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April 25, 2024
File: 23403-A
R1

Attention: Mario Minella

Re: Hydrogeological Investigation Report – Proposed Subdivision Development
Pinnacle Ridge, Anmore, BC

1.0 INTRODUCTION

The Pinnacle Ridge Hillside Estate comprises four parcels, totalling approximately 75 acres, along the Village of Anmore's eastern boundary. These parcels are under the ownership of three entities: MNP Ltd., Anmore Gate Limited Partnership and Bella Terra Investments 2 Inc. The collaborative efforts between the landowners have yielded a thoughtfully united site design that emphasizes connectivity throughout the area, a large network of green space and trails and strategically clustered housing to reduce the amount of development on steep slopes.

This application seeks to rezone the site from Residential 1 (R-1) zone to Comprehensive Development (CD) zone. Rezoning the site to the CD zone will allow for specific land use controls to address the site's hillside topography and allow for clustered housing. The proposed CD zone introduces new housing types (semi-detached and townhomes) in addition to single family homes which will be regulated by specific land use controls within the CD zone.

In addition, this application seeks to amend the Village of Anmore's Official Community Plan (OCP) to allow for a higher density on the site (3.5 units per acre) and development on slopes exceeding 30%. The intention is to cluster residential homes in areas of a gentler slope, whilst preserving steeper slopes as dedicated green space. The large areas of green space across the site are to be complemented with an extensive trail network, enriching the outdoor recreational opportunities for future residents.

The three parcels of development would include the extension of the existing Ridge Mountain Drive, which provides access to the east portion of the sites, the extension of North Charlotte Drive, which connects to Charlotte Crescent in Port Moody, along with new internal roads and cul-de-sacs. Each subdivision includes single family, duplex, townhomes, and apartment/stacked townhome over a single level below grade. Due to the sloping topography of the site, we envisage basements would typically daylight downslope and below grade foundation walls may extend up to 2 levels at the up-slope side of structures. The elevation of the basement slabs will vary across the site.

We recommend that this report is read in conjunction with the following parcel-specific reports:

- *GeoPacific, 2023. Geotechnical Investigation Report – Proposed Subdivision Development – The Summit (TREZ). Pinnacle Ridge, Anmore, BC.*
- *GeoPacific, 2023. Geotechnical Investigation Report – Proposed Subdivision Development – Anmore Gate, Pinnacle Ridge, Anmore, BC.*
- *GeoPacific, 2023. Geotechnical Investigation Report – Proposed Subdivision Development – Bella Terra Pinnacle Ridge, Anmore, BC*

This report presents the results of our hydrogeological monitoring and testing conducted at the site and provides recommendations pertaining to groundwater management for the design and construction of the proposed development. This report has been prepared exclusively for our client, for their use and the use of others on their design and construction team. We also expect this report will be relied upon by the Village of Anmore during their permit process. No other use of this report is permitted without written consent of GeoPacific.

2.0 SITE DESCRIPTION

Pinnacle Ridge Hillside Estate (henceforth referred to as the site) are located within the Pinnacle Ridge area of Anmore. The combined sites are bounded by forested private property to the north, single-family residential homes, Ridge Mountain Drive, and private property lots to the west and by crown land and the City of Port Moody boundary to the east and south. The three sites occupy a combined area of about 300,000 m^2. The site is sloped from northeast to southwest with elevations of approximately 427 m to 215 m geodetic.

The location of the site in relation to existing improvements is shown on our site plan, Drawing No. 23403-GW-01, following the text of this report. More detailed site descriptions for each of the individual properties is provided in the relevant geotechnical investigation reports completed (as noted above in Section 1.0).

3.0 INVESTIGATION

3.1 Drilling Investigation

GeoPacific Consultants Ltd. completed a geotechnical drilling investigation at the site on October 12th, 13th, and 16th, 2023. At that time, 21 solid stem auger boreholes were advanced up to 6.1 m below existing grades and eight standpipe piezometer groundwater monitoring wells were installed throughout the properties.

Selected test holes were supplemented with Dynamic Cone Penetration Test (DCPT) soundings to estimate the in-situ relative density of the upper soil profile. Selected test holes were completed as groundwater monitoring wells to aid in characterizing the hydrogeological conditions at the site. The drilling was completed utilizing a track mounted auger drill rig supplied and operated by Southland Drilling of Delta, BC. The investigations were supervised, and the soils encountered were logged in the field, by one of our technical staff.

Boreholes completed as monitoring wells were installed with 50 mm diameter PVC well tubing, surrounded by a sand filter medium at depth, for the purpose of ground water monitoring. The remaining test holes were backfilled with excavated soil upon completion of logging and sealed with bentonite chips, in accordance with Provincial abandonment requirements.

The approximate locations of the auger test holes and monitoring wells with respect to the development site are shown on our Drawing No. 23403-GW-01, following the text of this report. Test hole logs are provided in Appendix 'A' of this report.

4.0 GEOLOGICAL CONDITIONS

4.1 Mapped Geology

Based on the Geological Survey of Canada Map 1484A – the site is underlain by Vashon Drift (Va) deposits comprised of lodgement till (with sandy loam matrix) and minor flow till containing lenses and interbeds of glaciolacustrine laminate stony silt, and the site is underlain by Pre-Tertiary Mesozoic bedrock (PT) including granitic and associated rock types; where bedrock is not at the surface, it is overlain by glacial deposits and colluvium. Based on the Geological Survey of Canada Map 1151A – the glacial deposits are underlain by granodiorite of the Coast Plutonic Rocks.

4.2 Subsurface Conditions

A general description of the soils encountered at the site during our investigation is provided below. For specific subsurface soil descriptions at each test hole location, please review our test hole logs in Appendix 'A', following this report. A general description of the soils encountered during our drill investigation are as follows:

FORREST LITTER / TOPSOIL

Our test holes were completed in locations where forest litter/topsoil had been stripped as part of the temporary access roads; however, we anticipate 0.3 to 0.6 m of loose topsoil and forest litter are present at surfaces throughout the site. These surficial soils were observed to contain organics, roots, varying amounts of sand and silt and are dark brown and moist.

SANDY SILT to SILTY SAND (Post Glacial)

Sandy silt soil was observed at all test hole locations and extends 0.5 to 0.9 m below existing site grades at test hole locations. The sandy silt was observed to vary in relative density from loose to compact. Silty sand with trace gravel and occasional cobble was observed at excavation cuts for temporary access roads; however, this soil was generally stripped during clearing and access road at our test hole locations.

Sand and gravel soils were observed at TH23-06 directly below the sandy silt. These post glacial soils were noted to be compact to dense and were observed to extend down to depths of up to 1.1 m below existing site grades.

SILTY SAND AND GRAVEL (Glacial Till)

Glacial till was observed at all test holes at depths ranging from near surface to end of boreholes, at 6.1 m below existing site grades. DCPT refusal occurred at or near the top of the glacial till contact indicating that it is very dense. The glacial till is generally comprised of mixtures of silty sand and gravel with occasional cobbles and is grey and dry to moist. Exposed undisturbed glacial till was observed at localized areas along access road cuts slopes and was observed to be very dense to hard, showing no significant signs of erosion or disturbance from precipitation events. In our experience, frequent boulders may be present within the glacial till which may require splitting or removal during excavation.

Pre-Tertiary Bedrock

Based on our review of geological maps, pre-tertiary bedrock is present below the glacially deposited soils. Auger refusal at the Anmore Gate property to the south was encountered locally at 3.7 to 4.7 m below grade, indicating potential bedrock interface. We observed bedrock outcrops nearby at the northwest corner of Ridge Mountain Drive and North Charlotte Road, a potential bedrock outcrop or large boulder along the Ridge Mountain Drive alignment within the Anmore Gate property and observed a bedrock outcrop at the Meridian Cell Tower area to the east, during our geotechnical consulting for a new communication tower foundation support at this location in 2018.

For detailed soil descriptions please refer to our test hole logs provided in Appendix 'A' of this report.

5.0 HYDROGEOLOGICAL CONDITIONS

5.1 Mapped Aquifers and Hydrogeological Conceptualisation

The site is located in the Pinnacle Ridge area of Anmore, BC. Most of the site is not located within the mapped extent of any known groundwater aquifers, except for the southwest portion of the TREZ parcel which is mapped as being underlain by the Mossum Creek Confined Sand and Gravel Aquifer (Aquifer No. 924). The extent of the Mossum Creek aquifer has an area of approximately 4km^2 and the aquifer boundary has, according to the aquifer mapping report, available on the BC Water Atlas, has been delineated using spatially limited water well record information, topography, geological mapping, surface drainage features and the northern shoreline of Port Moody. It is described as a sand and gravel and possibly glaciolacustrine sand that is noted to be a complex of intertill aquifers. The vulnerability of the aquifer is described as low and the productivity is described as moderate. The geometric mean static water level, derived from 8 well records, is noted to be 9.07 m below ground level.

The aquifer is noted to be likely recharged from infiltration of precipitation and runoff on the upland areas to the east and west. Mossum Creek and Anmore Creek may be a source of recharge in the upland areas. Direction of groundwater flow in this aquifer, relatively to the subject site, is anticipated to be south westerly towards the inlet at Port Moody.

It should be noted that this aquifer (Aquifer No. 924) was not recorded on any of our test hole logs, and is mapped to be present in the southwest portion of the TREZ site only. No test holes were advanced in this area, however we do not anticipate that this aquifer will be encountered as it is expected to be present far below the proposed depth of excavation (which we assume to be no greater than 6-7 m).

Any groundwater encountered during the proposed excavation is therefore anticipated to be representative of perched groundwater that has accumulated at the upper contact of the glacial till soils or within sandy lenses within the glacial till soils. Perched groundwater encountered in glacial till soils typically tends to drain relatively quickly during excavation with the rate of perched groundwater seepage steadily decreasing to a near-negligible rate. Perched groundwater may be absent during the drier summer months, and is expected to be recharged following periods of sustained precipitation. Perched groundwater is anticipated to migrate downslope, and hence the flow direction of any perched groundwater is expected to be similar to topography and generally flow from northeast to southwest across the site.

