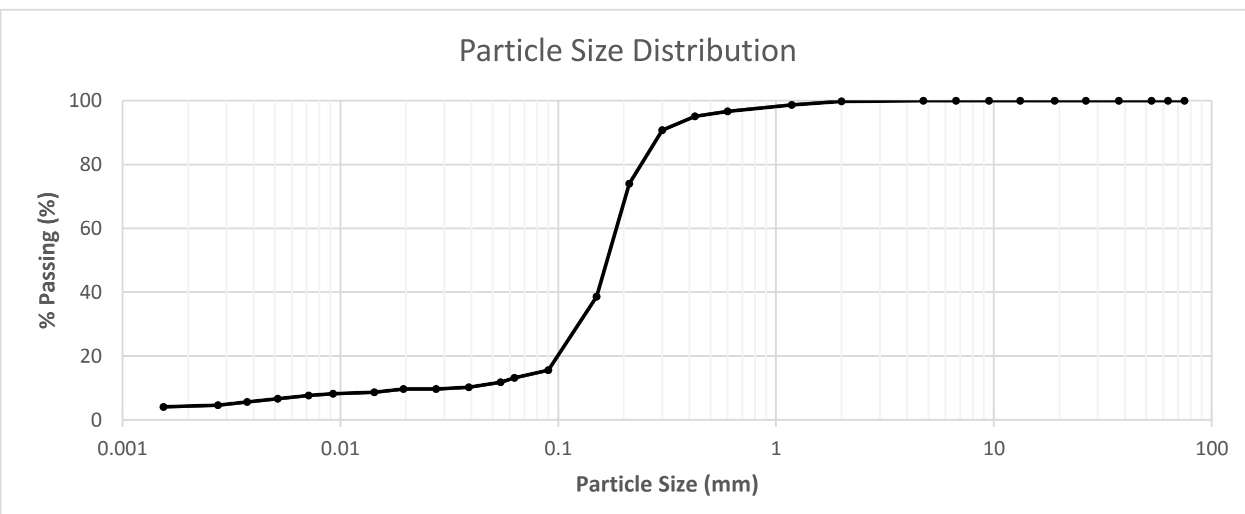
Test Results

Test Standard: NZS4402: 1986, Test 2.8.4

Dispersion: Sodium hexametaphosphate, pH = 9

Fraction Determined by Sieving			
Sieve Size mm	% Passing	Sieve Size mm	% Passing
75	100	2.00	100
63	100	1.18	99
53	100	0.600	97
37.5	100	0.425	95
26.5	100	0.300	91
19	100	0.212	74
13.2	100	0.150	39
9.5	100	0.090	16
6.7	100	0.063	13
4.75	100		

Fraction Determined by Hydrometer			
Particle Size mm	% Passing	Particle Size mm	% Passing
0.0544	12	0.0015	4
0.0388	10		
0.0275	10		
0.0195	10		
0.0143	9		
0.0093	8		
0.0072	8		
0.0052	7		
0.0037	6		
0.0027	5		



% Clay	% Silt	%Sand	% Gravel	Max. Size:
4	9	87	0	1.18mm

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PARTICLE SIZE DISTRIBUTION
WET SIEVE/HYDROMETER

Report No. **HYD: AKL25-00056-S07**

Issue No. 1

Client:	Watercare Services Ltd.
Project:	Raglan WWTP Consent
Project No:	4703642
Client Request ID:	4703642/112

ACCREDITED IANZ TESTING LABORATORY

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

Pritpal Singh
Authorised Signatory
14/04/2025

Sample Details

Sample ID:	AKL25-00056-S07	**Date Sampled:**	
Sampled By:		**Date Submitted:**	20/03/2024
Client Sample ID:	HA4	**Date Tested:**	10/04/2025
Location:	Raglan WWTP	**Soil Description:**	Silty SAND
Depth (m):	1.2		
Tested by:	P.Singh / F.Perese / J.Jacobs		

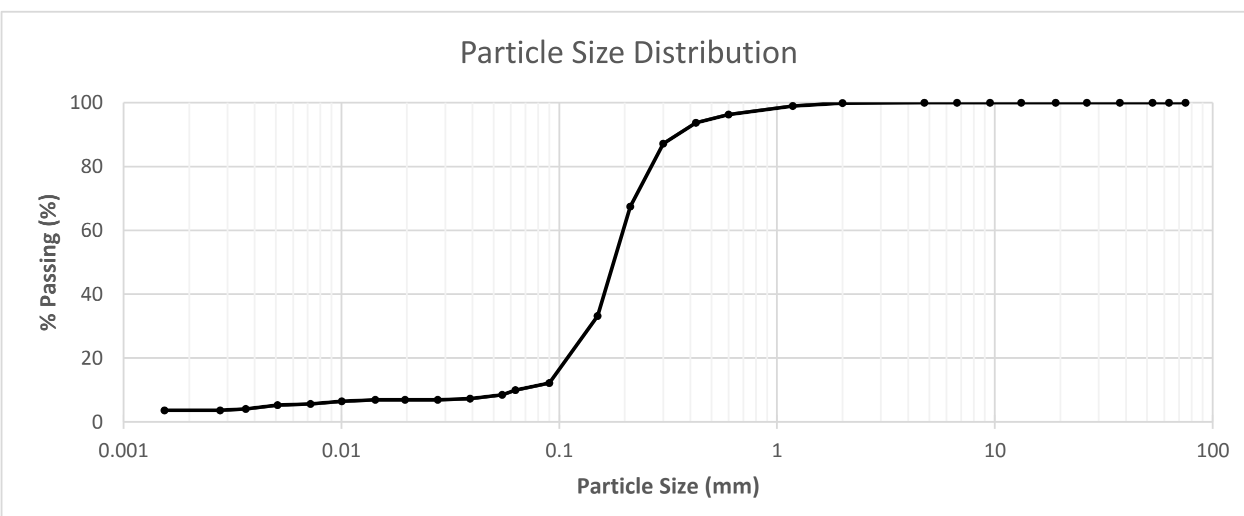
Test Results

Test Standard: NZS4402: 1986, Test 2.8.4

Dispersion: Sodium hexametaphosphate, pH = 9

Fraction Determined by Sieving			
Sieve Size mm	**% Passing**	**Sieve Size mm**	**% Passing**
75	100	2.00	100
63	100	1.18	99
53	100	0.600	96
37.5	100	0.425	94
26.5	100	0.300	87
19	100	0.212	67
13.2	100	0.150	33
9.5	100	0.090	12
6.7	100	0.063	10
4.75	100		

Fraction Determined by Hydrometer			
Particle Size mm	**% Passing**	**Particle Size mm**	**% Passing**
0.0547	8	0.0015	4
0.0390	7		
0.0277	7		
0.0196	7		
0.0143	7		
0.0101	6		
0.0072	6		
0.0051	5		
0.0036	4		
0.0028	4		



% Clay	% Silt	%Sand	% Gravel	Max. Size:
4	6	90	0	1.18mm

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293 Church Street
Onehunga
Auckland 1061

PARTICLE SIZE DISTRIBUTION
WET SIEVE/HYDROMETER

Report No. **HYD: AKL25-00056-S08**

Issue No. 1

Client:	Watercare Services Ltd.
Project:	Raglan WWTP Consent
Project No:	4703642
Client Request ID:	4703642/112

ACCREDITED TESTING LABORATORY

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

Pritpal Singh
Authorised Signatory
14/04/2025

Sample Details

Sample ID:	AKL25-00056-S08	**Date Sampled:**	
Sampled By:		**Date Submitted:**	20/03/2024
Client Sample ID:	DR2	**Date Tested:**	10/04/2025
Location:	Raglan WWTP	**Soil Description:**	SAND
Depth (m):	0		
Tested by:	P.Singh / F.Perese / J.Jacobs		

