Ridgeburn Limited

Ridgeburn Development Hydrogeological Site Investigations

TECHNICAL REPORT

WGA252389

WGA252389-HG-RP-0001_D

9 March 2026

Revision History

REV	DATE	ISSUE	ORIGINATOR	CHECKER	APPROVER
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C	25/02/2026	FINAL	CAJ	BAS	BAS
D	9/03/2026	FINAL	CAJ	BAS	BAS

Statement of Qualifications and Experience

Cameron Jasper (Author)

I am a Senior Hydrogeologist employed by Wallbridge Gilbert Aztec, an employee-owned engineering and environmental consultancy with over 700 staff distributed throughout New Zealand and Australia. I hold a Master of Science in Hydrology and Water Resources Science and a Bachelor of Science in Geology Earth Science. I am a member of the New Zealand Hydrological Society.

I have over 10 years professional experience as a consultant in hydrogeology, water resources science, and environmental investigations. My expertise includes the assessment of groundwater resources, stormwater and wastewater discharge effects, contaminant transport, and protection of community drinking water sources, with extensive project experience in Otago and New Zealand.

I have undertaken Assessments of Environmental Effects (AEE) and technical reviews supporting resource consenting for community wastewater discharges to land and water supplies. My experience in stormwater and wastewater management and discharge effects includes hydrogeological assessments, contaminant transport modelling and monitoring system designs for municipal wastewater discharges. I have undertaken numerous technical reviews of resource consent applications on behalf of Otago Regional Council, where my work primarily included hydrogeological review of on-site wastewater discharge proposals, contaminant transport assessment, and risk evaluation to domestic and community drinking water supplies.

My experience in protection of community drinking water sources includes source protection zone delineation, contamination risk assessments, and evaluation of wastewater and stormwater discharge effects on supply bores. My contaminant transport modelling includes nitrate, microbial, and emerging contaminants (PFAS) in groundwater systems, with application to wastewater discharges, stormwater, landfills, and contaminated sites.

I confirm that, in my capacity as author of this report, I have read and acted in accordance with the Environment Court of New Zealand Code of Conduct for Expert Witnesses (Practice Note 2023).

Brett Sinclair (Reviewer)

I am a Senior Principal Hydrogeologist and Associate employed by Wallbridge Gilbert Aztec, an employee-owned engineering and environmental consultancy with over 700 staff distributed throughout New Zealand and Australia.

I hold a Master of Science in Geology from Auckland University and a Postgraduate Certificate in Hydrogeology and Engineering Geology of Tropical and Subtropical Regions from the University of Tübingen, Germany. I have over 30 years professional experience as a consultant and contractor in hydrogeology, water resources science, and environmental investigations. I have worked internationally as a consultant, based in New Zealand, Australia and Germany. I am a member of the New Zealand Hydrological Society.

Since 2000 I have managed and undertaken numerous investigations within New Zealand for the supply of water for human consumption and horticultural, agricultural and industrial purposes. These investigations have included evaluation of water availability as part of the security of supply assessment. Over the same period, I have undertaken assessments of the effects for a wide range of stormwater and solid and liquid waste storage and disposal systems on groundwater, surface water and existing users. I have constructed and acted as technical advisor or reviewer for numerous groundwater flow and contaminant transport models for a wide range of purposes.

During the past fifteen years I have worked on and led on the assessment, consenting, design, construction, commissioning, monitoring and optimisation and managed aquifer recharge projects. I also have wide experience in mine water management, with a focus on minimising environmental impacts during operations and long-term site rehabilitation.

I confirm that, in my capacity as reviewer of this report, I have read and abide by the Environment Court of New Zealand’s Code of Conduct for Expert Witnesses Practice Note 2023.

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1 INTRODUCTION

1.1 Background

The Ridgeburn residential development (Ridgeburn) proposed by Ridgeburn Development Limited (RDL), a registered corporate entity associated with Gibbons Co Ltd (Gibbons Co), consists of residential lots, commercial, retail and recreational spaces. The proposed development is located at 122 Morven Ferry Road, between Arrowtown and the Kawarau River, Queenstown Lakes District (Figure 1).

Stormwater runoff within the development is to be managed with on-site swales, pipes and culverts, stormwater detention basins (dry ponds), plus constructed wetlands and ponds as documented in design drawings (McKenzie, 2026a) and a separate report on flooding effects (McKenzie, 2026b). Stormwater within the development is proposed to be detained within basins, ponds and existing wetlands, with excess stormwater discharged to the Arrow River via upgraded infrastructure along Morven Ferry Road.

The potable water supply to the development is proposed to be sourced from two new production bores that have been constructed and tested at the site. Site investigations have been carried out to determine aquifer parameters and the effects of taking groundwater from these bores, as well as their source protection. The water supply servicing strategy and proposed water treatment plant are provided by GWE (2026).

Ridgeburn is to be serviced by a dedicated wastewater treatment plant (WWTP), as documented in a separate report (BPO, 2026). The wastewater is to be treated to a high quality, including ultrafiltration and ultraviolet treatment stages. The proposed location of the WWTP is presented in Figure 2. RDL is proposing to utilise treated wastewater for irrigation within the development area.

Gibbons Co has retained Wallbridge Gilbert Aztec (WGANZ Pty Ltd; WGA) to investigate the soils, aquifers, and landforms of the landholdings related to Ridgeburn. This investigation, in addition to site investigations undertaken by Kirk Roberts, forms the basis for separate assessments of effects covering:

- The effects of the proposed stormwater management on groundwater and the receiving environment.
- The taking of groundwater for the development's potable supply, including the protection of the groundwater source; and
- The disposal and utilisation of treated wastewater for irrigating native plants within the development area.

This report is intended to be considered in conjunction with separate reports produced by WGA regarding:

1. The effects arising from the proposed stormwater management (WGA, 2026c)
2. The effects of the proposed groundwater take for water supply purposes (WGA, 2026b)
3. Wastewater disposal options and associated effects, including source protection (WGA, 2026a)

1.2 Scope of Services

The scope of services covered by this report is as follows:

- Compile and document background information of relevance to the type and extent of soils present within the investigation area. This information includes topographic, geological, hydrological, and geotechnical information.
- Compile and document geological and soil information that has been generated through site investigations for geotechnical purposes (by Kirk Roberts) and for irrigation infiltration assessment purposes (by WGA).
- Document soakage test data and associated analyses arising from site investigations undertaken by Kirk Roberts and by WGA.
- Summarise the potential flow acceptance capacity of soils investigated within the Ridgeburn area.
- Present analyses and interpretation of aquifer testing information and a site conceptual groundwater model in the context of groundwater implications from the development and operation of stormwater infrastructure on wetlands and neighbouring bores, groundwater abstraction from the production bores, and wastewater disposal options.

This report is produced to support the assessment and consenting of the groundwater take, community source protection, stormwater management, and treated wastewater discharge system for Ridgeburn. Consequently, this report should be considered in conjunction with the other WGA reports referred to in Section 1.1, and separate reports from other consultants as referred to throughout this report.

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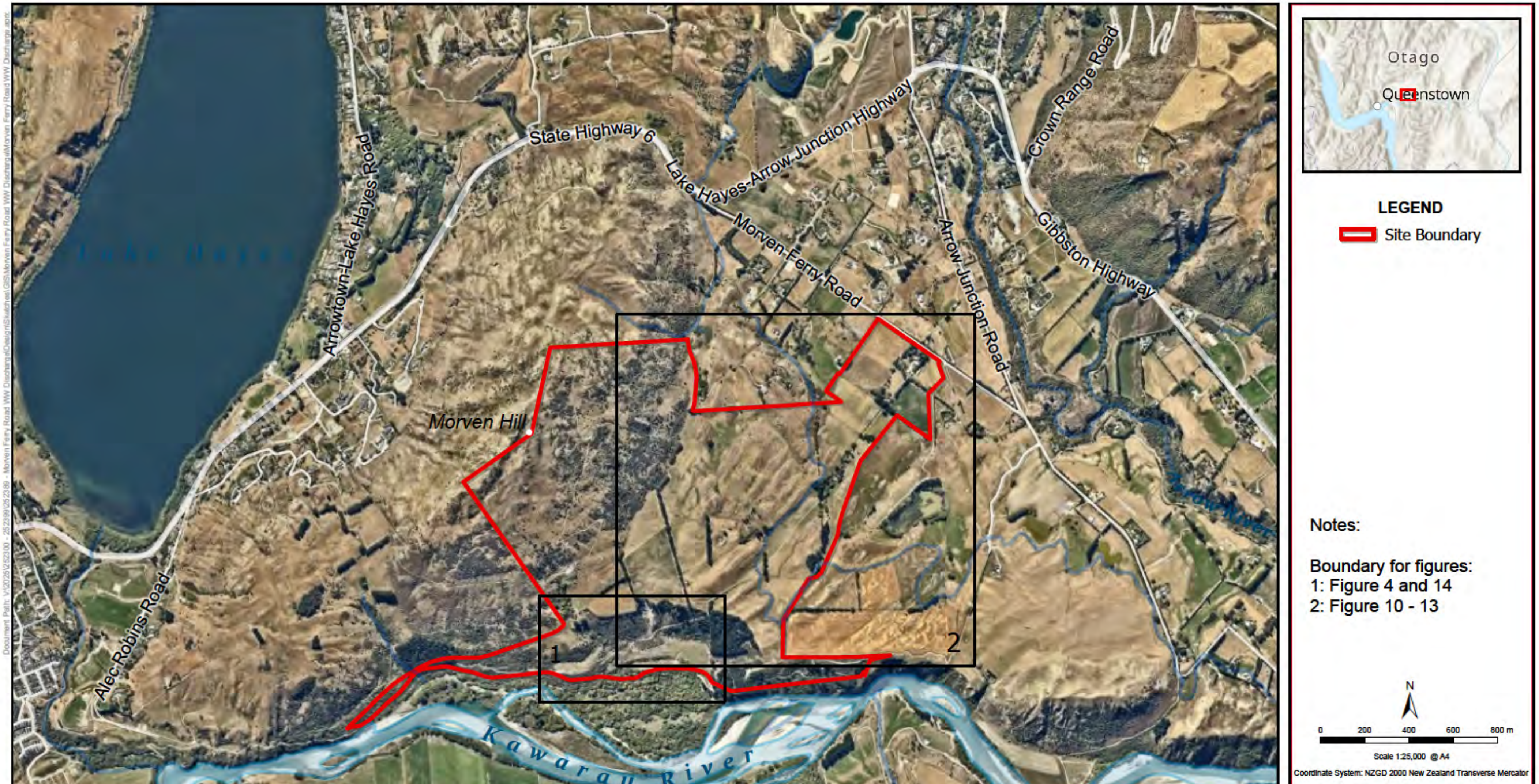

Notes:

Boundary for figures:
1: Figure 4 and 14
2: Figure 10 - 13

WGA

Figure 1

Ridgeburn Development
Locality Map

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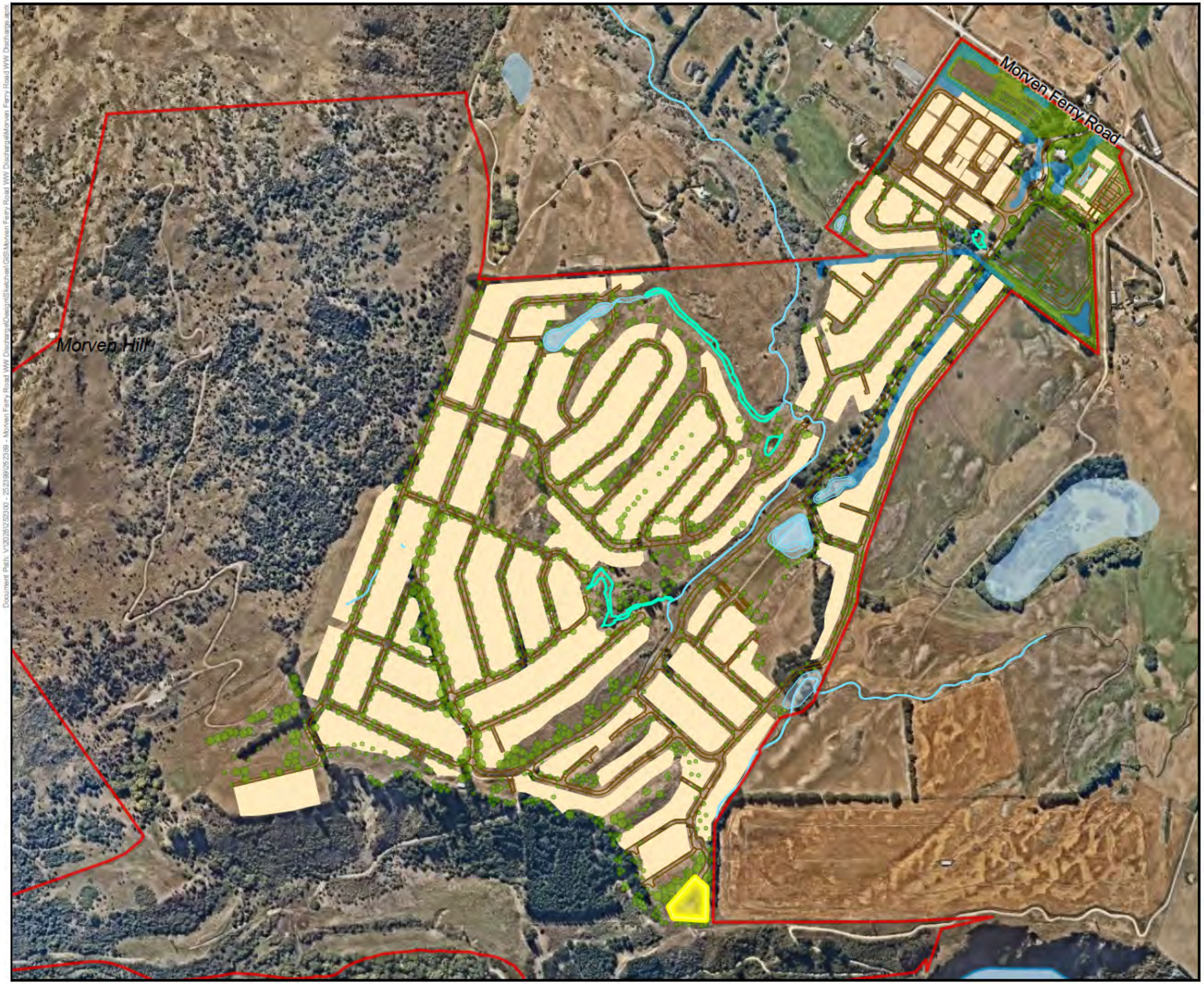

Scale 1:9,000 @ A4

Coordinate System: NZGD 2000 New Zealand Transverse Mercator

WGA

Figure **2**

Ridgeburn Wastewater
Treatment Plant
Location Map

2 ENVIRONMENT BACKGROUND

2.1 Topography and Geomorphology

The Ridgeburn residential and commercial development area is on an alluvial terrace at an elevation of between 380 m and 420 m above mean sea level (m RL) (Figure 3). This terrace, called the Residential Terrace for the purposes of this report, slopes gently downward toward Morven Ferry Road and the Arrow River, to the northeast of the development area. The terrace is bounded to the south by a steep drop-off, some 80 m in height, to the Kawerau River or locally to a series of lower terraces adjacent to the river. The conditions on the Residential Terrace are primarily relevant to aspects of the proposed stormwater management. In addition to this, localised irrigation of treated wastewater is proposed for parts of the Residential Terrace.

The northwestern section of the development area consists of a steeply sloping rocky hillslope that climbs to the isolated peak of Morven Hill at an elevation of 570 m RL. The lower eastern slopes of Morven Hill, toward the development, have a lower and smoother slope than higher on the hillside. To the south, Morven Hill drops off steeply toward the river terraces directly adjacent to the Kawarau River. The conditions on Morven Hill are primarily relevant to the proposed spray irrigation of treated wastewater on native vegetation.

The two production bores are located on terraces along the Kawarau River, collectively called the River Terraces for the purposes of this report. The River Terraces are at several different elevations, as indicated in the geomorphological sketch map presented in Figure 4 and summarised in Table 1. The terrace gradients are generally less than 5%. However, alluvial or colluvial fan deposits of several different ages have been deposited onto the Main Terrace, resulting in slopes exceeding 15% within the margins of the fans. Hydrogeological conditions across the River Terraces and immediate surroundings (i.e., the Kawarau River, floodplain, and drop off from the Residential Terrace) inform the source protection of the community supply bores and effects of the proposed groundwater take.

Several metres below the Lower Terrace is an evident flood plain for the Kawarau River, at an estimated elevation of 304 – 305 mRL. Although not specifically investigated as part of the site assessment documented in this report, the flood plain showed visual evidence of inundation and saturation of soils at low points at the time of a site visit (8 October 2025).

Table 1: Terrace Designations and Elevations

TERRACE NAME		ELEVATION (mRL)
Residential Terrace		380 – 420
River Terraces	Upper Terrace	338 – 344
	Mid Terrace(1)	362 – 332
	Main Terrace (including an 'Upper Main Terrace)(2)	316 – 320
	Lower Terrace	308 – 310
Kawarau River flood plain		Estimated at 304 – 305

Notes:

(1) Not specifically identified in geomorphological sketch map (Figure 4)

(2) Identified as Middle Terrace and Upper Mid Terrace in geomorphological sketch map (Figure 4)

N

0 200 400 600 800 m

Scale 1:15,000 @ A4

Coordinate System: NZGD 2000 New Zealand Transverse Mercator

LEGEND

- 🟥 Site Boundary
- ▨ Watercourse
- ☐ Property Boundaries
- — Contours
- - - Landscape Feature Boundaries

WGA

Figure **3**

Topographic Map of Ridgeburn Development Area

Scale 1:3,000 @ A4

Coordinate System: NZGD 2000 New Zealand Transverse Mercator

LEGEND

- ○ Pylon
- ⋀ Drop Off
- — Alluvial Fan
- - - Slope Break

WGA

Figure 4

Geomorphological Sketch Map of River Terraces

2.2 Geology

Morven Hill consists of schist bedrock, eroded to its current shape by the flow of glaciers passing it on all sides during the Pleistocene glaciations. The upper hillslopes are characterised by schist outcrops and poorly developed soils. The lower hillslopes toward Ridgeburn are composed by colluvial fan deposits, with more consistently developed soil horizons (Figure 5).

The Residential Terrace consists predominantly of a glacially eroded schist surface, on which glacial deposits and lake sediments were deposited when Lake Wakatipu was substantially higher than its current level (Barrell et al 1994, Turnbull 2000). At that time, the main outlet from Lake Wakatipu was toward the South, past Kingston. Terminal moraines deposited by older glaciers had blocked the current Kawerau River valley to the East of the investigation area. The thickness of the lake sediments increases toward the Kawarau River.

Lake sediments filled much of the current Kawerau River valley along the river stretch adjacent to Ridgeburn. The lake sediments generally consist of sand and micaceous silts, although fine gravel beds are also present (Barrell et al 1994). Erosion of the moraine deposits in the Kawerau River Valley resulted in a stepwise reduction in the level of Lake Wakatipu. Consequently, a series of terraces eroded into previously deposited lake sediments were created, which now constitute the River Terraces. The eroded hillslope below the Residential Terrace down to the River Terraces appears to consist exclusively of lake sediments and colluvium derived from these sediments. The exposed sedimentary deposits appear to have a thickness of at least 60 m, although detailed mapping of these sediments was not undertaken as part of this project.

Fine-grained lake sediments deposited on each of the River Terraces listed in Table 1 are likely to be limited to shallow surficial deposits. The deeper lake deposits underlying the River Terraces are likely older sediments deposited when the lake was substantially higher. However, the interface between older and younger sediments is not clearly identifiable from drillhole logs or even from surface exposures.

The main terrace identified in Figure 4 carries alluvial and colluvial deposits in the form of several fans, sourced from erosion of the Residential Terrace to the north (Barrell et al 1994). The relative age of the fans on the main terrace, based on the observed soil characteristics and vegetation cover, is indicated from oldest to youngest by the numbers 1 to 3 in Figure 4.

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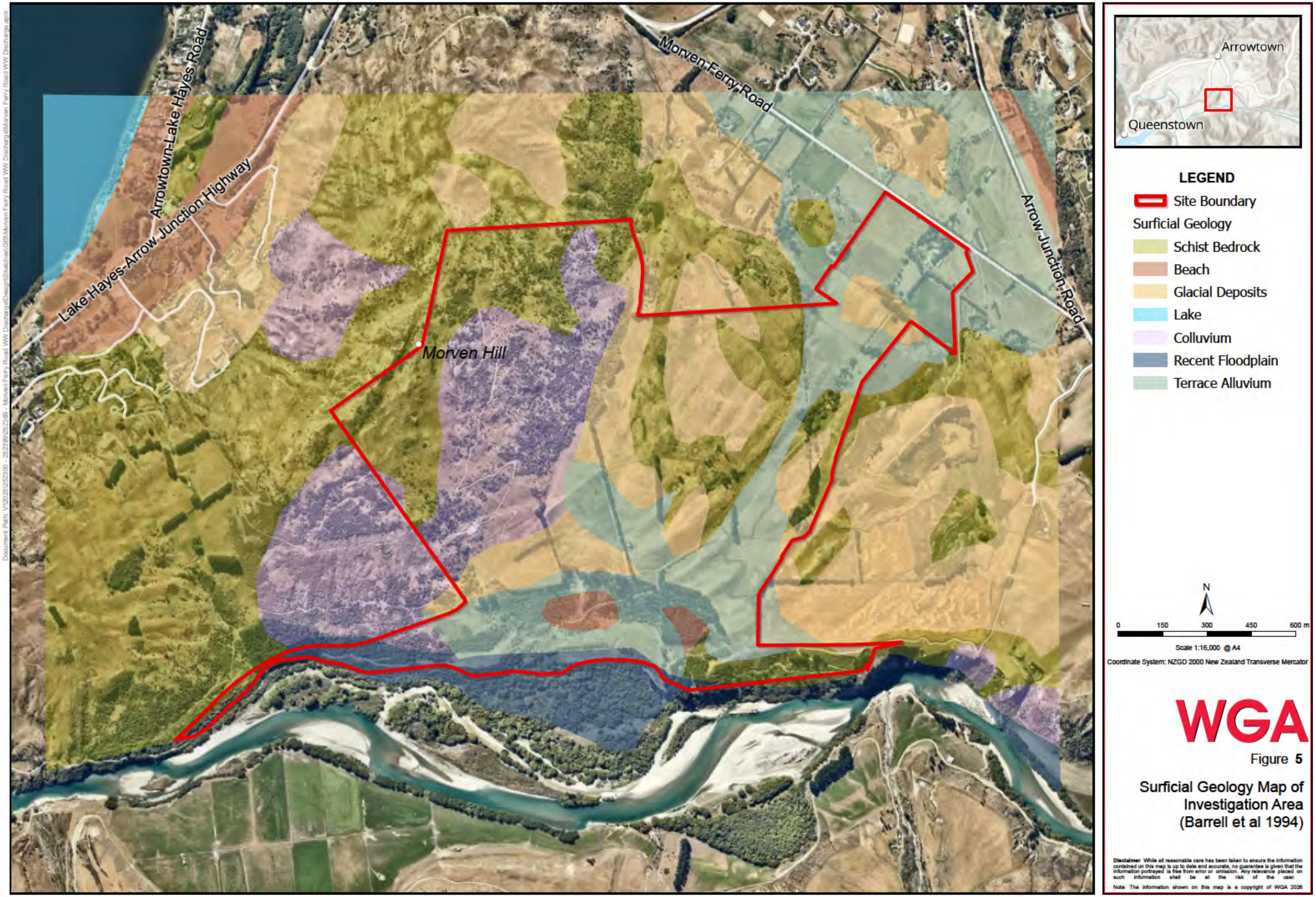

Figure 5

Surficial Geology Map of Investigation Area (Barrell et al 1994)

2.3 Hydrology

2.3.1 Kawarau River

River flow rates for the Kawarau River at Chard Road, approximately 2.5 km downstream from Ridgeburn, have been estimated and recorded by Earth Sciences New Zealand (ESNZ, formerly NIWA), with these records available through the Hydro Web Portal[1] and also the ORC Environmental Data Portal. Flow estimates are available for the period from August 1998 to January 2022, a period of approximately 32 years. The available flow estimates are only available on an approximately monthly basis throughout this period, with a total of 389 records.

A Kawarau River flow exceedance curve has been derived from the Chard Road flow estimates (Figure 6), which indicates that the 0.5 % low flow is approximately 60.3 m^3/s. In lieu of more accurate flow data for the Kawarau River, this flow rate has been accepted as an indication of the mean annual low flow in the river adjacent to Ridgeburn. The peak estimated flow recorded in the database is 626 m^3/day, which has been accepted as general guidance on high flows in the river for water quality effects assessment purposes.

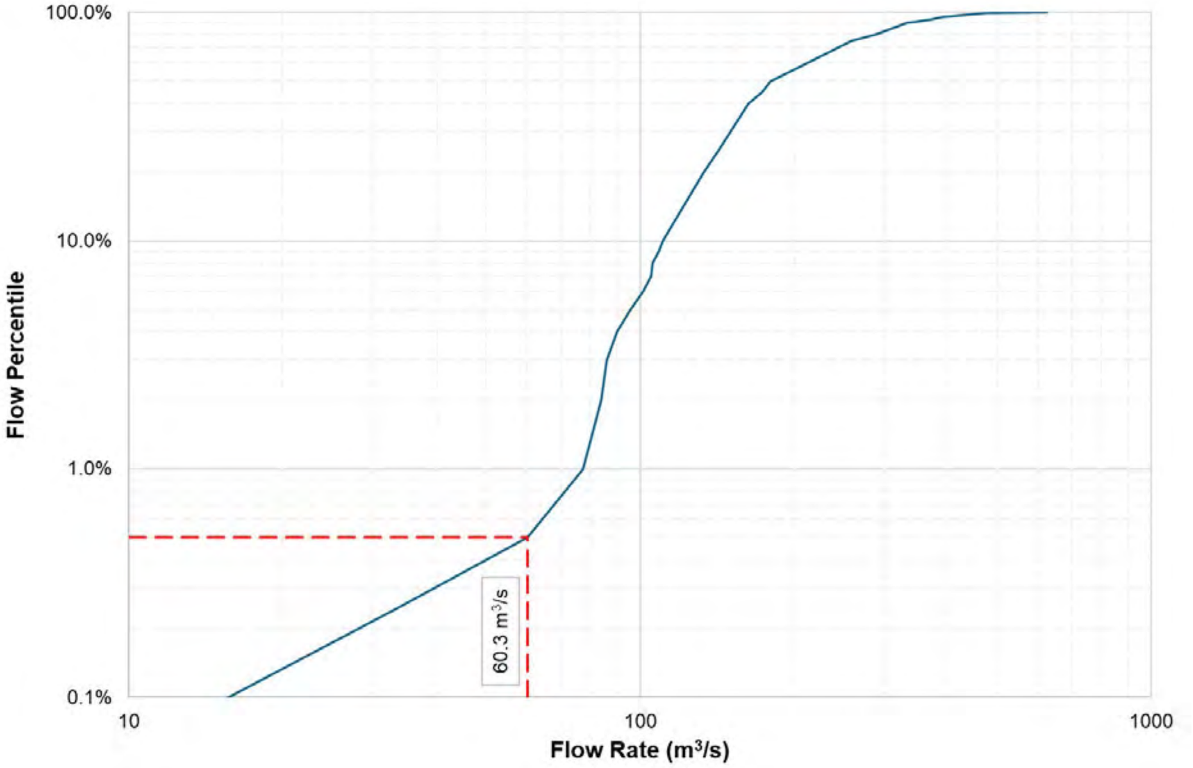

Figure 6: Kawarau River at Chard Road Flow Exceedance Curve

Water quality in the Kawarau River at Chard Road has been monitored by ESNZ (NIWA) since November 2017. Up until February 2025, the recording frequency was approximately monthly, with the frequency since then being approximately weekly.

The maximum and minimum nitrate-nitrogen (NO_3-N) concentrations detected during this sampling period were 0.036 mg/L and 0.0046 mg/L, respectively. The concentration of NO_3-N in the Kawarau River appears to be correlated to the river flow (Figure 7). However, there is considerable scatter in the relationship between these two parameters, and no correlation equation has been derived. Despite elevated nitrate during higher flows being apparent, the data also show that elevated nitrate concentrations can occur during low flow conditions within the Kawarau River.

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[1] https://hydrowebportal.niwa.co.nz/Data/DataSet/Chart/Location/AX2/DataSet/Discharge%20Value/NRWQN/Interval/AllData

The concentration of dissolved reactive phosphorus (DRP) detected in the Kawarau River has generally been close to or at the apparent laboratory detection limit of 0.001 mg/L, with few exceptions. The highest DRP concentration detected was 0.0031 mg/L in May 2023.

Otago Regional Council water quality limits for the Kawarau River downstream of the confluence with the Shotover River, under Schedule 15 of the Regional Plan, are presented in Table 2. Based on the data presented in Figure 7, the Kawarau River at Chard Road is expected to be comfortably in compliance with both the ORC Nitrate-Nitrite-Nitrogen limit and the DRP limit.

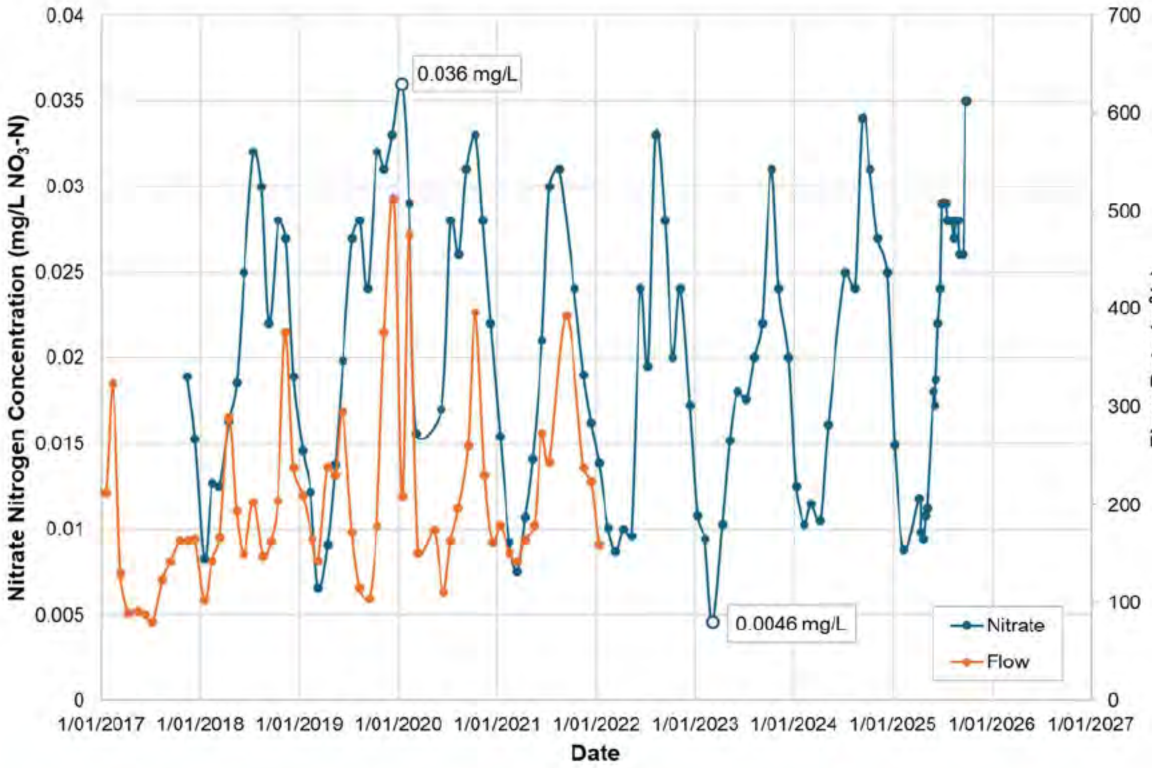

Figure 7: Nitrate Nitrogen Concentrations Detected in the Kawarau River at Chard Road

Table 2: Otago Regional Council Water Quality Limits for the Kawarau and Arrow Rivers

PARAMETER	UNITS	VALUE[(1)]
Nitrate-Nitrite-Nitrogen	mg/L-N	0.075
Dissolved Reactive Phosphorus	mg/L	0.01
Ammoniacal Nitrogen	mg/L-N	0.1
Escherichia coli	cfu/100mL	260
Turbidity	NTU	5

Note:

(1) The limits are achieved when 80% of samples collected at a site, when flows are at or below median flow, over a rolling 5-year period, meet or are better than the limits in Schedule 15.

2.3.2 Arrow River

River flow rates for the Arrow River at Cornwall Street, approximately 5 km upstream from Ridgeburn, have been estimated and recorded by ORC, with these records available through the Environmental Data Portal[2]. Flow estimates are available for the period from December 2010 to November 2025, a period of approximately 15 years. The estimates were produced on an approximately daily basis throughout this period, with a total of 5,434 records available.

An Arrow River flow exceedance curve has been derived from the Cornwall Street flow estimates (Figure 8), which indicates that the 0.5 % low flow is approximately 0.8 m^3/s. In lieu of flow data for the Arrow River closer Ridgeburn, this flow rate has been accepted as an indication of the mean annual low flow in the river adjacent to Ridgeburn. The peak estimated flow recorded in the database is 63 m^3/day, which has been accepted as providing guidance on high flows in the river for water quality effects assessment purposes.

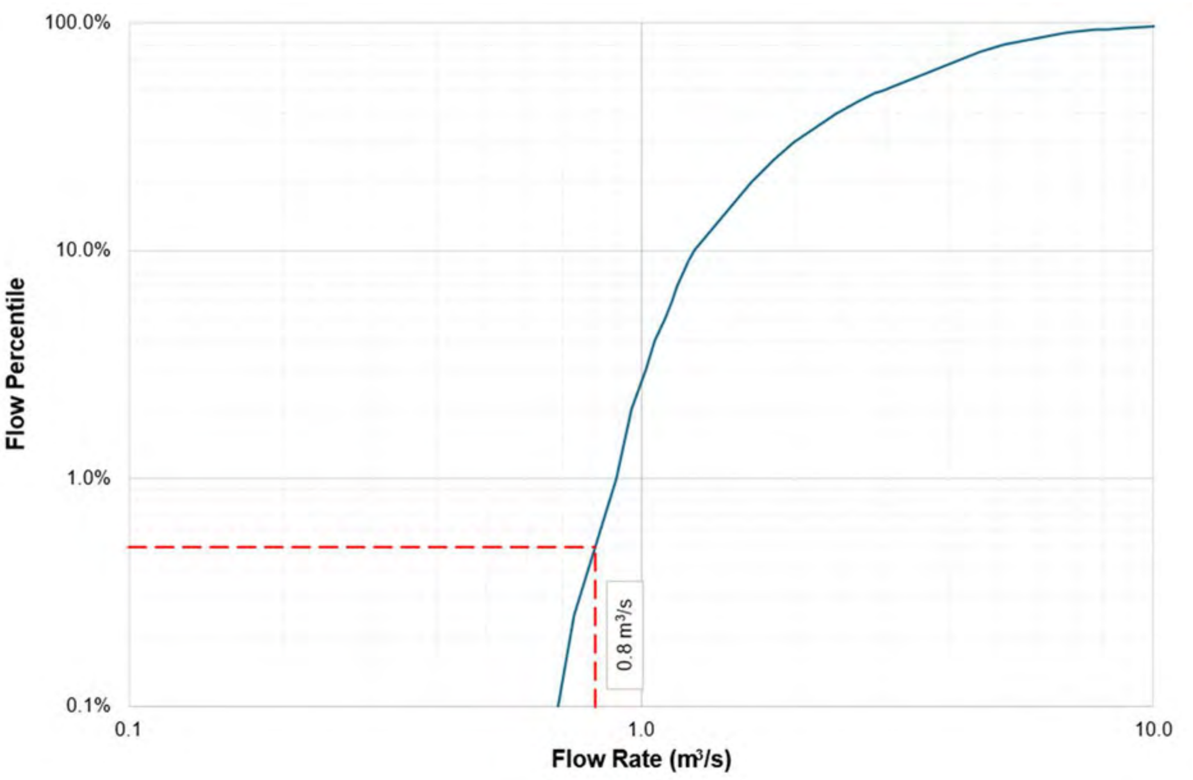

Figure 8: Arrow River at Cornwall Street Flow Exceedance Curve

Water quality in the Arrow River at Morven Ferry Road has been monitored by ORC since November 2017. Recording frequency has been approximately monthly.

The maximum and minimum nitrate-nitrogen (NO_3-N) concentrations detected during this sampling period were 0.31 mg/L and 0.036 mg/L, respectively. The concentration of NO_3-N in the Arrow River appears to be correlated to the river flow (Figure 9), where elevated nitrate typically occurs during periods of lower flows in the river.

The concentration of dissolved reactive phosphorus (DRP) detected in the Arrow River has generally been at or below the apparent laboratory detection limit of 0.001 mg/L, with few exceptions since 2019. The highest DRP concentration detected was 0.0064 mg/L in April 2022. This is conceptually consistent with the expected limited mobility of phosphorus, which binds strongly to soil and minerals.

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[2] https://envdata.orc.govt.nz/AQWebPortal/Data/DataSet/Export/Location/EW734/DataSet/Discharge/Master/Interval/AllData

Otago Regional Council has set water quality limits for the Arrow River through Receiving Water Group 2 under Schedule 15 of the Regional Plan, as it is a tributary to the Kawarau River within the Clutha/Mata-Au catchment. These water quality limits are the same as those for the Kawarau River (Table 2). Based on the data presented in Figure 9, it appears that the water in the Arrow River often exceeds the nitrate-nitrite-nitrogen value from Table 2 during summer.

Considering how the water quality limits are applied (refer to the note to Table 2), the lower reaches of the Arrow River are interpreted to be frequently non-compliance with the ORC water quality limits. It is estimated that only about 9.5% of water quality samples meet the water quality standard when flow is at or below the median flow of about 2.9 m^3/s. Therefore, there is limited capacity for further mobile nutrient inputs within the catchment. Robust nutrient management is therefore required within and around the development and Morven Hill spray irrigation areas that fall within the Arrow River groundwater source area.

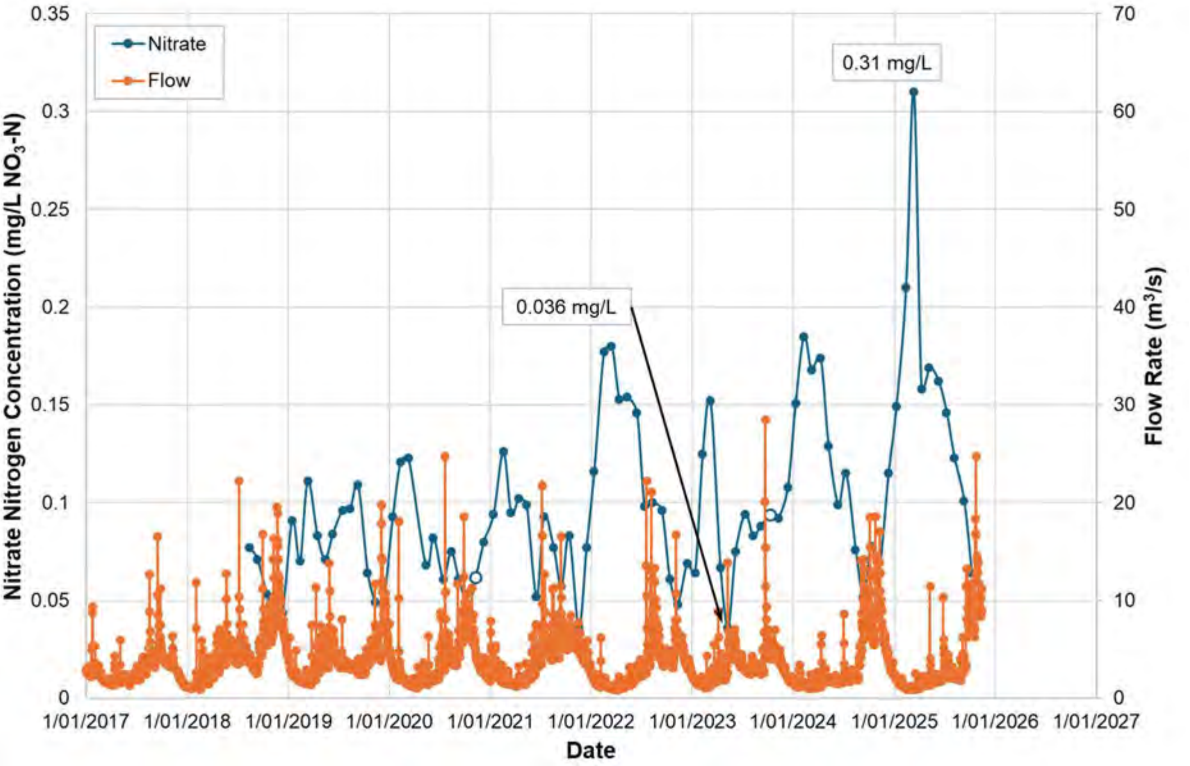

Figure 9: Nitrate Nitrogen Concentrations Detected in the Arrow River at Morven Ferry Road

2.3.3 Wetlands and Intermittent Waterways

Viridis Limited (Viridis) undertook ecological site investigations at the site in March and November 2025. These investigations identified one perennial (holding permanent water) wetland on-site and three intermittent (or ephemeral) wetlands that dry up during summer (Viridis, 2026). The perennial wetland is located along a southeast flowing natural drainage pathway (Figure 2). All on-site wetlands exist within either natural depressions or drainage features within the proposed residential development area.

These wetlands are located within the wider Arrow River catchment. Runoff water infiltrating into the ground from these wetlands is expected to ultimately discharge as groundwater to the Arrow River. Surface water discharging from these wetlands would flow along intermittent natural waterways in the direction of the Arrow River. One of these waterways is intersected by the Morven Road Water Race, with any flows in this waterway entering the water race. The water race ultimately discharges to the Kawarau River.

During winter months, the wetlands are expected to receive shallow groundwater sourced from within the proposed residential development area and potentially groundwater originating from Morven Hill. These wetlands will also receive surface runoff from their surface catchments. The perennial wetland is expected to receive shallow groundwater inputs throughout the summer, given this wetland is expected to be permanently wet. During the summer, the intermittent wetlands are interpreted to become disconnected from shallow groundwater and dry up due to evaporation and leakage (seepage losses) to the underlying groundwater system.

2.3.4 Ponds

Several farm ponds have been constructed on the Residential Terrace, presumably to provide improved water supply security to stock (Viridis 2026). These farm ponds appear to dry out on a seasonal basis. WGA expects that these ponds would act to recharge the underlying groundwater when they have received runoff from the surrounding catchment. However, they are unlikely to receive groundwater flows and discharge this water as surface flows exiting the site.

A larger farm pond is located on the Residential Terrace approximately 200 m east of the Ridgeburn boundary (Figure 3). This pond occupies a shallow topographic basin, with the outflow from the pond being toward the west. Although no investigations have been undertaken off-site, this pond is expected to contain permanent water. The shallow groundwater table within the surface catchment of this pond is interpreted as reflecting the overlying topography.

2.4 Groundwater Recharge

Climate data from the Queenstown weather station (5446) operated by NIWA, for the period 1970 to 2021, has been used to provide an approximation of seasonal soil moisture conditions at Ridgeburn. Although average monthly rainfall varies from month to month, it does not vary greatly on a seasonal basis (Table 3). In contrast, average monthly potential evapotranspiration is negligible through the winter months of May to August, while it exceeds approximately 90 mm through the summer months of November to February. Consequently, soil moisture deficits range from approximately 30 mm to 40 mm during these four summer months (Table 3).

A check on the Landcare soils maps for the Ridgeburn area indicates the Gibbston Soil, which covers Morven Hill, has a soil moisture capacity of approximately 60 mm. The soils covering the Residential and River Terraces have higher moisture capacities. On this basis, it is likely that under existing conditions that seepage losses from the soils to the underlying groundwater system predominantly occur through the months of May to October.

Table 3: Queenstown Weather Station (5446) Average Monthly Rainfall and PET (1970 – 2021)

MONTH	RAINFALL (mm)	POTENTIAL EVAPOTRANSPIRATION (mm)	SURPLUS/DEFICIT (mm)
January	78	118	-40
February	59	89	-31
March	69	58	10
April	68	21	47
May	90	3	88
June	77	0	77
July	69	0	68
August	72	9	63
September	80	34	46
October	86	68	18
November	68	96	-28
December	74	115	-42
Total	**889**	**612**	

Average annual groundwater recharge at Ridgeburn has been investigated by interrogating the national groundwater recharge dataset (GNS 2019). The dataset, which provides mean annual recharge rates in units of mm/day, indicates the following mean annual recharge rates for Ridgeburn:

- **Morven Hillslope:** 0.5 mm/day
- **Residential Terrace:** 0.5 mm/day
- **River Terraces:** 0.4 mm/day

As previously noted, these recharges are likely to occur predominantly through the months from May to October, or effectively 1 mm/day through this six-month period. Extended soil moisture retention within the root zone during the months from November to April works to reduce nutrient losses to groundwater by extending the period during which both water and the associated nutrients are accessible to plants and soil micro-organisms.

3 SOILS AND AQUIFER TESTING

3.1 Soil and Sediment Profiles

3.1.1 Morven Hill

Morven Hill is composed of schist bedrock left behind by glacial erosion. The upper slopes of Morven Hill are characterised by schist outcrops, separated by relic soils derived from weathering of the schist. The smoother lower slopes are characterised by colluvial deposits derived from exposed schist and soils higher up the slopes. These colluvial deposits are expected to increase in thickness toward the toe of the slope.

The schist bedrock of Morven Hill is assumed to be effectively impermeable for the purposes of this treated wastewater discharge assessment. This expectation is consistent with the findings from three exploration holes drilled into the schist of the Residential Terrace, which were all effectively “dry holes” although no hydraulic testing was undertaken on these holes (Section 3.1.2).

Shallow hand-auger investigations have been conducted on the slopes of Morven Hill as part of a geotechnical assessment for the site (Kirk Roberts, 2026). These investigations identified:

- Shallow silty soils (< 0.3 m thick) over colluvial deposits or weathered schist bedrock across the upper half of Morven Hill.
- Topsoil over colluvial deposits on the lower half generally 0.3 to 0.5 m thick and locally up to approximately 1.0 m thick overlying weathered schist.

The soils were predominantly classified as silty sands by Kirk Roberts (2026). At the toe of Morven Hill, test pits encountered topsoils over sand with local sandy gravel and gravelly sand to depths of up to 2.0 m bgl.

The soil map unit factsheet for Morven Hill (Landcare Research, 2025) indicates a well-drained loamy Pallic soil (Gibbston Soil schist derived windblown silt: Otago, Ao2sS) with increasing rock fragment contents with depth until bedrock is intersected at a depth of approximately 0.4 m. This description is consistent with the observations of soils on Morven Hill by Kirk Roberts (2026). The range of permeability estimates provided by Landcare Research (2025) for these soils is approximately 0.1 to 2.0 m/day. This range is consistent with guideline values for Category 3 to 4 loam soils.

3.1.2 Residential Terrace

A total of 15 soil test pits and 11 soakage tests in hand auger holes have been conducted by Kirk Roberts on the Residential Terrace (Figure 10). Copies of the hand auger logs for the holes drilled for soakage tests are presented in Appendix A.

Interpretation of the hand auger lithological logs indicates a trend in the shallow sediments underlying the Residential Terrace. The trend is of fining sediments, from gravelly sands in the north to sandy silts at the southern edge of the terrace (Figure 11). One auger hole, SK-05, intersected a coarser sandy gravel at a depth of 2.1 m before terminating in ‘dense ground’.

Observations recorded by Kirk Roberts regarding the soil moisture characteristics (Figure 12) indicate the shallow soils at the northwestern edge of the development were wet to saturated at the time of drilling in October 2025. This contrasts with the shallow sediments across the southern half of the development and along the eastern edge, which were characterised as moist rather than wet. Under normal circumstances, the coarser sediments in the north could be expected to be more free-draining than the finer sediments to the south. The reverse observation recorded by Kirk Roberts suggests either more recharge was occurring in the north or underlying denser soils and bedrock were limiting free drainage in the north. Drainage of these soils is considered further in Section 3.2.1.