5.2 Groundwater Monitoring Wells

Eight groundwater monitoring wells were installed at the site as part of the 2023 site investigation. The purpose of these wells was to confirm the elevation of the assumed perched groundwater across the site and to facilitate hydraulic property testing. The following table (Table 1) is a summary of the wells installed at the site.

Table 1 – Summary of Groundwater Monitoring Wells

Well No.	Screened Section (m bgs)	Geology of Screen Section
TH23-01A (MW23-01A)	3.0 - 4.5	Silty Sand and Gravel (Till)
TH23-04A (MW23-02A)	4.6 - 6.1	
TH23-06A (MW23-03A)	4.6 - 6.1	
TH23-02B (MW23-01B)	4.6 - 6.1	
TH23-07B (MW23-02B)	3.0 - 4.5	
TH23-09B (MW23-03B)	4.6 - 6.1	
TH23-02C (MW23-01C)	3.0 - 4.5	
TH23-03C (MW23-02C)	3.0 - 4.5	

After installation, the wells were subsequently developed using a PVC bailer. Each of the wells were observed to be dry after removing approximately a single well volume from each of the wells (with subsequently slow recovery observed). These observations during well development would suggest that the glacial till encountered at the site exhibit relatively low hydraulic conductivity values and as such are not expected to be capable storing significant quantities of groundwater.

5.3 Manual Groundwater Level Measurements

Manual groundwater level measurements were obtained on three occasions using a Heron Instruments water level meter. These water levels are summarised on the following table:

Table 2 – Manual Groundwater Monitoring Measurements (in meters below grade)

Well No.	7th Nov, 2023	13th Nov, 2023	30th Jan, 2024	Range (m)
TH23-01A (MW23-01A)	2.60	2.20	1.12	1.12 – 2.60
TH23-04A (MW23-02A)	4.27	4.25	3.07	3.07 – 4.27
TH23-06A (MW23-03A)	2.80	2.70	2.55	2.55 – 2.80
TH23-02B (MW23-01B)	3.00	2.30	0.60	0.60 – 3.00
TH23-07B (MW23-02B)	2.10	1.33	0.58	0.58 – 2.10
TH23-09B (MW23-03B)	1.85	1.75	0.75	0.75 – 1.85
TH23-02C (MW23-01C)	0.72	0.80	1.15	0.72 – 1.15
TH23-03C (MW23-02C)	0.60	0.30	0.35	0.30 – 0.60

5.4 Automated Groundwater Level Monitoring

The following graph (Figure 1) shows the groundwater levels recorded using automated pressure transducers at the site for the period between November 2023 and January 2024.

Figure 1 – Groundwater Levels recorded using Automated Pressure Transducers

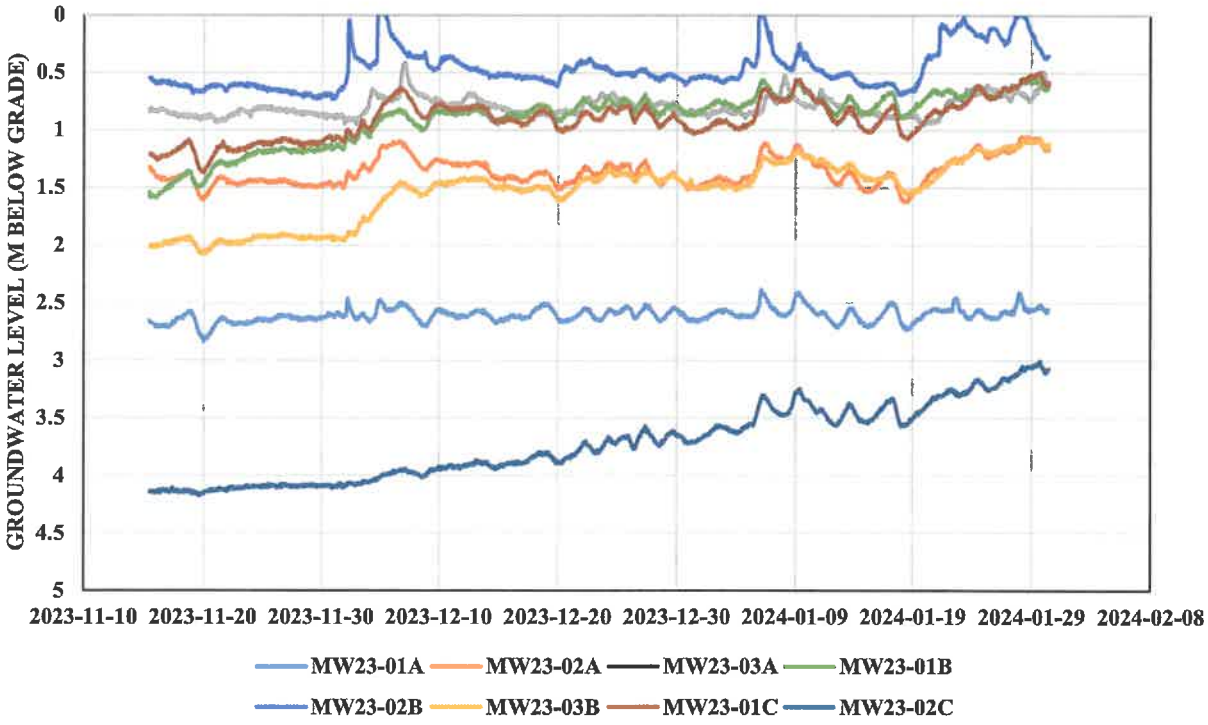

Figure 1, above, shows the groundwater levels relative to ground surface at each of the monitoring wells. The water levels have been presented in metres below ground surface for visualisation purposes, due to the considerable variation in elevations across the site.

Generally, each of the wells shows a similar trend in groundwater levels over-time with water levels generally increasing over the course of the monitoring period. This is consistent with our understanding of seasonal variation in groundwater levels whereby groundwater elevations generally increase through the wetter winter months. The above presented groundwater levels are expected to decrease during the drier summer months.

The groundwater trends presented above are representative of typical variation in perched groundwater in shallow glacial till soils. The groundwater levels presented would suggest that, depending on the time of year of excavation, that shallow perched groundwater may be encountered during excavation at depths of between about 0.5 m and 4.15 m.

At MW23-02B the perched groundwater level is shown to rise to ground surface on three occasions. This is shown to be a temporary occurrence, and this is likely due to water entering the well (which is screened between 3.0 m and 4.5 m) following a period of sustained or heavy precipitation. The hydraulic conductivity of soils surrounding the well screen is expected to be very low, and hence the well fills up at a rate faster than the soil can dissipate the water. We do not anticipate that this is representative of static artesian groundwater.

As discussed above, we infer this groundwater to be representative of perched groundwater derived from precipitation that is stored within sandier lenses of the glacial till and is not representative of recharge-driven static groundwater. Therefore, we anticipate groundwater seepage to be relatively minor and is expected to be manageable during construction using conventional methods such as trenching, sumps and sump pumps.

5.5 BC Water Atlas

A search was completed of the BC Water Atlas on the 21st March 2024. The search noted that 11 well records are mapped with 500 m of the site boundary. The following table (Table 3) is a summary of the well records.

Table 3 – Summary of BC Water Atlas Wells

Record No.	Orientation from site	Summary of Well Record
58219	310 m Northwest	Well was drilled to depth 83.0 m below ground level (bgl) in 1988. The soil was noted as clay and gravel/ boulders until 3.7 m, glacial till to depth 17.7 m, brown gravelly sand with boulder to 75.9 m, followed by clayey gravel with layers of wood to 80.8 m then gravelly fractured rock to 83.0 m. Well yield was noted to be 7 gpm.
55546	175 m Southwest	No well record found.
57338	256 m Northeast	Well was drilled to depth of 98.0 m bgl in 1987. The soil was noted as gravel and boulders until 3.7 m, thin layer of brown clay to 5.2 m, coarse sand and gravel with some cobbles followed by fine sand to 21.9 m, wet coarse gravel and sand to 36.6 m then till and boulders to 46.6 m. Granite bedrock was encountered at 46.6 m to 98.0 m. Water bearing fractured bedrock was noted at depths between 73.1 m to 82.2 m and 91.4 m to 97.5 m. Well yield was noted to be 1 gpm.
66977	322 m Soutwest	Well was drilled in 1989 and advanced to depth 110.0 m bgl. The soil was noted as glacial till to 7 m, thick layer of dry fine sand and gravel to 46.6 m, then clayey gravel with occasional boulders layer to 52.1 m. Granite bedrock was encountered at 52.1 m to termination depth. Water bearing fractured bedrock was noted at depths between 96.9 m to 110.0 m. No yield or flow rate values are provided.
74038	186 m Southwest	No well record found.
74085	186 m South	Well was drilled to depth of 105.0 m bgl in 1988. The soil was noted as glacial till with some boulders until 16.8 m, sandy clay to 21.3 m, gravelly till with occasional boulders to depth 26.8 m, followed by very dense clayey sand with some gravel to 57.9 m, clayey gravel layer with some boulders to 64.6 m. Granite bedrock was encountered at 64.6 m to termination depth. Water bearing bedrock was noted at depths between 68.6 m to 105.0 m. Well yield was noted to be 3 to 4 gpm.
78613	256 m Southeast	Well was drilled in 1995 and advanced to a depth of 160.0 m. The soil was noted as glacial till with some gravel to 26.5 m, followed by dry fine sand to 39.9 m interbedded between cemented gravel layer at 26.5 m to 34.1 m and 39.9 m to 57.0 m.

