871 Equestrian Court, Unit 1, Oakville ON L6L 6L7
Tel: 647-795-8153 | www.pecg.ca

Hydrogeological Assessment

Phase One Development

501 Harmony Road, Corbyville, Ontario

Palmer Project #
2200902

Prepared For
Black Bear Ridge GP Inc.

March 25, 2025

871 Equestrian Court, Unit 1, Oakville ON L6L 6L7
Tel: 647-795-8153 | www.pecg.ca

March 25, 2025

Alex Sharpe
Black Bear Ridge GP Inc.
501 Harmony Road Corbyville,
ON K0K 1V0
asharpe@spirecapital.ca

Dear Alex Sharpe:

Re: Hydrogeological Assessment

Project #: 2200902

Palmer (now part of SLR Consulting) is pleased to submit the attached report summarising the results of Hydrogeological Assessment for the proposed Phase One development located at 501 Harmony Road, Corbyville, ON.

Thank you for the opportunity to be of service on this project. We trust that this report will be satisfactory for your current needs. If you have any questions or require further information, please contact our office at your convenience.

This report is subject to the Statement of Limitations provided at the end of this report.

Yours truly,

Jason Cole, M.Sc., P.Geo.
Technical Discipline Manager, Hydrology and Hydrogeology

Executive Summary

The study was based on synthesising data and information acquired through Palmer's drilling and testing program completed for the proposed development, the existing study reports provided by the client and the available data and information from multiple public sources. The study was conducted in general accordance with Hydrogeological Assessment Submissions, Conservation Authority Guidelines to Support Development Applications (2013), Stormwater Management Planning and Design Manual of MECP (2003), Water Taking User Guide for Environmental Activity and Sector Registry of MECP (2022) and Karst (Unstable Bedrock) Investigation Guidelines of Quinte Conservation (2023).

The site was located in a drumlinized bevelled till plain with a drumlin occupying most of the site. The site is located in the Moira River Outlet watershed which is under the jurisdiction of Quinte Conservation. Source Water Protection mapping indicates the site is mapped as being a Highly Vulnerable Aquifer with a score of 6, the only source protection designation within and surrounding the site. The site is underlain with over 8.0 m of overburden above the bedrock of Verulam Formation. Both overburden and bedrock units make the regional supply aquifers for the site and surrounding areas.

Site water balance assessment show that the proposed development will lead to reduced infiltration by 23,735 m^3/year and increased runoff by 78,820 m^3/year. As the site is not located in WHPA-Q2, compensation of infiltration deficit is not required. However, the increased runoff should be treated with onsite LID features or stormwater management facilities to keep the pre-development hydroperiods of the PSWs.

A preliminary construction dewatering assessment with conservative assumptions has resulted in a required dewatering rate of more than 400,000 L/day. In this case a Category 3 PTTW would be required to support the dewatering operation. However, it is likely that the dewatering can be managed to be under 400,000 L/day by reducing excavation sizes and or potential grade increases. The preliminary construction dewatering assessment should be updated upon the availability of final grading plan and building grades.

Preliminary karst risk assessment concluded that no karst features are anticipated to exist within and nearby the site, the site conditions are not instrumental to karst development, and the site is not sensitive to any potential impacts of karst features. Karst impact to proposed structures and groundwater quality is not expected, and therefore, a detailed Phase 2 Technical Study as defined in the of Karst (Unstable Bedrock) Investigation Guidelines (Quinte Conservation, 2023) is not recommended.

Impacts of the proposed development to the PSWs can be mitigated based on the results of feature-based water balance assessment through onsite LID features or stormwater facilities designed to have enough capacity to absorb the increased runoff and to keep the pre-development hydroperiod. Impacts of the proposed development to source water are not anticipated as the site is not located in source water protection areas that have constraint policies. Impacts of the proposed development to private water wells are not expected as no water supply wells were located in the estimated dewatering zone of influence.

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1. Introduction

Palmer (now part of SLR Consulting) was retained by the Black Bear Ridge GP Inc. ("the client") to complete a Hydrogeological Assessment for the proposed Phase One development located at 501 Harmony Road, Corbyville, ON (K0K 1V0) (the "site" or "property") (**Figure 1**). It is Palmer's understanding that this assessment is required to support a zoning approval application with the City of Belleville and will be submitted as part of the Draft Subdivision Plan Application to the City of Belleville.

The site is approximately 84.3 ha in area and currently hosts farmland, a golf course and associated facilities, and natural areas.

The purpose of the Hydrogeological Assessment is to characterize the regional setting and site conditions, to assess the interaction between the proposed development and groundwater system as well as the impact of the proposed development to groundwater and related resource and environmental features.

The Hydrogeological Assessment was conducted in tandem with a Geotechnical Investigation, Environmental Site Assessment (ESA), and a Natural Heritage Review and Environmental Constraints Assessment all undertaken by Palmer.

1.1 Proposed Phase One Development

Based on the site plan (**Appendix A**) provided by Biglieri Group, dated July 30, 2024, the proposed Phase One development includes the following components:

- Low and medium density residentials;
- Resorts and entertainment facilities;
- Golf course;
- Traffic, sewer and utility systems;
- Park and open spaces;
- Stormwater management facilities; and
- Environmental areas.

Based on the Servicing Feasibility Review completed by Jewell Engineering (February 28, 2022) and the Planning Appraisal report completed by Bousfield (August 2003), the site is expected to be fully serviced with municipal water supply and sewage systems. However, it is noted that some on-site supply wells might be used for irrigation purposes for the golf course.

1.2 Methodology

1.2.1 Background and Record Review

A background and record review were conducted for the area hosting the site to help delineate the regional setting of the site, including physical setting and environmental setting. The regional setting will help delineate site conditions, help with data interpretation and impact assessment.

The sources of data and records reviewed included, but not limited to, Ontario Geological Survey (OGS) database (physiography, geology and boreholes), Ministry of the Environment, Conservation and Parks (MECP) database (well record, natural heritage, hydrology, source protection and environmental instruments), data from Quinte Conservation (watershed plan, subwatershed studies, source protection plan, stormwater criteria and LID), and data from the City of Belleville (official plan, zoning plan, permit application, well head protection policies and sewer use bylaw).

Four (4) previous study reports that may have relevance in hydrogeology were identified for the property, including:

1. Summary of Hydrogeological Data, Black Bear Ridge Residential and Recreational development, Site Investigation Services Limited, Nov 1999;
2. Preliminary Water Supply Evaluation, Proposed Black Bear Residential Development, WSP, February 6, 2017;
3. Environmental Monitoring Program, Black Bear Ridge Golf Club, Environmental Investigation LTD. August 9, 2004; and
4. Natural Heritage Review and Environmental Constraints Assessment for Black Bear Ridge Resort, Palmer, February 28, 2022.

The first study was for assessing water supply capacity of the site and was based on pumping test results for available supply wells on site. However, no map showing locations of test wells is found in the report, and the information from the report is not useful for the current Hydrogeological Assessment.

The second study was also for assessing the water supply capacity of the site, which has the similar study area as the current study and was based on 12 existing wells, among them four (4) hour pumping tests were conducted on seven (7) wells at rates ranging from 7.6 to 75 L/min. Six (6) groundwater samples were taken and tested against Ontario Drinking Water Quality Standards (ODWQS). The factual information on groundwater quantity and quality in this study will be referenced to in the current Hydrogeological Assessment. The third study was about surface water quality (two sampling locations) and groundwater quality (one hole). No location reference was provided in the report, and therefore this study is not useful for the current study. The fourth study was completed by Palmer and will serve as the major sources for natural heritage information for the current study.

1.2.2 Borehole Drilling, Monitoring Well Installation and Soil Sampling

Borehole drilling and monitoring well installation were undertaken by Palmer as part of the geotechnical investigation between August 24 to September 1, 2023. In total, fourteen (14) boreholes (BH23-1 to BH23-14) were drilled and all of them were installed with monitoring wells. All monitoring wells were developed in preparation for groundwater sampling, hydraulic conductivity testing and groundwater level monitoring following the standard Palmer practices. The monitoring wells were developed by purging three to five well volume of water or until the monitoring well was purged dry. Detailed information of the borehole and monitoring wells are listed in **Table 1.** Borehole and monitoring well logs are provided in **Appendix B**.

Information obtained from borehole drilling, including drilling observations and borehole logs, are essential in delineating subsurface physical conditions. Hydraulic testing and groundwater sampling from the monitoring wells provide critical information for characterizing groundwater conditions. The locations and

density of monitoring wells were determined to provide the most representative underground information for the whole site based on initial conceptual site plan. Further drilling and monitoring well installation may be required during next stage of the project.

Table 1. Summary of Completed Boreholes and Monitoring Wells

Borehole ID	Surface Elevation (masl)	Stick-up (m)	Screened Interval (mbgs)	Grain Size Analysis Sample ID	Groundwater Sampling
BH23-1	112.5	0.9	1.5 - 4.5	-	-
BH23-2	112.4	0.9	2.3 - 5.3	-	Yes
BH23-3	120.8	0.9	3.0 - 6.0	-	-
BH23-4	124.6	1.0	2.1 - 5.1	SS7	-
BH23-5	110.4	1.0	1.5 - 3.0	SS4	-
BH23-6	112.2	0.9	1.3 - 4.3	-	-
BH23-7	113.3	1.0	4.7 - 7.7	SS9	-
BH23-8	116.9	1.0	3.2 - 6.2	-	-
BH23-9	108.9	0.9	1.5 - 3.0	-	-
BH23-10	111.4	1.0	3.1 - 6.1	SS7	Yes
BH23-11	107.5	0.9	1.5 - 4.5	-	-
BH23-12	109.2	1.0	1.0 - 2.5	-	-
BH23-13	108.2	0.9	1.0 - 4.0	SS5	-
BH23-14	110.4	0.9	5.0 - 8.0	SS7	-

1.2.3 Mini-Piezometers Installation and Instrumentation

To monitor the interaction between groundwater and surface water, and to help delineate hydroperiod of natural features, five (5) mini-piezometers (MP1 to MP5) were installed on June 16, 2023 and data loggers were installed in all mini-piezometers (**Figure 1**). The installed MPs consist of a 2.5 cm (1 inch) Diameter steel pipe, with a 0.3 m (1 foot) screened interval length with a diameter of 1.9 cm (3/4 inch). MP installation and instrumentation details are listed in **Table 2**.

It should be noted that the MPs were installed in locations with permanent wetland water, so that the MP pipes also served as wetland water gauges. Both groundwater levels and wetland water stages were measured to the top of the same MP pipe. The interaction between wetland water and groundwater can be assessed accurately.

Table 2. Summary of Completed Mini-Piezometers

MP ID	Depth (mbgs)	Stick-up (m)
MP 1	1.5	0.7
MP 2	1.4	0.9
MP 3	1.2	1.0
MP 4	1	1.2
MP 5	1.4	0.9

1.2.4 Soil Classification and Grain Size Analysis

Soil samples were brought back to Palmer's geotechnical lab for detailed classification and grain size analysis. Soil classification was conducted following guidelines of ASTM D2487 and geological principles. The results of soil classification were presented in borehole logs which are provided in **Appendix B**.

Grain size analysis was completed in Palmer's geotechnical lab for six (6) representative samples (**Table 1**) following the MTO standards and ASTM standards (LS-702, ASTM D421, ASTM D422). The purpose of grain size analysis is to gauge the soil classification and to estimate the hydraulic conductivity (K-value) for the corresponding stratigraphy units. The grain size analysis results and K-value estimation results are provided in **Appendix C**.

1.2.5 Single well response tests (SWRTs)

On September 13, 2023, Palmer personnel conducted single well response testing (SWRTs) at twelve (12) monitoring wells to assess the hydraulic conductivity (K-value) of the screened soils. Depending on the soil grain sizes and groundwater levels, either falling head or rising-head tests were employed for all monitoring wells to estimate the hydraulic conductivity of the saturated soils at the site. Falling head conditions were created by inserting a solid PVC slug and rising head was created through taking out certain amount of water from the well with a bailer. The hydraulic conductivity was estimated with the rate of recovery in water levels following displacement. The water level recovery during each test was recorded with an automatic datalogger. The recovery was also gauged manually using a water level tape. SWRTs in all wells were terminated after either 90% recovery was achieved or 30 minutes had passed. The results of the SWRTs are provided in **Appendix D**.

1.2.6 Guelph Permeameter Tests

Guelph Permeameter (GP) tests were carried out on June 22 and September 7, 2023 at six (6) locations (GP1 to GP6) within the proposed development area (**Figure 1**). The manufacturer's operating instructions were followed to do the testing. GP tests were conducted in a constant head condition with the GP pipes extended into pre-augered holes with depths ranging from 0.3 to 0.5 m. Combined reservoir was used for GP1, GP3, GP4, GP5 and GP6 while inner reservoir was used for GP2. Field saturated hydraulic conductivity (K_{fs}) values were calculated using the Guelph Permeameter K-sat Calculator (2012). The results of the infiltration test are provided in **Appendix E**. It should be noted that further infiltration tests may be required to confirm the suitability of specific SWM and LID features to be implemented during detailed design stage.

1.2.7 Groundwater Sampling and Chemical Analysis

One round of groundwater sampling was conducted on August 10th, 2023 in general accordance with industry practises in Ontario and Palmer's standard operation procedure (SOP). Chemical analysis was conducted by ALS Environmental Laboratory, which has been accredited by the Canadian Association for Laboratory Accreditation (CALA). The groundwater sampling involved taking two samples from two different wells (BH23-2 and BH23-10) after purging the wells to stabilized field parameter values. The sample taken from BH23-2 was tested for ALS's General Chemistry 3 Package parameters. The sample taken from BH23-10 was tested for parameters of ALS's Potability Package. The results from both samples were

compared to the Ontario Drinking Water Quality Standards (ODQWS) and the Ontario Provincial Water Quality Objectives (PWQO). The tests results are provided as **Appendix F**.

1.2.8 Groundwater Level Monitoring and Monitoring Point Maintenance

Groundwater levels in the monitoring wells and mini-piezometers were monitored manually at a frequency appropriate to delineate seasonal trend and fluctuation. Surface water stage at each mini-piezometer were also measured for assess groundwater and surface water interaction. Dataloggers were installed in all mini-piezometers to acquire continuous groundwater level data and to pick up abnormal fluctuation. Maintenance for monitoring wells and mini-piezometers were carried out as necessary with each round of groundwater levels.

1.2.9 WWIS Well Record and PGMN Well Inventory

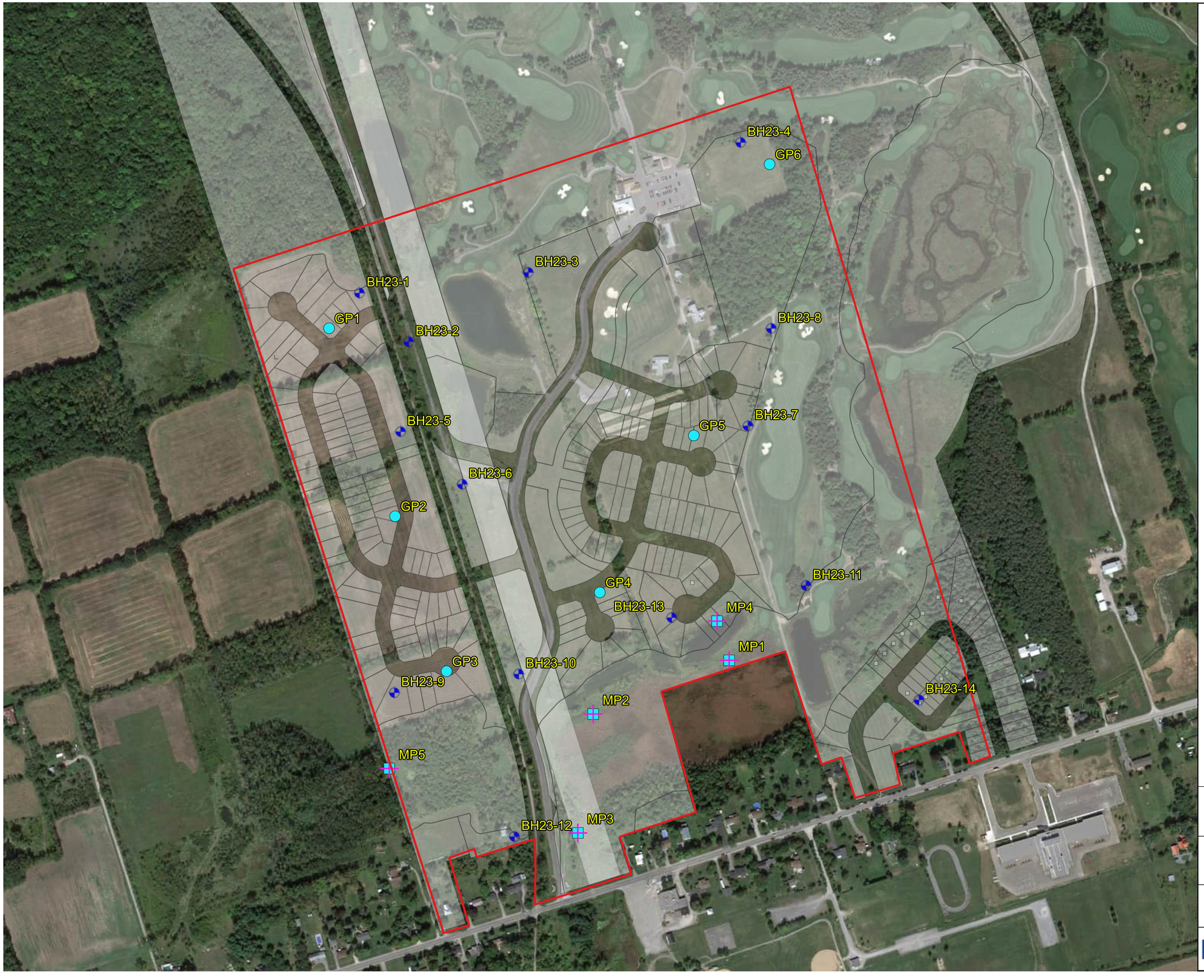
Ontario Regulation 903 and its amendments under the Ontario Water Sources Act requires well contractors to report drilled and bored well construction operations to the well owner and the Ontario Government since the late 1940s. In the late 1980s, all persons constructing dug wells were required to complete well records. Well records are required to be submitted to the MECP to document any well construction, alteration or abandonment of wells in Ontario. Over 790,000 well records have been submitted to the MECP over the years with approximately 15,000 to 24000 new well records received each year. The government has well record data from 1899 to present. Owing to long history of records and seamless coverage, the geology, material properties and groundwater information contained in well records have become the major sources of data for regional groundwater conditions.

Well records within 500 m from the site boundary as well as the well records within the site were queried from the database of the Water Well Information System (WWIS) of MECP for fields of well ID, completion date, well depth, static groundwater levels, aquifer type (bedrock or overburden well), pumping test results, water quality and water use. A total of 142 wells were identified. The results of well record inventory are provided in **Appendix G** and **Figure 8** shows the locations of the wells. MECP well records contain abundant information about stratigraphy, groundwater quantity and groundwater quality, which will be referred to or used in different parts of the report.

No Provincial Groundwater Monitoring Network (PGMN) well was identified within 3 km from the site.

1.2.10 Remote Sensing Interpretation, Terrain Analysis and and Site Inspection

Satellite images of different time facies were interpreted to delineate surficial features that might provide insight into karst development at the site. Terrain Analysis (Surface Analysis) is the analysis and interpretation of topographic features through geographic information systems. As part of terrain analysis, Lidar Derived Digital Terrain Model from provincial sources was used to create topographic contours for the areas within and adjacent to the site. The topographic contours plus the satellite image provide a general view of terrain characteristics and form the base for micro-topographic analysis. **Figure 4** shows terrain characteristics, drainage system and other surface water features. Site inspection was conducted on several occasions during June and September of 2023, which involved walking through natural and open areas within and surrounding the site to validate results of remote-sensing interpretation and terrain analysis and detect new surficial and shallow features that may indicate directly and indirectly the existence of karst features.



Legend

- Site Boundary
- Monitoring Well
- Mini-Piezometer
- Infiltration Test

0 100 200 300 m

North American Datum 1983
Universal Transverse Mercator Projection Zone 18

Scale: 1:5000
Page Size: Tabloid (11 x 17 inches)

Drawn: FL
Checked: NS

Date: Dec 2024

Source Notes:
Basemap: Google satellite imagery (2020)
Conceptual Site Plan (2024) was stacked .

Client
Black Bear Ridge GP Inc.

Project
501 Harmony Road, Corbyville, ON

TITLE
Site Location Plan

Palmer PART OF SLR

REF. NO 2200902

Figure 1

2. Site Characterization

2.1 Physiography and Natural Heritage

2.1.1 Geomorphology and Karstification

The site sits in Napanee Plain, a drumlinized bevelled till plain (**Figure 2**). Drumlin or drumlinoid ridges occur to the east of the site and glacial flutes occurs to the northeast of the site.

The site is generally situated on a drumlin which occupies the majority of the site. Other landform onsite include two positive landforms (knolls), one on the southwest corner and the other on northwest corner of the site, a wetland in the south part of the site, and ponds created as part of the golf course. The ground surface is undulating with elevations ranging from approximately 107 to 133 meters above sea level (masl), and in general sloping from northeast to southwest along the streamline direction of the drumlin (**Figure 4**).

Karstification refers to the process where carbonate or other soluble rocks outcrops at the ground surface or under a shallow depth of overburden cover and are exposed to leeching and dissolution by acidic or aggressive atmospheric water to produce a series of landform features, or karst, including sinkholes, caves, natural bridges, sinking streams, dry valleys, karren, stalactites, stalagmites, tufa etc. The site is located in Napanee and Kingston Plains Kast Region (OGS 2008). Areas mapped by OGS as Known Karst and Potential Karst border the northwest edge of the site (**Figure 3**). **Table 3** sums up the characteristics of the three classes of karst areas that OGS has mapped for the region and their closeness to the site.

Table 3. Karst Classification

Class	Formation	Lithology	Drift Cover	Karst Features	Location Relative to Site
Known Karst	Bobcaygeon	Limestone, with minor shales in upper part	No drift	Caves, sinkholes, karren, clint and grike, wave-cut caves, sea stacks	125 m
Inferred Karst	Gull River	Limestone, dolostone (towards base)	No drift	Known by extrapolation	3000 m
Potential Karst	Gull River	Limestone, dolostone (towards base)	No drift	Unknown	30 m

2.1.2 Drainage System and Surface Water Features

The site is located in the Moira River Outlet watershed under the jurisdiction of Quinte Conservation. Moira River is located 1.6 km to the west of the site. Several ponds were found within the site, all of them are man-made ponds based on Palmer's Natural Heritage Review. A marsh wetland and a few swamp wetlands were identified within the site. The marsh wetland and swamp wetlands and their nearby areas are regulated by Quinte Conservation.

Drainage system is not well developed within and surrounding the site. The only creek identified flowing through the southwest corner of the site originates from wetlands upstream to the northeast and flows southwest toward Moira River, however the creek disappears, or gets lost, before reaching Moira River. The disappearing creek is a sign of karstification.

2.1.3 Climate

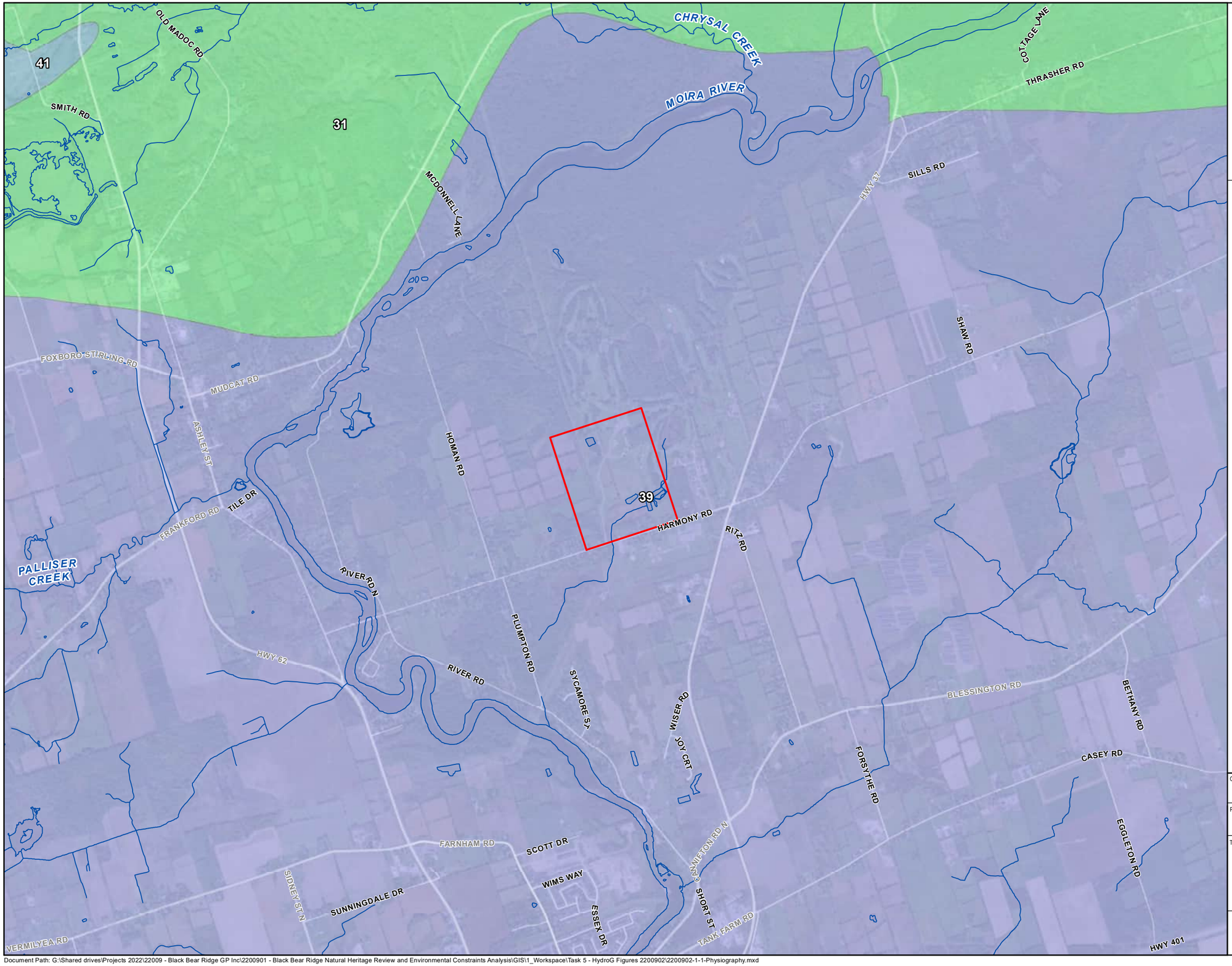
The Site is in a continental climate region with a warm, humid summer and a cold winter as well as wet spring, dry summer and moderate rainfall in autumn. The region is generally affected by warm, moist air masses from the south and cold, dry air masses from the north and experiences a wide range of weather conditions through the course of an average year. The **Table 4** lists the averaged and extreme daily values of major climate parameters collected at the closest climate station (Belleville Water Treatment Plant) for the period between 1981 and 2010.

Table 4. Monthly Averaged Climate Data (1981-2010)

Average Values	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daily Air T (°C)	-6.7	-5.1	-0.4	7	13.7	19	21.8	20.8	16.3	9.5	3.6	-2.6
Rainfall (mm)	30.6	29.4	40.3	69.2	81.2	74.5	65.1	75.5	91.9	84.9	84.7	44.6
Snowfall (cm)	36.8	28.6	22.1	6.5	0	0	0	0	0	0.2	11	34.5
Precipitation (mm)	67.3	58.1	62.4	75.8	81.3	74.5	65.1	75.5	91.9	85.2	95.7	79.1
Extreme Daily Values												
Extreme Daily Rainfall (mm)	51.1	64.3	53.2	51.1	76.5	82.6	106.2	88.4	103.9	64.8	69.6	68.6
Extreme Daily Snowfall (cm)	35.1	38.1	63.5	18.8	10.6	0	0	0	0	11.4	35.6	40.6

2.1.4 Natural Heritage Features

Based on Ontario Natural Heritage Areas mapping, two Provincially Significant Wetlands (PSWs) and two unevaluated wetlands were identified within the site. The PSW located at the south end of the site is named as Corbyville Wetland and is classified by Palmer's Natural Heritage report as Cattail Mineral Meadow Marsh (MAS). The PSW located to the west of the site is classified by Palmer's Natural Heritage report as Deciduous Swamp (SWD).



KEY MAP

LEGEND

- Study Area
- Watercourse[1]

Physiographic Region[2]

- 31: Peterborough Drumlin Field
- 39: Napanee Plain
- 41: Iroquois Plain

1. LIO/MNRF
2. Chapman, L.J. and Putnam, D.F. 2007. Physiography of southern Ontario; Ontario Geological Survey, Miscellaneous Release--Data 228.

0 200 400 600 800 1,000
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North American Datum 1983
Universal Transverse Mercator Projection Zone 18

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Drawn: CV
Checked: FL
Date: May 29, 2023

NORTH

Source Notes:
Imagery (2020) provided by ESRI map service. Contains information licensed under the Open Government Licence – Ontario.