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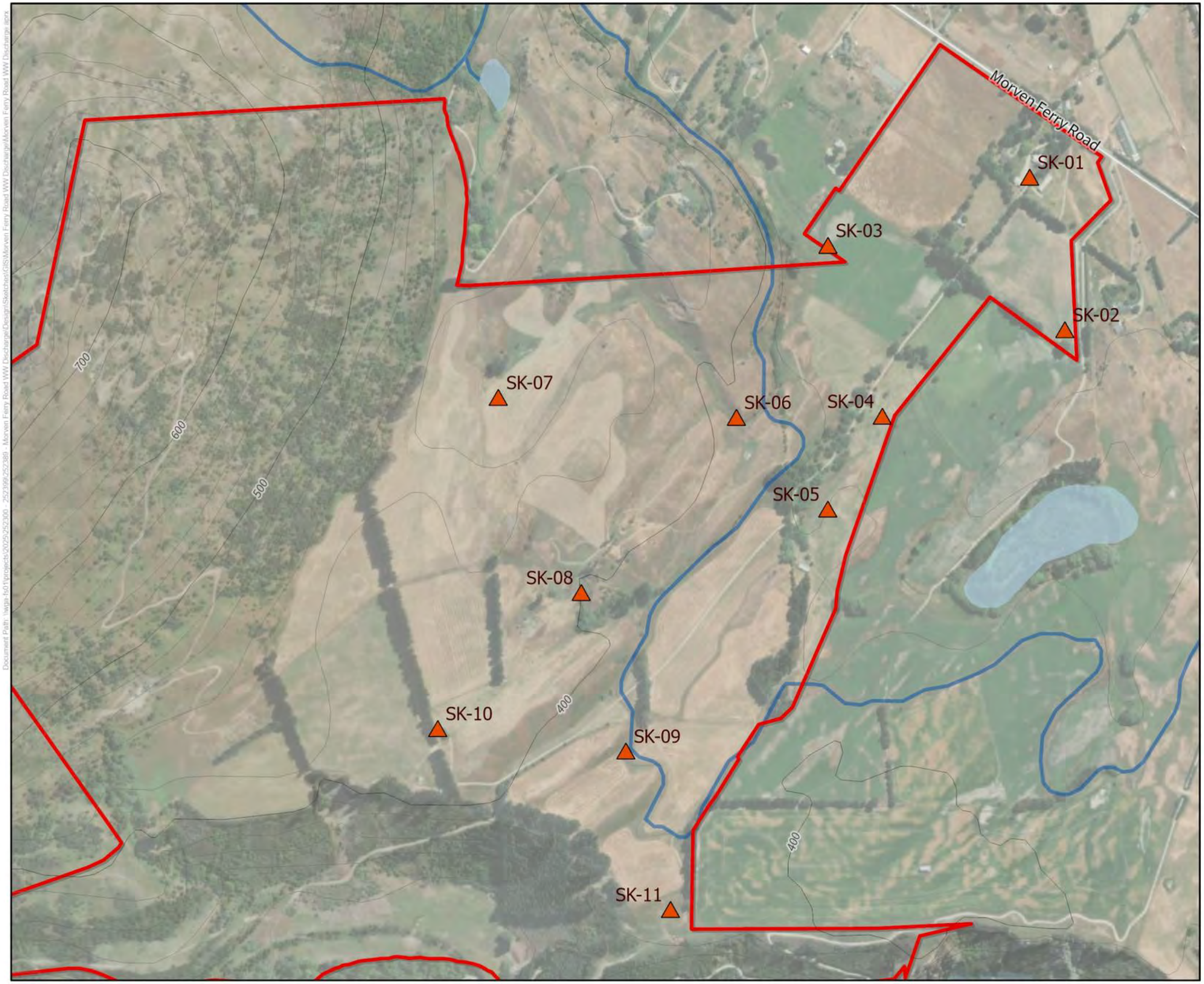

LEGEND

▲	Development Area Soakage Tests
—	Contours
▭	Site Boundary

N

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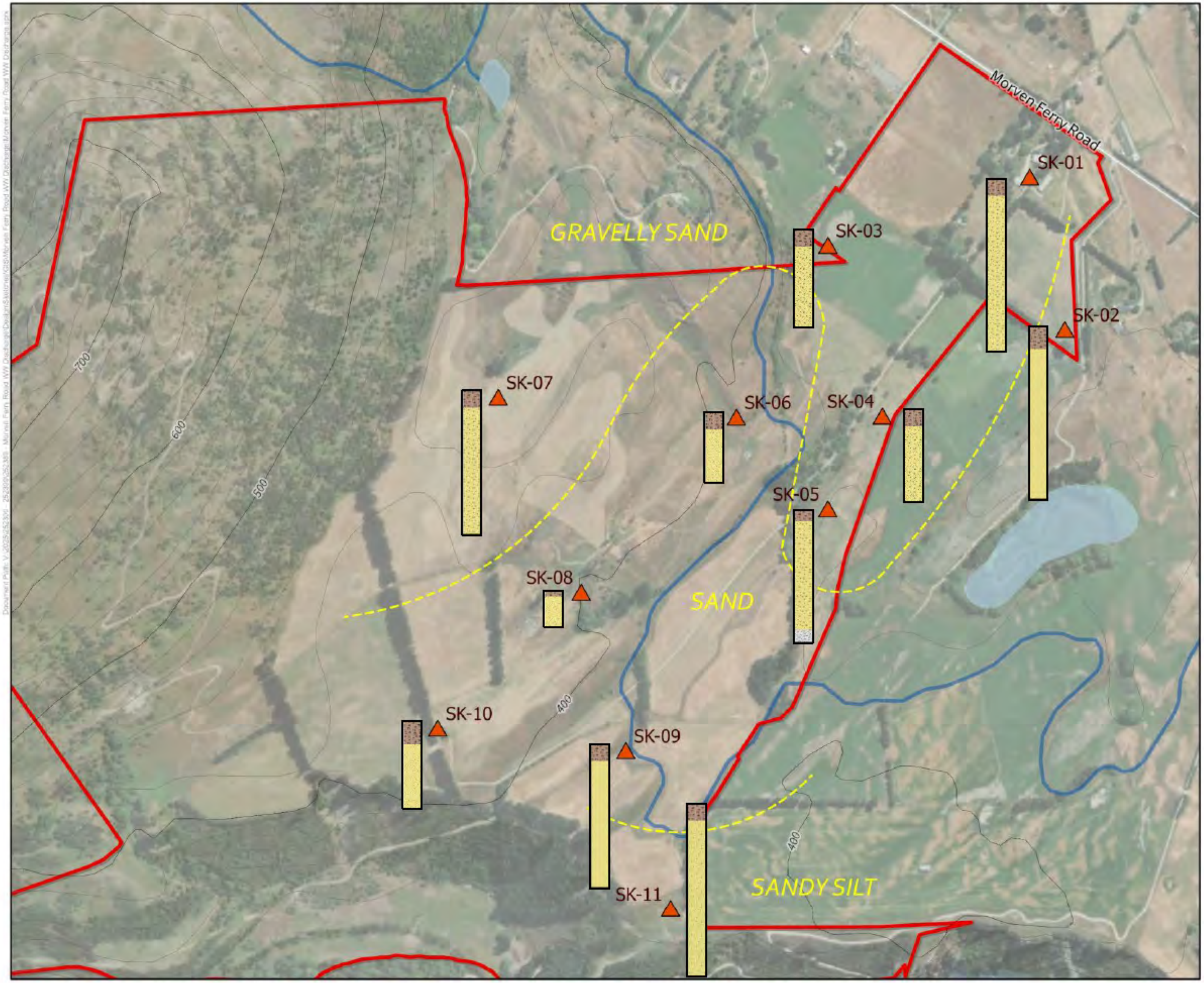
Scale 1:9,000 @ A4

Coordinate System: NZGD 2000 New Zealand Transverse Mercator

WGA

Figure **10**

Residential Terrace Hand Auger and Soakage Test Location Map



LEGEND

▲	Development Area Soakage Tests
- -	Lithological Boundary
—	Contours
▭	Site Boundary
▨	Topsoil
▨	Gravelly sand
▨	Sand
▨	Silty sand
▨	Sandy gravel

Scale 1:9,000 @ A4

Coordinate System: NZGD 2000 New Zealand Transverse Mercator

WGA

Figure 11

Residential Terrace Shallow Sediment Lithology Map

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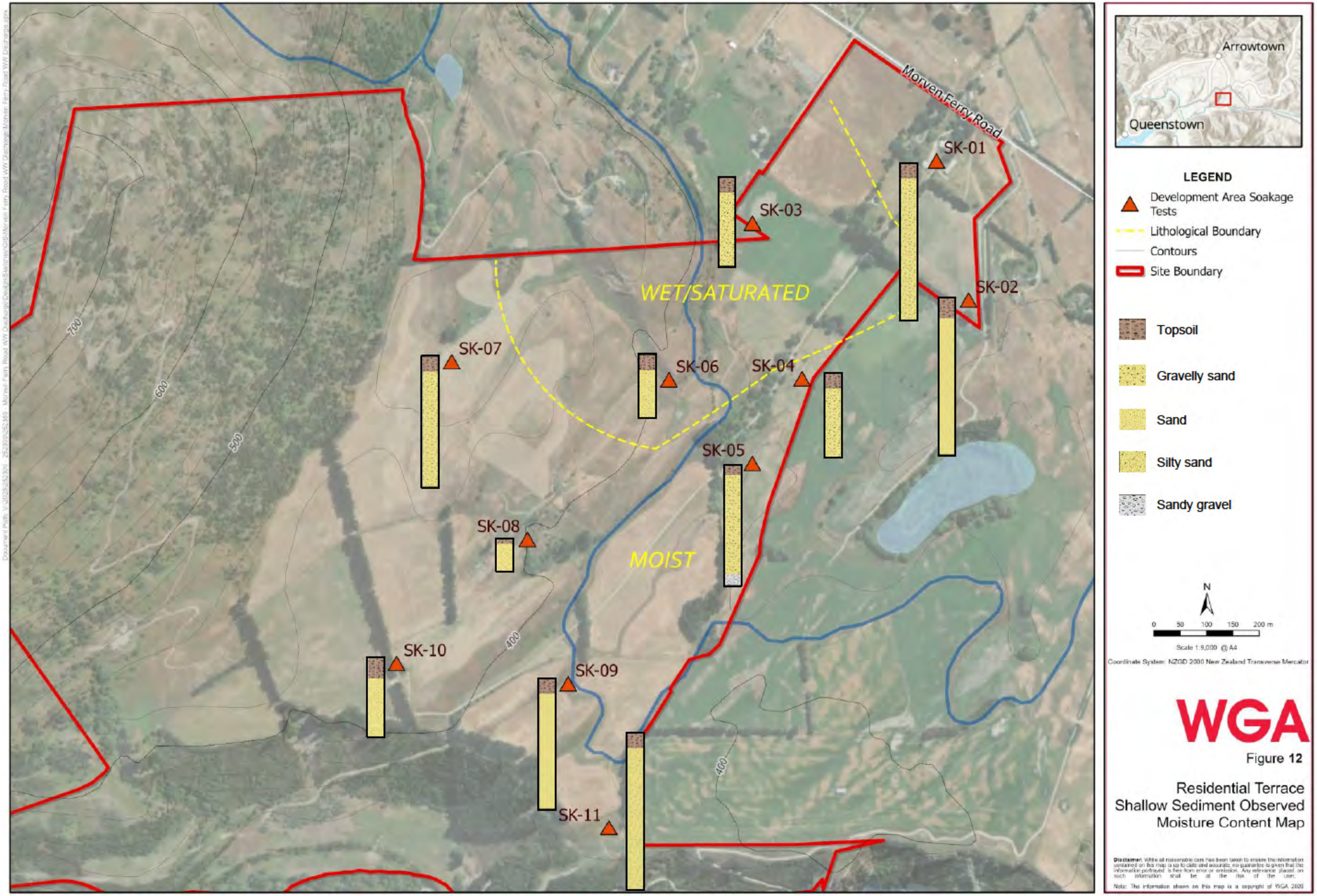
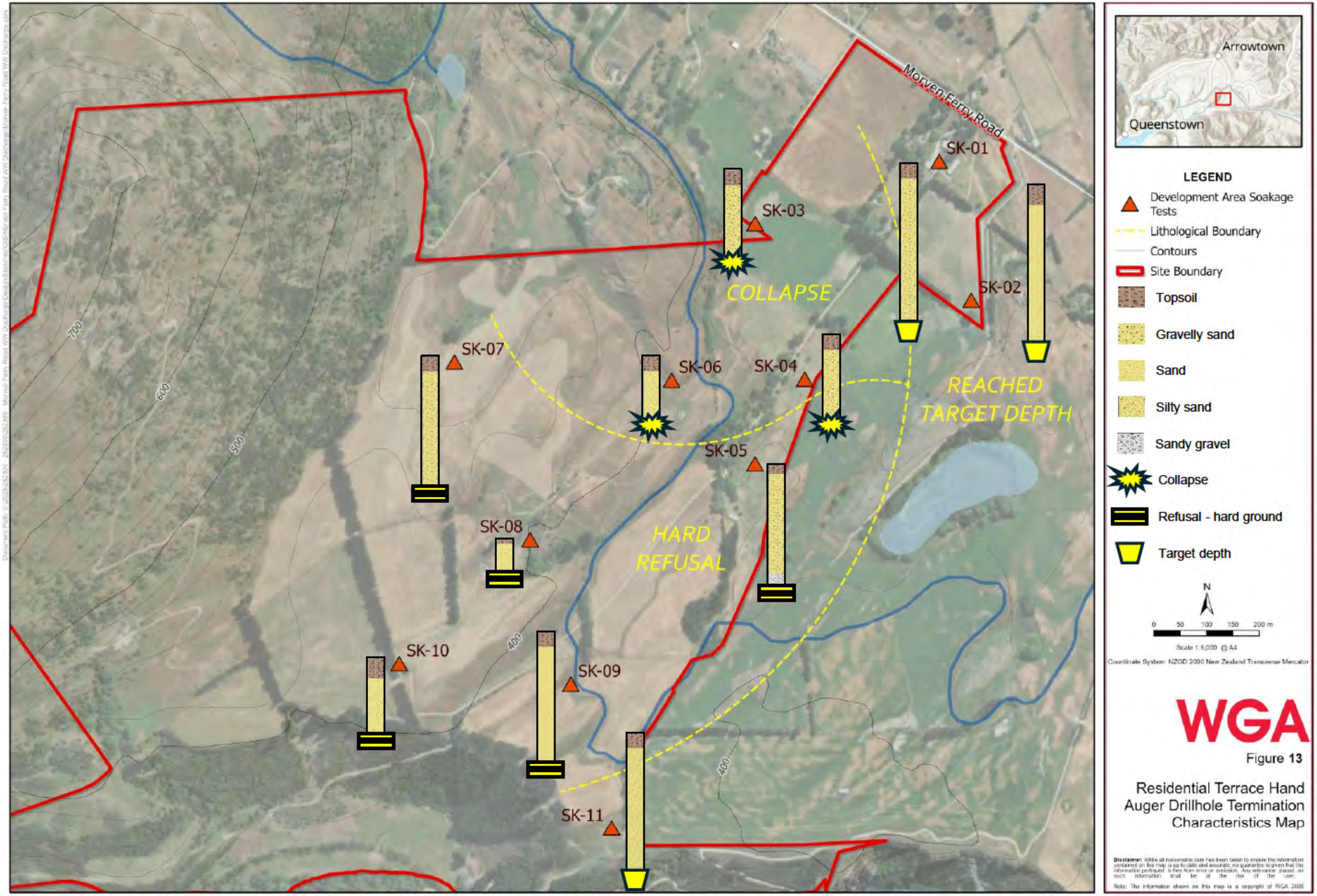


Figure 12

Residential Terrace
Shallow Sediment Observed
Moisture Content Map

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Any relevance placed on such information shall be at the risk of the user.



WGA

Figure 13

Residential Terrace Hand Auger Drillhole Termination Characteristics Map

Consideration of the auger hole termination depths and style (Figure 13) indicates the wet sediments in the northern section of the Residential Terrace were unstable and had a tendency to collapse. This contrasts with the auger holes across the southern and eastern areas of the development on the Residential Terrace, which tended to either meet hard refusal against 'dense ground' or would progress to the target depth. Collapsed auger holes were characteristic of wet or saturated ground.

In terms of the suitability of the soils for treated wastewater discharge, the observations recorded by Kirk Roberts from the hand auger investigations across the Residential Terrace suggest:

1. The southern and eastern areas of the development are likely to offer better discharge opportunities due to deeper groundwater or better drainage during winter.
2. The irrigation canal that crosses the development area from northwest to southeast may be losing water into the underlying soils and contributing to the observed soil saturation in the north. If this is the case, the planned piping of this canal under the development may reduce the levels of soil saturation at the northern end of the development.

3.1.3 River Terraces

3.1.3.1 Hand Auger Holes

WGA drilled a total of 13 hand auger holes to investigate the shallow soils on the River Terraces (Figure 14). The geological logs for these auger holes, HA1 to HA13, are provided in Appendix A. At most of the investigation points, two adjacent hand auger holes were drilled, one to approximately 0.4 m depth and the second to approximately 0.8 m depth. It was intended that the two holes would be used for near-simultaneous soakage tests targeting different depths in the soil profile.

Overall, each of the River Terraces is covered by a surficial fine sandy silt layer at least 0.9 m deep. The characteristics of these fine-grained layers are consistent between terraces. These fine sandy silt layers are interpreted as being post-glacial lake deposits.

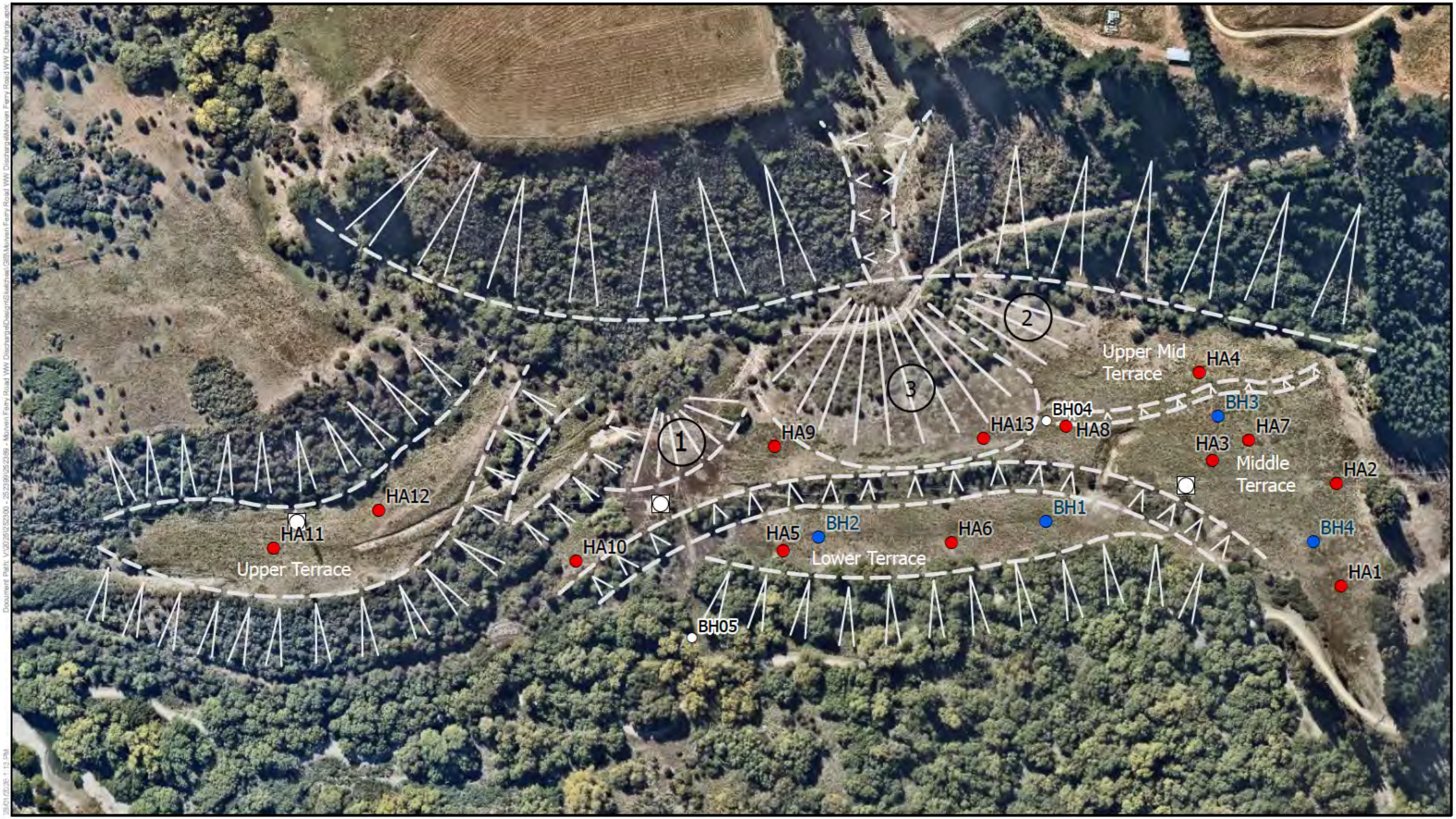
Observation of sediment exposures on eroded or excavated faces below the main terrace indicates the fine sediment is present to a depth of approximately 2.2 m BGL. Underlying that depth layers of coarse sands and fine gravels appear. These observations are consistent with the drillhole logs from investigation trenches and machine auger holes drilled by Kirk Roberts on the main terrace (Appendix A)

The main terrace is also partially covered by alluvial fans (Section 2.2), which are characterised by poorly sorted gravelly sandy silt deposits derived from the erosion of older lake deposits underlying the Residential Terrace. One hand auger hole (HA13) was drilled with difficulty into the lower slope of one of these fans. Two attempts resulted in shallow refusal due to the auger meeting cobble clasts, with the final attempt reaching refusal at the target depth of 0.7 m.

3.1.3.2 Deeper Piezometer Holes

Four deeper 100 mm diameter investigation holes (BH1 to BH4) have been drilled on the main and lower terraces, with two holes on each terrace (Figure 14). A 52 mm ID piezometer has been installed in each hole. Drillhole logs for these investigation holes are provided in Appendix A. The design specified that the piezometers should be screened within the uppermost gravels underlying the surficial sandy silt deposits.

The four deeper drillholes intersected strata ranging from sandy silts to gravels. In all four drillholes the uppermost sediment sequence from top to bottom consists of topsoil, silts, sands then gravelly sands. Below that depth the strata appear to become less continuous between the drillholes and more lensoid in nature. Groundwater was intersected at depths of 4.2 m in the holes drilled on the Lower Terrace, which is below the target depth for the two holes drilled on the Main Terrace. Neither of the holes drilled on the Main Terrace intersected groundwater.



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LEGEND

☐ Pylon	● Hand Auger Hole
∧ ∧ Drop Off	● Piezometer
Alluvial Fan	○ Water Supply Trail Bore
Slope Break	

WGA

Figure **14**

Drillhole and Trench Investigation
Locations for the Kawarau River Terraces

3.1.3.3 Water Supply Trial Bores

Two deep trial bores were drilled by SouthDrill on the River Terraces (Figure 14), to test for potential water supplies for the development. Copies of the driller's logs for each of these trial holes are provided in Appendix C.

BH04

The more northerly of the two deep water supply trial bores, BH04, was drilled on the Main Terrace, with the ground elevation at approximately 318 mRL. The drillhole intersected topsoils and sandy gravels to a depth of 8.4 m BGL, which is consistent with the deep soakage holes described above. Below that depth, silts and gravelly silts were intersected to a depth of 34.4 m BGL, with this unit interpreted as representing a confining layer. From 34.4 m to 38.8 m BGL silty gravels were intersected with 'large water flows'. Basement schist was intersected at 38.8 m BGL, with little water flow generated from this unit. The silty gravels intersected from 34.4 m to 38.8 m BGL in BH04 are considered to behave as a leaky confined aquifer with a thickness of approximately 4.4 m.

Prior to an initial stepped rate pumping test being performed on this bore, the static water level (SWL) was measured at 9.22 m below the top of casing (m BTOC), which is equivalent to 8.92 m BGL. At its closest approach, the Kawarau River is approximately 330 m from BH04, and it has an elevation of approximately 306 mRL at this point. The hydraulic gradient between BH04 and the river, assuming a direct hydraulic connection between the aquifer and the riverbed, is approximately 0.009 m/m. A pumping test performed on this unit is documented in Section 3.2.2.

BH05

The more southerly of the two deep water supply trial bores, BH05, was drilled on an access track from the Lower Terrace to the river flood plain, at an elevation of approximately 307 mRL. The measurement datum for groundwater levels was the top of casing, 0.96 m above ground level. Bore BH05 intersected topsoils and sandy gravels to a depth of 8.2 m BGL, which is consistent with BH04. Below that depth, bands of silts and silt-bound gravels were intersected to a depth of 28.8 m BGL, with this unit interpreted as representing a confining layer. Basement schist was intersected at 28.8 m BGL, and drilling continued to a depth of 102 m BGL. The schist intersected was apparently heavily fractured and produced substantial flows of water during the drilling. The driller's description of alternating hard and soft bands, together with substantial inflows of water is very unusual for basement schist rock mass in Otago. The observed flows led to the driller leaving almost the entire schist section as open hole, with the overlying sediments cased off.

Prior to a constant rate pumping test being performed on this bore, the SWL was measured at 0.28 m above the top of casing, which is equivalent to 308.3 m RL. This contrasts with the SWL measured immediately following completion of the bore, which was 1.24 m BTOC or approximately 306.8 m RL. At its closest approach, the Kawarau River is approximately 280 m from BH05, and it has an elevation of approximately 306.5 mRL at this point. The hydraulic gradient between BH05 and the river, assuming a direct hydraulic connection between the aquifer and the riverbed, is approximately 0.006 m/m. A pumping test performed on this schist is documented in Section 3.2.2.

3.2 Hydraulic Testing Programme and Results

3.2.1 Residential Terraces

A total of 11 soakage tests were undertaken by Kirk Roberts, distributed across the Residential Terrace. The data from these tests and the analysis results from Kirk Roberts are presented in Appendix B and summarised in Table 4.

Analyses by Kirk Roberts indicate eight out of the eleven soakage tests returned soakage rates of 0.03 m/hour (or $m^3/hr/m^2$). The only two results to reach or exceed 0.1 m/hour were from tests performed on soakage holes located toward the northeastern edge of Ridgeburn (Figure 15).

Overall, the interpreted soakage rates are low, with the highest rates interpreted as occurring toward the northeastern edge of the Ridgeburn area (SK-02 and SK-04, Figure 15). This observation is consistent with the interpreted gravelly sand and sand present in this area (Figure 15), combined with the lack of a hard base termination to the soakage hole (Figure 13).

Analysis of the soakage test data indicates the hydraulic conductivity of the soils tested is predominantly less 0.4 m/day, with only two results being equal to or exceeding 1 m/day (Table 4). The permeability of the soils, as expressed by the hydraulic conductivity values, is generally moderately low, indicative of a silty matrix even when the descriptions from the drillhole logs is of a sand or a gravelly sand (Figure 16). The soil permeability indicated from the soakage tests tends to increase toward the north, which is consistent with the coarsening trend in the sediments (Figure 16).

Table 4: Soakage Rates and Hydraulic Conductivity Derived from Soakage Tests on Residential Terrace (Kirk Roberts)

INVESTIGATION SOAKAGE HOLE	DEPTH (m)	HYDRAULIC CONDUCTIVITY (m/s)^(1,2)	HYDRAULIC CONDUCTIVITY (m/day)^(1,2)	KIRK ROBERTS SOAKAGE RATE ($m^3/hr/m^2$)
SK-01	3.00	5×10^{-6}	0.4	0.03
SK-02	3.00	4×10^{-6}	0.3	0.1
SK-03	1.70	3×10^{-6}	0.3	0.02
SK-04	1.60	7×10^{-5}	6	0.23
SK-05	2.30	2×10^{-7}	0.02	<0.005
SK-06	0.78	1×10^{-6}	0.1	0.01
SK-07	2.50	2×10^{-7}	0.02	0.01
SK-08	0.44	1×10^{-5}	1	0.07
SK-09	1.57	1×10^{-6}	0.1	0.02
SK-10	1.07	1×10^{-7}	0.01	0.01
SK-11	3.00	4×10^{-7}	0.04	0.01

Note:

(1) Refer to analysis sheets in Appendix B for uncertainty notes regarding hydraulic conductivity analysis results.

(2) Blue cells indicative of good permeability (>= 1 m/day), orange cells indicate moderate permeability (1 to 0.1 m/day), red cells indicate low permeability (< 0.1 m/day).

3.2.2 River Terraces

3.2.2.1 Shallow Sediments

Soakage tests have been used to investigate the hydraulic characteristics of shallow soils on each of the River Terraces. Hand auger holes were drilled to depths of up to 0.9 m and the drill hole cuttings were logged (Section 3.1). Each auger hole was then filled with water and the rate at which the water level dropped within the hole was recorded. WGA undertook a total of 25 falling head (soakage) tests in these hand auger holes. The resulting hydraulic test data was then analysed to provide an estimate for the hydraulic conductivity of the soils surrounding the auger hole. Copies of the analysis sheets are presented in Appendix B. The results for each terrace are summarised in Table 5 and a summary of the overall hydraulic behaviour of the soils for that terrace are summarised in Table 6. The hydraulic behaviour of the fine-grained soils is consistent across each of the terraces, and between terraces.

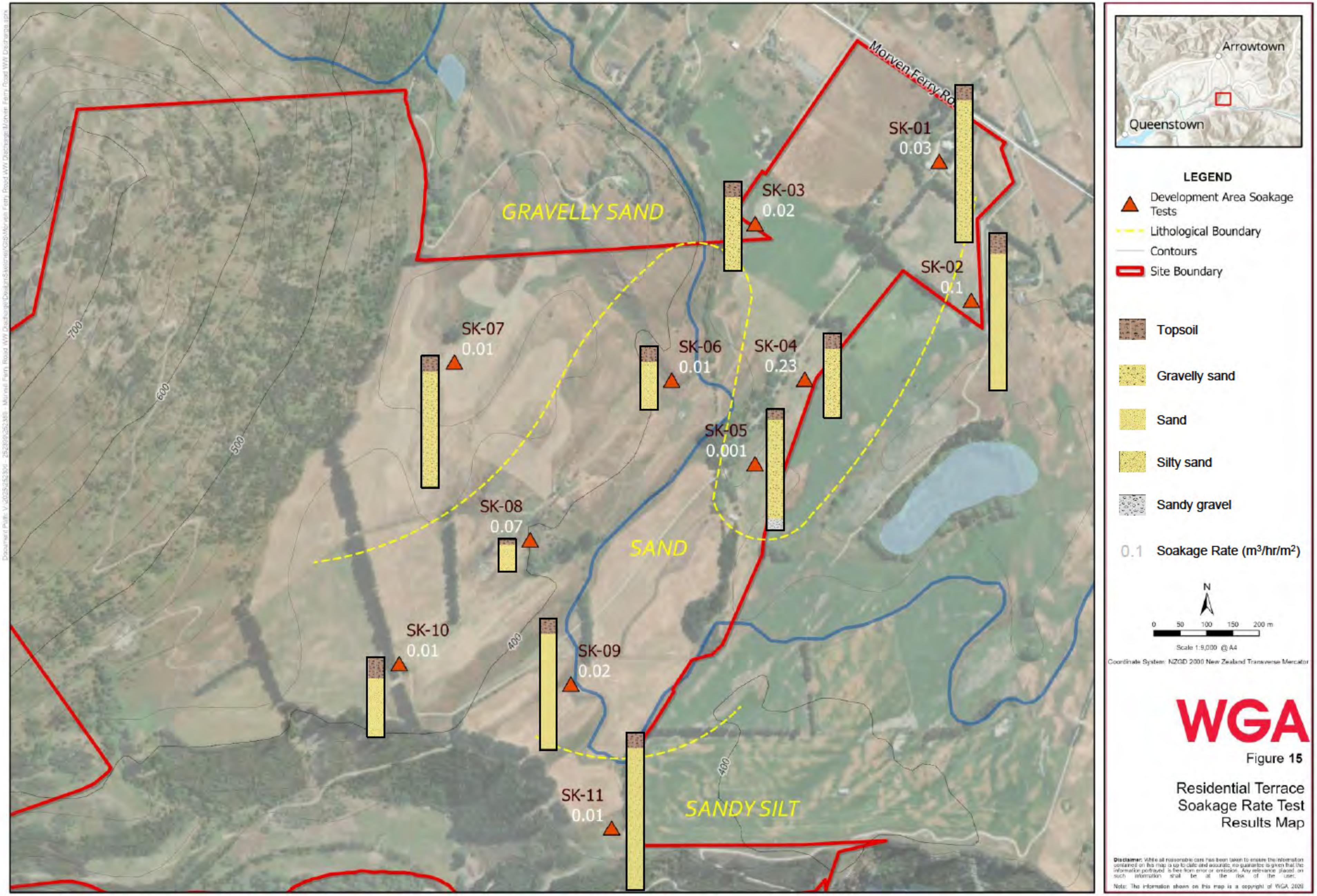

Figure **15**

Residential Terrace
Soakage Rate Test
Results Map

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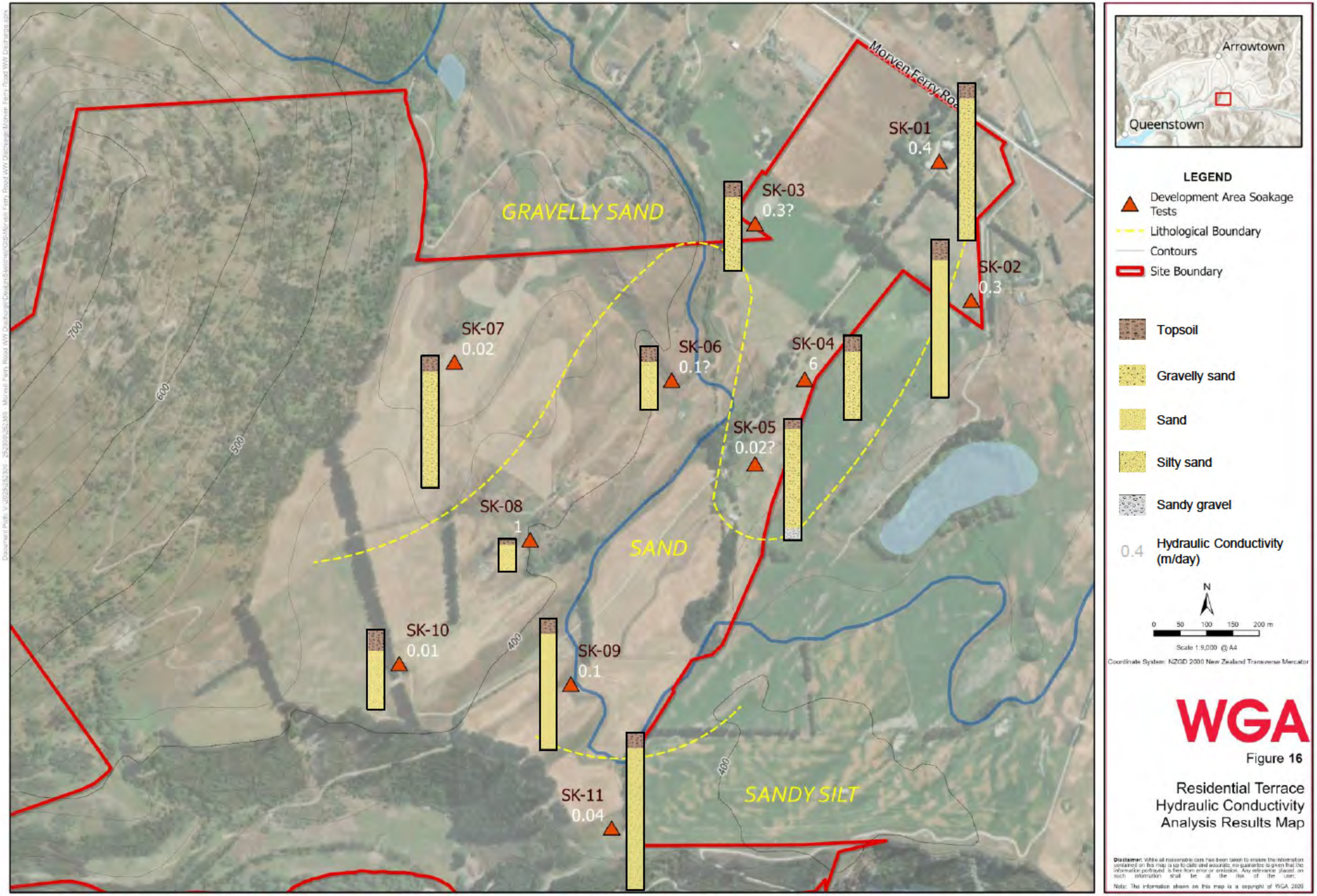


Figure 16

Residential Terrace
Hydraulic Conductivity
Analysis Results Map

Table 5: Hand Auger Drillhole Falling Head (Soakage) Test Results for River Terrace Soils

TEST	DEPTH (m)(1)	HYDRAULIC CONDUCTIVITY		TERRACE AREA
		(m/s)	(m/day)	
HA1 S	0.42	9×10^{-6}	0.8	Main Terrace
HA1 D	0.8	2×10^{-6}	0.2	Main Terrace
HA2 S	0.42	6×10^{-6}	0.5	Main Terrace
HA2 D	0.8	2×10^{-6}	0.2	Main Terrace
HA3 S	0.41	7×10^{-7}	0.06	Main Terrace
HA3 D	0.8	7×10^{-7}	0.06	Main Terrace
HA4 S	0.41	1×10^{-6}	0.1	Main Terrace
HA4 D	0.8	4×10^{-6}	0.4	Main Terrace
HE5 S	0.44	2×10^{-5}	1.4	Lower Terrace
HA5 D	0.8	8×10^{-6}	0.7	Lower Terrace
HA6 S	0.5	1×10^{-5}	0.9	Lower Terrace
HA6 D	0.8	9×10^{-6}	0.7	Lower Terrace
HA7 S	0.45	2×10^{-6}	0.2	Main Terrace
HA8 S	0.5	1×10^{-7}	0.01	Main Terrace
HA8 D	0.9	1×10^{-7}	0.01	Main Terrace
HA9 S	0.51	2×10^{-5}	1.4	Main Terrace
HA9 D	0.85	3×10^{-7}	0.02	Main Terrace
HA10 S	0.45	2×10^{-6}	0.1	Main Terrace
HA10 D	0.95	7×10^{-7}	0.06	Main Terrace
HA11 S	0.45	4×10^{-6}	0.4	Upper Terrace
HA11 D	0.6	2×10^{-6}	0.2	Upper Terrace
HA12 S	0.47	3×10^{-6}	0.2	Upper Terrace
HA12 D	0.9	2×10^{-6}	0.2	Upper Terrace
HA13	0.7	2×10^{-6}	0.2	Main Terrace Fan
SK-1		9×10^{-6}	0.8	Main Terrace Sand Bed
SK-2		5×10^{-6}	0.4	Main Terrace Sand Bed
SK-3		1×10^{-5}	1.1	Main Terrace Sand Bed

Note:

(1) Depth indicates depth of the hole in which the test was made.

Table 6: Falling Head (Soakage) Median Test Results for River Terrace Soils

PARAMETER	MEDIAN HYDRAULIC CONDUCTIVITY	
	(m/s)	(m/day)
Main Terrace Median	2×10^{-6}	0.1
Lower Terrace Median	1×10^{-5}	0.8
Upper Terrace Median	2×10^{-6}	0.2
Main Terrace Fan	2×10^{-6}	0.2

3.2.2.2 Deeper Piezometers

Four holes (BH1 to BH4) were drilled through the surficial soils on the Main and Lower River Terraces and were instrumented with piezometers screened in the uppermost three metres of the immediately underlying gravels. These 52 mm diameters piezometers were tested by Kirk Roberts using falling head tests. In each case, the tests were repeated three times as the recovery rates were rapid, and repeatability of the tests was important.

The recovery curves from these falling head tests were analysed to determine the hydraulic conductivity of the surrounding gravel sediments. Copies of the test analysis sheets are provided in Appendix B (Figures B31 to B42). The results from analysis of the failing head tests were consistent from site to site (Table 7), within a range from 1 x 10^{-4} to 4 x 10^{-4} m/s. The average hydraulic conductivity results for each of these piezometers (Table 7) indicate the permeability of these gravelly sand layers is approximately 100 times higher than the permeability of the surficial silts (Table 6).

Table 7: Falling Head Average Test Results for River Terrace Gravels

BORE ID	AVERAGE HYDRAULIC CONDUCTIVITY(1)	
	(m/s)	(m/day)
BH1	1.4 x 10^{-4}	12
BH2	2.7 x 10^{-4}	24
BH3	3.9 x 10^{-4}	34
BH4	4.1 x 10^{-4}	36
Average	3.1 x 10^{-4}	26

Note:

(1) Average of the results from three falling head tests performed on each piezometer.

3.2.2.3 Water Supply Trial Bores

Two deeper trial bores to test for potential water supplies for the development (BH04 and BH05) were drilled on the River Terraces (Section 3.1.3.3). Pumping tests were performed on these two bores by SouthDrill, with the raw data provided to WGA for analysis (Appendix C).

BH04

Conceptually, BH04 is screened in a 4.4 m thick gravel aquifer that is underlain by impermeable (relative to the aquifer) schist bedrock and overlain by a 26 m thick leaky silt confining layer. Above the confining layer is another gravel aquifer that contains a free groundwater surface. The bore is 150 mm diameter, with the flow rate applied being approximately 6.45 L/s. Consequently, well bore storage is expected to have a significant effect on the early-stage drawdown curve.

Analysis results from the pumping tests are summarised in Table 8, with copies of the analysis sheets provided in Appendix C. As no observation well was available to monitoring the drawdown from this test at a distance from BH04, the value derived for aquifer storativity is unreliable and not documented in Table 8.

Bore BH04 is located approximately 330 m from the Kawerau River at its closest approach. Based on the indicated aquifer transmissivity, the pumping rate and the length of the pumping test, it is reasonable to expect that the pumping test could have been influenced by recharge from the river. The results from the analysis method applied (Moench leaky confined aquifer method with a constant head in an overlying aquifer) suggest recharge from the river may have influenced drawdown during the pumping test.

Table 8: Hydraulic Test Results from Water Supply Trial Bores

PARAMETER	UNITS	BH04	BH05
Aquifer type		Gravel, leaky confined	Fractured rock, leaky confined
Analysis methodology applied		Moench (1985) leaky confined aquifer with constant head in overlying aquifer	Hantush (1960) leaky confined aquifer
Pumping rate applied	L/s	6.45	11.7
	m^3/day	560	1,010
Saturated aquifer thickness	m	4.4	73
Aquifer hydraulic conductivity	m/s	1.3×10^{-4}	8×10^{-7}
	m/day	10.9	0.07
Aquifer transmissivity	m^2/s	5.5×10^{-4}	6×10^{-5}
	m^2/day	48	5.2
Confining aquitard thickness	m	26	29
Confining aquitard vertical hydraulic conductivity (1)	m/s	1.6×10^{-8}	-
	m/day	0.0014	-

Note:

(1) The lack of appropriate data from observation wells means the values for hydraulic conductivity of the confining layer are subject to significant uncertainty.

BH05

Conceptually, BH05 is screened in heavily fractured zone of schist with a total exposed thickness in the drillhole of 73 m. The overlying 29 m of silts and other sediments were cased off and are interpreted to constitute a thick leaky silt confining layer. The bore is 150 mm diameter, with the flow rate applied being approximately 11.7 L/s. Consequently, well bore storage is expected to have a significant effect on the early-stage drawdown curve.

Analysis results from the pumping tests are summarised in Table 8, with copies of the analysis sheets provided in Appendix C. As no observation well was available to monitoring the drawdown from this test at a distance from BH05, the values for aquifer storativity and aquitard leakance are unreliable and not documented in Table 8.

Bore BH05 is located approximately 280 m from the Kawerau River at its closest approach. Based on the indicated aquifer transmissivity, the pumping rate and the length of the pumping test, it is reasonable to expect that the pumping test could have been influenced by recharge from the river. We note that the alternating hard and soft bands in the schist intersected suggest the drillhole intersected a complex and steeply dipping fault zone. Furthermore, the results from the analysis method applied (Hantush leaky confined aquifer method) suggest a strong hydraulic connection to a nearby water source. On this basis, it is reasonably expected that water drawn to BH05 by pumping is predominantly sourced from the Kawarau River.

As there was no separate observation bore available to monitor the pumping test on BH05, there is significant uncertainty in the hydraulic characteristics of the aquifer around this bore. The analysis outcomes incorporating a strong hydraulic conductivity to a surface water body suggest the pumping would have generated negligible drawdown in the surrounding aquifer. Although this outcome is reasonable and provides the best fitted curve to the drawdown data that we were able to achieve, it does not provide a conservative estimate of drawdown to inform the assessment of the source water protection zone (Section 4.4).

4 INTERPRETATION

4.1 Conceptual Groundwater Model

Morven Hill is composed of schist bedrock left behind by glacial erosion. This schist bedrock extends out underneath the Residential Terrace at shallow depth. To the south, the bedrock is interpreted to drop away steeply close to the River Terrace drop-off (Figure 17). The bedrock then extends out under the River Terraces at depths of several tens of at least 20 to 40 m. For the purposes of this wastewater disposal assessment, the schist bedrock can be considered as effectively impermeable.

The Residential Terrace is covered by glacial or alluvial soils and sediments several metres thick. Both the surface of this terrace and the underlying interface between the soils and the schist bedrock are interpreted to slope downward toward the northeast, as far as the Arrow River. Groundwater flows across the residential terrace are interpreted to be in a northeast direction, consistent with the overall topographic gradient. An on-site elongate perennial wetland follows a drainage flow path in a southeasterly direction. Shallow groundwater within higher ground surrounding this drainage pathway is interpreted to potentially discharge into this wetland. The other on-site seasonal wetlands are interpreted to potentially receive shallow groundwater inputs on a seasonal basis and otherwise lose to ground.

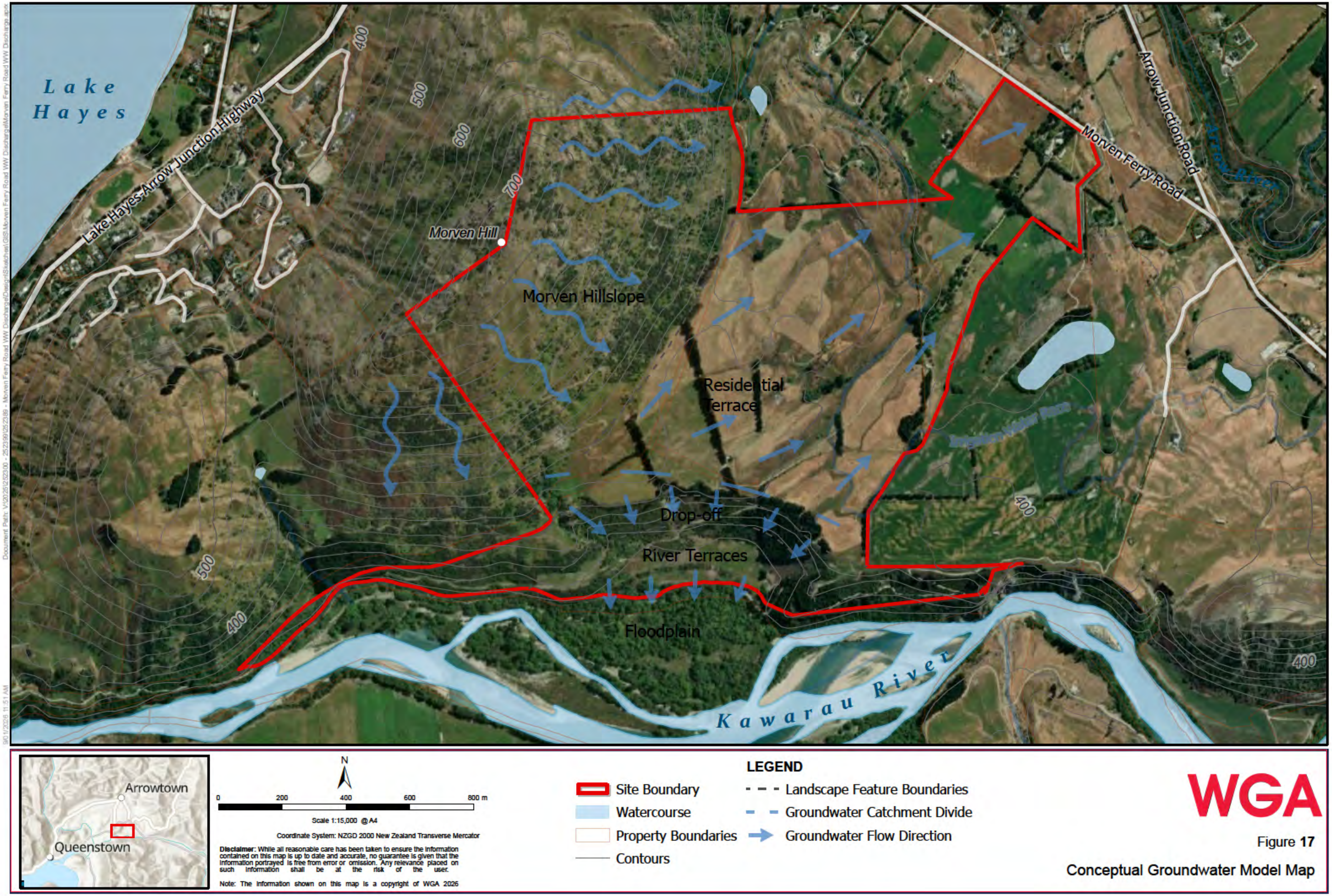
The Morven Road water race that crosses Ridgeburn (Figure 17) is likely to be hydraulically connected to the surrounding groundwater system. However, it is not clear from the available data whether the irrigation race is losing water to the groundwater or vice versa, or both, depending on season and the stretch of the water race being considered. The planned piping of the water race under Ridgeburn will disconnect the race hydraulically from the groundwater system.

A farm pond is located on the Residential Terrace approximately 200 m east of the Ridgeburn boundary (Figure 17). This pond occupies a shallow topographic basin, with the outflow from the pond being toward the west. Although no investigations have been undertaken off-site, the shallow groundwater table within the surface catchment of this pond is interpreted as reflecting the overlying topography. On that basis, it is expected that shallow groundwater flows exiting the Ridgeburn area of the Residential terrace will pass to the north of this pond rather than entering the pond's catchment basin.

Groundwater flow close to the southern edge of the Residential Terrace, and under the terrace drop-off to the south, is likely to be toward the south (Figure 17). The groundwater flow rates underneath the drop-off are likely to be small due to the limited catchment area. Most of the glacial and lake deposits exposed in the drop-off and underlying the southern edge of the residential terrace are expected to be unsaturated. No indications of groundwater discharges at the toe of the drop-off in the form of seeps or springs were found during the field investigations.

The sand and gravel aquifers underlying the Middle and Lower Terraces, together with the highly fractured schist intersected in BH05, are considered to be strongly connected to the Kawarau River. The depth to groundwater underlying the River Terraces varies, depending primarily on the elevation of the terrace surface. Observed depths to groundwater under the Middle and Lower Terraces were several metres, whereas groundwater under the river floodplain was effectively at surface during the October field investigation programme. However, depths to groundwater under the River Terraces will also vary in response to changes in water level in the Kawarau River due to the strong hydraulic connection between the river and these aquifers.

Groundwater abstracted for supply purposes through bores BH04 and BH05 is likely to be primarily recharged through seepage flows from the Kawarau River. The extent of groundwater drawdown in response to these proposed takes is expected to be limited to the aquifer areas underlying the River Terraces. Therefore, these proposed groundwater takes are considered to effectively be surface water takes through a stream depletion process.



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Coordinate System: NZGD 2000 New Zealand Transverse Mercator

Figure **17**

Conceptual Groundwater Model Map

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4.2 Treated Wastewater Loading Rates

4.2.1 Morven Hill

The soils of the Morven Hill slopes are expected to be Category 3 to 4 loam soils covering colluvium and weathered schist bedrock (Section 3.1.1). A loading rate using spray irrigation is limited to Category 4 soils, where 3.5 mm/day is considered appropriate (AS/NZS 1547 Table 5.2), provided allowances are made for system constructability. Refer to the assessment of wastewater discharge effects for further information (WGA 2026a).