Record No.	Orientation from site	Summary of Well Record
		Granite bedrock was encountered at 57.0 m to termination depth. Fractured bedrock was noted at depths between 152.7 m to 154.5 m. Well yield was noted to be 4 gpm.
31261	350 m South	Well was drilled to depth of 119.0 m in 1974. The soil was noted as glacial till and boulders until 12.2 m and to 23.8 m with compact silty sand interbedded within between depth 12.2 m to 20.4 m, followed by permeable soils consists of vary amount of sand and gravel to depth 59.1 m. Granite bedrock was encountered at 59.1 m to 119.0 m. Well yield was noted to be 1 gpm.
108180	387 m Southeast	Well was drilled in 1990 and advanced to depth 123.0 m. The soil was noted as glacial till and boulders to 29.6 m, followed by sand and gravel to 50 m, then very dense cemented gravel layer to 59.1 m. Granite bedrock was encountered at 59.1 m to termination depth. Fractured bedrock was noted at depths between 84.7 m to 86.6 m and 112.5 m to 113.7 m. Well yield was noted to be 8 gpm.
74086	377 m Southeast	Well was drilled to depth of 136.0 m in 1989. The soil was noted as glacial till until 12.2 m, coarse gravel and cobbles layer to depth 12.2 m, followed by sand and gravel layer to depth 59.1 m. Granite bedrock was encountered at 59.1 m to termination depth. Fracture granite was noted at 58.8 m to 59.4 m. Well yield was noted to be 5 gpm.
99784	426 m Southeast	Well was drilled in 1996 and advanced to depth 175.0 m. The soil was noted as fill to 5.5 m, compact silty sand and gravel layer to 31.1 m, followed by hard silty sand to 47.5 m, then very dense cemented gravel layer to 59.1 m. Granite bedrock was encountered at 59.1 m to termination depth. Fractured bedrock was noted at depths between 144.5 m to 146.9 m and 170.7 m to 175.0 m. Estimated well yield was noted to be 50 gpm.

5.6 Hydraulic Conductivity Testing

Slug testing was completed at selected groundwater monitoring wells, to determine the hydraulic conductivity of the underlying strata across the site. The electronic piezometer was set to a 1 or 6 second sampling rate and an initial water level was recorded. A PVC bailer was used to create a near-instantaneous change in water head, and water levels were subsequently monitored until near recovery was measured (where achievable). The results of our conductivity testing are summarized in Table 4.

Table 4 – Hydraulic Conductivity Testing

Well No.	Screened Geology	Bouwer & Rice Method (m/s)
TH23-01A (MW23-01A)	Silty Sand and Gravel (Till)	3.06×10^{-08}
TH23-04A (MW23-02A)		1.40×10^{-07}
TH23-06A (MW23-03A)		1.21×10^{-06}
TH23-02B (MW23-01B)		1.59×10^{-06}
TH23-07B (MW23-02B)		1.85×10^{-08}
TH23-09B (MW23-03B)		8.45×10^{-08}
TH23-02C (MW23-01C)		4.92×10^{-07}
TH23-03C (MW23-02C)		-
Geomean		1.81×10^{-07}

***No test could be completed at MW23-02C as there was insufficient water column.**

The results of the falling head slug test were analyzed with Aquifer Test Pro 10.0 and are presented in Appendix 'B'.

5.7 Groundwater Summary

The preceding sections describe a detailed hydrogeological study completed at the site. The automated groundwater monitoring data, presented on Figure 1, indicates that groundwater levels in the glacial till vary between about 0.5 m and 4.15 m below grade. The slug testing results, presented on Table 4, generally conform to the soil descriptions presented in Section 3.0 (i.e., the estimated hydraulic conductivities fall within a reasonable expected range for soils that are representative of very dense glacial till deposits).

Given the information presented above, we do not anticipate significant groundwater seepage will occur to the proposed excavation either during construction or in the post-construction condition. A seepage analysis is included below in Section 6.0 which will provide an estimate of seepage rates to the site.

6.0 SEEPAGE ANALYSIS

Due to the considerable size of the site, it is not practical to complete a seepage analysis for each of the proposed excavations at this stage. To provide a guide on likely groundwater seepage rates we have prepared a typical excavation section using our soil and groundwater information as described in the previous sections. The following seepage analysis was undertaken using a finite element computer program SEEP/W (GeoStudio, 2024) to provide an initial estimate for the groundwater inflows into the excavation areas for the site.

Considering our field observations and experience in the area, the following assumptions were considered in the finite element seepage analysis:

1) All materials are modelled as saturated;
2) As a conservative measure, a constant head boundary for recharge to the seepage model was assumed to be 30 m from the excavation;
3) The slope is assumed to be 1V/5H;
4) The excavation depths were assumed to be 1 m below grade on the downgradient side and 9 m below grade on the upgradient side;
5) The excavation is assumed to be 40 m x 40 m (i.e., area equivalent to 1,600 m^2);
6) Several groundwater heads (0 m, -1.0 m, -2.0 m and -3.0 m) were modelled to assess the seepage rate for various scenarios, with flow assumed to be from the up-gradient direction only due to the slopes of the site;
7) The hydraulic conductivity of the post-glacial sediments has been assumed, from our experience of similar soils , to be 5.0 x 10^{-06} m/s;
8) The hydraulic conductivity of the glacial till has been estimated, from the geometric mean of slug testing results, to be 1.81 x 10^{-07} m/s. To assess the sensitivity of the model the value for hydraulic conductivity of the till was also modelled at 5.43 x 10^{-07} m/s (i.e., 3 x the estimated value);
9) The calculated seepage volumes are based on inflows from subsurface groundwater only. Inflows as a result of precipitation are not included.

The following table is a summary of seepage rates estimated using the above assumptions:

Table 5 – Summary of Seepage Analysis Workings

Scenario	Estimated Flow Rate (L/min)	Estimated Flow Rate (per 1,000 m^2)
Hydraulic Conductivity of Glacial Till – 1.81 x 10^{-07}		
Groundwater head at 3 m below grade	2.8	1.7
Groundwater head at 2 m below grade	3.2	2.0
Groundwater head at 1 m below grade	3.7	2.3
Groundwater head at 0 m below grade	4.3	2.7
Hydraulic Conductivity of Glacial Till –5.43 x 10^{-07}		
Groundwater head at 3 m below grade	5.9	3.7
Groundwater head at 2 m below grade	6.6	4.1
Groundwater head at 1 m below grade	7.3	4.6
Groundwater head at 0 m below grade	8.0	5.0

The seepage model estimated that peak perched groundwater seepage, for an excavation as described in the above assumptions, could range between 2.8 L and 4.3 L/min for the entire excavation or between 1.7 L and 2.7L/min per 1,000 m^2 of excavation. This model assumes a constant head is present 30 m from the excavation edge, and hence is reasonably conservative. Flow rates during the warmer summer months may cease entirely as the mechanism for groundwater recharge (i.e., sustained precipitation) is absent. The graphical representations of our seepage analysis results are included in Appendix 'C'.

The seepage analysis has been undertaken based on some assumptions and in conjunction with the limitations of the software which include analysis in two-dimensional space with a somewhat simplified soil stratigraphy. The layers within the model have been inferred based on borehole logs. Slight variations in elevations, soil conditions, and fluctuating groundwater levels will ultimately impact the actual flow volumes encountered in the excavation. GeoPacific can provide actual groundwater inflows through field measurements once the excavation is underway.

7.0 GROUNDWATER IMPACT ASSESSMENT

GeoPacific conducted an impact assessment to demonstrate that there will be no significant impacts resulting from groundwater extraction or diversion from the site.

I. *Ground Subsidence*

Given the soils encountered at the site there is very low risk of ground subsidence. Very dense glacial till soils are not expected to be prone to settlement associated with the draining of perched groundwater. The post-glacial soils encountered at the site are similarly dense and are also not anticipated to be at risk of settlement from draining perched groundwater. Additionally, any dewatering is anticipated to be entirely passive and no active dewatering is anticipated. The risk of groundwater subsidence occurring due to proposed activities at the site is therefore low.

II. *Impacts to Nearby Wells*

A summary of groundwater supply wells, located within 500 m of the site, is shown above in Table 3. Each of the well records describes a water supply well that is screened into the underlying granitic bedrock, which we assume to be present between 3 m and 10 m below the proposed lowest excavation depths across the site and hence is not expected to be encountered. The well records state the wells were drilled between 1974 and 1996 (and hence pre-date the construction of water supply reservoirs above the site and as such the wells may no longer be active). There are therefore no impacts anticipated to any surrounding water supply wells (as shown on the BC Water Atlas Website).

III. *Surface Water and Historic Streams*

The two major named surface water features are Mossum Creek (which at its nearest is 450 m west of the site) and West Noons Creek (which at its nearest is 385 m east of the site). Neither of which are expected to impact on the proposed development. A detailed hydrology review is included in the relevant geotechnical investigation reports as described above in Section 1.0. Ultimately there are no significant impact to the proposed developments associated with the presence of drainage features.

If the project design changes, then this report should be revisited and updated.

8.0 GROUNDWATER MANAGEMENT PLAN

8.1 Construction

Any perched groundwater ingress and precipitation during construction will be directed to a sump. The sump is to be constructed at the low point(s) of the excavation to the specifications outlined on the Erosion and Sediment Control Plan. Water will then be pumped from the sump to the onsite water treatment system which includes CO2 adjustment, settling tanks and mechanical filtration. Discharge water will then be directed to a catch basin adjacent to the site.

8.2 Post-Construction

In the post-construction condition, any basement or below grade levels should include a perimeter drain board that is connected to underslab fills and a sump. We anticipate that any condensation, surface run-off or discreet perched groundwater that enters the perimeter drains would be directed to the underslab sump and is assumed to gravity drain to storm infrastructure.

9.0 DISCUSSION

This report summarises the groundwater monitoring, testing and analysis completed at the site. The soils encountered were noted to be a relatively thin (~ 1-2 m) surficial covering of post-glacial soils over very dense glacial till. The hydraulic conductivity testing completed at the site suggests that the glacial till soils are of low permeability and hence are unlikely to be capable of storing or transmitting significant quantities of groundwater.

A seepage analysis was completed, described above in Section 6.0, which estimated groundwater seepage into a representative excavation. The model output suggests that groundwater seepage into the representative excavation would vary between 1.7 L and 2.7 L/min per 1,000 m^2 of excavation. A sensitivity analysis was completed, to assess the effect on seepage rates from increasing the hydraulic conductivity of the glacial till subsoils. Increasing the hydraulic conductivity of the till by 3 times increased seepage rates to between 3.7 and 5 L/min. These estimated rates are expected to reduce further as the perched groundwater drains into the excavation over-time and may reduce to a negligible rate or cease entirely following prolonged dry periods.