CLIENT
Black Bear Ridge GP Inc

PROJECT
Black Bear Ridge

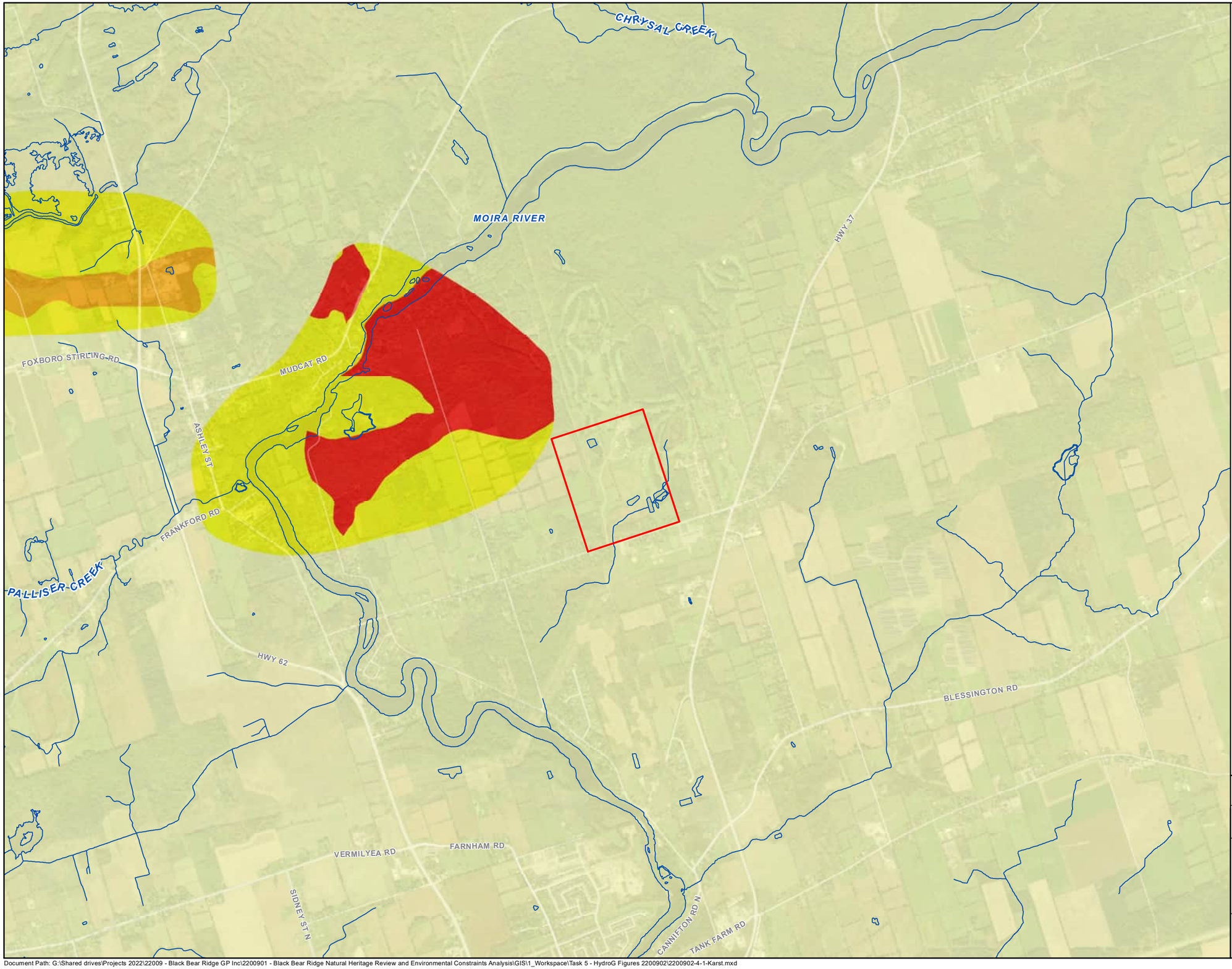
TITLE
Physiography

Palmer

REF. NO. 2200902-1-1

Figure 2

Document Path: G:\Shared drives\Projects 2022\22009 - Black Bear Ridge GP Inc\2200901 - Black Bear Ridge Natural Heritage Review and Environmental Constraints Analysis\GIS\1_Workspace\Task 5 - HydroG Figures 2200902\2200902-1-1-Physiography.mxd



LEGEND

- Study Area
- Watercourse[1]

Karst of Southern Ontario[2]

Known Karst	*observed, measured field data or data from Published reports. Key features include: karren, cave types and associated precipitates, sinkholes and disappearing streams*
Inferred Karst	*regions of carbonate bedrock units highlighted as most vulnerable or susceptible to karstification, where direct field observations have not been made by OGS staff or other sources. A natural extrapolation of the known karst areas for given rock units*
Potential Karst	*areas of carbonate rock units identified as most susceptible to karst processes*
Unknown	*or no observed evidence of karstification due to the character of bedrock, lack of outcrop and/or relative thickness of overburden*

1. LIO/MNRF
2. Brunton, F.R. and Dodge, J.E.P (2008). Karst map of Southern Ontario, including Manitoulin Island; Ontario Geological Survey, Groundwater Resource Study 5

0 200 400 600 800 1,000
METRE SCALE

North American Datum 1983
Universal Transverse Mercator Projection Zone 18

Scale: 1:30,000
Page Size: Tabloid (11 x 17 inches)

Drawn: CV
Checked: FL
Date: May 29, 2023

NORTH

Source Notes:
Imagery (2020) provided by ESRI map service. Contains information licensed under the Open Government Licence – Ontario.

CLIENT
Black Bear Ridge GP Inc

PROJECT
Black Bear Ridge

TITLE
Karst

Palmer

REF. NO. 2200902-4-1

Figure 3

Document Path: G:\Shared drives\Projects 2022\22009 - Black Bear Ridge GP Inc\2200901 - Black Bear Ridge Natural Heritage Review and Environmental Constraints Analysis\GIS\1_Workspace\Task 5 - HydroG Figures 2200902\2200902-4-1-Karst.mxd

Legend

- Site Boundary
- Topo Contours
- Water Course
- Water Body
- Wetland

0 100 200 300 m

North American Datum 1983
Universal Transverse Mercator Projection Zone 18

Scale: 1:5000
Page Size: Tabloid (11 x 17 inches)

Drawn: FL
Checked: NS

Date: Dec 2024

Source Notes:
Basemap: Google satellite imagery (2020)
Toopgraphical contours were derieved from lidar cloud of Ontario (2019)

Client	Black Bear Ridge GP Inc.
Project	501 Harmony Road, Corbyville, ON
TITLE	Terrain nd Drainage
Palmer PART OF SLR	REF. NO 2200902
	Figure 4

2.2 Geology and Stratigraphy

Geotectonically the site is located in the west sub-platform of the St. Lawrence Platform, 80 km west of Frontenac Arch and 20 km south of the Canadian Field.

The surficial geology within the site as mapped by OGS (**Figure 5**) consists of two units, a till unit (5b) and organic deposits (20). The till unit covers majority of the site and consists of a stone-poor, sandy silt to silty sand-textured till (Newmarket Till or equivalent). The organic deposits develop along the lost creek and the associated wetlands and ponds, and consists of peat, muck or marl depending on the location and nature of organic contents.

The bedrock geology as mapped by OGS (Figure 6) consists of the Verulam Formation, part of Simcoe Group deposited during Middle Ordovician (O_2) period. The Verulam Formation consists of interbedded micritic to coarse grained fossiliferous limestone with interbeds of calcareous shale; light to dark grey, brown grey, thin to medium bedded; bioturbation; intraclasts; ripple and trough cross lamination; channel and graded beds. Verulam Formation was deposited in an environment of open, normal marine shelf or ramp to shallow shoal. Based on the MECP well records (**Appendix G**), the bedrock depths within the site range from 8.0 to 12.0 m, with one outlier of 21.3 m on the location of highest point.

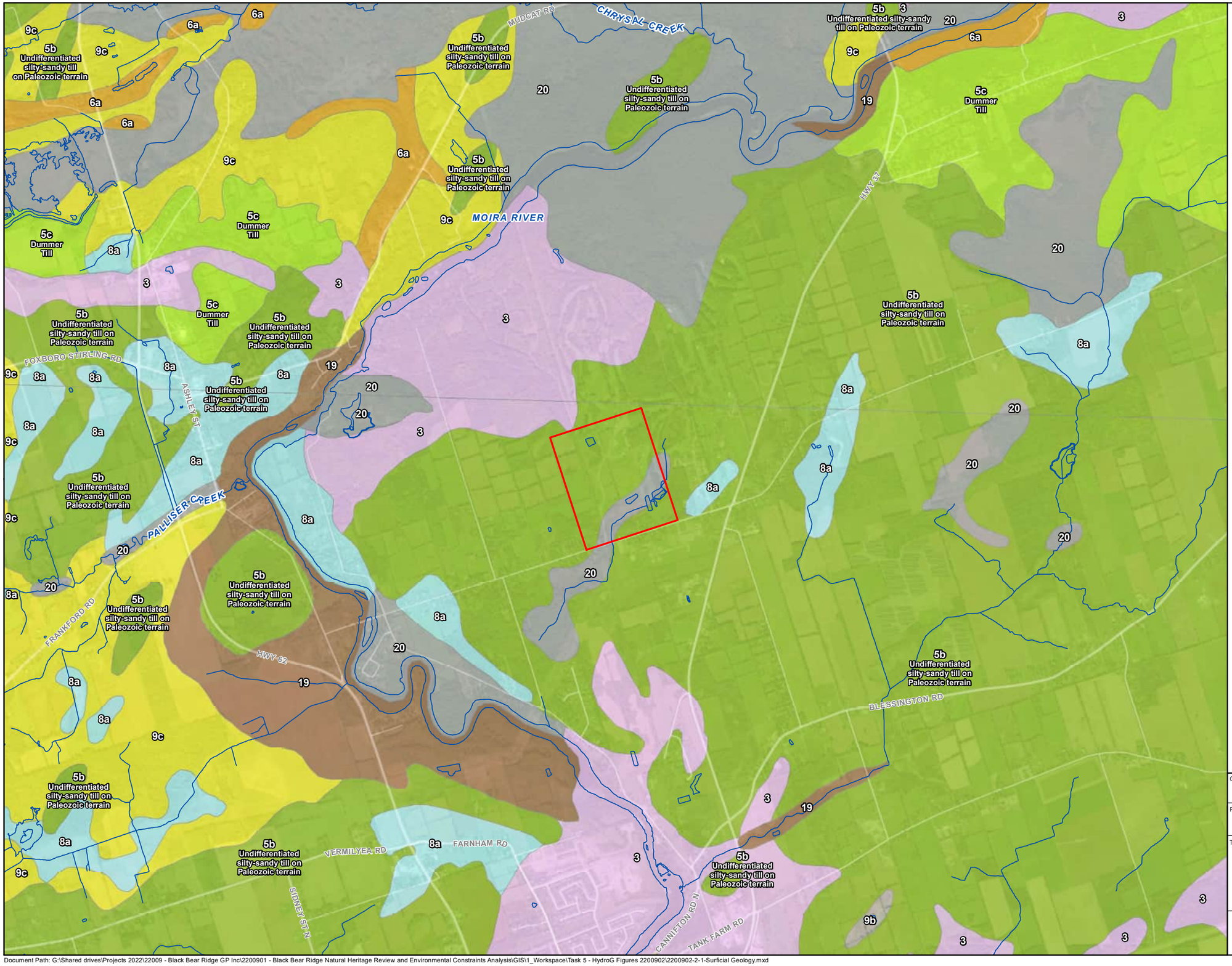
The stratigraphy under the site was characterized based on the regional information and the findings from the Palmer's drilling program as introduced above (**Table 1** and **Appendix B**). **Table 5** summarises the stratigraphy under the site including major lithological units, bottom depth ranges, natural water content and mechanical properties.

Table 5. Summary of Stratigraphy

Unit	Borehole ID	Bottom Depth (mbgs)	Moisture	N-Value	Interpretation
Fill (sandy silt)	All boreholes	0.7-2.4	Moist	11-13	Reworked native soil
Sandy silt	BH23-1, 2, 5, 6, 9	1.5-3.7	Moist	14-38	Upper Ice-contact
Sand and gravel	BH23-1, 2, 3, 5, 6, 9, 11, 13, 14	3.0-8.3	Wet	22-49	
Sand	BH23-2	5.3	Wet	54-300	
Sandy silt till	BH23-3, 4, 7, 8	5.3-6.5	Moist	23-150	Newmarket Till
Silt to gravel	BH23-7, 14	7.7-8.3*	Moist to wet	80-120	Lower ice-contact
Bedrock	Well records				Verulam FM

* Borehole depths.

As the summary of stratigraphy shows, the site is underlain with a suite of over-compacted clastic overburden materials deposited in proglacial to glacial environment. The upper ice-contact units occurring above the till unit have the potential to form significant aquifers. The low ice-contact unit have the potential to form a localized insignificant confined aquifer. Verulam Formation underlays the overburden and makes a significant supply aquifer to residents within and surrounding the site owning to its lateral continuity and secondary porosity created by solution and fractures.



LEGEND

Study Area

Watercourse[1]

Surficial Geology[2]

Phanerozoic / Cenozoic / Quaternary / Recent

20: Organic deposits *(peat, muck, marl)*

19: Modern alluvial deposits *(clay, silt, sand, gravel, may contain organic remains)*

Phanerozoic / Cenozoic / Quaternary / Pleistocene

9c: Coarse-textured glaciolacustrine deposits *(Foreshore and basinal deposits)*

8a: Fine-textured glaciolacustrine deposits *(Massive-well laminated)*

7b: Glaciofluvial deposits *(Gravelly deposits)*

6a: Ice-contact stratified deposits *(In moraines, eskers, kames and crevasse fills)*

5b: TillI *(Stone-poor, sandy silt to silty sand-textured till on Paleozoic terrain)*

5c: TillI *(Stony, sandy silt to silty sand-textured till on Paleozoic terrain)*

Phanerozoic / Paleozoic

3: Paleozoic bedrock

1. LIO/MNRF
2. Ontario Geological Survey 2010 (Mapped at 1:50,000). Surficial geology of southern Ontario; Ontario Geological Survey. Miscellaneous Release - Data 128 - Revised

0 200 400 600 800 1,000
METRE SCALE

North American Datum 1983
Universal Transverse Mercator Projection Zone 18

Scale: 1:30,000
Page Size: Tabloid (11 x 17 inches)

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Source Notes:
Imagery (2020) provided by ESRI map service. Contains information licensed under the Open Government Licence – Ontario.

NORTH

CLIENT
Black Bear Ridge GP Inc

PROJECT
Black Bear Ridge

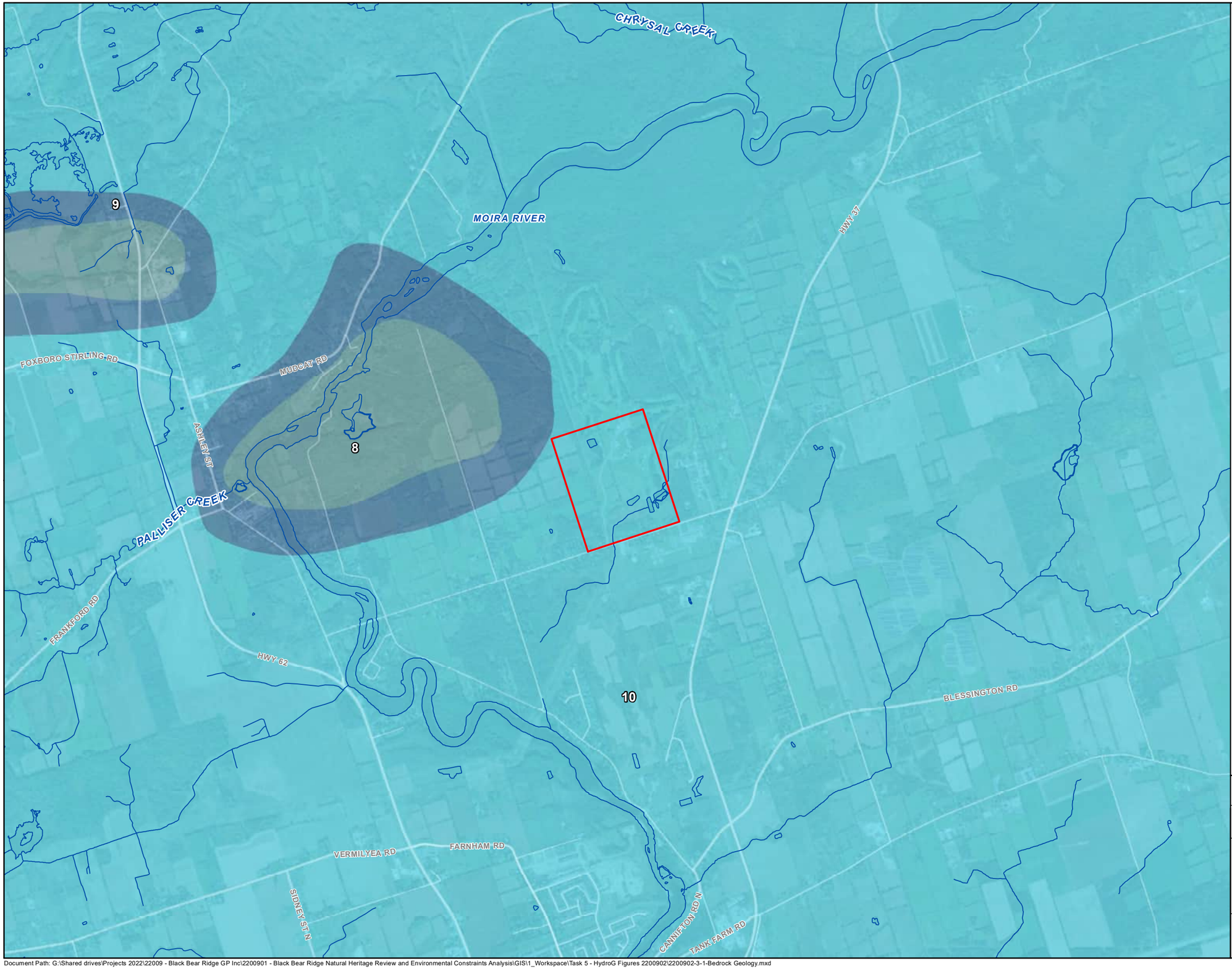
TITLE
Surficial Geology

Palmer

REF. NO. 2200902-2-1

Figure 5

Document Path: G:\Shared drives\Projects 2022\22009 - Black Bear Ridge GP Inc\2200901 - Black Bear Ridge Natural Heritage Review and Environmental Constraints Analysis\GIS\1_Workspace\Task 5 - HydroG Figures 2200902\2200902-2-1-Surficial Geology.mxd



LEGEND

Study Area

Watercourse[1]

Paleozoic Bedrock Geology[2]

Middle Ordovician - Simcoe Group

10: Verulam *(limestone and shale)*

9: Bobcaygeon *(limestone, with minor shales in upper part)*

8: Gull River *(limestone, with dolostone beds towards base)*

1. LIO/MNRF
2. Armstrong, D.K. and Dodge, J.E.P. Paleozoic Geology Map of Southern Ontario; Ontario Geological Survey, Miscellaneous Release--Data 219

0 200 400 600 800 1,000
METRE SCALE

North American Datum 1983
Universal Transverse Mercator Projection Zone 18

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CLIENT
Black Bear Ridge GP Inc

PROJECT
Black Bear Ridge

TITLE
Bedrock Geology

Palmer

REF. NO. 2200902-3-1

Figure 6

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2.3 Site Groundwater Conditions

2.3.1 Source Protection, Water Supply and Sewerage System

The site is located within the Quinte Region Source Protection Area under the Quinte Region Source Protection Plan. The Source Protection Plan designated the following 10 types of vulnerable areas:

- Wellhead Protection Area (WHPA)-Quality;
- Wellhead Protection Area E-(GUDI);
- Intake Protection Zone-Quality;
- Intake Protection Zone-Quantity;
- Issue Contributing Area;
- Significant Groundwater Recharge Area;
- Highly Vulnerable Aquifer (HVA);
- Event Based Area;
- Wellhead Protection Area (WHPA) Q1-Quantity;
- Wellhead Protection Area Q2-Quantity.

Based on the provincial source protection mapping, the Official Plan of Belleville and the above source protection plan (**Figure 7**), the following source protection designations were identified within the site:

- Highly Vulnerable Aquifer with a score of 6.

The results of well records inventory were summarized **Table 6** and displayed in **Figure 8**. Most wells are supply wells which were built from 1950 to 2020, reflecting long history of private water supply. Majority of the 142 wells are for water supply, tapping groundwater from limestone aquifer and gravel aquifer. The bedrock depths range from 1.5 to 25 m. Water from most wells are fresh, with one well having sulphur water (Well ID: 2911409). Based on extremely low yield of this well, it may be completed in a shale formation.

Table 6. Summary of Well Records

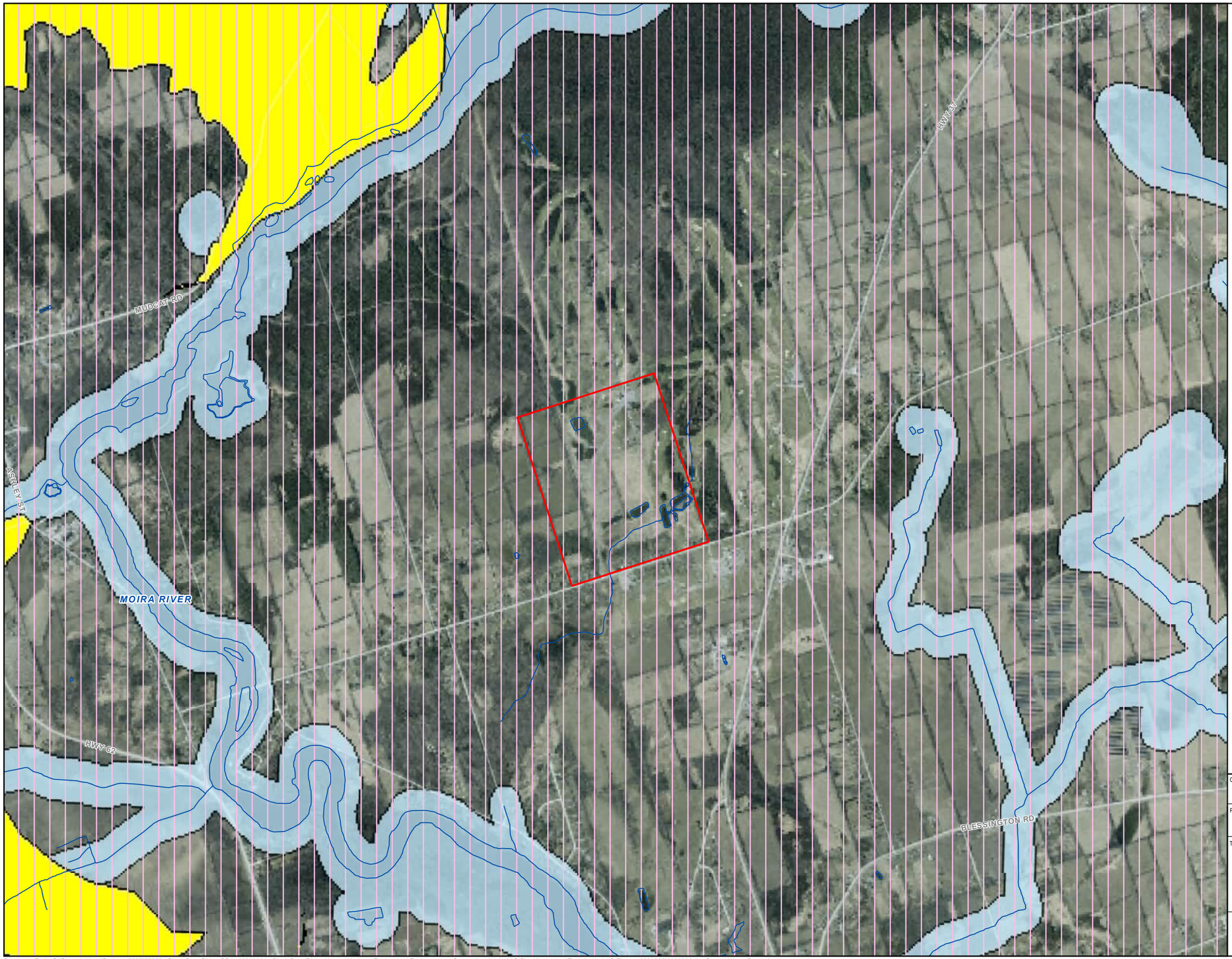
Classification		Record Number (142)
Water Use	Domestic / livestock	103
	Commercial	4
	Industrial	1
	Municipal/public	7
	Monitoring	2
	Monitoring and Test Hole	0
	Irrigation	0
	Decommissioned	0
	Unknow/Not used	24
Water Quality	Fresh	80
	Salty/Sulphur	2
	Unknow/untested	60
Aquifer	Overburden	77
	Bedrock	66
	Unknown	0

The depths of overburden wells range from 6.1 to 22.9 m, most of them being supply wells. Based on understanding of the proposed development, the depths of the subsurface work should be less than 6.1 m, and the impact to the shallow off-site wells or the existing water supply wells at the site is not anticipated.

Based on the Official Plan of the City of Belleville, the site is currently located outside of the Urban Serviced Area of Belleville. The municipal servicing is not available at the site and surrounding area. Therefore, the site and surrounding area are serviced with private supply wells and on-site septic system.

The Official Plan designated the site as Fully Serviced Resort Area, which means the site will only be allowed to develop on full municipal services. The proposed development at the site will be fully serviced by Belleville municipal water and sanitary sewer services.

Based on visual observations during the field work of Palmer staff, 13 supply wells were identified in the development area. One well is used for supplying water to administrative buildings and all the other supply wells are used for irrigation of golf courses. All these supply wells were found in working conditions. No information is available about which wells will be decommissioned. Bases on the Site Plan, the supply wells located within the footprints of development features will be decommissioned. Some supply wells might be retained for irrigation purposes. It is also noted that the client also operates three PTTWs to take water from Moira River for irrigation purposes.



LEGEND

Study Area

Watercourse[1]

Source Water Protection[2]

Intake Protection Zone 3

Highly Vulnerable Aquifer

Significant Groundwater Recharge Area

Score 6

1. LIO/MNRF
2. *Source Protection Information Atlas*, MECP © King's Printer for Ontario 2023

0 200 400 600 800 1,000

METRE SCALE

North American Datum 1983
Universal Transverse Mercator Projection Zone 18

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Page Size: Tabloid (11 x 17 inches)

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Checked: FL
Date: May 29, 2023

NORTH

Source Notes:
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CLIENT
Black Bear Ridge GP Inc

PROJECT
Black Bear Ridge

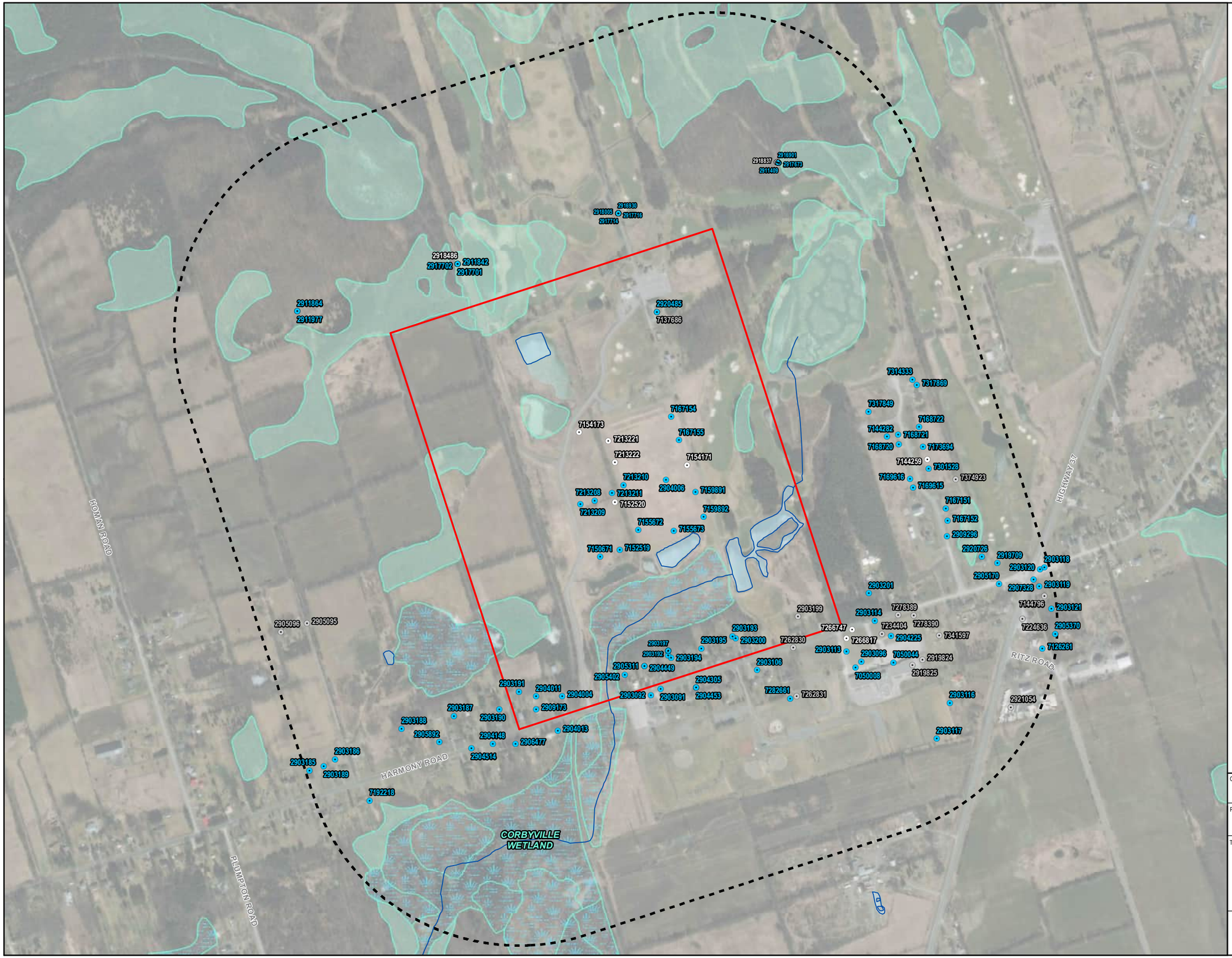
TITLE
Source Water Protection

Palmer

REF. NO. 2200902-5-1

Figure 7

Document Path: G:\Shared drives\Projects 2022\22009 - Black Bear Ridge GP Inc\2200901 - Black Bear Ridge Natural Heritage Review and Environmental Constraints Analysis\GIS\1_Workspace\Task 5 - HydroG Figures 2200902\2200902-5-1-Source Water Protection Areas.mxd



LEGEND

Well Record within 500m[1]

by Well Use

- Water Supply
- Test Well/Monitoring Well
- N/A

- Watercourse[2]
- Study Area
- 500m Study Area Buffer

Wetland[2]

- Evaluated-Provincial
- Not Evaluated as per OWES

1. MECP
2. LIO/MNRF

0 100 200 300 400 500

METRE SCALE

North American Datum 1983
Universal Transverse Mercator Projection Zone 18

Scale: 1:8,500
Page Size: Tabloid (11 x 17 inches)

Drawn: CV
Checked: FL
Date: Dec 17, 2024

NORTH

Source Notes:
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CLIENT
Black Bear Ridge GP Inc

PROJECT
Black Bear Ridge

TITLE
MECP Well Records within 500m of Study Area

Palmer

REF. NO. 2200902-8-2

Figure 8

Document Path: G:\Shared drives\Projects 2022\22009 - Black Bear Ridge GP Inc\2200901 - BBR Natural Heritage Review & Enviro Constraints Analysis\GIS\1_Workspace\Task 5 - HydroG Figures 2200902\2200902-8-2-MECP Well Records.mxd

2.3.2 Groundwater Levels, Flow Direction and Gradient

Four rounds of manual groundwater level measurement have been conducted for all wells installed for the project. The manual measurement results were summarized in **Table 7.** While no nested monitoring well locations were installed on site, groundwater depths show no apparent trend of increasing with well depths for monitoring wells and well records, indicating the vertical gradient of groundwater flow might be insignificant, and groundwater levels in different depths of a well should be similar.