4.2.2 Residential Terrace

A range of sediment lithologies was intersected by soakage holes drilled on the Residential Terrace, including sandy sediments. However, the hydraulic conductivity values derived from analysis of the tests (Section 3.2.1) indicates the soils are Category 4 as set out in Table 5.1 of the AS/NZS 1547. On this basis, subsurface dripline irrigation loading rates are likely to be equivalent to those appropriate for loams (3.5 mm/day, AS/NZS 1547 Table 5.2), with allowances to be made for slope gradients within the development area. Refer to the assessment of wastewater discharge effects for further information (WGA 2026a).

4.3 Development Stormwater Management

The proposed development, including stormwater management infrastructure and impervious surfaces, would result in changes to the hydrological behaviour of existing stormwater catchments supplying surface water and groundwater to the on-site wetlands. The site investigations undertaken by Kirk Roberts and Viridis inform the hydrogeological conditions and behaviour of these on-site wetlands, as per the conceptual groundwater model presented above. One on-site wetland is expected to be perennial (wet across the seasons) as a result of natural stormwater and groundwater inputs (Section 2.3.3).

According to McKenzie (2026b), the projected changes to stormwater flows are relatively small (up to a 10% increase in flow to the perennial wetland during a two-year storm under their modelled climate change scenario). Spatially distributed groundwater recharge within the wetland catchments is expected to be reduced due to placement of impervious surfaces. However, focused recharge to groundwater within the wetland catchments is expected to increase through the operation of proposed constructed wetlands, ponds, and dry basins designed to attenuate flooding effects related to extreme storm events. The proposed dry basins and swales are also expected to increase shallow groundwater recharge up-gradient from and around the existing on-site wetlands during low-level precipitation events. Further to this, treated wastewater is proposed to be utilised for irrigation of native plants on Morven Hill (WGA 2026a). Morven Hill forms a primary groundwater recharge area within the on-site perennial wetland catchment. Refer to the assessment of stormwater hydrogeological effects for further information (WGA 2026c).

4.4 Groundwater Take and Water Supply Bore Protection Area

Site investigations inform the hydrogeology of the River Terraces area, where the two proposed community water supply bores are located. The site testing provides a basis for characterising groundwater flow and contaminant transport for the groundwater take assessment of effects and community source water protection zone.

The shallow sediments underlying the topsoil across the River Terraces are considered descriptively to be Category 4 weakly structured clay loams, as set out in Table 5.1 of the AS/NZS 1547. The indicative permeability of these Category 4 soils is in the range from 0.12 to 0.5 m/day, which is consistent with the median results from the soakage tests performed by WGA (Table 6).

Underlying these shallow sediments are more gravelly, permeable, aquifer strata, as encountered by the deeper piezometers described in Section 3.2.2.2. The shallow gravel aquifer strata screened by the deeper piezometers is interpreted to the hydraulically connected to the Kawarau River, which is approximately 200 m to 400 m from most areas on the River Terraces.

A preliminary calculation of water supply bore capacities has been undertaken to support the designation of protection areas for these bores. A more detailed assessment of water supply bore performance and treatment for potable supply is provided by GWE (2026). The preliminary estimate (Table 9) indicates BH04 and BH05 have production capacities of approximately 600 and 1,880 m^3/day, respectively. These flow rates are appropriate and conservative for the assessment of the water supply protection areas.

The analysis of the aquifer parameters from the pumping test performed on BH05 indicates a direct hydraulic connection to the Kawarau River (Section 3.2.2.3). Consequently, projected groundwater drawdown in the aquifer is negligible, even after 365 days pumping at 1,880 m^3/day. For the purposes of defining a source water protection area, we have discounted the potential direct connection river and have utilised instead the projected aquifer drawdown derived from the BH04 pumping test.

The assumption regarding the applicability of the projected aquifer drawdown derived from the BH04 pumping test to define a combined source water protection area is not considered to be a significant one. The River Terraces are laterally highly restricted by the Kawarau River and the steeply rising schist bedrock at the southern edge of the Residential Terrace. For this reason, the extent of groundwater drawdown in the aquifers around the water supply bores is not a key factor in defining the source water protection area.

Table 9: Preliminary Water Supply Bore Capacity Estimates

PARAMETER	UNITS	BH04	BH05
Depth	m BGL	37.79	102.96
Base of Casing	m BGL	34.79	65
Static Water Level	m BGL	8.92	0.28
Test Flow Rate	L/s	6.45	11.7
	m^3/day	557	1,010
Available Drawdown (1)	m	18.9	57.7
Test Drawdown	m	17.4	31.0
Specific Capacity Approximation	m^3/day/m	32.0	32.6
Bore Production Capacity	m^3/day	600	1,880
	L/s (2)	6.9	21.8

Note:

(1) The calculation of available drawdown includes an allowance of 2 m to install the pump above the base off the board casing and a further 5 m for cavitation protection.

(2) The flow rate in L/s is an average over 24 hours equivalent to the m^3/day value.

An indicative groundwater drawdown curve following a pumping period of 365 days, derived from the pumping test performed on BH04, is presented in Figure 18. There is considerable uncertainty regarding the extent and magnitude of groundwater drawdown that would arise from the use of BH04 as a water supply bore. However, the key point is that the drawdown would extend across most of the area occupied by the River Terraces. Importantly, if both BH04 and BH05 were utilised for water supply purposes, the combined drawdown would extend across all of the area occupied by the river terraces.

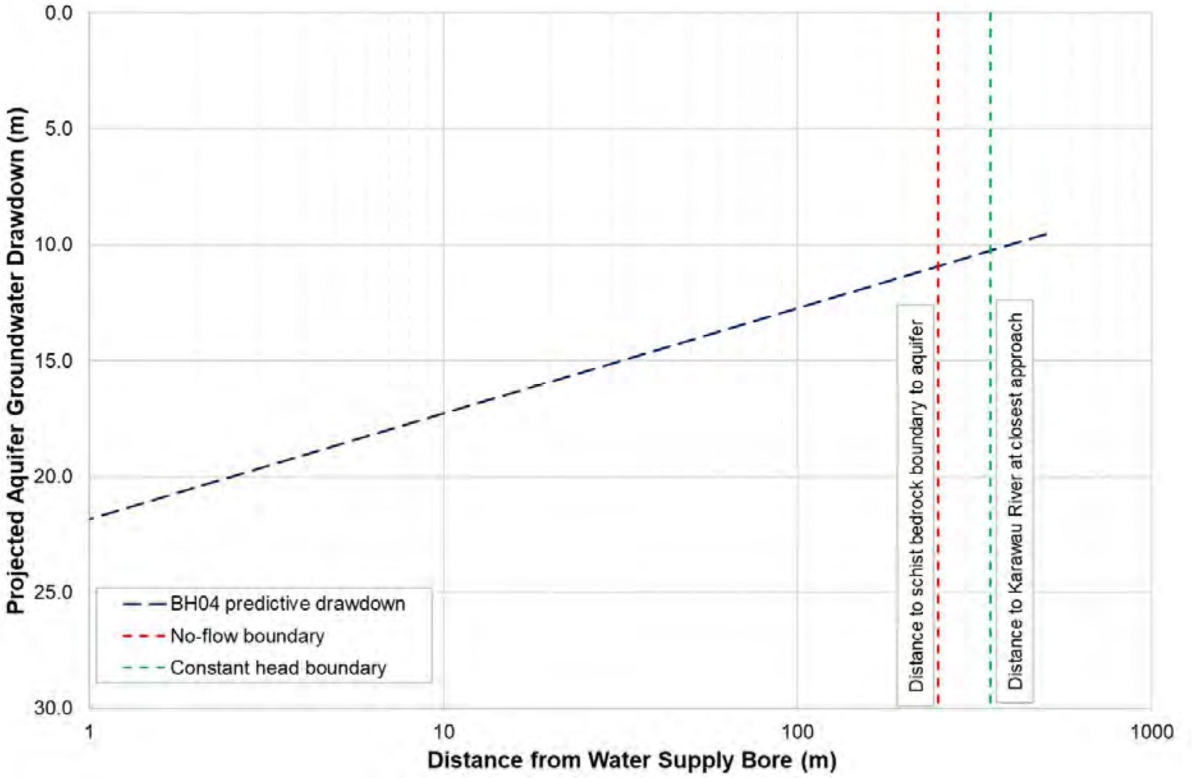


Figure 18: Indicative Magnitude and Extent of Groundwater Drawdown Around BH04

The hydraulic boundaries to the aquifers underlying the river terraces are:

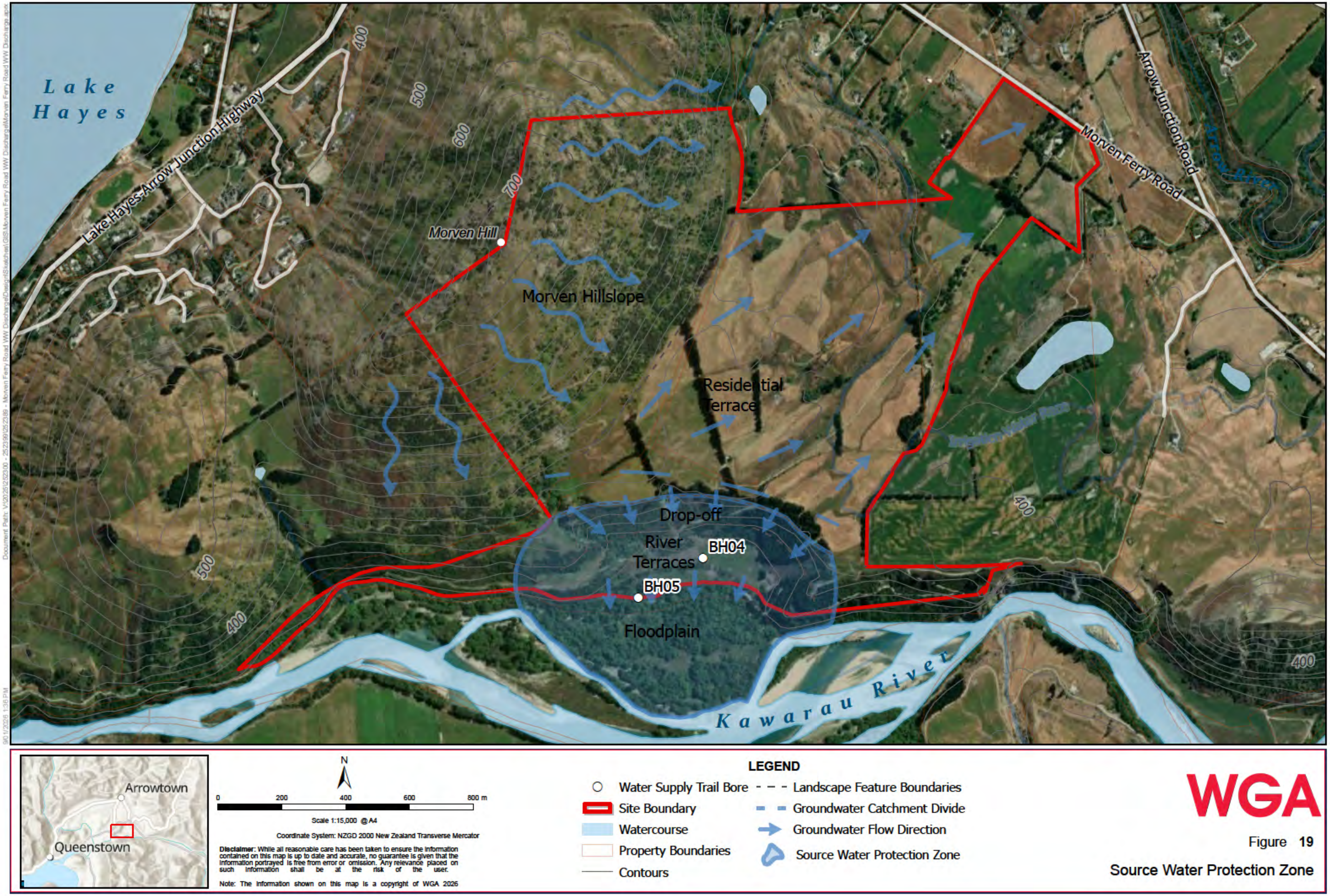
1. The Kawarau River and any branches of the river, which would act as recharge boundaries.
2. The schist bedrock underlying the Residential Terrace, which would effectively act as a no-flow boundary. To the north of this boundary groundwater drawdown and contributing recharge would be insignificant.

In terms of a groundwater protection zone around the two proposed water supply bores, this zone would effectively include and be limited to all of the River Terrace areas as shown on Figure 19. This protection zone would extend south and outside the Ridgeburn development area to include the Kawarau River floodplain.

The irrigation of treated wastewater to Morven Hill slopes would not impact on the groundwater protection zone as water seeping through soils on the hillslopes would be primarily taken up by soils underlying the residential terrace. Groundwater flow in these soils is toward the northeast, in a direction consistent with the topographic gradient (Figure 17). In effect, seepage water from Morven Hill would be transported in the subsurface away from the two proposed water supply bores. The groundwater drawdown cones generated by the proposed abstraction would not affect the groundwater system on the Residential Terrace.

The southwest extent of Morven Hill within the Ridgeburn boundary above the Residential Terrace is marginally within the interpreted groundwater recharge area to River Terraces (including the Kawarau River Alluvial Ribbon Aquifer). This area of Morven Hill represents approximately 10 ha (about 6%) of the approximate total groundwater recharge area to the Kawarau Ribbon Alluvial Ribbon Aquifer of 160 ha. Much of this recharge area is outside of the Ridgeburn boundary to the southwest.

The fraction of the proposed groundwater abstraction sourced from up-gradient groundwater recharge is estimated to be about 3% of the total take, with contributions from the Kawarau River making up the remainder (WGA 2026b). Therefore, only about 0.2% of the proposed groundwater take is expected to be sourced from recharge within proposed irrigation areas on Morven Hill. The groundwater protection zone is informed by assessment of the potential exposure pathway between the edge of the Residential Terrace and the production bores. This assessment indicates suitable attenuation is provided by the groundwater protection zone, with treated wastewater irrigation predominantly proposed outside of this zone on the Residential Terrace and Morven Hill (WGA 2026a).



Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Any relevance placed on such information shall be at the risk of the user.

Note: The information shown on this map is a copyright of WGA 2026

Figure 19

Source Water Protection Zone

Document Path: V:\2025\252300 - 252399\252389 - Morven Ferry Road WW Discharge\Design\Sketches\GIS\Morven Ferry Road WW Discharge\Morven Ferry Road WW Discharge.aprx

9/01/2026 1:36 PM

5 CLOSURE

The information presented in this report is principally factual in nature, combined with interpretive material related to the current groundwater systems at Ridgeburn. This report was produced to support the WGA groundwater effects assessments produced to support the application for resource consents authorising the Ridgeburn development to take and treat groundwater for potable community supply, manage and discharge stormwater, and utilise treated wastewater for irrigation discharge to land. The contents of this report should be considered in conjunction with the relevant WGA hydrogeological assessment of environmental effects reports (groundwater, wastewater, and stormwater).

6 REFERENCES

B & A 2025. Ridgeburn Mixed Use Development, 122 Morven Ferry Road. Fast-track Approvals Act 2024 referral application. Report produced for Ridgeburn Limited by Barker & Associates Limited. 25 June 2025.

Barrell D J A, Riddolls B W, Riddolls P M, Thomson R 1994. Surficial geology of the Wakatipu Basin, western Central Otago, New Zealand. Institute of Geological & Nuclear Sciences. Science Report 94/39.

BPO 2026. Ridgeburn wastewater treatment plant design report. Draft report produced for Gibbons Co Ltd by BPO Ltd. BPO report J9024. Dated 28 January 2026.

GNS Science 2019. Nationwide groundwater recharge model [data set]. GNS Science. https://doi.org/10.21420/MPSD-P640.

GWE 2026. Ridgeburn – Arrowtown Junction, Water Supply Servicing Strategy. Prepared for Gibbons Co by GWE Consulting Engineers.

Hantush M S 1960. Modification of the theory of leaky aquifers. Journal of Geophysical Research 65 (11) 3713-3725.

Kirk Roberts 2025. Geotechnical Review for Proposed Development at Morven Ferry Road, Queenstown. Report produced for Ridgeburn Limited by Kirk Roberts Consulting Engineers Ltd. Kirk Roberts reference 2555087. 20 May 2025.

Kirk Roberts 2026. Geotechnical Assessment Report – 122 Morven Ferry Road, Arrow Junction. Report No. 2555087 REP001 GEO, Revision C, Draft. Prepared for Gibbons Developments Limited by Kirk Roberts Consulting Engineers Ltd.

McKenzie 2026a. Ridgeburn, 122 Morven Ferry Road, Arrow Junction, Queenstown. Stormwater Plans, Resource Consent Drawings, prepared for Gibbons Developments by McKenzie & Co Ltd.

McKenzie 2026b. Ridgeburn, 122 Morven Ferry Road, Arrow Junction, Queenstown. Flooding Assessment, prepared for Gibbons Developments by McKenzie & Co Ltd.

Manaaki Whenua - Landcare Research 2025. S-map soil map unit factsheet for Ao2sS Otago region. Generated 17 November 2025 from S-map Online. https://smap.landcareresearch.co.nz/maps-and-tools/app?gislayer=Otago&soilmapuc=Ao2sS&factsheetType=undefined&siblingNumber=undefined&objectId=undefined&pinCoordinate=1271937.223920639%2C5008468.646006416

Moench A F 1985. Transient flow to a large-diameter well in an aquifer with storative semiconfining layers. Water Resources Research 21 (8) 1121-1131.

Theis C V 1935. The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using groundwater storage. American Geophysical Union Transactions 16, 519-524.

Turnbull I M 2000. Geology of the Wakatipu area. Institute of Geological & Nuclear Sciences 1:250,000 geological map 18.

Viridis 2026. Ridgeburn, Morven Ferry Road, ecological impact assessment. Report prepared for: Ridgeburn Limited by Viridis Limited. January 2026. Viridis document 10339-004-A.

WGA 2026a. Ridgeburn Development Wastewater Disposal and Effects. Report produced for Ridgeburn Ltd by Wallbridge Gilbert Aztec NZ Pty Ltd. WGA report WGA252389-HG-RP-0002_E.

WGA 2026b. Ridgeburn Development Groundwater Take Effects Assessment. Report produced for Ridgeburn Ltd by Wallbridge Gilbert Aztec NZ Pty Ltd. WGA report WGA252389-HG-RP-0003_B.

WGA 2026c. Ridgeburn Development Stormwater Hydrogeological Effects Assessment. Report produced for Ridgeburn Ltd by Wallbridge Gilbert Aztec NZ Pty Ltd. WGA report WGA252389-HG-RP-0004_A.

APPENDIX A
GEOLOGICAL LOGS

MACHINE BOREHOLE LOG

KIRK ROBERTS CONSULTING

Client: Gibbons Developments Ltd
Site Address: Morven Ferry Road
Town/City: Queenstown
Job No.: 2555087

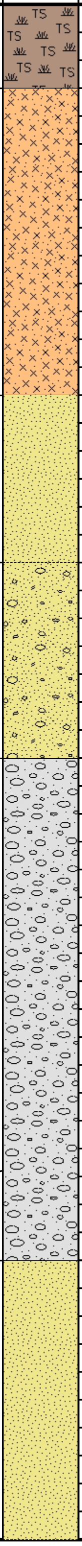
Weather: Fine
Borehole: BH-01
Type:

Latitude:
Logged By: TJ
Logged Date: 10/12/25

Longitude:
Checked By: OB
Checked Date: 10/12/25

Date:
Operator:
Datum: NZGD 2000

Geological Formation	DESCRIPTION	GRAPHIC	DEPTH	ELEVATION	TCR (%) 25 50 75	SPT N-VALUE (Uncorrected) 10 20 30 40	SPT DATA (Uncorrected)	INSTALLATION
Topsoil	Silty sandy TOPSOIL; dark grey. Moist, non-plastic; sand, fine.	TS						
	SILT, with some sand; dark grey. Moist, non-plastic; sand, fine.		1.0	-1.0				
	SAND, with minor silt; dark grey. Moist, non-plastic, sand, fine.		2.0	-2.0				
	Gravelly SAND; dark grey. Moist, sand, fine to coarse; gravel, fine, subround.							
	Sandy GRAVEL; grey . Moist, gravel, fine to medium, subround; sand, fine to coarse. 4.2m: Ground water.		3.0 4.0	-3.0 -4.0				
	SAND, with minor gravel; brownish. Moist, sand, fine; gravel, fine to medium, subround.		5.0	-5.0				



REMARKS

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Test Bore log tests give an indication of the ground condition at the location of the tests only. While they are representative of typical conditions across the site, they do not identify variations in the ground away from the test locations.

Elevation datum and coordinates sourced from council GIS LiDAR contours.

Water Level Measurements

Generated by GEROC Core-GS

MACHINE BOREHOLE LOG

Client: Gibbons Developments Ltd
Site Address: Morven Ferry Road
Town/City: Queenstown
Job No.: 2555087

Weather: Fine
Borehole: BH-01
Type:

Latitude:
Logged By: TJ
Logged Date: 10/12/25

Longitude:
Checked By: OB
Checked Date: 10/12/25

Date:
Operator:
Datum: NZGD 2000

Geological Formation	DESCRIPTION	GRAPHIC	DEPTH	ELEVATION	TCR (%) 25 50 75	SPT N-VALUE (Uncorrected) 10 20 30 40	SPT DATA (Uncorrected)	INSTALLATION
	[CONT] SAND, with minor gravel; brownish. Moist, sand, fine; gravel, fine to medium, subround.	▨						
		▨	6.0	6.0				
		▨	7.0	7.0				
		▨	8.0	8.0				
		▨	9.0	9.0				
	SAND, with some gravel; grey . Moist, sand, fine to coarse; gravel, fine to medium, subround.							
	End of Borehole- Target Depth. EOH: 10.00m		10.0	10.0				

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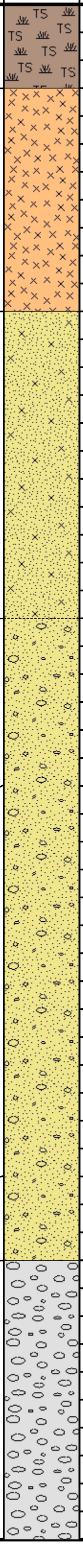
Elevation datum and coordinates sourced from council GIS LiDAR contours.

Water Level Measurements

MACHINE BOREHOLE LOG

Client: Gibbons Developments Ltd
Site Address: Morven Ferry Road
Town/City: Queenstown
Job No.: 2555087
Weather: Fine
Borehole: BH-02
Type:
Latitude:
Longitude:
Date:
Logged By: TJ
Checked By: OB
Operator:
Logged Date: 10/12/25
Checked Date: 10/12/25
Datum: NZGD 2000



Geological Formation	DESCRIPTION	GRAPHIC	DEPTH	ELEVATION	TCR (%) 25 50 75	SPT N-VALUE (Uncorrected) 10 20 30 40	SPT DATA (Uncorrected)	INSTALLATION
Topsoil	Silty TOPSOIL, with minor sand; dark grey. Moist, non-plastic; sand, fine.							
	SILT, with minor sand; dark grey. Moist, non-plastic; sand, fine.		1.0	-1.0				
	SAND, with some silt; dark grey. Moist, non-plastic, sand, fine to medium.		2.0	-2.0				
	Gravelly SAND; light grey . Moist, sand, fine to medium; gravel, fine to medium, subround. 2.8m: SAND. Sand, coarse. 4.2m: Ground water.		3.0 4.0	-3.0 -4.0				
	GRAVEL, with minor sand; grey . Moist, gravel, fine to coarse, subround; sand, coarse.		5.0	-5.0				

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Elevation datum and coordinates sourced from council GIS LiDAR contours.

Water Level Measurements

Generated by GEROC Core-GS

MACHINE BOREHOLE LOG

Client: Gibbons Developments Ltd
Site Address: Morven Ferry Road
Town/City: Queenstown
Job No.: 2555087

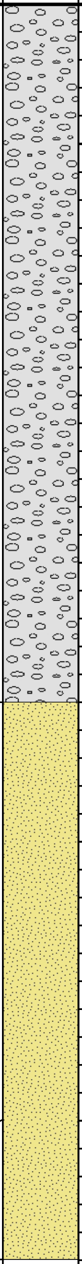
Weather: Fine
Borehole: BH-02
Type:

Latitude:
Logged By: TJ
Logged Date: 10/12/25

Longitude:
Checked By: OB
Checked Date: 10/12/25

Date:
Operator:
Datum: NZGD 2000

Geological Formation	DESCRIPTION	GRAPHIC	DEPTH	ELEVATION	TCR (%) 25 50 75	SPT N-VALUE (Uncorrected) 10 20 30 40	SPT DATA (Uncorrected)	INSTALLATION
	[CONT] GRAVEL, with minor sand; grey . Moist, gravel, fine to coarse, subround; sand, coarse.		6.0 7.0	-6.0 -7.0				
	SAND; grey . Moist, sand, fine to medium. 9.5m: With minor gravel. Gravel, medium to coarse.		8.0 9.0	-8.0 -9.0				
	End of Borehole - Target Depth. EOH: 10.00m		10.0	-10.0				



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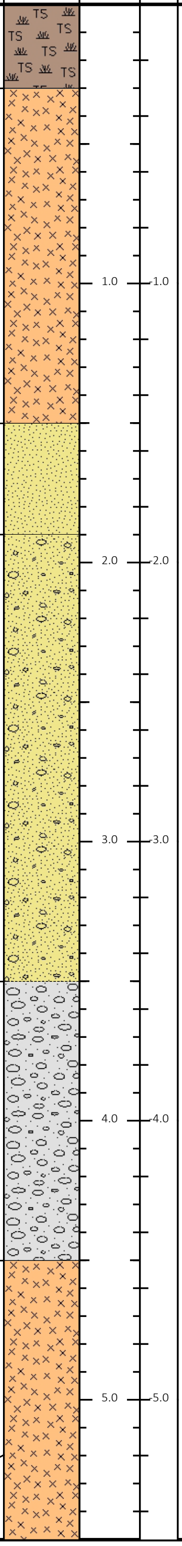
Elevation datum and coordinates sourced from council GIS LiDAR contours.

Water Level Measurements

MACHINE BOREHOLE LOG

KIRK ROBERTS CONSULTING

Client: Gibbons Developments Ltd
Site Address: Morven Ferry Road
Town/City: Queenstown
Job No.: 2555087
Weather: Fine
Borehole: BH-03
Type:
Latitude:
Longitude:
Date:
Logged By: TJ
Checked By: OB
Operator:
Logged Date: 10/12/25
Checked Date: 10/12/25
Datum: NZGD 2000



Geological Formation	DESCRIPTION	GRAPHIC	DEPTH	ELEVATION	TCR (%) 25 50 75	SPT N-VALUE (Uncorrected) 10 20 30 40	SPT DATA (Uncorrected)	INSTALLATION
Topsoil	Silty TOPSOIL, with minor sand; dark grey. Moist, non-plastic; sand, fine.							
	SILT, with minor sand; dark grey. Moist, non-plastic; sand, fine.							
	SAND; dark grey. Moist, sand, fine to medium.							
	Gravelly SAND; grey . Dry, sand, fine to coarse; gravel, fine, subangular.							
	Sandy GRAVEL; grey . Moist, gravel, fine to medium, subround; sand, fine to medium.							
	SILT, with minor sand; gark grey. Non-plastic; sand, fine. 5.2m: With some gravel; brownish. Gravel, coarse.							

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Elevation datum and coordinates sourced from council GIS LiDAR contours.

Water Level Measurements

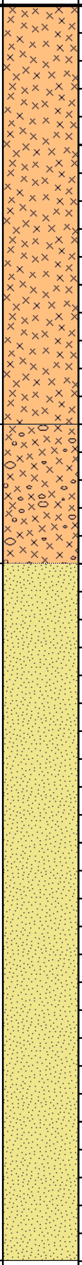
MACHINE BOREHOLE LOG

KIRK ROBERTS CONSULTING

Client: Gibbons Developments Ltd
Site Address: Morven Ferry Road
Town/City: Queenstown
Job No.: 2555087

Weather: Fine
Borehole: BH-03
Type:

Latitude:
Longitude:
Date:
Logged By: TJ
Checked By: OB
Operator:
Logged Date: 10/12/25
Checked Date: 10/12/25
Datum: NZGD 2000



Geological Formation	DESCRIPTION	GRAPHIC	DEPTH	ELEVATION	TCR (%) 25 50 75	SPT N-VALUE (Uncorrected) 10 20 30 40	SPT DATA (Uncorrected)	INSTALLATION
	[CONT] SILT, with minor sand; gark grey. Non-plastic; sand, fine.		6.0	-6.0				
	Gravelly SILT; grey . Moist, non-plastic; gravel, fine to coarse, angular.		7.0	-7.0				
	SAND; dark grey. Moist, sand, fine.		8.0 9.0	-8.0 -9.0				
	End of Borehole - Target Depth. EOH: 10.00m		10.0	-10.0				

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Elevation datum and coordinates sourced from council GIS LiDAR contours.

Water Level Measurements

MACHINE BOREHOLE LOG

KIRK ROBERTS CONSULTING

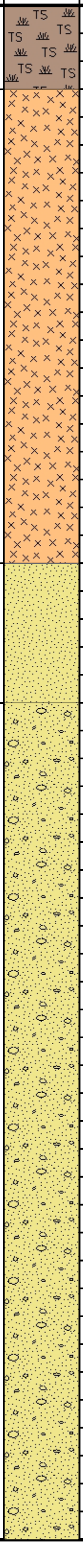
Client: Gibbons Developments Ltd
Site Address: Morven Ferry Road
Town/City: Queenstown
Job No.: 2555087

Weather: Fine
Borehole: BH-04
Type:

Latitude:
Logged By: TJ
Logged Date: 10/12/25

Longitude:
Checked By: OB
Checked Date: 10/12/25

Date:
Operator:
Datum: NZGD 2000



Geological Formation	DESCRIPTION	GRAPHIC	DEPTH	ELEVATION	TCR (%) 25 50 75	SPT N-VALUE (Uncorrected) 10 20 30 40	SPT DATA (Uncorrected)	INSTALLATION
Topsoil	Silty TOPSOIL, with minor sand; dark brown. Moist, non-plastic; sand, fine.							
	SILT, with minor sand; dark grey. Moist, non-plastic; sand, fine.		1.0	-1.0				
	SAND; dark grey. Moist, sand, fine to coarse.		2.0	-2.0				
	Gravelly SAND; grey . Moist, sand, fine to coarse; gravel, fine to medium, subangular to subround.		3.0 4.0 5.0	-3.0 -4.0 -5.0				

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Elevation datum and coordinates sourced from council GIS LiDAR contours.

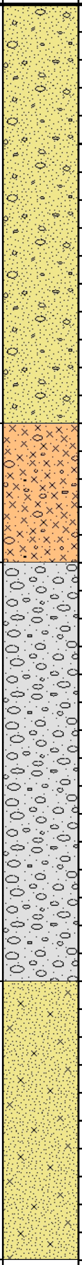
Water Level Measurements

MACHINE BOREHOLE LOG

Client: Gibbons Developments Ltd
Site Address: Morven Ferry Road
Town/City: Queenstown
Job No.: 2555087

Weather: Fine
Borehole: BH-04
Type:

Latitude:
Longitude:
Date:
Logged By: TJ
Checked By: OB
Operator:
Logged Date: 10/12/25
Checked Date: 10/12/25
Datum: NZGD 2000



Geological Formation	DESCRIPTION	GRAPHIC	DEPTH	ELEVATION	TCR (%) 25 50 75	SPT N-VALUE (Uncorrected) 10 20 30 40	SPT DATA (Uncorrected)	INSTALLATION
	[CONT] Gravelly SAND; grey . Moist, sand, fine to coarse; gravel, fine to medium, subangular to subround.		6.0	-6.0				
	Sandy gravelly SILT; light grey. Dry, non-plastic; sand, fine, gravel, fine to coarse, angular.		7.0	-7.0				
	Sandy GRAVEL; dark grey. Moist, gravel, fine to coarse, subangular to subround; sand, fine to coarse.		8.0	-8.0				
	Silty SAND, with minor gravel; dark grey. Moist, non-plastic, sand, fine; gravel, fine to medium.		9.0	-9.0				
	End of Borehole - Target Depth. EOH: 10.00m		10.0	-10.0				

REMARKS

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Test Bore log tests give an indication of the ground condition at the location of the tests only. While they are representative of typical conditions across the site, they do not identify variations in the ground away from the test locations.
Elevation datum and coordinates sourced from council GIS LiDAR contours.

Water Level Measurements

HAND AUGER RESULTS

KIRK ROBERTS CONSULTING

Client:	Gibbons Developments Ltd	Job No.:	2555087
Site Address:	Morven Ferry Road	Hand Auger No.	HA-SK-01
Town/City:	Queenstown	Scala Penetrometer:	
Operator:	SSA	Date:	14/10/25
Logged By:	SSA	Weather:	Sunny/dry
Logged Date:	14/10/25	Datum:	NZGD 2000
Checked By:	OMB	Termination:	Target Depth Achieved
Checked Date:	28/10/25		

Geological Formation	Depth (m)	Elevation	Sample Description	Graphic	USCS	Dr	Water Table	Undrained Shear Strength Su (kPa)	Blows per 100 mm of Penetration
Topsoil	0.0–0.3		Sandy SILT; dark brown. Moist, non-plastic; sand, fine to medium; With trace rootlets.	TS			Groundwater Not Encountered		
Late Pleistocene River Deposits	0.3–3.0	-0.5 to -3.0	Gravelly SAND; dark brown. Moist, sand, fine to coarse; gravel, fine to medium, subangular to round.						
	3.0	-3.0	End of Borehole. EOH: 3.00m						

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

Elevation scale: -0.5, -1.0, -1.5, -2.0, -2.5, -3.0, -3.5, -4.0, -4.5

Blows per 100 mm of Penetration: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

Remarks:
Scala Penetrometer and Test Bore log tests give an indication of the ground condition at the location of the tests only. While they are representative of typical conditions across the site, they do not identify variations in the ground away from the test locations.
Elevation datum sourced from council GIS LiDAR contours.

HAND AUGER RESULTS

KIRK ROBERTS CONSULTING

Client:	Gibbons Developments Ltd	Job No.:	2555087
Site Address:	Morven Ferry Road	Hand Auger No.	HA-SK-02
Town/City:	Queenstown	Scala Penetrometer:	
Operator:	SSA	Date:	14/10/25
Logged By:	SSA	Weather:	Sunny/dry
Logged Date:	14/10/25	Datum:	NZGD 2000
Checked By:	OMB	Termination:	Target Depth Achieved
Checked Date:	28/10/25		

Geological Formation	Depth (m)	Elevation	Sample Description	Graphic	USCS	Dr	Water Table	Undrained Shear Strength Su (kPa)	Blows per 100 mm of Penetration 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Topsoil			Sandy SILT; dark brown. Moist; sand, fine to coarse; With trace rootlets.	TS			Groundwater Not Encountered		
Late Pleistocene River Deposits	0.5 1.0 1.5 2.0 2.5	-0.5 -1.0 -1.5 -2.0 -2.5	SAND, with some gravel; dark brown. Moist, sand, fine to coarse; gravel, fine to medium, subangular to subround.						
	3.0 3.5 4.0 4.5	-3.0 -3.5 -4.0 -4.5	End of Borehole. EOH: 3.00m						

Remarks:
Scala Penetrometer and Test Bore log tests give an indication of the ground condition at the location of the tests only. While they are representative of typical conditions across the site, they do not identify variations in the ground away from the test locations.
Elevation datum sourced from council GIS LiDAR contours.

HAND AUGER RESULTS

KIRK ROBERTS CONSULTING

Client:	Gibbons Developments Ltd	Job No.:	2555087
Site Address:	Morven Ferry Road	Hand Auger No.	HA-SK-03
Town/City:	Queenstown	Scala Penetrometer:	
Operator:	SSA	Date:	14/10/25
		Weather:	Sunny/dry
Logged By:	SSA	Checked By:	OMB
Logged Date:	14/10/25	Checked Date:	28/10/25
		Datum:	NZGD 2000
		Termination:	Terminated due to Collapse

Geological Formation	Sample Description	Graphic	USCS	Dr	Water Table	Undrained Shear Strength Su (kPa)	Blows per 100 mm of Penetration
Topsoil	Sandy SILT; dark brown. Saturated, non-plastic; sand, fine to medium; With minor rootlets.	TS					
Late Pleistocene River Deposits	Gravelly SAND. Saturated, sand, fine to coarse; gravel, fine to coarse, subangular to subround, completely weathered to highly weathered.						
	End of Borehole - Terminated due to Collpase. EOH: 1.70m						

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

Elevation: -0.5, -1.0, -1.5, -2.0, -2.5, -3.0, -3.5, -4.0, -4.5

Blows per 100 mm of Penetration: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

Remarks:
Scala Penetrometer and Test Bore log tests give an indication of the ground condition at the location of the tests only. While they are representative of typical conditions across the site, they do not identify variations in the ground away from the test locations.
Elevation datum sourced from council GIS LiDAR contours.

HAND AUGER RESULTS

KIRK ROBERTS CONSULTING

Client:	Gibbons Developments Ltd	Job No.:	2555087
Site Address:	Morven Ferry Road	Hand Auger No.	HA-SK-04
Town/City:	Queenstown	Scala Penetrometer:	
Operator:	SSA	Date:	14/10/25
Logged By:	SSA	Weather:	Sunny/dry
Logged Date:	14/10/25	Datum:	NZGD 2000
Checked By:	OMB	Termination:	Terminated due to Collapse
Checked Date:	28/10/25		

Geological Formation	Depth (m)	Elevation	Sample Description	Graphic	USCS	Dr	Water Table	Undrained Shear Strength Su (kPa)	Blows per 100 mm of Penetration 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Late Pleistocene River Deposits			Sandy SILT; dark brown. Moist, non-plastic; sand, fine to coarse; With minor rootlets.	▨					
			Gravelly SAND. Wet to saturated, sand, fine to coarse; gravel, fine to coarse, subangular to subround.	▨					
	0.5	-0.5							
	1.0	-1.0							
							∇		
	1.5	-1.5							
			End of Borehole - Terminated due to Collapse EOH: 1.60m						
	2.0	-2.0							
	2.5	-2.5							
	3.0	-3.0							
	3.5	-3.5							
	4.0	-4.0							
	4.5	-4.5							

Remarks:

Scala Penetrometer and Test Bore log tests give an indication of the ground condition at the location of the tests only. While they are representative of typical conditions across the site, they do not identify variations in the ground away from the test locations.

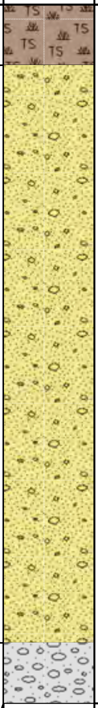
Elevation datum sourced from council GIS LiDAR contours.

HAND AUGER RESULTS

KIRK ROBERTS CONSULTING

Client:	Gibbons Developments Ltd			Job No.:	2555087
Site Address:	Morven Ferry Road			Hand Auger No.	HA-SK-05
Town/City:	Queenstown			Scala Penetrometer:	
Operator:	SSA			Date:	14/10/25
				Weather:	Sunny/dry
Logged By:	SSA	Checked By:	OMB	Datum:	NZGD 2000
Logged Date:	14/10/25	Checked Date:	28/10/25	Termination:	Refusal on Dense Ground

Geological Formation	Depth (m)	Sample Description	Graphic	USCS	D_r	Water Table	Undrained Shear Strength Su (kPa)	Blows per 100 mm of Penetration
Topsoil	0.0–0.2	Sandy SILT; dark brown. Moist, non-plastic; sand, fine to coarse; With trace rootlets.				Groundwater Not Encountered		
Late Pleistocene River Deposits	0.2–2.1	Gravelly SAND; dark brownish grey. Moist, sand, fine to coarse; gravel, fine to medium, subangular to subround.						
Rakaia Terrane	2.1–2.3	Sandy GRAVEL; dark grey. Moist to wet, gravel, fine to coarse, angular to subround, completely weathered to highly weathered, schist; sand, fine to coarse.						
		End of Borehole - Refusal on Dense Ground. EOH: 2.30m						



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

Elevation: -0.5, -1.0, -1.5, -2.0, -2.5, -3.0, -3.5, -4.0, -4.5

Blows per 100 mm of Penetration: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

Remarks:
Scala Penetrometer and Test Bore log tests give an indication of the ground condition at the location of the tests only. While they are representative of typical conditions across the site, they do not identify variations in the ground away from the test locations.
Elevation datum sourced from council GIS LiDAR contours.

HAND AUGER RESULTS

KIRK ROBERTS
CONSULTING

Client:	Gibbons Developments Ltd	Job No.:	2555087
Site Address:	Morven Ferry Road	Hand Auger No.	HA-SK-06
Town/City:	Queenstown	Scala Penetrometer:	
Operator:	SSA	Date:	14/10/25
Logged By:	SSA	Weather:	Sunny/dry
Logged Date:	14/10/25	Datum:	NZGD 2000
Checked By:	OMB	Termination:	Terminated due to Collapse
Checked Date:	28/10/25		

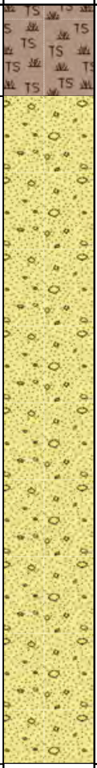
Geological Formation	Depth (m)	Elevation	Sample Description	Graphic	USCS	Dr	Water Table	Undrained Shear Strength Su (kPa)	Blows per 100 mm of Penetration 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Topsoil			Sandy SILT; dark brown. Moist to saturated, non-plastic; sand, fine to medium; With trace rootlets.	TS			▽		
Rakaia Terrane	0.5 1.0	-0.5 -1.0	SAND, with minor gravel; dark grey. Moist to saturated, sand, fine to medium; gravel, fine to medium, angular to subround, completely weathered to highly weathered, schist.						
	1.5 2.0 2.5 3.0 3.5 4.0 4.5	-1.5 -2.0 -2.5 -3.0 -3.5 -4.0 -4.5	End of Borehole - Termination due to Collapse. EOH: 1.20m						

Remarks:
Scala Penetrometer and Test Bore log tests give an indication of the ground condition at the location of the tests only. While they are representative of typical conditions across the site, they do not identify variations in the ground away from the test locations.
Elevation datum sourced from council GIS LiDAR contours.

HAND AUGER RESULTS

KIRK ROBERTS CONSULTING

Client:	Gibbons Developments Ltd	Job No.:	2555087
Site Address:	Morven Ferry Road	Hand Auger No.	HA-SK-07
Town/City:	Queenstown	Scala Penetrometer:	
Operator:	SSA	Date:	14/10/25
Logged By:	SSA	Weather:	Sunny/dry
Logged Date:	14/10/25	Datum:	NZGD 2000
Checked By:	OMB	Termination:	Refusal on Dense Ground
Checked Date:	28/10/25		



Geological Formation	Depth (m)	Elevation	Sample Description	Graphic	USCS	Dr	Water Table	Undrained Shear Strength Su (kPa)	Blows per 100 mm of Penetration 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Topsoil			Sandy SILT; dark brown. Moist to wet, non-plastic; sand, fine to medium; With minor rootlets.				Groundwater Not Encountered		
Rakaia Terrane	0.5	-0.5	Gravelly SAND; dark grey. Moist, sand, fine to medium; gravel, fine, angular to round, completely weathered to highly weathered.						
	1.0	-1.0							
	1.5	-1.5							
	2.0	-2.0							
	2.5	-2.5	End of Borehole - Refusal on Dense Ground. EOH: 2.50m						
	3.0	-3.0							
	3.5	-3.5							
	4.0	-4.0							
	4.5	-4.5							

Remarks:
Scala Penetrometer and Test Bore log tests give an indication of the ground condition at the location of the tests only. While they are representative of typical conditions across the site, they do not identify variations in the ground away from the test locations.
Elevation datum sourced from council GIS LiDAR contours.

HAND AUGER RESULTS

KIRK ROBERTS CONSULTING

Client:	Gibbons Developments Ltd	Job No.:	2555087
Site Address:	Morven Ferry Road	Hand Auger No.	HA-SK-08
Town/City:	Queenstown	Scala Penetrometer:	
Operator:	SSA	Date:	14/10/25
Logged By:	SSA	Weather:	Sunny/dry
Logged Date:	14/10/25	Datum:	NZGD 2000
Checked By:	OMB	Termination:	Refusal on Dense Ground
Checked Date:	28/10/25		

Geological Formation	Depth (m)	Elevation	Sample Description	Graphic	USCS	Dr	Water Table	Undrained Shear Strength Su (kPa)	Blows per 100 mm of Penetration 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Top soil			Sandy SILT; dark brown. Moist, non-plastic; sand, fine to coarse; With trace rootlets.	TS			ndwater Not Encount		
Rakaia Terrane			SAND, with some gravel. Moist, sand, fine to medium; gravel, fine to medium, angular to subround, completely weathered to highly weathered, schist; Very weak to extremely weak rock.						
	0.5	-0.5							
			End of Borehole - Refusal on Hard Ground. EOH: 0.60m						
	1.0	-1.0							
	1.5	-1.5							
	2.0	-2.0							
	2.5	-2.5							
	3.0	-3.0							
	3.5	-3.5							
	4.0	-4.0							
	4.5	-4.5							

Remarks:
Scala Penetrometer and Test Bore log tests give an indication of the ground condition at the location of the tests only. While they are representative of typical conditions across the site, they do not identify variations in the ground away from the test locations.
Elevation datum sourced from council GIS LiDAR contours.

HAND AUGER RESULTS

KIRK ROBERTS CONSULTING

Client:	Gibbons Developments Ltd	Job No.:	2555087
Site Address:	Morven Ferry Road	Hand Auger No.	HA-SK-09
Town/City:	Queenstown	Scala Penetrometer:	

Operator:	SSA			Date:	14/10/25
				Weather:	Sunny/dry
Logged By:	SSA	Checked By:	OMB	Datum:	NZGD 2000
Logged Date:	14/10/25	Checked Date:	28/10/25	Termination:	Refusal on Dense Ground

Geological Formation	Depth (m)	Elevation	Sample Description	Graphic	USCS	Dr	Water Table	Undrained Shear Strength Su (kPa)	Blows per 100 mm of Penetration 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Topsoil			Sandy SILT; dark brown. Moist, non-plastic; sand, fine to medium; With trace rootlets.	TS			Groundwater Not Encountered		
Late Pleistocene River Deposits	0.5 1.0 1.5 2.0	-0.5 -1.0 -1.5 -2.0	SAND, with some gravel; dark greyish brown. Moist to wet, sand, fine to coarse; gravel, fine to medium, angular to subround; With trace limonite staining.						
	2.5 3.0 3.5 4.0 4.5	-2.5 -3.0 -3.5 -4.0 -4.5	End of Borehole - Refusal on Dense Ground EOH: 2.50m						

Remarks:
Scala Penetrometer and Test Bore log tests give an indication of the ground condition at the location of the tests only. While they are representative of typical conditions across the site, they do not identify variations in the ground away from the test locations.
Elevation datum sourced from council GIS LiDAR contours.

HAND AUGER RESULTS

Client:	Gibbons Developments Ltd	Job No.:	2555087
Site Address:	Morven Ferry Road	Hand Auger No.	HA-SK-10
Town/City:	Queenstown	Scala Penetrometer:	
Operator:	SSA	Date:	14/10/25
Logged By:	SSA	Weather:	Sunny/dry
Logged Date:	14/10/25	Datum:	NZGD 2000
Checked By:	OMB	Termination:	Refusal on Dense Ground
Checked Date:	28/10/25		

Geological Formation	Depth (m)	Elevation	Sample Description	Graphic	USCS	Dr	Water Table	Undrained Shear Strength Su (kPa)	Blows per 100 mm of Penetration 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Topsoil			Silty SAND; dark brown. Moist to wet, non-plastic, sand, fine to coarse; with trace rootlets.	TS			Groundwater Not Encountered		
Late Pleistocene River Deposits	0.5 1.0	-0.5 -1.0	SAND, with some gravel; dark greyish brown. Moist to wet, sand, fine to coarse; gravel, fine to medium, subangular to subround, completely weathered to highly weathered, schist.						
	1.5 2.0 2.5 3.0 3.5 4.0 4.5	-1.5 -2.0 -2.5 -3.0 -3.5 -4.0 -4.5	End of Borehole - Refusal on Dense Ground. EOH: 1.50m						

Remarks:
Scala Penetrometer and Test Bore log tests give an indication of the ground condition at the location of the tests only. While they are representative of typical conditions across the site, they do not identify variations in the ground away from the test locations.
Elevation datum sourced from council GIS LiDAR contours.

HAND AUGER RESULTS

KIRK ROBERTS
CONSULTING

Client:	Gibbons Developments Ltd	Job No.:	2555087
Site Address:	Morven Ferry Road	Hand Auger No.	HA-SK-11
Town/City:	Queenstown	Scala Penetrometer:	

Operator:	SSA			Date:	14/10/25
Logged By:	SSA	Checked By:	OMB	Weather:	Sunny/dry
Logged Date:	14/10/25	Checked Date:	28/10/25	Datum:	NZGD 2000
				Termination:	Target Depth Achieved

Geological Formation	Depth (m)	Elevation	Sample Description	Graphic	USCS	D_r	Water Table	Undrained Shear Strength Su (kPa)	Blows per 100 mm of Penetration 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Topsoil			Sandy SILT; dark brown. Moist, non-plastic; sand, fine to medium; With minor rootlets.	TS			Groundwater Not Encountered		
Late Pleistocene River Deposits	0.5 1.0 1.5 2.0 2.5	-0.5 -1.0 -1.5 -2.0 -2.5	Silty SAND, with trace clay and gravel; dark brownish grey. Moist, non-plastic, sand, fine to medium; gravel, fine, angular to subround.						
	3.0 3.5 4.0 4.5	-3.0 -3.5 -4.0 -4.5	End of Borehole. EOH: 3.00m						

Remarks:
Scala Penetrometer and Test Bore log tests give an indication of the ground condition at the location of the tests only. While they are representative of typical conditions across the site, they do not identify variations in the ground away from the test locations.
Elevation datum sourced from council GIS LiDAR contours.