Ultimately, we anticipate that some perched groundwater may be encountered during the proposed excavation works, though this is expected to drain relatively rapidly into the excavation by gravity with flows eventually decreasing further to a negligible rate or ceasing. Subsequent inflows of perched groundwater are anticipated following periods of sustained precipitation, whereby rainwater may accumulate at the upper contact of the low permeability to impermeable glacial till soils and temporarily seep into the excavation. It should be noted that we anticipate that the excavation would be completed in the drier summer months.

We anticipate that any construction dewatering can be completed using conventional methods such as trenching, sumps and sump pumps, with any accumulated water being subsequently directed to the ESC system where it is treated prior to discharge to the nearest catch basin. To prevent the buildup of hydrostatic pressure acting on the parkade wall or floor slab, we recommend that the below grade portion of the development incorporate a perimeter drainage board connected to underslab fills and a sump.

Lastly, monitoring wells can create preferential pathways for groundwater to travel and flow from zones of higher pressure towards areas with lower pressure and therefore it is recommended that any wells installed at the site be decommissioned in accordance with Provincial requirements.

10.0 DISCUSSION

This report has been prepared exclusively for our client for the purpose of providing recommendations pertaining to groundwater management for the design and construction of the proposed residential development, temporary excavations, and related earthworks. The report remains the property of GeoPacific Consultants Ltd. and unauthorized use of, or duplication of, this report is prohibited.

We are pleased to assist you with this project and we trust that this information is helpful and sufficient for your purposes at this time. Should you require any further details or if you would like clarification of any of the above, please do not hesitate to call or contact us.

For:

GeoPacific Consultants Ltd.

Sean Heffernan, M.Sc., P.Geo.
Senior Hydrogeologist

Reviewed by:

Wyatt Johnson, B.Eng., P.Eng.
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Matt Kokan, M.A.Sc., P.Eng.
Principal

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LEGEND:

- SITE BOUNDARY
- GROUNDWATER MONITORING WELL
- TEST HOLE
- BC WATER ATLAS WELLS

NOTES

LOCATION OF SITE BOUNDARY, TEST HOLES AND GROUNDWATER MONITORING WELLS ARE APPROXIMATE.

REFERENCE:

Basemap copyright Google (2024)

GEOPACIFIC CONSULTANTS

DATE:		
2024-03-21		
DRAWN BY:	APPROVED BY:	REVIEWED BY:
SRH	MJK	SRH
SCALE:		
NTS		

HYDROGEOLOGICAL INVESTIGATION

PINNACLE RIDGE DEVELOPMENT, ANMORE, BC

SITE PLAN

FILE NO.: 23403-GW-01

DWG. NO.: 23403-GW-01

REVISIONS:

A.

B.

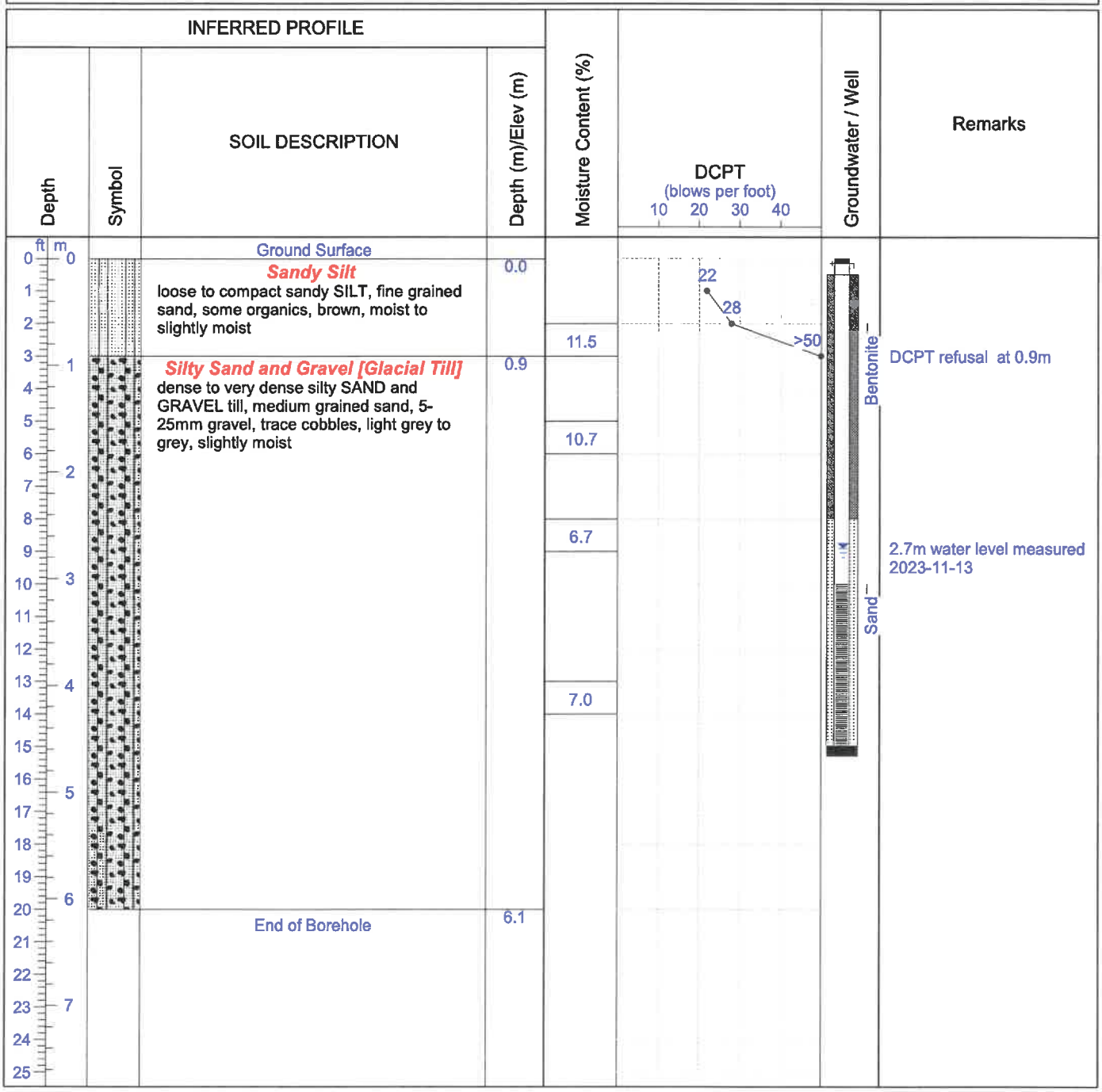
C.

APPENDIX A

Test Hole Log: TH23-01 (MW23-01)

File: 23403-A
Project: THE SUMMIT (TREZ)
Client: MNP LTD
Site Location: PINNACLE RIDGE ESTATE, ANMORE

GEOPACIFIC CONSULTANTS
1779 West 75th Avenue, Vancouver, BC, V6P 6P2
Tel: 604-439-0922 Fax:604-439-9189



Logged: SH
Method: Solid Stem Auger
Date: 2023-Oct-12

Datum: Ground Elevation
Figure Number: A.01
Page: 1 of 1

Test Hole Log: TH23-02

File: 23403-A
Project: THE SUMMIT (TREZ)
Client: MNP LTD
Site Location: PINNACLE RIDGE ESTATE, ANMORE

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INFERRED PROFILE

Depth (ft / m)	Symbol	SOIL DESCRIPTION	Depth (m)/Elev (m)	Moisture Content (%)	DCPT (blows per foot) 10 20 30 40	Groundwater / Well	Remarks
0 / 0		Ground Surface					
		Sandy Silt loose to compact sandy SILT, fine grained sand, some organics, brown, moist to slightly moist	0.0		6		
2 / 1		***Silty Sand and Gravel [Glacial Till]*** dense to very dense silty SAND and GRAVEL till, medium grained sand, 5-20mm gravel, trace cobbles, light grey to grey, slightly moist	0.6	10.4	19		DCPT refusal at 0.9m
4 / 1					>50		
8 / 2				8.2			
10 / 3							
13 / 4				7.3			
16 / 5							
19 / 6				6.4			
20 / 6		End of Borehole	6.1				
23 / 7							
25							

Logged: SH
Method: Solid Stem Auger
Date: 2023-Oct-12

Datum: Ground Elevation
Figure Number: A.02
Page: 1 of 1

Test Hole Log: TH23-03

File: 23403-A
Project: THE SUMMIT (TREZ)
Client: MNP LTD
Site Location: PINNACLE RIDGE ESTATE, ANMORE

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Depth (ft / m)	Symbol	SOIL DESCRIPTION	Depth (m)/Elev (m)	Moisture Content (%)	DCPT (blows per foot) 10 20 30 40	Groundwater / Well	Remarks
0 / 0		Ground Surface					
		Sandy Silt loose to compact sandy SILT, medium to coarse grained sand, some organics, brown, moist to slightly moist	0.0		12, 12, 17, >50		
3 / 1		***Silty Sand and Gravel [Glacial Till]*** dense to very dense silty SAND and GRAVEL till, medium grained sand, 5-20mm gravel, trace cobbles, light grey to grey, slightly moist	0.8	10.4			DCPT refusal at 1.2m
				8.2			
				7.3			
				6.4			
20 / 6		End of Borehole	6.1				

Logged: SH
Method: Solid Stem Auger
Date: 2023-Oct-12

Datum: Ground Elevation
Figure Number: A.03
Page: 1 of 1

Test Hole Log: TH23-04 (MW23-02)

File: 23403-A
Project: THE SUMMIT (TREZ)
Client: MNP LTD
Site Location: PINNACLE RIDGE ESTATE, ANMORE