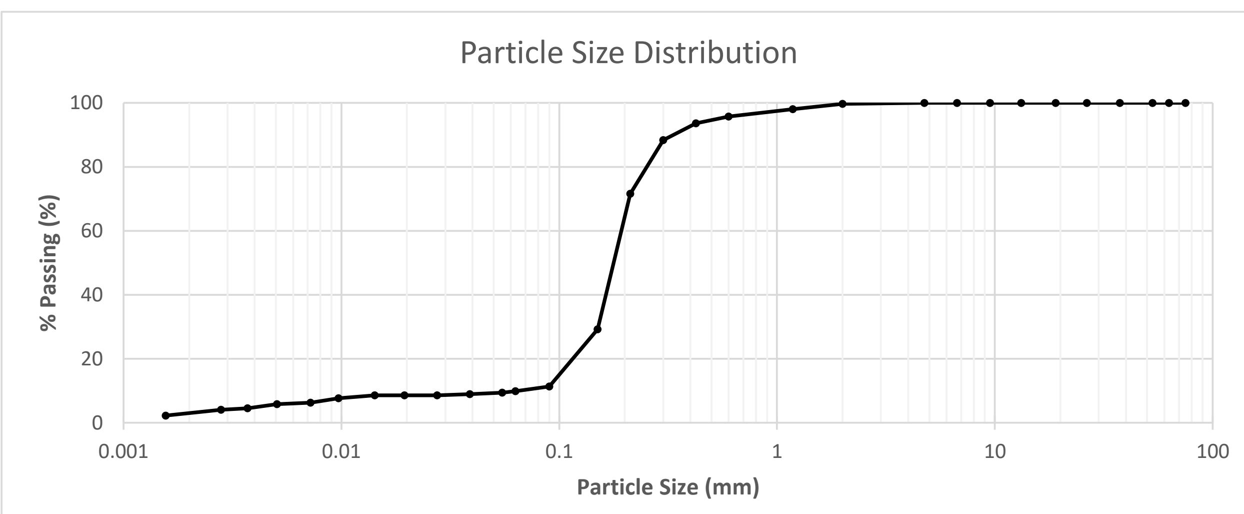
Test Results

Test Standard: NZS4402: 1986, Test 2.8.4

Dispersion: Sodium hexametaphosphate, pH = 9

Fraction Determined by Sieving			
Sieve Size mm	**% Passing**	**Sieve Size mm**	**% Passing**
75	100	2.00	100
63	100	1.18	98
53	100	0.600	96
37.5	100	0.425	94
26.5	100	0.300	88
19	100	0.212	72
13.2	100	0.150	29
9.5	100	0.090	11
6.7	100	0.063	10
4.75	100		

Fraction Determined by Hydrometer			
Particle Size mm	**% Passing**	**Particle Size mm**	**% Passing**
0.0547	9	0.0016	2
0.0388	9		
0.0275	9		
0.0195	9		
0.0142	9		
0.0097	8		
0.0072	6		
0.0051	6		
0.0037	4		
0.0028	4		



% Clay	% Silt	%Sand	% Gravel	Max. Size:
3	7	90	0	1.18mm

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Onehunga
Auckland 1061

PARTICLE SIZE DISTRIBUTION
WET SIEVE/HYDROMETER

Report No. **HYD: AKL25-00056-S09**

Issue No. 1

Client:	Watercare Services Ltd.
Project:	Raglan WWTP Consent
Project No:	4703642
Client Request ID:	4703642/112

ACCREDITED IANZ TESTING LABORATORY

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

Pritpal Singh
Authorised Signatory
14/04/2025

Sample Details

Sample ID: AKL25-00056-S09
Sampled By:
Client Sample ID: HA6
Location: Raglan WWTP
Depth (m): 0
Tested by: P.Singh / F.Perese / J.Jacobs

Date Sampled:
Date Submitted: 20/03/2024
Date Tested: 10/04/2025
Soil Description: SAND

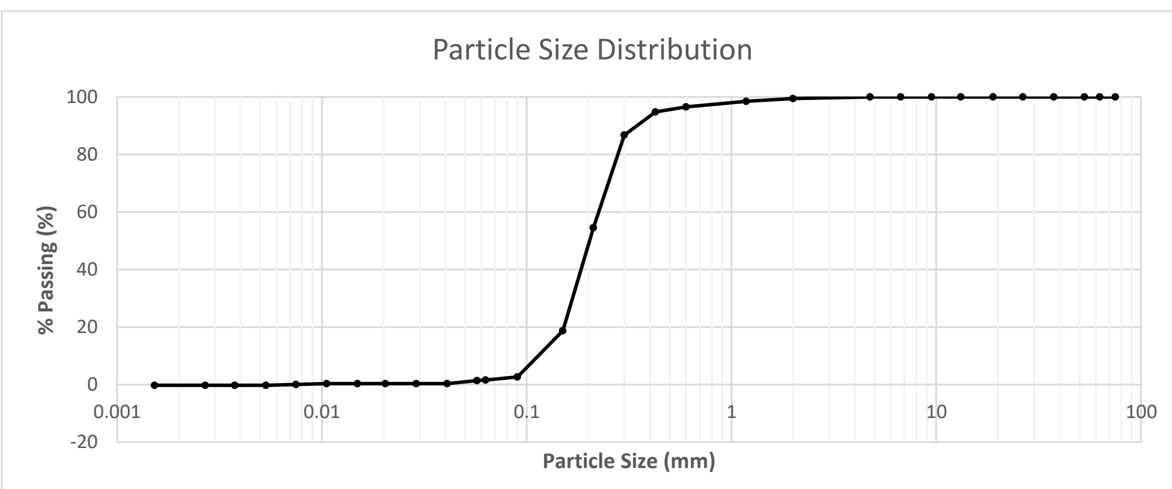
Test Results

Test Standard: NZS4402: 1986, Test 2.8.4

Dispersion: Sodium hexametaphosphate, pH = 9

Fraction Determined by Sieving			
Sieve Size mm	% Passing	Sieve Size mm	% Passing
75	100	2.00	99
63	100	1.18	98
53	100	0.600	97
37.5	100	0.425	95
26.5	100	0.300	87
19	100	0.212	55
13.2	100	0.150	19
9.5	100	0.090	3
6.7	100	0.063	2
4.75	100		

Fraction Determined by Hydrometer			
Particle Size mm	% Passing	Particle Size mm	% Passing
0.0572	1	0.0015	0
0.0409	0		
0.0289	0		
0.0205	0		
0.0149	0		
0.0106	0		
0.0075	0		
0.0053	0		
0.0038	0		
0.0027	0		



% Clay	% Silt	%Sand	% Gravel	Max. Size:
0	2	97	1	2.00mm

D

Appendix D – Estimation of Permeability Based on PSD Analysis

Estimation of Permeability based on PSD Analysis

The possibility of obtaining concrete values for the passing of small granulometric diameters (d10 and d20) allows the application of analytical estimation methods that provide specific quantitative results. These are the Hazen Method (1911) and the Kasenow Method (2002).

The estimation of permeability values applying the method of the U.S. Bureau of Reclamation (Kasenow, 2002), collected in "Determination of Hydraulic Conductivity from Grain Size Analysis," Kasenow, M. 2002. pg. 83, is based on the less restrictive diameter d20, using the following expression:

$$K\ (m/day) = 311 \cdot d20^{\,2.3}$$

where d20 corresponds to the diameter (in mm) that allows 20% of the grains in the sample to pass through. The result obtained is given in meters per day (m/day).

Table 1 Permeability estimations based on Kasenow (d20

PERMEABILITY ESTIMATION (Kasenow 2002)				
ID	**Depth (m)**	**d_{20} (mm)**	**K (m/day)**	**K (m/s)**
HA2	0.5-1.0	0.068	**6.42E-01**	**7.43E-06**
HA2	1.5-2	0.14	**3.38E+00**	**3.91E-05**
HA3	0.0-0.5	0.042	**2.12E-01**	**2.45E-06**
HA3	0.5-1.0	-	**-**	**-**
HA3	1.0-1.5	-	**-**	**-**
HA4	0.0-0.75	0.11	**1.94E+00**	**2.25E-05**
HA4	0.75-1.0	0.11	**1.94E+00**	**2.25E-05**
HA4	0.0-0.75	0.11	**1.94E+00**	**2.25E-05**
HA4	0.75-1.0	0.11	**1.94E+00**	**2.25E-05**
HA5	0.5-0.6	0.06	**4.81E-01**	**5.57E-06**
DR1	0-0.1	0.0361	**1.50E-01**	**1.73E-06**
HA6	0.5-0.6	0.12	**2.37E+00**	**2.74E-05**
HA7	0.2-0.3	0.15	**3.96E+00**	**4.58E-05**
HA7	1.0-1.1	0.0266	**7.41E-02**	**8.58E-07**
HA8	0.5-0.6	0.1	**1.56E+00**	**1.80E-05**
HA8	1.2-1.3	0.12	**2.37E+00**	**2.74E-05**
DR2	0-0.1	0.12	**2.37E+00**	**2.74E-05**
HA10	0.1-0.2	0.16	**4.59E+00**	**5.32E-05**

*: d_{10} value was inferred from the curve

In contrast, the Hazen Formula (1911) (in Weight, 2008) provides more precise values, as it is based on d10. However, granulometric analyses that yield this diameter are scarce within conventional geotechnical analyses (often requiring granulometry by sedimentation):

$$K\ (m/day) = 8{,}64 \cdot C \cdot d10^{2}$$

where d10 corresponds to the diameter (in mm) that allows 10% of the grains in the sample to pass through, and C is a coefficient that depends on the grain size and the uniformity U, which in turn is defined as:

$$U = d60 / d10$$

where d60 corresponds to the diameter (in mm) that allows 60% of the grains in the sample to pass through. Sediment is considered poorly graded for values of U > 6 (non-uniform and heterogeneous); conversely, it is considered well graded for U < 3 (uniform, homogeneous).