Bore Construction Report

SOUTHDRILL
EXPLORATION & PILING

OFFICE USE ONLY

Date received:	Accession number:	Signed:
Bore number: **sou 2852 hole no140**	Entered IRIS date:	Invoice date:

GENERAL DETAILS

Client/Consent holder's name: **Cameron**		Consent number: **RM25.435.01**
Location/Address: **122 Morven Ferry Road Queenstown**		
Grid reference - Easting: **1271608m E**	Northing: **5008548m N**	Mobile phone: [redacted]
Sketch plan attached: **Yes**	Photos attached: **Yes**	Home phone:

DRILLING DETAILS

Drilling company: **SouthDrill Ltd**	Driller: **Rowland Harrex**
Machine/Rig: **Western Star Drilling Rig [QCL493]**	Fleet no. **2030**
Drill method(s): **Air Rotary**	

BORE CONSTRUCTION DETAILS

Start date: **12/11/2025**	Finish date: **24/11/2025**
Bore diameter: **200mm**	Casing material: **Steel**
Screen material: **s/s**	
Screen diameter (inside): **156mm**	Screen diameter (outside): **162mm**
Screen slots: **2.5mm**	Overdrilled: **Yes**

PUMPING/WATER DETAILS

Dry bore: **No**	If dry, was casing retrieved?	Bore filled in:
Development period: **39 hours**	Development method: **Airlifted**	
Yield/test pumping: **Pumped**	Test pump period: **27 hours**	
Test pump rate: **6.5 litres/second**	Method of measuring reate: **meter**	
Comments: **3 stage pump test and 24 hr constant rate**		
Pumped water level: **25.53 metres**		

WATER QUALITY ETC

Bacterial water test: **Yes**	Chemical water test: **Yes**
Casing top sealed: **Yes**	Impervious seal at ground: **Yes**

Comments:
water test taken by hydrologist

BORE LOG (METRES BELOW REFERENCE POINT)

0m–0.4m	top soils
0.4m–8.4m	brown silty gravels
8.4m–11.9m	blue silts large cobbels
11.9m–22m	blue silts odd gravels
22m–34.4m	blue silts
34.4m–38.8m	silty gravels large water flow
38.8m–41.83m	tight silty gravels possible schist
41.83m	tryed to get water flow 41.83-38.83 with 3m screen not much flow pulled screen and caseing back

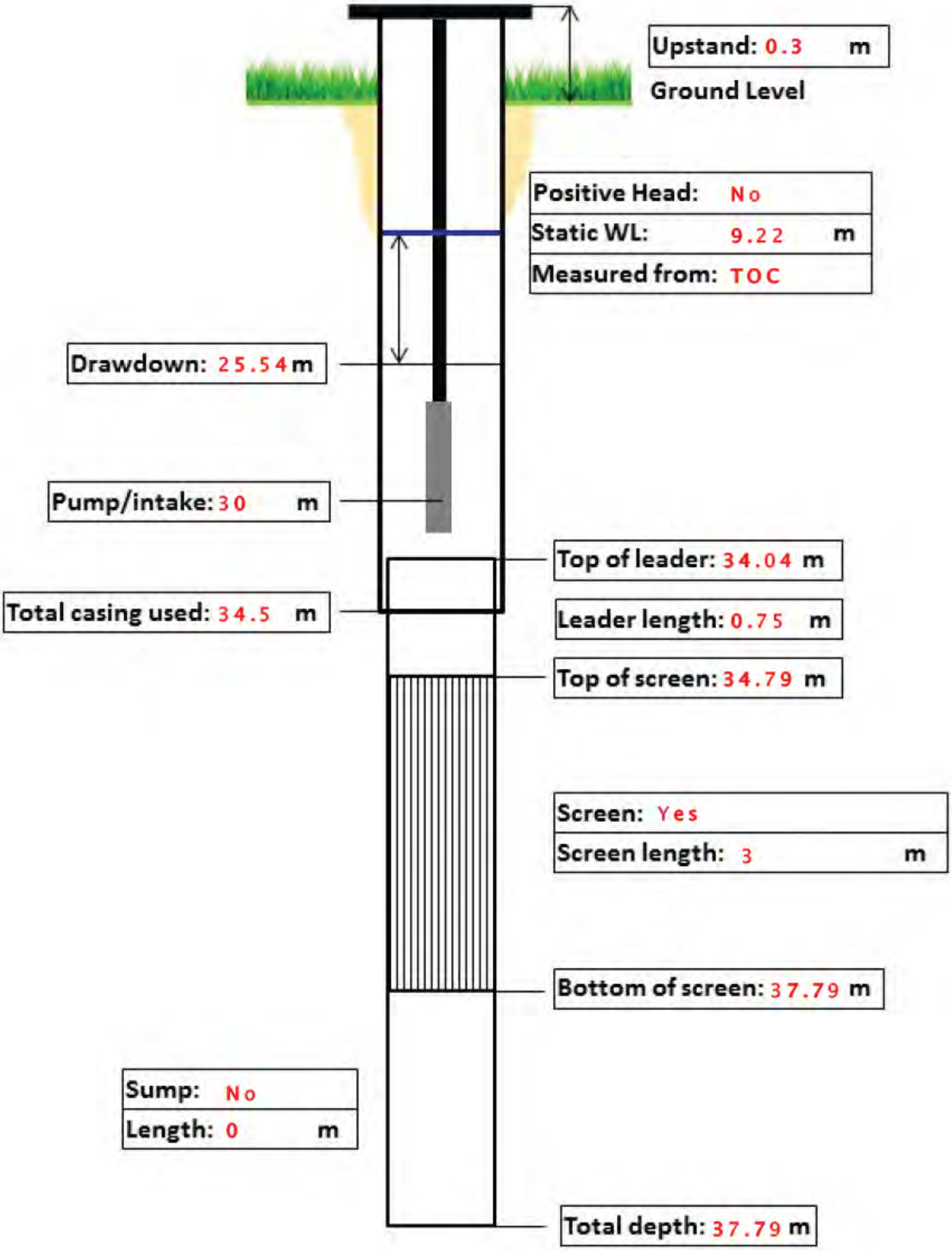
Do you intend to drill more bores under this Land Use Consent number? **No**	
If yes, number of bores drilled:	Number of bore logs provided:

PTO for bore diagram

SOUTHDRILL
EXPLORATION & PILING

Bore Construction Diagram

Bore number:
sou 2852 hole no140



Upstand: 0.3 m

Ground Level

Positive Head: No

Static WL: 9.22 m

Measured from: TOC

Drawdown: 25.54 m

Pump/intake: 30 m

Top of leader: 34.04 m

Total casing used: 34.5 m

Leader length: 0.75 m

Top of screen: 34.79 m

Screen: Yes

Screen length: 3 m

Bottom of screen: 37.79 m

Sump: No

Length: 0 m

Total depth: 37.79 m

Bore Construction Report

SOUTHDRILL
EXPLORATION & PILING

OFFICE USE ONLY		
Date received:	Accession number:	Signed:
Bore number: **2852 bore no5**	Entered IRIS date:	Invoice date:

GENERAL DETAILS		
Client/Consent holder's name: **Cameron**		Consent number: **RM25.435.05**
Location/Address: **122 MORVEN FERRY ROAD**		
Grid reference - Easting: **1271404m E**	Northing: **5008426m N**	Mobile phone: [redacted]
Sketch plan attached: **Yes**	Photos attached: **Yes**	Home phone:

DRILLING DETAILS	
Drilling company: **SouthDrill Ltd**	Driller: **Rowland Harrex**
Machine/Rig: **Western Star Drilling Rig [QCL493]**	Fleet no. **2030**
Drill method(s): **Air Rotary**	

BORE CONSTRUCTION DETAILS	
Start date: **21/11/2025**	Finish date: **05/12/2025**
Bore diameter: **200mm**	Casing material: **Steel**
Screen material: **N/A**	
Screen diameter (inside): **0mm**	Screen diameter (outside): **0mm**
Screen slots: **0mm**	Overdrilled: **Yes**

PUMPING/WATER DETAILS		
Dry bore: **No**	If dry, was casing retrieved?	Bore filled in:
Development period: **29 hours**	Development method: **Airlifted**	
Yield/test pumping: **Pumped**	Test pump period: **28 hours**	
Test pump rate: **11.7 litres/second**	Method of measuring reate: **METER**	
Comments: **DID 2 STAGE PUMP TEST AND 26HRS CONSTANT RATE**		
Pumped water level: **32.5 metres**		

WATER QUALITY ETC	
Bacterial water test: **Yes**	Chemical water test: **Yes**
Casing top sealed: **Yes**	Impervious seal at ground: **Yes**
Comments: **TOKE HILL LAB TEST WHEN DEVELOPING AND CONSALTENT DID HIS OWN WILL WE PUMPED 0.63NTU**	

BORE LOG (METRES BELOW REFERENCE POINT)	
0m–3.1m	TOP SOILS ODD GRAVEL
3.1m–8.2m	SANDY GRAVELS
8.2m–15.2m	BLUE SILTS ODD GRAVELS
15.2m–20.2m	TIGHT SILTS GRAVELS
20.2m–28.8m	BANDS BLUE SILTS AND GRAVELS
28.8m–30.89m	SCHIST ROCK
30.89m–42m	OPEN HOLE 30.89M SOFT AND HARD BANDS SCHIST BLOWING ABOUT 2 LTS/SEC WATER
42m–60m	SOFT AND HARD BANDS SCHIST BLOWING 10-15 LTS/SEC aprox
60m–72m	SCHIST HARD SMALL SOFT ZONES BLOWING 10-15LTS/SEC PLUS aprox
72m–73.2m	SOFT ZONE POSSABLY MORE WATER FLOW
73.2m–100m	SCHIST HARD SMALL SOFT ZONES
100m–102m	SOFT FRACTUERD HOLE CAVEING IN
102m	6inch CASEING TO 66M

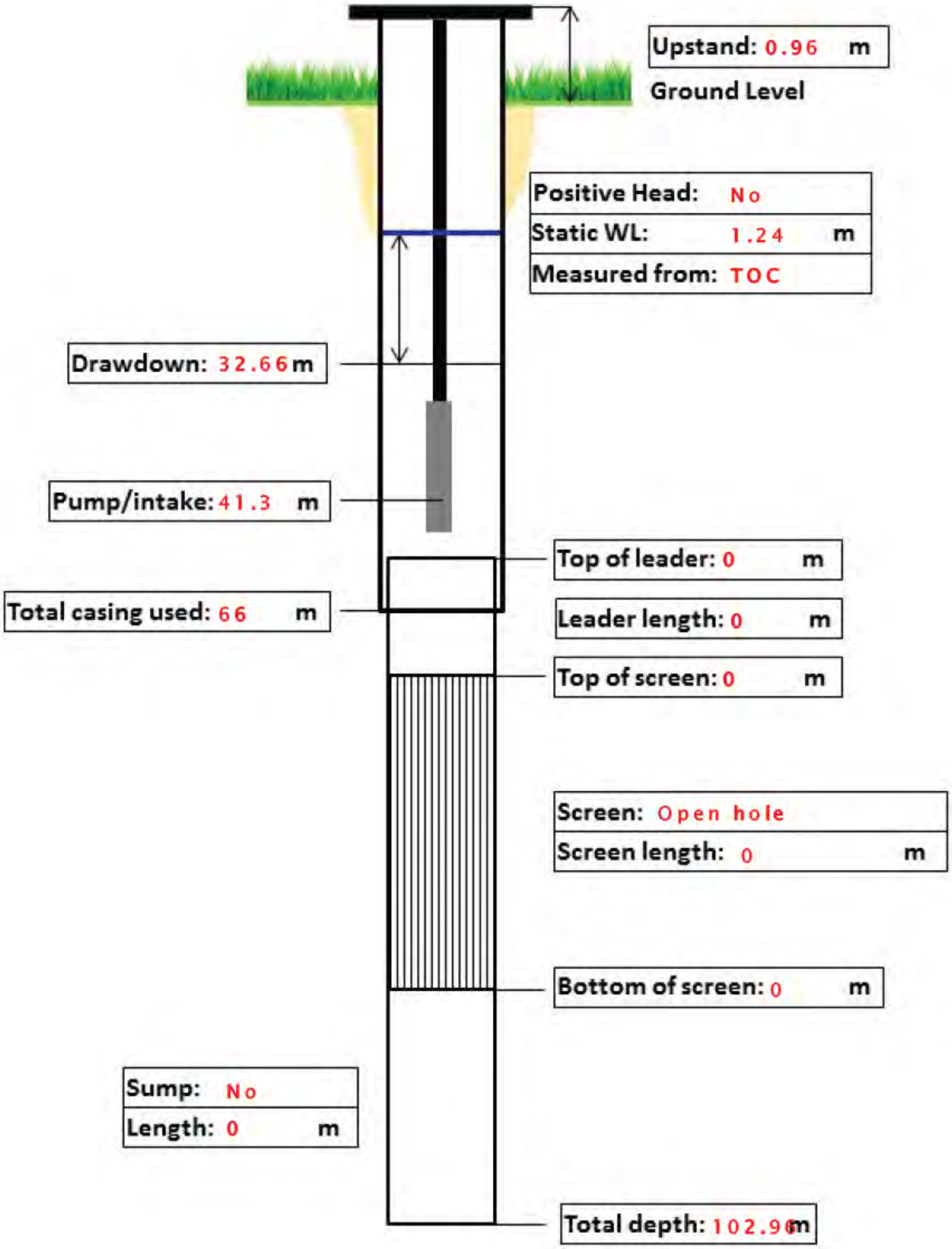
Do you intend to drill more bores under this Land Use Consent number? **No**	
If yes, number of bores drilled:	Number of bore logs provided:

PTO for bore diagram

SOUTHDRILL
EXPLORATION & PILING

Bore Construction Diagram

Bore number:
2852 bore no5



Upstand: 0.96 m

Ground Level

Positive Head: No

Static WL: 1.24 m

Measured from: TOC

Drawdown: 32.66 m

Pump/intake: 41.3 m

Top of leader: 0 m

Total casing used: 66 m

Leader length: 0 m

Top of screen: 0 m

Screen: Open hole

Screen length: 0 m

Bottom of screen: 0 m

Sump: No

Length: 0 m

Total depth: 102.96 m

HAND AUGER INVESTIGATION RECORD

Figure No: A 1

WGA

CLIENT: Gibbons Co
PROJECT: Ridgeburn
Project #: WGA252389
Location: 122 Morven Ferry Road
Hand Auger ID: HA1
Drilling Date / Time: 7 October 2025
Field Record By: C Jasper

Location Description: Middle terrace, east of the alluvial fans, eastern end.
NZTM E: 1271777 **NZTM N:** 5008454 **Elevation (mRL):** 318.3
Hole diameter (mm): 52 **Terminal depth (m):** 800
Weather: Fine. No prior rain during this day.
Drilling notes: Drilling completed in two stages: 7/10/2025 13:30 and 14:55.
Groundwater: None intersected

Lithological Log

FROM (mm BGL)	TO (mm BGL)	Description	Soil Type	Soil Sample
0	50	Moist humic friable LOAM with grass/roots and very fine micaceous sand. Light greyish brown.	-	-
50	400	SILT with minor very fine micaceous sand. Light grey to light brown. Very moist with rootlets.	-	-
400	800	SILT with minor very fine micaceous sand and trace clay. Crumbly to slightly plastic. Light brown. Very moist with rootlets.	-	-

Drill Cutting Photo

Location Sketch

Hydraulic Testing Notes

Shallow tests when hole at terminal depth of 400 mm.
Falling head test 1. Date/time: 7 October 2025 13:05. Solinst Levelogger 5, LT M10, 003-2179723
Falling head test 2. Date/time: 7 October 2025 13:53. Solinst Levelogger 5 LT M10, 003-2179723
Solinst transducer removed from HA1 at 14:41
Deep test when hole at terminal depth of 800 mm.
Falling head test. Date/time: 7 October 2025 16:55. Manual record.

Observations:

Log sheet by: B. Sinclair 9/10/2025
Checked by: C. Jasper 10/10/2025

HAND AUGER INVESTIGATION RECORD

Figure No: A 2

CLIENT: Gibbons Co
PROJECT: Ridgeburn
Project #: WGA252389
Location: 122 Morven Ferry Road
Hand Auger ID: HA2
Drilling Date / Time: 7 October 2025
Field Record By: C Jasper

Location Description: Middle terrace, east of the alluvial fans, eastern end.
NZTM E: 1271774 **NZTM N:** 5008512 **Elevation (mRL):** 318.0
Hole diameter (mm): 52 **Terminal depth (m):** 800
Weather: Fine. No prior rain during this day.
Drilling notes: Shallow hole drilled to 400 mm. Adjacent deeper hole drilled to 800 mm
Groundwater: None intersected

Lithological Log

FROM (mm BGL)	TO (mm BGL)	Description	Soil Type	Soil Sample
0	50	Moist humic friable LOAM with grass/roots and very fine micaceous sand. Light greyish brown.	-	-
50	400	SILT with minor very fine micaceous sand. Light grey to light brown. Very moist with rootlets.	-	-
400	600	SILT with minor very fine micaceous sand and trace clay. Crumbly to slightly plastic. Light brown. Very moist with rootlets.	-	-
600	800	SILT with minor very fine micaceous sand and clay. Slightly plastic. Greenish to greyish Light brown. Very moist with rootlets.	-	-

Drill Cutting Photo

Location Sketch

Hydraulic Testing Notes

Shallow test when hole at terminal depth of 420 mm.
Falling head test. Date/time: 7 October 2025 12:23:31. Solinst Levelogger 5, LT M10, 003-2179720
Solinst transducer removed from HA1 at 14:23
Deep test when hole at terminal depth of 800 mm.
Falling head test. Date/time: 7 October 2025 16:50. Manual record.

Observations:

Log sheet by: B. Sinclair 9/10/2025
Checked by: C. Jasper 10/10/2025

HAND AUGER INVESTIGATION RECORD

Figure No: A 3

WGA

CLIENT: Gibbons Co
PROJECT: Ridgeburn
Project #: WGA252389
Location: 122 Morven Ferry Road
Hand Auger ID: HA3
Drilling Date / Time: 7 October 2025
Field Record By: C Jasper

Location Description: Middle terrace, east of the alluvial fans.
NZTM E: 1271703 **NZTM N:** 5008526 **Elevation (mRL):** 317.5
Hole diameter (mm): 52 **Terminal depth (m):** 800
Weather: Fine. No prior rain during this day.
Drilling notes: Shallow hole drilled to 400 mm. Adjacent deeper hole drilled to 800 mm
Groundwater: None intersected

Lithological Log

FROM (mm BGL)	TO (mm BGL)	Description	Soil Type	Soil Sample
0	50	Moist humic friable LOAM with grass/roots and very fine micaceous sand. Light greyish brown.	-	-
50	300	SILT with minor very fine micaceous sand. Light grey to light brown. Very moist with rootlets.	-	-
300	400	SILT with minor very fine micaceous sand and trace clay. Slightly plastic. Light brown. Very moist with rootlets.	-	-
400	800	SILT with minor very fine micaceous sand and clay. Slightly to moderately plastic and greenish to greyish light brown.	-	-

Drill Cutting Photo

Location Sketch

Hydraulic Testing Notes

Shallow tests when hole at terminal depth of 400 mm.
Falling head test. Date/time: 7 October 2025 4:49. Solinst Levelogger 5, LT M10, 003-2179723
Solinst transducer removed from HA1 8 October 2025, 9:27.
Deep test in an immediately adjacent hole with a terminal depth of 800 mm.
Falling head test. Date/time: 7 October 2025 16:30. Manual record.

Observations:

Log sheet by: B. Sinclair 9/10/2025
Checked by: C. Jasper 10/10/2025

HAND AUGER INVESTIGATION RECORD

Figure No: A 4

WGA

CLIENT: Gibbons Co
PROJECT: Ridgeburn
Project #: WGA252389
Location: 122 Morven Ferry Road
Hand Auger ID: HA4
Drilling Date / Time: 7 October 2025
Field Record By: C Jasper

Location Description: Upper middle terrace.
NZTM E: 1271695 **NZTM N:** 5008576 **Elevation (mRL):** 318.8
Hole diameter (mm): 52 **Terminal depth (m):** 800
Weather: Fine. No prior rain during this day.
Drilling notes:
Groundwater: None intersected

Lithological Log

FROM (mm BGL)	TO (mm BGL)	Description	Soil Type	Soil Sample
0	50	Moist humic friable LOAM with grass/roots and very fine micaceous sand and trace clay. Light greyish brown and slightly plastic.	-	-
50	300	SILT with minor very fine micaceous sand and clay. Light grey to light brown. Slightly to moderatelly plastic and very moist with rootlets.	-	-
300	400	SILT with minor very fine micaceous sand and clay. Moderatelly plastic. Light brown. Very moist with rootlets.	-	-
400	800	SILT with minor very fine micaceous sand and clay. Slightly to moderately plastic and light brown.	-	-

Drill Cutting Photo

Location Sketch

Hydraulic Testing Notes

Shallow tests when hole at terminal depth of 410 mm.
Falling head test. Date/time: 7 October 2025 15:23. Solinst Levelogger 5, LT M10, 003-2179720
Solinst transducer removed from HA1 at 19:17
Deep test in immediately adjacent hole with a terminal depth of 800 mm.
Falling head test. Date/time: 7 October 2025 17:07. Manual record.

Observations:

Log sheet by: B. Sinclair 9/10/2025
Checked by: C. Jasper 10/10/2025

HAND AUGER INVESTIGATION RECORD

Figure No: A 5

WGA

CLIENT: Gibbons Co
PROJECT: Ridgeburn
Project #: WGA252389
Location: 122 Morven Ferry Road
Hand Auger ID: HA5
Drilling Date / Time: 7 October 2025
Field Record By: C Jasper

Location Description: Lower terrace, western end.
NZTM E: 1271457 **NZTM N:** 5008474 **Elevation (mRL):** 309.3
Hole diameter (mm): 52 **Terminal depth (m):** 800
Weather: Fine. No prior rain during this day.
Drilling notes:
Groundwater: None intersected

Lithological Log

FROM (mm BGL)	TO (mm BGL)	Description	Soil Type	Soil Sample
0	50	Moist humic friable LOAM with grass/roots and very fine micaceous sand. Light greenish/greyish brown.	-	-
50	400	SILT with minor very fine micaceous sand. Light greyish brown. Friable and moist with rootlets.	-	-
400	800	SILT with minor very fine micaceous sand and trace clay. friable to very slightly plastic. Light brown. Moist with rootlets.	-	-

Drill Cutting Photo

Location Sketch

Hydraulic Testing Notes

Shallow tests when hole at terminal depth of 445 mm.
Falling head test 1. Date/time: 8 October 2025 10:16:35. Solinst Levelogger 5, LT M10, 003-2179720
Falling head test 2. Date/time: 8 October 2025 11:09:37. Solinst Levelogger 5, LT M10, 003-2179720
Solinst transducer removed from HA1 at 11:54
Deep test in immediately adjacent hole at terminal depth of 800 mm.
Falling head test. Date/time: 8 October 2025 10:31. Manual record.

Observations:

Log sheet by: B. Sinclair 9/10/2025
Checked by: C. Jasper 10/10/2025

HAND AUGER INVESTIGATION RECORD

Figure No: A 6

CLIENT: Gibbons Co
PROJECT: Ridgeburn
Project #: WGA252389
Location: 122 Morven Ferry Road
Hand Auger ID: HA6
Drilling Date / Time: 7 October 2025
Field Record By: C Jasper

Location Description: Lower terrace, eastern end.
NZTM E: 1271553 **NZTM N:** 5008478 **Elevation (mRL):** 309.2
Hole diameter (mm): 52 **Terminal depth (m):** 800
Weather: Fine. No prior rain during this day.
Drilling notes:
Groundwater: None intersected

Lithological Log

FROM (mm BGL)	TO (mm BGL)	Description	Soil Type	Soil Sample
0	50	Moist humic friable LOAM with grass/roots and very fine micaceous sand. Light greenish/greyish brown.	-	-
50	500	SILT with minor very fine micaceous sand. Light greyish brown. Friable and moist with rootlets.	-	-
500	800	SILT with minor very fine micaceous sand and trace clay. friable to very slightly plastic. Light greenish to greyish brown. Moist with rootlets.	-	-

Drill Cutting Photo

Location Sketch

Hydraulic Testing Notes

Shallow test when hole at terminal depth of 500 mm.
Falling head test. Date/time: 8 October 2025 10:24. Manual record.

Deep test in immediately adjacent hole at terminal depth of 800 mm.
Falling head test. Date/time: 8 October 2025 10:24. Manual record.

Observations:

Log sheet by: B. Sinclair 9/10/2025
Checked by: C. Jasper 10/10/2025

HAND AUGER INVESTIGATION RECORD

Figure No: A 7

CLIENT: Gibbons Co
PROJECT: Ridgeburn
Project #: WGA252389
Location: 122 Morven Ferry Road
Hand Auger ID: HA7
Drilling Date / Time: 8 October 2025 9:30
Field Record By: B Sinclair

Location Description: Middle terrace, approximately 50 m NE from power pylon
NZTM E: 1271724 **NZTM N:** 5008537 **Elevation (mRL):** 317.5
Hole diameter (mm): 52 **Terminal depth (m):** 900
Weather: Fine. No rain during previous 48 hours.
Drilling notes: Shallow hole drilled to 500 mm. Adjacent deeper hole drilled to 900 mm
Groundwater: None intersected

Lithological Log

FROM (mm BGL)	TO (mm BGL)	Description	Soil Type	Soil Sample
0	50	Silty LOAM with roots and grass.	-	-
50	200	SILT with minor clay, micaceous sand, crumbly. Medium brown. Moist. Rootlets throughout	-	-
200	900	Clayey SILT, micaceous, moist. Crumbly when rolled at field moisture content	-	-

Drill Cutting Photo

Location Sketch

Hydraulic Testing Notes

Shallow tests when hole at terminal depth of 450 mm.

Falling head test 1. Date/time: 8 October 2025 09:58. Solinst Levelogger 5, LT M10, 003-2179723

Deep test when hole at terminal depth of 900 mm.

Falling head test. Date/time: 8 October 2025 10:57. Monitored manually.

Observations:

Log sheet by: B. Sinclair 9/10/2025
Checked by: C. Jasper 10/10/2025

HAND AUGER INVESTIGATION RECORD

Figure No: A 8

WGA

CLIENT: Gibbons Co
PROJECT: Ridgeburn
Project #: WGA252389
Location: 122 Morven Ferry Road
Hand Auger ID: HA8
Drilling Date / Time: 8 October 2025 10:40
Field Record By: B Sinclair

Location Description: Middle terrace, approximately 50 m W from power pylon, adjacent to outer toe of alluvial fan
NZTM E: 1271619 **NZTM N:** 5008545 **Elevation (mRL):** 317.0
Hole diameter (mm): 52 **Terminal depth (m):** 900
Weather: Fine. No rain during previous 48 hours.
Drilling notes: Shallow hole drilled to 500 mm. Adjacent deeper hole drilled to 900 mm
Groundwater: None intersected

Lithological Log

FROM (mm BGL)	TO (mm BGL)	Description	Soil Type	Soil Sample
0	50	Silty LOAM, with rootlets and grass.	-	-
50	300	SILT with minor clay, micaceous, rootlets throughout. Medium grey brown. Moist. Crumbly, slightly plastic at field moisture content	-	-
300	900	Clayey SILT, micaceous Medium greenish grey-brown. Moist. Crumbly at field moisture content, slightly plastic.	-	-

Drill Cutting Photo

Location Sketch

Hydraulic Testing Notes

Shallow test when hole at terminal depth of 500 mm.
Falling head test. Date/time: 8 October 2025 10:55. Recorded manually.

Deep test in immediately adfjacent hole at terminal depth of 900 mm.
Falling head test. Date/time: 8 October 2025 10:57. Recorded manually

Observations:

Log sheet by: B. Sinclair 9/10/2025
Checked by: C. Jasper 10/10/2025

HAND AUGER INVESTIGATION RECORD

Figure No: A 9

CLIENT:	Gibbons Co
PROJECT:	Ridgeburn
Project #:	WGA252389
Location:	122 Morven Ferry Road
Hand Auger ID:	HA9
Drilling Date / Time:	8 October 2025 12:00
Field Record By:	B Sinclair

Location Description: Middle terrace, approximately 50 m NE from western pylon.

NZTM E: 1271452 **NZTM N:** 5008534 **Elevation (mRL):** 317.8

Hole diameter (mm): 52 **Terminal depth (m):** 850

Weather: Fine. No rain during previous 48 hours.

Drilling notes: Shallow hole drilled to 450 mm. Adjacent deeper hole drilled to 850 mm

Groundwater: None intersected

Lithological Log

FROM (mm BGL)	TO (mm BGL)	Description	Soil Type	Soil Sample
0	100	Organic silty LOAM, with rootlets and grass.	-	-
100	250	Clayey SILT, rootlets throughout. Medium greenish brown. Moist. Crumbly, slightly plastic at field moisture content	-	-
250	550	Fine silty SAND, micaceous, non-cohesive. Yellowish greenish brown. Moist.	-	-
550	850	Clayey SILT, medium greenish brown, moist Crumbly, slightly plastic at field moisture content	-	-

Drill Cutting Photo

Location Sketch

Hydraulic Testing Notes

Shallow test when hole at terminal depth of 400 mm.

Falling head test. Date/time: 8 October 2025 12:17. Solinst pressure transducer 2179720.

Deep test in immediately adjacent hole at terminal depth of 850 mm.

Falling head test. Date/time: 8 October 2025 12:17.

Observations: Hole drilled approximately 13 m SE from toe of shallow alluvial fan 2.
Drill cuttings photo taken 12:20.

Log sheet by: B. Sinclair 9/10/2025
Checked by: C. Jasper 10/10/2025

HAND AUGER INVESTIGATION RECORD

Figure No: A 10

WGA

CLIENT: Gibbons Co
PROJECT: Ridgeburn
Project #: WGA252389
Location: 122 Morven Ferry Road
Hand Auger ID: HA10
Drilling Date / Time: 8 October 2025 13:00
Field Record By: B Sinclair

Location Description: Extreme western end of middle terrace, approximately 50 m W from western pylon
NZTM E: 1271338 **NZTM N:** 5008468 **Elevation (mRL):** 317.0
Hole diameter (mm): 52 **Terminal depth (m):** 950
Weather: Fine. No rain during previous 48 hours.
Drilling notes: Shallow hole drilled to 450 mm. Adjacent deeper hole drilled to 950 mm
Groundwater: None intersected

Lithological Log

FROM (mm BGL)	TO (mm BGL)	Description	Soil Type	Soil Sample
0	50	Sandy silty LOAM, with rootlets and grass.	-	-
50	350	SILT, medium brown. Crumbly. Moist.	-	-
350	450	Clayey SILT, micaceous. Medium brown. Moist. Slightly plastic at field moisture content.	-	-
450	950	Clayey SILT, light brown, moist More plastic at field moisture content	-	-

Drill Cutting Photo

Location Sketch

Hydraulic Testing Notes

Shallow test when hole at terminal depth of 450 mm.
Falling head test. Date/time: 8 October 2025 13:20. Manual record.

Deep test in immediately adjacent hole at terminal depth of 950 mm.
Falling head test. Date/time: 8 October 2025 13:23. Manual record.

Observations:

Log sheet by: B. Sinclair 9/10/2025
Checked by: C. Jasper 10/10/2025

HAND AUGER INVESTIGATION RECORD

Figure No: A 11

CLIENT: Gibbons Co
PROJECT: Ridgeburn
Project #: WGA252389
Location: 122 Morven Ferry Road
Hand Auger ID: HA11
Drilling Date / Time: 8 October 2025 13:40
Field Record By: C. Jasper

Location Description: Top terrace, approximately 20 m W from pylon
NZTM E: 1271165 **NZTM N:** 5008475 **Elevation (mRL):** 344.3
Hole diameter (mm): 52 **Terminal depth (m):** 850
Weather: Fine. No rain during previous 48 hours.
Drilling notes: Shallow hole drilled to 440 mm. Adjacent deeper hole drilled to 850 mm
Groundwater: None intersected

Lithological Log

FROM (mm BGL)	TO (mm BGL)	Description	Soil Type	Soil Sample
0	100	Organic silty LOAM, brown, fibrous.	-	-
100	300	Clayey SILT, Moist. Crumbly at field moisture content.	-	-
300	850	SILT, micaceous. Light grey brown. Moist.	-	-

Drill Cutting Photo

Location Sketch

Hydraulic Testing Notes

Shallow test when hole at terminal depth of 450 mm.
Falling head test. Date/time: 8 October 2025 14:07. Solinst pressure transducer 2179723.

Deep test when hole at terminal depth of 600 mm.
Falling head test. Date/time: 8 October 2025 14:27. Solinst pressure transducer 2179720.

Observations: Drill cutting photo taken 14:14.

Log sheet by: B. Sinclair 9/10/2025
Checked by: C. Jasper 10/10/2025

HAND AUGER INVESTIGATION RECORD

Figure No: A 12

CLIENT: Gibbons Co
PROJECT: Ridgeburn
Project #: WGA252389
Location: 122 Morven Ferry Road
Hand Auger ID: HA12
Drilling Date / Time: 8 October 2025 14:35
Field Record By: B Sinclair

Location Description: Middle of top terrace, approximately 30 m E from pylon
NZTM E: 1271225 **NZTM N:** 5008497 **Elevation (mRL):** 344.7
Hole diameter (mm): 52 **Terminal depth (m):** 900
Weather: Fine. No rain during previous 48 hours.
Drilling notes: Shallow hole drilled to 470 mm. Adjacent deeper hole drilled to 900 mm
Groundwater: None intersected

Lithological Log

FROM (mm BGL)	TO (mm BGL)	Description	Soil Type	Soil Sample
0	50	Organic silty LOAM, dark brown, rootlets.	-	-
50	400	SILT, micaceous, dark brown Slightly moist. Crumbly at field moisture content.	-	-
400	900	Clayey SILT, crumbly, micaceous. Medium grey brown. Slightly moist. Slightly plastic at field moisture content.	-	-

Drill Cutting Photo

Location Sketch

Hydraulic Testing Notes

Shallow test when hole at terminal depth of 440 mm.
Falling head test. Date/time: 8 October 2025 14:44. Manual record.

Deep test when hole at terminal depth of 850 mm.
Falling head test. Date/time: 8 October 2025 14:44. Manual record.

Observations: Drill cutting photo taken 14:30.

Log sheet by: B. Sinclair 9/10/2025
Checked by: C. Jasper 10/10/2025

HAND AUGER INVESTIGATION RECORD

Figure No: A 13

CLIENT: Gibbons Co
PROJECT: Ridgeburn
Project #: WGA252389
Location: 122 Morven Ferry Road
Hand Auger ID: HA13
Drilling Date / Time: 8 October 2025 16:00
Field Record By: C. Jasper

Location Description: Lower slope of middle alluvial fan on middle terrace
NZTM E: 1271572 **NZTM N:** 5008538 **Elevation (mRL):** 318.9
Hole diameter (mm): 52 **Terminal depth (m):** 700
Weather: Fine. No rain during previous 48 hours.
Drilling notes: Hole drilled to 700 mm
Groundwater: None intersected

Lithological Log

FROM (mm BGL)	TO (mm BGL)	Description	Soil Type	Soil Sample
0	50	Sandy LOAM, very friable, organic.	-	-
50	700	Silty, gravelly fine SAND. Clasts sub-rounded to well rounded. Max diameter approx. 25 mm. Larger clasts probably led to refusal in first two test holes. Moist through entire column.	-	-

Drill Cutting Photo

Location Sketch

Hydraulic Testing Notes

Test when hole at terminal depth of 700 mm.

Falling head test. Date/time: 8 October 2025, approximately 16:30. Manual record.

Observations: Two initial auger holes reached refusal at about 250 mm due to striking cobbles or large gravel.
Third attempt reached refusal at 700 mm for same reason.
Surface clasts to 250 mm diameter observed.

Log sheet by: B. Sinclair 9/10/2025
Checked by: C. Jasper 10/10/2025

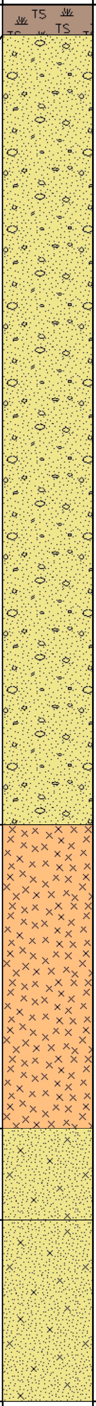
TEST PIT RESULTS

KIRK ROBERTS CONSULTING

Client:	Gibbons Developments Ltd	**Job No.:**	2555087
Site Address:	Morven Ferry Road	**Test Pit No.**	TP-1
Town/City:	Queenstown	**Scala Penetrometer:**	
Operator:	MH	**Date:**	05/05/25
Logged By:	MH	**Weather:**	Fine
Logged Date:	05/05/25	**Datum:**	
Checked By:	OB	**Termination:**	
Checked Date:	07/05/25		

Geological Formation	Depth (m)	Elevation	Sample Description	Graphic	USCS	D_r	Water Table	Undrained Shear Strength Su (kPa)	Blows per 100 mm of Penetration
			Sandy silty TOPSOIL; dark brown. Moist; with rootlets.	TS			Groundwater Not Encountered		
	0.5 1.0 1.5 2.0 2.5	-0.5 -1.0 -1.5 -2.0 -2.5	Silty SAND, with some gravel, with trace cobbles; brownish grey. Medium dense, moist to wet, non-plastic, sand, fine to medium; gravel, fine to medium, subround to subangular.						
	3.0 3.5	-3.0 -3.5	SILT, with trace clay; brownish grey. Medium dense, moist, non-plastic.						
			SAND; brownish yellow. Medium dense, moist, sand, medium.						
	4.0 4.5	-4.0 -4.5	Silty SAND, with trace gravel. Medium dense, moist, non-plastic, sand, fine to medium; gravel, fine, subround.						
			EOH: 4.60m						

Blows per 100 mm scale: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19



Remarks:
Scala Penetrometer and Test Bore log tests give an indication of the ground condition at the location of the tests only. While they are representative of typical conditions across the site, they do not identify variations in the ground away from the test locations.
Elevation datum sourced from council GIS LiDAR contours.

Generated with CORE-GS

TEST PIT RESULTS

Client:	Gibbons Developments Ltd	**Job No.:**	2555087
Site Address:	Morven Ferry Road	**Test Pit No.**	TP-2
Town/City:	Queenstown	**Scala Penetrometer:**	
Operator:	MH	**Date:**	05/05/25
Logged By:	MH	**Weather:**	Fine
Logged Date:	05/05/25	**Datum:**	
Checked By:	OB	**Termination:**	
Checked Date:	07/05/25		

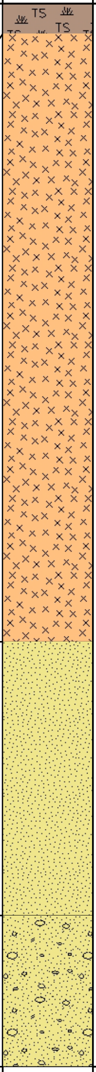
Geological Formation	Depth (m)	Elevation	Sample Description	Graphic	USCS	D_r	Water Table	Undrained Shear Strength Su (kPa)	Blows per 100 mm of Penetration 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
			Sandy silty TOPSOIL; dark brown. Moist; with rootlets.	TS			Groundwater Not Encountered		
	0.5	-0.5	Silty SAND, with some gravel, with trace cobbles; brownish grey. Medium dense, moist to wet, non-plastic, sand, fine to medium; gravel, fine to medium, subround to subangular.						
	1.0 1.5 2.0	-1.0 -1.5 -2.0	SILT, with trace clay and sand; brownish grey. Medium dense, moist, non-plastic, sand; fine.						
	2.5	-2.5	SAND, with minor gravel; greyish. Loose, moist, sand, fine to coarse; gravel, fine, subround.						
	3.0	-3.0	Gravelly SAND; yellowish grey. Medium dense, moist, sand, medium to coarse; gravel, fine, subround to subangular.						
	3.5 4.0 4.5	-3.5 -4.0 -4.5	Unable to auger further due to inferred cobble obstruction. EOH: 3.30m						

Remarks:
Scala Penetrometer and Test Bore log tests give an indication of the ground condition at the location of the tests only. While they are representative of typical conditions across the site, they do not identify variations in the ground away from the test locations.
Elevation datum sourced from council GIS LiDAR contours.

TEST PIT RESULTS

Client: Gibbons Developments Ltd
Site Address: Morven Ferry Road
Town/City: Queenstown
Job No.: 2555087
Test Pit No. TP-3
Scala Penetrometer:

Operator: MH
Logged By: MH
Logged Date: 05/05/25
Checked By: OB
Checked Date: 07/05/25
Date: 05/05/25
Weather: Fine
Datum:
Termination:



Geological Formation	Depth (m)	Elevation	Sample Description	Graphic	USCS	D_r	Water Table	Undrained Shear Strength Su (kPa)	Blows per 100 mm of Penetration
			Sandy silty TOPSOIL; dark brown. Moist; with rootlets.				Groundwater Not Encountered		
			SILT, with trace clay; brownish grey. Medium dense, moist, non-plastic.						
			SAND; light grey. Medium dense, moist, sand, fine to medium.						
			Gravelly SAND with trace cobbles; yellowish grey. Medium dense, moist, sand, medium to coarse; gravel, fine, subround to subangula; cobbles, subrounded.						
			End of borehole due to borehole collapsing. EOH: 3.50m						

Depth (m)	Elevation
0.5	-0.5
1.0	-1.0
1.5	-1.5
2.0	-2.0
2.5	-2.5
3.0	-3.0
3.5	-3.5
4.0	-4.0
4.5	-4.5

Blows per 100 mm of Penetration: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

Remarks:
Scala Penetrometer and Test Bore log tests give an indication of the ground condition at the location of the tests only. While they are representative of typical conditions across the site, they do not identify variations in the ground away from the test locations.
Elevation datum sourced from council GIS LiDAR contours.

HAND AUGER RESULTS

KIRK ROBERTS CONSULTING

Client:	Gibbons Developments Ltd	**Job No.:**	2555087
Site Address:	Morven Ferry Road	**Hand Auger No.**	HA-4
Town/City:	Queenstown	**Scala Penetrometer:**	

Operator:	MH			**Date:**	05/05/25
				Weather:	Fine
Logged By:	MH	**Checked By:**	OB	**Datum:**	
Logged Date:	05/05/25	**Checked Date:**	07/05/25	**Termination:**	

Geological Formation	Depth (m)	Elevation	Sample Description	Graphic	USCS	D_r	Water Table	Undrained Shear Strength Su (kPa)	Blows per 100 mm of Penetration 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
			Sandy silty TOPSOIL; dark brown. Moist; with rootlets.	TS			Groundwater Not Encountered		
			Gravelly SAND, with minor silt, with trace cobbles; light yellowish brown. Medium dense, dry to moist, non-plastic, sand, fine to medium; gravel, fine to coarse, subround.						
	0.5	-0.5							
	1.0	-1.0							
	1.5	-1.5							
	2.0	-2.0	EOH: 2.00m						

Remarks:
Scala Penetrometer and Test Bore log tests give an indication of the ground condition at the location of the tests only. While they are representative of typical conditions across the site, they do not identify variations in the ground away from the test locations.
Elevation datum sourced from council GIS LiDAR contours.

HAND AUGER RESULTS

KIRK ROBERTS CONSULTING

Client:	Gibbons Developments Ltd	**Job No.:**	2555087
Site Address:	Morven Ferry Road	**Hand Auger No.**	HA-5
Town/City:	Queenstown	**Scala Penetrometer:**	
Operator:	MH	**Date:**	05/05/25
Logged By:	MH	**Weather:**	Fine
Checked By:	OB	**Datum:**	
Logged Date:	05/05/25	**Termination:**	
Checked Date:	07/05/25		

Geological Formation	Depth (m)	Elevation	Sample Description	Graphic	USCS	D_r	Water Table	Undrained Shear Strength Su (kPa)	Blows per 100 mm of Penetration (1–19)
			Sandy silty TOPSOIL; dark brown. Moist; with rootlets.	TS					
			Silty SAND, with some gravel; brown. Gravel, fine to medium, subround to subangular.				Groundwater Not Encountered		
	0.5	-0.5							
	1.0	-1.0							
	1.5	-1.5							
	2.0	-2.0	EOH: 2.00m						

Remarks:
Scala Penetrometer and Test Bore log tests give an indication of the ground condition at the location of the tests only. While they are representative of typical conditions across the site, they do not identify variations in the ground away from the test locations.
Elevation datum sourced from council GIS LiDAR contours.

APPENDIX B

FALLING HEAD TEST RECORDS AND ANALYSES

KIRK ROBERTS CONSULTING	**JOB TITLE**	Morven Ferry Road		
	ADDRESS	Morven Ferry Road, Queenstown		
	DATE	7/05/2025	**PRODUCED BY**	MH
	JOB No.	2555087	**CHECKED BY**	OB

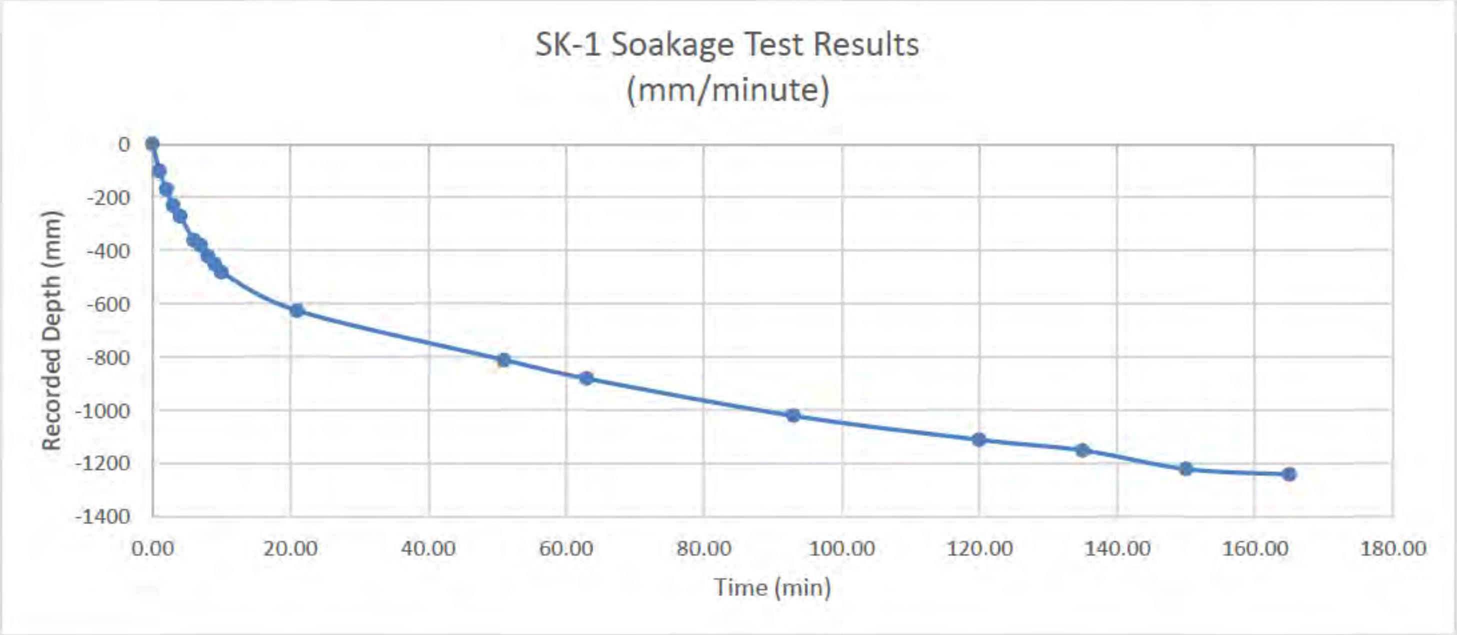
Soakage assessment and calculations undertaken in accordance with QLDC SLUCOP and Auckland City Council Soakage Design Manual 2003.

(a) Percolation rate = $P_1 = \frac{D \times gradient \times 1000}{4 \times d^*} =$

SK-1 Borehole Soakage - refer to borehole log for soil profile

Test Hole Diameter	**0.2**	m
Soakage Column Height	**1300**	mm

Time (mins)	Recorded Depth (mm)	Drop (mm)	Drainage Rate (mm/hr)	Test Drainage Surface Area (m^2)	y	x	Percolation Rate L/m2/min
0.00	0	0					
1.00	-100	-100	-6000	0.8482			
2.00	-170	-70	-4200	0.7854			
3.00	-230	-60	-3600	0.7414			
4.00	-270	-40	-2400	0.7037			
6.00	-360	-90	-2700	0.6786			
7.00	-380	-20	-1200	0.6220			
8.00	-420	-40	-2400	0.6095			
9.00	-450	-30	-1800	0.5843			
10.00	-480	-30	-1800	0.5655			
21.00	-625	-145	-791	0.5466			
51.00	-810	-185	-370	0.4555			
63.00	-880	-70	-350	0.3393			
93.00	-1020	-140	-280	0.2953			
120.00	-1110	-90	-200	0.2073			
135.00	-1150	-40	-160	0.1508			
150.00	-1220	-70	-280	0.1257			
165.00	-1240	-20	-80	0.0817	**20.0**	**30.0**	**0.4762**



Soakage Rate	28.6	L/m2/hr
Design Soakage Rate FOS2	**14.29**	L/m2/hr

JOB TITLE	Morven Ferry Road			
ADDRESS	Morven Ferry Road, Queenstown			
DATE	7/05/2025	**PRODUCED BY**	MH	
JOB No.	2555087	**CHECKED BY**	OB	

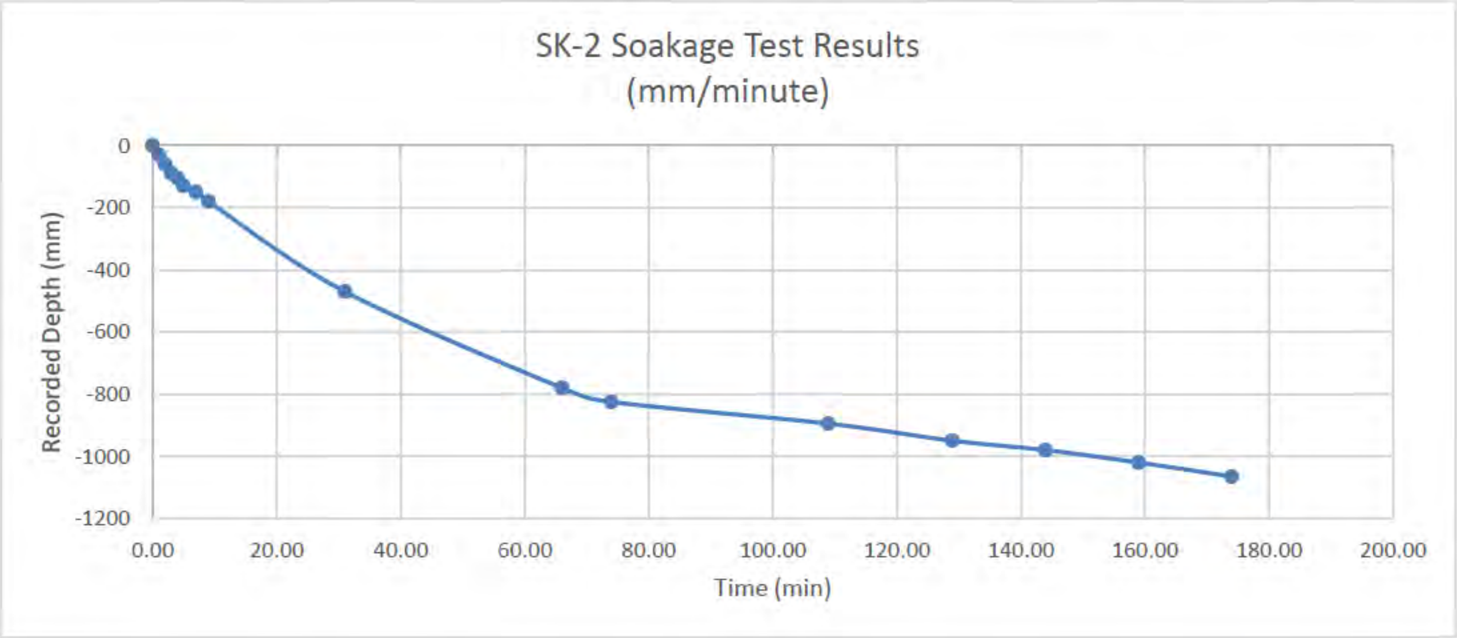
Soakage assessment and calculations undertaken in accordance with QLDC SLUCOP and Auckland City Council Soakage Design Manual 2003.