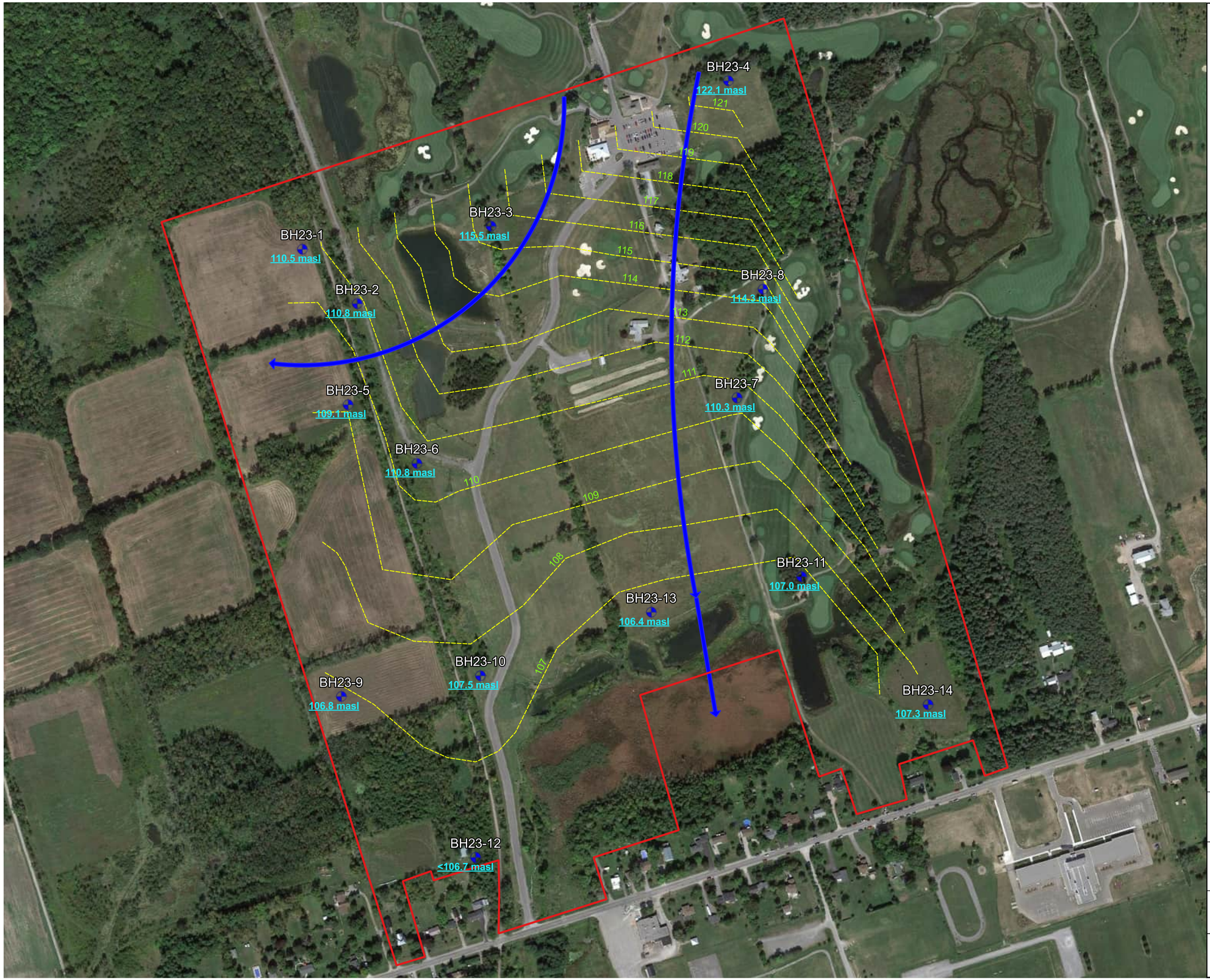
Table 7. Groundwater Levels

Well ID	Surface Elevation (masl)	Depth (mbgs)	29-Aug-23		07-Sep-23		13-Sep-23		19-Oct-23	
			mbgs	masl	mbgs	masl	mbgs	masl	mbgs	masl
BH23-1	112.53	4.54	-	-	2	110.53	1.58	110.95	2.04	110.49
BH23-2	112.36	5.62	0.25	112.11	1.07	111.29	1.32	111.04	1.58	110.78
BH23-3	120.78	6.06	3.58	117.20	3.86	116.92	4.16	116.62	5.32	115.46
BH23-4	124.56	5.1	1.15	123.41	1.99	122.57	2.07	122.49	2.48	122.08
BH23-5	110.39	3.27	-	-	1.77	108.62	1.14	109.25	1.34	109.05
BH23-6	112.16	4.3	1.26	110.90	2.28	109.88	2	110.16	1.36	110.80
BH23-7	113.3	7.47	0.81	112.49	2.67	110.63	1.95	111.35	2.99	110.31
BH23-8	116.93	6.16	0.48	116.45	0.71	116.22	1.97	114.96	2.5	114.43
BH23-9	108.94	2.88		-	2.26	106.68	2.6	106.34	2.11	106.83
BH23-10	111.37	6.11	1.8	109.57	2.65	108.72	2.87	108.50	3.87	107.50
BH23-11	107.48	4.27	0.37	107.11	0.82	106.66	0.85	106.63	0.90	106.58
BH23-12	109.2	2.49	dry	-	dry	-	dry	-	dry	-
BH23-13	108.24	3.86	1.93	106.31	1.58	106.66	1.73	106.51	1.85	106.39
BH23-14	110.36	7.92	1.29	109.07	2.46	107.90	2.58	107.78	3.08	107.28

Hydrostratiphic structure under the site can be characterized as shallow bedrock aquitard, overlain with interfingered lens of till aquitard and sand and gravel aquifers (**Table 5**). Owing to the non-continuity of till aquitard, significant vertical gradient is not anticipated. Among all the monitoring wells only monitoring well BH23-11, located in the lowest area (108.0 masl) to the south end of the development area shows weak upward vertical gradient, and all the other monitoring wells show downward vertical gradient. Further characterization of vertical gradient and artesian condition with nested monitoring wells might be needed during the next stage of the project.

Based on monitoring data from October 19, 2023, groundwater table elevation contours have been created (**Figure 9**). The groundwater elevation contours generally reflect a subdued form of ground surface topography, with the predominant direction of groundwater flow from northeast to southwest and south. The horizontal gradients range from 1.5% to 3%. Groundwater table elevation contours particularly near the edge of the site may be influenced by the lack of data near and outside the site boundaries.

Based on the monitoring data from October 19, 2023, groundwater table depth (mbgs) contours have been created using interpolating groundwater depths between monitoring well locations (**Figure 10a**). Two areas of shallow groundwater table were identified which center around BH23-2 and BH23-5, and BH23-11. This figure does not reflect smaller scale changes in topography between the borehole locations. To address this, **Figure 10b** was created based on subtracting topographical contours with the groundwater table



Legend

- Site Boundary
- Monitoring Well
- GW Table Elev Contour
- GW Flow Direction

0 100 200 300 m

North American Datum 1983
Universal Transverse Mercator Projection Zone 18

Scale: 1:4500
Page Size: Tabloid (11 x 17 inches)

Drawn: FL
Checked: NS

Date: Dec 2024

Source Notes:
Basemap: Google satellite imagery (2020)
Groundwater table elevation contours were based on measurement on October 19, 2023

Client
Black Bear Ridge GP Inc.

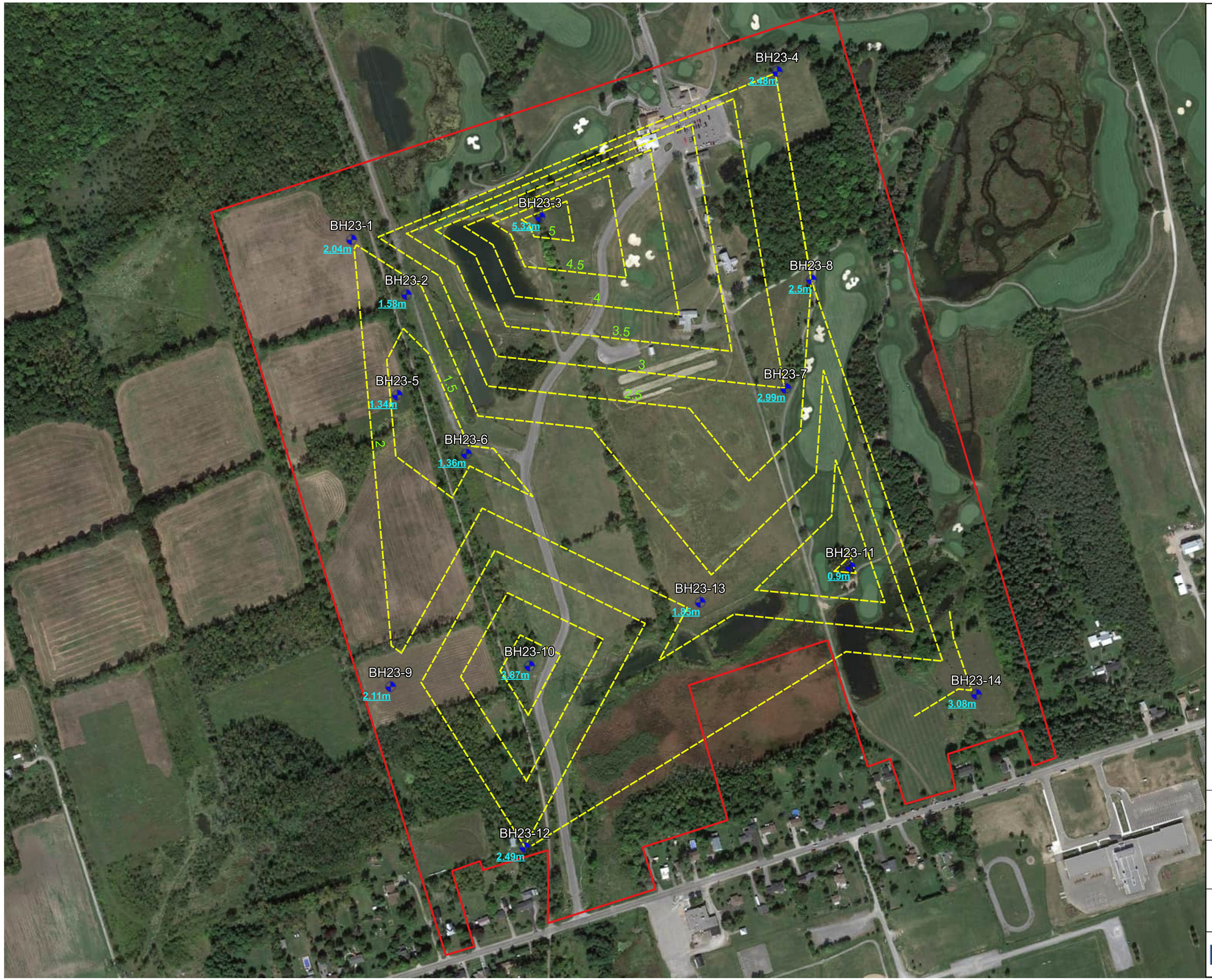
Project
501 Harmony Road, Corbyville, ON

TITLE Groundwater Table Elevation Countour and Flow Direction

Palmer PART OF SLR

REF. NO 2200902

Figure 9



Legend

- Site Boundary
- Monitoring Well
- GW Table Depth Contour

0 100 200 300 m

North American Datum 1983
Universal Transverse Mercator Projection Zone 18

Scale: 1:4500
Page Size: Tabloid (11 x 17 inches)

Drawn: FL
Checked: NS

Date: Dec 2024

Source Notes:
Basemap: Google satellite imagery (2020).
Groundwater depth data were based on measurement on October 19, 2023

Client
Black Bear Ridge GP Inc.

Project
501 Harmony Road, Corbyville, ON

TITLE
Groundwater Table Depth Contours Interpolated at Borehole Locations

Palmer PART OF SLR

REF. NO 2200902

Figure 10a

Legend

- Site Boundary
- Monitoring Well
- GW Table Depth Contour

0 100 200 300 m

North American Datum 1983
Universal Transverse Mercator Projection Zone 18

Scale: 1:4500
Page Size: Tabloid (11 x 17 inches)

Drawn: FL
Checked: NS

Date: Dec 2024

Source Notes:
Basemap: Google satellite imagery (2020).
Groundwater depth data were based on measurement on October 19, 2023

Client
Black Bear Ridge GP Inc.

Project
501 Harmony Road, Corbyville, ON

TITLE
Groundwater Table Depth Contours Compared to Ground Surface Topography

Palmer | PART OF SLR

REF. NO 2200902

Figure 10b

contours. However, this also has limitations as while there are smaller scale changes in ground surface elevation, the groundwater levels remain interpolated between locations which does not reflect smaller scale groundwater level changes that likely exist between locations, and as mentioned above the groundwater level data is influenced by the lack of data near the outside of the monitoring well network (e.g. east side of site with negative values).

It should be noted that the density of monitoring wells is not enough to produce an accurate groundwater table elevation contour map and groundwater table depth contour map.

Further groundwater levels monitoring will be conducted during 2024 and 2025 to catch seasonal variability of conditions on the site as recommended by the City of Belleville.

2.3.3 Hydraulic Conductivity

2.3.3.1 Hydraulic Conductivity from Single Well Response Test

Hydraulic conductivity (K) -values of the saturated soils were estimated through single well response tests (SWRTs) or slug or bail tests, which have been introduced above. Slug-in or slug-out tests were conducted for all monitoring wells except BH23-9 and BH23-12 due to insufficient water in well casing. The testing records were analyzed using the Bouwer-Rice (1976) method (unconfined aquifers) or Hvorslev method (confined aquifers) with AQTESOLVTM software. The slug test results are summarized in **Table 8**, and the analysis reports are attached as **Appendix D**.

Table 8. Hydraulic Conductivity from Slug Tests

Well ID	Screened Interval (mbgs)	Screened Unit	K (m/s)
BH23-1	1.5 - 4.5	Sandy silt to sand and gravel	$1.9x10^{-6}$
BH23-2	2.3 - 5.3	Gravelly sand to sand	$9.3x10^{-7}$
BH23-3	3.0 - 6.0	Sandy silt till to sandy silt	$1.8x10^{-8}$
BH23-4	2.1 - 5.1	Sandy silt till with sand and gravel interbed	$2.5x10^{-6}$
BH23-5	1.5 - 3.0	Sandy silt to clayey silt	$1.7x10^{-8}$
BH23-6	1.3 - 4.3	Silty clay to clayey silt	$2.0x10^{-8}$
BH23-7	4.7 - 7.7	Sandy silt till to clayey silt	$2.5x10^{-7}$
BH23-8	3.2 - 6.2	Sandy silt	$6.5x10^{-8}$
BH23-10	3.1 - 6.1	Sandy silt	$1.1x10^{-7}$
BH23-11	1.5 - 4.5	Gravelly sand	$1.1x10^{-7}$
BH23-13	1.0 - 4.0	Sandy silt fill to sand and gravel	$4.2x10^{-8}$
BH23-14	5.0 - 8.0	Gravelly sand to clayey silt	$4.5x10^{-8}$

2.3.3.2 Hydraulic Conductivity from Grain Size Analysis

Six (6) soil samples taken from six (6) boreholes were analyzed for grain size as part of the study. The samples were taken from different depths, which represents middle to deep vadose zones as well as the saturated zone. The results of grain size analysis were used to get K values based on the following empirical equation. The resultant K values are listed in **Table 9**.

$$K\ (Sauerbrei, 1932) = \frac{\rho g}{\mu}[(3.75 \times 10^{-5}) \times \tau]\left[\frac{n^3}{(1-n)^2}\right] d_{17}^2\ \frac{cm}{s}$$

Where K = hydraulic conductivity (cm/s)
ρ = $3.1x10^{-8}T^3 - 7.0x10^{-6}T^2 + 4.19x10^{-5}T + 0.99985$
g = 980 cms^{-2}
μ = $-7.0x10^{-8}T^3 + 1.002x10^{-5}T^2 – 5.7x10^{-4}T + 0.0178$
τ = $1.093x10^{-4}T^2 + 2.102x10^{-2}T + 0.5889$
n = porosity as a fraction of aquifer volume (0.30 for sand and gravel, 0.35 for till)
T = water temperature (°C) (20)

Table 9. Hydraulic Conductivity from Grain Size Analysis

Well ID	Sample ID	Depth Range (mbgs)	Soil Classification	K-value (m/s)
BH23-4	SS7	4.6 - 4.9	Sandy silt till	$1.6x10^{-8}$
BH23-5	SS4	2.3 - 2.9	Silty sand and gravel	$3.7x10^{-7}$
BH23-7	SS9	6.1 - 6.7	Sandy silt	$7.8x10^{-9}$
BH23-10	SS7	4.6 - 4.9	Sandy silt	$1.8x10^{-7}$
BH23-13	SS5	3.0 - 3.6	Sand and gravel	$4.2x10^{-5}$
BH23-14	SS7	6.1 - 6.7	Sand and gravel/clayey silt	$3.2x10^{-6}$

2.3.3.3 Hydraulic Conductivity from Guelph Permeameter Tests

A Guelph Permeameter (GP) was designed to obtain measurements of field saturated hydraulic conductivity of shallow unsaturated soils, which has been introduced above, and the test results are provided in **Appendix E**. **Table 10** summarizes the test results.

Due to high density of soil, the depths of testing were limited to root zone. Therefore, the k-values might be affected by tilling, root holes and burrows, and the results may not completely in line with encountered soil types.

Table 10. Hydraulic Conductivity from Infiltration Tests

GP ID	Depth (mbgs)	Soil Classification	K-value (m/s)
GP1	0.3	Clay Silt some sand	$1.7x10^{-4}$
GP2	0.5	silty clay	$4.6x10^{-7}$
GP3	0.4	silt trace clay and sand	$1.2x10^{-4}$
GP4	0.5	clayey silt some sand	$5.0x10^{-5}$
GP5	0.4	clayey silt trace gravel	$2.0x10^{-5}$
GP6	0.3	sandy silt	$1.4x10^{-4}$

2.3.4 Infiltration Rate

To inform the design of infiltration facilities as part of LID and stormwater management, infiltration rates for the overburden soils were estimated through the following empirical equation correlating K values and infiltration rate provided in Ontario Ministry of Municipal Affairs and Housing (OMMAH) Supplementary Guidelines to the Ontario Building Code 1997, and in the Low Impact Development Stormwater Management Planning and Design Guide (TRCA/CVC, 2010):

$$K = (6 \times 10^{-11}) I^{3.7363}$$

Where:
K = hydraulic conductivity (cm/s)
I = infiltration rate (mm/hr)

Rearranging for infiltration rate, we obtain the following relationship:

$$I = \left[\frac{K}{6 \times 10^{-11}}\right]^{\frac{1}{3.7363}}$$

The estimated infiltrate rates are listed in **Table 11.**

Table 11. Infiltration Rate

Test Method	Investigation Point ID	Depth Range (mbgs)	K-value (m/s)	Infiltration Rate		Geometric Mean		90th Percentile	
				mm/hour	cm/min	mm/hour	cm/min	mm/hour	cm/min
GP Test	GP1	0.33	$1.7x10^{-4}$	183	0.30	41	0.07	170	0.28
	GP2	0.48	$4.6x10^{-7}$	38	0.06				
	GP3	0.36	$1.2x10^{-4}$	167	0.28				
	GP4	0.50	$5.0x10^{-5}$	132	0.22				
	GP5	0.40	$2.0x10^{-5}$	103	0.17				
	GW6	0.25	$1.4x10^{-4}$	174	0.29				
Slug Test	BH23-1	1.5-4.5	$1.9x10^{-6}$	55	0.09				
	BH23-2	2.3-5.3	$9.3x10^{-7}$	45	0.08				
	BH23-3	3.0-6.0	$1.8x10^{-8}$	16	0.03				
	BH23-4	2.1-5.1	$2.5x10^{-6}$	59	0.10				
	BH23-5	1.5-3.0	$1.7x10^{-8}$	16	0.03				
	BH23-6	1.3-4.3	$2.3x10^{-8}$	17	0.03				
	BH23-7	4.7-7.7	$2.5x10^{-7}$	32	0.05				
	BH23-8	3.2-6.2	$6.5x10^{-8}$	22	0.04				
	BH23-9	1.5-3.0	-	-	-				
	BH23-10	3.1-6.1	$1.1x10^{-7}$	25.6	0.04				
	BH23-11	1.5-4.5	$1.1x10^{-7}$	25.6	0.04				
	BH23-12	1.0-2.5	-	-	-				
	BH23-13	1.0-4.0	$4.2x10^{-8}$	19.8	0.03				
	BH23-14	5.0-8.0	$4.5x10^{-8}$	20.2	0.03				
	BH23-4	4.6-4.9	$1.6x10^{-8}$	15.3	0.03				

Grain Size Analysis	BH23-5	2.3-2.9	$3.7x10^{-7}$	35.5	0.06				
	BH23-7	6.1-6.7	$7.8x10^{-9}$	12.6	0.02				
	BH23-10	4.6-4.9	$1.8x10^{-7}$	29.2	0.05				
	BH23-13	3.0-3.6	$4.2x10^{-5}$	125.8	0.21				
	BH23-14	6.1-6.7	$3.2x10^{-6}$	63.2	0.11				

It should be noted that many factors affect k-values, such as lithology, sedimentological structures, well construction, sample amount and testing operation. K-values from different methods should be assessed statistically. The k-values from grain size analysis are generally greater than the k-values from slug tests. These discrepancies, especially for BH23-13 and BH23-14, may be due to the existence of fine materials in screened formation and the loss of fine materials in soil samples analysed for grain size gradation. Nonetheless, the k-values from slug tests prevail when selecting k-values to do calculation analysis as they best represent the bulk hydraulic conductivity of formations.

2.3.5 Groundwater Chemistry

Regional information from the MECP well records and previous studies as presented above did not identify any groundwater quality issues for the site and surrounding areas. Groundwater quality was observed during drilling and sampling, and no visual and olfactory evidence of contamination such as visible petroleum hydrocarbon film or sheen as well as smell and odor were noted.

As introduced above, two samples were taken from two different wells (BH23-2 and BH23-10) after purging the wells to stabilized field parameter values. The sample taken from BH23-2 was tested for parameter of ALS's General Chemistry 3 Package. The sample taken from BH23-10 was tested for parameters of ALS's Potability Package. The results from both samples were compared to the Ontario Drinking Water Quality Standards (ODQWS) and the Ontario Provincial Water Quality Objectives (PWQO). **Table 12** lists the exceedances above the ODWQS and PWQO. None of these exceedances are health related, indicating the groundwater quality is good.

Table 12. Exceedances Over ODWQS and PWQO

Analyte	ODWQS	PWQO	Lowest Detection Limit	Units	BH23-10	BH23-2
Alkalinity, total (as CaCO3)	30-500	-	1	mg/L	631	-
Colour, apparent	5	-	2.0	CU	40.2	78.8
Hardness	80-100	-	0.5	mg/L	669	281
TDS	500	-	10	mg/L	648	-
Turbidity	5	-	0.10	NTU	5.22	11
Aluminum	0.1	0.075	0.003	mg/L	0.142	0.176
Manganese	0.05	-	0.0001	mg/L	0.0758	-

As part of the Phase Two Environmental Site Assessment (ESA) for the proposed development conducted by Palmer, ten (10) groundwater samples were taken from eight (8) monitoring wells and were tested for two groups of suspected contaminants including Polycyclic Aromatic Hydrocarbons Surrogates (PAH) and

Organochlorine Pesticides (OP). The test results were compared with the Table 1 Standards of O. Reg. 153. No exceedance was identified, indicating the groundwater under the site has not receive significant anthropogenic contaminants.

2.4 Water Levels from Mini-Piezometers

Monitoring data from the mini-piezometers installed in the wetlands include groundwater levels measured within the mini-piezometer pipes and surface water levels outside the mini-piezometer pipes. **Table 13** summarises the monitoring results. As the monitoring results show, surface water levels were typically higher than groundwater levels in majority of monitoring events. It can be assessed that the surface water infiltrates into the ground to recharge the groundwater in most of the wetlands during summer and fall months. Further ongoing monitoring is required to determine if this changes seasonally.

Figure *11* shows the hydrographs for the continuous records of groundwater levels and manual monitoring results for the five mini-piezometers.

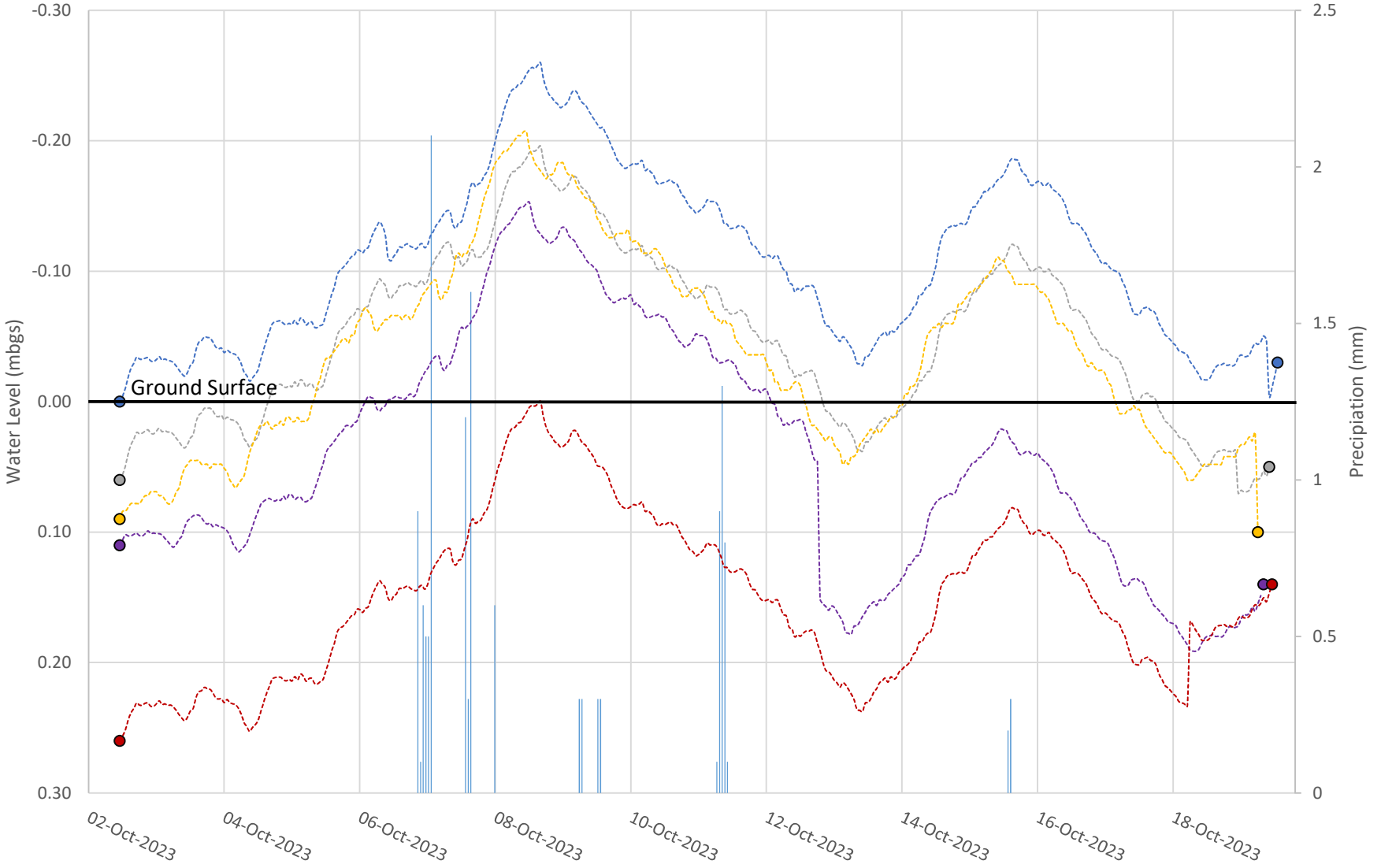
It should be noted that topographical contours (**Figure 4**) were created from point Lidar cloud and have unspecified resolution. Groundwater table contours were interpreted with a few data points just to show large spatial trend. Interaction between groundwater and surface can not be assessed with the data of such quality, and that is the reason that MPs were installed to characterise groundwater and surface water interaction.

Table 13. Water Level Monitoring Results from MPs

MP ID		Water Levels (mbtor)		
		June 16, 23	Sept 13, 23	Oct 19, 23
MP1	In	2.11	0.70	0.70
	Out	0.70	0.74	0.72
	Gradient	-0.9	0.0	0.01
MP2	In	1.71	0.82	0.91
	Out	0.81	0.83	0.91
	Gradient	-0.7	0.0	0
MP3	In	1.60	0.98	1.12
	Out	0.97	1.02	1.05
	Gradient	-0.5	0.0	-0.06
MP4	In	1.72	1.35	1.36
	Out	1.07	1.17	1.27
	Gradient	-0.7	-0.2	-0.09
MP5	In	1.80	1.15	0.99
	Out	0.76	0.85	0.85
	Gradient	-0.8	-0.2	-0.10

mbtor – meters below top of riser.
In – groundwater levels within MP.
Out – surface water levels outside the MP.
Gradient: minus-downgradient, positive-upgradient.
***No measurement due to frozen.**

Figure 11. BBR Mini-Piezometer Hydrograph



3. Site Water Balance Assessment

The Official Plan of the City of Belleville states that “This Plan supports the minimization of erosion and changes in water balance, and prepare for the impacts of a changing climate through the effective management of stormwater, including the use of green infrastructure and low impact development”. The Official Plan of Hasting County also requires that planning for stormwater management shall minimize changes in water balance and erosion.

The site water balance assessment was conducted to address concerns from agencies regarding stormwater management and to provide inputs to stormwater management design. The water balance assessment was conducted in general accordance with the Hydrogeological Assessment Submissions, Conservation Authority Guidelines to Support Development Applications (2013) and Stormwater Management Planning and Design Manual of MECP (2003), and consists of the following steps:

- Water surplus determination;
- Land use unit delineation and infiltration factor determination for pre- and post-development scenarios;
- Pre- and post-development water balance analysis; and
- Low Impact Development (LID) considerations.

The site water balance assessment was completed for the site in order to assess the extent of impact of the proposed development through the percentage change of reduced infiltration and increased runoff.

It should be noted that a Feature-Based Water Balance Assessment (FBWBA) should be conducted to assess impact to the specific wetland features. It is recommended that a FBWBA be conducted at a future stage of the project.

3.1 Water Surplus

Water surplus for pervious vegetated areas is estimated with the Thornthwaite and Mather water balance method (1957) which is an accounting procedure based on a reasonable principle to quantify components of the hydrologic cycle as expressed in the following equation:

$P = ET + R + I + \Delta S$

P= Precipitation (mm/year)
ET= Evapotranspiration (mm/year)
R= Runoff (mm/year)
I= Infiltration (mm/year)
ΔS= Change in groundwater storage (mm/year)

And where:
R+I=Water surplus (mm/year)

Palmer developed an in-house spreadsheet program to execute the Thornthwaite and Mather water balance analysis. The input data includes:

- Long term (30 years) monthly average precipitation and temperature collected from closest climate station (Belleville Water Treatment Plan) for the period between 1981 and 2010) (**Table 4**);
- Degrees of altitude = 44.15°;
- Soil moisture storage capacity for major soil types and land use units within the site:
  - coarse till (sandy silt) plus farmland = 100 mm;
  - coarse till (sandy silt) plus grassland and golf coarse = 150 mm;
  - coarse till (sandy till) plus woodland = 350 mm; and
  - organic soil plus mixed vegetation = 200 mm.

Water surplus for each combination of major soil types and land use types was calculated, and then a weighted average of water surplus for the whole site was calculated based on the area of each major land use unit. The weighted average water surplus will be used for the whole site for the pervious areas under the pre-development scenario and the water surplus for grassland will be used for landscaped area for the post-development scenario. **Table 14** sums up the results of the Thornthwaite and Mather water balance analysis.