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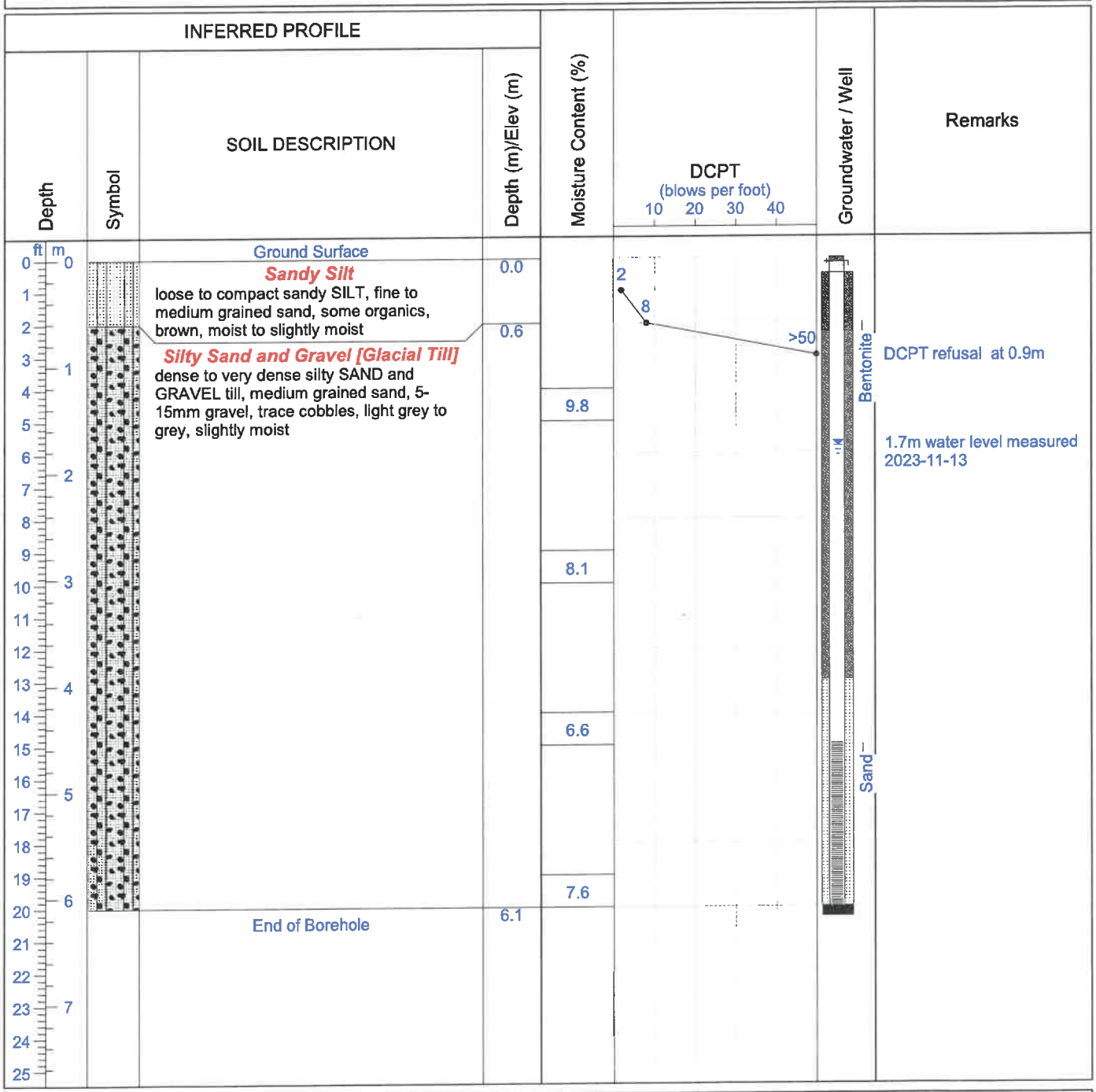

Logged: SH
Method: Solid Stem Auger
Date: 2023-Oct-12

Datum: Ground Elevation
Figure Number: A.04
Page: 1 of 1

Test Hole Log: TH23-05

File: 23403-A
Project: THE SUMMIT (TREZ)
Client: MNP LTD
Site Location: PINNACLE RIDGE ESTATE, ANMORE

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Tel: 604-439-0922 Fax:604-439-9189

Depth (ft / m)	Symbol	SOIL DESCRIPTION	Depth (m)/Elev (m)	Moisture Content (%)	DCPT (blows per foot) 10 20 30 40	Groundwater / Well	Remarks
0 / 0		Ground Surface					
0 – 3 / 0 – 1		***Sandy Silt*** loose to compact sandy SILT, medium to coarse grained sand, some organics, brown, moist to slightly moist	0.0		4, 10		
3 – 20 / 1 – 6		***Silty Sand and Gravel [Glacial Till]*** dense to very dense silty SAND and GRAVEL till, medium grained sand, 5-20mm gravel, trace cobbles, light grey to grey, slightly moist	0.8	9.2 9.0 8.1 7.4	>50, >50		DCPT refusal at 1.2m
20 / 6		End of Borehole	6.1				

Logged: SH
Method: Solid Stem Auger
Date: 2023-Oct-12

Datum: Ground Elevation
Figure Number: A.05
Page: 1 of 1

Test Hole Log: TH23-06 (MW23-03)

File: 23403-A
Project: THE SUMMIT (TREZ)
Client: MNP LTD
Site Location: PINNACLE RIDGE ESTATE, ANMORE

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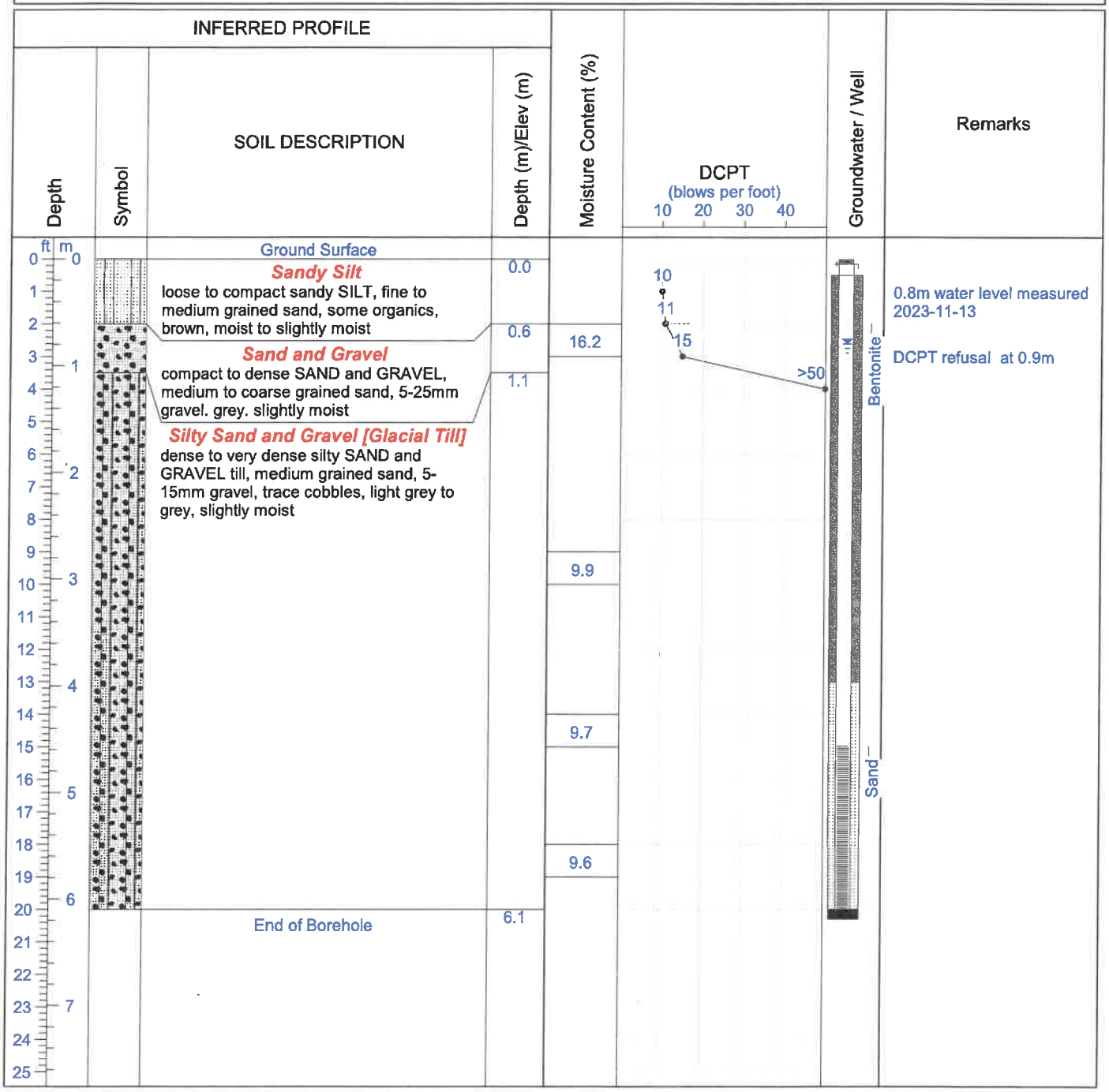

Logged: SH
Method: Solid Stem Auger
Date: 2023-Oct-12

Datum: Ground Elevation
Figure Number: A.06
Page: 1 of 1

Test Hole Log: TH23-07

File: 23403-A
Project: THE SUMMIT (TREZ)
Client: MNP LTD
Site Location: PINNACLE RIDGE ESTATE, ANMORE

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Tel: 604-439-0922 Fax:604-439-9189

INFERRED PROFILE

Depth (ft / m)	Symbol	SOIL DESCRIPTION	Depth (m)/Elev (m)	Moisture Content (%)	DCPT (blows per foot) 10 20 30 40	Groundwater / Well	Remarks
0 / 0		Ground Surface					
0–2 / 0–0.5		***Sandy Silt*** loose to compact sandy SILT, medium to coarse grained sand, some organics, brown, moist to slightly moist	0.0 – 0.5		4 → >50		DCPT refusal at 0.6m
2–20 / 0.5–6.1		***Silty Sand and Gravel [Glacial Till]*** dense to very dense silty SAND and GRAVEL till, medium grained sand, 5-20mm gravel, trace cobbles, light grey to grey, slightly moist	0.5 – 6.1	16.2 9.9 9.7			
20 / 6.1		End of Borehole	6.1				