Considering the values of parameter U and the predominant granulometry of the sample, the Hazen coefficient C is finally estimated according to the following graph (constructed based on numerical values - Weight, 2008).

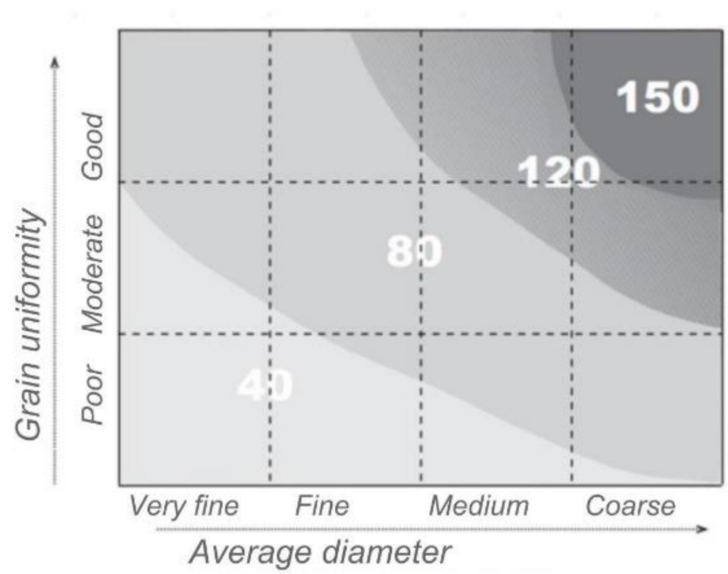


Figure 1 Chart for estimating Hazen's coefficient C (drawn based on numerical values from Weight, 2008).

Table 2 Permeability estimations based on Hazen (d10)

PERMEABILITY ESTIMATION (Hazen (1911) in Weight (2008))							
ID	**Depth (m)**	**d_{10} (mm)**	**d_{60} (mm)**	**U**	**C**	**K (m/day)**	**K (m/s)**
HA2	0.5-1.0	0.06	0.095	1.58	100	**3.11E+00**	**3.60E-05**
HA2	1.5-2	0.1	0.17	1.70	100	**8.64E+00**	**1.00E-04**
HA3	0.0-0.5	0.001*	0.12	120.00	50	**4.32E-04**	**5.00E-09**
HA3	0.5-1.0	-	-	-	-	**-**	**-**
HA3	1.0-1.5	-	-	-	-	**-**	**-**
HA4	0.0-0.75	0.085	0.17	2.00	100	**6.24E+00**	**7.23E-05**

HA4	0.75-1.0	0.08	0.17	2.13	100	**5.53E+00**	**6.40E-05**
HA4	0.0-0.75	0.085	0.17	2.00	100	**6.24E+00**	**7.23E-05**
HA4	0.75-1.0	0.08	0.17	2.13	100	**5.53E+00**	**6.40E-05**
HA5	0.5-0.6	0.0052	0.15	28.85	40	**9.35E-03**	**1.08E-07**
DR1	0-0.1	0.0014	0.18	128.57	40	**6.77E-04**	**7.84E-09**
HA6	0.5-0.6	0.08	0.16	2.00	100	**5.53E+00**	**6.40E-05**
HA7	0.2-0.3	0.1	0.2	2.00	100	**8.64E+00**	**1.00E-04**
HA7	1.0-1.1	0.0014	0.18	128.57	40	**6.77E-04**	**7.84E-09**
HA8	0.5-0.6	0.0387	0.18	4.65	80	**1.04E+00**	**1.20E-05**
HA8	1.2-1.3	0.063	0.199	3.16	80	**2.74E+00**	**3.18E-05**
DR2	0-0.1	0.063	0.19	3.02	80	**2.74E+00**	**3.18E-05**
HA10	0.1-0.2	0.11	0.23	2.09	100	**1.05E+01**	**1.21E-04**

Of all available granulometric analyses, only those whose curves intersected or closely approached diameters d10 and/or d20 were deemed suitable for the application of these two analytical methods. The remainder were ineffective for such estimations, as permeability is primarily determined by the finest granulometric fraction, thus restricting the applicability to Breddin's Abacus (1963).

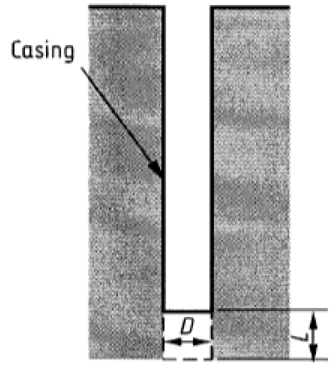
Additionally, attention is drawn to the type of mean used for the values—logarithmic rather than arithmetic. When comparing different orders of magnitude, the use of linear means (such as arithmetic) assigns a weight 10 times greater to the maximum value obtained, compared to those of an immediately lower order of magnitude (and successively). In this sense, the average value obtained would be clearly overestimated if calculated linearly (arithmetic mean), and its order of magnitude would tend to approximate that of the maximum individual value within the data population.

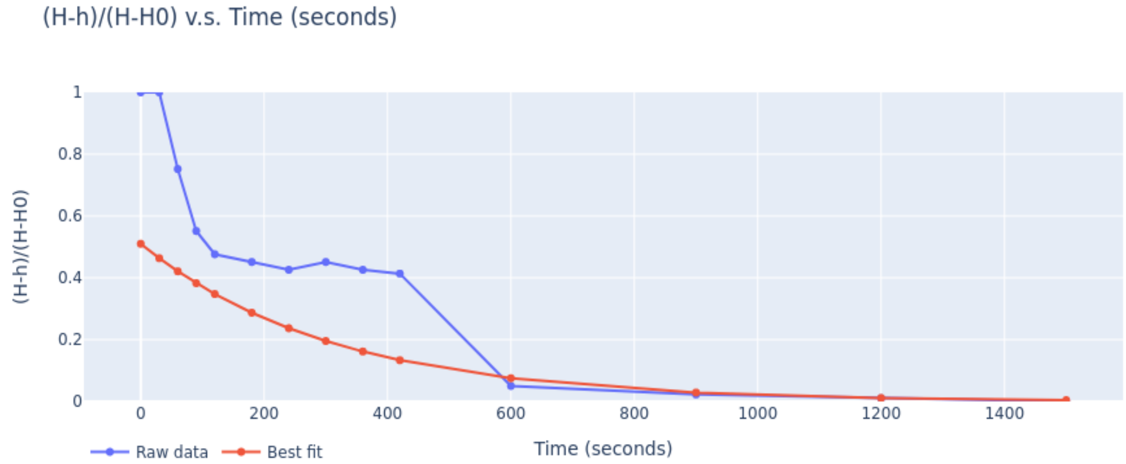
E

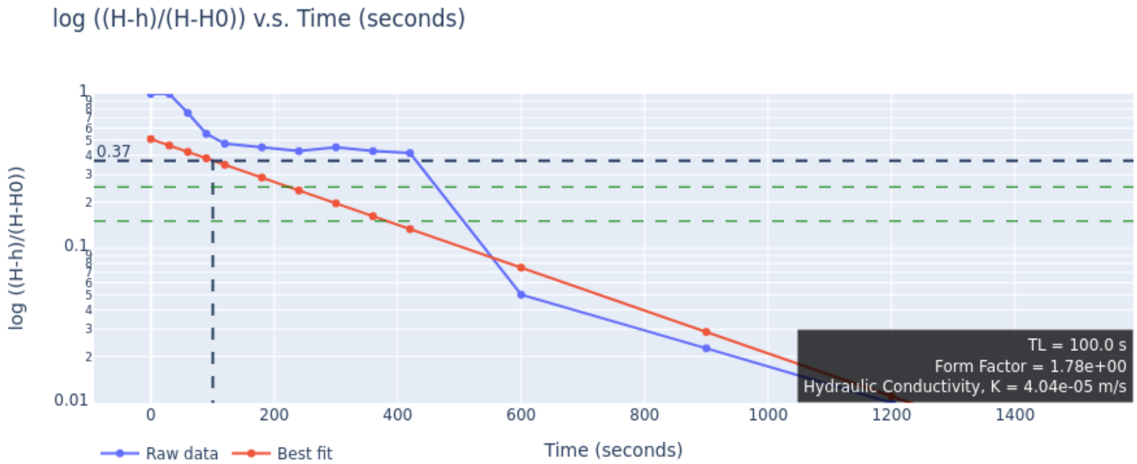
Appendix E – Falling Head Conductivity Tests Results