Table 14. Water Surplus

Month	Mean Temperature (°C)	Total Precipitation (mm)	Actual Evapotranspiration (mm)	Water Surplus (mm)			
				Farmland	Grassland	woodland	Mixed Coverage and Wetland
January	-6.7	67.3	0.0	67.3	67.3	67.3	67.3
February	-5.1	58.1	0.0	58.1	58.1	58.1	58.1
March	-0.4	62.4	0.0	62.4	62.4	62.4	62.4
April	7.0	75.8	33.6	42.2	42.2	42.2	42.2
May	13.7	81.3	114.3	-27.0	-33.0	-41.0	-36.0
June	19.0	74.5	95.5	-14.0	-21.0	-28.0	-23.0
July	21.8	65.1	71.1	-6.0	-6.0	-15.0	-12.0
August	20.8	75.5	69.5	5.0	6.0	11.0	9.0
September	16.3	91.9	81.6	10.3	10.3	10.3	10.3
October	9.5	85.2	40.0	45.2	45.2	45.2	45.2
November	3.6	95.7	11.1	84.6	84.6	84.6	84.6
December	-2.6	79.1	0.0	79.1	79.1	79.1	79.1
Year		911.9	516.7	407.2	395.2	376.2	387.2
Weighted Average				386.7			

Water surplus for impervious areas (building rooves, impervious pavement etc.) was calculated based on the assumption that 10% of total precipitation will evaporate off impervious surfaces (acceptable range is 10% to 20%). Total precipitation adopted based on this is 820.7 mm/year.

3.2 Land Use Unit Delineation, Infiltration Factors and Impervious Factors

Delineation of land use units for current site conditions (pre-development) was based on topography, surficial soil, and land cover at the site, and the delineation of land use units for the proposed development (post-development) was based on the conceptual site plan provided by the client (**Appendix A**). Infiltration factors for each land use unit was calculated based on the scoring table presented in the Stormwater Management Planning and Design Manual of MECP (2003) and in the MECP Hydrogeological Technical Information Requirements for Land Development Applications (1995). Impervious factors were based on empirical values well accepted in Ontario. **Table 15** summarizes the results of land unit delineation, infiltration factors and impervious factors for pre- and post- development scenarios. It is noted that the ground surface slope gradient is estimated from the topographical contours (**Figure 4**) with aid of GIS classification.

Table 15. Land Use Units, Infiltration Factors and Impervious Factors for Pre- and Post-Development

Pre-Development						
Land Use Unit	Area (ha)	Slope Gradient	Soil	Land Cover	Infiltration Factor*	Impervious Factor
Farmland	9.16	0.2	0.3	0.1	0.6	0
Grassland and Golf course	36.16	0.1	0.2	0.1	0.4	0
Woodland	10.55	0.1	0.2	0.2	0.5	0
Wetland and Organic Soil Area	22.70	0.3	0.3	0.2	0.8	0
Pond	3.12	0.3	0.2	0	0.5	0
Building/Pave	2.58	0.2	0	0	0.2	0.9
Total	84.27	-	-	-	-	-
Post-Development						
Land Use Unit	Area (ha)	Slope Gradient	Soil	Land Cover	Infiltration Factor*	Impervious Factor
Low Density (R1)	17.34	0.2	0.2	0.1	0.5	0.41
Low Density (R4)	5.23	0.2	0.2	0.1	0.5	0.30
Resort and Entertainment	1.92	0.2	0.2	0.1	0.5	1.0
Parks and Open Space	19.66	0.2	0.3	0.1	0.6	0.07
Golf Course	15.56	0.1	0.2	0.1	0.4	0
Stormwater Management	1.82	0.3	0.2	0	0.5	0.5
Right of Ways	10.55	0.20	0.2	0.1	0.5	0.07
Environmental	12.19	0.2	0.3	0.2	0.7	0
Total	84.27	-	-	-	-	-

***Applies only to pervious areas.**

3.3 Water Balance for Pre-Development and Post-Development

Water balance values for pre- and post-development scenarios were calculated based on the values of water surplus, areas of land use units, infiltration factors and impervious factors as determined above. **Table 16** summarizes the results of water balance calculation, which shows that the proposed development will cause a reduction of infiltration of 23,735 m^3/year and an increase in runoff of 78,820 m^3/year.

Table* 16. *Water Balance for Pre- and Post-Development

Pre-Development						
Land Use Unit	Area (ha)	Water Surplus (mm/year)	Infiltration Factor*	Impervious Factor	Runoff (m^3/year)	Infiltration (m^3/year)
Farmland	9.16	821/387**	0.6	0	14,172	21,258
Grassland and Golf course	36.16	821/387	0.4	0	83,893	55,928
Woodland	10.55	821/387	0.5	0	20,402	20,402
Wetland and Organic Soil Area	22.70	821/387	0.8	0	17,556	70,225
Pond	3.12	821/387	0.5	0	6,033	6,033
Building/Pave	2.58	821/387	0.2	0.9	19,818	199
Total	84.27		-	-	161,873	174,044
Post-Development						
Land Use Unit	Area (ha)	Water Surplus (mm/year)	Infiltration Factor*	Impervious Factor	Runoff (m^3/year)	Infiltration (m^3/year)
Low Density (R1)	17.34	821/395**	0.75	0.41	78,563	20,216
Low Density (R4)	5.23	821/395	0.75	0.30	20,111	7,234
Resort and Entertainment	1.92	821/395	0.75	1.0	15,758	0
Parks and Open Space	19.66	821/395	0.7	0.07	40,198	43,355
Golf Course	15.56	821/395	0.4	0	36,896	24,597
Stormwater Management	1.82	821/395	0.5	0.5	9,267	1,798
Right of Ways	10.55	821/395	0.75	0.07	25,448	19,388
Environmental	12.19	821/395	0.7	0	14,452	33,722
Total	84.27		-	-	240,693	150,310
Pre- to Post- Development Change					78,820	-23,735
Pre- to Post- Development Change (%)					49%	-14%

***apply only to previous areas.**

****water surplus for impervious area/water surplus for pervious area.**

3.4 LID Design Considerations

The water balance results indicate that the proposed development will reduce groundwater recharge by 23,735 m^3/year. As the site is not in a WHPA-Q2, it is not mandatory that groundwater recharge pre-

development be maintained post-development through LID measures. However, as present above, both the City of Belleville and Hasting County support the minimization of erosion and changes in water balance through the effective management of stormwater, including the use of green infrastructure and low impact development (LID). Therefore, LID measures are recommended to treat the increased runoff of 78,820 m^3/year.

Based on the Low Impact Development Stormwater Management Planning and Design Guide (CVC and TRCA), the major site constraints for LID design includes a low infiltration rate and a shallow groundwater table. As presented above, the infiltration rate of soil samples at the site ranges from 0.02 to 0.3 cm/min with geometric mean of 0.07 cm/min; indicating that the soils have moderate capacity in taking in water. Therefore, LID features with various depths can be considered. Depending on requirement of agencies, a factor of safety 2.5 or other values should be considered for designing infiltration facilities.

As shown in **Figure 10**, recorded groundwater levels range from 1.0 to 4.0 mbgs. Considering site grading, most of the site can accommodate shallow LID features while only some areas can accommodate deep LID features, areas surrounding BH23-2, BH23-5 and BH23-11 with shallow groundwater levels, surficial and shallow LID features should be considered.

Based on the site stratigraphy (**Table 5**), the LID features should be targeted in the sandy silt unit or upper sand and gravel unit. Further infiltration test is needed to confirm the infiltration rates at these locations.

4. Preliminary Construction Dewatering Assessment

Dewatering for construction is conducted to fulfil three purposes: provide a dry working condition, help maintain ground stability, and help maintain a healthy and safe working environment. The requirement for construction dewatering depends on groundwater levels and the depths of excavation for structures and utilities. Based on monitoring data collected up to date and as shown in **Figure 10**, the groundwater levels range from 0.85 to 4.16 mbgs. As required by the client, one level of basement is considered for all buildings. Excavation is required for basement foundations for all buildings, and for trenches of sewerage and utility lines. The depth of excavation is usually assumed to be 3.0 m for basement foundation, 4.0 m for trenches for utility lines and also 4.0 m for stormwater management ponds with additional 0.5 m of over-excavation. As excavation depths are deeper than groundwater level depths at most of the site, construction dewatering must be considered.

It should be noted that the construction dewatering assessment is for a large development site instead of a single building. The result is at its very best preliminary, but it will provide preliminary information for permitting and impact assessment. Further detailed construction dewatering may be required when detailed design and further investigation data become available.

4.1 Dewatering Assessment Areas and Excavation Parameters

To facilitate the assessment of dewatering requirement, the site is divided into four (4) dewatering assessment areas (**Figure 12**) based on groundwater table depth distribution and the proposed building

features. Excavation parameters include excavation depths, areas, and excavated soils. **Table 17** lists the details of each assessment area and excavation parameters. The groundwater levels in **Table 17** are the representative recorded groundwater levels. The excavation area is the area of each dewatering area based on the assumption that all building features within each dewatering area are to be constructed at the same time, which is the most aggressive case in dewatering rate estimation.

Table 17. Dewatering Assessment Areas and Excavation Parameters

Division of Site	Area 1	Area 2	Area 3	Area 4
Development Features	Resort	Residential	Residential	Residential
Monitoring Wells	BH23-3	BH23-1, 5	BH23-6, 9	BH23-6, 7
GW Levels (mbgs)	2.5-4.0	1.5	2.0	2.0
Excavation Depth (mbgs)	3.5	3.5	3.5	3.5
Soil Excavated	Sandy silt to sandy silt till	Sandy silt, a bit wet sandy gravel at bottom	Silty clay to sandy silt	Clayey silt to sandy silt till
Typical Excavation Dimension (m^2)	57,917	57,286	34,631	66,362
Groundwater Level Target (mbgs)	4.0	4.0	4.0	4.0

4.2 Dewatering Rate Estimation

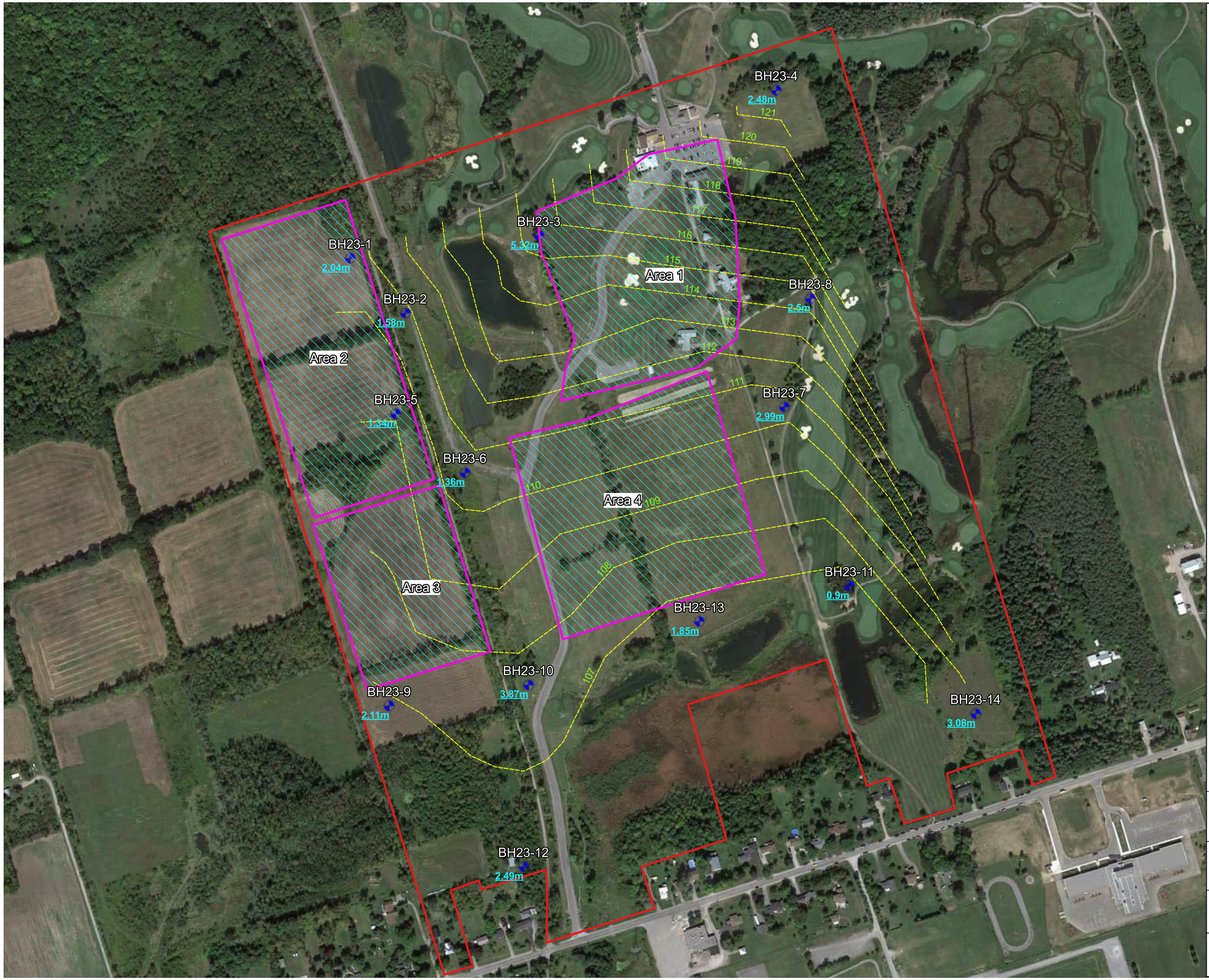
Dewatering rate (L/day) is a key parameter for implementing construction dewatering and assessing impact as a result of dewatering. The dewatering required incorporates three kinds of potential water flow or seepage into excavation trenches or pits, which includes static groundwater seepage, storage of groundwater that has to be depleted before groundwater flow reaches a static state, and storm water. Considering the nature of the proposed development, only static groundwater seepage is assessed.

Static Groundwater Seepage and Influence Zone:
Based on the recorded groundwater levels and the stratigraphic units at the site as characterized above, the aquifer system within excavation depths is unconfined. The static groundwater seepage is estimated with the following Dupuit-Thiem equation for equivalent wells such as shafts or pits with dimension ratio of less than 1.5:

$$Q = K(H^2 - h_w^2) / [\log (R / r_w)]$$

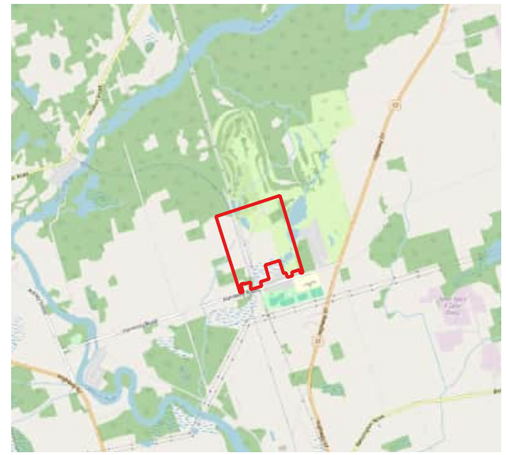
The static groundwater seepage for trenches is estimated with the following Dupuit-Thiem equation for two ends of the trench plus the drainage trench equation for the trench body:

$$Q = K(H^2 - h_w^2) / [\log (R / r_w)] + xK(H^2 - h^2)/L$$



Legend

- Site Boundary
- Monitoring Well
- GW Table Depth Contour
- Dewatering Assessment Area



0 100 200 300 m

North American Datum 1983
Universal Transverse Mercator Projection Zone 18

Scale: 1:4500
Page Size: Tabloid (11 x 17 inches)

Drawn: FL
Checked: NS

Date: Dec 2024

Source Notes:
Basemap: Google satellite imagery (2020)

Client
Black Bear Ridge GP Inc.

Project
501 Harmony Road, Corbyville, ON

TITLE
Dewatering Assessment Area

Palmer PART OF SLR

REF. NO 2200902

Figure 12

Q = pumping rate
K = hydraulic conductivity (m/s)
H = original water level (m) above lower aquitard
h_w = targeted level (m) above the lower aquitard
R = influence radius (combined) (m)
r_w = well radius or equivalent radius (m)
x=length of trench (m)
w=width of trench (m)
L=line source distance (m) which is the greater of $R_0/2$ or 10 m

Radius of influence zone is calculated with Sichart equation:

$R_0 = C(H-h_w) K^{1/2}$
C =3000 for well.
$R = R_o+r_w$

Well equivalent radius is calculated as follows:

r_w = SQRT (excavation area/π)

Groundwater levels recorded during the summer and fall were used for dewatering rate estimation. To account for this, one (1) m was added to the highest groundwater level recorded for seasonal variation, however this seasonal fluctuation should be assessed further through groundwater level monitoring during all seasons and specifically during the spring when water levels are typically highest. The dewatering drawdown (H) was estimated based on the assumed seasonally high groundwater levels recorded and the lowest targeted groundwater levels to represents the worst-case scenario. K-value for calculating static seepage was selected from the slug test results for the monitoring wells within or close to the dewatering area. If there are more than one monitoring wells within a dewatering area, the highest k-value was used. It should be noted that the dewatering assessment is not for certain building or structure, and therefore, the soil condition at certain point was not considered.

Excavation in Arear 2 straddles two drastically different formations, and therefore, the dewatering for Area 2 was broken into two stages: upper stage through fine soil and lower stage through coarse soil.

Storage of Groundwater:
The storage of groundwater was estimated based on effective porosity of excavated soil and the volume of excavated saturated soil plus the volume of saturated soil enclosed by drawdown cone and influence zone column. Based on the classification of soil encountered in the boreholes, no wet and saturated zones were identified under the site within the zone of excavation for Area 1, 3 and 4 and the soil encountered in boreholes are mostly fine-grained soil. Free gravity flow of groundwater during construction is not anticipated in these three dewatering assessment areas. Consequently, storge of groundwater will not be considered for Area 1, 3 and 4. Lower part of the excavation in Area 2 will go through saturated gravel and sand. Free draining during excavation for the saturated gravel and sand is anticipated, and therefore, storge is considered for the excavation in Area 2.

Stormwater:

Based on Palmer's experience, 25 mm/day rainfall intensity is used to estimate potential stormwater that may accumulate in the excavation pits during excavation as this rainfall intensity represent 95% storm events in Southern Ontario.

Dewatering Summary:

Table 18 lists the input parameters and output values for dewatering quantity estimation for areal development features such as residential buildings and resort facilities. **Table 19** lists the input parameters and output values for dewatering quantity estimation for linear development features such as storm and sanitary sewers. The results show that before adding the stormwater the estimated dewatering rates range from 1,733 to greater than 463,347 L/day for the building areas depending on the sequence and combinations of construction activities. The estimated dewatering rate for a typical length of trench before adding stormwater ranges from 53 to 11,567 L/day.

Table 18. Dewatering Analysis Results for Typical Areal Development Features

Division of Site	Area 1	Area 2 (Upper Stage)	Area 2 (Lower Stage)	Area 2 (Combined)	Area 3	Area 4
Development Features	Resort	Residential	Residential	-	Residential	Residential
Monitoring Wells	BH23-3	BH23-1, 5	BH23-1, 5	-	BH23-6, 9	BH23-6, 7
GW Levels (mbgs)	2.5-4.0	1.5	3.0	-	2.0	2.0
Excavation Depth (mbgs)	3.5	3.0	3.5	-	3.5	3.5
Soil Excavated	Sandy silt to sandy silt till	Sandy silt	Sandy gravel	-	Silty clay to sandy silt	Clayey silt to sandy silt till
Excavation Dimension (m^2)	57,917	57,286 (159x360)	57,286 (159x360)	-	34,631	66,362
Groundwater Level Target (mbgs)	4.0	3.0	4.0	-	4.0	4.0
K (m/s)	$1.8x10^{-8}$	$1.7x10^{-8}$	$1.9x10^{-6}$	-	$2.0x10^{-8}$	$2.5x10^{-7}$
H (m)	0.7	1.5	1	2.5	2	2
h (m)	0	0	0	-	0	0
R_0 (m)	0.3	10.3	4.1	14.3	1.0	3.0
Storm (mm/day)	25	25		-	25	25
Q_{static} (L/day)	1,155	1712	25,735	-	2,698	13,285
$Q_{StaticFOU=1.5}$ (L/day)	1,733	2,568	38,603	-	4,047	19,928
$Q_{Storage}$ (L/day)	0	0	422,176	-	0	0
Subtotal $_{GW}$ (L/day)	1,733	2,568	460,779	-	4,047	19,928
$Q_{storm=25mm}$ (L/day)	1,447,925	1,432,150	-	-	865,775	1,659,050
Area Total (L/day)	1,449,658	1,434,718	460,779	1,895,497	869,822	1,678,978

Table 19. Dewatering Analysis Results for Typical construction Length of Trenches

Division of Site	Area 1	Area 2 (Stage 1)	Area 2 (Stage 2)	Area 2 (Combined)	Area 3	Area 4
Development Features	Resort	Residential	Residential	-	Residential	Residential
Monitoring Wells	BH23-3	BH23-1, 5	BH23-1, 5	-	BH23-6, 9	BH23-6, 7
GW Levels (mbgs)	2.5-4.0	1.5	3.0	-	2.0	2.0
Excavation Depth (mbgs)	4.5	4.5	4.5	-	4.5	4.5
Soil Excavated	Sandy silt to sandy silt till	Sandy silt	Sandy gravel	-	Silty clay to sandy silt	Clayey silt to sandy silt till
Excavation Dimension (m^2)	2x30	2x30	2x30	-	2x30	2x30
Groundwater Level Target (mbgs)	5.0	3.0	5.0	-	5.0	5.0
K (m/s)	$1.8x10^{-8}$	$1.7x10^{-8}$	$1.9x10^{-6}$	-	$2.0x10^{-8}$	$2.5x10^{-7}$
H (m)	1.7	1.5	2	3.5	3	3
h (m)	0	0	0	-	0	0
R_0 (m)	0.7	0.6	8.3	8.9		
Storm (mm/day)	25	25	25	-	25	25
Q_{static} (L/day)	43	35	2,943	2,978	111	963
$Q_{StaticFOS=1.5}$ (L/day)	65	53	4,415	4,468	167	1,445
$Q_{Storage}$ (L/day)	0	0	11,567	11,567	0	0
Subtotal $_{GW}$ (L/day)	65	53	15,982	16,035	167	1,445
$Q_{storm=25mm}$ (L/day)	1,500	1,500	1,500	-	1,500	1,500
Area Total (L/day)	1,565	1,553	17,482	16,035	1,667	2,945

It should be noted that the above preliminary assessment should be updated when the final grading plan and building grades for major building features are available. Furthermore, construction during drier conditions and construction sequencing may reduce dewatering volumes.

4.3 Location of Discharge and Dewatering Methods

MECP construction dewatering guides provided several options for discharging pumped water, including:

- Discharge to a sewage works that has the appropriate environmental compliance approval (ECA).
- Transfer to a waste management system that has the appropriate environmental compliance approval (ECA) or is registered under the non-hazardous waste transportation systems EASR.
- Discharge to a municipal sanitary sewer or storm sewer in accordance with any municipal requirements.
- Discharge to surface land.

Depending on the available space, discharge to surface land is recommended. The contractor is responsible for design and construction of infiltration facilities. Best management practices should be exercised to prevent erosion, flooding and groundwater contamination. Based on the predicted pumping rate, sump pumps should be adequate for controlling groundwater that may accumulate in the excavation pits or trenches.

4.4 PTTW, EASR and Municipal Permits

Water taking in Ontario is governed with Section 34 of Ontario Water Resources Act and its Regulation 387/04. The act and regulation require that no person shall take more than 50,000 litres of water on any day by any means except in accordance with a permit.

Construction dewatering is governed with Part II. 2 of Environmental Protection Act and its Regulation 63/16. Based on the act and regulation, construction dewatering with rates between 50,000 and 400,000 L/day can be registered on the Environmental Activity and Sector Registry (EASR) if the impact to natural resource and environment is not significant and no sensitive features are involved.

Based on the above analysis and understanding of the water taking legislations, the maximum construction dewatering for this project is expected to be above 400,000 L/day even without adding stormwater contribution, a Category 3 PTTW application would be required.

5. Karst Risk Assessment

The purpose of the karst risk assessment is to assess the potential existence of karst features and their impacts. Karst features will impose two types of risks to the proposed development, structure impact and groundwater quality impact. The structure impact includes potential collapse of foundation into sinkholes or other types of solution spaces under the overburden, and differential settlement caused by high bedrock top relief. The groundwater quality impact is caused by karst features such as underground bedrock channels, tunnels and enlarged bedrock fissures that could serve as transport pathways to short-circuit contamination sources with groundwater supply aquifer.

This preliminary karst assessment is conducted in general accordance with the documents of Karst (Unstable Bedrock) Investigation Guidelines, Quinte Conservation, 2023, Guidelines for Geological and Geotechnical Investigations in Ontario Karst Terrains (OGS, Brunton, 2013) and Karst Assessment Guidelines (Virginia Cave Board, 2009).

This preliminary karst assessment was based on the results of terrain analysis and site inspection as introduced above (**Figure 4**) as well as all pertinent information of the site conditions and regional setting. This preliminary karst assessment breaks into discussions of the following components:

- Regional setting;
- Ground surface topography and bedrock topography review;
- Stratigraphy assessment of overburden and bedrock;
- Assessment of drainages and hydrology; and
- Groundwater levels and groundwater chemistry.

5.1 Regional Setting

Based on the above characterization (**Figure 3** and **Table 3**), the site is located about 30 m away from the Potential Karst area, 125 m away from the Known Kart area and 3000 m away from the Inferred Karst area and. Consequently, the site is not set in any class of karst areas as delineated by OGS.

5.2 Ground Surface Topography and Bedrock Topography

As shown in **Figure 4**, The site is generally situated on a drumlin which occupies the majority of the site. Other landform units include two positive landforms (knolls), one on the southwest corner and the other on northwest corner of the site, a wetland on the south part of the site, and ponds created as part of the golf course. The ground surface of the site has elevations ranging from approximately 107 to 133 masl.

Positive closed landforms were identified in the northwest and southwest portions of the site, while negative closed landforms (closed depressions) were not observed. No sinkholes, caves, solution channels and kart valley were observed within and surrounding the site.

Of the fourteen boreholes drilled to depths from 3.27 to 7.92 mbgs (**Table 1**), none of them encountered bedrock. Well record data (**Appendix G**) show that the bedrock top at the site is fairly flat, ranging from 8.0 to 12.0 mbgs. Therefore, the thickness of overburden should be greater than 8.0 m. Thick overburden and limited bedrock elevation change indicate that bedrock ledges, shelves and pinnacles are not anticipated and the karst features under the site will not impose significant effects to the proposed structures even if they exist.

5.3 Lithology of Overburden and Bedrock

Based on borehole logs (**Appendix B** and **Table 5**) and the MECP well records (**Appendix G** and **Figure 8**) , the lithology of the overburden consists of mainly over-compacted ice-contact deposits and coarse till with thickness ranging from 8.0 to 12.0 m. Based on the results of in-situ standard penetration test (N-Value in **Table 5**), both the ice-contact deposits and coarse till unit have large shear strength and bearing capacity, and are not susceptible to differential settlement.

Based on OGS mappings, the bedrock under the overburden at the site consists of Verulam Formation with thicknesses ranging from 30 to 60 m. The formation is characterized as interbedded micritic to coarse grained fossiliferous limestone with interbeds of calcareous shale. Based on the Hazardous Sites Technical Guide of MNR (1996), Verulam Formation is not karst prone.

5.4 Surface Drainage and Surface Water Features

As shown in **Figure 4**, drainage system within and surrounding the site includes a creek, several ponds and wetlands. The creek originates from wetlands upstream to the northeast and flows through the southwest corner of the site toward Moira River. The creek disappears at a location about 1 km southwest of the site.

The ponds found within the sites are man-made ponds based on Palmer's Natural Heritage Review. A marsh wetland and a few swamps wetlands were identified within the site. Based on site inspection and monitoring results (**Table 13** and
Figure *11*), water stages of the ponds and the wetlands located both upstream and downstream the site are fairly stable. The stable water stages indicate that potential existence of underground voids linked with these features is not anticipated.

Based on remote sensing interpretation and ground-truthing, none of the above surface water features appear to be internal drained, there are no dispearing reaches of the creek within and surrounding the site, and no springs were identified within and surrounding the site.

5.5 Groundwater Levels and Groundwater Chemistry

As characterized above, groundwater levels from all monitoring wells range from 1.0 to 4.0 mbgs (**Table 7**), which are far above the bedrock top. Based on the stratigraphy structure (**Table 5**), the groundwater in the overburden is hydraulically connected with groundwater in bedrock. Consequently, the bedrock is constantly submerged under water. The groundwater in contact with bedrock is not circulated and mixed with atmosphere and is depleted of carbonic acid. Consequently, on-going karstification is not expected.

Groundwater chemical analysis results (**Appendix F**) shows that PH values of groundwater range from 7.4 to 8.0, indicating that groundwater is in weak alkaline condition, which is not conductive to karstification.

Langelier Index (LI) of the groundwater samples range from 0.86 to 1.0, which is far above the critical value of 0.31. Therefore, the calcium carbonate is in an over-saturated condition, which will lead to calcium carbonate precipitation instead of dissolution.

5.6 Summary of Discussions and Recommendations

Based on the above discussions, no karst features are anticipated to exist within and nearby the site, the site conditions are not conductive to karst development, and the site is not sensitive to potential impacts of karst features. Consequently, the karst impact to proposed structures and groundwater quality is not expected, and therefore, a detailed Phase 2 Technical Study as defined in the of Karst (Unstable Bedrock) Investigation Guidelines (Quinte Conservation, 2023) is not recommended.

6. Impact Assessment and Mitigation

The construction and operation of the proposed development both have the potential to cause quantity and quality impact of groundwater to natural heritage, municipal water sources and private water supply. The following impact assessment is based on the understanding of the physical and environmental settings of the site, the knowledge of the site subsurface conditions, results of water balance assessments, dewatering assessment, karst assessment, and the nature of construction and operation of the proposed development. The following presents the assessment of impact to each major resource and environmental feature and ways of mitigation if the impact is negative.

6.1 Natural Heritage Features

As presented above, the major natural heritage features within and close to the site include two Provincially Significant Wetlands (PSWs) and two unevaluated wetlands. The PSW located at the south end of the site is named as Corbyville Wetland, and is classified by Palmer's Natural Heritage report as Cattail Mineral Meadow Marsh (MAS). The PSW located to the west of the site is classified by Palmer's Natural Heritage report as Deciduous Swamp (SWD). Mini-piezometer monitoring data (**Table 13**) collected up to date shows that both wetlands do not receive significant groundwater input, and therefore, the hydroperiod of these

wetlands is determined primarily by surface water input. The water balance assessment shows that the proposed development will decrease groundwater recharge by 23,735 m^3/year and increase runoff by 78,820 m^3/year. The recharge deficit will not affect these wetlands as the wetlands do not receive groundwater input, but the increased runoff lead to deep water stage and longer time of inundation. To maintain the pre-development hydroperiod of these wetlands, the increased runoff should be treated with onsite low impact development (LID) features or diverted to stormwater ponds designed to be able to maintain the hydroperiods of these two PSWs.

During construction dewatering, it is recommended to discharge on site such that it will not discharge into the wetland areas. Should this not be considered feasible, further assessment of the expected discharge water quality will be needed to access impacts to the wetlands and determine discharge options.

6.2 Source Water Protection

As presented above, the site is located in Highly Vulnerable Aquifer with a score of 6. No other source protection designations were identified within and immediately nearby the site. Therefore, no source protection policies apply to the site as a result of the proposed development. Highly Vulnerable Aquifer under the site indicates that the groundwater in supply aquifer under the site is vulnerable to contamination, however, a spill management plan implemented as part of common construction management activities will address the concern.