Logged: SH
Method: Solid Stem Auger
Date: 2023-Oct-12

Datum: Ground Elevation
Figure Number: A.07

Test Hole Log: TH23-08

File: 23403-A
Project: THE SUMMIT (TREZ)
Client: MNP LTD
Site Location: PINNACLE RIDGE ESTATE, ANMORE

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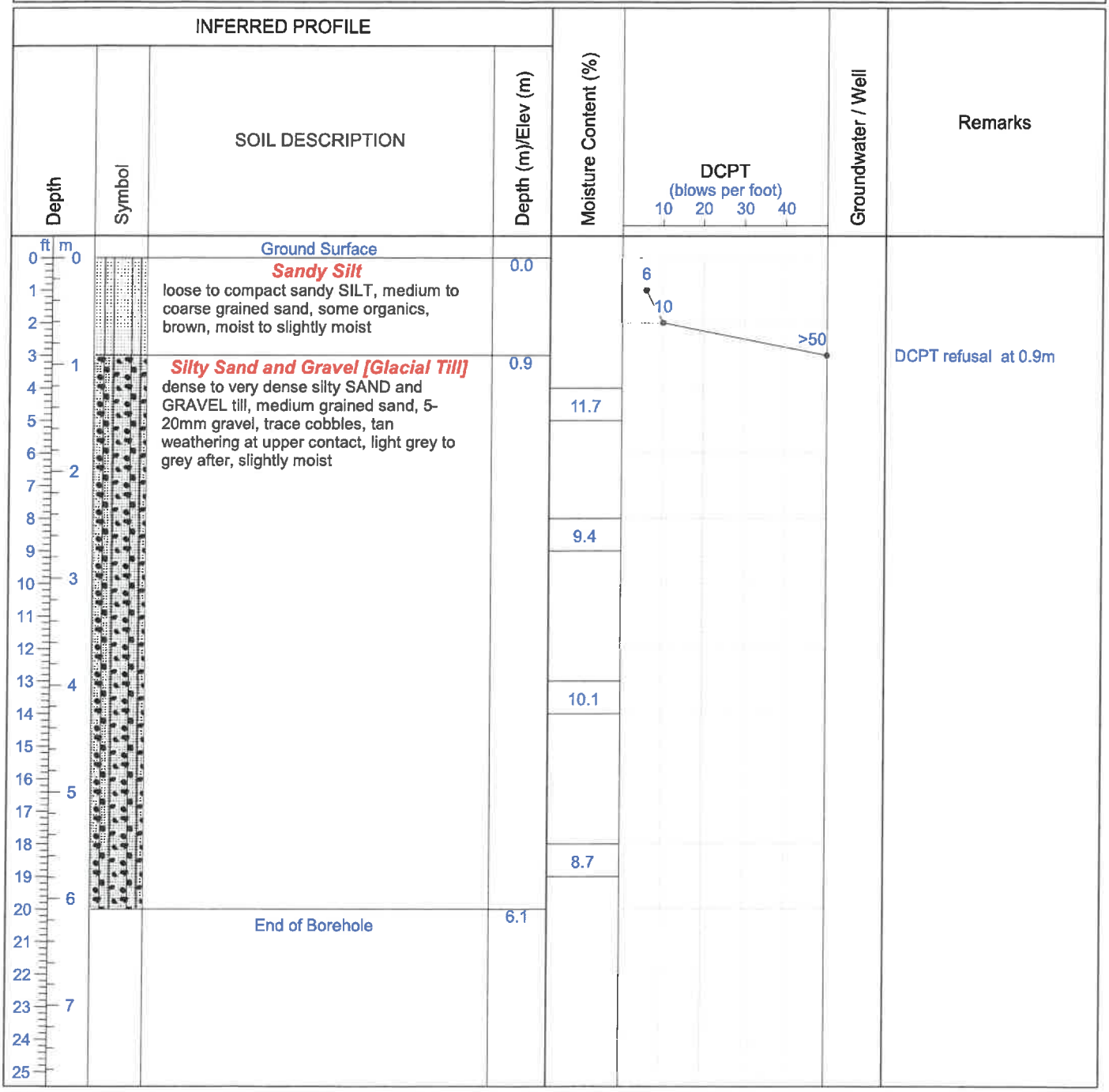
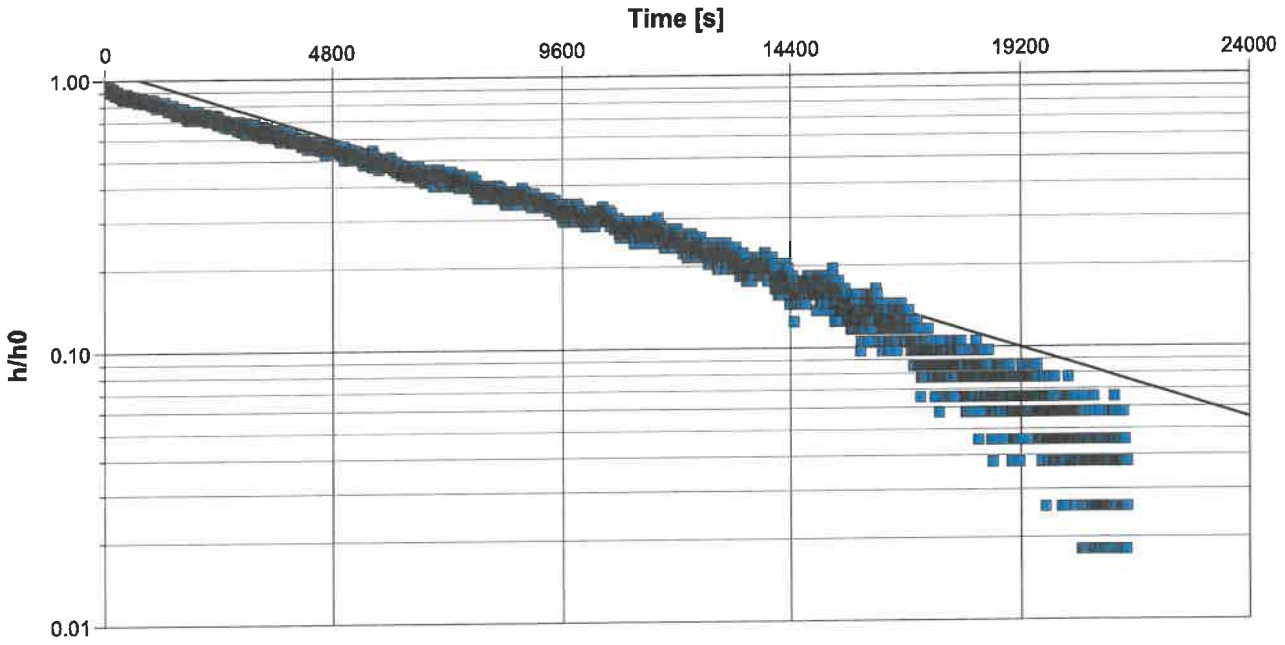


Logged: SH
Method: Solid Stem Auger
Date: 2023-Oct-12

Datum: Ground Elevation
Figure Number: A.08
Page: 1 of 1

APPENDIX B

	Slug Test Analysis Report	
	Project: Proposed Residential Subdivision Development	
	Number: 23403	
	Client: Christen Luxury Homes	
Location: Pinnacle Ridge Estate, Anmore	Slug Test: MW23-01	Test Well: Well 1
Test Conducted by: PMCS		Test Date: 2023-11-15
Analysis Performed by: PMCS	MW23-01 B&R	Analysis Date: 2023-11-15
Aquifer Thickness: 10.00 m		

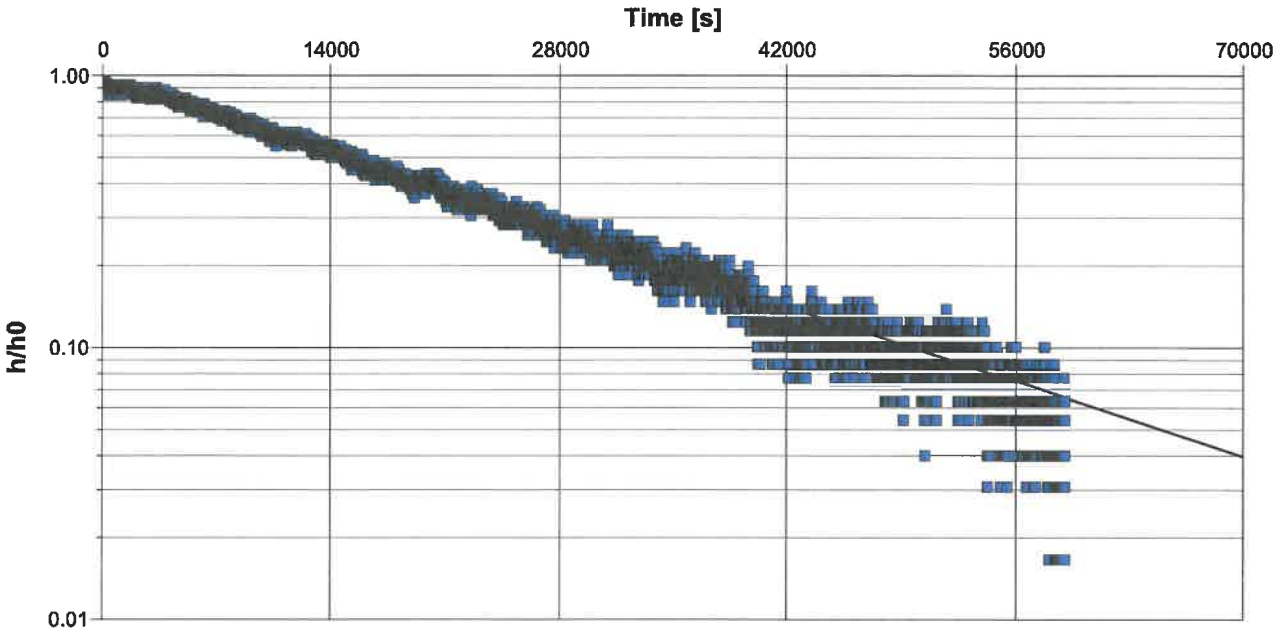


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/s]
Well 1	8.45×10^{-8}

	Slug Test Analysis Report
	Project: Proposed Residential Subdivision Development
	Number: 23403
	Client: Christen Luxury Homes