Falling Head Test Analysis – BH02 (1)

Parameter	Value
Inputs	
Test Configuration	Well point or hole extended in uniform soil
Casing / Inner Diameter	96mm
Gravel Pack / Hole Diameter	96mm
Screen Length	0.8m
Top of Screen	0.2mbgl
Base of Screen	1mbgl
Top of Casing	0m
Standing Water Level Below Top of Casing	0.4mbTOC
Results	
Time Lag Factor	100.0s
Form Factor	1.78e+00
Hydraulic Conductivity	4.04e-05m/s

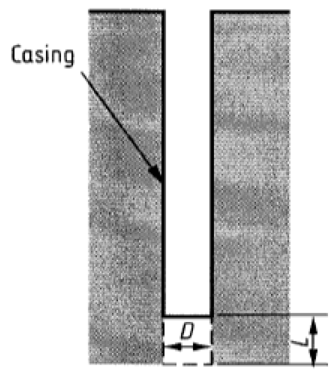




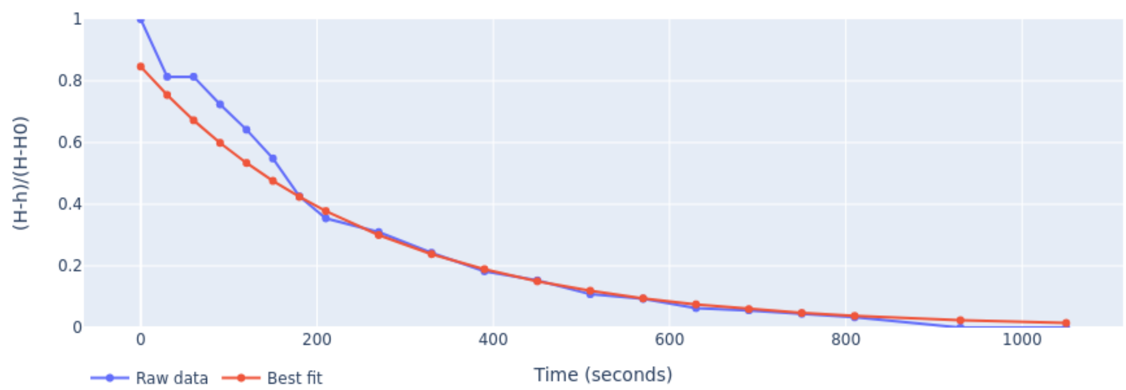


Falling Head Test Analysis – BH02 (2)

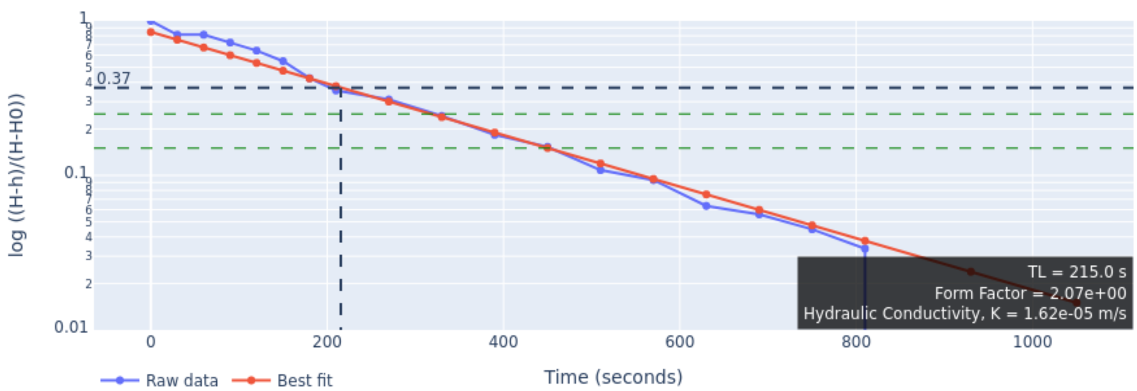
Parameter	Value
Inputs	
Test Configuration	Well point or hole extended in uniform soil
Casing / Inner Diameter	96mm
Gravel Pack / Hole Diameter	96mm
Screen Length	1m
Top of Screen	4mbgl
Base of Screen	5mbgl
Top of Casing	0m
Standing Water Level Below Top of Casing	2.78mbTOC
Results	
Time Lag Factor	215.0s
Form Factor	2.07e+00
Hydraulic Conductivity	1.62e-05m/s



(H-h)/(H-H0) v.s. Time (seconds)

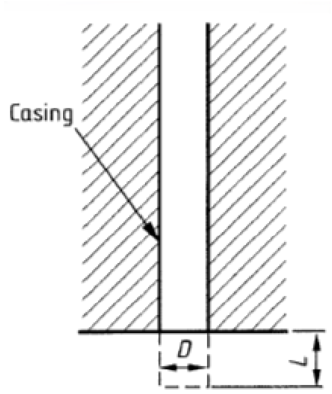


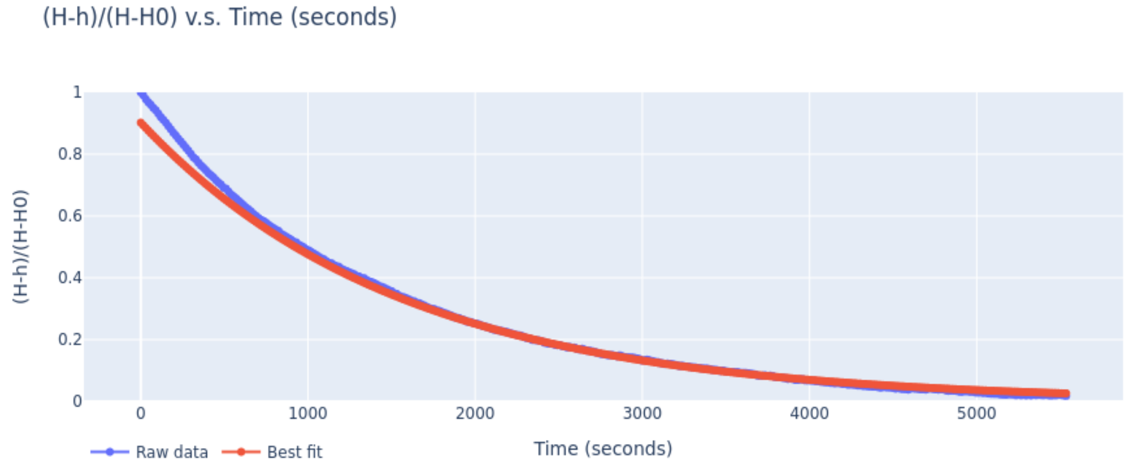
log ((H-h)/(H-H0)) v.s. Time (seconds)

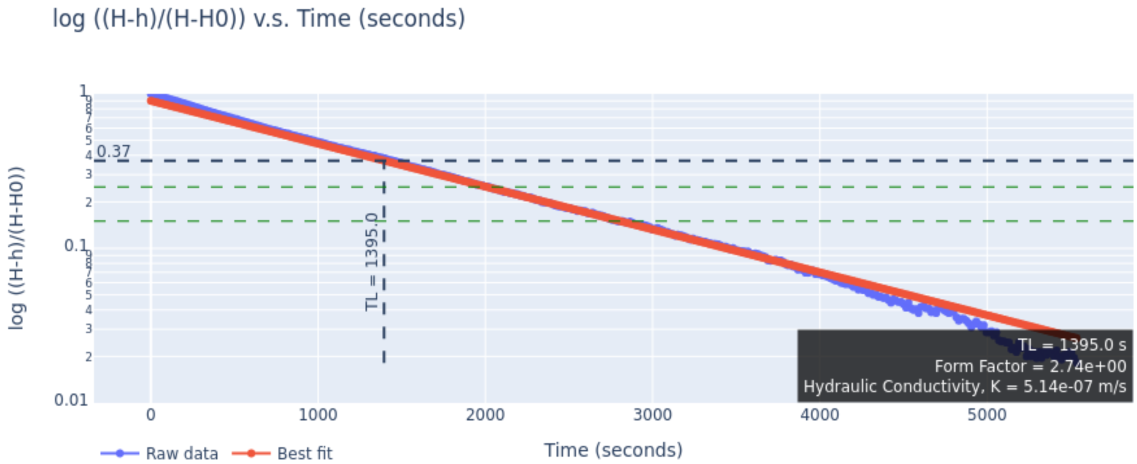


Falling Head Test Analysis – HA2

Parameter	Value
Inputs	
Test Configuration	Well point or hole extended at impervious boundary
Casing / Inner Diameter	50mm
Gravel Pack / Hole Diameter	50mm
Screen Length	2m
Top of Screen	0mbgl
Base of Screen	2mbgl
Top of Casing	0m
Standing Water Level Below Top of Casing	0.32mbTOC
Results	
Time Lag Factor	1395.0s
Form Factor	2.74e+00
Hydraulic Conductivity	5.14e-07m/s