6.3 Private Water Wells

As presented above, the site is located outside of the current Urban Serviced Area of Belleville and the site and surrounding area are serviced with private supply wells and onsite septic system. However, the proposed development will be fully serviced by Belleville municipal water and sanitary sewer services as provided in the Official Plan of the City of Belleville, indicating the neighboring residents may receive access to municipal water and sanitary sewer services with the completion of the proposed development.

There is potential impact to the private water wells from construction dewatering. However, based on the above results of dewatering assessment, the maxim influence zone is 14.3 m measuring from the excavation boundary and no water supply wells were located in the influence zones of all dewatering assessment areas, and therefore, the impact of construction dewatering to private water wells owned by other property owners is not anticipated. A well monitoring program is recommended nevertheless to obtain information on private water wells in order to confirm and supplement this assessment.

As shown in **Figure 8**, a number of supply wells were identified within the site boundary owned and operated by the client. The site plan (**Appendix A**) shows that majority of the supply wells are located within the development area and therefore, will be decommissioned prior to start of grading. Only one supply well, 2920485, may be potentially kept for future use. Well record of 2920485 (**Appendix G**) show that the well was completed in limestone formation and taps water from a limestone aquifer ranging in depths from 21 to 29 m. Construction dewatering will take water from shallow formation and will not have effect to the supply aquifer of this well, and impact to this well is not anticipated.

7. Conclusions and Recommendations

Based on the above site characterization, site water balance assessment, preliminary construction dewatering assessment, preliminary karst risk assessment, and impact assessment, the following conclusions and recommendations are presented as follows:

- The site is underlain with 8.0 to 12.0 m thick overburden sediments that consist of ice-contact sand and gravel deposits and sandy silt till deposits within investigation depths. The bedrock underneath the overburden is Verulam Formation of interbedded micritic to coarse grained fossiliferous limestone with interbeds of calcareous shale;

- Groundwater levels from monitoring wells range from approximately 1 to 4 mbgs at the site with a predominant flow direction of southward towards the Moira River. Groundwater level depths show no apparent trend of increasing with well depths for monitoring wells and well records, indicating the vertical gradient of groundwater flow might be insignificant. Further drilling and monitoring well installation were recommended to characterize vertical gradient and artesian condition at the site;

- Groundwater level and surface water level data collected from mini-piezometers generally showed downward gradients during the June 2023 monitoring event, but much close to neutral gradient during September and October 2023. It can be assessed that the surface water infiltrates into the ground to recharge the groundwater in most of the wetlands during summer months, but additional assessment is required to determine if this changes seasonally;

- Hydraulic conductivity values (k-values) vary drastically with depths, grain size of soils and even testing methods. The k-values generally decrease with depths and increase with grain size of formations. Shallow root zone has the highest k-values owing to root holes, burrow and tilling. The infiltration rate for shallow formations has a geometric value of 0.07 cm/min ;

- Groundwater quality is fresh and no visual or olfactory evidence of contamination such as visible petroleum hydrocarbon film or sheen as well as smell and odor were recorded during drilling or sampling. Analytical results for two samples did not identify health related exceedances over ODWQS. Only one exceedance, aluminum, was identified over PWQO;

- Two Provincially Significant Wetlands (PSWs) and two unevaluated wetlands were identified within the site. Monitoring results for the mini-piezometers installed in the PSWs show that hydroperiods of these wetlands are mainly controlled by surface runoff based on monitoring data collected so far. The wetland hydroperiod should be confirmed with further water level monitoring;

- The site water balance analysis shows the proposed development will cause a reduction of infiltration of 23,735 m^3/year and an increase in runoff of 78,820 m^3/year. Considering the large development area, the increased runoff can be treated through either onsite LID features or stormwater management facilities. It should be noted that compensation of reduced infiltration is not mandatory as the site is not located WHPA-Q2 area;

- Preliminary construction dewatering assessment indicated that the required dewatering rate could be over 400,000 m^3/day and a Category 3 PTTW have to be acquired to support a dewatering

operation. However, if the dewatering can be managed to be under 400,000 L/day by reducing excavation sizes and or potential grade increases in which case an EASR would be required. The preliminary construction dewatering assessment should be updated upon the availability of final grading plan and building grades and the results of further investigation;

- Preliminary karst risk assessment concluded that karst features are anticipated to exist within the site, the site conditions are not conductive to karst development, and the site is not sensitive to potential impacts of karst features. Karst impact to proposed structures and groundwater quality is not expected, and therefore, a detailed Phase 2 Technical Study as defined in the of Karst (Unstable Bedrock) Investigation Guidelines (Quinte Conservation, 2023) is not recommended; and

- The impact of the proposed development to the PSWs can be mitigated based on the results of feature-based water balance assessment through onsite LID features or stormwater facilities designed to have enough capacity to absorb the increased runoff and to keep the pre-development hydroperiod. The impact of the proposed development to source water is not anticipated as the site is not located in source water protection areas that have constraint policies. The impact of the proposed development to private water wells are not expected as no supply wells were located in the influence zone, however well monitoring program is recommended nevertheless to obtain information on private water wells in order to confirm and supplement this assessment.

The above hydrogeological assessment is based on the assumptions that the client and the contractors will undertake the execution and construction of the project following all applicable codes, regulations, guidelines and BPMs, and these assumptions will end up being realized through actual construction activities. This hydrogeological report should be considered preliminary until the final project design can assessed. Groundwater systems and other natural systems are highly complex and can have significant uncertainties between investigation locations. Additional hydrogeological testing and monitoring is expected to be required as the project moves forward.

8. Certification

This report was prepared, reviewed and approved by the undersigned: In the acknowledgement of the practice of geoscience in Ontario, this report was partly prepared by Tanvi Paterl, B.Sc., G.I.T. Tanvi is no longer with Palmer.

Prepared By:

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Approved By:

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MECP. MAP Well Records of Ontario
https://www.ontario.ca/environment-and-energy/map-well-records

MECP. Ontario Source Protection Atlas.
https://www.gisapplication.lrc.gov.on.ca/SourceWaterProtection/Index.html?site=SourceWaterProtection&viewer=SWPViewer&locale=en-US

MECP. Provincial Groundwater Monitoring Network
https://www.ontario.ca/environment-and-energy/map-provincial-groundwater-monitoring-network

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https://www.mndm.gov.on.ca/en/mines-and-minerals/applications/ogsearth
The Hydrogeology of Southern Ontario, Second Edition, 2003, S.N. Singer, C.K. Cheng, and M.G. Scafe. MECP.

Water Well Information System (WWIS) of Ontario, Dataset
https://data.ontario.ca/dataset/well-records

Statement of Limitations

The extent of this study was limited to the specific scope of work for which we were retained and that is described in this report. Palmer has assumed that the information provided by the client or any secondary sources of information are factual and accurate. Palmer accepts no responsibility for any deficiency, misstatement or inaccuracy contained in this report as a result of omissions, misinterpretations or negligent acts from relied upon data. Judgment has been used by Palmer in the interpretation of the information provided but subsurface physical and chemical characteristics may differ from regional scale geology mapping and vary between or beyond well/borehole locations given the inherent variability in geological conditions.

Palmer is not a guarantor of the geological or groundwater conditions at the subject site, but warrants only that its work was undertaken and its report prepared in a manner consistent with the level of skill and diligence normally exercised by competent geoscience professionals practicing in the Province of Ontario. Our findings, conclusions and recommendations should be evaluated in light of the limited scope of our work.

The information and opinions expressed in the Report are for the sole benefit of the Client. NO OTHER PARTY MAY USE OR RELY UPON THE REPORT OR ANY PORTION THEREOF WITHOUT PALMER'S WRITTEN CONSENT AND SUCH USE SHALL BE ON SUCH TERMS AND CONDITIONS AS PALMER MAY EXPRESSLY APPROVE. Ownership in and copyright for the contents of the Report belongs to Palmer. Any use which a third party makes of the Report is the sole responsibility of such third party. Palmer accepts no responsibility whatsoever for damages suffered by any third party resulting from use of the Report without Palmer's express written permission. Should the project design change following issuance of the Report, Palmer must be provided the opportunity to review and revise the Report in light of such alteration or variation.

Appendix A

Site Plan
(Biglieri Group 2024)

APPROVAL STAMP:

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O AND 11

E

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I _EVILLE

TY OF HASTINGS

SCALE 1 : 5000

T 14923-B-24

ON LAND SURVEYORS

RY 21, 2024

MOIRA RIVER

MOIRA RIVER

Hydro Breaker 390' East

Plastic Pipe 228' East

Plastic Pipe 183' East

LOT 10

LOT 11

LOT 12

CONCESSION 6

BETWEEN CONSESSIONS 5 AND 6 (TRAVELLED)

ORIGINAL

TOWER

DWELLING

SHED

PART 1 21R-19631

PART 1 21R-8534

PART 1 21R-4747

PART 2 21R-4644

PART 2 21R-2397 EASEMENT INSTRUMENT 29305

PART 1 21R-9722

PART 1 21R-18057

PART 1 21R-2905

21R-17015

Existing Agricultural

Existing Golf Course

HOMAN ROAD

HARMONY ROAD

HIGHWAY 37

FD SIB

SIB

LEGEND

- SINGLE DETACHED
- TOWNHOUSES
- MIXED USE
- GOLF RESORT ACCOMMODATIONS
- RIVER RESORT
- GOLF COURSE
- GOLF COURSE RELATED
- PARKS AND OPEN SPACE
- NATURAL HERITAGE SYSTEM
- STORMWATER MANAGMENT POND
- UTILITY
- SPECIAL POLICY AREAS OVERLAY
- EXISTING FLOOD PLAIN OVERLAY
- SUBJECT SITE BOUNDARY

TITLE:

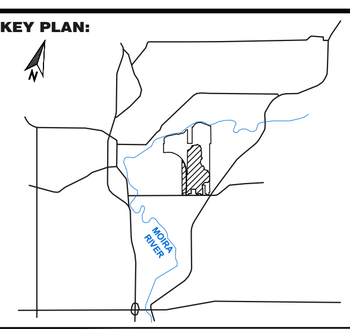
CONCEPTUAL MASTER PLAN

LEGAL DESCRIPTION:

Part of Lots 8, 9, 10 and 11, Concession 5
Part of Lots 7, 8, 9, 10 and 11, Concession 6
Township of Thurlow
Now in the City of Belleville
County of Hastings

BLACK BEAR RIDGE GP INC.

KEY PLAN:



BLACK BEAR RIDGE VILLAGE

SURVEYOR'S CERTIFICATE:

I HEREBY CERTIFY THAT THE BOUNDARIES OF THE LANDS TO BE SUBDIVIDED AS SHOWN ON THIS PLAN AND THEIR RELATIONSHIP TO THE ADJACENT LANDS ARE ACCURATE AND CORRECTLY SHOWN IN ACCORDANCE WITH A PLAN OF SURVEY PREPARED BY

SURVEYOR
WATSON LAND SURVEYORS, OLS.

DATE

OWNER'S CERTIFICATE:

I HEREBY AUTHORIZE **THE BIGLIERI GROUP LTD.** TO PREPARE AND SUBMIT THIS DRAFT PLAN OF SUBDIVISION TO THE CITY OF BELLEVILLE

NAME
COMPANY

JULY 30, 2024
DATE

REQUIRED INFORMATION:

AS REQUIRED UNDER SECTION 51(17) OF THE PLANNING ACT R.S.O. 1990.

(a) SEE PLAN
(b) SEE PLAN
(c) SEE KEY MAP
(d) SEE SCHEDULE OF LAND USE
(e) SEE PLAN
(f) SEE PLAN
(f.1) N/A
(g) SEE PLAN
(h) MUNICIPAL SERVICES AVAILABLE
(i) SANDY SILT, SILTY SAND, AND CLAYEY SILT
(j) SEE PLAN
(k) MUNICIPAL SERVICES AVAILABLE
(l) SEE PLAN

NOTE:
DISTANCES AND/OR COORDINATES SHOWN ON THIS PLAN ARE IN METRES AND CAN BE CONVERTED TO FEET BY DIVIDING BY 0.3048.

REVISIONS

No.	Description	Date	Int.
3			
2			
1			

PROJECT No.:	22826
DATE:	July 30, 2024
SCALE:	1:3000
DRAFTED BY:	EC
CHECKED BY:	MP
DRAWING No.:	CMP-01

BIGLIERI GROUP

2472 Kingston Road, Toronto
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(416) 693-9155
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Appendix B

Borehole Logs
(Palmer 2023)

Well Log BH23-1

PROJECT: Geotechnical Investigation - Black Bear Ridge

CLIENT: Black Bear Ridge GP Inc.

PROJECT LOCATION: Belleville, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan N 4902111.72 E 308623.04

Method: Solid Stem Augers

Diameter: 200 mm

Date: Sep-01-2023

REF. NO.: 2200902

ENCL NO.: 1

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
112.5	Ground Surface											
0.0	**FILL:** sandy silt, some gravel, contains cobbles, trace to some sand, brown, moist, compact		1	SS	13		Concrete / Sand					
			2	SS	11		112 / Bentonite					
111.1							Sand					
1.5	**SANDY SILT:** some gravel, contains cobbles, brown, moist, compact		3	SS	14	▽	111 / W. L. 111.0 m Sep 23, 2013					Auger grinding
			4	SS	34		110					
109.6							Screen					
3.0	**SAND AND GRAVEL:** trace silt, contains cobbles, brown, wet, compact		5	SS	28		109					Wet spoon below
107.9							108 / Bentonite					
4.6	**END OF BOREHOLE:** 1. Upon completion of drilling, a 50mm diameter monitoring well was installed in the borehole. 2. Water Level Readings: Date W. L. Depth (mBGS)		6	SS	50/ initial 25mm							Auger and spoon refusal

GROUNDWATER ELEVATIONS

Shallow/ Single Installation 1st ▽ 2nd ▼ Deep/Dual Installation 1st ▽ 2nd ▼

GRAPH NOTES + 3, × 3: Numbers refer to Sensitivity ○ 8=3% Strain at Failure

Palmer

Well Log BH23-2

PROJECT: Geotechnical Investigation - Black Bear Ridge

CLIENT: Black Bear Ridge GP Inc.

Method: Hollow Stem Augers

PROJECT LOCATION: Belleville, ON

Diameter: 229 mm

REF. NO.: 2200902

DATUM: Geodetic

Date: Aug-26-2023

ENCL NO.: 2

BH LOCATION: See Borehole Location Plan N 4902043.94 E 308690.94

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
112.4	Ground Surface										
112.2 0.0	**TOPSOIL:** 125mm						Concrete				
0.1	**FILL:** sandy silt, some gravel, trace clay, brown, moist, compact		1	SS	11		Sand				
111.7							112				
0.7	**SILTY SAND:** some gravel, trace clay, contains cobbles, brown, moist, dense		2	SS	38		Bentonite				
1 110.9						▽	W. L. 111.0 m Sep 23, 2013				
1.5	**GRAVELY SAND:** trace silt, contains cobbles, grey, wet, compact to dense		3	SS	22		Sand				
2	contains sand layers		4	SS	49		110				Wet spoon below
3 109.4											
3.0	**SAND:** some gravel, trace silt, contains cobbles, grey, wet, very dense		5	SS	54		109				
	contains gravelly sand layer						Screen				
4			6	SS	92		108				
			7	SS	50/ 50mm						
5	contains gravelly sand layers										
107.0											
5.3	**END OF BOREHOLE:** 1. Upon completion of drilling, a 50mm diameter monitoring well was installed in the borehole. 2. Water Level Readings: Date W. L. Depth (mBGS)										Auger and Spoon refusal

GROUNDWATER ELEVATIONS

Shallow/ Single Installation 1st ▽ 2nd ▼ Deep/Dual Installation 1st ▼ 2nd ▼

GRAPH NOTES + 3, × 3: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

Well Log BH23-3

PROJECT: Geotechnical Investigation - Black Bear Ridge

CLIENT: Black Bear Ridge GP Inc.

PROJECT LOCATION: Belleville, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan N 4902139.85 E 308856.49

Method: Solid Stem Augers

Diameter: 150 mm

Date: Aug-24-2023

REF. NO.: 2200902

ENCL NO.: 3

ELEV / DEPTH (m)	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS "N" 0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
120.8	Ground Surface											
120.7	**TOPSOIL:** 125mm						Concrete					
0.1	**Fill:** sandy silt, trace gravel, contains rootlets, contains cobbles, brown to grey, moist, dense to compact		1	SS	44		Sand					
			2	SS	26		120					
			3	SS	22		Bentonite 119					
118.3												
2.4	**GRAVEL:** some sand, trace silt, grey, moist, dense		4	SS	43		118 Sand					
117.8												
3.0	**SANDY SILT TILL:** some gravel, trace clay, grey, moist, compact to very dense		5	SS	23		117					
			6	SS	55	▽	W. L. 116.6 m Sep 23, 2013					
			7	SS	90/ 225mm		Screen 116					
115.5												
5.3	**SANDY SILT:** some gravel, contains cobbles, brown, moist, very dense		8	SS	50/ initial 125mm		115					
114.6			9	SS	50/ initial 125mm		Bentonite					Auger grinding
6.2	**END OF BOREHOLE:** 1. Upon completion of drilling, a 50mm diameter monitoring well was installed in the borehole. 2. Water Level Readings: Date W. L. Depth (mBGS)											

GROUNDWATER ELEVATIONS

Shallow/ Single Installation ▽ 1st ▼ 2nd Deep/Dual Installation ▽ 1st ▼ 2nd

GRAPH NOTES +³, ×³: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

Palmer

Well Log BH23-4

PROJECT: Geotechnical Investigation - Black Bear Ridge

CLIENT: Black Bear Ridge GP Inc.

Method: Solid Stem Augers

PROJECT LOCATION: Belleville, ON

Diameter: 150 mm

REF. NO.: 2200902

DATUM: Geodetic

Date: Aug-27-2023

ENCL NO.: 4

BH LOCATION: See Borehole Location Plan N 4902319.86 E 309150.04

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
124.6	Ground Surface										
0.0 / 124.4	**TOPSOIL:** 200mm						Concrete				
0.2 / 123.9	**FILL:** silt, trace clay, trace sand, contains cobbles, brown, moist, compact		1	SS	21		Sand				
0.7	**FILL:** sand, some gravel, trace silt, contains cobbles, brown, moist, compact		2	SS	29		124 Bentonite				
1			3	SS	11		123				
2 / 122.4							Sand				
2.2	**SILTY SAND TILL:** some gravel, trace clay, contains cobbles, brown, moist, dense		4	SS	48		W. L. 122.5 m Sep 23, 2013 122				
3 / 121.6											
3.0 / 120.8	**SAND AND GRAVEL:** trace silt, contains cobbles, brown, moist, very dense		5	SS	50		121 Screen				
3.7	**SANDY SILT TILL:** trace clay, trace gravel, brown to grey, moist, very dense		6	SS	50/ 125mm						
4			7	SS	50/ 125mm		120				
5			8	SS	50/ 100mm		Bentonite 119				
118.9											
118.8 / 5.7	**SAND AND GRAVEL:** trace silt,										
5.8	grey, wet, very dense		9	SS	50/ initial 25mm						Auger and Spoon refusal
	END OF BOREHOLE: 1. Upon completion of drilling, a 50mm diameter monitoring well was installed in the borehole. 2. Water Level Readings: Date W. L. Depth (mBGS)										

GROUNDWATER ELEVATIONS

Shallow/ Single Installation 1st ▽ 2nd ▼ Deep/Dual Installation 1st ▽ 2nd ▼

GRAPH NOTES: $+^3$, $\times^3$: Numbers refer to Sensitivity; $\circ^{\varepsilon=3\%}$ Strain at Failure

Well Log BH23-5

PROJECT: Geotechnical Investigation - Black Bear Ridge

CLIENT: Black Bear Ridge GP Inc.

PROJECT LOCATION: Belleville, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan N 4901919.43 E 308679.52

Method: Solid Stem Augers

Diameter: 200 mm

Date: Sep-01-2023

REF. NO.: 2200902

ENCL NO.: 5

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
110.4	Ground Surface										
0.0	**FILL:** clayey silt, trace sand, trace gravel, contains rootlets, brown, moist, loose to compact		1	SS	4		Concrete / Sand 110				
			2	SS	14		Bentonite / W. L. 109.3 m Sep 23, 2013 / Sand				
1.5 / 108.9	**SANDY SILT:** some gravel, contains cobbles, brown, moist, compact		3	SS	30						Wet spoon below
2.2 / 107.4	**CLAYEY SILT:** trace gravel, trace sand, contains weathered shale, grey, wet, hard		4	SS	44		Screen 108				
3.0 / 106.7	**SANDY GRAVEL:** trace silt, trace clay, contains cobbles, brown, wet, dense		5	SS	39		Bentonite				Auger refusal
3.7	**END OF BOREHOLE:** 1. Upon completion of drilling, a 50mm diameter monitoring well was installed in the borehole. 2. Water Level Readings: Date W. L. Depth (mBGS)										

GROUNDWATER ELEVATIONS

Shallow/ Single Installation 1st ▽ 2nd ▼ Deep/Dual Installation 1st ▼ 2nd ▼

GRAPH NOTES + 3, × 3: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

Well Log BH23-6

PROJECT: Geotechnical Investigation - Black Bear Ridge

CLIENT: Black Bear Ridge GP Inc.

PROJECT LOCATION: Belleville, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan N 4901846.81 E 308764.83

Method: Solid Stem Augers

Diameter: 150 mm

Date: Aug-24-2023

REF. NO.: 2200902

ENCL NO.: 6

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	BLOWS 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION
112.2	Ground Surface						
112.0	**TOPSOIL:** 100mm						Concrete
0.1	**FILL:** silty clay, trace sand, trace gravel, trace organics, brown, moist, loose to very loose		1	SS	8		Sand 112
							Bentonite
1			2	SS	3		Sand 111
110.7							
1.5	**SILTY CLAY:** trace sand, trace gravel, brown to grey, moist, loose		3	SS	8		
2						▽	W. L. 110.2 m Sep 23, 2013
110.0							
2.2	**CLAYEY SILT:** some to trace sand, trace gravel, contains cobbles, grey, moist, very stiff		4	SS	26		Screen
3			5	SS	27		109
108.4							
3.7	**SAND AND GRAVEL:** trace silt, trace gravel, contains cobbles, grey, moist, very dense		6	SS	50/ initial 100mm		108
4							
107.9							
4.3	**END OF BOREHOLE:** 1. Upon completion of drilling, a 50mm diameter monitoring well was installed in the borehole. 2. Water Level Readings: Date W. L. Depth (mBGS)						

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH (kPa) (20 40 60 80 100)
○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%) (10 20 30)

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

REMARKS AND GRAIN SIZE DISTRIBUTION (%)

GR SA SI CL

GROUNDWATER ELEVATIONS

Shallow/ Single Installation 1st ▽ 2nd ▼ Deep/Dual Installation 1st ▼ 2nd ▼

GRAPH NOTES + 3, × 3: Numbers refer to Sensitivity ○ 3=3% Strain at Failure

Well Log BH23-7

PROJECT: Geotechnical Investigation - Black Bear Ridge

CLIENT: Black Bear Ridge GP Inc.

PROJECT LOCATION: Belleville, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan N 4901927.81 E 309160.36

Method: Solid Stem Augers

Diameter: 150 mm

Date: Aug-25-2023

REF. NO.: 2200902

ENCL NO.: 7

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
113.3	Ground Surface											
113.0 / 0.3	**TOPSOIL:** 50mm						Concrete					
0.4	**FILL:** sandy silt, trace clay, trace gravel, contains rootlets, contains cobbles, brown, moist, compact		1	SS	14		Sand					
1	contains gravel layer		2	SS	26		113					
111.9							112					
1.5	**SANDY SILT TILL:** some gravel, trace clay, contains cobbles, grey, moist, compact to very dense		3	SS	29		W. L. 111.4 m Sep 23, 2013					
2			4	SS	30		Bentonite					
3	contains gravelly sand layer		5	SS	52		110					
4			6	SS	70		109					
							Sand					
5			7	SS	85							
107.9							108					
5.4	**CLAYEY SILT:** some gravel, trace sand, contains cobbles, grey, moist, hard		8	SS	97							
6							Screen					
107.3							107					
6.0	**SANDY SILT:** trace clay, trace gravel, contains cobbles, grey, moist, very dense		9	SS	80							Auger grinding
7												
105.7							106					
7.7	**END OF BOREHOLE:** 1. Upon completion of drilling, a 50mm diameter monitoring well was installed in the borehole. 2. Water Level Readings: Date W. L. Depth (mBGS)		10	SS	50/ initial 25mm		Bentonite					

GROUNDWATER ELEVATIONS

Shallow/ Single Installation 1st 2nd Deep/Dual Installation 1st 2nd

GRAPH NOTES + 3, × 3: Numbers refer to Sensitivity ○ 8 ε=3% Strain at Failure

Well Log BH23-8

PROJECT: Geotechnical Investigation - Black Bear Ridge

CLIENT: Black Bear Ridge GP Inc.

PROJECT LOCATION: Belleville, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan N 4902062.26 E 309192.4

Method: Solid Stem Augers

Diameter: 150 mm

Date: Aug-26-2023

REF. NO.: 2200902

ENCL NO.: 8

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
116.9	Ground Surface							
116.8	**TOPSOIL:** 100mm						Concrete	
0.1	**FILL:** sandy silt, trace to some gravel, trace clay, contains rootlets, contains cobbles, brown, moist to wet, compact to dense		1	SS	13		Sand	
			2	SS	38		116	
115.5								
1.5	**SANDY SILT:** trace to some gravel, trace clay, contains cobbles, contains boulders, brown, moist to wet, very dense		3	SS	52		Bentonite	
	contains sand layers						115	
							W. L. 115.0 m Sep 23, 2013	
			4	SS	82		Sand	
			5	SS	98/ 275mm			
			6	SS	50/ 100mm		113	
			7	SS	50/ initial 100mm		Screen	Spoon bouncing
							112	
			8	SS	98/ 225mm			
							111	
			9	SS	95/ 225mm		Bentonite	
110.5								
6.5	**END OF BOREHOLE:** 1. Upon completion of drilling, a 50mm diameter monitoring well was installed in the borehole. 2. Water Level Readings: Date W. L. Depth (mBGS)							

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%): 10 20 30

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

GROUNDWATER ELEVATIONS

Shallow/ Single Installation 1st 2nd Deep/Dual Installation 1st 2nd

GRAPH NOTES: $+^3$, $\times^3$: Numbers refer to Sensitivity; $\circ^{\varepsilon=3\%}$ Strain at Failure

Palmer

Well Log BH23-9

PROJECT: Geotechnical Investigation - Black Bear Ridge

CLIENT: Black Bear Ridge GP Inc.

PROJECT LOCATION: Belleville, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan N 4901558.25 E 308671.03

Method: Solid Stem Augers

Diameter: 200 mm

Date: Sep-01-2023

REF. NO.: 2200902

ENCL NO.: 9

ELEV / DEPTH (m)	DESCRIPTION	NUMBER	TYPE	BLOWS 0.3 m "N"	GROUND WATER CONDITIONS	ELEVATION	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
108.9	Ground Surface						
108.8 / 0.1	**TOPSOIL:** 50mm					Concrete	
	FILL: sandy silt, trace gravel, contains cobbles, brown, moist, loose to compact	1	SS	9		Sand	
		2	SS	11		Bentonite 108	
107.5 / 1.5	**SANDY SILT:** trace gravel, contains cobbles, brown, moist, compact to dense	3	SS	20		Sand	
		4	SS	34		107 Screen W. L. 106.3 m Sep 23, 2013	
106.0 / 3.0	**GRAVEL:** trace sand, grey, moist, very dense	5	SS	50/ initial 100mm		106 Bentonite	Auger refusal Spoon refusal
105.8 / 3.2	**END OF BOREHOLE:** 1. Upon completion of drilling, a 50mm diameter monitoring well was installed in the borehole. 2. Water Level Readings: Date W. L. Depth (mBGS)						

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%): 10 20 30

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

GROUNDWATER ELEVATIONS

Shallow/ Single Installation 1st ▽ 2nd ▼ Deep/Dual Installation 1st ▼ 2nd ▼

GRAPH NOTES: $+^3$, $\times^3$: Numbers refer to Sensitivity; ○ ε_f=3% Strain at Failure

Well Log BH23-10

PROJECT: Geotechnical Investigation - Black Bear Ridge

CLIENT: Black Bear Ridge GP Inc.

PROJECT LOCATION: Belleville, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan N 4901584.2 E 308843.37

Method: Solid Stem Augers

Diameter: 150 mm

Date: Aug-24-2023

REF. NO.: 2200902

ENCL NO.: 10

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
111.4	Ground Surface							
111.0	**TOPSOIL:** 100mm						Concrete	
0.1	**FILL:** sandy silt, trace to some gravel, trace clay, contains rootlets, contains cobbles, brown, moist, compact to dense		1	SS	13		Sand	
							111	
			2	SS	48			
							110	
			3	SS	27		Bentonite	
109.2								
2.2	**SILTY SAND:** some gravel, trace clay, contains cobbles, brown, moist, dense		4	SS	41		109	
108.4							W. L. 108.5 m Sep 23, 2013	
3.0	**SANDY SILT:** some gravel, contains cobbles, brown, moist, very dense		5	SS	50/ initial 125mm			
							108	Auger grinding
			6	SS	50/ initial 125mm			
							107	
			7	SS	50/ 125mm		Screen	
			8	SS	50/ 125mm		106	
			9	SS	50/ 125mm		Bentonite	
105.0							105	
6.4	**END OF BOREHOLE:** 1. Upon completion of drilling, a 50mm diameter monitoring well was installed in the borehole. 2. Water Level Readings: Date W. L. Depth (mBGS)							

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%): 10 20 30

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

GROUNDWATER ELEVATIONS

Shallow/ Single Installation 1st 2nd Deep/Dual Installation 1st 2nd

GRAPH NOTES: $+^3$, $\times^3$: Numbers refer to Sensitivity; $\circ^{\varepsilon=3\%}$ Strain at Failure

Palmer

Well Log BH23-11

PROJECT: Geotechnical Investigation - Black Bear Ridge

CLIENT: Black Bear Ridge GP Inc.

Method: Solid Stem Augers

PROJECT LOCATION: Belleville, ON

Diameter: 150 mm

REF. NO.: 2200902

DATUM: Geodetic

Date: Aug-25-2023

ENCL NO.: 11

BH LOCATION: See Borehole Location Plan N 4901706.58 E 309240.53

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
107.5	Ground Surface										
107.4	**TOPSOIL:** 75mm						Concrete				
0.1	**FILL:** sandy silt, trace gravel, contains rootlets, brown, moist, very loose to compact		1	SS	4		Sand				
							107				
			2	SS	24		Bentonite W. L. 106.6 m Sep 23, 2013				
106.5											
1.0	**SAND :** trace silt, trace gravel, brown, moist to wet, compact						Sand				
106.0											
1.5	**GRAVELY SAND:** trace silt, brown, wet, compact to very dense		3	SS	28		106				Wet spoon below
2											
			4	SS	41		105				
3							Screen				
			5	SS	44		104				
4			6	SS	68/ 250mm						
103.0							103				
4.5	**END OF BOREHOLE:** 1. Upon completion of drilling, a 50mm diameter monitoring well was installed in the borehole. 2. Water Level Readings: Date W. L. Depth (mBGS)										Auger refusal

GROUNDWATER ELEVATIONS

Shallow/ Single Installation 1st ▽ 2nd ▼ Deep/Dual Installation 1st ▼ 2nd ▼

GRAPH NOTES + 3, × 3: Numbers refer to Sensitivity ○ 3=3% Strain at Failure

Palmer

Well Log BH23-12

PROJECT: Geotechnical Investigation - Black Bear Ridge

CLIENT: Black Bear Ridge GP Inc.