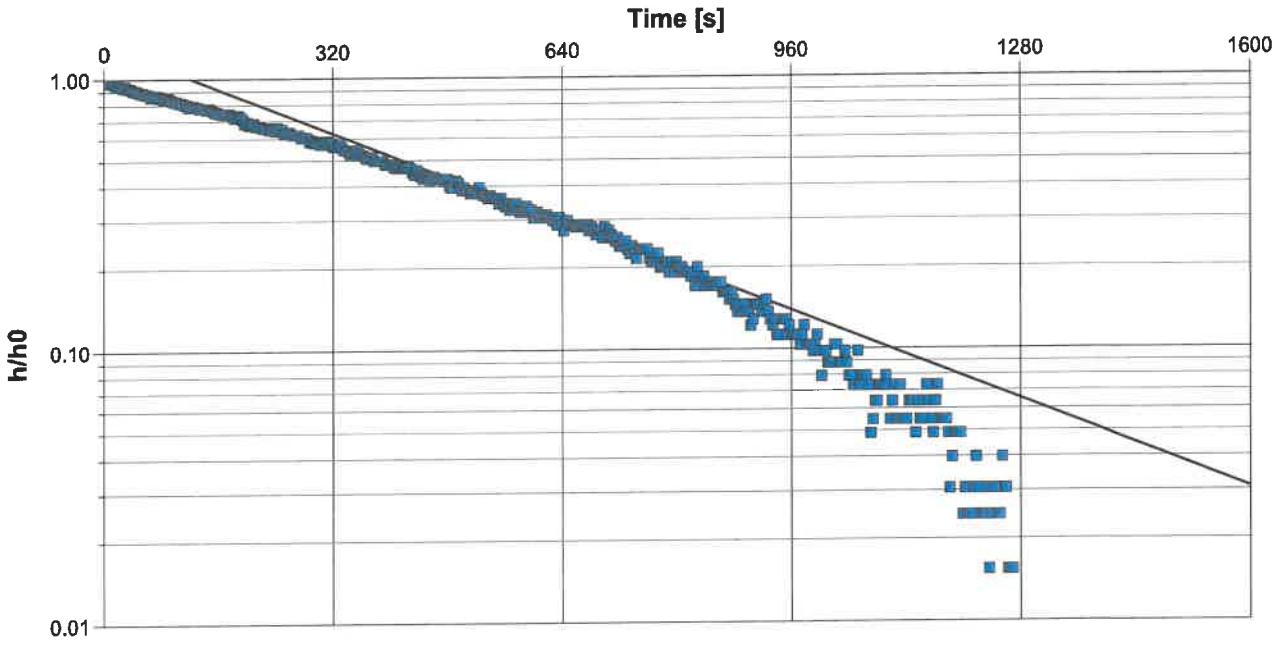
Location: Pinnacle Ridge Estate, Anmore	Slug Test: MW23-03	Test Well: Well 1
Test Conducted by: PMCS		Test Date: 2023-11-16
Analysis Performed by: PMCS	MW23-03 B&R 1	Analysis Date: 2023-11-16
Aquifer Thickness: 10.00 m		



Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/s]	
Well 1	3.06×10^{-8}	

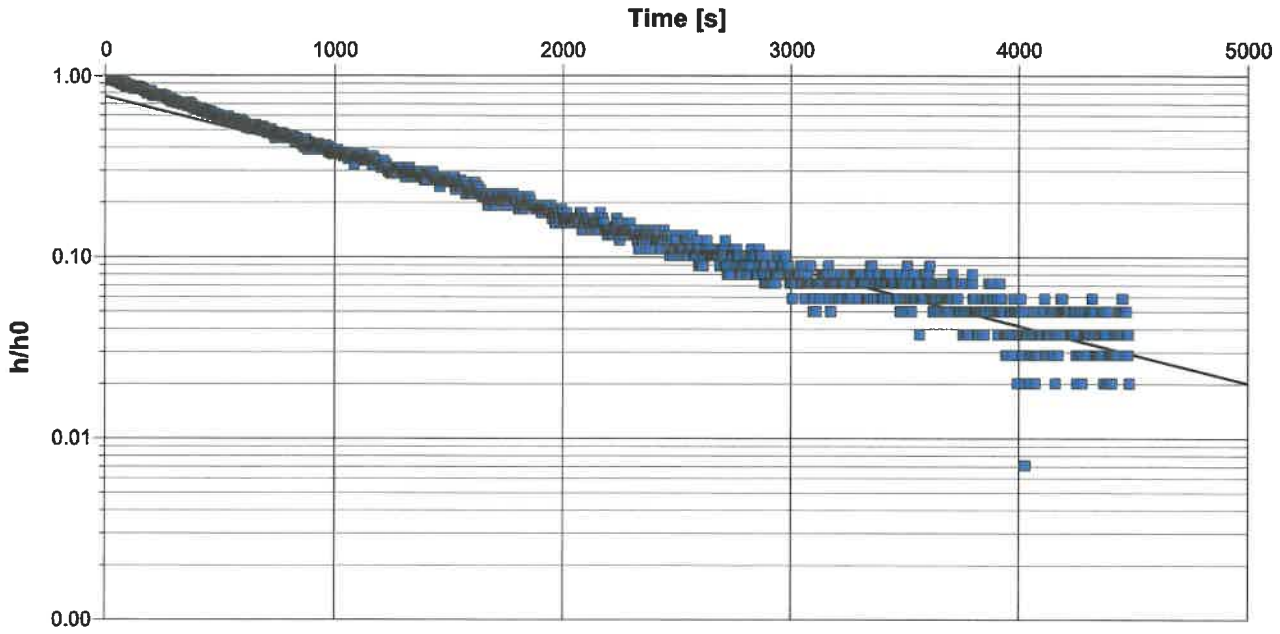
	Slug Test Analysis Report	
	Project: Proposed Residential Subdivision Development	
	Number: 23403	
	Client: Christen Luxury Homes	
Location: Pinnacle Ridge Estate, Anmore	Slug Test: MW23-04	Test Well: Well 1
Test Conducted by: PMCS		Test Date: 2023-11-16
Analysis Performed by: PMCS	MW23-04 B&R	Analysis Date: 2023-11-16
Aquifer Thickness: 10.00 m		



Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/s]	
Well 1	1.59×10^{-6}	

	Slug Test Analysis Report	
	Project: Proposed Residential Subdivision Development	
	Number: 23403	
	Client: Christen Luxury Homes	
Location: Pinnacle Ridge Estate, Anmore	Slug Test: MW23-05	Test Well: Well 1
Test Conducted by: PMCS		Test Date: 2023-11-16
Analysis Performed by: PMCS	MW23-05 B&R	Analysis Date: 2023-11-16
Aquifer Thickness: 10.00 m		

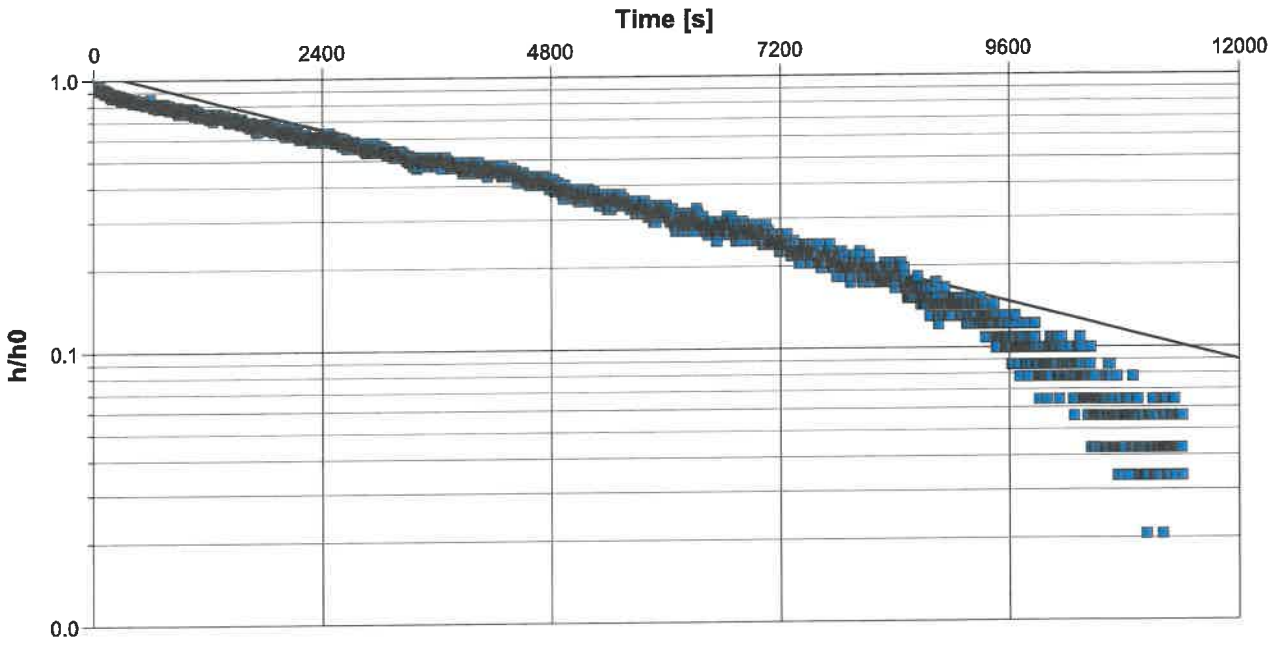


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/s]	
Well 1	4.92×10^{-7}	

	Slug Test Analysis Report
	Project: Proposed Residential Subdivision Development
	Number: 23403
	Client: Christen Luxury Homes