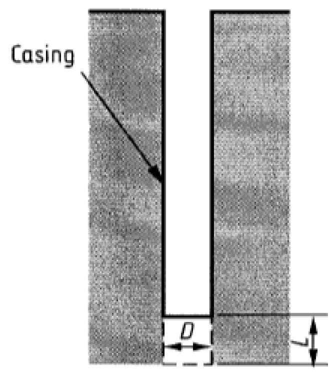




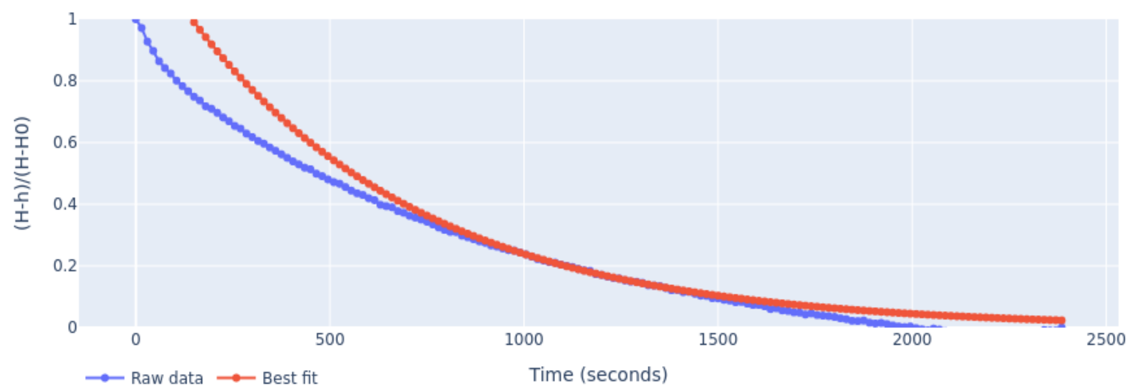


Falling Head Test Analysis – HA3

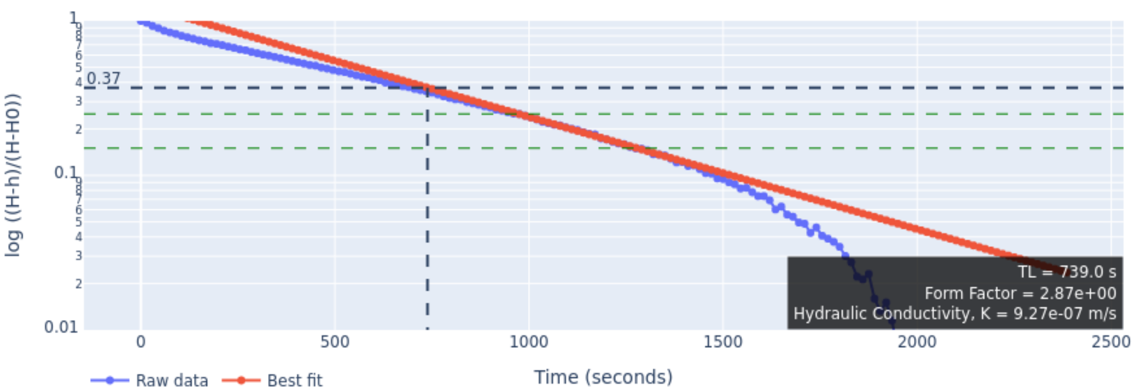
Parameter	Value
Inputs	
Test Configuration	Well point or hole extended in uniform soil
Casing / Inner Diameter	50mm
Gravel Pack / Hole Diameter	50mm
Screen Length	2m
Top of Screen	0mbTOC
Base of Screen	2mbTOC
Top of Casing	0m
Standing Water Level Below Top of Casing	0.27mbTOC
Results	
Time Lag Factor	739.0s
Form Factor	2.87e+00
Hydraulic Conductivity	9.27e-07m/s



(H-h)/(H-H0) v.s. Time (seconds)

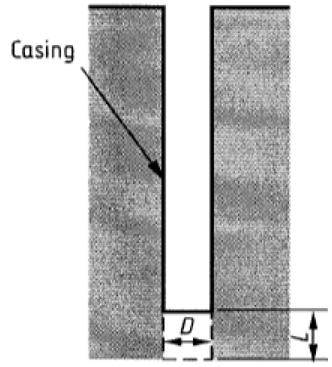


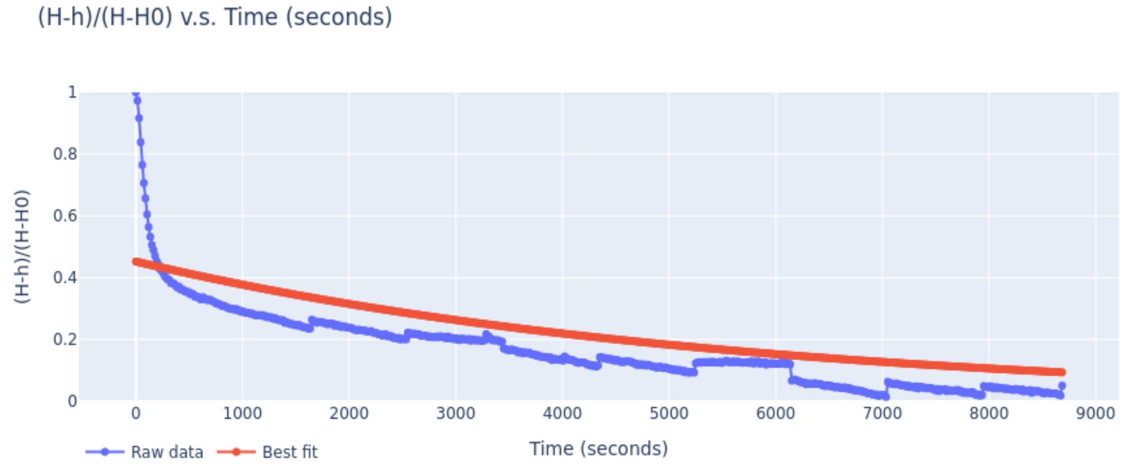
log ((H-h)/(H-H0)) v.s. Time (seconds)

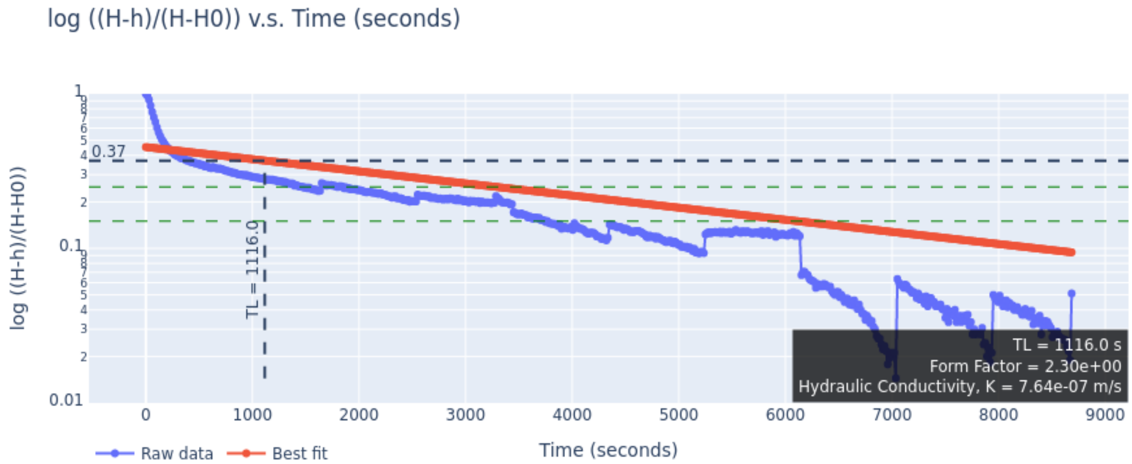


Falling Head Test Analysis – HA6

Parameter	Value
Inputs	
Test Configuration	Well point or hole extended in uniform soil
Casing / Inner Diameter	50mm
Gravel Pack / Hole Diameter	50mm
Screen Length	1.5m
Top of Screen	0mbTOC
Base of Screen	1.5mbTOC
Top of Casing	0m
Standing Water Level Below Top of Casing	0.18mbTOC
Results	
Time Lag Factor	1116.0s
Form Factor	2.30e+00
Hydraulic Conductivity	7.64e-07m/s