Method: Solid Stem Augers

PROJECT LOCATION: Belleville, ON

Diameter: 150 mm

REF. NO.: 2200902

DATUM: Geodetic

Date: Aug-27-2023

ENCL NO.: 12

BH LOCATION: See Borehole Location Plan N 4901359.31 E 308837.37

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS "N" 0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT / NATURAL MOISTURE CONTENT / LIQUID LIMIT (w_P w w_L) / WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
109.2	Ground Surface											
109.1 / 0.0	**TOPSOIL:** 125mm						Concrete					
0.1 / 108.5	**FILL:** sandy silt, trace clay, trace gravel, contains rootlets, contains cobbles, brown, moist, loose		1	SS	9		Sand / Bentonite					
0.7 / 106.8	**FILL:** trace to some gravel, trace clay, contains cobbles, brown, moist, compact to very dense		2	SS	27		Sand / 108					
			3	SS	50/ intial 100mm		Screen / 107					Auger grinding Spoon bouncing
106.7 / 2.4	**SAND:** some silt, trace gravel, contains cobbles, brown, moist, very dense		4	SS	50/ 50mm							Auger refusal
2.5	**END OF BOREHOLE:** 1. Upon completion of drilling, a 50mm diameter monitoring well was installed in the borehole. 2. Water Level Readings: Date W. L. Depth (mBGS)											

GROUNDWATER ELEVATIONS

Shallow/ Single Installation 1st ▽ 2nd ▼ Deep/Dual Installation 1st ▼ 2nd ▼

GRAPH NOTES + 3, × 3: Numbers refer to Sensitivity ○ 8 ε=3% Strain at Failure

Well Log BH23-13

PROJECT: Geotechnical Investigation - Black Bear Ridge

CLIENT: Black Bear Ridge GP Inc.

PROJECT LOCATION: Belleville, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan N 4901662.47 E 309054.71

Method: Solid Stem Augers

Diameter: 150 mm

Date: Aug-24-2023

REF. NO.: 2200902

ENCL NO.: 13

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
108.2	Ground Surface							
0.0 / 108.1	**TOPSOIL:** 175mm						Concrete	
0.2	**FILL:** sandy silt, trace clay, trace gravel, contains rootlets, brown, moist, very loose		1	SS	4		Sand	
							Bentonite	
			2	SS	2		Sand	
1							107	
			3	SS	1		W. L. 106.5 m Sep 23, 2013	
2 / 106.0							106	
2.2	**SAND AND GRAVEL:** trace to some silt, contains cobbles, brown, wet, compact to very dense		4	SS	26		Screen	Wet spoon below
3	contains weathered shale fragments		5	SS	62		105	
4 / 104.1							Bentonite	
4.1	**END OF BOREHOLE:** 1. Upon completion of drilling, a 50mm diameter monitoring well was installed in the borehole. 2. Water Level Readings: Date W. L. Depth (mBGS)		6	SS	50/ intial 25mm			Auger grinding

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH (kPa): ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE; 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%): 10 20 30

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

GROUNDWATER ELEVATIONS

Shallow/ Single Installation 1st ▽ 2nd ▼ Deep/Dual Installation 1st ▽ 2nd ▼

GRAPH NOTES: $+^3$, $\times^3$: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

Well Log BH23-14

PROJECT: Geotechnical Investigation - Black Bear Ridge

CLIENT: Black Bear Ridge GP Inc.

PROJECT LOCATION: Belleville, ON

DATUM: Geodetic

BH LOCATION: See Borehole Location Plan N 4901548.56 E 309396.65

Method: Hollow Stem Augers

Diameter: 229 mm

Date: Aug-25-2023

REF. NO.: 2200902

ENCL NO.: 14

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	ELEVATION	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
110.4	Ground Surface							
110.0	**TOPSOIL:** 100mm						Concrete	
0.1	**FILL:** sandy silt, trace to some clay, trace gravel, trace rootlets, contains cobbles, brown to grey, moist, loose to compact		1	SS	8		Sand 110	
1			2	SS	13			
108.9							109	
1.5	**SILTY SAND:** trace clay, trace gravel, contains cobbles, grey, moist, compact		3	SS	13			
2 108.2								
2.2	**SANDY SILT TILL:** some clay, trace gravel, grey, moist, compact		4	SS	18		108 W. L. 107.8 m Sep 23, 2013	
3			5	SS	23		107	
4 106.3								Auger grinding
4.1	**GRAVELLY SAND:** trace silt, contains cobbles, grey, moist, dense		6	SS	37		106	
5							Sand	
104.7							105	
5.6	**CLAYEY SILT:** trace silt, contains cobbles, grey, moist, hard							
6 104.0			7	SS	49		104	
6.4	**SAND AND GRAVEL:** trace to some silt, contains cobbles, contains red fragments, grey, wet, dense to very dense						Screen	
7							103	
8 102.1			8	SS	50/ intial 125mm			Wet spoon below
8.3	**END OF BOREHOLE:** 1. Upon completion of drilling, a 50mm diameter monitoring well was installed in the borehole. 2. Water Level Readings: Date W. L. Depth (mBGS)		9	SS	50/ intial 25mm		Bentonite	

DYNAMIC CONE PENETRATION RESISTANCE PLOT — 20 40 60 80 100

SHEAR STRENGTH (kPa) — ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE & Sensitivity × LAB VANE — 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%) — 10 20 30

POCKET PEN. (Cu) (kPa)

NATURAL UNIT WT (kN/m³)

GROUNDWATER ELEVATIONS

Shallow/ Single Installation 1st ▽ 2nd ▼ Deep/Dual Installation 1st ▽ 2nd ▼

GRAPH NOTES + 3, × 3: Numbers refer to Sensitivity ○ 8 ε=3% Strain at Failure

Appendix C

Grain Size Analysis and K-Value Estimation (Palmer 2023)

Palmer

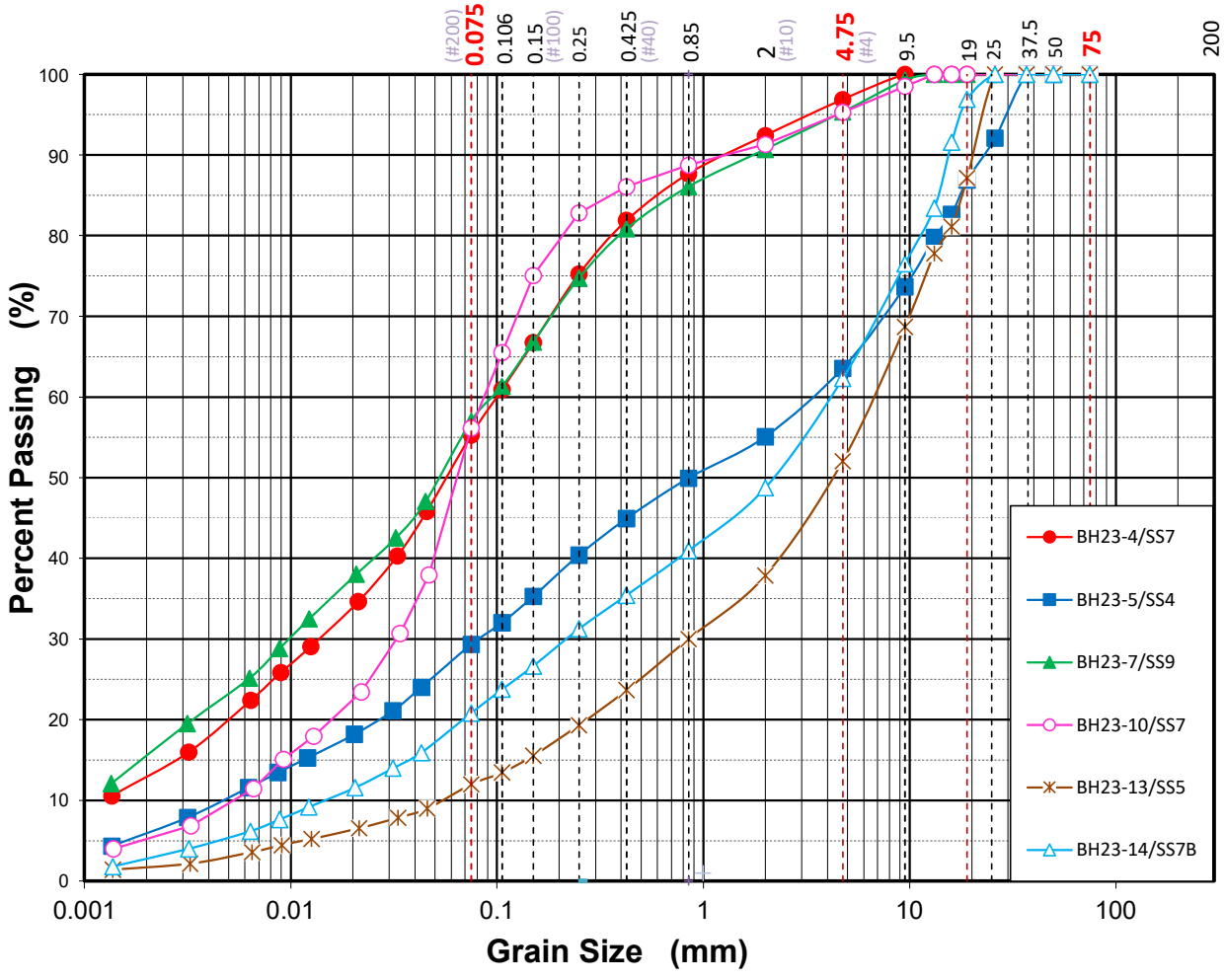
Palmer Environmental Consulting Group Inc.
871 Equestrain Ct, Unit 1
Oakville, ON L6L 6L7

Particle Size Distribution Report

Project No.:	2200902	Lab No.:	R23-003
Project Name:	Black Bear Ridge Geotechnical Investigation	Tested By:	BW
Client:	Black Bear Ridge GP Inc.	Checked By:	TO
Location:	Belleville, Ontario	Date:	10/19/2023

Test Results

Test No.	Sample No.	Clay	Silt	Sand			Gravel		Cobble+	Remarks
				Fine	Medium	Coarse	Fine	Coarse		
1	BH23-4/SS7	12	43	42			3			
2	BH23-5/SS4	6	23	35			36			
3	BH23-7/SS9	15	42	38			5			
4	BH23-10/SS7	5	51	39			5			
5	BH23-13/SS5	2	10	40			48			
6	BH23-14/SS7B	3	18	41			38			
7										
8										

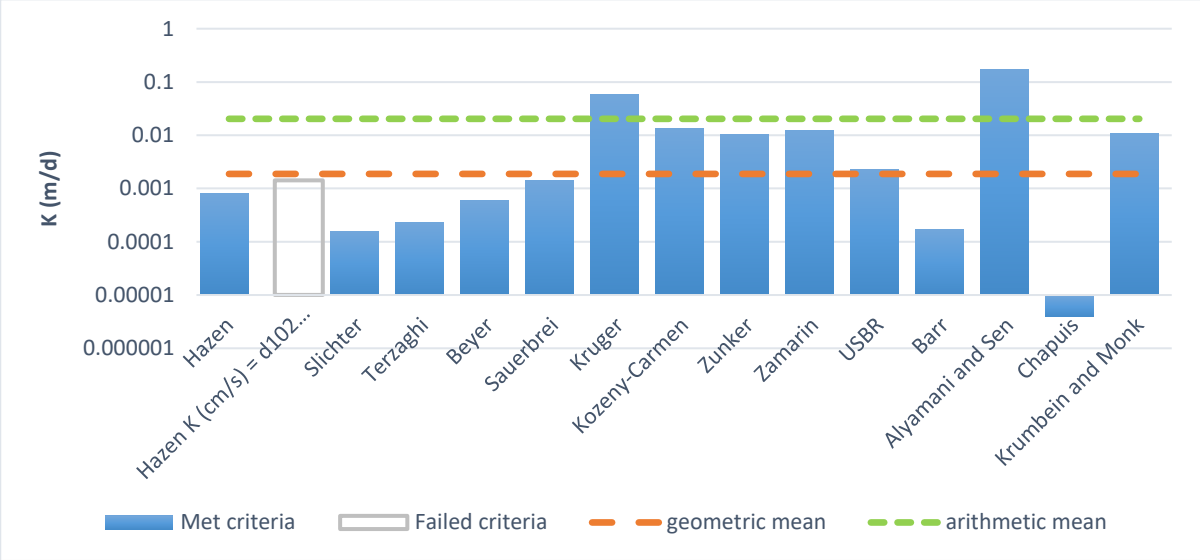


Hydraulic Conductivity Report

Sample ID: BH23-4/SS7 Date: Oct 2023

Sample Mass (g): T (oC): 20

Poorly sorted silt low in fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d
Hazen	.936E-06	.936E-08	0.00
Hazen K (cm/s) = d_{10} (mm)	.165E-05	.165E-07	0.00
Slichter	.184E-06	.184E-08	0.00
Terzaghi	.262E-06	.262E-08	0.00
Beyer	.687E-06	.687E-08	0.00
Sauerbrei	.162E-05	.162E-07	0.00
Kruger	.661E-04	.661E-06	0.06
Kozeny-Carmen	.157E-04	.157E-06	0.01
Zunker	.120E-04	.120E-06	0.01
Zamarin	.141E-04	.141E-06	0.01
USBR	.268E-05	.268E-07	0.00
Barr	.197E-06	.197E-08	0.00
Alyamani and Sen	.202E-03	.202E-05	0.17
Chapuis	.450E-08	.450E-10	0.00
Krumbein and Monk	.124E-04	.124E-06	0.01
geometric mean	.217E-05	.217E-07	0.00
arithmetic mean	.235E-04	.235E-06	0.02

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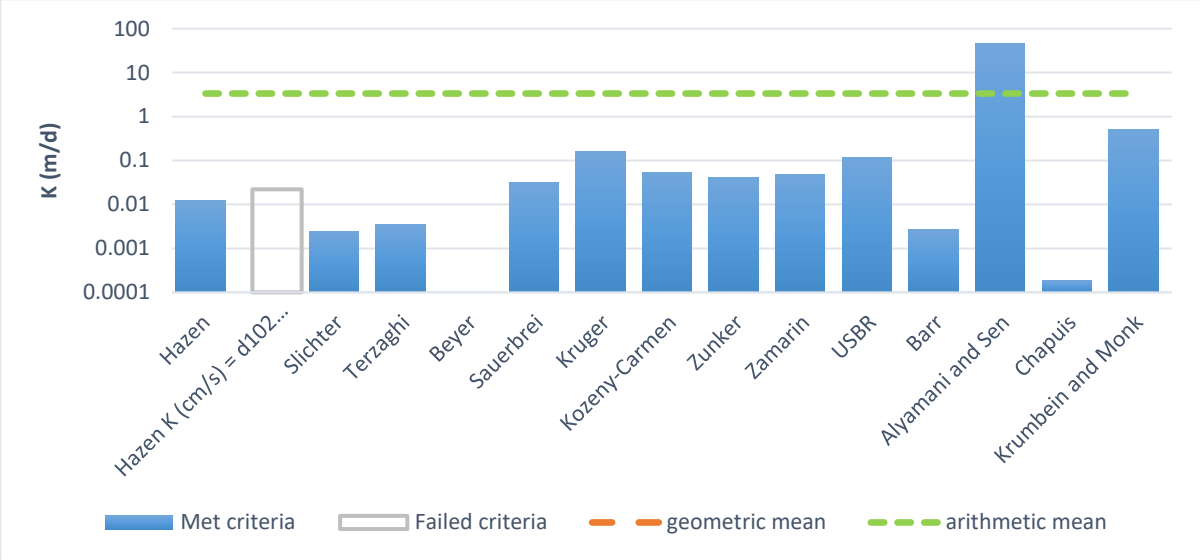
Hydraulic Conductivity Report

Sample ID: BH23-5/SS4 Date: Oct 2023

Sample Mass (g): T (oC): 20

Poorly sorted sand low in fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d
Hazen	.145E-04	.145E-06	0.01
Hazen K (cm/s) = d_{10} (mm)	.256E-04	.256E-06	0.02
Slichter	.284E-05	.284E-07	0.00
Terzaghi	.405E-05	.405E-07	0.00
Beyer	-.202E-05	-.202E-07	0.00
Sauerbrei	.367E-04	.367E-06	0.03
Kruger	.184E-03	.184E-05	0.16
Kozeny-Carmen	.614E-04	.614E-06	0.05
Zunker	.473E-04	.473E-06	0.04
Zamarin	.563E-04	.563E-06	0.05
USBR	.133E-03	.133E-05	0.11
Barr	.305E-05	.305E-07	0.00
Alyamani and Sen	.531E-01	.531E-03	45.91
Chapuis	.213E-06	.213E-08	0.00
Krumbein and Monk	.581E-03	.581E-05	0.50
geometric mean	#NUM!	#NUM!	#NUM!
arithmetic mean	.388E-02	.388E-04	3.35

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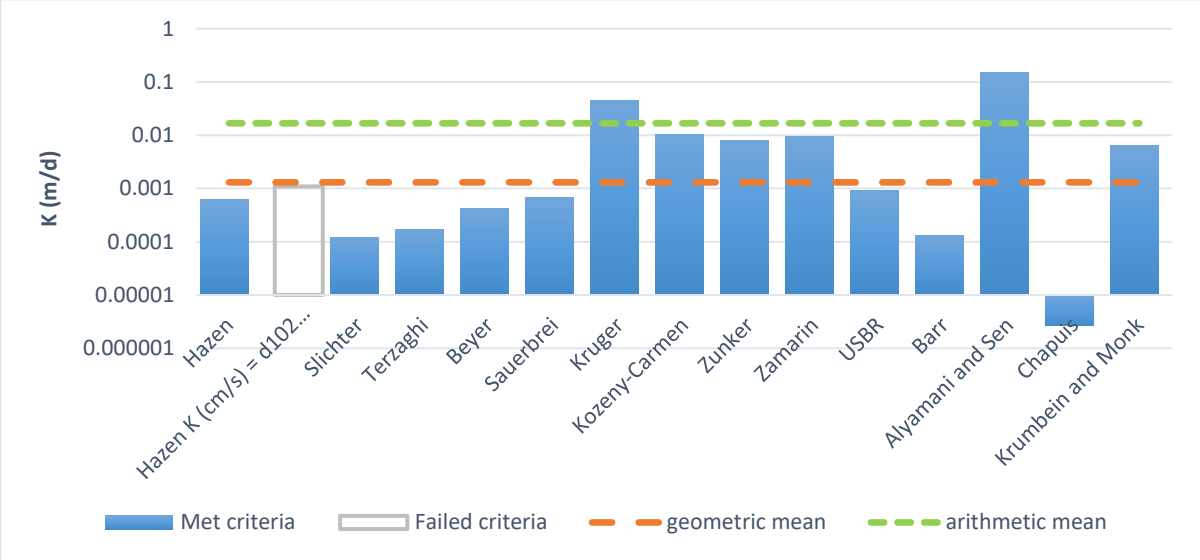
Hydraulic Conductivity Report

Sample ID: BH23-7/SS9 Date: Oct 2023

Sample Mass (g): T (oC): 20

Poorly sorted silt low in fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d
Hazen	.713E-06	.713E-08	0.00
Hazen K (cm/s) = d_{10} (mm)	.126E-05	.126E-07	0.00
Slichter	.140E-06	.140E-08	0.00
Terzaghi	.200E-06	.200E-08	0.00
Beyer	.498E-06	.498E-08	0.00
Sauerbrei	.780E-06	.780E-08	0.00
Kruger	.520E-04	.520E-06	0.04
Kozeny-Carmen	.120E-04	.120E-06	0.01
Zunker	.920E-05	.920E-07	0.01
Zamarin	.109E-04	.109E-06	0.01
USBR	.106E-05	.106E-07	0.00
Barr	.150E-06	.150E-08	0.00
Alyamani and Sen	.177E-03	.177E-05	0.15
Chapuis	.307E-08	.307E-10	0.00
Krumbein and Monk	.756E-05	.756E-07	0.01
geometric mean	.151E-05	.151E-07	0.00
arithmetic mean	.194E-04	.194E-06	0.02

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Hydraulic Conductivity Report

Sample ID: BH23-10/SS7 Date: Oct 2023

Sample Mass (g): T (oC): 20

Poorly sorted sand low in fines

Estimation of Hydraulic Conductivity	cm/s	m/s	m/d
Hazen	.186E-04	.186E-06	0.02
Hazen K (cm/s) = d_{10} (mm)	.291E-04	.291E-06	0.03
Slichter	.378E-05	.378E-07	0.00
Terzaghi	.563E-05	.563E-07	0.00
Beyer	.224E-04	.224E-06	0.02
Sauerbrei	.179E-04	.179E-06	0.02
Kruger	.118E-03	.118E-05	0.10
Kozeny-Carmen	.579E-04	.579E-06	0.05
Zunker	.423E-04	.423E-06	0.04
Zamarin	.504E-04	.504E-06	0.04
USBR	.342E-04	.342E-06	0.03
Barr	.414E-05	.414E-07	0.00
Alyamani and Sen	.971E-04	.971E-06	0.08
Chapuis	.342E-06	.342E-08	0.00
Krumbein and Monk	.561E-04	.561E-06	0.05
geometric mean	.186E-04	.186E-06	0.02
arithmetic mean	.378E-04	.378E-06	0.03

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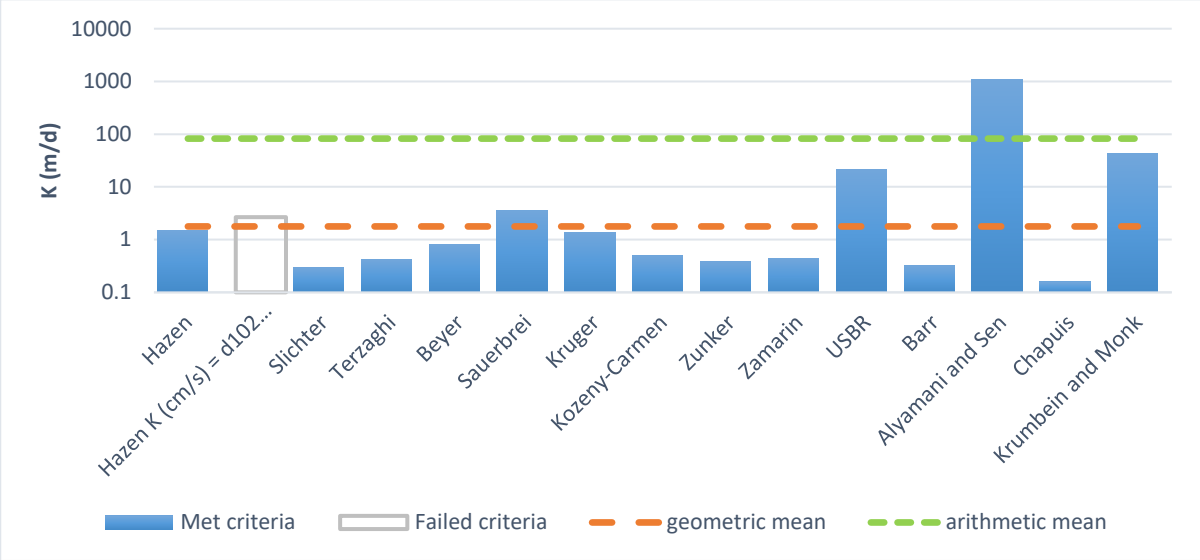
Hydraulic Conductivity Report

Sample ID: BH23-13/SS5 Date: Oct 2023

Sample Mass (g): T (oC): 20

Poorly sorted gravel low in fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d
Hazen	.174E-02	.174E-04	1.51
Hazen K (cm/s) = d_{10} (mm)	.308E-02	.308E-04	2.66
Slichter	.343E-03	.343E-05	0.30
Terzaghi	.489E-03	.489E-05	0.42
Beyer	.950E-03	.950E-05	0.82
Sauerbrei	.415E-02	.415E-04	3.59
Kruger	.161E-02	.161E-04	1.39
Kozeny-Carmen	.573E-03	.573E-05	0.49
Zunker	.438E-03	.438E-05	0.38
Zamarin	.518E-03	.518E-05	0.45
USBR	.249E-01	.249E-03	21.51
Barr	.367E-03	.367E-05	0.32
Alyamani and Sen	.125E+01	.125E-01	1079.24
Chapuis	.182E-03	.182E-05	0.16
Krumbein and Monk	.490E-01	.490E-03	42.35
geometric mean	.206E-02	.206E-04	1.78
arithmetic mean	.953E-01	.953E-03	82.35

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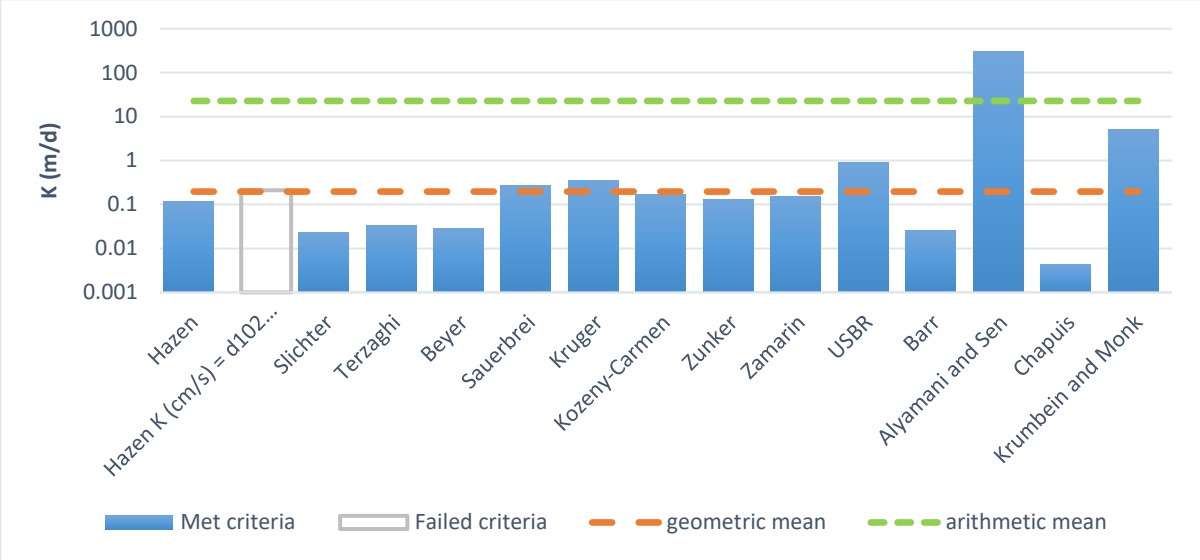
Hydraulic Conductivity Report

Sample ID: BH23-14/SS7 Date: Oct 2023

Sample Mass (g): T (oC): 20

Poorly sorted gravel low in fines



Estimation of Hydraulic Conductivity	cm/s	m/s	m/d
Hazen	.137E-03	.137E-05	0.12
Hazen K (cm/s) = d_{10} (mm)	.242E-03	.242E-05	0.21
Slichter	.270E-04	.270E-06	0.02
Terzaghi	.384E-04	.384E-06	0.03
Beyer	.324E-04	.324E-06	0.03
Sauerbrei	.318E-03	.318E-05	0.27
Kruger	.400E-03	.400E-05	0.35
Kozeny-Carmen	.191E-03	.191E-05	0.17
Zunker	.148E-03	.148E-05	0.13
Zamarin	.178E-03	.178E-05	0.15
USBR	.106E-02	.106E-04	0.91
Barr	.289E-04	.289E-06	0.02
Alyamani and Sen	.359E+00	.359E-02	310.41
Chapuis	.507E-05	.507E-07	0.00
Krumbein and Monk	.599E-02	.599E-04	5.18
geometric mean	.227E-03	.227E-05	0.20
arithmetic mean	.263E-01	.263E-03	22.70

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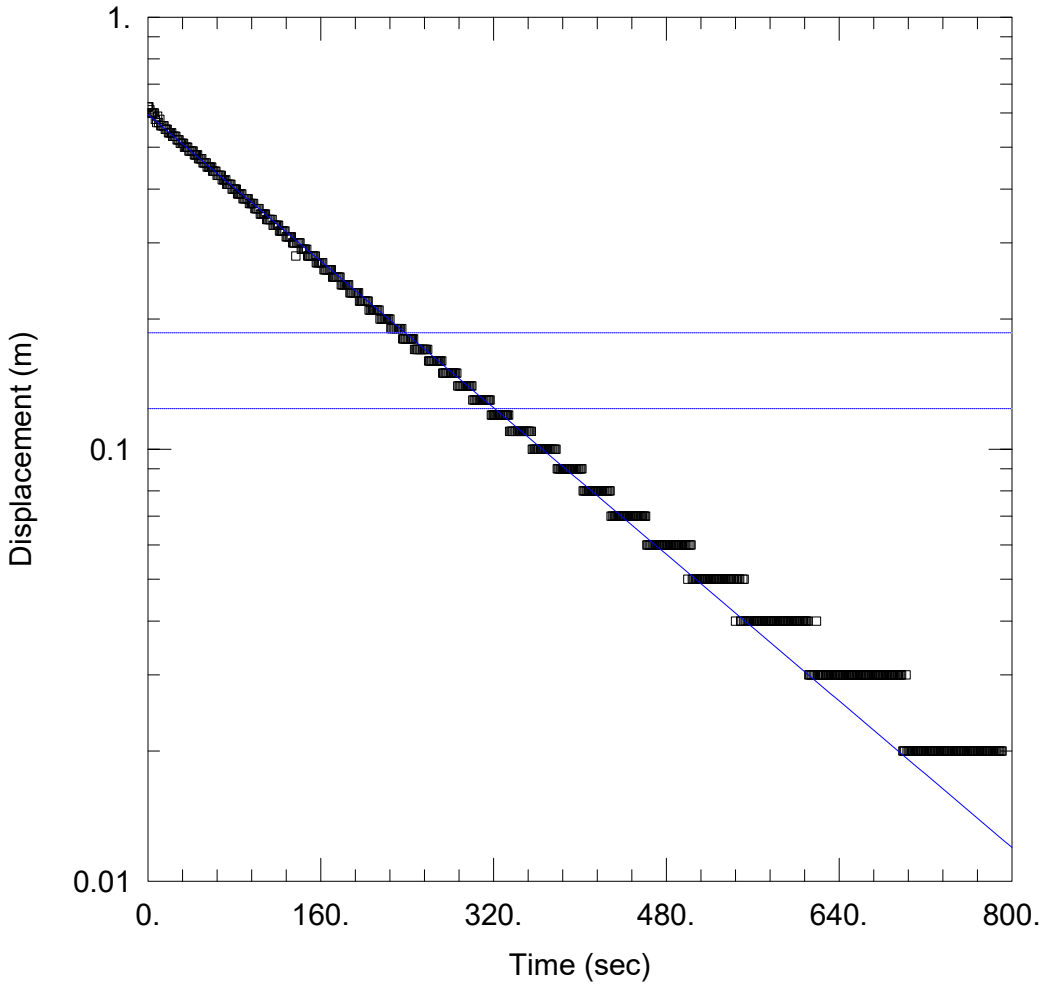
Appendix D