Location: Pinnacle Ridge Estate, Anmore	Slug Test: MW23-06	Test Well: Well 1
Test Conducted by: PMCS		Test Date: 2023-11-16
Analysis Performed by: PMCS	MW23-06 B&R	Analysis Date: 2023-11-16
Aquifer Thickness: 10.00 m		

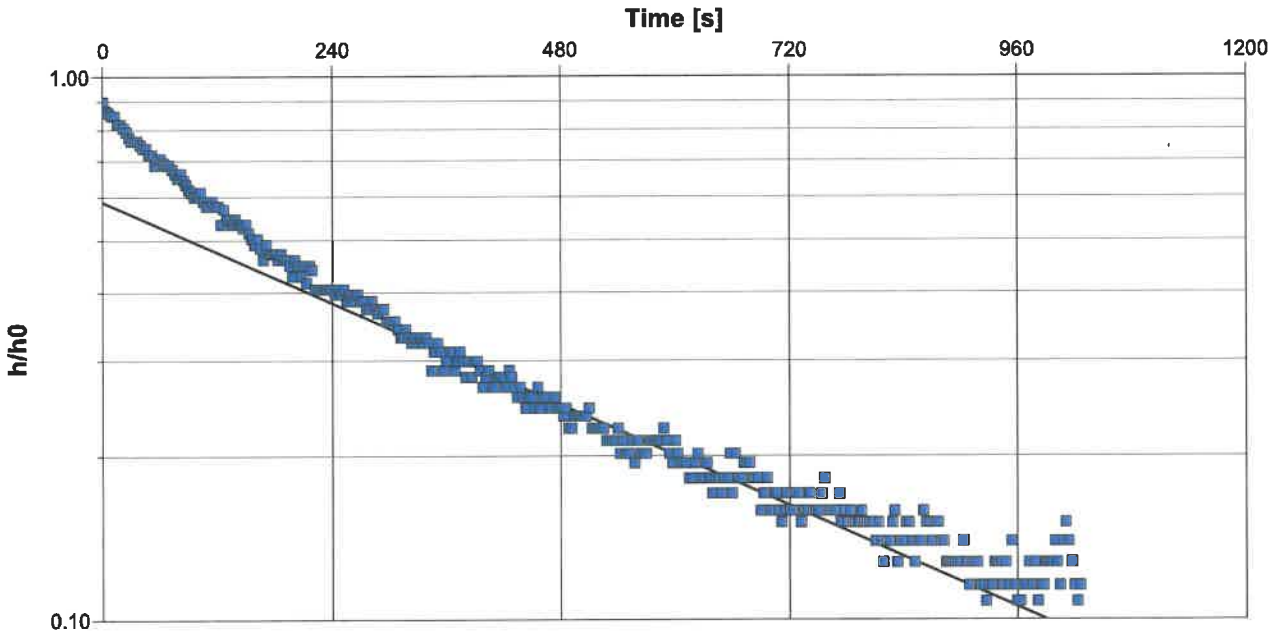


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/s]	
Well 1	1.40×10^{-7}	

	Slug Test Analysis Report
	Project: Proposed Residential Subdivision Development
	Number: 23403
	Client: Christen Luxury Homes

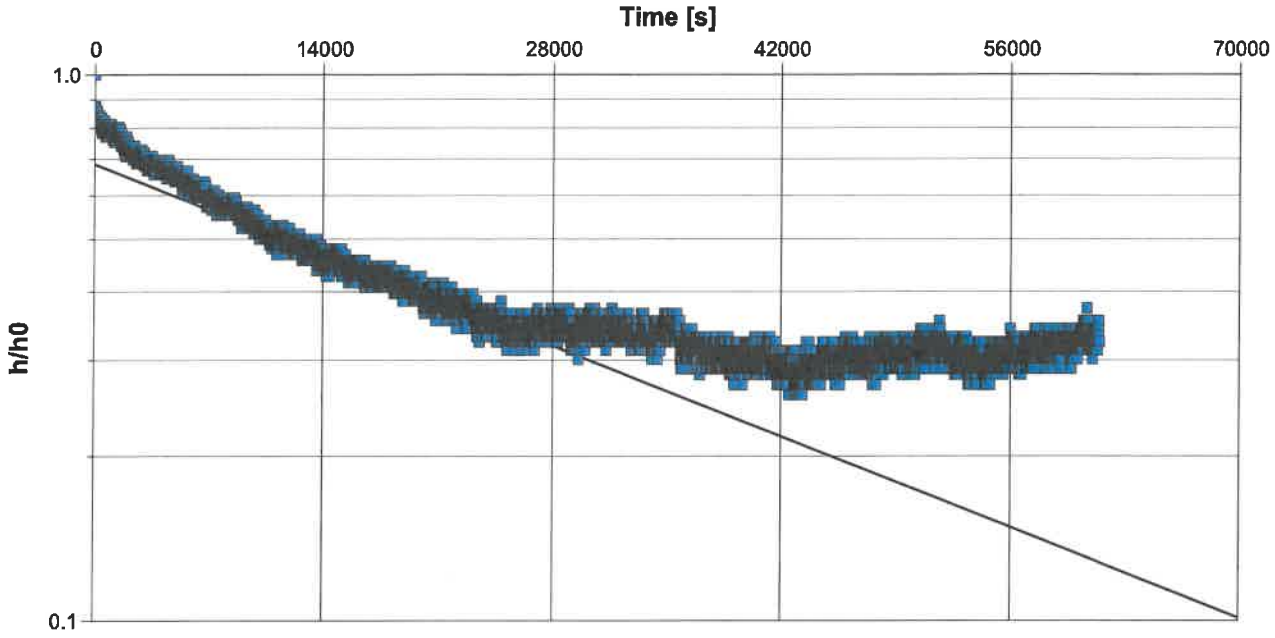
Location: Pinnacle Ridge Estate, Anmore	Slug Test: MW23-07	Test Well: Well 1
Test Conducted by: PMCS		Test Date: 2023-11-16
Analysis Performed by: PMCS	MW23-07 B&R	Analysis Date: 2023-11-16
Aquifer Thickness: 10.00 m		



Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/s]	
Well 1	1.21×10^{-6}	

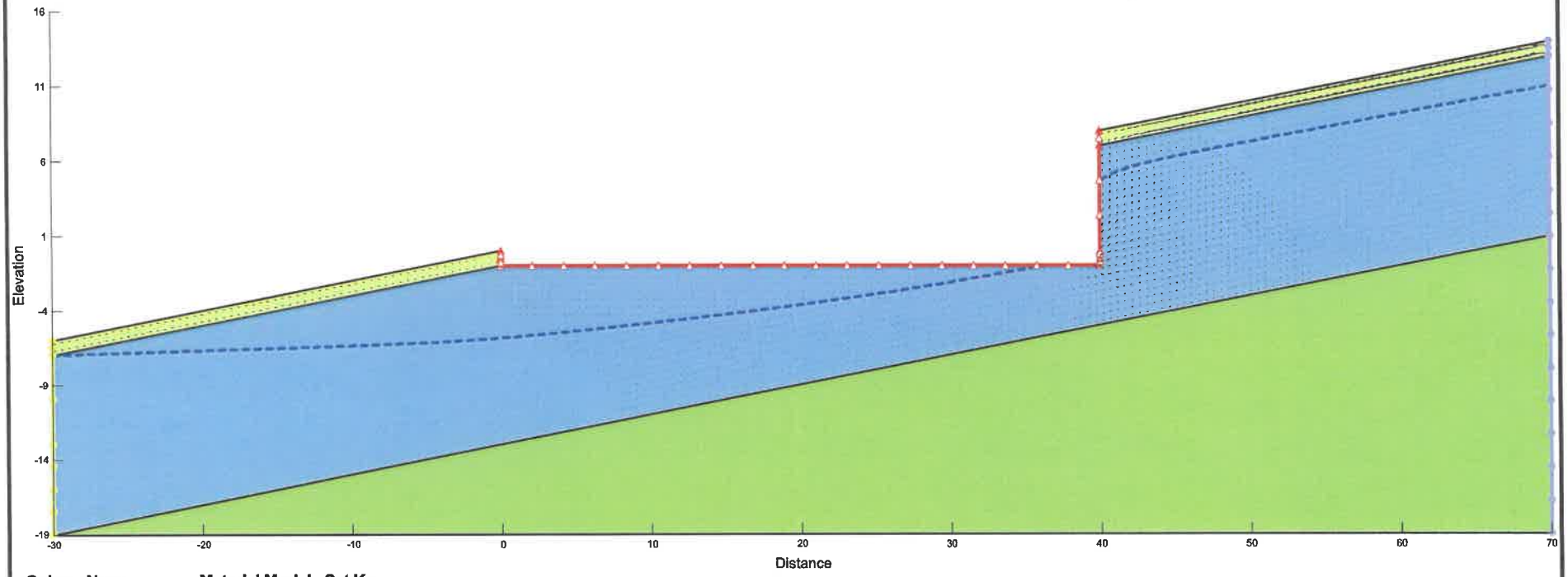
	Slug Test Analysis Report	
	Project: Proposed Residential Subdivision Development	
	Number: 23403	
	Client: Christen Luxury Homes	
Location: Pinnacle Ridge Estate, Anmore	Slug Test: MW23-08	Test Well: Well 1
Test Conducted by: PMCS		Test Date: 2023-11-16
Analysis Performed by: PMCS	MW23-08 B&R	Analysis Date: 2023-11-16
Aquifer Thickness: 10.00 m		



Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/s]	
Well 1	1.85×10^{-8}	

APPENDIX C



Color	Name	Material Model	Sat Kx (m/sec)
	Bedrock	Saturated Only	1e-08
	glacial till	Saturated Only	1.81e-07
	Surficial Soils	Saturated Only	5e-06

Project: PROPOSED DEVELOPMENT	**Job No.: 23403**
Model: SEEP/W Analysis (2)	Date: 21 MARCH, 2024
Method: Steady-State	Scale : 1:400
Site Address : PINNACLE RIDGE DEVELOPMENT, ANMORE, BC	Analysis by: SRH

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23403 SEEPAGE ANALYSIS.gsz