(a) Percolation rate = $P_1 = \dfrac{D \times gradient \times 1000}{4 \times d^*} =$

SK-1 Borehole Soakage - refer to borehole log for soil profile

Test Hole Diameter	**0.2**	m
Soakage Column Height	**1620**	mm

Time (mins)	Recorded Depth (mm)	Drop (mm)	Drainage Rate (mm/hr)	Test Drainage Surface Area (m^2)	y	x	Percolation Rate L/m2/min
0.00	0	0					
1.00	-30	-30	-1800	1.0493			
2.00	-60	-30	-1800	1.0304			
3.00	-90	-30	-1800	1.0116			
4.00	-105	-15	-900	0.9927			
5.00	-130	-25	-1500	0.9833			
7.00	-150	-20	-600	0.9676			
9.00	-180	-30	-900	0.9550			
31.00	-470	-290	-791	0.9362			
66.00	-780	-310	-531	0.7540			
74.00	-825	-45	-338	0.5592			
109.00	-895	-70	-120	0.5309			
129.00	-950	-55	-165	0.4869			
144.00	-980	-30	-120	0.4524			
159.00	-1020	-40	-160	0.4335			
174.00	-1065	-45	-180	0.4084	**45.0**	**30.0**	**0.1299**



Soakage Rate	7.8	L/m2/hr
Design Soakage Rate FOS2	**3.90**	L/m2/hr

KIRK ROBERTS CONSULTING

JOB TITLE	Morven Ferry Road		
ADDRESS	Morven Ferry Road, Queenstown		
DATE	7/05/2025	**PRODUCED BY**	MH
JOB No.	2555087	**CHECKED BY**	OB

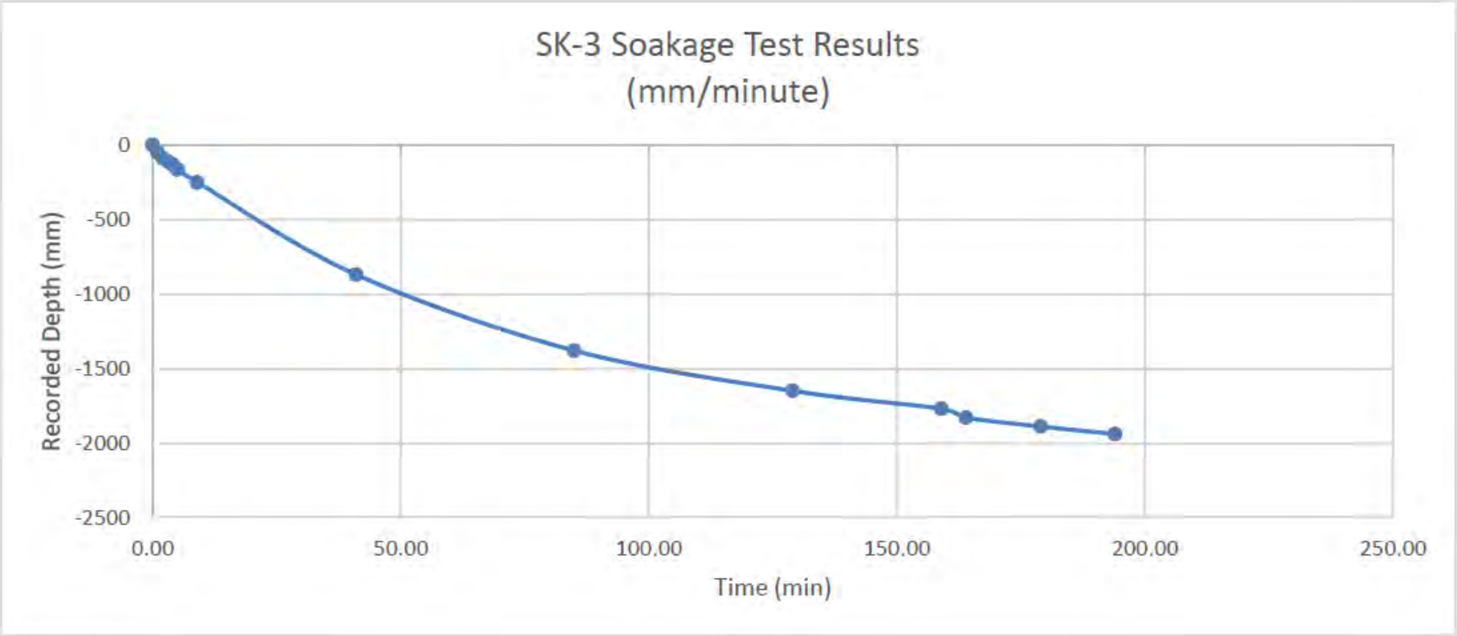
Soakage assessment and calculations undertaken in accordance with QLDC SLUCOP and Auckland City Council Soakage Design Manual 2003.

(a) Percolation rate = $P_1 = \frac{D \times gradient \times 1000}{4 \times d^*} =$

SK-1 Borehole Soakage - refer to borehole log for soil profile

Test Hole Diameter	**0.2**	m
Soakage Column Height	**2070**	mm

Time (mins)	Recorded Depth (mm)	Drop (mm)	Drainage Rate (mm/hr)	Test Drainage Surface Area (m^2)	y	x	Percolation Rate L/m2/min
0.00	0	0					
1.00	-50	-50	-3000	1.3320			
2.00	-85	-35	-2100	1.3006			
3.00	-110	-25	-1500	1.2786			
4.00	-130	-20	-1200	1.2629			
5.00	-165	-35	-2100	1.2504			
9.00	-250	-85	-1275	1.2284			
41.00	-870	-620	-1163	1.1750			
85.00	-1380	-510	-695	0.7854			
129.00	-1650	-270	-368	0.4650			
159.00	-1770	-120	-240	0.2953			
164.00	-1830	-60	-720	0.2199			
179.00	-1890	-60	-240	0.1822			
194.00	-1940	-50	-200	0.1445	**50.0**	**30.0**	**0.5376**



Soakage Rate	0.0	L/m2/hr
Design Soakage Rate FOS2	**0.00**	L/m2/hr

KIRK ROBERTS
CONSULTING

JOB TITLE	Morven Ferry Road		
ADDRESS	Morven Ferry Road, Queenstown		
DATE	7/05/2025	**PRODUCED BY**	MH
JOB No.	2555087	**CHECKED BY**	OB

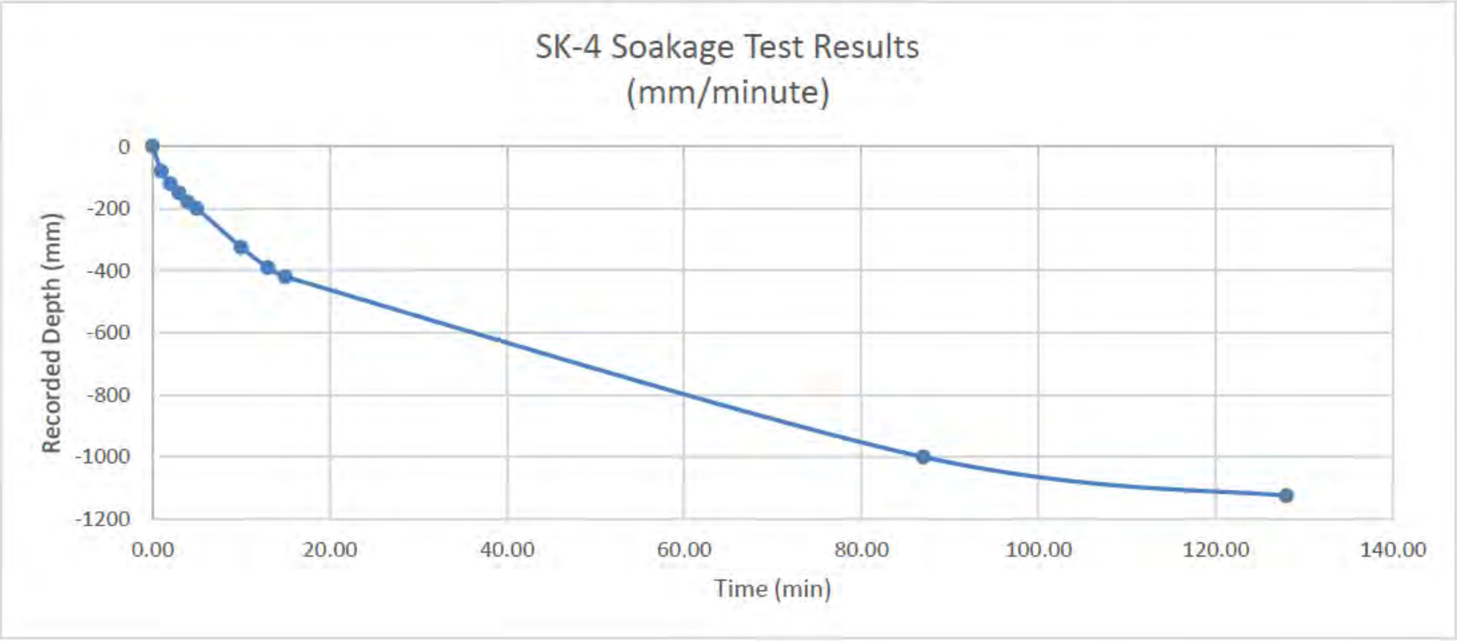
Soakage assessment and calculations undertaken in accordance with QLDC SLUCOP and Auckland City Council Soakage Design Manual 2003.

(a) Percolation rate = $P_1 = \frac{D \times gradient \times 1000}{4 \times d^*} =$

SK-1 Borehole Soakage - refer to borehole log for soil profile

Test Hole Diameter	**0.2**	m
Soakage Column Height	**1200**	mm

Time (mins)	Recorded Depth (mm)	Drop (mm)	Drainage Rate (mm/hr)	Test Drainage Surface Area (m^2)	y	x	Percolation Rate L/m2/min
0.00	0	0					
1.00	-80	-80	-4800	0.7854			
2.00	-120	-40	-2400	0.7351			
3.00	-150	-30	-1800	0.7100			
4.00	-180	-30	-1800	0.6912			
5.00	-200	-20	-1200	0.6723			
10.00	-325	-125	-1500	0.6597			
13.00	-390	-65	-1300	0.5812			
15.00	-420	-95	-1140	0.5812			
87.00	-1000	-610	-495	0.5404			
128.00	-1125	-705	-374	0.5215	**705.0**	**113.0**	**0.7297**



Soakage Rate	43.8	L/m2/hr
Design Soakage Rate FOS2	**21.89**	L/m2/hr

KIRK ROBERTS CONSULTING

JOB TITLE	Morven Ferry Road		
ADDRESS	Morven Ferry Road, Queenstown		
DATE	7/05/2025	**PRODUCED BY**	MH
JOB No.	2555087	**CHECKED BY**	OB

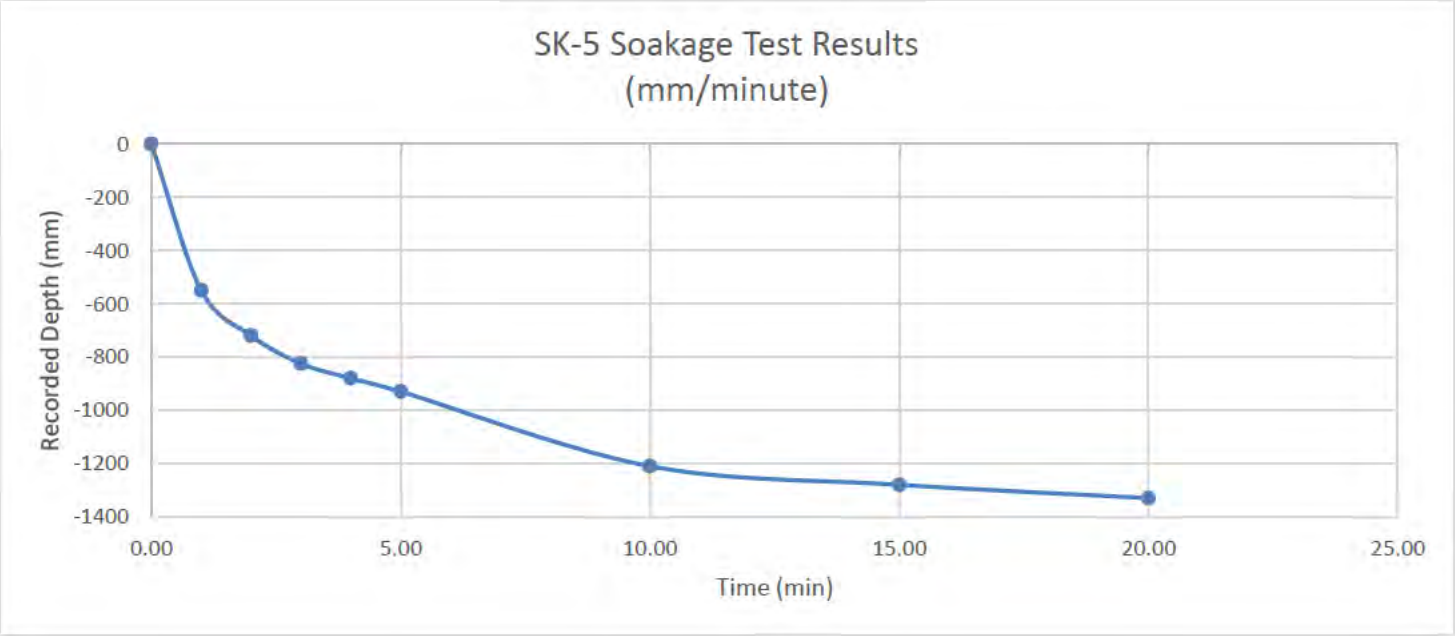
Soakage assessment and calculations undertaken in accordance with QLDC SLUCOP and Auckland City Council Soakage Design Manual 2003.

(a) Percolation rate = $P_1 = \frac{D \times gradient \times 1000}{4 \times d\,*} =$

SK-1 Borehole Soakage - refer to borehole log for soil profile

Test Hole Diameter	**0.2**	m
Soakage Column Height	**1350**	mm

Time (mins)	Recorded Depth (mm)	Drop (mm)	Drainage Rate (mm/hr)	Test Drainage Surface Area (m^2)	y	x	Percolation Rate L/m2/min
0.00	0	0					
1.00	550	-550	-33000	0.8796			
2.00	720	-170	-10200	1.2252			
3.00	825	-105	-6300	1.3320			
4.00	880	-55	-3300	1.3980			
5.00	930	-50	-3000	1.4326			
11.00	1210	-280	-2800	1.4640			
16.00	1280	-70	-840	1.6399			
21.00	1330	-120	-1440	1.6839	**120.0**	**10.0**	**0.2190**

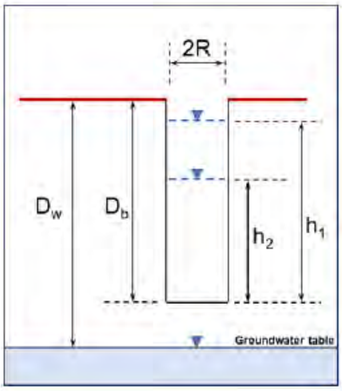


Soakage Rate	13.1	L/m2/hr
Design Soakage Rate FOS2	**6.57**	L/m2/hr

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client:	Gibbons Co
Project:	Ridgeburn Development
Project No:	WGA252389
Location:	Morven Ferry Rd
Bore No:	BH1 Test 1
Figure No:	B 47

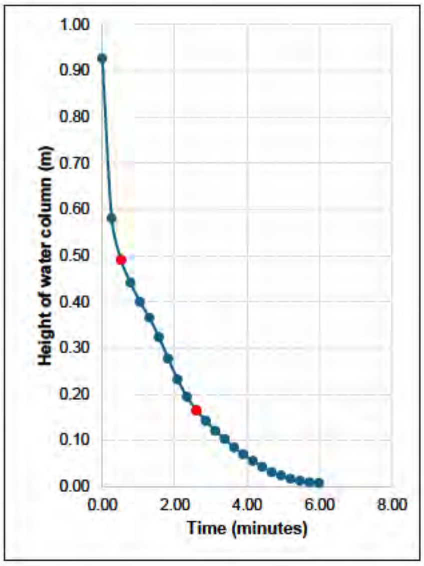


$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.033	m	Drillhole radius
D_b		m	Drillhole depth
D_w	-	m	Depth to groundwater table (SWL), if known
date	NA		Date of SWL measurement
time	NA		Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0.00		0.927	-0.025
1	0.26		0.581	-0.224
2	0.52		0.491	-0.295
3	0.78		0.442	-0.339
4	1.04		0.400	-0.381
5	1.30		0.366	-0.418
6	1.56		0.324	-0.468
7	1.82		0.277	-0.532
8	2.08		0.232	-0.604
9	2.34		0.195	-0.676
10	2.60		0.165	-0.740
11	2.86		0.143	-0.798
12	3.12		0.121	-0.861
13	3.38		0.103	-0.921
14	3.64		0.085	-0.994
15	3.90		0.070	-1.063
16	4.16		0.056	-1.141
17	4.42		0.043	-1.226
18	4.68		0.032	-1.319
19	4.94		0.024	-1.389
20	5.20		0.017	-1.472
21	5.46		0.013	-1.532
22	5.72		0.009	-1.587
23	5.98		0.008	-1.613
24				
25				
26				
27				
28				
29				
30				



t_1	0.52	h_1	0.491	y_1	-0.295
t_2	2.6	h_2	0.165	y_2	-0.740

Hydraulic conductivity (k)

1E-04	**m/s**
11.7	**m/day**

Tested by:	Kirk Roberts	4/12/2025
Analysed by:	J. Manning	11/12/2025
Checked by:	B. Sinclair	12/12/2025

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

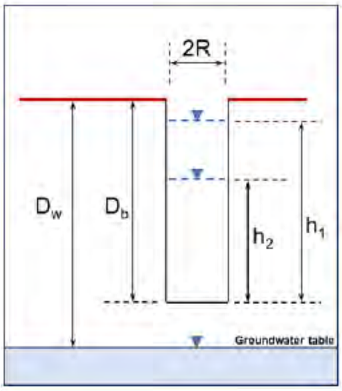
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Piezometer radius calculated on basis of 52 mm ID screen iside 100 mm drillhole, with annulus space containing clean grtavel pack with drainable porosity of 0.25.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client: Gibbons Co
Project: Ridgeburn Development
Project No: WGA252389
Location: Morven Ferry Rd
Bore No: BH1 Test 2
Figure No: B 48

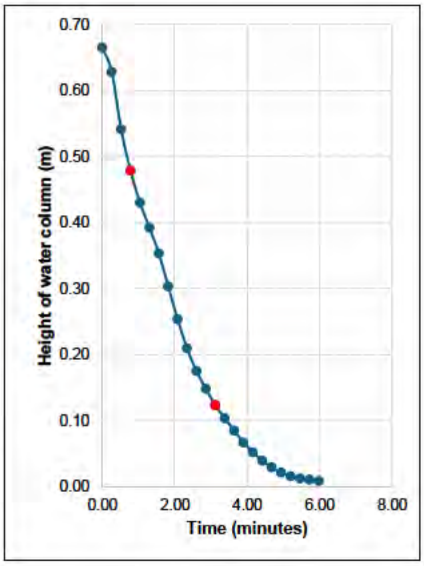


$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.033	m	Drillhole radius
D_b		m	Drillhole depth
D_w	-	m	Depth to groundwater table (SWL), if known
date	NA		Date of SWL measurement
time	NA		Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0.00		0.665	-0.166
1	0.26		0.628	-0.191
2	0.52		0.541	-0.253
3	0.78		0.479	-0.305
4	1.04		0.430	-0.350
5	1.30		0.393	-0.388
6	1.56		0.353	-0.432
7	1.82		0.304	-0.495
8	2.08		0.254	-0.568
9	2.34		0.210	-0.646
10	2.60		0.175	-0.717
11	2.86		0.148	-0.783
12	3.12		0.123	-0.854
13	3.38		0.104	-0.921
14	3.64		0.085	-0.994
15	3.90		0.067	-1.078
16	4.16		0.052	-1.163
17	4.42		0.039	-1.253
18	4.68		0.029	-1.338
19	4.94		0.022	-1.420
20	5.20		0.016	-1.491
21	5.46		0.012	-1.541
22	5.72		0.011	-1.564
23	5.98		0.009	-1.599
24				
25				
26				
27				
28				
29				
30				



t_1	0.78	h_1	0.479	y_1	-0.305
t_2	3.12	h_2	0.123	y_2	-0.854

Hydraulic conductivity (k)

1E-04 **m/s**
12.8 **m/day**

Tested by:	Kirk Roberts	4/12/2025
Analysed by:	J. Manning	11/12/2025
Checked by:	B. Sinclair	12/12/2025

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

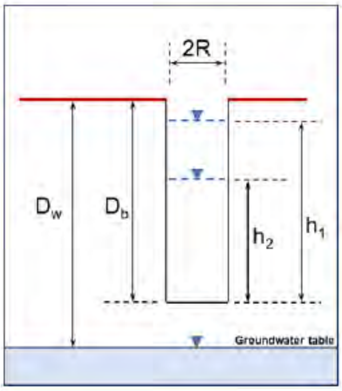
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Piezometer radius calculated on basis of 52 mm ID screen iside 100 mm drillhole, with annulus space containing clean grtavel pack with drainable porosity of 0.25.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client: Gibbons Co
Project: Ridgeburn Development
Project No: WGA252389
Location: Morven Ferry Rd
Bore No: BH1 Test 3
Figure No: B 49



$$k = 1.15R\frac{log(h_1+R/2)-log(h_2+R/2)}{t_2-t_1}$$

R	0.033	m	Drillhole radius
D_b		m	Drillhole depth
D_w	-	m	Depth to groundwater table (SWL), if known
date	NA		Date of SWL measurement
time	NA		Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0.00		0.656	-0.172
1	0.26		0.599	-0.211
2	0.52		0.512	-0.277
3	0.78		0.459	-0.323
4	1.04		0.413	-0.367
5	1.30		0.376	-0.407
6	1.56		0.329	-0.461
7	1.82		0.275	-0.536
8	2.08		0.225	-0.618
9	2.34		0.185	-0.696
10	2.60		0.155	-0.766
11	2.86		0.130	-0.834
12	3.12		0.107	-0.908
13	3.38		0.088	-0.981
14	3.64		0.069	-1.066
15	3.90		0.052	-1.167
16	4.16		0.039	-1.252
17	4.42		0.029	-1.344
18	4.68		0.021	-1.427
19	4.94		0.015	-1.509
20	5.20		0.012	-1.539
21	5.46		0.010	-1.573
22	5.72		0.008	-1.609
23	5.98		0.006	-1.650
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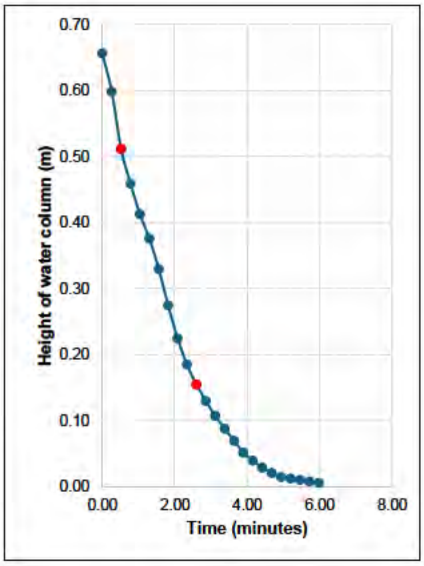


t_1	0.52	h_1	0.512	y_1	-0.277
t_2	2.6	h_2	0.155	y_2	-0.766

Hydraulic conductivity (k)

1E-04	**m/s**
12.8	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	Kirk Roberts	4/12/2025
Analysed by:	J. Manning	11/12/2025
Checked by:	B. Sinclair	12/12/2025

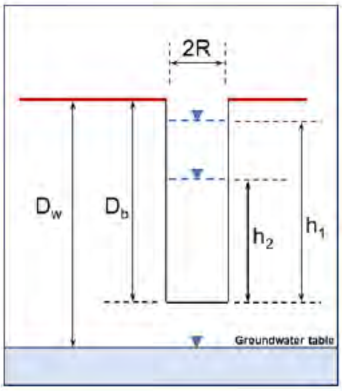
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Piezometer radius calculated on basis of 52 mm ID screen iside 100 mm drillhole, with annulus space containing clean grtavel pack with drainable porosity of 0.25.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client: Gibbons Co
Project: Ridgeburn Development
Project No: WGA252389
Location: Morven Ferry Rd
Bore No: BH2 Test 1
Figure No: B 50



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.033	m	Drillhole radius
D_b		m	Drillhole depth
D_w	-	m	Depth to groundwater table (SWL), if known
date	NA		Date of SWL measurement
time	NA		Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0.00		0.053	-1.157
1	0.05		0.044	-1.219
2	0.10		0.035	-1.286
3	0.15		0.030	-1.336
4	0.20		0.025	-1.386
5	0.25		0.021	-1.425
6	0.30		0.018	-1.469
7	0.35		0.015	-1.496
8	0.40		0.014	-1.517
9	0.45		0.013	-1.538
10	0.55		0.010	-1.570
11	0.60		0.008	-1.607
12	0.75		0.007	-1.633
13	0.95		0.005	-1.662
14	1.15		0.004	-1.690
15	1.35		0.003	-1.706
16	1.55		0.002	-1.721
17				
18				
19				
20				
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27				
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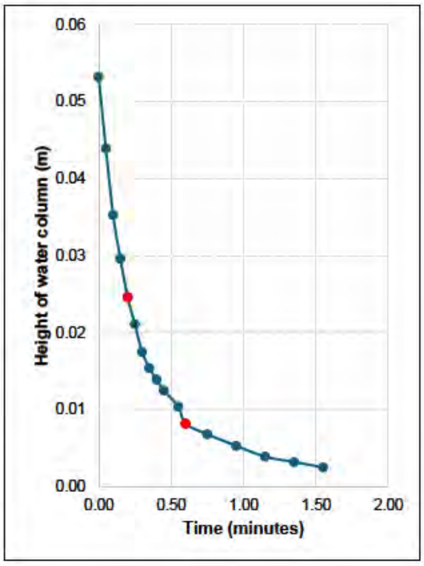


t_1	0.2	**h_1**	0.025	**y_1**	-1.386
t_2	0.6	**h_2**	0.008	**y_2**	-1.607

Hydraulic conductivity (k)

3E-04 **m/s**
30.2 **m/day**

Tested by:	Kirk Roberts	4/12/2025
Analysed by:	J. Manning	11/12/2025
Checked by:	B. Sinclair	12/12/2025

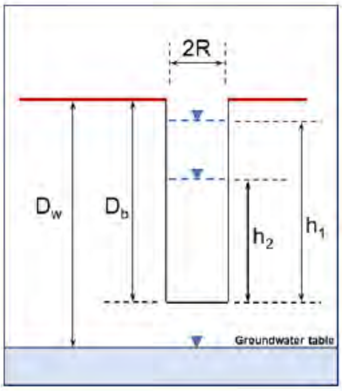
Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Piezometer radius calculated on basis of 52 mm ID screen iside 100 mm drillhole, with annulus space containing clean grtavel pack with drainable porosity of 0.25.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

Client: Gibbons Co
Project: Ridgeburn Development
Project No: WGA252389
Location: Morven Ferry Rd
Bore No: BH2 Test 2
Figure No: B 51

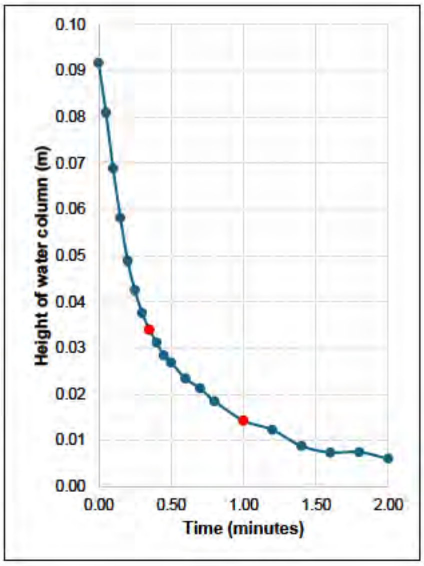


$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.033 m	Drillhole radius
D_b	m	Drillhole depth
D_w	- m	Depth to groundwater table (SWL), if known
date	NA	Date of SWL measurement
time	NA	Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0.00		0.092	-0.966
1	0.05		0.081	-1.011
2	0.10		0.069	-1.069
3	0.15		0.058	-1.127
4	0.20		0.049	-1.184
5	0.25		0.043	-1.229
6	0.30		0.038	-1.267
7	0.35		0.034	-1.297
8	0.40		0.031	-1.321
9	0.45		0.028	-1.348
10	0.50		0.027	-1.363
11	0.60		0.023	-1.399
12	0.70		0.021	-1.423
13	0.80		0.019	-1.456
14	1.00		0.014	-1.511
15	1.20		0.012	-1.541
16	1.40		0.009	-1.597
17	1.60		0.007	-1.622
18	1.80		0.008	-1.620
19	2.00		0.006	-1.646
20	2.20		0.006	-1.658
21	2.40		0.005	-1.672
22	2.60		0.003	-1.701
23	2.80		0.003	-1.701
24	3.00		0.003	-1.714
25	3.20		0.003	-1.714
26	3.40		0.002	-1.730
27	3.60		0.002	-1.730
28	3.80		0.001	-1.764
29	4.00		0.002	-1.730
30	4.20		0.001	-1.747



t_1	0.35	h_1	0.034	y_1	-1.297
t_2	1	h_2	0.014	y_2	-1.511

Hydraulic conductivity (k)

2E-04	**m/s**
18.1	**m/day**

Tested by:	Kirk Roberts	4/12/2025
Analysed by:	J. Manning	11/12/2025
Checked by:	B. Sinclair	12/12/2025

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

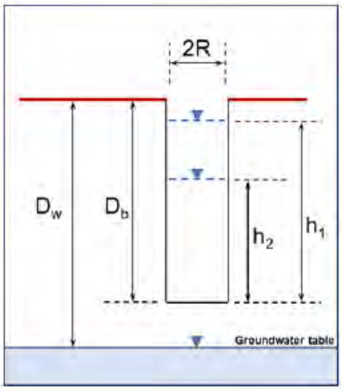
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Piezometer radius calculated on basis of 52 mm ID screen iside 100 mm drillhole, with annulus space containing clean grtavel pack with drainable porosity of 0.25.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client:	Gibbons Co
Project:	Ridgeburn Development
Project No:	WGA252389
Location:	Morven Ferry Rd
Bore No:	BH2 Test 3
Figure No:	B 52



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.033	m	Drillhole radius
D_b		m	Drillhole depth
D_w	-	m	Depth to groundwater table (SWL), if known
date	NA		Date of SWL measurement
time	NA		Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t) (minutes)	Depth to water (d_w) (m)	Height of water (h(t)) (m)	y(t) = log(h(t)+R/2) (m)
0	0.00		0.042	-1.232
1	0.05		0.040	-1.248
2	0.10		0.036	-1.282
3	0.15		0.030	-1.333
4	0.20		0.025	-1.382
5	0.25		0.022	-1.420
6	0.30		0.017	-1.481
7	0.35		0.014	-1.521
8	0.40		0.012	-1.553
9	0.45		0.009	-1.587
10	0.50		0.008	-1.613
11	0.60		0.006	-1.652
12	0.70		0.004	-1.695
13	0.80		0.002	-1.728
14	0.90		0.001	-1.762
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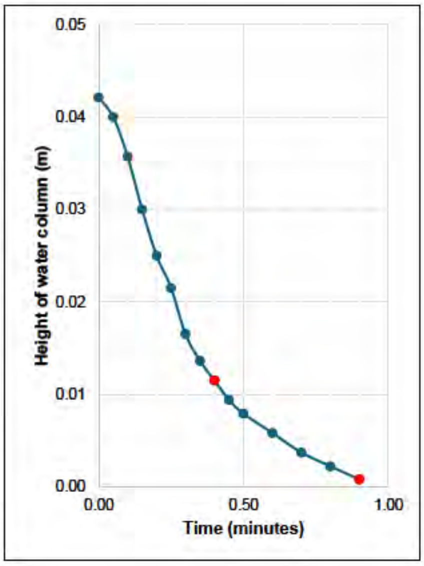


t_1	0.4	h_1	0.012	y_1	-1.553
t_2	0.9	h_2	0.001	y_2	-1.762

Hydraulic conductivity (k)

3E-04	**m/s**
22.9	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	Kirk Roberts	4/12/2025
Analysed by:	J. Manning	11/12/2025
Checked by:	B. Sinclair	12/12/2025

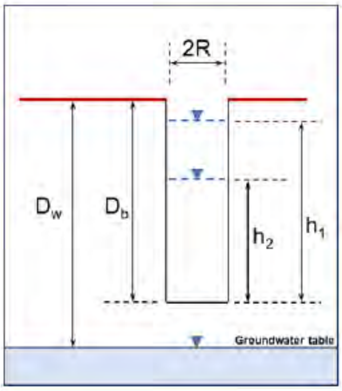
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Piezometer radius calculated on basis of 52 mm ID screen iside 100 mm drillhole, with annulus space containing clean grtavel pack with drainable porosity of 0.25.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client:	Gibbons Co
Project:	Ridgeburn Development
Project No:	WGA252389
Location:	Morven Ferry Rd
Bore No:	BH3 Test 1
Figure No:	B 53



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.033	m	Drillhole radius
D_b		m	Drillhole depth
D_w	-	m	Depth to groundwater table (SWL), if known
date	NA		Date of SWL measurement
time	NA		Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0.00		2.743	0.441
1	0.20		2.451	0.392
2	0.40		2.196	0.345
3	0.60		2.003	0.305
4	0.80		1.816	0.263
5	1.00		1.635	0.218
6	1.20		1.487	0.177
7	1.40		1.340	0.132
8	1.60		1.209	0.088
9	1.80		1.076	0.038
10	2.00		0.952	-0.014
11	2.20		0.832	-0.071
12	2.40		0.717	-0.134
13	2.60		0.596	-0.213
14	2.80		0.470	-0.313
15	3.00		0.355	-0.429
16	3.20		0.250	-0.575
17	3.40		0.154	-0.767
18	3.60		0.064	-1.096
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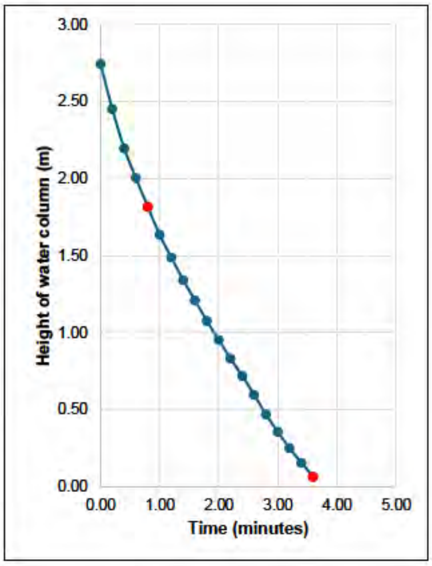


t_1	0.80	h_1	1.816	y_1	0.263
t_2	3.60	h_2	0.064	y_2	-0.767

Hydraulic conductivity (k)

2E-04	**m/s**
20.1	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	Kirk Roberts	4/12/2025
Analysed by:	J. Manning	11/12/2025
Checked by:	B. Sinclair	12/12/2025

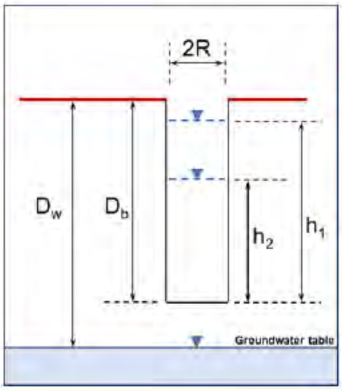
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Piezometer radius calculated on basis of 52 mm ID screen iside 100 mm drillhole, with annulus space containing clean grtavel pack with drainable porosity of 0.25.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client:	Gibbons Co
Project:	Ridgeburn Development
Project No:	WGA252389
Location:	Morven Ferry Rd
Bore No:	BH3 Test 2
Figure No:	B 54



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.033	m	Drillhole radius
D_b		m	Drillhole depth
D_w	-	m	Depth to groundwater table (SWL), if known
date	NA		Date of SWL measurement
time	NA		Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0.00		2.210	0.348
1	0.20		1.984	0.301
2	0.40		1.704	0.236
3	0.60		1.488	0.177
4	0.80		1.289	0.116
5	1.00		1.104	0.049
6	1.20		0.938	-0.020
7	1.40		0.765	-0.107
8	1.60		0.624	-0.194
9	1.80		0.482	-0.303
10	2.00		0.350	-0.436
11	2.20		0.228	-0.611
12	2.40		0.124	-0.852
13	2.60		0.023	-1.400
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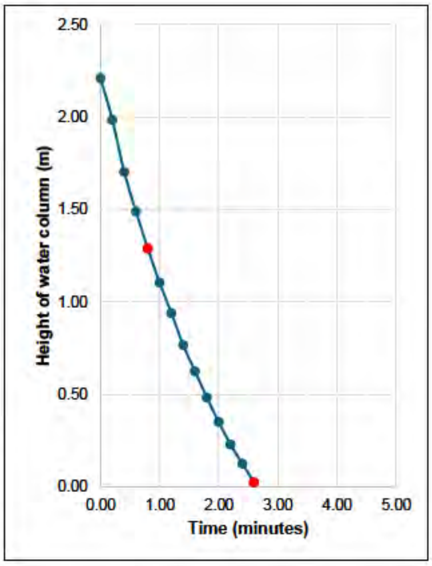


t_1	0.80	h_1	1.289	y_1	0.116
t_2	2.60	h_2	0.023	y_2	-1.400

Hydraulic conductivity (k)

5E-04	**m/s**
46.0	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	Kirk Roberts	4/12/2025
Analysed by:	J. Manning	11/12/2025
Checked by:	B. Sinclair	12/12/2025

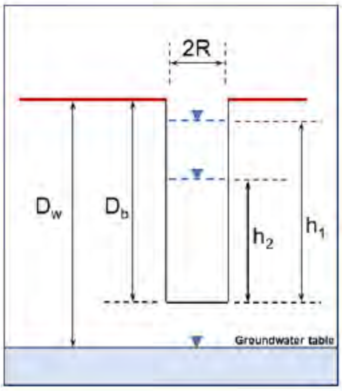
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Piezometer radius calculated on basis of 52 mm ID screen iside 100 mm drillhole, with annulus space containing clean grtavel pack with drainable porosity of 0.25.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client: Gibbons Co
Project: Ridgeburn Development
Project No: WGA252389
Location: Morven Ferry Rd
Bore No: BH3 Test 3
Figure No: B 55



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R 0.033 m Drillhole radius
D_b m Drillhole depth
D_w - m Depth to groundwater table (SWL), if known
date NA Date of SWL measurement
time NA Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0.00		2.407	0.384
1	0.20		2.124	0.331
2	0.40		1.810	0.262
3	0.60		1.570	0.200
4	0.80		1.370	0.142
5	1.00		1.195	0.083
6	1.20		1.035	0.022
7	1.40		0.879	-0.048
8	1.60		0.741	-0.121
9	1.80		0.623	-0.194
10	2.00		0.503	-0.284
11	2.20		0.391	-0.390
12	2.40		0.288	-0.517
13	2.60		0.193	-0.678
14	2.80		0.111	-0.894
15	3.00		0.036	-1.281
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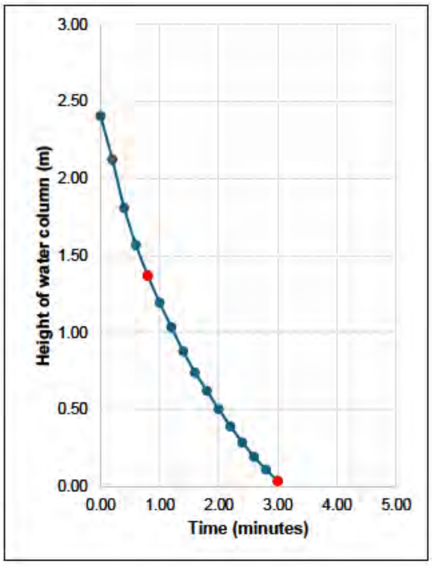


t_1	0.80	h_1	1.370	y_1	0.142
t_2	3.00	h_2	0.036	y_2	-1.281

Hydraulic conductivity (k)

4E-04 **m/s**
35.4 **m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	Kirk Roberts	4/12/2025
Analysed by:	J. Manning	11/12/2025
Checked by:	B. Sinclair	12/12/2025

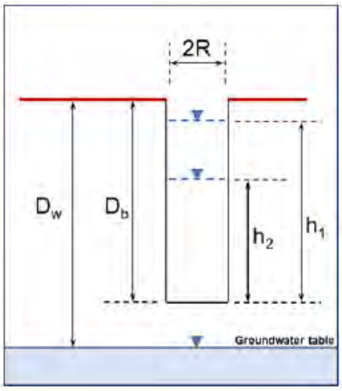
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Piezometer radius calculated on basis of 52 mm ID screen iside 100 mm drillhole, with annulus space containing clean grtavel pack with drainable porosity of 0.25.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client:	Gibbons Co
Project:	Ridgeburn Development
Project No:	WGA252389
Location:	Morven Ferry Rd
Bore No:	BH4 Test 1
Figure No:	B 56



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.033	m	Drillhole radius
D_b		m	Drillhole depth
D_w	-	m	Depth to groundwater table (SWL), if known
date	NA		Date of SWL measurement
time	NA		Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0.00		2.151	0.336
1	0.20		1.688	0.232
2	0.40		1.342	0.133
3	0.60		1.091	0.044
4	0.80		0.838	-0.068
5	1.00		0.637	-0.185
6	1.20		0.465	-0.317
7	1.40		0.310	-0.487
8	1.60		0.180	-0.706
9	1.80		0.052	-1.167
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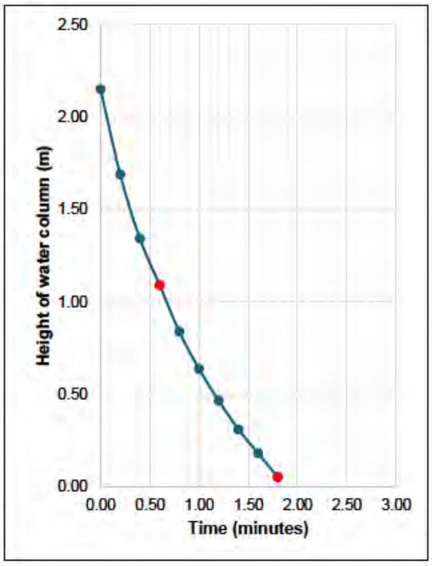


t_1	0.60	h_1	1.091	y_1	0.044
t_2	1.80	h_2	0.052	y_2	-1.167

Hydraulic conductivity (k)

6E-04	**m/s**
55.2	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	Kirk Roberts	4/12/2025
Analysed by:	J. Manning	11/12/2025
Checked by:	B. Sinclair	12/12/2025

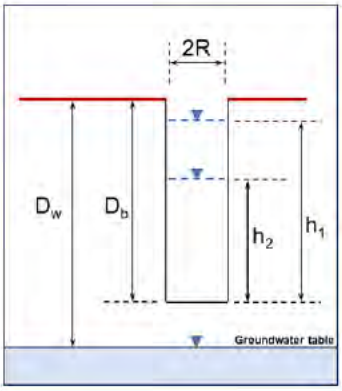
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Piezometer radius calculated on basis of 52 mm ID screen iside 100 mm drillhole, with annulus space containing clean grtavel pack with drainable porosity of 0.25.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client:	Gibbons Co
Project:	Ridgeburn Development
Project No:	WGA252389
Location:	Morven Ferry Rd
Bore No:	BH4 Test 2
Figure No:	B 57



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.033	m	Drillhole radius
D_b		m	Drillhole depth
D_w	-	m	Depth to groundwater table (SWL), if known
date	NA		Date of SWL measurement
time	NA		Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0.00		2.824	0.453
1	0.20		2.018	0.308
2	0.40		1.833	0.267
3	0.60		1.603	0.209
4	0.80		1.344	0.134
5	1.00		1.133	0.061
6	1.20		0.940	-0.019
7	1.40		0.759	-0.110
8	1.60		0.612	-0.202
9	1.80		0.481	-0.303
10	2.00		0.367	-0.416
11	2.20		0.270	-0.542
12	2.40		0.165	-0.741
13	2.60		0.069	-1.071
14	2.80		0.001	-1.759
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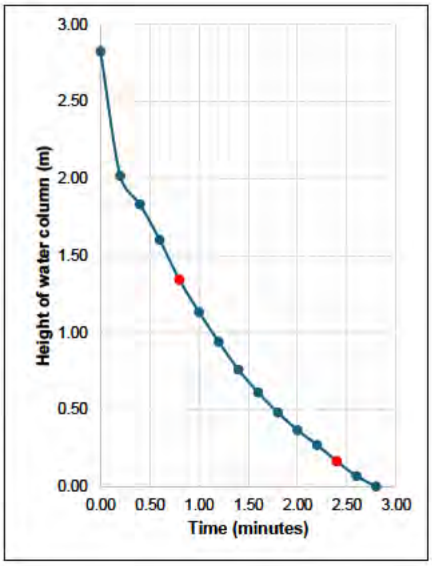


t_1	0.80	h_1	1.344	y_1	0.134
t_2	2.40	h_2	0.165	y_2	-0.741

Hydraulic conductivity (k)

3E-04	**m/s**
29.9	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	Kirk Roberts	4/12/2025
Analysed by:	J. Manning	11/12/2025
Checked by:	B. Sinclair	12/12/2025

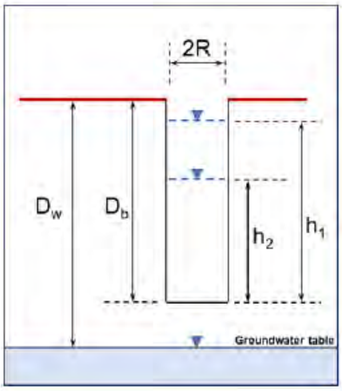
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Piezometer radius calculated on basis of 52 mm ID screen iside 100 mm drillhole, with annulus space containing clean grtavel pack with drainable porosity of 0.25.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client: Gibbons Co
Project: Ridgeburn Development
Project No: WGA252389
Location: Morven Ferry Rd
Bore No: BH4 Test 2
Figure No: B 58



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.033	m	Drillhole radius
D_b		m	Drillhole depth
D_w	-	m	Depth to groundwater table (SWL), if known
date	NA		Date of SWL measurement
time	NA		Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0.00	-3.221	3.221	0.510
1	0.20	-2.155	2.155	0.337
2	0.40	-1.862	1.862	0.274
3	0.60	-1.760	1.760	0.250
4	0.80	-1.541	1.541	0.193
5	1.00	-1.323	1.323	0.127
6	1.20	-1.141	1.141	0.063
7	1.40	-0.954	0.954	-0.013
8	1.60	-0.798	0.798	-0.089
9	1.80	-0.658	0.658	-0.171
10	2.00	-0.535	0.535	-0.258
11	2.20	-0.423	0.423	-0.357
12	2.40	-0.329	0.329	-0.462
13	2.60	-0.238	0.238	-0.594
14	2.80	-0.153	0.153	-0.771
15	3.00	-0.066	0.066	-1.086
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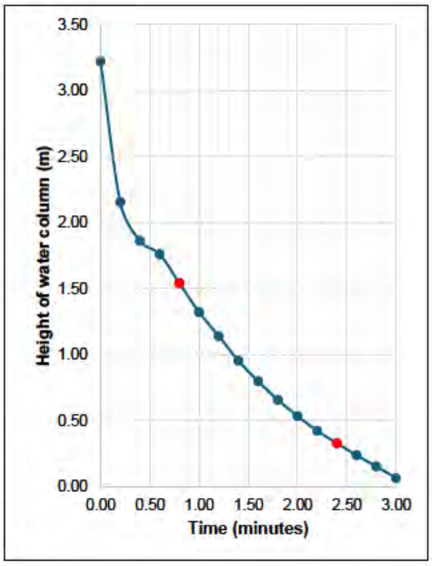


t_1	0.80	h_1	1.541	y_1	0.193
t_2	2.40	h_2	0.329	y_2	-0.462

Hydraulic conductivity (k)

3E-04	**m/s**
22.4	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

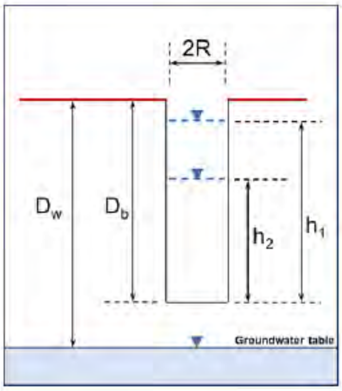
Tested by:	Kirk Roberts	4/12/2025
Analysed by:	J. Manning	11/12/2025
Checked by:	B. Sinclair	12/12/2025

Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Piezometer radius calculated on basis of 52 mm ID screen iside 100 mm drillhole, with annulus space containing clean grtavel pack with drainable porosity of 0.25.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: SK-01
Figure No: B 31



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.075	m	Drillhole radius
D_b	3	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	28-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.000	3.000	0.483
1	1	0.100	2.900	0.468
2	2	0.180	2.820	0.456
3	3	0.250	2.750	0.445
4	4	0.320	2.680	0.434
5	5	0.366	2.634	0.427
6	10	0.560	2.440	0.394
7	15	0.720	2.280	0.365
8	20	0.810	2.190	0.348
9	25	0.940	2.060	0.322
10	30	1.060	1.940	0.296
11	60	1.550	1.450	0.172
12	90	1.840	1.160	0.078
13	120	2.070	0.930	-0.014
14	150	2.160	0.840	-0.057
15	180	2.280	0.720	-0.121
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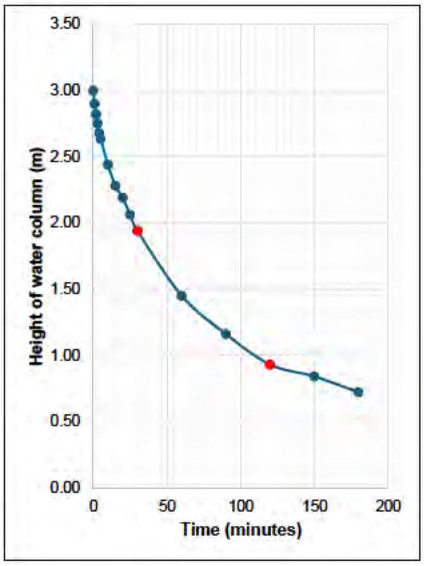


t_1	30	h_1	1.940	y_1	0.296
t_2	120	h_2	0.930	y_2	-0.014

Hydraulic conductivity (k)

5E-06 **m/s**
0.4 **m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by: KRL 28/10/2025
Analysed by: B. Sinclair 3/11/2025
Checked by:

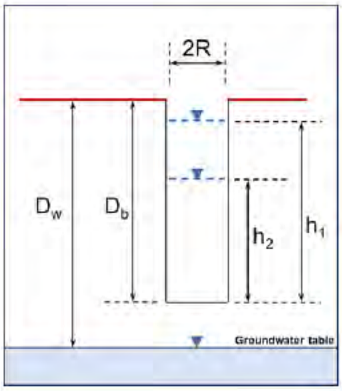
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Silty TOPSOIl to 0.3 m, then gravelly SAND to 3.0 m.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client:	Gibbons Co
Project:	Morven Ferry Road Soils Assessment
Project No:	252389
Location:	
Bore No:	SK-02
Figure No:	B 32



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.075	m	Drillhole radius
D_b	3	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	28-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.000	3.000	0.483
1	1	0.850	2.150	0.340
2	2	1.180	1.820	0.269
3	3	1.300	1.700	0.240
4	4	1.300	1.700	0.240
5	5	1.310	1.690	0.237
6	10	1.370	1.630	0.222
7	15	1.420	1.580	0.209
8	20	1.470	1.530	0.195
9	25	1.470	1.530	0.195
10	30	1.480	1.520	0.192
11	60	1.520	1.480	0.181
12	90	1.700	1.300	0.126
13	120	1.700	1.300	0.126
14	150	1.710	1.290	0.123
15	180	1.750	1.250	0.110
16	210	1.800	1.200	0.093
17	240	1.800	1.200	0.093
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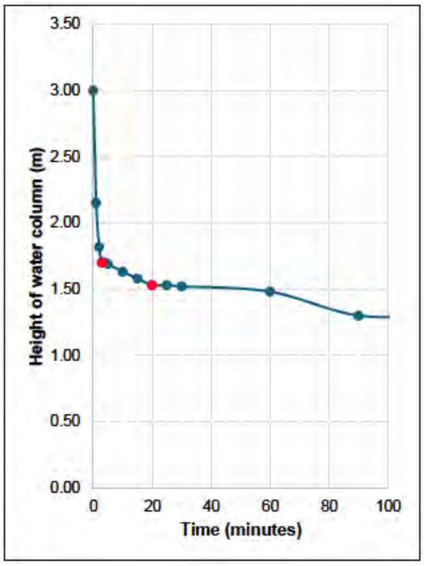


t_1	3	h_1	1.700	y_1	0.240
t_2	20	h_2	1.530	y_2	0.195

Hydraulic conductivity (k)

4E-06	**m/s**
0.3	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	KRL	28/10/2025
Analysed by:	B. Sinclair	3/11/2025
Checked by:		

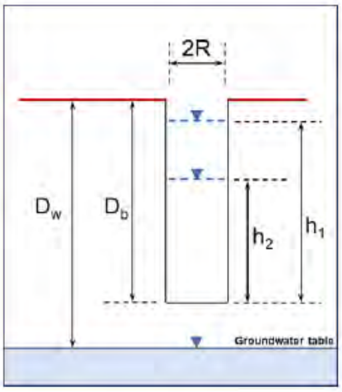
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Silty TOPSOIL to 0.4 m, then gravelly SAND to 3.0 m.
Suspect groundwater mounding may have impacted late recovery curve.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client:	Gibbons Co
Project:	Morven Ferry Road Soils Assessment
Project No:	252389
Location:	
Bore No:	SK-03
Figure No:	B 33



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.075	m	Drillhole radius
D_b	1.7	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	28-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.000	1.700	0.240
1	1	0.060	1.640	0.225
2	2	0.100	1.600	0.214
3	3	0.110	1.590	0.212
4	4	0.110	1.590	0.212
5	5	0.120	1.580	0.209
6	10	0.160	1.540	0.198
7	15	0.170	1.530	0.195
8	20	0.170	1.530	0.195
9	25	0.180	1.520	0.192
10	30	0.180	1.520	0.192
11	60	0.200	1.500	0.187
12	90	0.200	1.500	0.187
13	120	0.200	1.500	0.187
14	150	0.200	1.500	0.187
15	180	0.200	1.500	0.187
16	210	0.200	1.500	0.187
17	240	0.200	1.500	0.187
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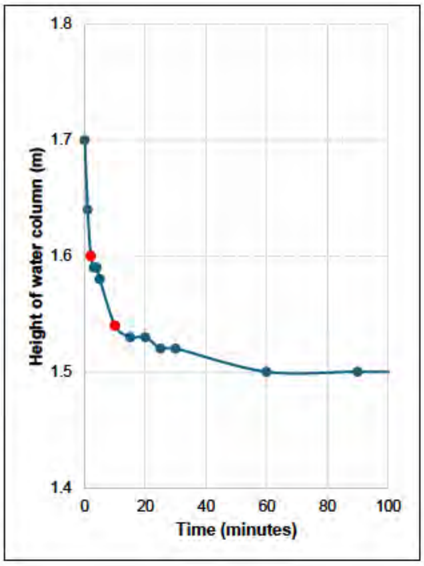


t_1	2	h_1	1.600	y_1	0.214
t_2	10	h_2	1.540	y_2	0.198

Hydraulic conductivity (k)

3E-06 **m/s**
0.3 **m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

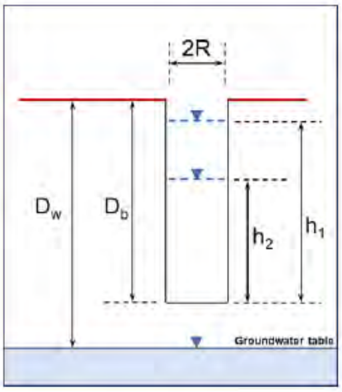
Tested by:	KRL	28/10/2025
Analysed by:	B. Sinclair	3/11/2025
Checked by:		

Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Silty TOPSOIl to 0.3 m, then gravelly SAND to 1.7 m.
Interpreted groundwater table at surface during drilling.
Suspect groundwater mounding may have impacted recovery curve. ANALYSIS VALIDITY UNCERTAIN.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

Client:	Gibbons Co
Project:	Morven Ferry Road Soils Assessment
Project No:	252389
Location:	
Bore No:	SK-04
Figure No:	B 34



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.075	m	Drillhole radius
D_b	1.6	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	28-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.000	1.600	0.214
1	1	0.290	1.310	0.130
2	2	0.510	1.090	0.052
3	3	0.690	0.910	-0.023
4	4	0.860	0.740	-0.109
5	5	0.990	0.610	-0.189
6	10	1.150	0.450	-0.312
7	15	1.210	0.390	-0.369
8	20	1.230	0.370	-0.390
9	25	1.230	0.370	-0.390
10	30	1.250	0.350	-0.412
11	60	1.320	0.280	-0.498
12	90	1.320	0.280	-0.498
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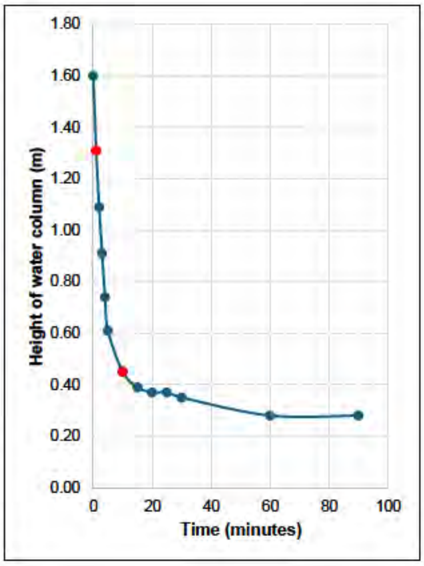


t_1	1	**h_1**	1.310	**y_1**	0.130
t_2	10	**h_2**	0.450	**y_2**	-0.312

Hydraulic conductivity (k)

7E-05	**m/s**
6	**m/day**

Tested by:	KRL	28/10/2025
Analysed by:	B. Sinclair	3/11/2025
Checked by:		

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

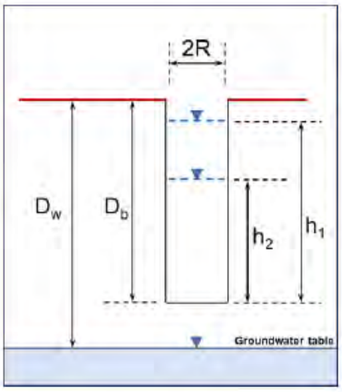
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Sandy SILT to 0.3 m, then gravelly SAND to 1.6 m.
Groundwater table recorded at 1.4 m BGL during drilling.
Data after 10 minutes affected by groundwater mounding. Ground starting condition "wet".

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: SK-05
Figure No: B 35



$$k = 1.15R\frac{log(h_1+R/2)-log(h_2+R/2)}{t_2-t_1}$$

R	0.075	m	Drillhole radius
D_b	2.3	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	28-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.000	2.300	0.369
1	1	0.000	2.300	0.369
2	2	0.000	2.300	0.369
3	3	0.010	2.290	0.367
4	4	0.020	2.280	0.365
5	5	0.030	2.270	0.363
6	10	0.030	2.270	0.363
7	15	0.040	2.260	0.361
8	20	0.050	2.250	0.359
9	25	0.050	2.250	0.359
10	30	0.050	2.250	0.359
11	60	0.080	2.220	0.354
12	90	0.080	2.220	0.354
13	120	0.080	2.220	0.354
14	150	0.090	2.210	0.352
15	180	0.090	2.210	0.352
16	210	0.090	2.210	0.352
17	240	0.090	2.210	0.352
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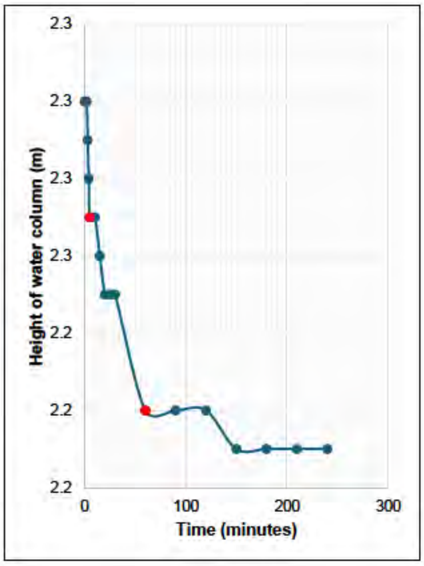


t_1 5 h_1 2.270 y_1 0.363
t_2 60 h_2 2.220 y_2 0.354

Hydraulic conductivity (k)

2E-07 m/s
0.02 m/day

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

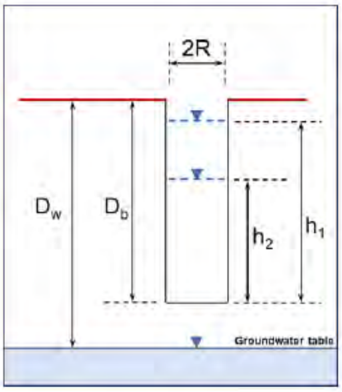
Tested by: KRL 28/10/2025
Analysed by: B. Sinclair 3/11/2025
Checked by:

Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Sandy SILT to 0.2 m, then gravelly SAND to 2.1 m, then wet sandy GRAVEL to refusal at 2.3 m.
Although no groundwater table intersected during drilling or on falling head test sheet, suspect groundwater table is shallow, impacting recovery curve. ANALYSIS VALIDITY UNCERTAIN.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: SK-06
Figure No: B 36



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.075	m	Drillhole radius
D_b	0.78	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	28-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.000	0.780	-0.088
1	1	0.050	0.730	-0.115
2	2	0.065	0.715	-0.123
3	3	0.070	0.710	-0.126
4	4	0.075	0.705	-0.129
5	5	0.080	0.700	-0.132
6	10	0.100	0.680	-0.144
7	15	0.110	0.670	-0.150
8	20	0.120	0.660	-0.156
9	25	0.130	0.650	-0.163
10	30	0.140	0.640	-0.169
11	60	0.170	0.610	-0.189
12	90	0.220	0.560	-0.224
13	120	0.240	0.540	-0.238
14	150	0.280	0.500	-0.270
15	180	0.300	0.480	-0.286
16	210	0.330	0.450	-0.312
17	240	0.350	0.430	-0.330
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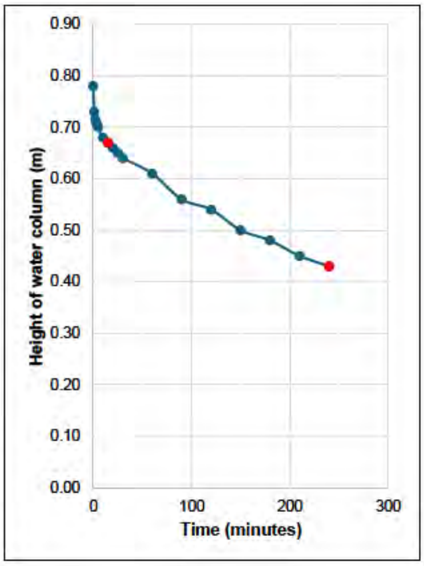


t_1	15	h_1	0.670	y_1	-0.150
t_2	240	h_2	0.430	y_2	-0.330

Hydraulic conductivity (k)

1E-06 **m/s**
0.1 **m/day**

Tested by:	KRL	28/10/2025
Analysed by:	B. Sinclair	3/11/2025
Checked by:		

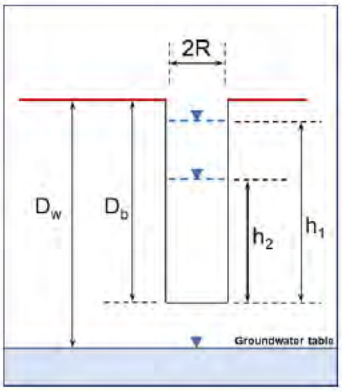
Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Silty TOPSOIL to 0.3 m, then SAND to 1.2 m.
Groundwater table recorded at 0.1 m during drilling. No mention of groundwater table in soakage test log.
Groundwater mounding may have impacted recovery curve. ANALYSIS VALIDITY UNCERTAIN.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

Client:	Gibbons Co
Project:	Morven Ferry Road Soils Assessment
Project No:	252389
Location:	
Bore No:	SK-07
Figure No:	B 37



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.075	m	Drillhole radius
D_b	2.5	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	28-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.000	2.500	0.404
1	1	0.030	2.470	0.399
2	2	0.040	2.460	0.398
3	3	0.050	2.450	0.396
4	4	0.060	2.440	0.394
5	5	0.065	2.435	0.393
6	10	0.080	2.420	0.390
7	15	0.090	2.410	0.389
8	20	0.100	2.400	0.387
9	25	0.105	2.395	0.386
10	30	0.110	2.390	0.385
11	60	0.140	2.360	0.380
12	90	0.160	2.340	0.376
13	120	0.190	2.310	0.371
14	150	0.210	2.290	0.367
15	180	0.235	2.265	0.362
16	210	0.250	2.250	0.359
17	240	0.270	2.230	0.356
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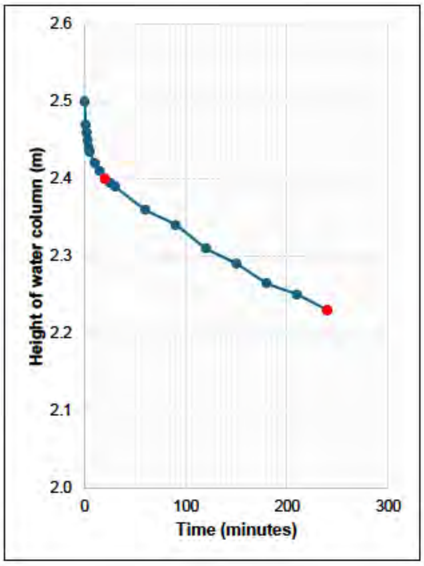


t_1	20	h_1	2.400	y_1	0.387
t_2	240	h_2	2.230	y_2	0.356

Hydraulic conductivity (k)

2E-07	**m/s**
0.02	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

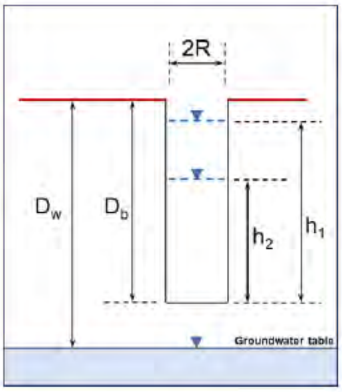
Tested by:	KRL	28/10/2025
Analysed by:	B. Sinclair	3/11/2025
Checked by:		

Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Sandy silt TOPSOIL to 0.3 m, then gravelly SAND to 2.5 m.
No mention of groundwater table in drilling log.
Drillhole terminated on refusal. Therefore ANALYSIS VALIDITY UNCERTAIN.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: SK-08
Figure No: B 38



$$k = 1.15R\frac{log(h_1+R/2)-log(h_2+R/2)}{t_2-t_1}$$

R	0.075	m	Drillhole radius
D_b	0.44	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	28-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.000	0.440	-0.321
1	1	0.045	0.395	-0.364
2	2	0.075	0.365	-0.395
3	3	0.090	0.350	-0.412
4	4	0.110	0.330	-0.435
5	5	0.120	0.320	-0.447
6	10	0.165	0.275	-0.505
7	15	0.200	0.240	-0.557
8	20	0.220	0.220	-0.589
9	25	0.240	0.200	-0.624
10	30	0.260	0.180	-0.663
11	60	0.340	0.100	-0.862
12	90	0.410	0.030	-1.171
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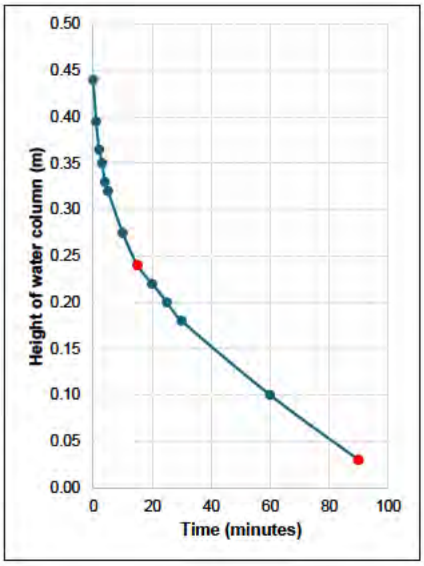


t_1	15	**h_1**	0.240	**y_1**	-0.557
t_2	90	**h_2**	0.030	**y_2**	-1.171

Hydraulic conductivity (k)

1E-05 **m/s**
1.0 **m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

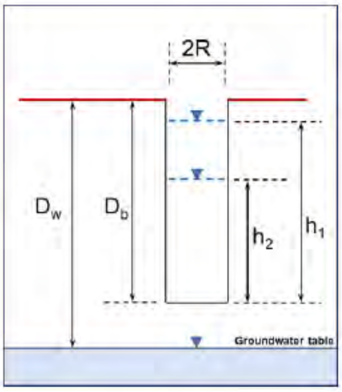
Tested by: KRL 28/10/2025
Analysed by: B. Sinclair 3/11/2025
Checked by:

Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Sandy SILT to 0.1 m, then SAND to 0.6 m.
Groundwater not encountered during drilling.
Drillhole terminated on refusal on hard ground. ANALYSIS VALIDITY UNCERTAIN if mounding induced.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: SK-09
Figure No: B 39



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.075	m	Drillhole radius
D_b	1.57	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	28-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.00	1.570	0.206
1	1	0.05	1.520	0.192
2	2	0.09	1.480	0.181
3	3	0.11	1.460	0.175
4	4	0.13	1.440	0.170
5	5	0.16	1.410	0.161
6	10	0.25	1.320	0.133
7	15	0.31	1.260	0.113
8	20	0.36	1.210	0.096
9	25	0.39	1.180	0.085
10	30	0.43	1.140	0.071
11	60	0.55	1.020	0.024
12	90	0.61	0.960	-0.001
13	120	0.66	0.910	-0.023
14	150	0.70	0.870	-0.042
15	180	0.74	0.830	-0.062
16	210	0.75	0.820	-0.067
17	240	0.76	0.810	-0.072
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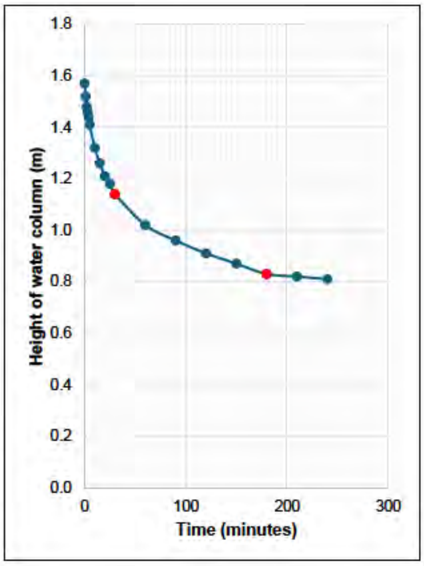


t_1	30	h_1	1.140	y_1	0.071
t_2	180	h_2	0.830	y_2	-0.062

Hydraulic conductivity (k)

1E-06	m/s
0.1	m/day

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	KRL	28/10/2025
Analysed by:	B. Sinclair	3/11/2025
Checked by:		

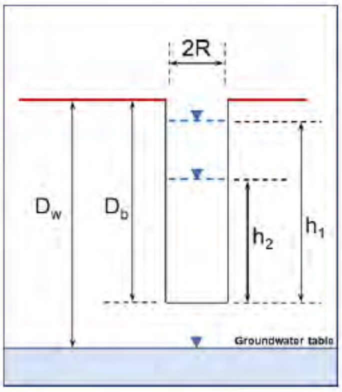
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Sandy silt TOPSOIL to 0.3 m, then SAND to 2.5 m, with drilling refusal at that point on "dense ground".
Groundwater table not encountered during drilling.
ANALYSIS VALIDITY UNCERTAIN if mounding induced - suggested by slow recovery curve over last hour.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: SK-10
Figure No: B 40



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.075	m	Drillhole radius
D_b	1.07	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	28-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.000	1.070	0.044
1	1	0.005	1.065	0.042
2	2	0.015	1.055	0.038
3	3	0.025	1.045	0.034
4	4	0.030	1.040	0.032
5	5	0.035	1.035	0.030
6	10	0.045	1.025	0.026
7	15	0.045	1.025	0.026
8	20	0.050	1.020	0.024
9	25	0.050	1.020	0.024
10	30	0.060	1.010	0.020
11	60	0.060	1.010	0.020
12	90	0.060	1.010	0.020
13	120	0.070	1.000	0.016
14	150	0.070	1.000	0.016
15	180	0.080	0.990	0.012
16	210	0.080	0.990	0.012
17	240	0.090	0.980	0.008
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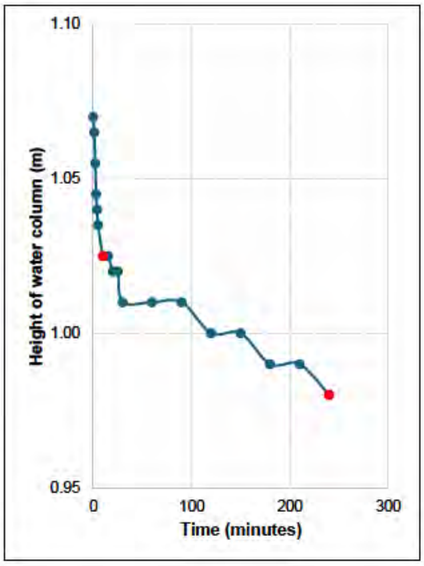


t_1	10	h_1	1.025	y_1	0.026
t_2	240	h_2	0.980	y_2	0.008

Hydraulic conductivity (k)

1E-07 **m/s**
0.01 **m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

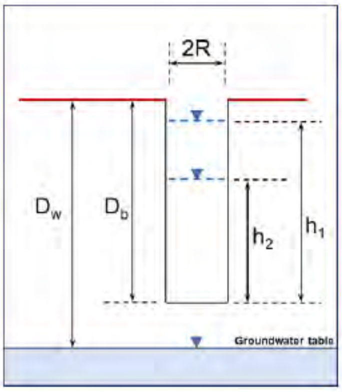
Tested by:	KRL	28/10/2025
Analysed by:	B. Sinclair	3/11/2025
Checked by:		

Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Silt sand TOPSOIL to 0.4 m, then SAND to 1.5 m. Refusal on 'dense ground'.
Groundwater not encountered during drilling.
Recovery data through topsoil section ignored in analysis.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: SK-11
Figure No: B 41



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.075	m	Drillhole radius
D_b	3	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	28-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.00	3.000	0.483
1	1	0.03	2.970	0.478
2	2	0.05	2.950	0.475
3	3	0.05	2.950	0.475
4	4	0.05	2.950	0.475
5	5	0.06	2.940	0.474
6	10	0.09	2.910	0.469
7	15	0.10	2.900	0.468
8	20	0.10	2.900	0.468
9	25	0.11	2.890	0.466
10	30	0.12	2.880	0.465
11	60	0.19	2.810	0.454
12	90	0.26	2.740	0.444
13	120	0.30	2.700	0.437
14	150	0.33	2.670	0.433
15	180	0.39	2.610	0.423
16	210	0.45	2.550	0.413
17	240	0.52	2.480	0.401
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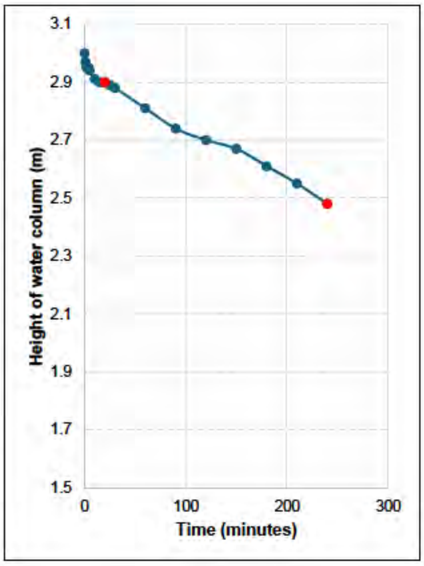


t_1	20	h_1	2.900	y_1	0.468
t_2	240	h_2	2.480	y_2	0.401

Hydraulic conductivity (k)

4E-07 **m/s**
0.04 **m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by: KRL 28/10/2025
Analysed by: B. Sinclair 3/11/2025
Checked by:

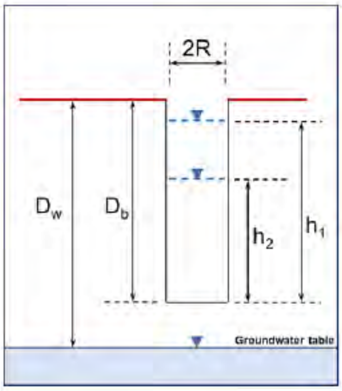
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Sandy silt TOPSOIL to 0.3 m, followed by silty SAND to 3.0 m. Groundwater table not encountered during drilling.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: HA1 Shallow
Figure No: B 1



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.025	m	Drillhole radius
D_b	0.42	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	7-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.001	0.419	-0.365
1	1	0.035	0.385	-0.401
2	3	0.080	0.340	-0.453
3	4	0.095	0.325	-0.472
4	5	0.109	0.311	-0.490
5	6	0.120	0.300	-0.505
6	7	0.131	0.289	-0.521
7	8	0.142	0.278	-0.537
8	9	0.152	0.268	-0.552
9	10	0.168	0.252	-0.578
10	12.5	0.193	0.227	-0.621
11	15	0.216	0.204	-0.665
12	17.5	0.236	0.184	-0.707
13	20	0.251	0.169	-0.741
14	22.5	0.268	0.152	-0.784
15	25	0.282	0.138	-0.822
16	27.5	0.293	0.127	-0.855
17	30	0.305	0.115	-0.894
18	32.5	0.318	0.102	-0.941
19	35	0.331	0.089	-0.994
20	37.5	0.341	0.079	-1.039
21	40	0.353	0.067	-1.100
22	42.5	0.365	0.055	-1.171
23	45	0.376	0.044	-1.248
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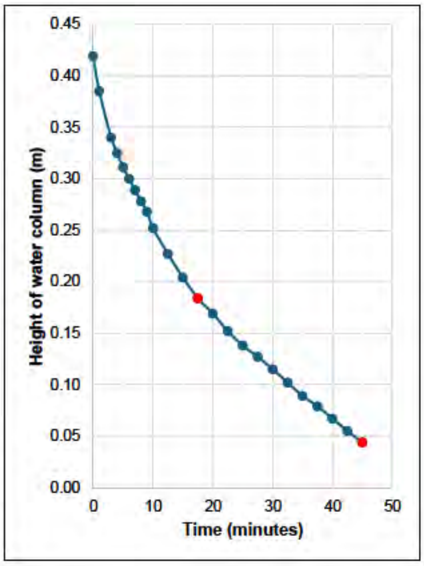


t_1	17.5	**h_1**	0.184	**y_1**	-0.707
t_2	45	**h_2**	0.044	**y_2**	-1.248

Hydraulic conductivity (k)

9E-06	**m/s**
0.8	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	C. Jasper	7/10/2025
Analysed by:	B. Sinclair	13/10/2025
Checked by:	C. Jasper	

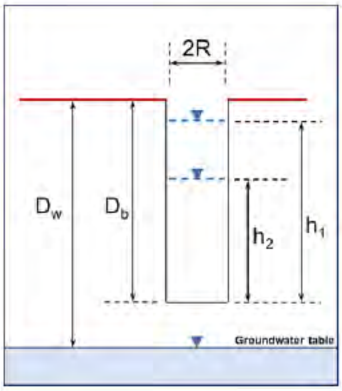
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Tested material consisted of LOAM (0 - 50 mm), SILT (50 - 400 mm) and clayey SILT (400 - 800 mm).
Depth to groundwater unknown.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: HA1 Shallow
Figure No: B 2



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.025	m	Drillhole radius
D_b	0.425	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	7-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.000	0.425	-0.359
1	1	0.040	0.385	-0.401
2	3	0.075	0.350	-0.441
3	4	0.087	0.338	-0.455
4	5	0.096	0.329	-0.467
5	6	0.107	0.318	-0.481
6	7	0.119	0.306	-0.497
7	8	0.132	0.293	-0.515
8	9	0.143	0.282	-0.531
9	10	0.151	0.274	-0.543
10	12.5	0.173	0.252	-0.578
11	15	0.195	0.230	-0.615
12	17.5	0.212	0.213	-0.647
13	20	0.227	0.198	-0.677
14	22.5	0.242	0.183	-0.709
15	25	0.256	0.169	-0.741
16	27.5	0.272	0.153	-0.781
17	30	0.285	0.140	-0.817
18	32.5	0.300	0.125	-0.862
19	35	0.316	0.109	-0.915
20	37.5	0.327	0.098	-0.957
21	40	0.336	0.089	-0.994
22	42.5	0.346	0.079	-1.039
23	45	0.358	0.067	-1.100
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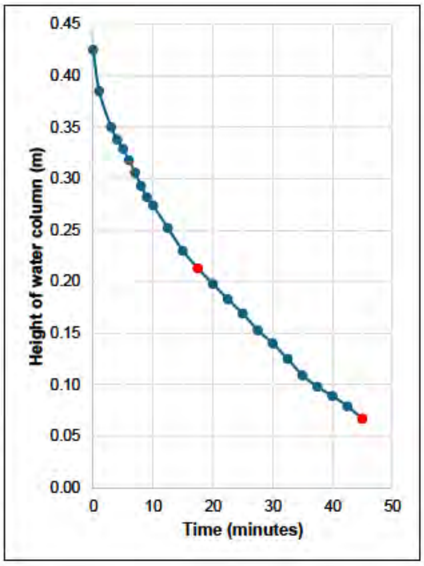


t_1	17.5	h_1	0.213	y_1	-0.647
t_2	45	h_2	0.067	y_2	-1.100

Hydraulic conductivity (k)

8E-06 **m/s**
0.7 **m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	C. Jasper	7/10/2025
Analysed by:	B. Sinclair	13/10/2025
Checked by:	C. Jasper	

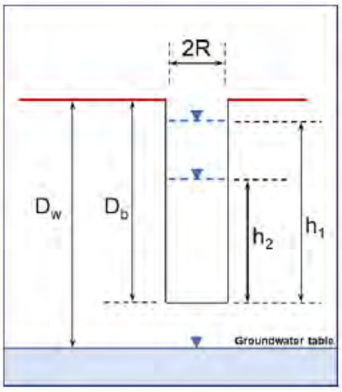
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Tested material consisted of LOAM (0 - 50 mm), SILT (50 - 400 mm) and clayey SILT (400 - 800 mm).
Depth to groundwater unknown.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: HA1 Deep
Figure No: B 3



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.025	m	Drillhole radius
D_b	0.8	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	7-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.000	0.800	-0.090
1	1	0.030	0.770	-0.107
2	18	0.249	0.551	-0.249
3	42	0.360	0.440	-0.344
4	54	0.400	0.400	-0.385
5	70	0.460	0.340	-0.453
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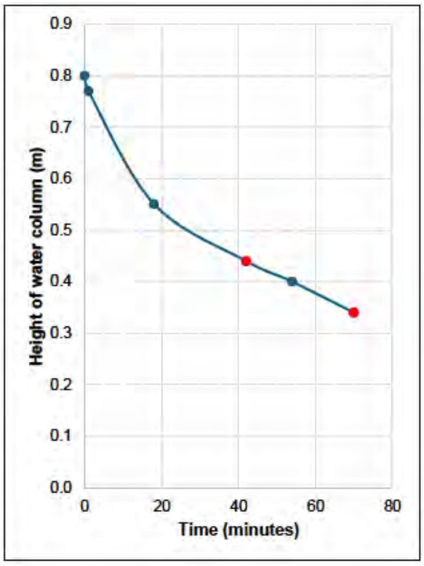


t_1	42	h_1	0.440	y_1	-0.344
t_2	70	h_2	0.340	y_2	-0.453

Hydraulic conductivity (k)

2E-06	**m/s**
0.2	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	B. Sinclair	7/10/2025
Analysed by:	B. Sinclair	9/10/2025
Checked by:	C. Jasper	

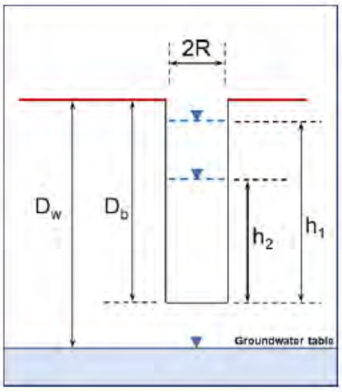
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Tested material consisted of LOAM (0 - 50 mm), SILT (50 - 400 mm) and clayey SILT (400 - 800 mm).
Depth to groundwater unknown.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client:	Gibbons Co
Project:	Morven Ferry Road Soils Assessment
Project No:	252389
Location:	
Bore No:	HA2 Shallow
Figure No:	B 4



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.025	m	Drillhole radius
D_b	0.42	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	7-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.058	0.362	-0.427
1	1	0.074	0.346	-0.446
2	3	0.116	0.304	-0.500
3	4	0.129	0.291	-0.518
4	5	0.142	0.278	-0.537
5	6	0.152	0.268	-0.552
6	7	0.161	0.259	-0.566
7	8	0.169	0.251	-0.579
8	9	0.177	0.243	-0.593
9	10	0.185	0.235	-0.606
10	12.5	0.202	0.218	-0.637
11	15	0.216	0.204	-0.665
12	17.5	0.228	0.192	-0.689
13	20	0.240	0.180	-0.716
14	22.5	0.251	0.169	-0.741
15	25	0.263	0.157	-0.771
16	27.5	0.271	0.149	-0.792
17	30	0.281	0.139	-0.820
18	32.5	0.291	0.129	-0.849
19	35	0.301	0.119	-0.881
20	37.5	0.309	0.111	-0.908
21	40	0.317	0.103	-0.937
22	42.5	0.325	0.095	-0.969
23	45	0.333	0.087	-1.002
24	47.5	0.340	0.080	-1.034
25	50	0.346	0.074	-1.063
26	52.5	0.353	0.067	-1.100
27	55	0.357	0.063	-1.122
28	57.5	0.363	0.057	-1.158
29				
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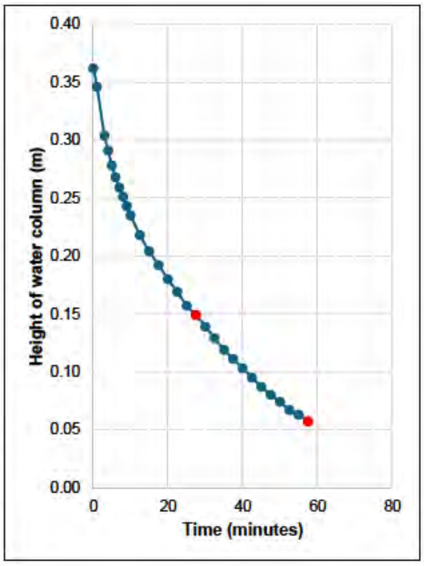


t_1	27.5	**h_1**	0.149	**y_1**	-0.792
t_2	57.5	**h_2**	0.057	**y_2**	-1.158

Hydraulic conductivity (k)

6E-06	**m/s**
0.5	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	C Jasper	7/10/2025
Analysed by:	B. Sinclair	13/10/2025
Checked by:	C. Jasper	

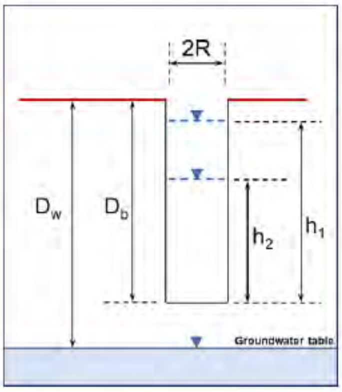
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Tested material consisted of LOAM (0 - 50 mm), SILT (50 - 400 mm) and clayey SILT (400 - 800 mm).
Depth to groundwater unknown.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: HA2 Deep
Figure No: B 5



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.025	m	Drillhole radius
D_b	0.8	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	7-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.000	0.800	-0.090
1	2	0.040	0.760	-0.112
2	8	0.140	0.660	-0.172
3	22	0.270	0.530	-0.266
4	44	0.385	0.415	-0.369
5	55	0.430	0.370	-0.417
6	73	0.480	0.320	-0.478
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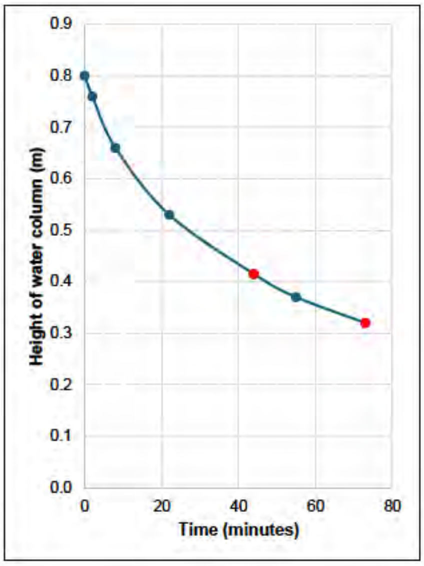


t_1	44	h_1	0.415	y_1	-0.369
t_2	73	h_2	0.320	y_2	-0.478

Hydraulic conductivity (k)

2E-06	**m/s**
0.2	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	B. Sinclair	7/10/2025
Analysed by:	B. Sinclair	9/10/2025
Checked by:	C. Jasper	

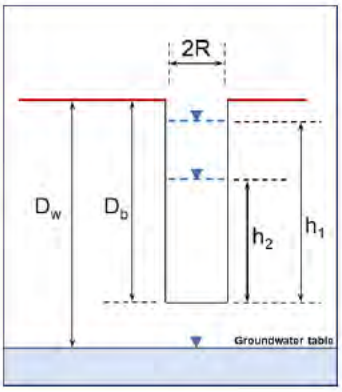
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes:

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: HA3 Shallow
Figure No: B 6



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.025	m	Drillhole radius
D_b	0.409	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	7-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.000	0.409	-0.375
1	1	0.039	0.370	-0.417
2	3	0.046	0.363	-0.425
3	4	0.051	0.358	-0.431
4	5	0.055	0.354	-0.436
5	6	0.058	0.351	-0.439
6	7	0.061	0.348	-0.443
7	8	0.063	0.346	-0.446
8	9	0.066	0.343	-0.449
9	10	0.069	0.340	-0.453
10	15	0.079	0.330	-0.465
11	20	0.089	0.320	-0.478
12	25	0.100	0.309	-0.493
13	30	0.110	0.299	-0.507
14	40	0.125	0.284	-0.528
15	50	0.140	0.269	-0.551
16	60	0.157	0.252	-0.578
17	70	0.170	0.239	-0.599
18	80	0.181	0.228	-0.619
19	90	0.189	0.220	-0.634
20	100	0.196	0.213	-0.647
21	125	0.219	0.190	-0.694
22	150	0.236	0.173	-0.732
23	175	0.256	0.153	-0.781
24	200	0.273	0.136	-0.828
25	250	0.295	0.114	-0.898
26	300	0.314	0.095	-0.969
27	350	0.333	0.076	-1.053
28	500	0.366	0.043	-1.256
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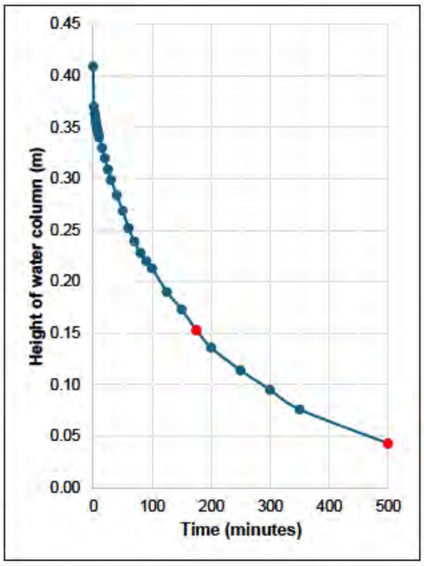


t_1	175	h_1	0.153	y_1	-0.781
t_2	500	h_2	0.043	y_2	-1.256

Hydraulic conductivity (k)

7E-07 **m/s**
0.06 **m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	C. Jasper	7/10/2025
Analysed by:	B. Sinclair	13/10/2025
Checked by:	C. Jasper	

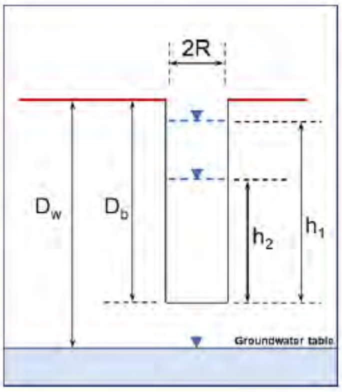
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes:

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client:	Gibbons Co
Project:	Morven Ferry Road Soils Assessment
Project No:	252389
Location:	
Bore No:	HA3 Deep
Figure No:	B 7



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.025	m	Drillhole radius
D_b	0.8	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	7-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.000	0.800	-0.090
1	10	0.030	0.770	-0.107
2	30	0.130	0.670	-0.166
3	61	0.200	0.600	-0.213
4	73	0.225	0.575	-0.231
5	91	0.260	0.540	-0.258
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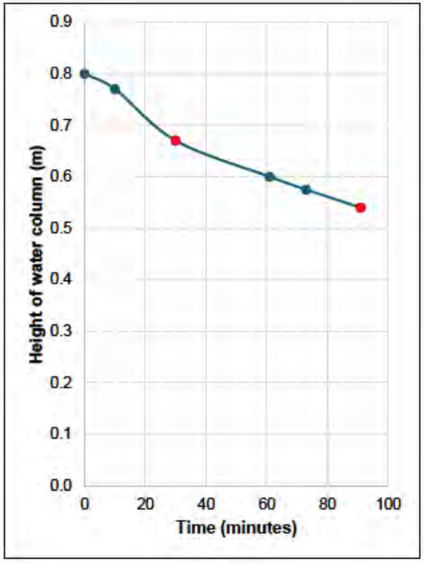


t_1	30	h_1	0.670	y_1	-0.166
t_2	91	h_2	0.540	y_2	-0.258

Hydraulic conductivity (k)

7E-07	**m/s**
0.06	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	B. Sinclair	7/10/2025
Analysed by:	B. Sinclair	9/10/2025
Checked by:	C. Jasper	

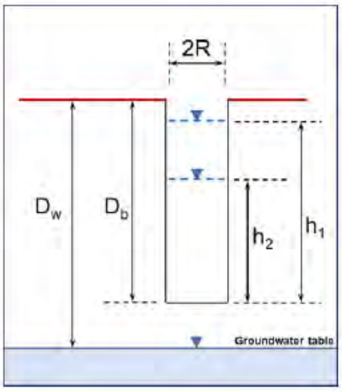
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes:

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: HA4 Shallow
Figure No: B 8

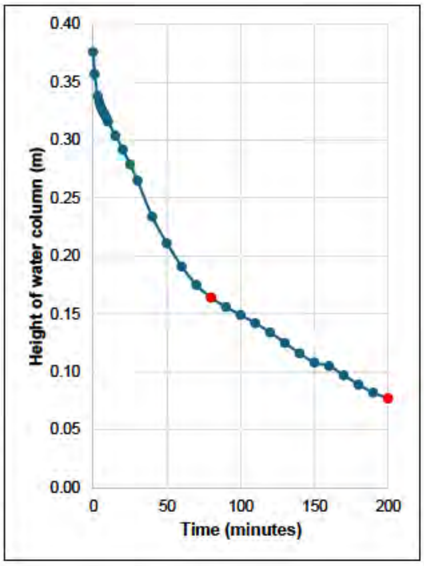


$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.025	m	Drillhole radius
D_b	0.409	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	7-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.033	0.376	-0.411
1	1	0.052	0.357	-0.432
2	3	0.071	0.338	-0.455
3	4	0.076	0.333	-0.462
4	5	0.080	0.329	-0.467
5	6	0.083	0.326	-0.470
6	7	0.085	0.324	-0.473
7	8	0.087	0.322	-0.476
8	9	0.090	0.319	-0.480
9	10	0.093	0.316	-0.483
10	15	0.105	0.304	-0.500
11	20	0.117	0.292	-0.516
12	25	0.130	0.279	-0.535
13	30	0.144	0.265	-0.557
14	40	0.175	0.234	-0.608
15	50	0.198	0.211	-0.651
16	60	0.218	0.191	-0.691
17	70	0.234	0.175	-0.727
18	80	0.245	0.164	-0.753
19	90	0.253	0.156	-0.773
20	100	0.260	0.149	-0.792
21	110	0.267	0.142	-0.811
22	120	0.275	0.134	-0.834
23	130	0.284	0.125	-0.862
24	140	0.293	0.116	-0.891
25	150	0.301	0.108	-0.919
26	160	0.304	0.105	-0.930
27	170	0.312	0.097	-0.961
28	180	0.320	0.089	-0.994
29	190	0.327	0.082	-1.025
30	200	0.332	0.077	-1.048



t_1	80	h_1	0.164	y_1	-0.753
t_2	200	h_2	0.077	y_2	-1.048

Hydraulic conductivity (k)

1E-06	**m/s**
0.1	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

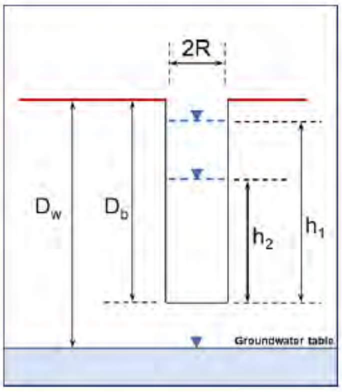
Tested by:	C. Jasper	7/10/2025
Analysed by:	B. Sinclair	13/10/2025
Checked by:	C. Jasper	

Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes:

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: HA4 Deep
Figure No: B 9



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.025	m	Drillhole radius
D_b	0.8	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	7-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.00	0.800	-0.090
1	2	0.06	0.740	-0.123
2	9	0.16	0.640	-0.185
3	21	0.29	0.510	-0.282
4	34	0.40	0.400	-0.385
5	47	0.51	0.290	-0.519
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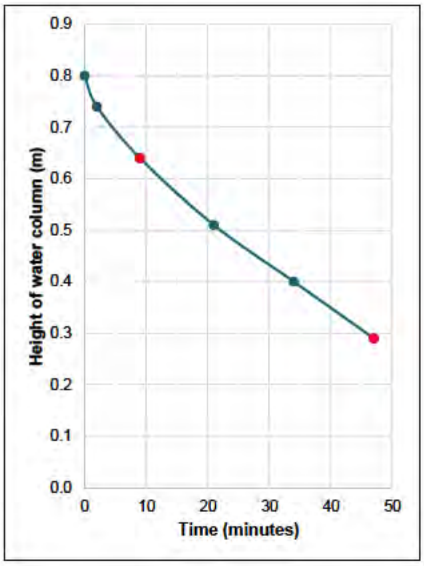


t_1	9	h_1	0.640	y_1	-0.185
t_2	47	h_2	0.290	y_2	-0.519

Hydraulic conductivity (k)