Single Well Response Test (Palmer 2023)



WELL TEST ANALYSIS

Data Set: G:\...\BH23-1.aqt
Date: 09/29/23 Time: 12:24:59

PROJECT INFORMATION

Company: Palmer
Project: 2200902
Test Well: BH23-1
Test Date: test

AQUIFER DATA

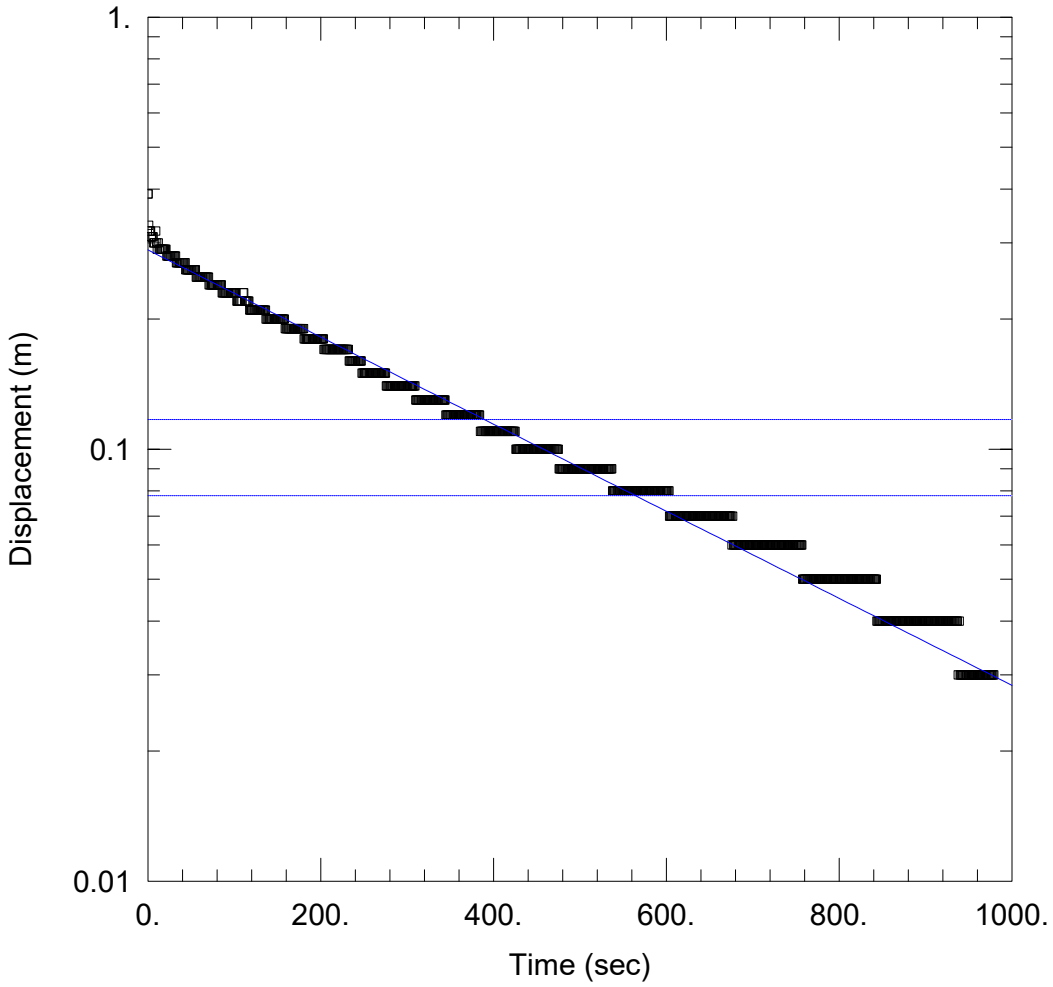
Saturated Thickness: 2.24 m Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (BH23-1)

Initial Displacement: 0.62 m
Total Well Penetration Depth: 3. m
Casing Radius: 0.025 m
Static Water Column Height: 2.24 m
Screen Length: 3. m
Well Radius: 0.076 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 1.864E-6 m/sec
y0 = 0.5945 m



WELL TEST ANALYSIS

Data Set: G:\...\BH23-2.aqt
Date: 09/29/23 Time: 12:25:33

PROJECT INFORMATION

Company: Palmer
Project: 2200902
Test Well: BH23-2
Test Date: 09/13/2023

AQUIFER DATA

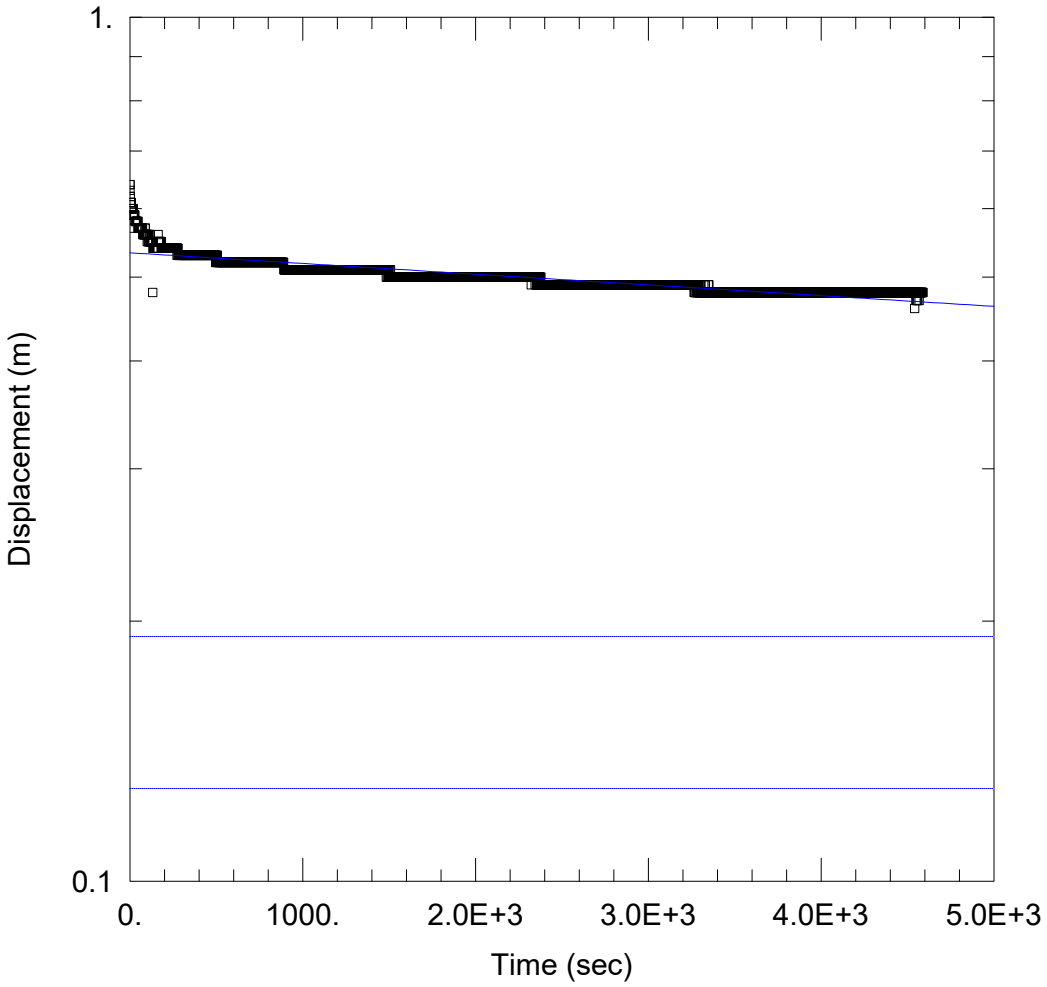
Saturated Thickness: 3.62 m Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (BH23-2)

Initial Displacement: 0.39 m
Total Well Penetration Depth: 3.62 m
Casing Radius: 0.025 m
Static Water Column Height: 3.62 m
Screen Length: 3. m
Well Radius: 0.076 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 9.299E-7 m/sec
y0 = 0.289 m



WELL TEST ANALYSIS

Data Set: G:\...\BH23-3.aqt
Date: 09/29/23 Time: 12:26:05

PROJECT INFORMATION

Company: Palmer
Project: 2200902
Test Well: BH23-3
Test Date: 09/13/2023

AQUIFER DATA

Saturated Thickness: 1.27 m Anisotropy Ratio (Kz/Kr): 0.1

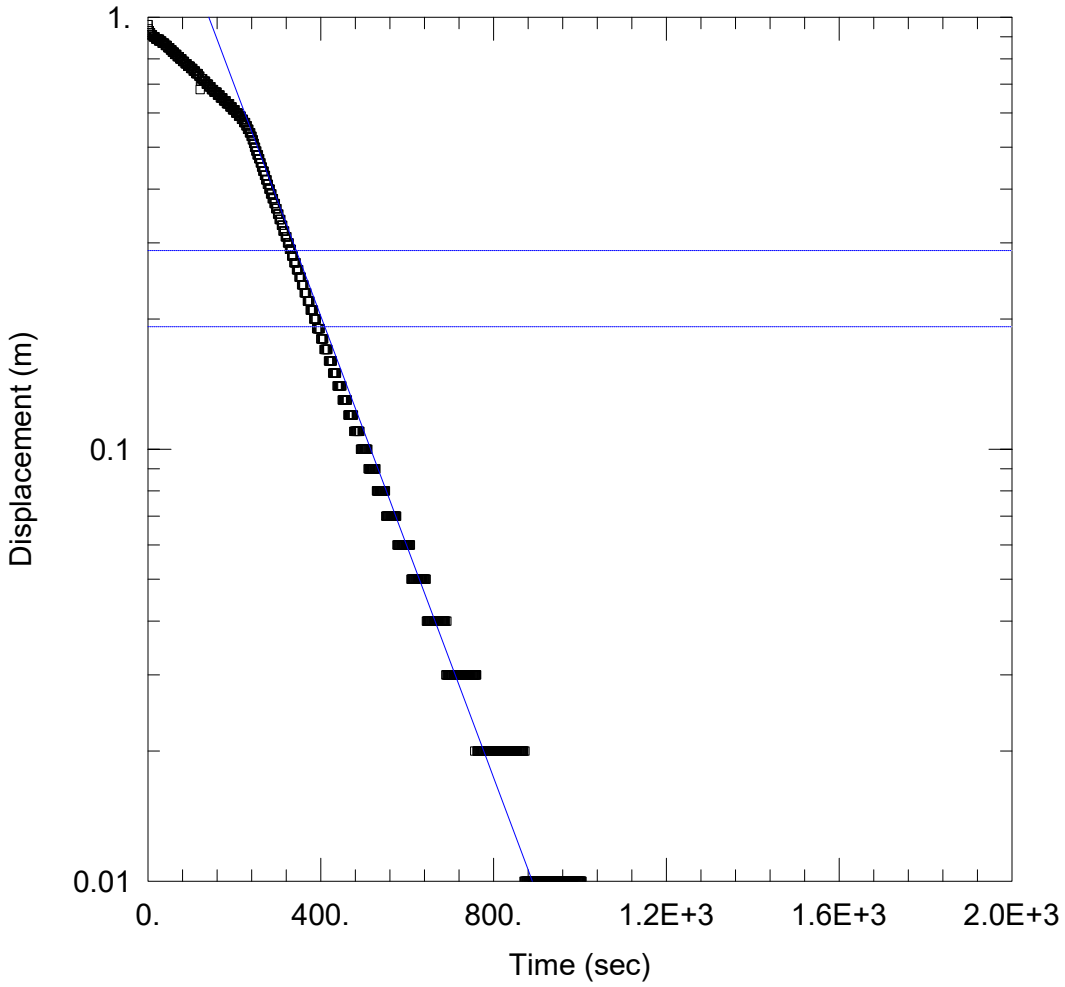
WELL DATA (BH23-3)

Initial Displacement: 0.64 m
Total Well Penetration Depth: 3. m
Casing Radius: 0.025 m
Static Water Column Height: 1.27 m
Screen Length: 3. m
Well Radius: 0.076 m
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 1.79E-8 m/sec y0 = 0.5336 m



WELL TEST ANALYSIS

Data Set: G:\...\BH23-4.aqt
Date: 10/25/23 Time: 09:33:56

PROJECT INFORMATION

Company: Palmer
Project: 2200902
Test Well: BH23-4
Test Date: 09/13/2023

AQUIFER DATA

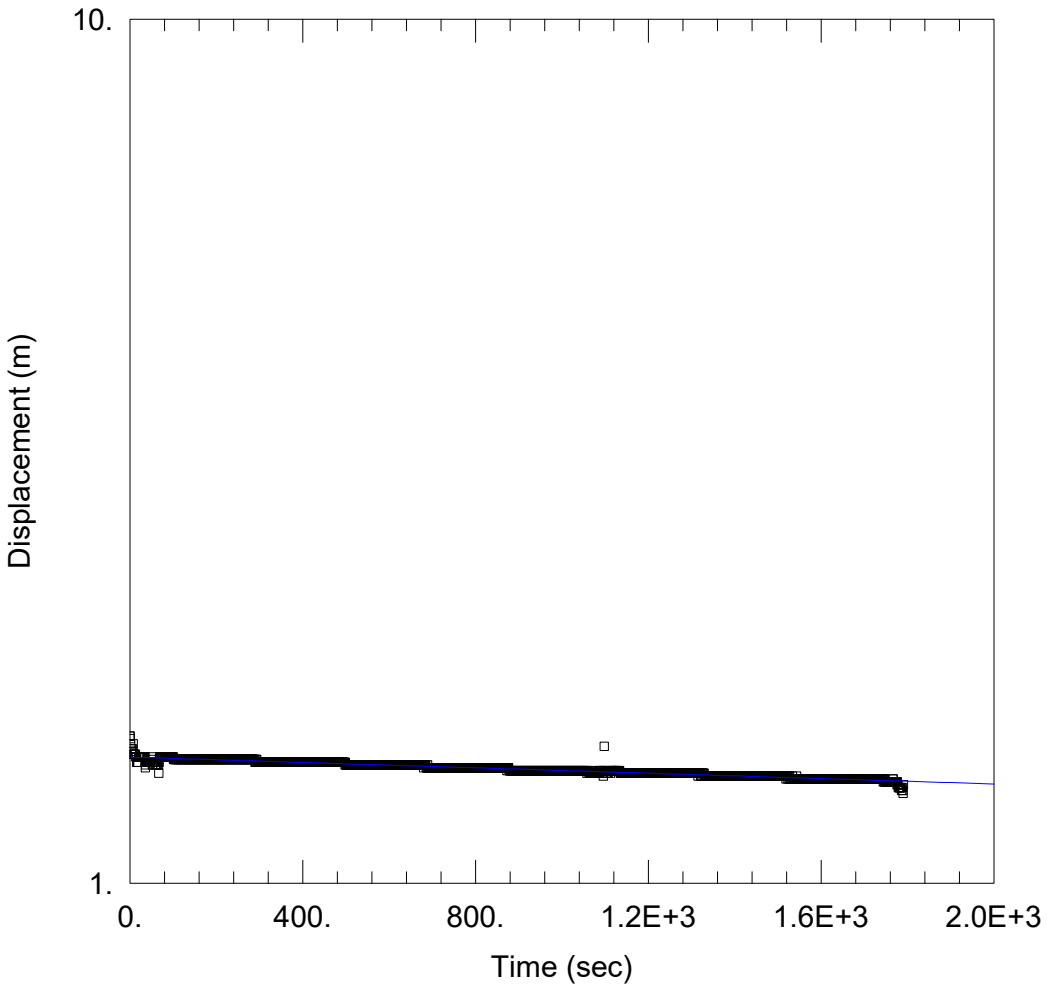
Saturated Thickness: 2.18 m Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (BH23-4)

Initial Displacement: 0.96 m
Total Well Penetration Depth: 3. m
Casing Radius: 0.0254 m
Static Water Column Height: 2.18 m
Screen Length: 3. m
Well Radius: 0.0762 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 2.48E-6 m/sec
y0 = 2.376 m



WELL TEST ANALYSIS

Data Set: G:\...\BH23-5.aqt
Date: 09/29/23 Time: 12:26:53

PROJECT INFORMATION

Company: Palmer
Project: 2200902
Test Well: BH23-5
Test Date: 09/13/2023

AQUIFER DATA

Saturated Thickness: 1.48 m Anisotropy Ratio (Kz/Kr): 0.1

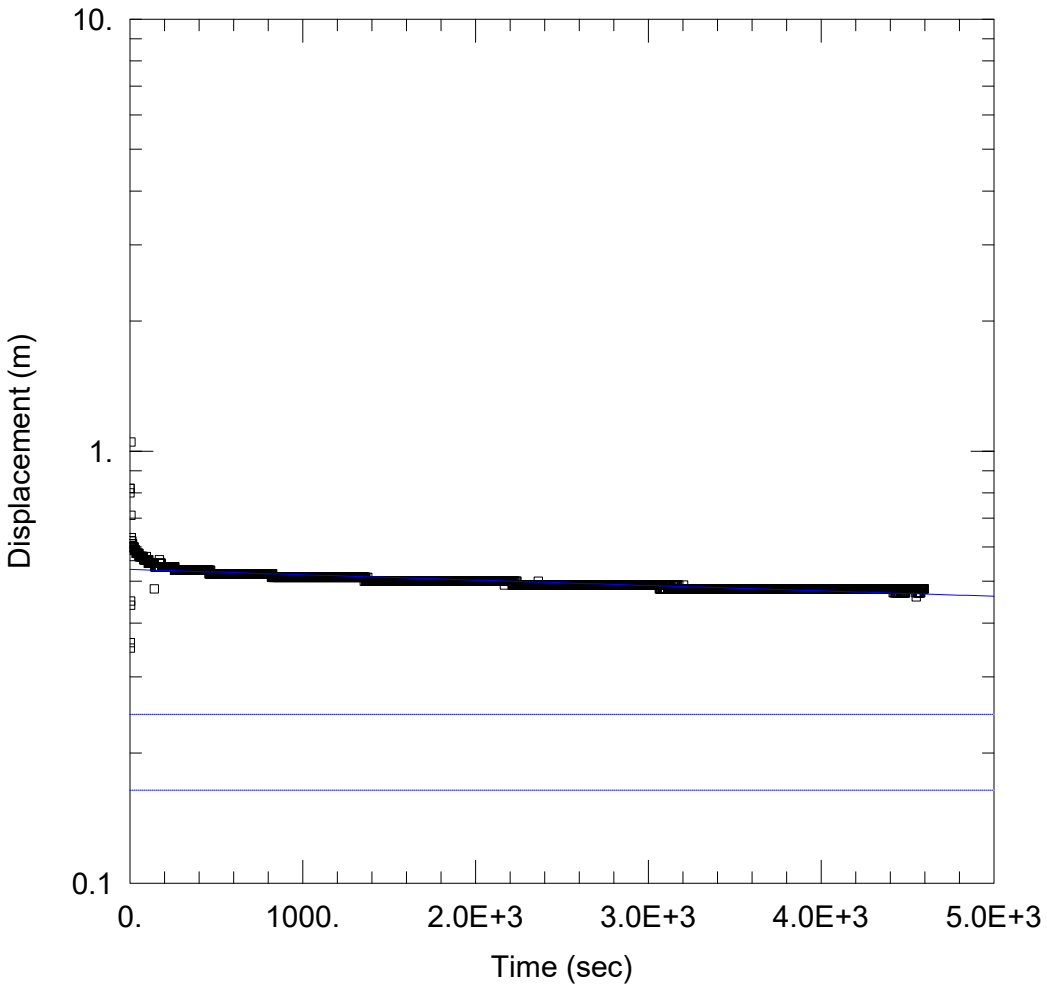
WELL DATA (BH23-5)

Initial Displacement: 1.48 m
Total Well Penetration Depth: 1.5 m
Casing Radius: 0.0254 m
Static Water Column Height: 1.28 m
Screen Length: 1.5 m
Well Radius: 0.0762 m
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 1.719E-8 m/sec y0 = 1.399 m



WELL TEST ANALYSIS

Data Set: G:\...\BH23-6.aqt
Date: 10/30/23 Time: 13:18:43

PROJECT INFORMATION

Company: Palmer
Project: 2200902
Test Well: BH23-6
Test Date: 09/13/2023

AQUIFER DATA

Saturated Thickness: 0.57 m Anisotropy Ratio (Kz/Kr): 0.1

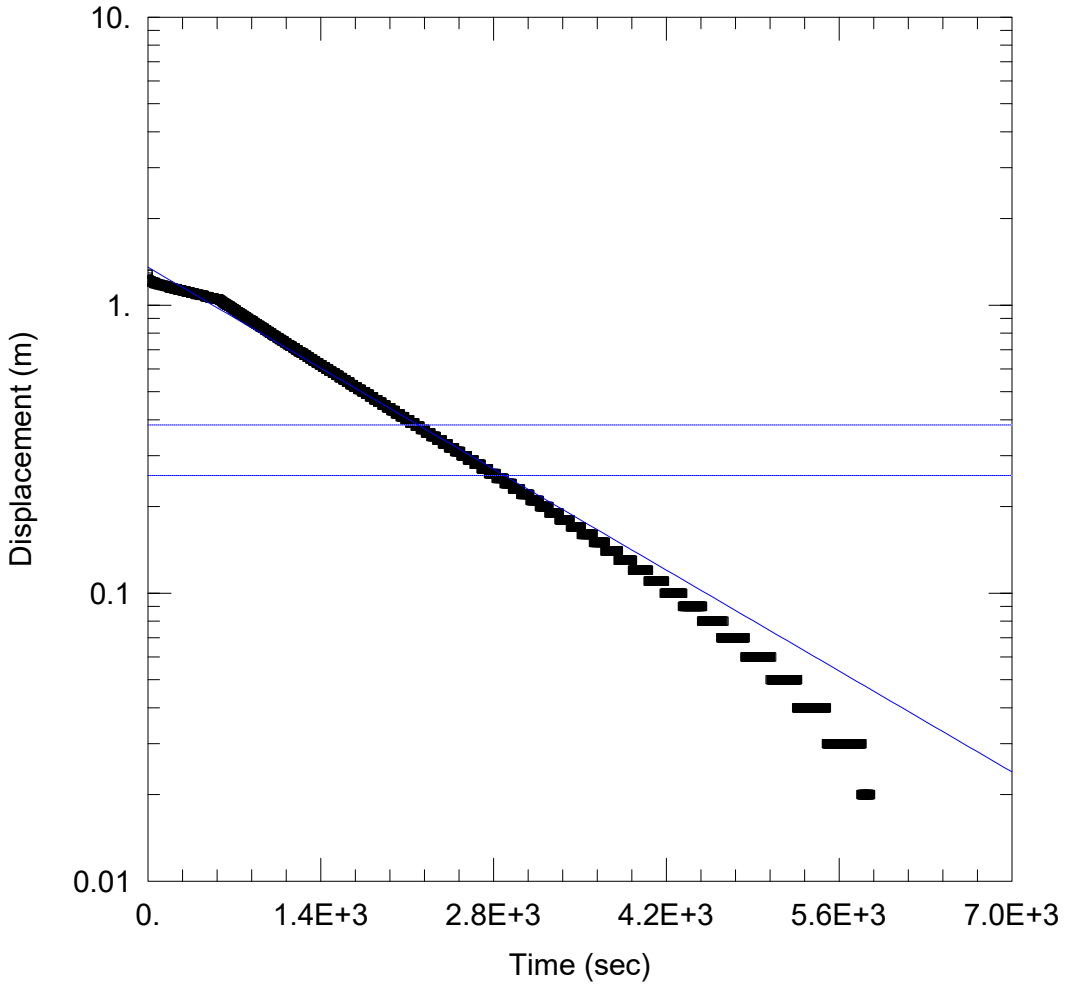
WELL DATA (BH23-6)

Initial Displacement: 0.82 m
Total Well Penetration Depth: 0.57 m
Casing Radius: 0.0254 m
Static Water Column Height: 0.57 m
Screen Length: 0.57 m
Well Radius: 0.0762 m
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 2.328E-8 m/sec y0 = 0.5324 m



WELL TEST ANALYSIS

Data Set: G:\...\BH23-7.aqt
Date: 09/29/23 Time: 12:27:32

PROJECT INFORMATION

Company: Palmer
Project: 2200902
Test Well: BH23-7
Test Date: 09/13/2023

AQUIFER DATA

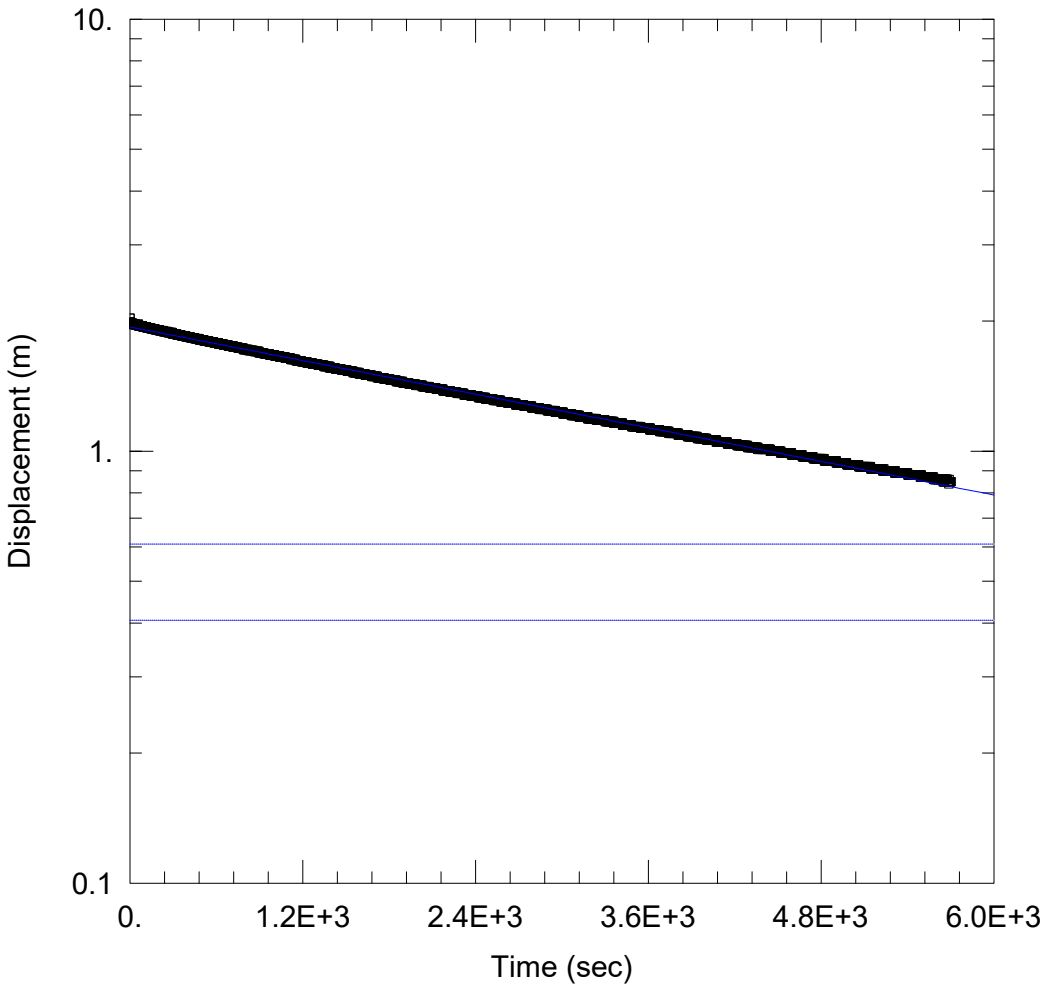
Saturated Thickness: 4.63 m Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (BH23-7)

Initial Displacement: 1.28 m
Total Well Penetration Depth: 4.63 m
Casing Radius: 0.0254 m
Static Water Column Height: 4.63 m
Screen Length: 3. m
Well Radius: 0.0762 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 2.48E-7 m/sec
y0 = 1.353 m



WELL TEST ANALYSIS

Data Set: G:\...\BH23-8.aqt
Date: 09/29/23 Time: 12:27:58

PROJECT INFORMATION

Company: Palmer
Project: 2200902
Test Well: BH23-8
Test Date: 09/13/2023

AQUIFER DATA

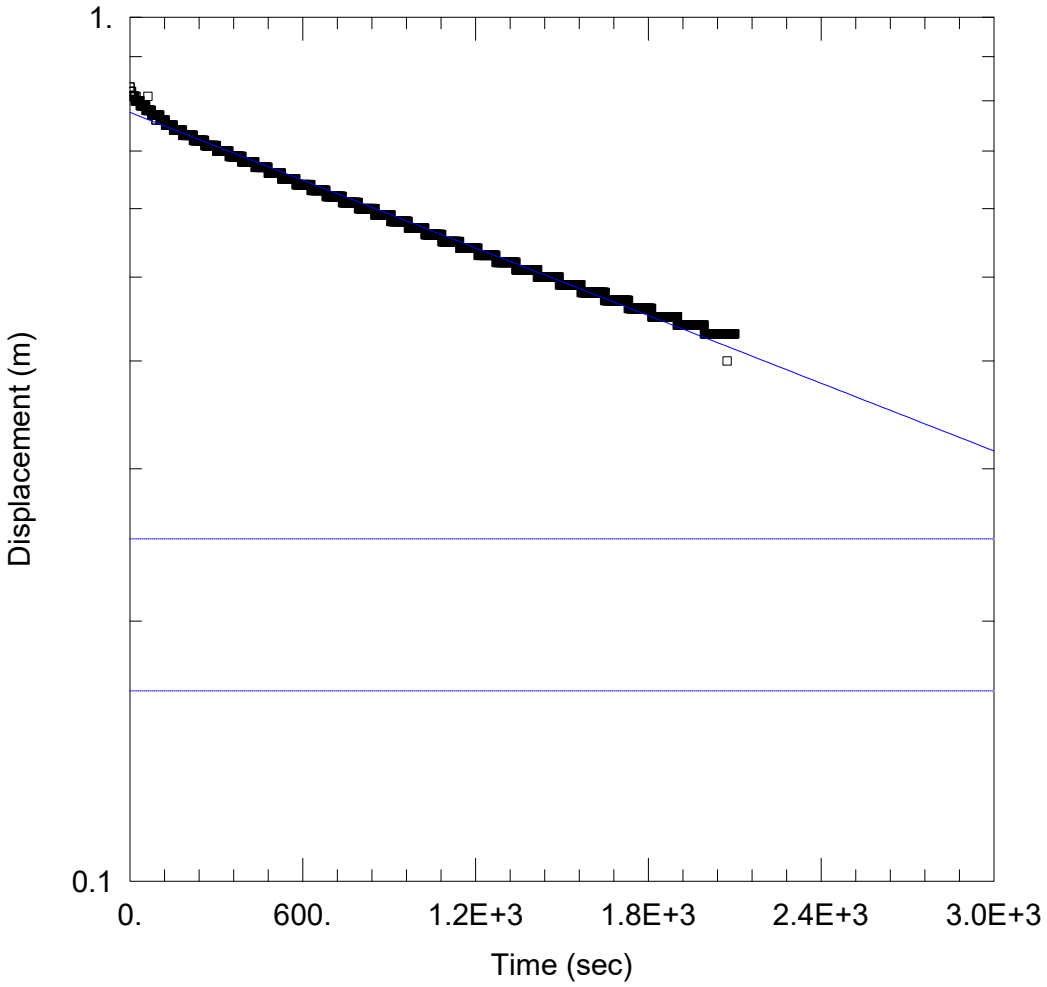
Saturated Thickness: 3.39 m Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (BH23-8)