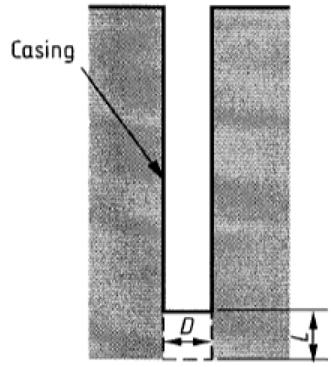


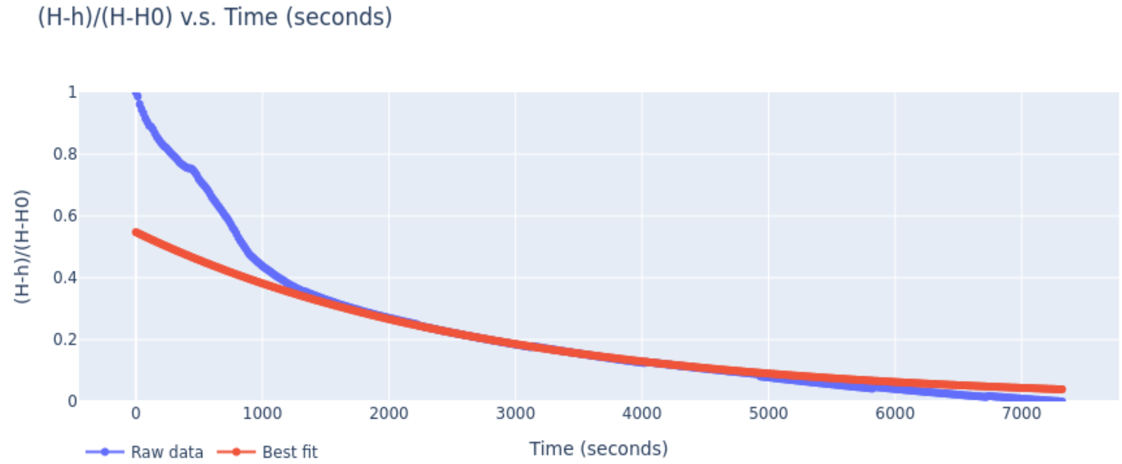


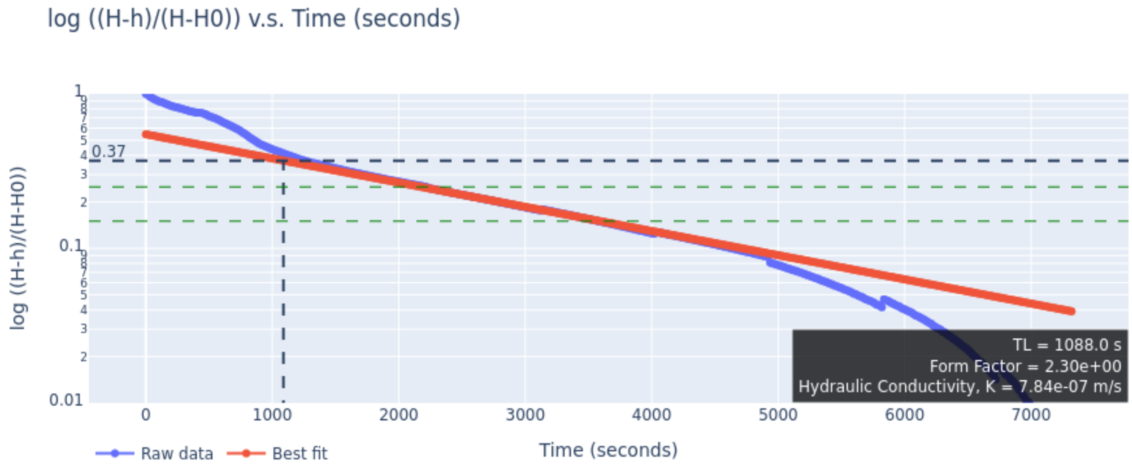


Falling Head Test Analysis – HA7

Parameter	Value
Inputs	
Test Configuration	Well point or hole extended in uniform soil
Casing / Inner Diameter	50mm
Gravel Pack / Hole Diameter	50mm
Screen Length	1.5m
Top of Screen	0mbTOC
Base of Screen	1.5mbTOC
Top of Casing	0m
Standing Water Level Below Top of Casing	1.44mbTOC
Results	
Time Lag Factor	1088.0s
Form Factor	2.30e+00
Hydraulic Conductivity	7.84e-07m/s

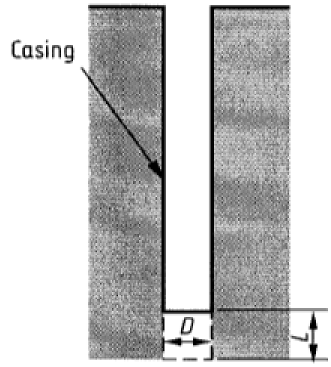


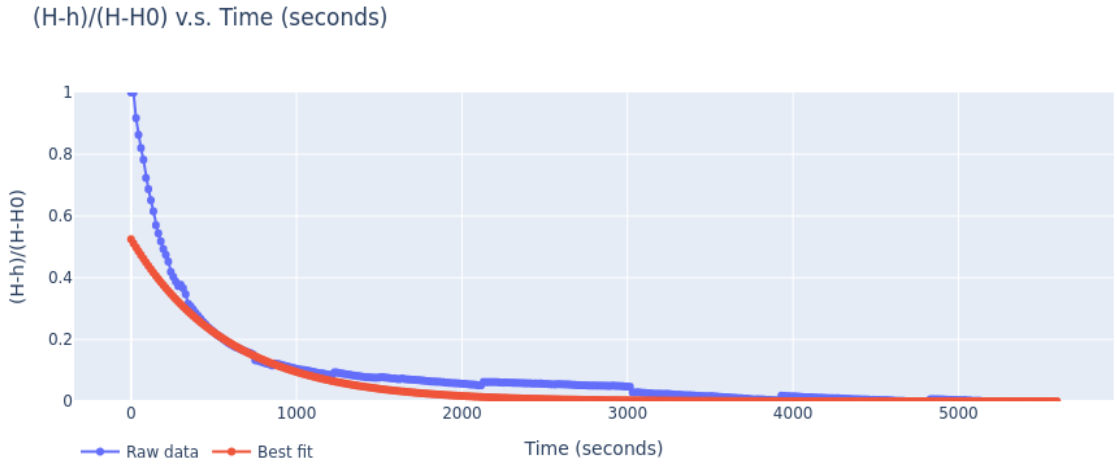


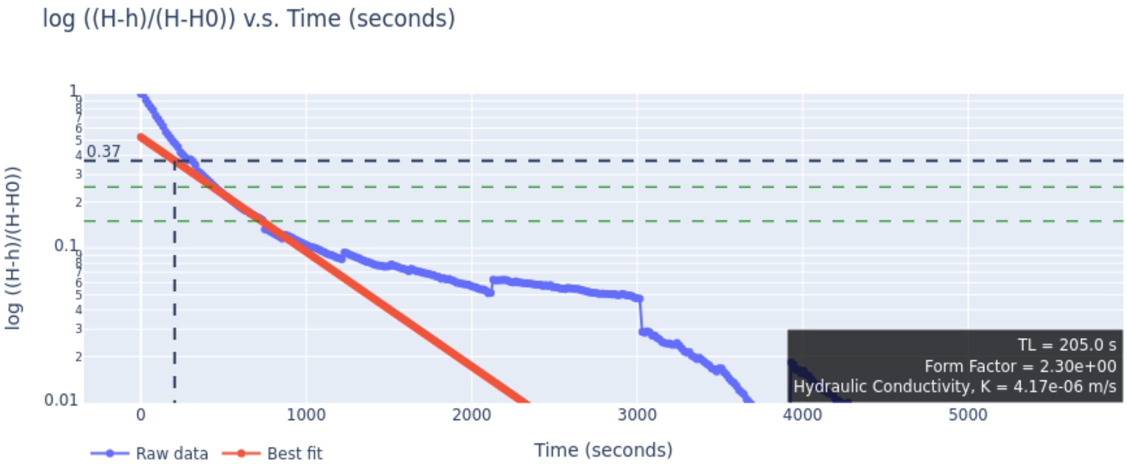


Falling Head Test Analysis – HA8

Parameter	Value
Inputs	
Test Configuration	Well point or hole extended in uniform soil
Casing / Inner Diameter	50mm
Gravel Pack / Hole Diameter	50mm
Screen Length	1.5m
Top of Screen	0mbTOC
Base of Screen	1.5mbTOC
Top of Casing	0m
Standing Water Level Below Top of Casing	0.52mbTOC
Results	
Time Lag Factor	205.0s
Form Factor	2.30e+00
Hydraulic Conductivity	4.17e-06m/s