4E-06	**m/s**
0.4	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	B. Sinclair	7/10/2025
Analysed by:	B. Sinclair	9/10/2025
Checked by:	C. Jasper	

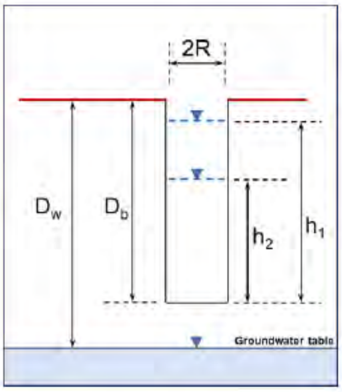
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes:

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: HA5 Shallow
Figure No: B 10



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.025	m	Drillhole radius
D_b	0.444	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	7-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.000	0.444	-0.341
1	1	0.030	0.414	-0.370
2	3	0.093	0.351	-0.439
3	4	0.119	0.325	-0.472
4	5	0.141	0.303	-0.501
5	6	0.162	0.282	-0.531
6	7	0.181	0.263	-0.560
7	8	0.198	0.246	-0.588
8	9	0.213	0.231	-0.614
9	10	0.227	0.217	-0.639
10	12.5	0.262	0.182	-0.711
11	15	0.289	0.155	-0.776
12	17.5	0.311	0.133	-0.837
13	20	0.332	0.112	-0.905
14	22.5	0.349	0.095	-0.969
15	25	0.364	0.080	-1.034
16	27.5	0.375	0.069	-1.089
17	30	0.388	0.056	-1.164
18	32.5	0.399	0.045	-1.240
19	35	0.411	0.033	-1.342
20	37.5	0.420	0.024	-1.438
21	40	0.431	0.013	-1.593
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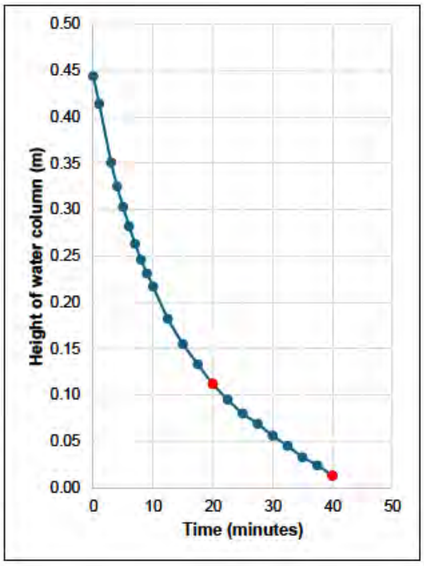


t_1	20	h_1	0.112	y_1	-0.905
t_2	40	h_2	0.013	y_2	-1.593

Hydraulic conductivity (k)

2E-05	**m/s**
1	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	C. Jasper	8/10/2025
Analysed by:	B. Sinclair	13/10/2025
Checked by:	C. Jasper	

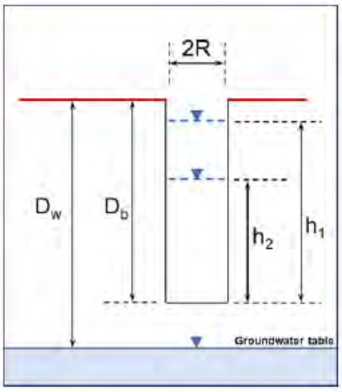
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes:

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: HA5 Deep
Figure No: B 11



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.025	m	Drillhole radius
D_b	0.8	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	7-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.00	0.800	-0.090
1	1	0.03	0.770	-0.107
2	2	0.06	0.740	-0.123
3	8	0.19	0.610	-0.206
4	22	0.36	0.440	-0.344
5	30	0.43	0.370	-0.417
6	35	0.46	0.340	-0.453
7	40	0.49	0.310	-0.491
8	67	0.62	0.180	-0.716
9	92	0.70	0.100	-0.949
10	126	0.80	0.000	-1.903
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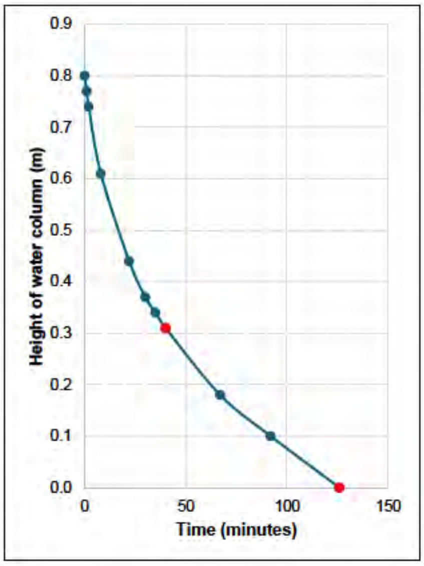


t_1	40	h_1	0.310	y_1	-0.491
t_2	126	h_2	0.000	y_2	-1.903

Hydraulic conductivity (k)

8E-06 **m/s**
0.7 **m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	C. Jasper	8/10/2025
Analysed by:	B. Sinclair	9/10/2025
Checked by:	C. Jasper	

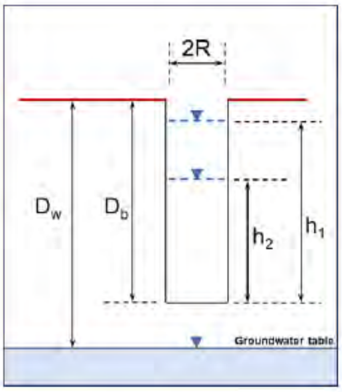
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes:

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: HA6 Shallow
Figure No: B 12



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.025	m	Drillhole radius
D_b	0.5	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	8-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.00	0.500	-0.290
1	1	0.04	0.460	-0.326
2	13	0.22	0.280	-0.534
3	18	0.27	0.230	-0.615
4	31	0.36	0.140	-0.817
5	40	0.39	0.110	-0.912
6	49	0.44	0.060	-1.140
7	69	0.49	0.010	-1.648
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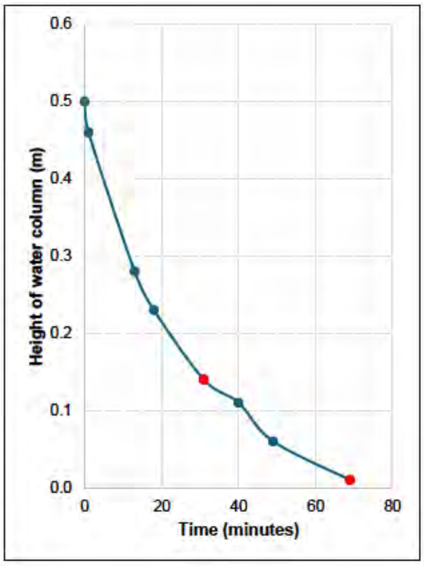


t_1	31	h_1	0.140	y_1	-0.817
t_2	69	h_2	0.010	y_2	-1.648

Hydraulic conductivity (k)

1E-05	**m/s**
0.9	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	B. Sinclair	8/10/2025
Analysed by:	B. Sinclair	9/10/2025
Checked by:	C. Jasper	

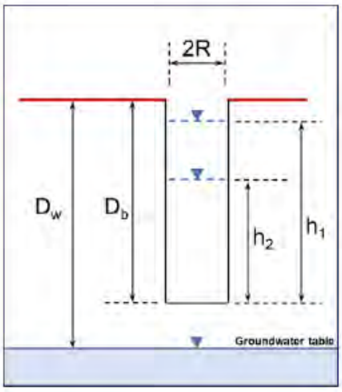
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes:

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: HA6 Deep
Figure No: B 13



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.025	m	Drillhole radius
D_b	0.8	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	7-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.00	0.800	-0.090
1	1	0.04	0.760	-0.112
2	13	0.28	0.520	-0.274
3	18	0.34	0.460	-0.326
4	31	0.46	0.340	-0.453
5	40	0.52	0.280	-0.534
6	49	0.58	0.220	-0.634
7	69	0.66	0.140	-0.817
8	95	0.72	0.080	-1.034
9	129	0.80	0.000	-1.903
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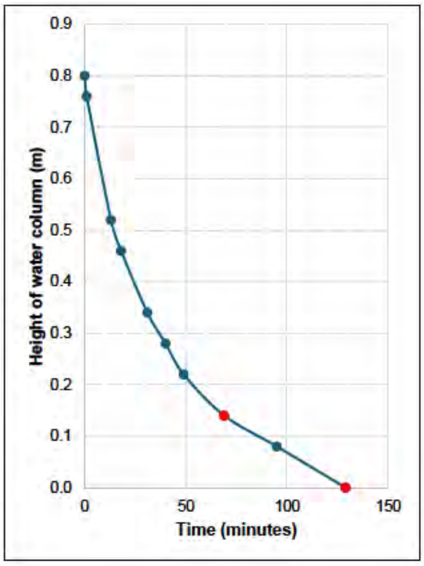


t_1	69	h_1	0.140	y_1	-0.817
t_2	129	h_2	0.000	y_2	-1.903

Hydraulic conductivity (k)

9E-06	**m/s**
0.7	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

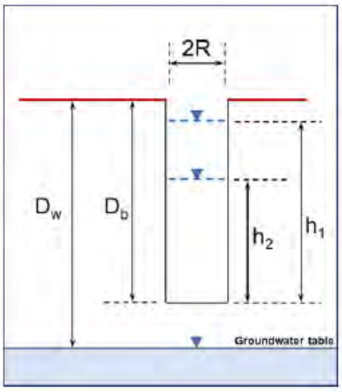
Tested by:	C. Jasper	8/10/2025
Analysed by:	B. Sinclair	9/10/2025
Checked by:	C. Jasper	

Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes:

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: HA7 Shallow
Figure No: B 14

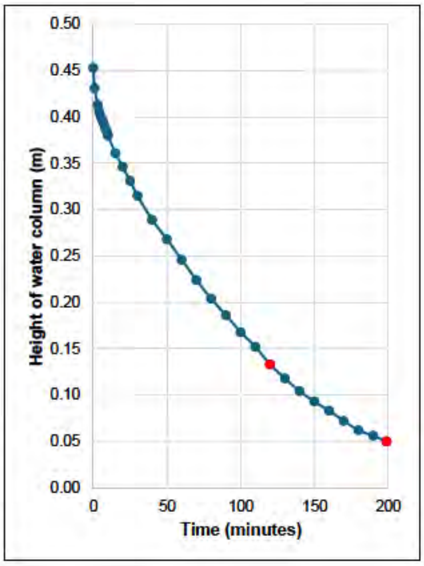


$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.025	m	Drillhole radius
D_b	0.453	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	7-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.000	0.453	-0.332
1	1	0.022	0.431	-0.353
2	3	0.040	0.413	-0.371
3	4	0.047	0.406	-0.378
4	5	0.052	0.401	-0.384
5	6	0.056	0.397	-0.388
6	7	0.059	0.394	-0.391
7	8	0.064	0.389	-0.396
8	9	0.068	0.385	-0.401
9	10	0.073	0.380	-0.406
10	15	0.092	0.361	-0.428
11	20	0.107	0.346	-0.446
12	25	0.122	0.331	-0.464
13	30	0.138	0.315	-0.485
14	40	0.164	0.289	-0.521
15	50	0.185	0.268	-0.552
16	60	0.207	0.246	-0.588
17	70	0.229	0.224	-0.626
18	80	0.249	0.204	-0.665
19	90	0.267	0.186	-0.702
20	100	0.285	0.168	-0.744
21	110	0.301	0.152	-0.784
22	120	0.320	0.133	-0.837
23	130	0.335	0.118	-0.884
24	140	0.349	0.104	-0.934
25	150	0.360	0.093	-0.977
26	160	0.370	0.083	-1.020
27	170	0.381	0.072	-1.073
28	180	0.391	0.062	-1.128
29	190	0.397	0.056	-1.164
30	199	0.403	0.050	-1.204



t_1	120	h_1	0.133	y_1	-0.837
t_2	199	h_2	0.050	y_2	-1.204

Hydraulic conductivity (k)

2E-06	**m/s**
0.2	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	C. Jasper	7/10/2025
Analysed by:	B. Sinclair	13/10/2025
Checked by:	C. Jasper	

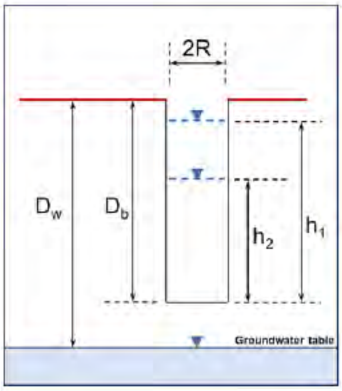
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Tested material consisted of clayey SILT.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: HA8 Shallow
Figure No: B 16



$$k = 1.15R\frac{log(h_1+R/2)-log(h_2+R/2)}{t_2-t_1}$$

R	0.025	m	Drillhole radius
D_b	0.5	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	8-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.00	0.500	-0.290
1	3	0.03	0.475	-0.312
2	10	0.04	0.460	-0.326
3	20	0.05	0.455	-0.330
4	30	0.05	0.450	-0.335
5	45	0.06	0.445	-0.340
6	95	0.06	0.437	-0.347
7	136	0.08	0.420	-0.364
8	210	0.10	0.400	-0.385
9	240	0.11	0.390	-0.395
10	289	0.12	0.380	-0.406
11	320	0.13	0.370	-0.417
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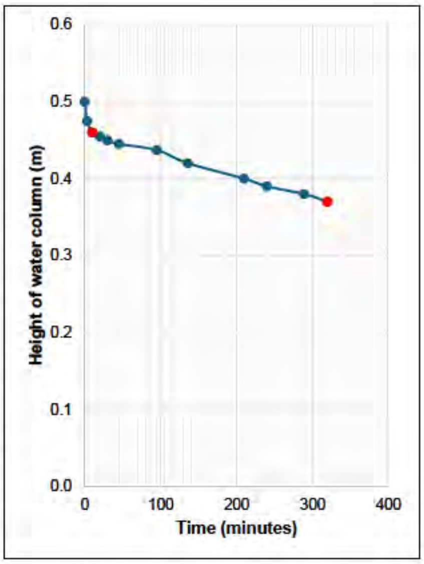


t_1	10	h_1	0.460	y_1	-0.326
t_2	320	h_2	0.370	y_2	-0.417

Hydraulic conductivity (k)

1E-07	m/s
0.01	m/day

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

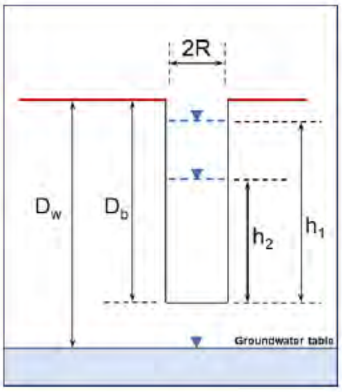
Tested by:	B. Sinclair	8/10/2025
Analysed by:	B. Sinclair	9/10/2025
Checked by:	C. Jasper	

Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Tested material consisted of clayey SILT.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: HA8 Deep
Figure No: B 17



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.025	m	Drillhole radius
D_b	0.9	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	8-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.00	0.900	-0.040
1	2	0.04	0.860	-0.059
2	8	0.05	0.850	-0.064
3	18	0.06	0.840	-0.069
4	28	0.07	0.830	-0.074
5	43	0.09	0.815	-0.082
6	93	0.12	0.780	-0.101
7	134	0.16	0.740	-0.123
8	208	0.20	0.700	-0.147
9	238	0.21	0.690	-0.153
10	287	0.23	0.670	-0.166
11	318	0.24	0.660	-0.172
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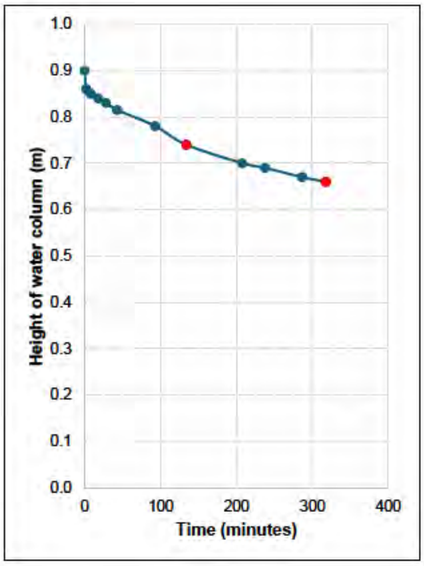


t_1	134	h_1	0.740	y_1	-0.123
t_2	318	h_2	0.660	y_2	-0.172

Hydraulic conductivity (k)

1E-07	**m/s**
0.01	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	BAS, CJ	8/10/2025
Analysed by:	B. Sinclair	9/10/2025
Checked by:	C. Jasper	

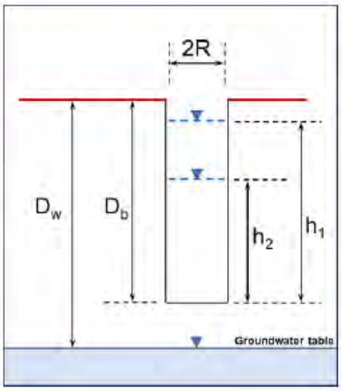
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Tested material consisted of clayey SILT.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client:	Gibbons Co
Project:	Morven Ferry Road Soils Assessment
Project No:	252389
Location:	
Bore No:	HA9 Shallow
Figure No:	B 18



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.025	m	Drillhole radius
D_b	0.511	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	7-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.000	0.511	-0.281
1	1	0.050	0.461	-0.325
2	3	0.176	0.335	-0.459
3	4	0.223	0.288	-0.522
4	5	0.254	0.257	-0.569
5	6	0.276	0.235	-0.606
6	7	0.286	0.225	-0.624
7	8	0.298	0.213	-0.647
8	9	0.306	0.205	-0.663
9	10	0.314	0.197	-0.679
10	12	0.341	0.170	-0.739
11	14	0.358	0.153	-0.781
12	16	0.370	0.141	-0.814
13	18	0.383	0.128	-0.852
14	20	0.395	0.116	-0.891
15	22	0.408	0.103	-0.937
16	24	0.419	0.092	-0.981
17	26	0.432	0.079	-1.039
18	28	0.443	0.068	-1.094
19	30	0.455	0.056	-1.164
20	32	0.466	0.045	-1.240
21	34	0.476	0.035	-1.323
22	36	0.486	0.025	-1.426
23	38	0.494	0.017	-1.530
24	40	0.504	0.007	-1.710
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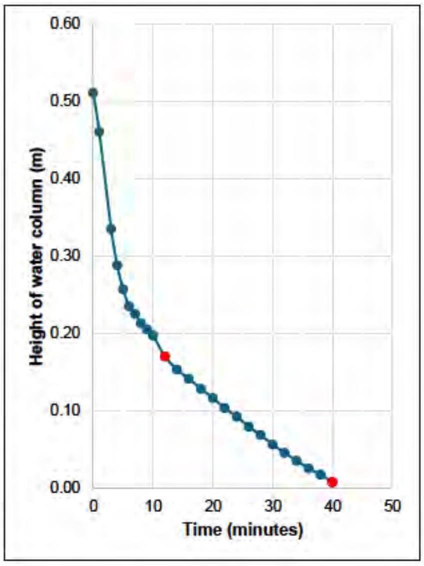


t_1	12	h_1	0.170	y_1	-0.739
t_2	40	h_2	0.007	y_2	-1.710

Hydraulic conductivity (k)

2E-05	**m/s**
1	**m/day**

Tested by:	C. Jasper	8/10/2025
Analysed by:	B. Sinclair	13/10/2025
Checked by:	C. Jasper	

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

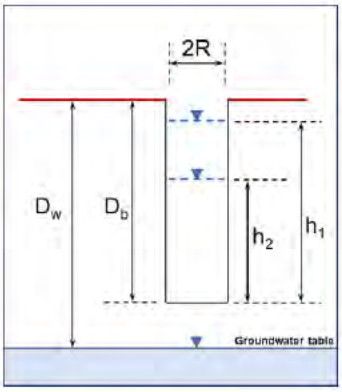
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Tested material consisted of fine silty SADND overlain by clayey SILT.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: HA9 Deep
Figure No: B 19



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.025	m	Drillhole radius
D$_b$	0.85	m	Drillhole depth
D$_w$		m	Depth to groundwater table (SWL), if known
date	8-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d$_w$)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.00	0.850	-0.064
1	2	0.07	0.780	-0.101
2	4	0.15	0.700	-0.147
3	7	0.23	0.620	-0.199
4	12	0.32	0.530	-0.266
5	24	0.44	0.410	-0.374
6	47	0.50	0.350	-0.441
7	66	0.53	0.320	-0.478
8	133	0.57	0.280	-0.534
9	161	0.58	0.270	-0.549
10	247	0.60	0.250	-0.581
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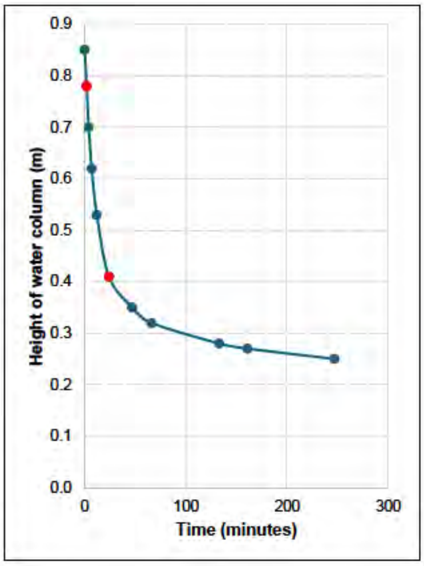


t$_1$	2	h$_1$	0.780	y$_1$	-0.101
t$_2$	24	h$_2$	0.410	y$_2$	-0.374

Hydraulic conductivity (k)

6E-06	**m/s**
0.5	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	B. Sinclair	8/10/2025
Analysed by:	B. Sinclair	9/10/2025
Checked by:	C. Jasper	

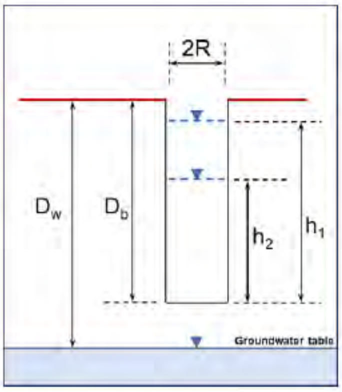
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Material tested is clayey SILT to 250 mm, then fine silty SAND to 55 mm, then clayey SILT to 850 mm.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: HA9 Deep
Figure No: B 20



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.025	m	Drillhole radius
D_b	0.85	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	8-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.00	0.850	-0.064
1	2	0.07	0.780	-0.101
2	4	0.15	0.700	-0.147
3	7	0.23	0.620	-0.199
4	12	0.32	0.530	-0.266
5	24	0.44	0.410	-0.374
6	47	0.50	0.350	-0.441
7	66	0.53	0.320	-0.478
8	133	0.57	0.280	-0.534
9	161	0.58	0.270	-0.549
10	247	0.60	0.250	-0.581
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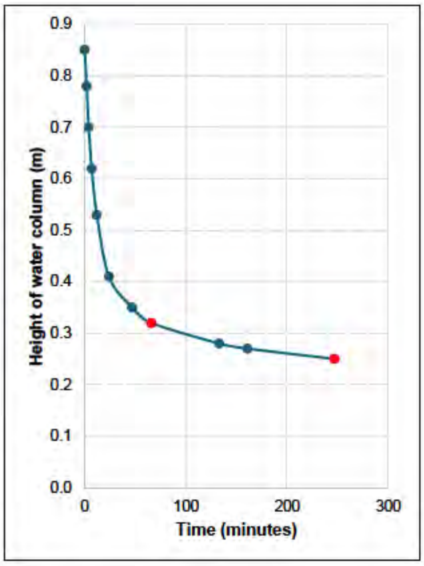


t_1	66	h_1	0.320	y_1	-0.478
t_2	247	h_2	0.250	y_2	-0.581

Hydraulic conductivity (k)

3E-07	**m/s**
0.02	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

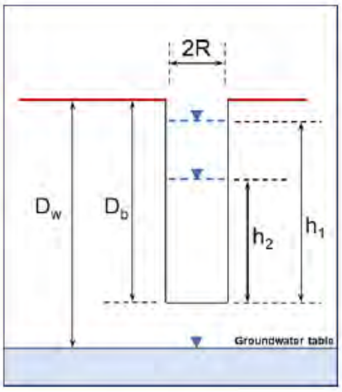
Tested by:	B. Sinclair	8/10/2025
Analysed by:	B. Sinclair	9/10/2025
Checked by:	C. Jasper	

Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Material tested is clayey SILT to 250 mm, then fine silty SAND to 55 mm, then clayey SILT to 850 mm.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

Client:	Gibbons Co
Project:	Morven Ferry Road Soils Assessment
Project No:	252389
Location:	
Bore No:	HA10 Shallow
Figure No:	B 21



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.025	m	Drillhole radius
D_b	0.45	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	8-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.000	0.450	-0.335
1	1	0.040	0.410	-0.374
2	2	0.040	0.410	-0.374
3	6	0.060	0.390	-0.395
4	8	0.080	0.370	-0.417
5	25	0.125	0.325	-0.472
6	74	0.240	0.210	-0.653
7	102	0.280	0.170	-0.739
8	180	0.360	0.090	-0.989
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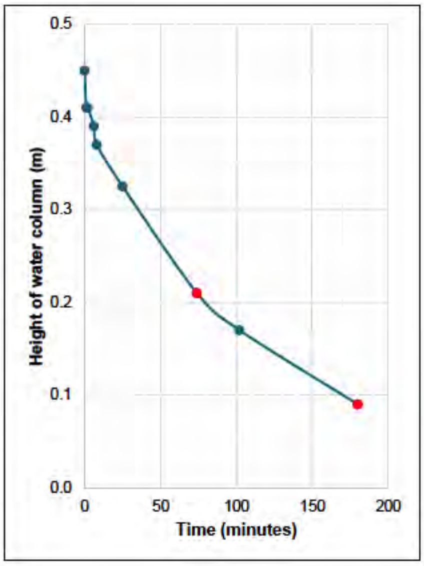


t_1	74	h_1	0.210	y_1	-0.653
t_2	180	h_2	0.090	y_2	-0.989

Hydraulic conductivity (k)

2E-06	**m/s**
0.1	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	BAS; CJ	8/10/2025
Analysed by:	B. Sinclair	9/10/2025
Checked by:	C. Jasper	

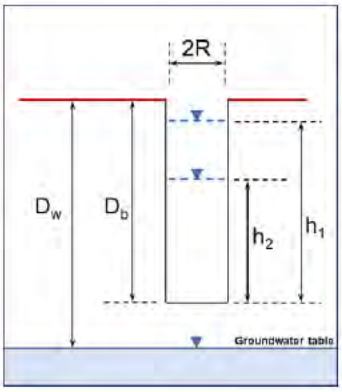
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Tested material consisted of SILT to 350 mm then clayey SILT.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: HA10 Deep
Figure No: B 22



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.025	m	Drillhole radius
D_b	0.95	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	8-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.00	0.950	-0.017
1	4	0.03	0.920	-0.030
2	6	0.06	0.890	-0.045
3	23	0.16	0.795	-0.093
4	71	0.34	0.610	-0.206
5	99	0.40	0.550	-0.250
6	177	0.52	0.430	-0.354
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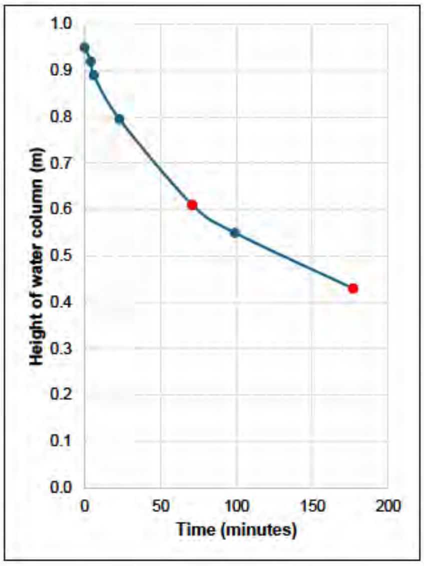


t_1	71	**h_1**	0.610	**y_1**	-0.206
t_2	177	**h_2**	0.430	**y_2**	-0.354

Hydraulic conductivity (k)

7E-07	**m/s**
0.06	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	B. Sinclair	8/10/2025
Analysed by:	B. Sinclair	9/10/2025
Checked by:	C. Jasper	

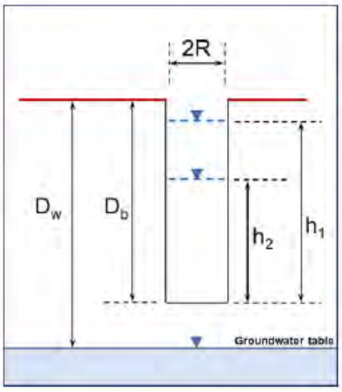
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Tested material consisted of SILT to 350 mm then clayey SILT to 950 mm.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: HA11 Shallow
Figure No: B 23



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.025	m	Drillhole radius
D_b	0.453	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	7-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.037	0.416	-0.368
1	1	0.053	0.400	-0.385
2	3	0.070	0.383	-0.403
3	4	0.077	0.376	-0.411
4	5	0.082	0.371	-0.416
5	6	0.088	0.365	-0.423
6	7	0.093	0.360	-0.429
7	8	0.099	0.354	-0.436
8	9	0.104	0.349	-0.442
9	10	0.109	0.344	-0.448
10	15	0.132	0.321	-0.477
11	20	0.152	0.301	-0.504
12	25	0.172	0.281	-0.532
13	30	0.189	0.264	-0.558
14	40	0.219	0.234	-0.608
15	50	0.246	0.207	-0.659
16	60	0.272	0.181	-0.713
17	70	0.294	0.159	-0.766
18	80	0.315	0.138	-0.822
19	90	0.343	0.110	-0.912
20	100	0.362	0.091	-0.985
21	110	0.380	0.073	-1.068
22	120	0.392	0.061	-1.134
23	130	0.406	0.047	-1.225
24	140	0.420	0.033	-1.342
25	145	0.426	0.027	-1.403
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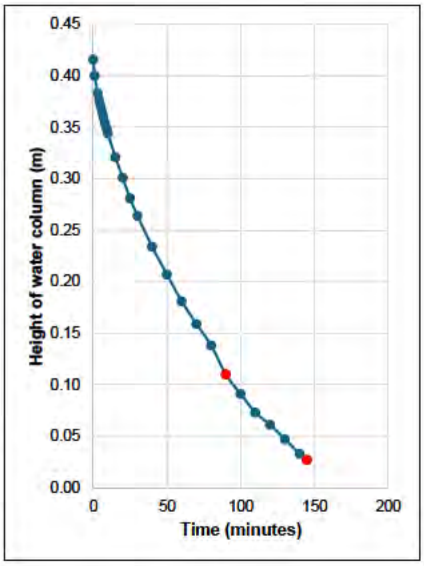


t_1	90	h_1	0.110	y_1	-0.912
t_2	145	h_2	0.027	y_2	-1.403

Hydraulic conductivity (k)

4E-06	**m/s**
0.4	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	C. Jasper	7/10/2025
Analysed by:	B. Sinclair	13/10/2025
Checked by:	C. Jasper	

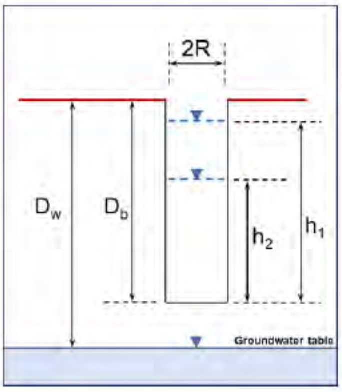
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Material tested consists of clayey SILT to 300 mm then SILT.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: HA11 Deep
Figure No: B 24



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.025	m	Drillhole radius
D_b	0.6	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	7-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.002	0.598	-0.214
1	1	0.005	0.595	-0.216
2	3	0.014	0.586	-0.223
3	4	0.021	0.579	-0.228
4	5	0.028	0.572	-0.233
5	6	0.034	0.566	-0.238
6	7	0.040	0.560	-0.242
7	8	0.046	0.554	-0.247
8	9	0.052	0.548	-0.251
9	10	0.060	0.540	-0.258
10	15	0.094	0.506	-0.285
11	20	0.123	0.477	-0.310
12	25	0.151	0.449	-0.336
13	30	0.174	0.426	-0.358
14	35	0.197	0.403	-0.381
15	40	0.219	0.381	-0.405
16	45	0.238	0.362	-0.427
17	50	0.255	0.345	-0.447
18	55	0.274	0.326	-0.470
19	60	0.291	0.309	-0.493
20	65	0.307	0.293	-0.515
21	70	0.324	0.276	-0.540
22	75	0.338	0.262	-0.561
23	80	0.351	0.249	-0.583
24	85	0.363	0.237	-0.603
25	90	0.377	0.223	-0.628
26	95	0.389	0.211	-0.651
27	100	0.400	0.200	-0.673
28	110	0.419	0.181	-0.713
29	120	0.439	0.161	-0.761
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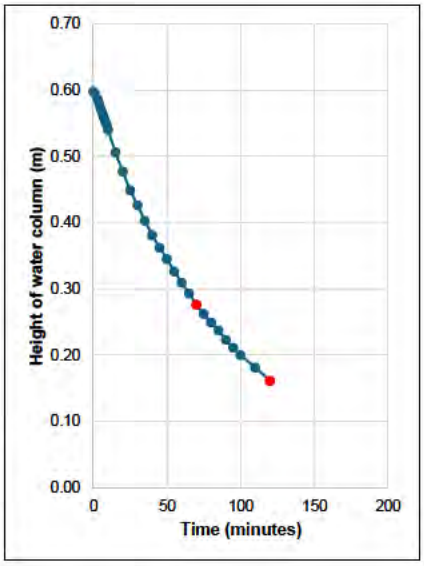


t_1	70	h_1	0.276	y_1	-0.540
t_2	120	h_2	0.161	y_2	-0.761

Hydraulic conductivity (k)

2E-06 **m/s**
0.2 **m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

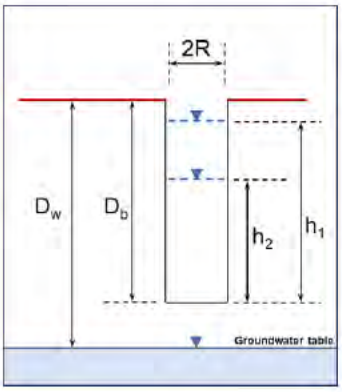
Tested by: C. Jasper 8/10/2025
Analysed by: B. Sinclair 13/10/2025
Checked by: C. Jasper

Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Material tested consists of clayey SILT to 300 mm then SILT.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: HA12 Shallow
Figure No: B 25



$$k = 1.15R\frac{log(h_1+R/2)-log(h_2+R/2)}{t_2-t_1}$$

R	0.025	m	Drillhole radius
D_b	0.47	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	8-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.000	0.470	-0.317
1	3	0.050	0.420	-0.364
2	8	0.090	0.380	-0.406
3	13	0.125	0.345	-0.447
4	22	0.170	0.300	-0.505
5	38	0.230	0.240	-0.598
6	105	0.380	0.090	-0.989
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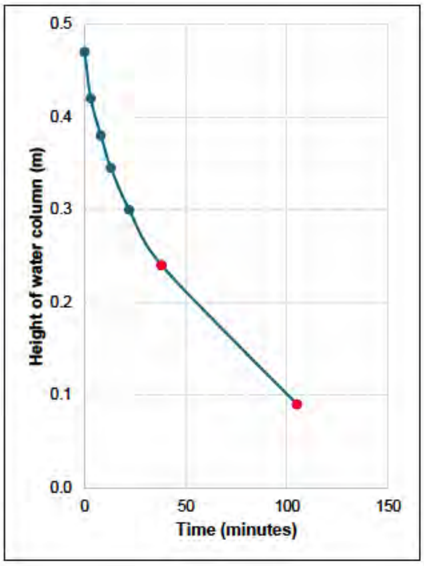


t_1	38	h_1	0.240	y_1	-0.598
t_2	105	h_2	0.090	y_2	-0.989

Hydraulic conductivity (k)

3E-06	**m/s**
0.2	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	B. Sinclair	8/10/2025
Analysed by:	B. Sinclair	9/10/2025
Checked by:	C. Jasper	

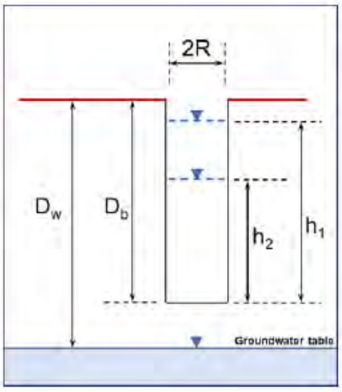
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Tested material consisted of SILT to 400 mm then clayey SILT.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: HA12 Deep
Figure No: B 26



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.025	m	Drillhole radius
D_b	0.9	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	8-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0	0.00	0.900	-0.040
1	3	0.09	0.810	-0.085
2	9	0.17	0.735	-0.126
3	14	0.22	0.680	-0.160
4	23	0.30	0.605	-0.209
5	39	0.38	0.520	-0.274
6	105	0.64	0.260	-0.565
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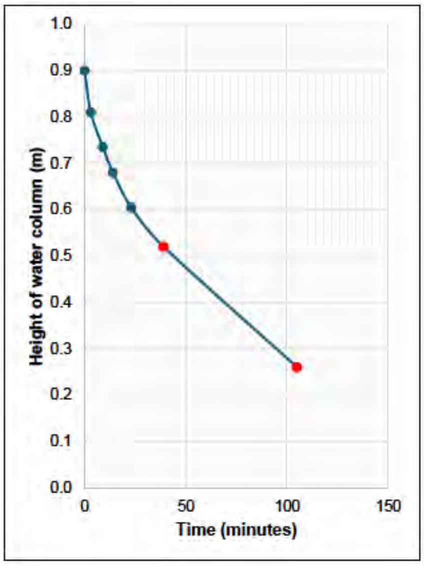


t_1	39	h_1	0.520	y_1	-0.274
t_2	105	h_2	0.260	y_2	-0.565

Hydraulic conductivity (k)

2E-06 **m/s**
0.2 **m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

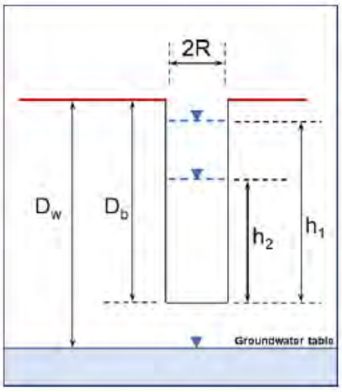
Tested by:	B. Sinclair	8/10/2025
Analysed by:	B. Sinclair	9/10/2025
Checked by:	C. Jasper	

Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Tested material consisted of SILT to 400 mm then clayey SILT.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: HA13
Figure No: B 27



$$k = 1.15R\frac{log(h_1+R/2)-log(h_2+R/2)}{t_2-t_1}$$

R	0.025	m	Drillhole radius
D_b	0.7	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	8-Oct-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0.00	0.00	0.700	-0.147
1	2.67	0.09	0.610	-0.206
2	5.17	0.14	0.565	-0.238
3	8.83	0.20	0.505	-0.286
4	12.83	0.23	0.470	-0.317
5	16.25	0.25	0.450	-0.335
6	22.00	0.28	0.420	-0.364
7	33.67	0.33	0.375	-0.412
8	47.50	0.37	0.330	-0.465
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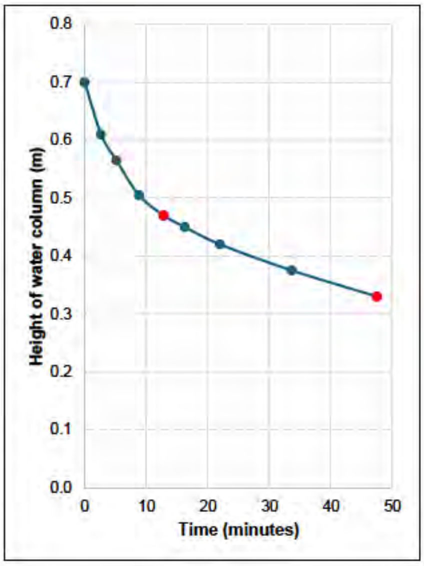


t_1	12.83	h_1	0.470	y_1	-0.317
t_2	47.50	h_2	0.330	y_2	-0.465

Hydraulic conductivity (k)

2E-06	**m/s**
0.2	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	C. Jasper	8/10/2025
Analysed by:	B. Sinclair	9/10/2025
Checked by:	C. Jasper	

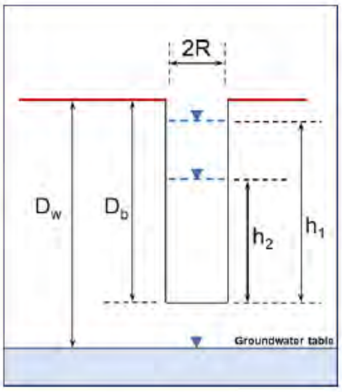
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes: Tested material consisted of silty gravelly fine SAND.

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: SK-1 Kirk Roberts
Figure No: B28



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.1	m	Drillhole radius
D_b	1.35	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	7-May-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0.00	0.00	1.350	0.146
1	1.00	0.10	1.250	0.114
2	2.00	0.17	1.180	0.090
3	3.00	0.23	1.120	0.068
4	4.00	0.27	1.080	0.053
5	6.00	0.36	0.990	0.017
6	7.00	0.38	0.970	0.009
7	8.00	0.42	0.930	-0.009
8	9.00	0.45	0.900	-0.022
9	10.00	0.48	0.870	-0.036
10	21.00	0.63	0.725	-0.111
11	51.00	0.81	0.540	-0.229
12	63.00	0.88	0.470	-0.284
13	93.00	1.02	0.330	-0.420
14	120.00	1.11	0.240	-0.538
15	135.00	1.15	0.200	-0.602
16	150.00	1.22	0.130	-0.745
17	165.00	1.24	0.110	-0.796
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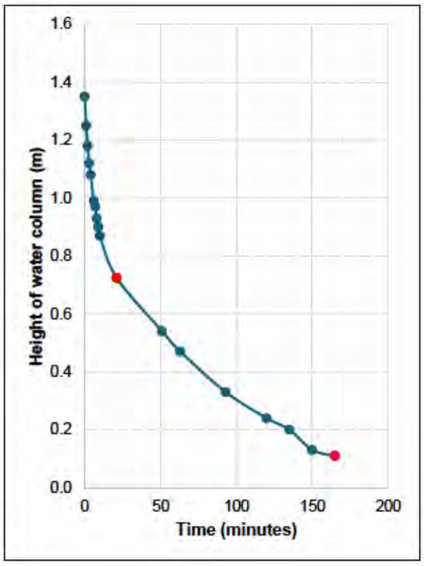


t_1	21	h_1	0.725	y_1	-0.111
t_2	165	h_2	0.110	y_2	-0.796

Hydraulic conductivity (k)

9E-06	**m/s**
0.8	**m/day**

Tested by:	Kirk Roberts	7/05/2025
Analysed by:	B. Sinclair	9/10/2025
Checked by:	C. Jasper	

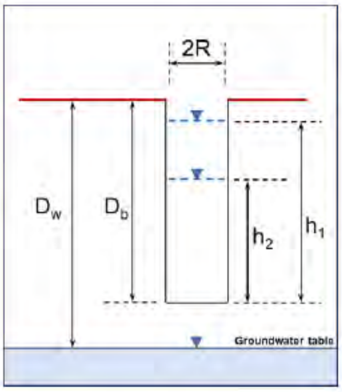
Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes:

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: SK-2 Kirk Roberts
Figure No: B29



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.1	m	Drillhole radius
D_b	1.3	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	7-May-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0.00	0.00	1.300	0.130
1	1.00	0.03	1.270	0.121
2	2.00	0.06	1.240	0.111
3	3.00	0.09	1.210	0.100
4	4.00	0.11	1.195	0.095
5	5.00	0.13	1.170	0.086
6	7.00	0.15	1.150	0.079
7	9.00	0.18	1.120	0.068
8	31.00	0.47	0.830	-0.056
9	66.00	0.78	0.520	-0.244
10	74.00	0.83	0.475	-0.280
11	109.00	0.90	0.405	-0.342
12	129.00	0.95	0.350	-0.398
13	144.00	0.98	0.320	-0.432
14	159.00	1.02	0.280	-0.481
15	174.00	1.07	0.235	-0.545
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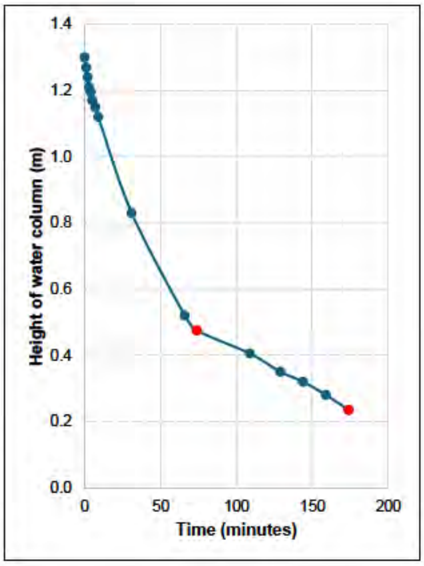


t_1	74	h_1	0.475	y_1	-0.280
t_2	174	h_2	0.235	y_2	-0.545

Hydraulic conductivity (k)

5E-06	**m/s**
0.4	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	Kirk Roberts	7/05/2025
Analysed by:	B. Sinclair	9/10/2025
Checked by:	C. Jasper	

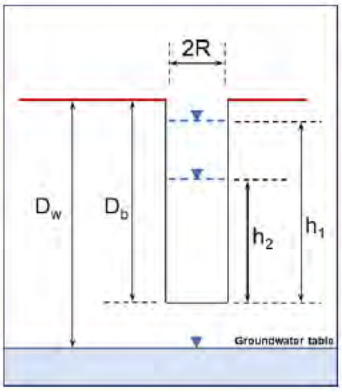
Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes:

FALLING HEAD TEST - UNCASED BORE - ABOVE GROUNDWATER TABLE

WGA

Client: Gibbons Co
Project: Morven Ferry Road Soils Assessment
Project No: 252389
Location:
Bore No: SK-3 Kirk Roberts
Figure No: B30



$$k = 1.15R\frac{log(h_1 + R/2) - log(h_2 + R/2)}{t_2 - t_1}$$

R	0.1	m	Drillhole radius
D_b	2.07	m	Drillhole depth
D_w		m	Depth to groundwater table (SWL), if known
date	7-May-25		Date of SWL measurement
time			Time of SWL measurement

Analysis assumes bore does not fully penetrate aquifer

Reading	Elapsed time (t)	Depth to water (d_w)	Height of water (h(t))	y(t) = log(h(t)+R/2)
	(minutes)	(m)	(m)	(m)
0	0.00	0.00	2.070	0.326
1	1.00	0.05	2.020	0.316
2	2.00	0.09	1.985	0.309
3	3.00	0.11	1.960	0.303
4	4.00	0.13	1.940	0.299
5	5.00	0.17	1.905	0.291
6	9.00	0.25	1.820	0.272
7	41.00	0.87	1.200	0.097
8	85.00	1.38	0.690	-0.131
9	129.00	1.65	0.420	-0.328
10	159.00	1.77	0.300	-0.456
11	164.00	1.83	0.240	-0.538
12	179.00	1.89	0.180	-0.638
13	194.00	1.94	0.130	-0.745
14				
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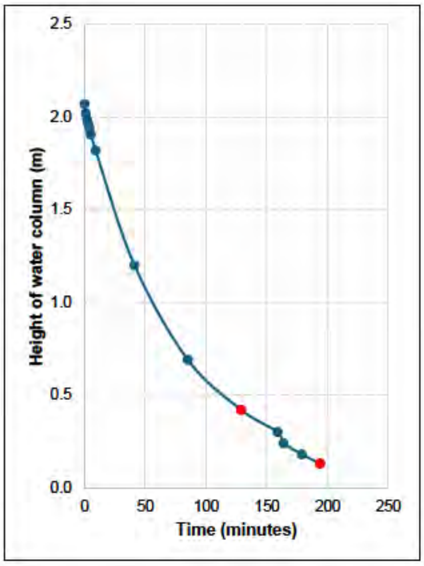


t_1	129	h_1	0.420	y_1	-0.328
t_2	194	h_2	0.130	y_2	-0.745

Hydraulic conductivity (k)

1E-05	**m/s**
1.1	**m/day**

Reference: Oosterbaan & Nijland (2006) Determining the saturated hydraulic conductivity. Equation 12.14. in Ritzema H P (2006) Drainage Principles and Applications. International Institute for Land Reclamation and Improvement Publication 16. Wageningen, The Netherlands

Tested by:	Kirk Roberts	7/05/2025
Analysed by:	B. Sinclair	9/10/2025
Checked by:	C. Jasper	

Assumptions: Groundwater table is deep enough that mounding or up-coning does not affect infiltration rates.
Horizontal hydraulic conductivity = vertical hydraulic conductivity.

Notes:

APPENDIX C

WATER SUPPLY TRIAL BORE PUMPING TEST RECORDS AND ANALYSES

Bore Construction Report

SOUTHDRILL
EXPLORATION & PILING

OFFICE USE ONLY		
Date received:	Accession number:	Signed:
Bore number: **sou 2852 hole no140**	Entered IRIS date:	Invoice date:

GENERAL DETAILS		
Client/Consent holder's name: **Cameron**		Consent number: **RM25.435.01**
Location/Address: **122 Morven Ferry Road Queenstown**		
Grid reference - Easting: **1271608m E**	Northing: **5008548m N**	Mobile phone: **02108851148**
Sketch plan attached: **Yes**	Photos attached: **Yes**	Home phone:

DRILLING DETAILS	
Drilling company: **SouthDrill Ltd**	Driller: **Rowland Harrex**
Machine/Rig: **Western Star Drilling Rig [QCL493]**	Fleet no. **2030**
Drill method(s): **Air Rotary**	

BORE CONSTRUCTION DETAILS	
Start date: **12/11/2025**	Finish date: **24/11/2025**
Bore diameter: **200mm**	Casing material: **Steel**
Screen material: **s/s**	
Screen diameter (inside): **156mm**	Screen diameter (outside): **162mm**
Screen slots: **2.5mm**	Overdrilled: **Yes**

PUMPING/WATER DETAILS		
Dry bore: **No**	If dry, was casing retrieved?	Bore filled in:
Development period: **39 hours**	Development method: **Airlifted**	
Yield/test pumping: **Pumped**	Test pump period: **27 hours**	
Test pump rate: **6.5 litres/second**	Method of measuring reate: **meter**	
Comments: **3 stage pump test and 24 hr constant rate**		
Pumped water level: **25.53 metres**		

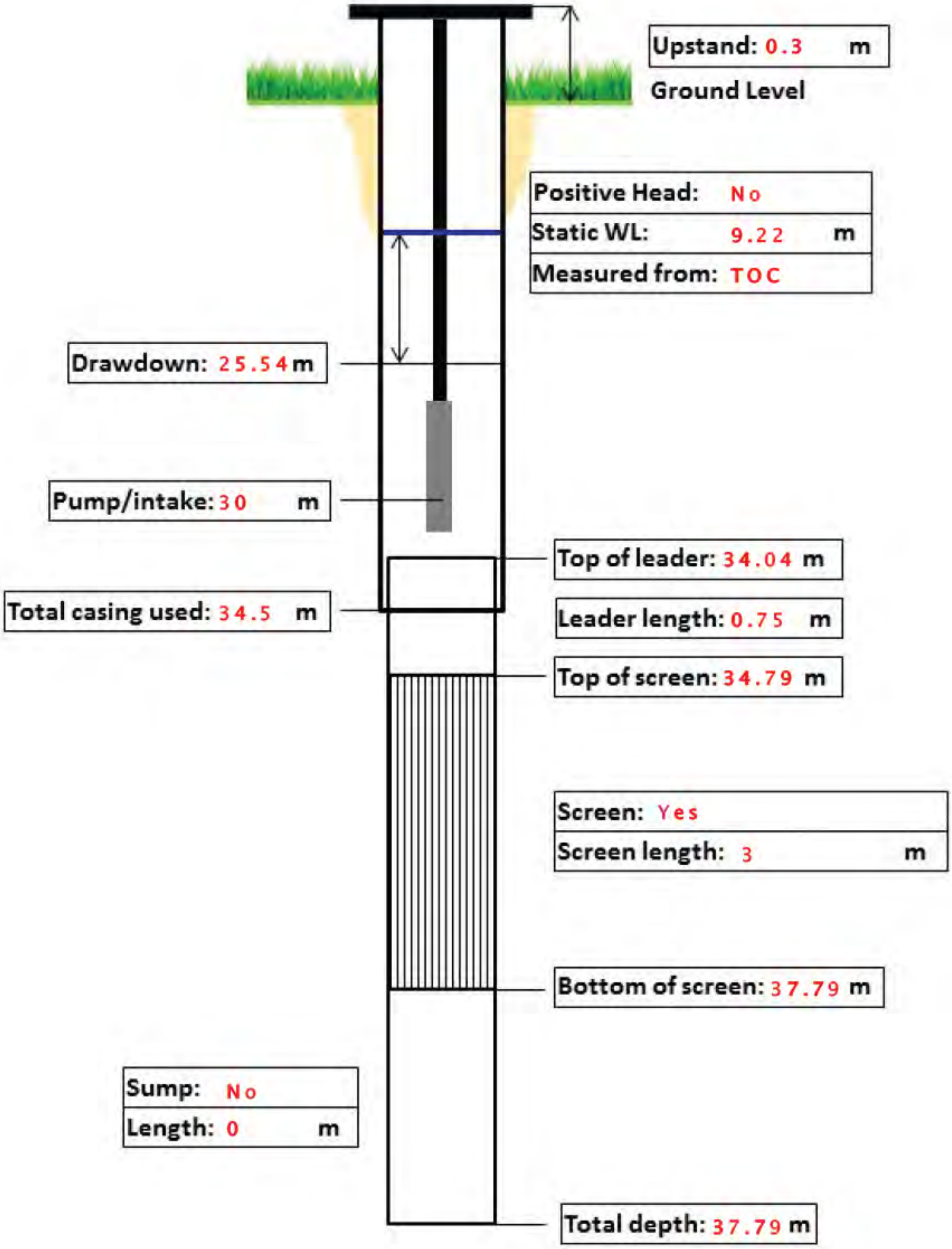
WATER QUALITY ETC	
Bacterial water test: **Yes**	Chemical water test: **Yes**
Casing top sealed: **Yes**	Impervious seal at ground: **Yes**
Comments: **water test taken by hydrologist**	

BORE LOG (METRES BELOW REFERENCE POINT)	
0m–0.4m	top soils
0.4m–8.4m	brown silty gravels
8.4m–11.9m	blue silts large cobbels
11.9m–22m	blue silts odd gravels
22m–34.4m	blue silts
34.4m–38.8m	silty gravels large water flow
38.8m–41.83m	tight silty gravels possible schist
41.83m	tryed to get water flow 41.83-38.83 with 3m screen not much flow pulled screen and caseing back
Do you intend to drill more bores under this Land Use Consent number? **No**	
If yes, number of bores drilled:	Number of bore logs provided:

PTO for bore diagram

Bore Construction Diagram

Bore number:
sou 2852 hole no140



Upstand: 0.3 m

Ground Level

Positive Head: No

Static WL: 9.22 m

Measured from: TOC

Drawdown: 25.54 m

Pump/intake: 30 m

Top of leader: 34.04 m

Total casing used: 34.5 m

Leader length: 0.75 m

Top of screen: 34.79 m

Screen: Yes

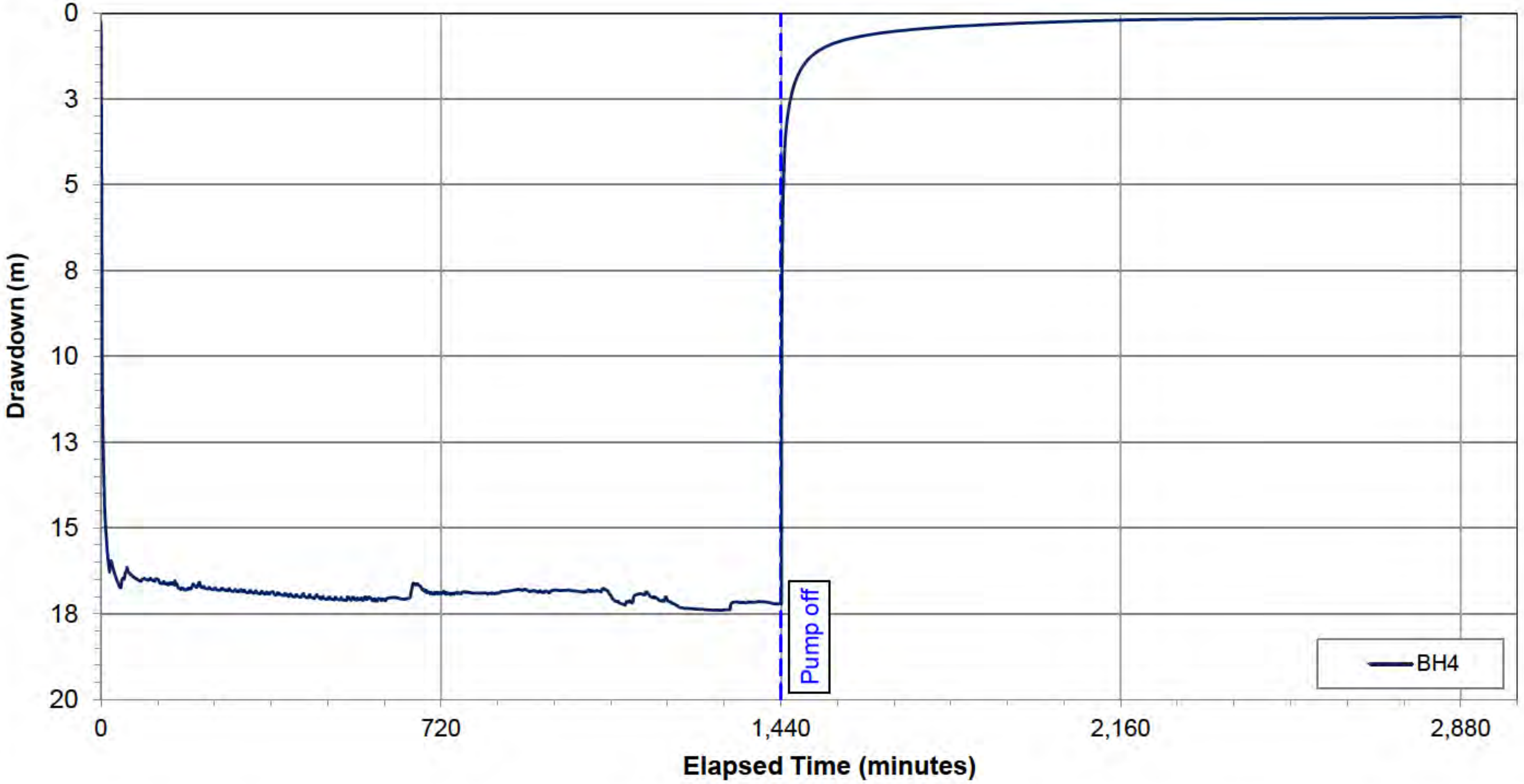
Screen length: 3 m

Bottom of screen: 37.79 m

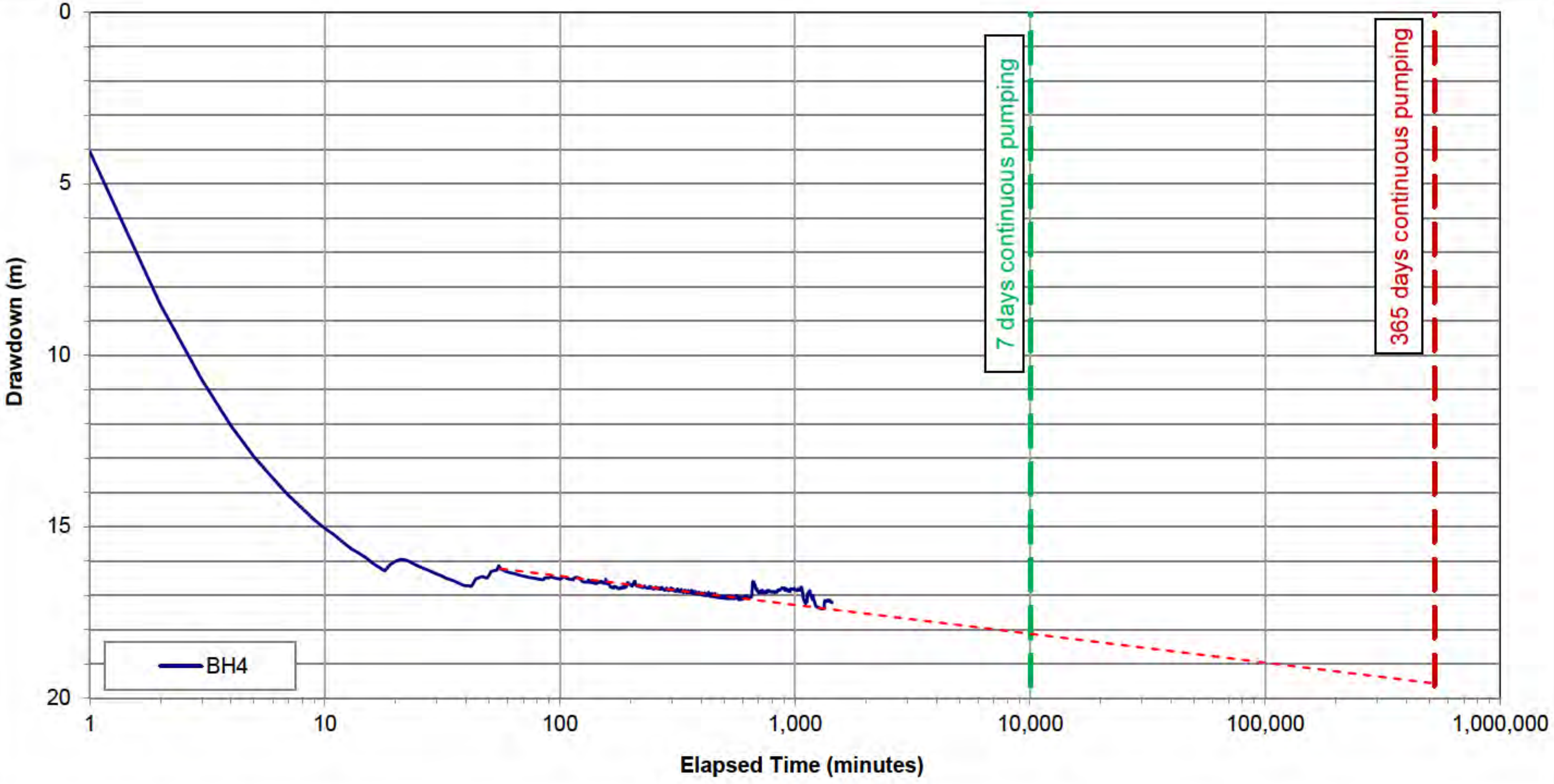
Sump: No

Length: 0 m

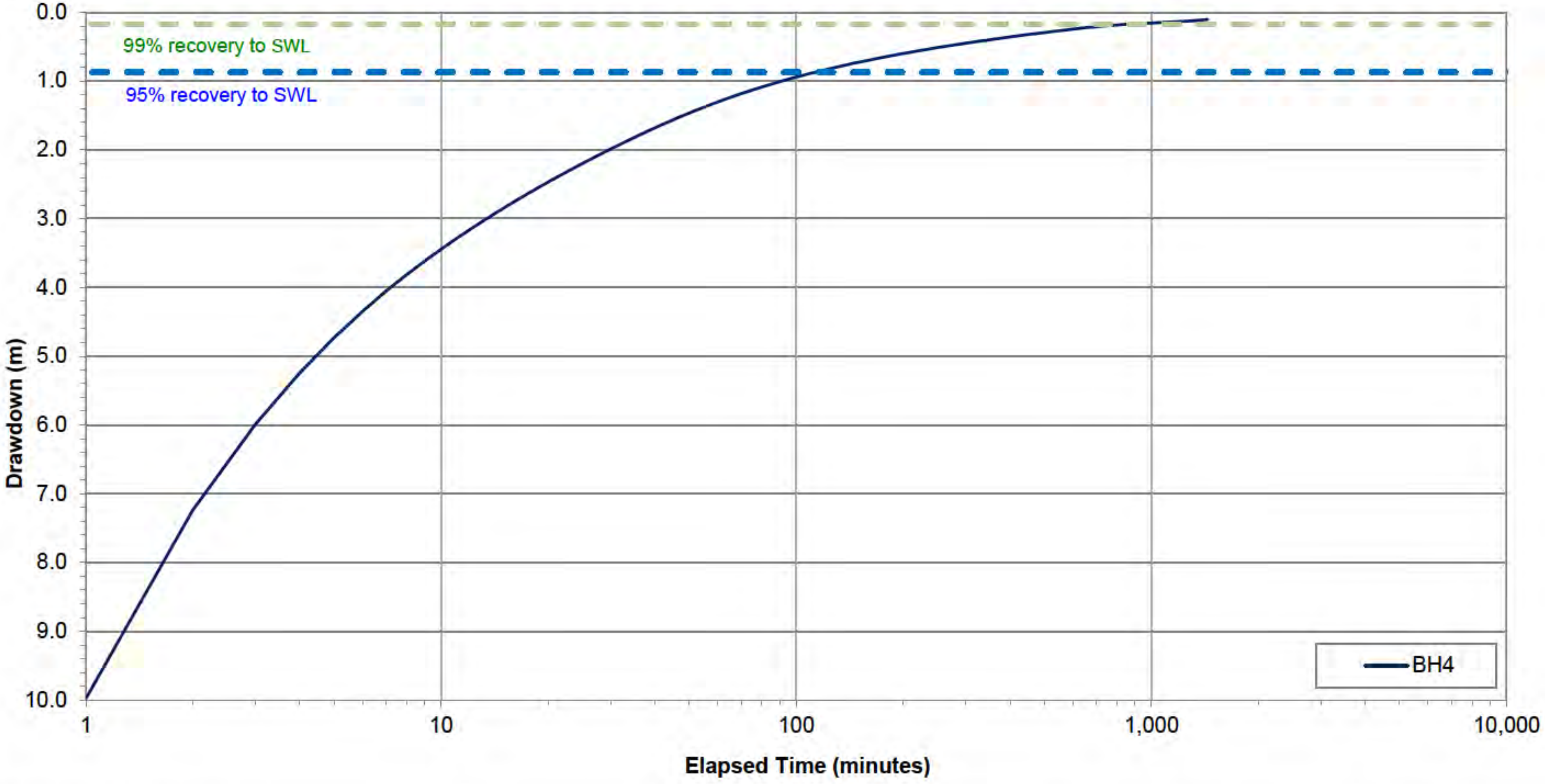
Total depth: 37.79 m



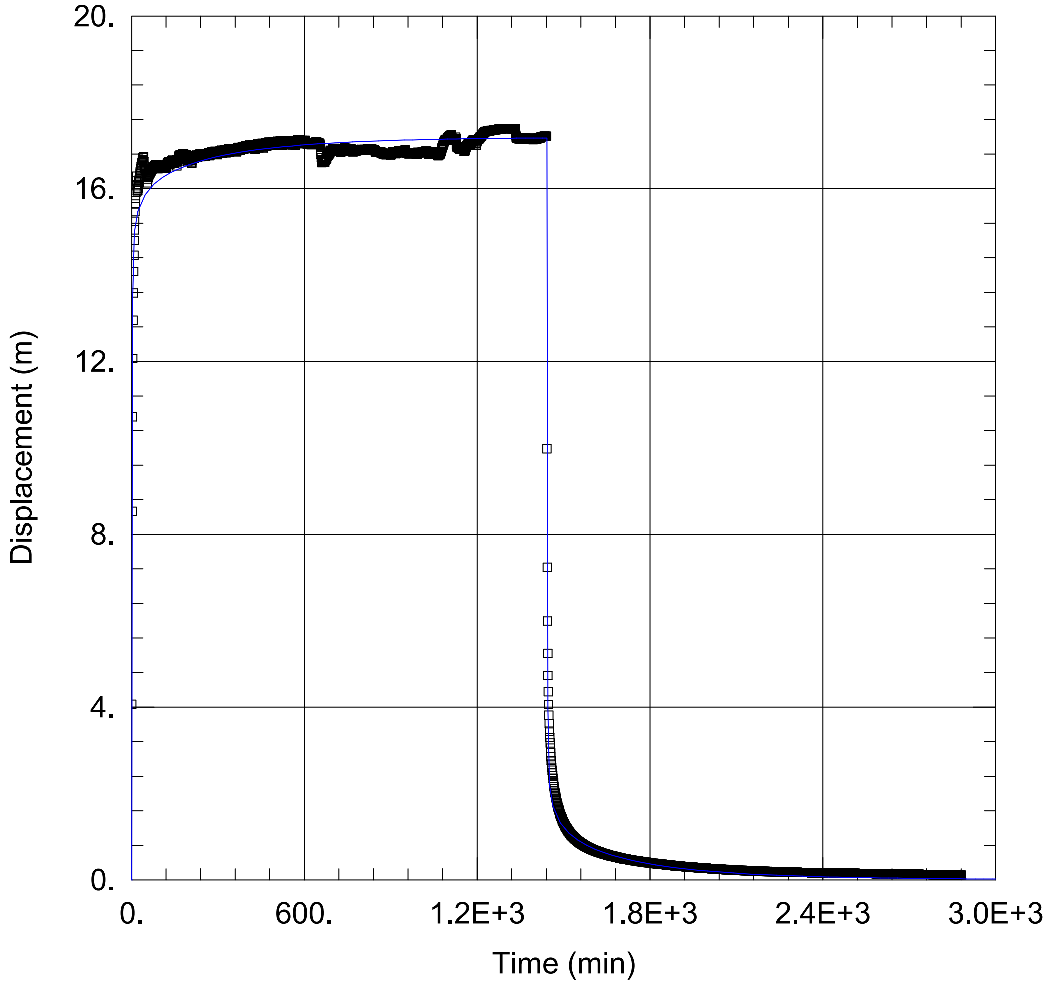
Water Supply Trial BH4 **122 Morven Ferry Road**	TITLE	**Constant Rate Pumping Test Drawdown and Recovery, 19-20 November 2025** **Normal - Normal Scale Plot. Data supplied by SouthDrill.**			
WGA	DRAWN J. Manning	DATE 12 December 2025		JOB NO. WGA252389	
	CHECKED B. Sinclair	SCALE na		DWG. NO. na	
	REVIEWED B. Sinclair	FILE NO. na		FIGURE NO. C1	



Water Supply Trial BH4 **122 Morven Ferry Road**	TITLE	**Projected Drawdown Following 120 Days Continuous Pumping Period** **Log - Normal Scale Plot. Data supplied by SouthDrill.**			
WGA	DRAWN	J. Manning	DATE	12 December 2025	JOB NO. WGA252389
	CHECKED	B. Sinclair	SCALE	na	DWG. NO. na
	REVIEWED	B. Sinclair	FILE NO.	na	FIGURE NO. C2



Water Supply Trial BH4 **122 Morven Ferry Road**	TITLE	**Constant Rate Pumping Test Recovery Percentage, 19-20 November 2025** **Log - Normal Scale Plot. Data supplied by SouthDrill.**			
WGA	DRAWN	J. Manning	DATE	12 December 2025	JOB NO. WGA252389
	CHECKED	B. Sinclair	SCALE	na	DWG. NO. na
	REVIEWED	B. Sinclair	FILE NO.	na	FIGURE NO. C3



WELL TEST ANALYSIS

Data Set: V:\...\BH4 - leaky.aqt
Date: 12/16/25 Time: 17:39:26

PROJECT INFORMATION

Company: WGA
Project: WGA252389

AQUIFER DATA

Saturated Thickness: 4.4 m
Anisotropy Ratio (Kz/Kr): 1.
Aquitard Thickness (b'): 26. m
Aquitard Thickness (b"): 1. m

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
BH4	0	0

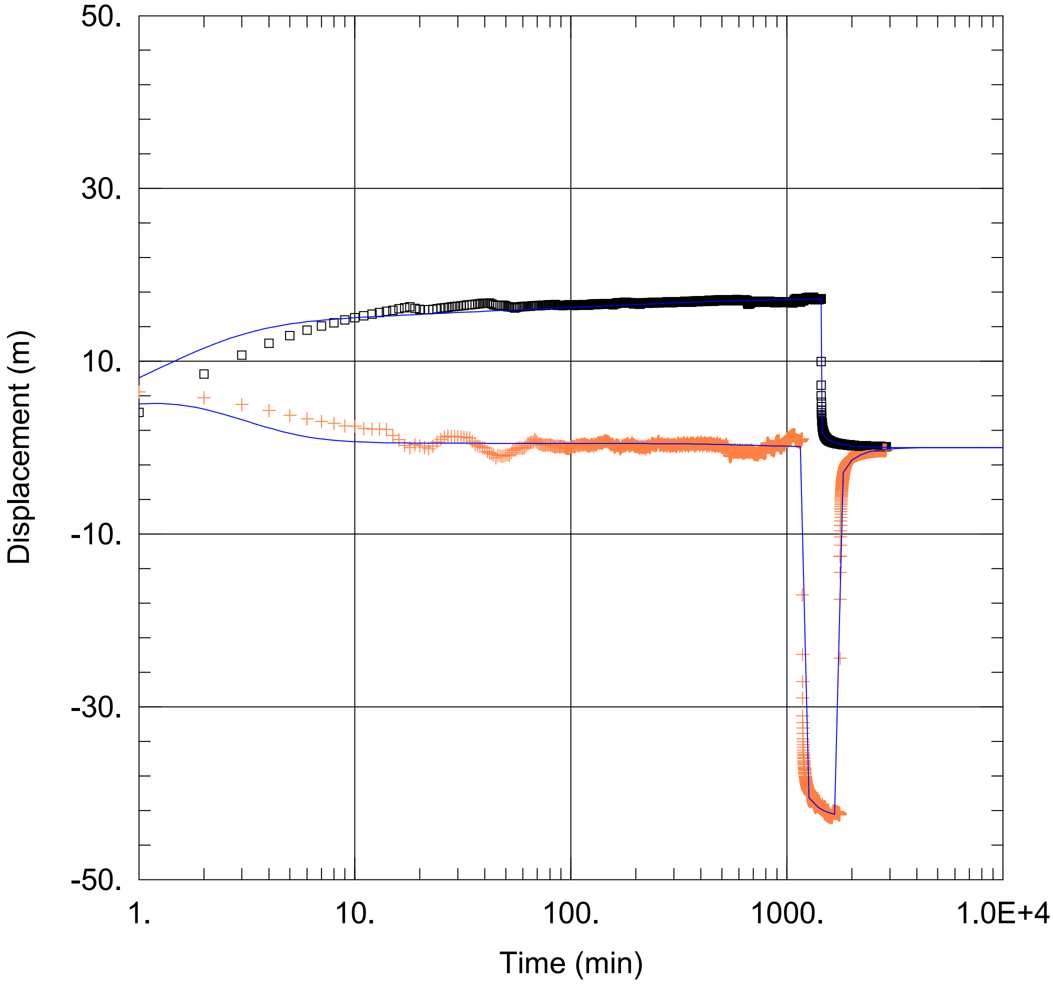
Observation Wells

Well Name	X (m)	Y (m)
□ BH4	0	0

SOLUTION

Aquifer Model: Leaky
Solution Method: Moench (Case 1)

T = 47.83 m^2/day
S = 9.632E-8
r/B' = 0.0001054
ß' = 0.0006079
r/B" = 0.
ß" = 0.
Sw = 0.
r(w) = 0.1 m
r(c) = 0.1 m



WELL TEST ANALYSIS

Data Set: V:\...\BH4 - leaky.aqt
Date: 12/16/25 Time: 17:37:53

PROJECT INFORMATION

Company: WGA
Project: WGA252389

AQUIFER DATA

Saturated Thickness: 4.4 m
Aquitard Thickness (b'): 26. m
Anisotropy Ratio (Kz/Kr): 1.
Aquitard Thickness (b"): 1. m

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
BH4	0	0

Observation Wells

Well Name	X (m)	Y (m)
▫ BH4	0	0

SOLUTION

Aquifer Model: Leaky
Solution Method: Moench (Case 1)

T = 47.83 m^2/day
r/B' = 0.0001054
r/B" = 0.
Sw = 0.
r(c) = 0.1 m
S = 9.632E-8
ß' = 0.0006079
ß" = 0.
r(w) = 0.1 m

Bore Construction Report

SOUTHDRILL
EXPLORATION & PILING

OFFICE USE ONLY

Date received:	Accession number:	Signed:
Bore number: **2852 bore no5**	Entered IRIS date:	Invoice date:

GENERAL DETAILS

Client/Consent holder's name: **Cameron**		Consent number: **RM25.435.05**
Location/Address: **122 MORVEN FERRY ROAD**		
Grid reference - Easting: **1271404m E**	Northing: **5008426m N**	Mobile phone: **02108851148**
Sketch plan attached: **Yes**	Photos attached: **Yes**	Home phone:

DRILLING DETAILS

Drilling company: **SouthDrill Ltd**	Driller: **Rowland Harrex**
Machine/Rig: **Western Star Drilling Rig [QCL493]**	Fleet no. **2030**
Drill method(s): **Air Rotary**	

BORE CONSTRUCTION DETAILS

Start date: **21/11/2025**	Finish date: **05/12/2025**
Bore diameter: **200mm**	Casing material: **Steel**
Screen material: **N/A**	
Screen diameter (inside): **0mm**	Screen diameter (outside): **0mm**
Screen slots: **0mm**	Overdrilled: **Yes**

PUMPING/WATER DETAILS

Dry bore: **No**	If dry, was casing retrieved?	Bore filled in:
Development period: **29 hours**	Development method: **Airlifted**	
Yield/test pumping: **Pumped**	Test pump period: **28 hours**	
Test pump rate: **11.7 litres/second**	Method of measuring reate: **METER**	
Comments: **DID 2 STAGE PUMP TEST AND 26HRS CONSTANT RATE**		
Pumped water level: **32.5 metres**		

WATER QUALITY ETC

Bacterial water test: **Yes**	Chemical water test: **Yes**
Casing top sealed: **Yes**	Impervious seal at ground: **Yes**
Comments: **TOKE HILL LAB TEST WHEN DEVELOPING AND CONSALTENT DID HIS OWN WILL WE PUMPED 0.63NTU**	

BORE LOG (METRES BELOW REFERENCE POINT)

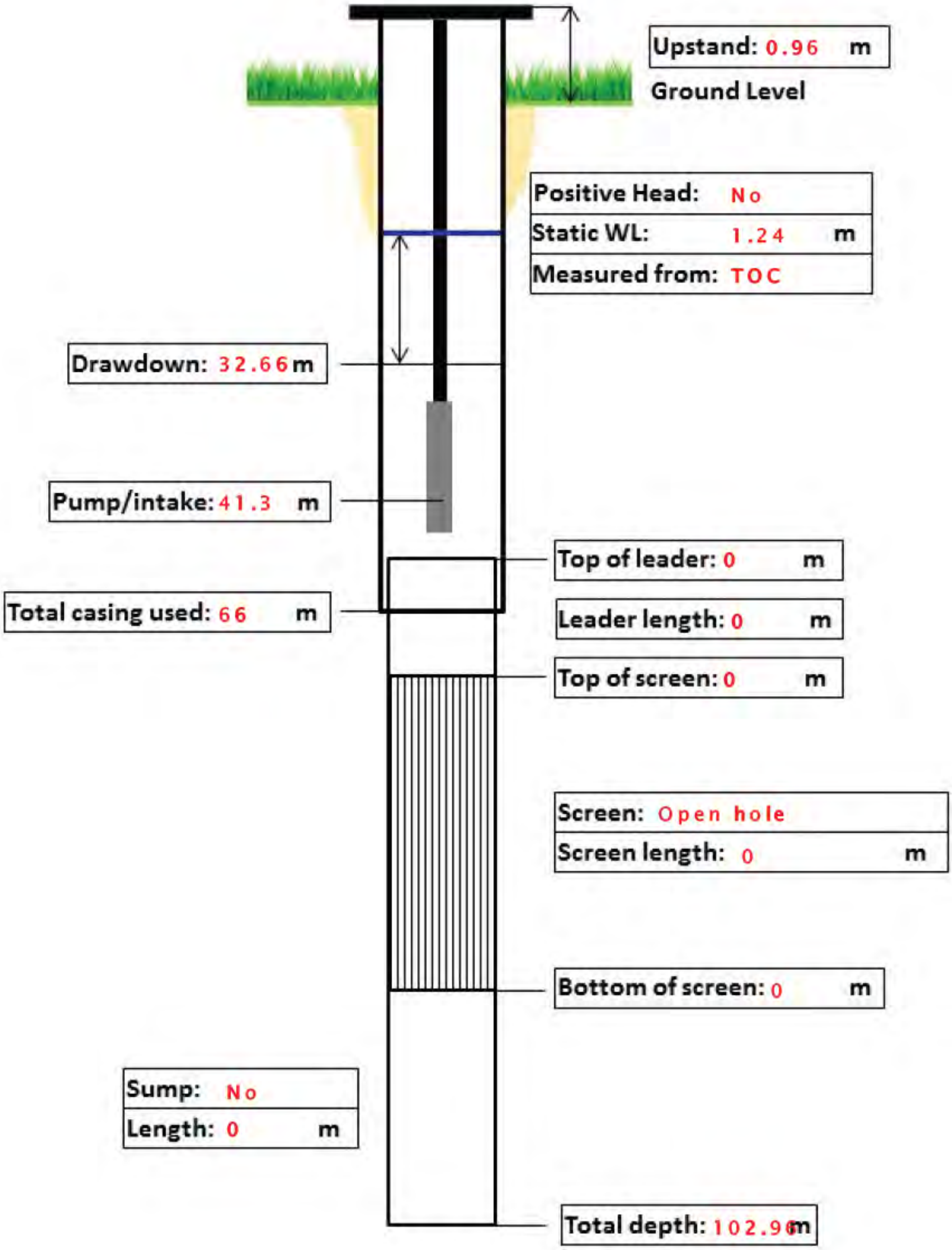
0m–3.1m	TOP SOILS ODD GRAVEL
3.1m–8.2m	SANDY GRAVELS
8.2m–15.2m	BLUE SILTS ODD GRAVELS
15.2m–20.2m	TIGHT SILTS GRAVELS
20.2m–28.8m	BANDS BLUE SILTS AND GRAVELS
28.8m–30.89m	SCHIST ROCK
30.89m–42m	OPEN HOLE 30.89M SOFT AND HARD BANDS SCHIST BLOWING ABOUT 2 LTS/SEC WATER
42m–60m	SOFT AND HARD BANDS SCHIST BLOWING 10-15 LTS/SEC aprox
60m–72m	SCHIST HARD SMALL SOFT ZONES BLOWING 10-15LTS/SEC PLUS aprox
72m–73.2m	SOFT ZONE POSSABLY MORE WATER FLOW
73.2m–100m	SCHIST HARD SMALL SOFT ZONES
100m–102m	SOFT FRACTUERD HOLE CAVEING IN
102m	6inch CASEING TO 66M

Do you intend to drill more bores under this Land Use Consent number? **No**	
If yes, number of bores drilled:	Number of bore logs provided:

PTO for bore diagram

Bore Construction Diagram

Bore number:
2852 bore no5



Upstand: 0.96 m

Positive Head: No

Static WL: 1.24 m

Measured from: TOC

Drawdown: 32.66 m

Pump/intake: 41.3 m

Top of leader: 0 m

Total casing used: 66 m

Leader length: 0 m

Top of screen: 0 m

Screen: Open hole

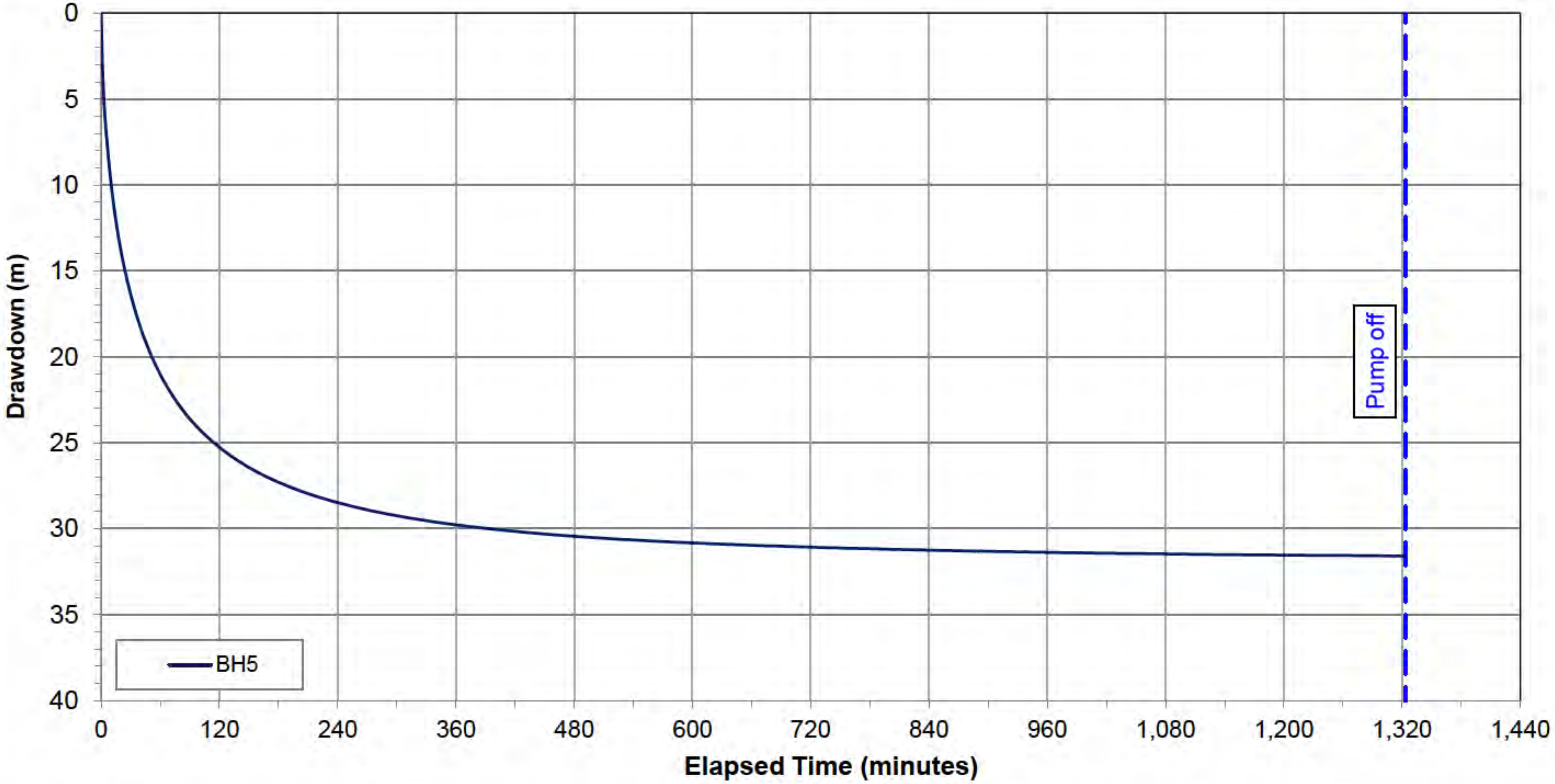
Screen length: 0 m

Bottom of screen: 0 m

Sump: No

Length: 0 m

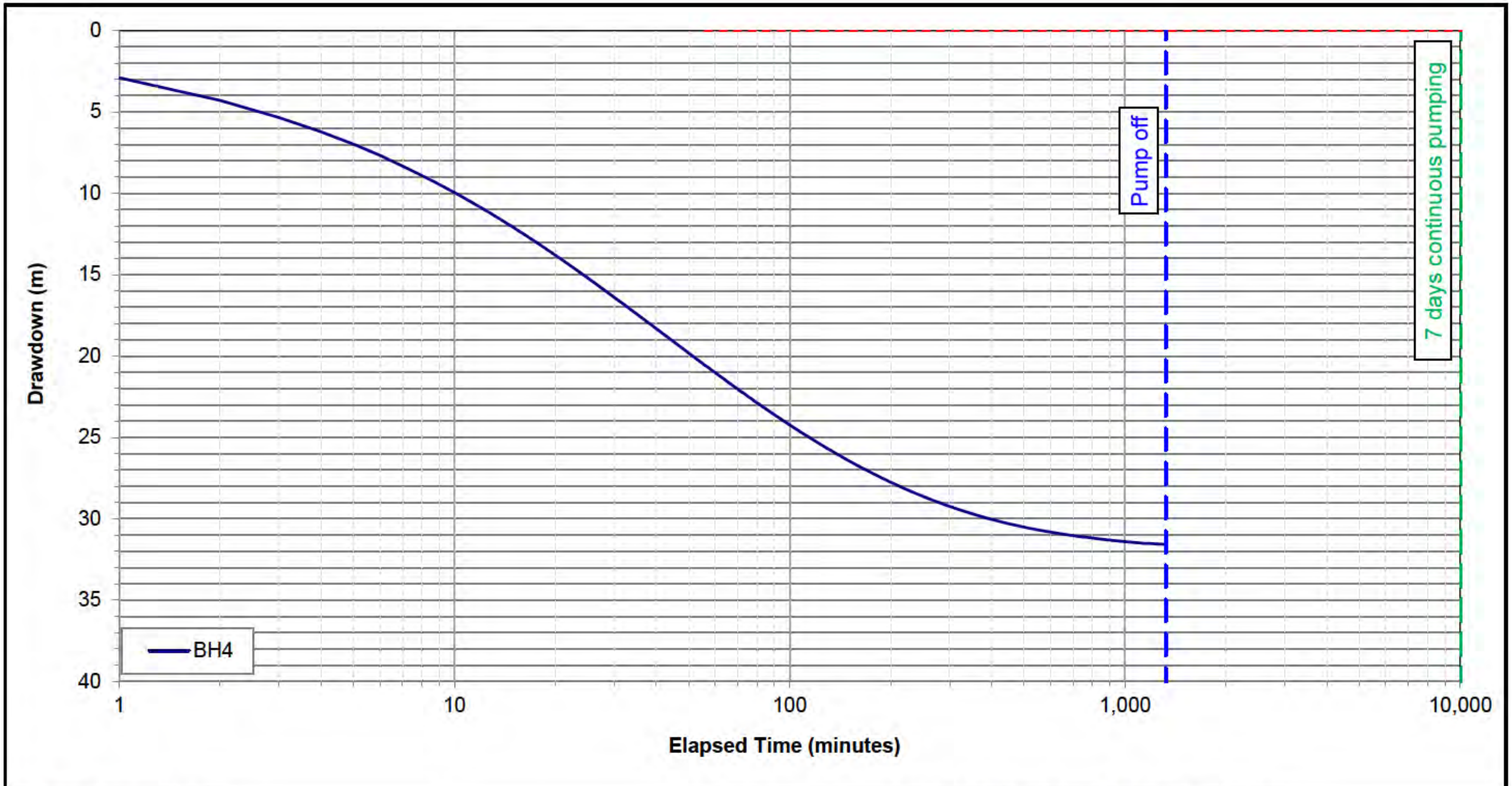
Total depth: 102.96 m



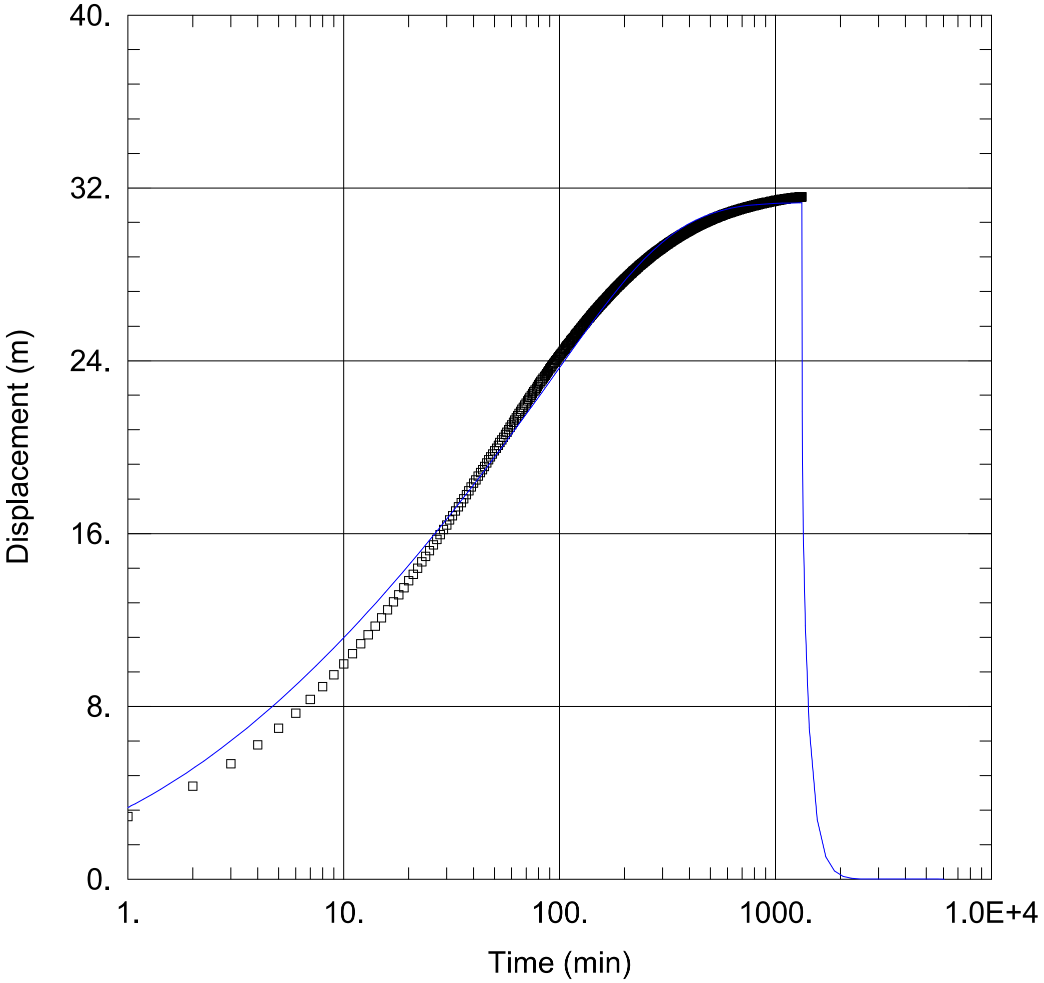
Water Supply Trial BH5
122 Morven Ferry Road

WGA

TITLE	**Constant Rate Pumping Test Drawdown, 3 December 2025** **Normal - Normal Scale Plot. Data supplied by SouthDrill.**				
DRAWN	B. Sinclair	DATE	15 December 2025	JOB NO.	WGA252389
CHECKED	J Manning	SCALE	na	DWG. NO.	na
REVIEWED	B. Sinclair	FILE NO.	na	FIGURE NO.	C4



Water Supply Trial BH5 **122 Morven Ferry Road**	TITLE	**Constant Rate Pumping Test Drawdown, 3 December 2025** **Log - Normal Scale Plot. Data supplied by SouthDrill.**			
WGA	DRAWN	B. Sinclair	DATE	15 December 2025	JOB NO. WGA252389
	CHECKED	J Manning	SCALE	na	DWG. NO. na
	REVIEWED	B. Sinclair	FILE NO.	na	FIGURE NO. C5



WELL TEST ANALYSIS

Data Set: V:\...\BH5 - Hantush leaky.aqt
Date: 12/15/25
Time: 17:25:27

PROJECT INFORMATION

Company: WGA
Project: WGA252389

AQUIFER DATA

Saturated Thickness: 73. m
Anisotropy Ratio (Kz/Kr): 301.
Aquitard Thickness (b'): 29. m
Aquitard Thickness (b"): 1. m

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
BH5	0	0

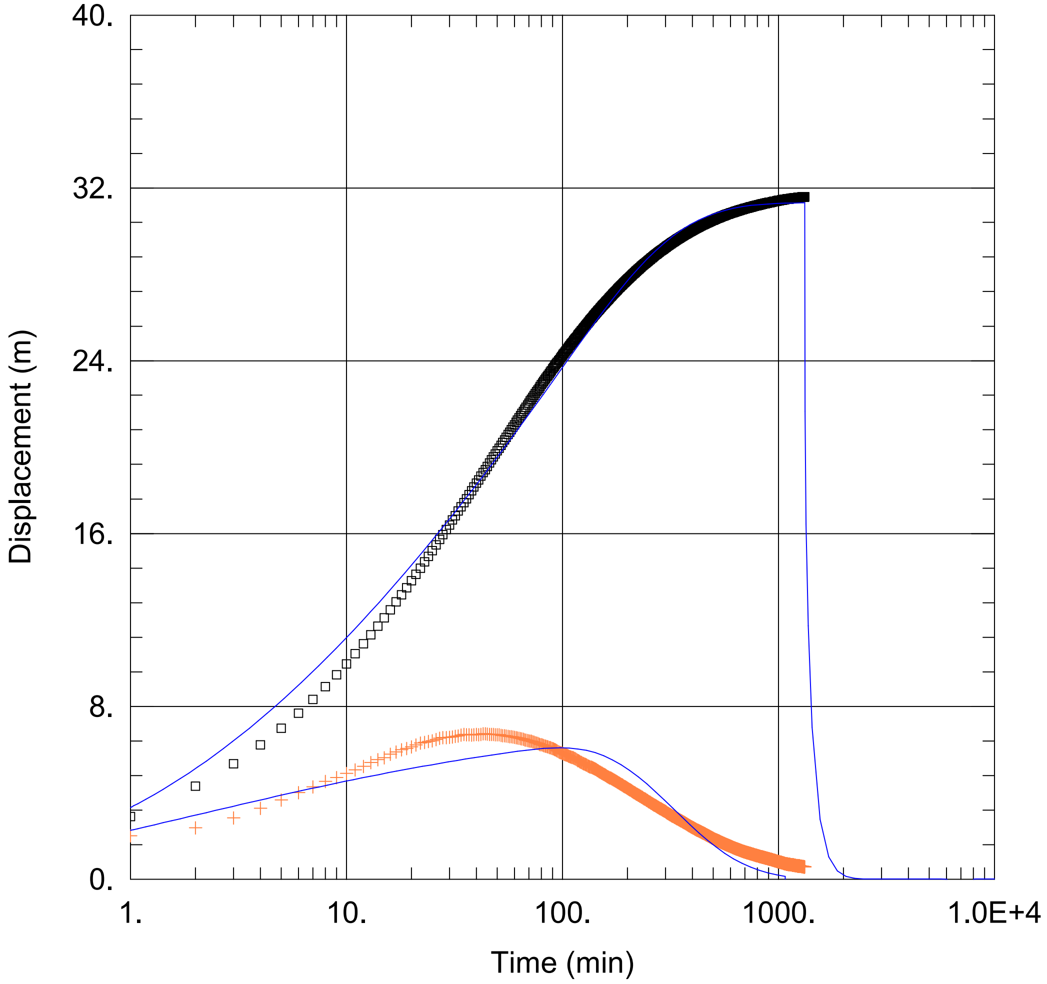
Observation Wells

Well Name	X (m)	Y (m)
□ BH5	0	0

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 5.174 m^2/day
S = 0.001291
r/B' = 0.4531
ß' = 20.
r/B" = 0.
ß" = 0.



WELL TEST ANALYSIS

Data Set: V:\...\BH5 - Hantush leaky.aqt
Date: 12/15/25 Time: 17:24:44

PROJECT INFORMATION

Company: WGA
Project: WGA252389

AQUIFER DATA

Saturated Thickness: 73. m
Anisotropy Ratio (Kz/Kr): 301.
Aquitard Thickness (b'): 29. m
Aquitard Thickness (b"): 1. m

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
BH5	0	0

Observation Wells

Well Name	X (m)	Y (m)
□ BH5	0	0

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 5.174 m^2/day
S = 0.001291
r/B' = 0.4531
ß' = 20.
r/B" = 0.
ß" = 0.

WGA

FOR FURTHER INFORMATION CONTACT:

Cameron Jasper
Senior Hydrogeologist

[redacted]

WGA.COM.AU
WGANZ.CO.NZ

[redacted]