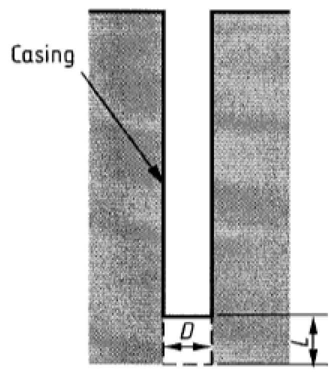


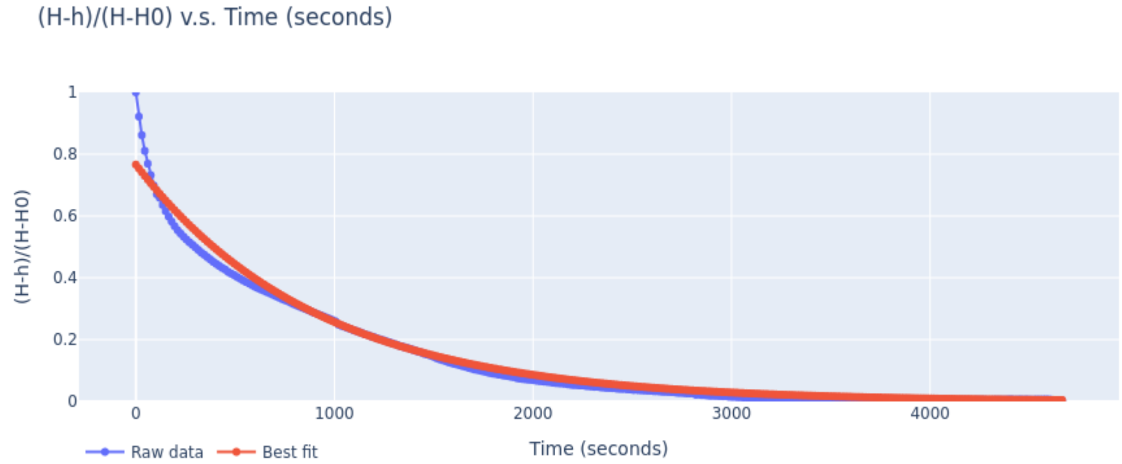


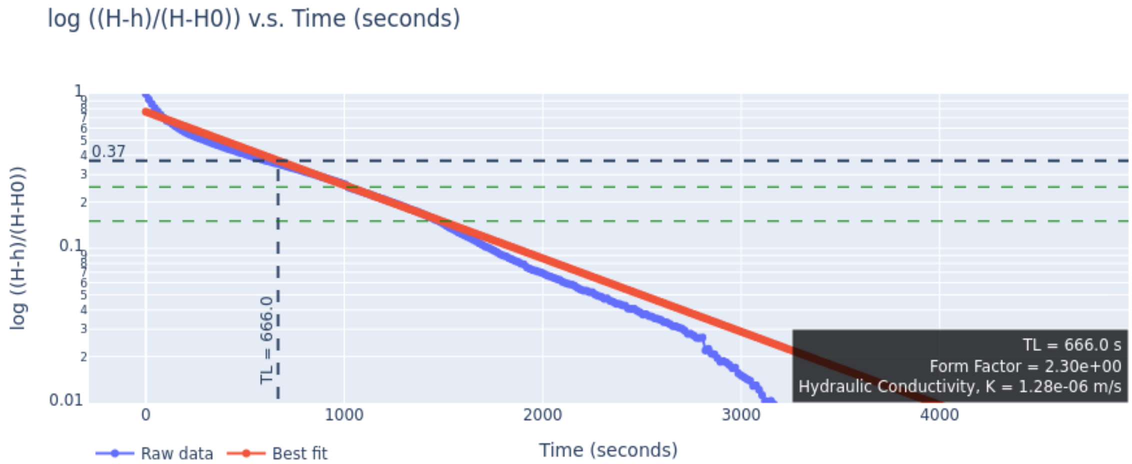


Falling Head Test Analysis – HA9

Parameter	Value
Inputs	
Test Configuration	Well point or hole extended in uniform soil
Casing / Inner Diameter	50mm
Gravel Pack / Hole Diameter	50mm
Screen Length	1.5m
Top of Screen	0mbTOC
Base of Screen	1.5mbTOC
Top of Casing	0m
Standing Water Level Below Top of Casing	0.97mbTOC
Results	
Time Lag Factor	666.0s
Form Factor	2.30e+00
Hydraulic Conductivity	1.28e-06m/s



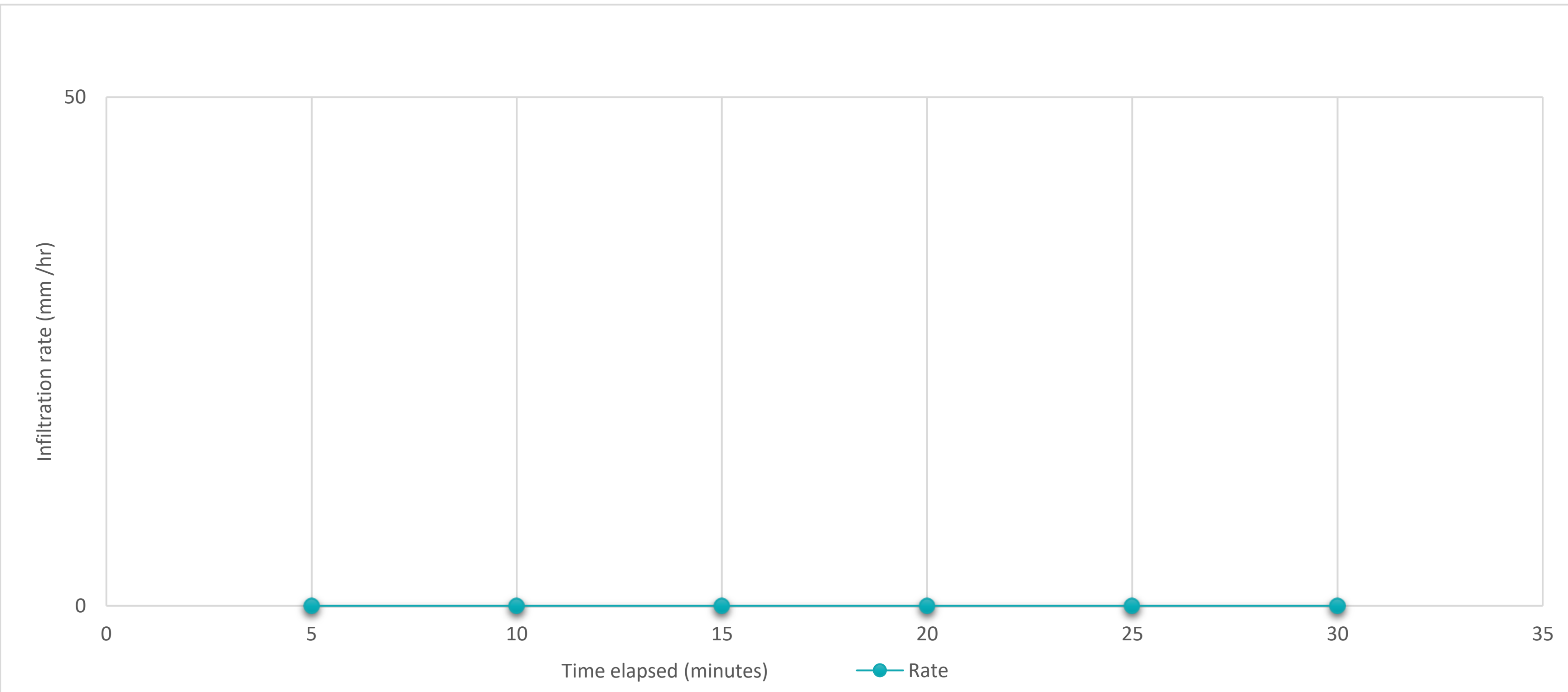




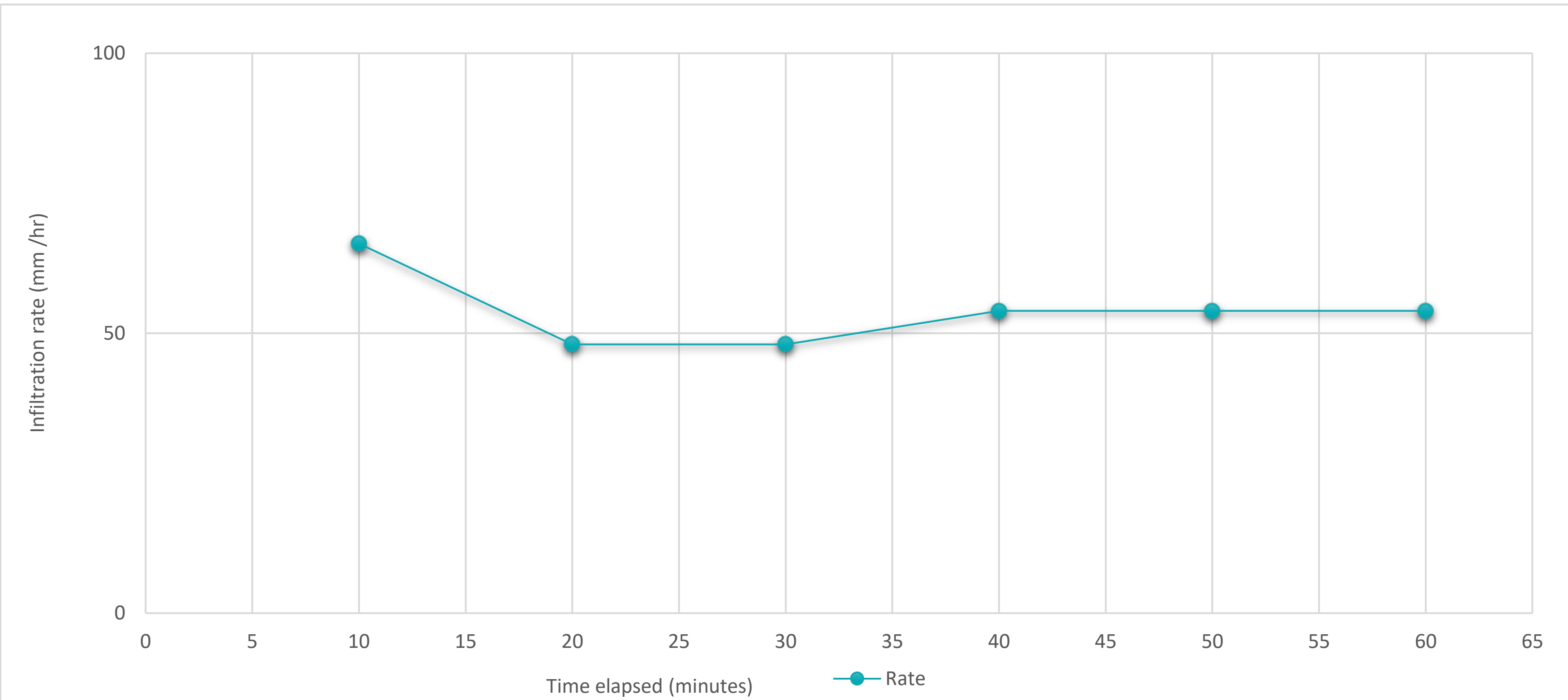
F

Appendix F – Double Ring Infiltration Test Field Results

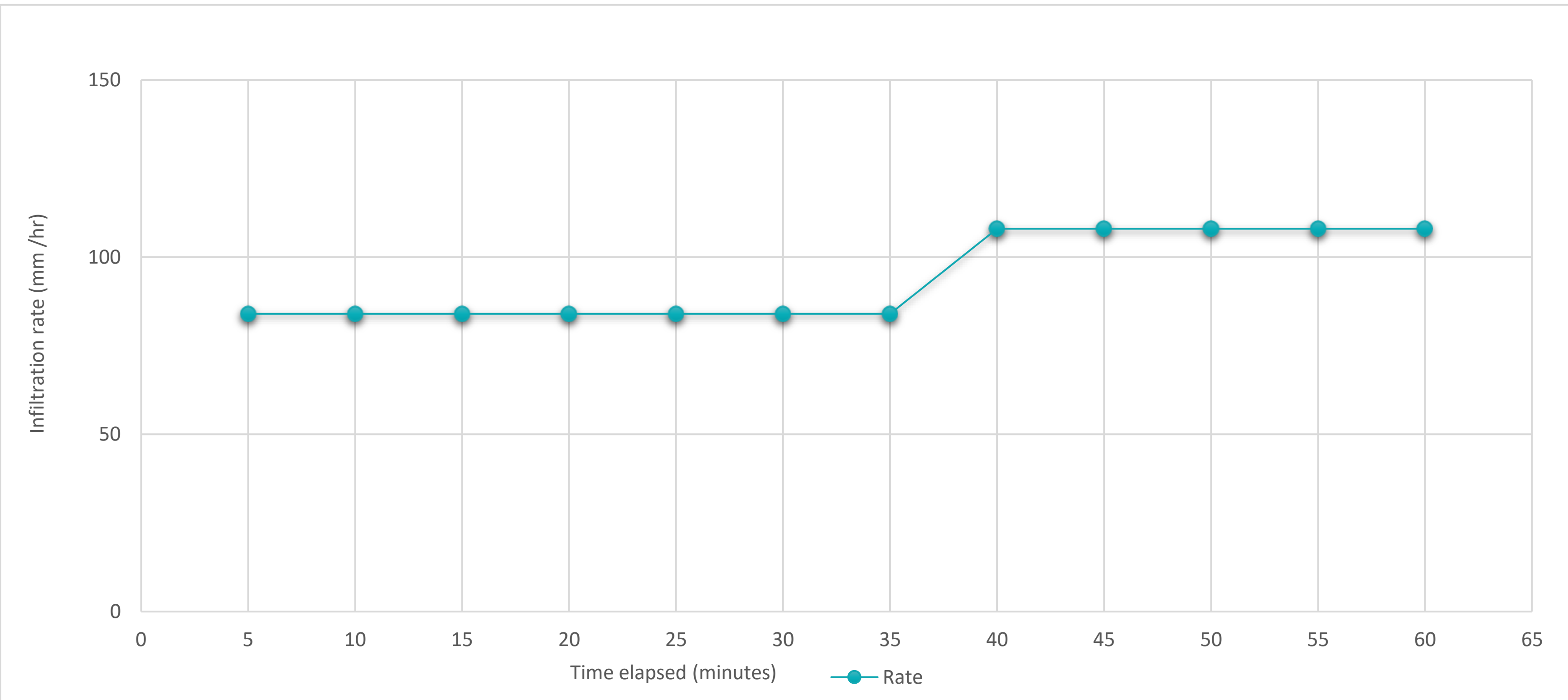
Double Ring Infiltrometer Test					
Job Name	Raglan Wastewater Consent			Job Number	4703642
Client	Watercare Waikato			Test ID	DR01
Location	Nganurui Beach Gully			Easting	1761414.008
Tested by	HF/JC	Date	6/03/2025	Northing	5813534.131
Groundwater level	-	Start time	12:30 pm	Elevation (mRL)	13.8
Pre-soak	No	Base of test (mBGL)	0.3	Circuit (method)	Mt Eden
Inner ring (cm)	15	Outer ring (cm)	30	Datum (method)	NZTM
Tested Soil	Clayey SILT			Infiltration Rate (mm/hr)	0



Double Ring Infiltrometer Test					
Job Name	Raglan Wastewater Consent			Job Number	4703642
Client	Watercare Waikato			Test ID	DR02
Location	Nganurui Beach Gully			Easting	1761376.023
Tested by	HF/JC	Date	6/03/2025	Northing	5813535.45
Groundwater level	-	Start time	15:30	Elevation (mRL)	7.7
Pre-soak	No	Base of test (mBGL)	0.3	Circuit (method)	Mt Eden
Inner ring (cm)	15	Outer ring (cm)	30	Datum (method)	NZTM
Tested Soil	Silty fine SAND			Infiltration Rate (mm/hr)	54



Double Ring Infiltrometer Test					
Job Name	Raglan Wastewater Consent			Job Number	4703642
Client	Watercare Waikato			Test ID	DR03
Location	Nganurui Beach Gully			Easting	1761380.649
Tested by	HF/JC	Date	7/03/2025	Northing	5813542.461
Groundwater level	-	Start time	9:30	Elevation (mRL)	5.7
Pre-soak	No	Base of test (mBGL)	0.2	Circuit (method)	Mt Eden
Inner ring (cm)	15	Outer ring (cm)	30	Datum (method)	NZTM
Tested Soil	Silty fine to medium SAND			Infiltration Rate (mm/hr)	108



Double Ring Infiltrometer Test					
Job Name	Raglan Wastewater Consent			Job Number	4703642
Client	Watercare Waikato			Test ID	DR04
Location	Nganurui Beach Gully			Easting	1761377.686
Tested by	HF/JC	Date	7/03/2025	Northing	5813555.111
Groundwater level	-	Start time	12:00	Elevation (mRL)	5.4
Pre-soak	No	Base of test (mBGL)	0.1	Circuit (method)	Mt Eden
Inner ring (cm)	15	Outer ring (cm)	30	Datum (method)	NZTM
Tested Soil	Medium to coarse SAND (beach sands)			Infiltration Rate (mm/hr)	804