Initial Displacement: 2.03 m
Total Well Penetration Depth: 4.89 m
Casing Radius: 0.0254 m
Static Water Column Height: 3.39 m
Screen Length: 3. m
Well Radius: 0.0762 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 6.48E-8 m/sec
y0 = 1.938 m



WELL TEST ANALYSIS

Data Set: G:\...\BH23-10.aqt
Date: 09/29/23 Time: 12:28:32

PROJECT INFORMATION

Company: Palmer
Project: 2200902
Test Well: BH23-10
Test Date: 09/13/2023

AQUIFER DATA

Saturated Thickness: 2.54 m Anisotropy Ratio (Kz/Kr): 0.1

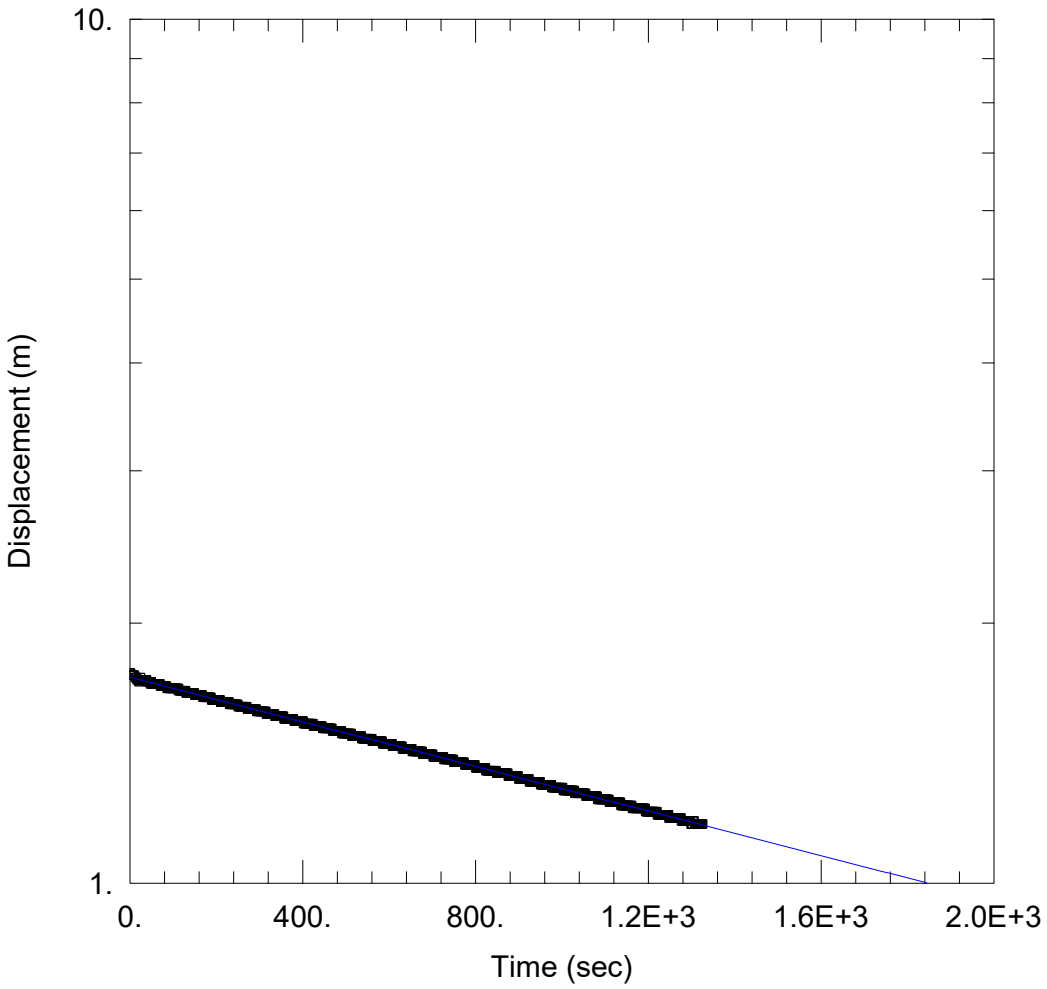
WELL DATA (BH23-10)

Initial Displacement: 0.83 m
Total Well Penetration Depth: 3. m
Casing Radius: 0.0254 m
Static Water Column Height: 2.54 m
Screen Length: 3. m
Well Radius: 0.0762 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 1.056E-7 m/sec y0 = 0.7757 m



WELL TEST ANALYSIS

Data Set: G:\...\BH23-11.aqt
Date: 09/29/23 Time: 12:29:17

PROJECT INFORMATION

Company: Palmer
Project: 2200902
Test Well: BH23-11
Test Date: 09/13/2023

AQUIFER DATA

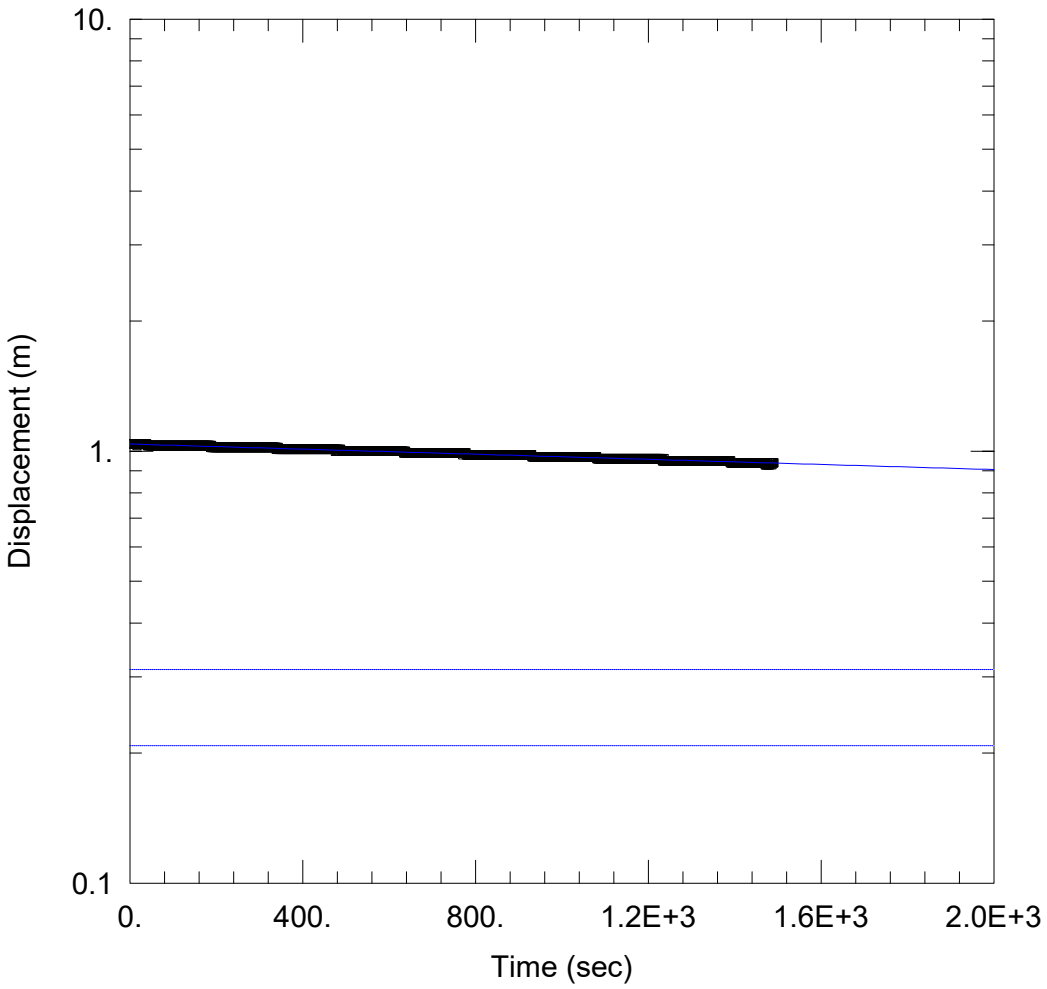
Saturated Thickness: 2.53 m Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (BH23-11)

Initial Displacement: 1.75 m
Total Well Penetration Depth: 3. m
Casing Radius: 0.0254 m
Static Water Column Height: 2.53 m
Screen Length: 3. m
Well Radius: 0.0762 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 1.047E-7 m/sec
y0 = 1.731 m



WELL TEST ANALYSIS

Data Set: G:\...\BH23-13.aqt
Date: 09/29/23 Time: 12:29:36

PROJECT INFORMATION

Company: Palmer
Project: 2200902
Test Well: BH23-13
Test Date: 09/13/2023

AQUIFER DATA

Saturated Thickness: 1.36 m Anisotropy Ratio (Kz/Kr): 0.1

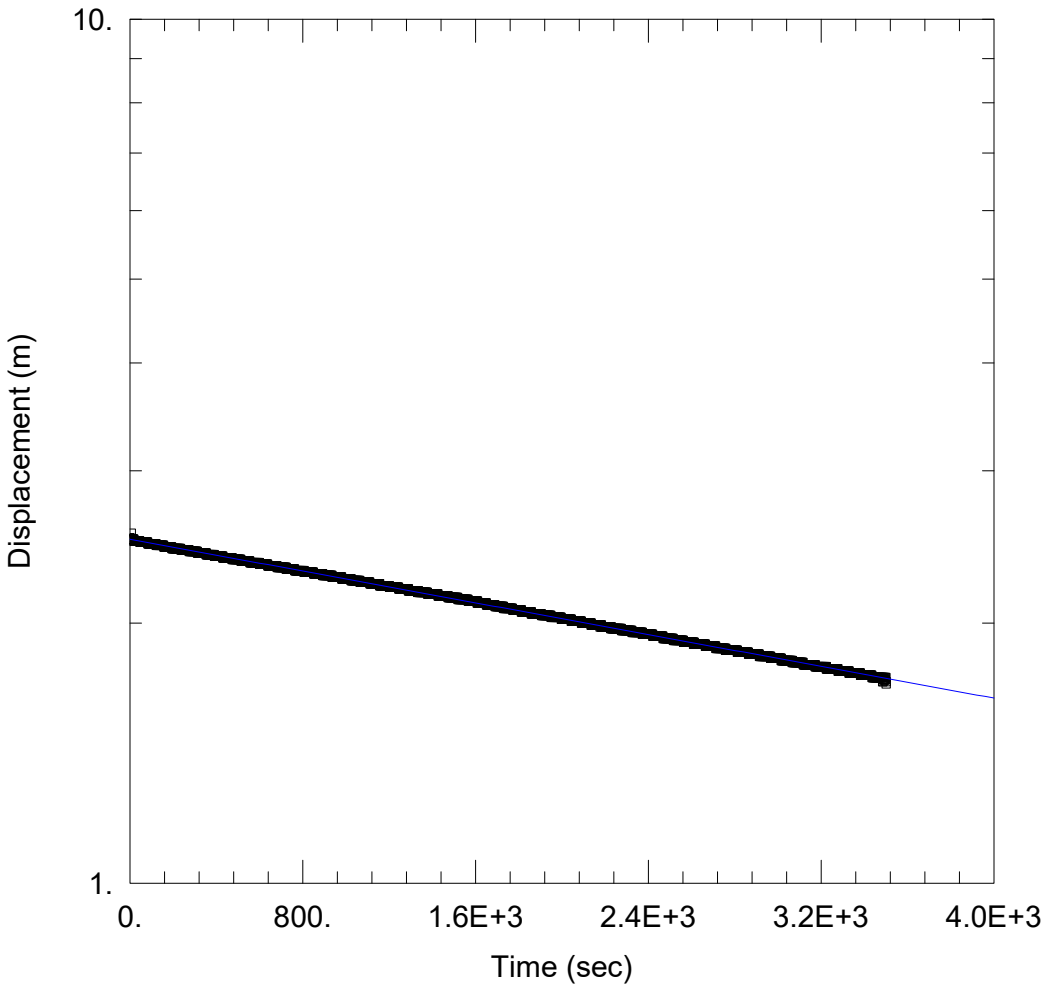
WELL DATA (BH23-13)

Initial Displacement: 1.04 m
Total Well Penetration Depth: 3. m
Casing Radius: 0.0254 m
Static Water Column Height: 1.36 m
Screen Length: 3. m
Well Radius: 0.0762 m
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 4.153E-8 m/sec y0 = 1.038 m



WELL TEST ANALYSIS

Data Set: G:\...\BH23-14.aqt
Date: 09/29/23 Time: 12:30:01

PROJECT INFORMATION

Company: Palmer
Project: 2200902
Test Well: BH23-14
Test Date: 09/13/2023

AQUIFER DATA

Saturated Thickness: 4.54 m Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (BH23-14)

Initial Displacement: 2.5 m
Total Well Penetration Depth: 4.54 m
Casing Radius: 0.0254 m
Static Water Column Height: 4.54 m
Screen Length: 3. m
Well Radius: 0.0762 m

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 4.54E-8 m/sec y0 = 2.5 m

Appendix E

Guelph Permeameter Test (Palmer 2023)

GP1

Guelph Permeameter Calculations

Input

Result

Support: ali@soilmoisture.com

Head #1

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): 1
Enter water Head Height ("H" in cm): 15
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.4000

Res Type	35.22
H	15
a	3
H/a	5
a*	0.12
C0.01	1.518
C0.04	1.629
C0.12	1.667
C0.36	1.667
C	1.667
R	0.400
Q	0.235
pi	3.142

$\alpha^* =$ 0.12 (cm^{-1})

$C =$ 1.666893

$Q =$ 0.2348

$K_{fs} =$		
	1.74E-04	cm/sec
	1.05E-02	cm/min
	1.74E-06	m/sec
	4.12E-03	inch/min
	6.86E-05	inch/sec

$\Phi_m =$ 1.45E-03 (cm^2/min)

Head #2

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): 2
Enter water Head Height ("H" in cm): 10
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 2

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.2000

Res Type	2.16
H	10
a	3
H/a	3.33333
a*	0.04
C0.01	1.21841
C0.04	1.29023
C0.12	1.28754
C0.36	1.28754
C	1.29023
R	0.200
Q	0.0072
pi	3.1415

$\alpha^* =$ 0.04 (cm^{-1})

$C =$ 1.290234

$Q =$ 0.0072

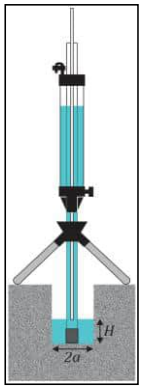
$K_{fs} =$		
	4.16E-06	cm/sec
	2.49E-04	cm/min
	4.16E-08	m/ses
	9.82E-05	inch/min
	1.64E-06	inch/sec

$\Phi_m =$ 1.04E-04 (cm^2/min)

Average

$K_{fs} =$		
	8.92E-05	cm/sec
	5.35E-03	cm/min
	8.92E-07	m/s
	2.11E-03	inch/min
	3.51E-05	inch/sec

$\Phi_m =$ 7.78E-04 (cm^2/min)



Two Head Method

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): 2

Enter the first water Head Height ("H1" in cm): 5
Enter the second water Head Height ("H2" in cm): 10

Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 2

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

$\alpha^* =$ 0.04 (cm^{-1})

Steady State Rate of Water Level Change ("R1" in cm/min): 0.1500

Steady State Rate of Water Level Change ("R2" in cm/min): 0.2000

$Q_1 =$ 0.0054

$Q_2 =$ 0.0072

$C_1 =$ 0.842059

$C_2 =$ 1.290234

Res Type:	2.16
H1/a:	1.666667
H2/a:	3.333333
C1-0.01:	0.809485
C2-0.01:	1.21841
C1-0.04:	0.842059
C2-0.04:	1.290234
C1-0.12:	0.803154
C2-0.12:	1.287543
C1-0.36:	0.803154
C2-0.36:	1.287543

$G_1 =$ 0.005197

$G_2 =$ 0.003981

$G_3 =$ 0.058806

$G_4 =$ 0.024517

$K_{fs} =$		
	6.03E-07	cm/sec
	3.62E-05	cm/min
	6.03E-09	m/sec
	1.42E-05	inch/min
	2.37E-07	inch/sec

$\Phi_m =$ 1.41E-04 (cm^2/min)

Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and α^* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	$\alpha^*(cm^{-1})$	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_1/a}{2.102 + 0.118(H_1/a)}\right)^{0.655}$ $C_2 = \left(\frac{H_2/a}{2.102 + 0.118(H_2/a)}\right)^{0.655}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091(H_1/a)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091(H_2/a)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where R is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm^2/s), α^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm) , H_2 is the second head of water established in borehole (cm) and $C$is Shape factor (from Table 2).

One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{\alpha^*}\right)}$ $\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)\alpha^* + 2\pi H_1}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_2 = \frac{H_1 C_2}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $K_{fs} = G_2Q_2 - G_1Q_1$ $G_3 = \frac{(2H_2^2 + a^2C_2)C_1}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_4 = \frac{(2H_1^2 + a^2C_1)C_2}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $\Phi_m = G_3Q_1 - G_4Q_2$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	

GP2

Guelph Permeameter Calculations

Input

Result

Support: ali@soilmoisture.com

Head #1

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): 2
Enter water Head Height ("H" in cm): 25
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.0300

Res Type	2.16
H	25
a	3
H/a	8.333
a*	0.12
C0.01	1.948
C0.04	2.132
C0.12	2.246
C0.36	2.246
C	2.246
R	0.030
Q	0.001
pi	3.142

α^* = 0.12 (cm^{-1})

C = 2.246256
Q = 0.00108

K_{fs} = 4.58E-07 cm/sec
2.75E-05 cm/min
4.58E-09 m/sec
1.08E-05 inch/min
1.80E-07 inch/sec

Φ_m = 3.81E-06 (cm^2/min)

Head #2

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): 2
Enter water Head Height ("H" in cm): 10
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 2

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.2000

Res Type	2.16
H	10
a	3
H/a	3.33333
a*	0.04
C0.01	1.21841
C0.04	1.29023
C0.12	1.28754
C0.36	1.28754
C	1.29023
R	0.200
Q	0.0072
pi	3.1415

α^* = 0.04 (cm^{-1})

C = 1.290234
Q = 0.0072

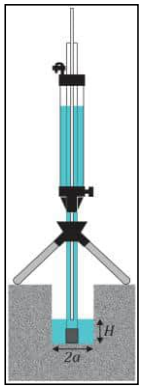
K_{fs} = 4.16E-06 cm/sec
2.49E-04 cm/min
4.16E-08 m/ses
9.82E-05 inch/min
1.64E-06 inch/sec

Φ_m = 1.04E-04 (cm^2/min)

Average

K_{fs} = 2.31E-06 cm/sec
1.38E-04 cm/min
2.31E-08 m/s
5.45E-05 inch/min
9.08E-07 inch/sec

Φ_m = 5.39E-05 (cm^2/min)



Two Head Method

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): 2

Enter the first water Head Height ("H1" in cm): 5
Enter the second water Head Height ("H2" in cm): 10

Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 2

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

α^* = 0.04 (cm^{-1})

Steady State Rate of Water Level Change ("R1" in cm/min): 0.1500

Steady State Rate of Water Level Change ("R2" in cm/min): 0.2000

Q_1 = 0.0054

Q_2 = 0.0072

C_1 = 0.842059

C_2 = 1.290234

Res Type:	2.16
H1/a:	1.666667
H2/a:	3.333333
C1-0.01:	0.809485
C2-0.01:	1.21841
C1-0.04:	0.842059
C2-0.04:	1.290234
C1-0.12:	0.803154
C2-0.12:	1.287543
C1-0.36:	0.803154
C2-0.36:	1.287543

G_1 = 0.005197

G_2 = 0.003981

G_3 = 0.058806

G_4 = 0.024517

K_{fs} = 6.03E-07 cm/sec
3.62E-05 cm/min
6.03E-09 m/sec
1.42E-05 inch/min
2.37E-07 inch/sec

Φ_m = 1.41E-04 (cm^2/min)

Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and α^* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	$\alpha^*(cm^{-1})$	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_1/a}{2.102 + 0.118(H_1/a)}\right)^{0.655}$ $C_2 = \left(\frac{H_2/a}{2.102 + 0.118(H_2/a)}\right)^{0.655}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091(H_1/a)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091(H_2/a)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where R is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm^2/s), α^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm) , H_2 is the second head of water established in borehole (cm) and $C$is Shape factor (from Table 2).

One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{\alpha^*}\right)}$ $\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)\alpha^* + 2\pi H_1}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_2 = \frac{H_1 C_2}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $K_{fs} = G_2Q_2 - G_1Q_1$ $G_3 = \frac{(2H_2^2 + a^2C_2)C_1}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_4 = \frac{(2H_1^2 + a^2C_1)C_2}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $\Phi_m = G_3Q_1 - G_4Q_2$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	

GP3

Guelph Permeameter Calculations

Input

Result

Support: ali@soilmoisture.com

Head #1

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): 1
Enter water Head Height ("H" in cm): 25
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 3

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.5000

Res Type	35.22
H	25
a	3
H/a	8.333
a*	0.12
C0.01	1.948
C0.04	2.132
C0.12	2.246
C0.36	2.246
C	2.246
R	0.500
Q	0.294
pi	3.142

$\alpha^* =$ 0.12 (cm^{-1})

$C =$ 2.246256
$Q =$ 0.2935

$K_{fs} =$	1.24E-04	cm/sec
	7.46E-03	cm/min
	1.24E-06	m/sec
	2.94E-03	inch/min
	4.90E-05	inch/sec

$\Phi_m =$ 1.04E-03 (cm^2/min)

Head #2

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): 2
Enter water Head Height ("H" in cm): 10
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 2

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.2000

Res Type	2.16
H	10
a	3
H/a	3.33333
a*	0.04
C0.01	1.21841
C0.04	1.29023
C0.12	1.28754
C0.36	1.28754
C	1.29023
R	0.200
Q	0.0072
pi	3.1415

$\alpha^* =$ 0.04 (cm^{-1})

$C =$ 1.290234
$Q =$ 0.0072

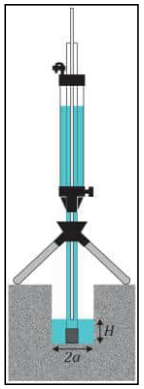
$K_{fs} =$	4.16E-06	cm/sec
	2.49E-04	cm/min
	4.16E-08	m/ses
	9.82E-05	inch/min
	1.64E-06	inch/sec

$\Phi_m =$ 1.04E-04 (cm^2/min)

Average

$K_{fs} =$	6.43E-05	cm/sec
	3.86E-03	cm/min
	6.43E-07	m/s
	1.52E-03	inch/min
	2.53E-05	inch/sec

$\Phi_m =$ 5.70E-04 (cm^2/min)



Two Head Method

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): 2

Enter the first water Head Height ("H1" in cm): 5
Enter the second water Head Height ("H2" in cm): 10

Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 2

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

$\alpha^* =$ 0.04 (cm^{-1})

Steady State Rate of Water Level Change ("R1" in cm/min): 0.1500

Steady State Rate of Water Level Change ("R2" in cm/min): 0.2000

$Q_1 =$ 0.0054

$Q_2 =$ 0.0072

$C_1 =$ 0.842059

Res Type:	2.16
H1/a:	1.666667
H2/a:	3.333333
C1-0.01:	0.809485
C2-0.01:	1.21841
C1-0.04:	0.842059
C2-0.04:	1.290234
C1-0.12:	0.803154
C2-0.12:	1.287543
C1-0.36:	0.803154
C2-0.36:	1.287543

$C_2 =$ 1.290234

$G_1 =$ 0.005197

$G_2 =$ 0.003981

$G_3 =$ 0.058806

$G_4 =$ 0.024517

$K_{fs} =$	6.03E-07	cm/sec
	3.62E-05	cm/min
	6.03E-09	m/sec
	1.42E-05	inch/min
	2.37E-07	inch/sec

$\Phi_m =$ 1.41E-04 (cm^2/min)

Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and α^* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	$\alpha^*(cm^{-1})$	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_1/a}{2.102 + 0.118(H_1/a)}\right)^{0.655}$ $C_2 = \left(\frac{H_2/a}{2.102 + 0.118(H_2/a)}\right)^{0.655}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091(H_1/a)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091(H_2/a)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where R is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm^2/s), α^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm) , H_2 is the second head of water established in borehole (cm) and C is Shape factor (from Table 2).

One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{\alpha^*}\right)}$ $\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)\alpha^* + 2\pi H_1}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_2 = \frac{H_1 C_2}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $K_{fs} = G_2Q_2 - G_1Q_1$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	$G_3 = \frac{(2H_2^2 + a^2C_2)C_1}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_4 = \frac{(2H_1^2 + a^2C_1)C_2}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $\Phi_m = G_3Q_1 - G_4Q_2$

GP4

Guelph Permeameter Calculations

Input

Result

Support: ali@soilmoisture.com

Head #1

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): 1
Enter water Head Height ("H" in cm): 15
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 2

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.2000

Res Type	35.22
H	15
a	3
H/a	5
a*	0.04
C0.01	1.518
C0.04	1.629
C0.12	1.667
C0.36	1.667
C	1.629
R	0.200
Q	0.117
pi	3.142

a^* = 0.04 (cm^{-1})

C = 1.629144
Q = 0.1174

K_{fs} = 5.01E-05 cm/sec
3.01E-03 cm/min
5.01E-07 m/sec
1.18E-03 inch/min
1.97E-05 inch/sec

Φ_m = 1.25E-03 (cm^2/min)

Head #2

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): 2
Enter water Head Height ("H" in cm): 10
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 2

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.2000

Res Type	2.16
H	10
a	3
H/a	3.33333
a*	0.04
C0.01	1.21841
C0.04	1.29023
C0.12	1.28754
C0.36	1.28754
C	1.29023
R	0.200
Q	0.0072
pi	3.1415

a^* = 0.04 (cm^{-1})

C = 1.290234
Q = 0.0072

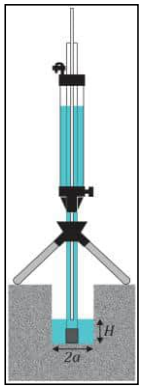
K_{fs} = 4.16E-06 cm/sec
2.49E-04 cm/min
4.16E-08 m/ses
9.82E-05 inch/min
1.64E-06 inch/sec

Φ_m = 1.04E-04 (cm^2/min)

Average

K_{fs} = 2.71E-05 cm/sec
1.63E-03 cm/min
2.71E-07 m/s
6.41E-04 inch/min
1.07E-05 inch/sec

Φ_m = 6.78E-04 (cm^2/min)



Two Head Method

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): 2

Enter the first water Head Height ("H1" in cm): 5
Enter the second water Head Height ("H2" in cm): 10

Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 2

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

a^* = 0.04 (cm^{-1})

Steady State Rate of Water Level Change ("R1" in cm/min): 0.1500

Steady State Rate of Water Level Change ("R2" in cm/min): 0.2000

Q_1 = 0.0054

Q_2 = 0.0072

C_1 = 0.842059

Res Type:	2.16
H1/a:	1.666667
H2/a:	3.333333
C1-0.01:	0.809485
C2-0.01:	1.21841
C1-0.04:	0.842059
C2-0.04:	1.290234
C1-0.12:	0.803154
C2-0.12:	1.287543
C1-0.36:	0.803154
C2-0.36:	1.287543

C_2 = 1.290234

G_1 = 0.005197

G_2 = 0.003981

G_3 = 0.058806

G_4 = 0.024517

K_{fs} = 6.03E-07 cm/sec
3.62E-05 cm/min
6.03E-09 m/sec
1.42E-05 inch/min
2.37E-07 inch/sec

Φ_m = 1.41E-04 (cm^2/min)

Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and a^* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	$a^*(cm^{-1})$	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_1/a}{2.102 + 0.118(H_1/a)}\right)^{0.655}$ $C_2 = \left(\frac{H_2/a}{2.102 + 0.118(H_2/a)}\right)^{0.655}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091(H_1/a)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091(H_2/a)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where R is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm^2/s), a^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm) , H_2 is the second head of water established in borehole (cm) and $C$is Shape factor (from Table 2).

One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{a^*}\right)}$ $\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)a^* + 2\pi H_1}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_2 = \frac{H_1 C_2}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $K_{fs} = G_2Q_2 - G_1Q_1$ $G_3 = \frac{(2H_2^2 + a^2C_2)C_1}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_4 = \frac{(2H_1^2 + a^2C_1)C_2}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $\Phi_m = G_3Q_1 - G_4Q_2$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	

GP5

Guelph Permeameter Calculations

Input

Result

Support: ali@soilmoisture.com

Head #1

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): 1
Enter water Head Height ("H" in cm): 20
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 2

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.1000

Res Type	35.22
H	20
a	3
H/a	6.667
a*	0.04
C0.01	1.755
C0.04	1.903
C0.12	1.98
C0.36	1.98
C	1.903
R	0.100
Q	0.059
pi	3.142

α^* = 0.04 (cm^{-1})

C = 1.903071
Q = 0.0587

K_{fs} =	1.96E-05	cm/sec
	1.17E-03	cm/min
	1.96E-07	m/sec
	4.62E-04	inch/min
	7.70E-06	inch/sec

Φ_m = 4.89E-04 (cm^2/min)

Head #2

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): 2
Enter water Head Height ("H" in cm): 10
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 2

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.2000

Res Type	2.16
H	10
a	3
H/a	3.33333
a*	0.04
C0.01	1.21841
C0.04	1.29023
C0.12	1.28754
C0.36	1.28754
C	1.29023
R	0.200
Q	0.0072
pi	3.1415

α^* = 0.04 (cm^{-1})

C = 1.290234
Q = 0.0072

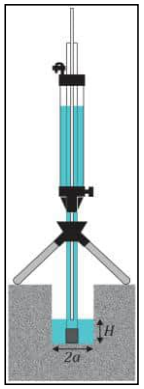
K_{fs} =	4.16E-06	cm/sec
	2.49E-04	cm/min
	4.16E-08	m/ses
	9.82E-05	inch/min
	1.64E-06	inch/sec

Φ_m = 1.04E-04 (cm^2/min)

Average

K_{fs} =	1.19E-05	cm/sec
	7.12E-04	cm/min
	1.19E-07	m/s
	2.80E-04	inch/min
	4.67E-06	inch/sec

Φ_m = 2.97E-04 (cm^2/min)



Two Head Method

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): 2

Enter the first water Head Height ("H1" in cm): 5
Enter the second water Head Height ("H2" in cm): 10

Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 2

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

α^* = 0.04 (cm^{-1})

Steady State Rate of Water Level Change ("R1" in cm/min): 0.1500

Steady State Rate of Water Level Change ("R2" in cm/min): 0.2000

Q_1 = 0.0054

Q_2 = 0.0072

C_1 = 0.842059

C_2 = 1.290234

G_1 = 0.005197

G_2 = 0.003981

G_3 = 0.058806

G_4 = 0.024517

Res Type:	2.16
H1/a:	1.666667
H2/a:	3.333333
C1-0.01:	0.809485
C2-0.01:	1.21841
C1-0.04:	0.842059
C2-0.04:	1.290234
C1-0.12:	0.803154
C2-0.12:	1.287543
C1-0.36:	0.803154
C2-0.36:	1.287543

K_{fs} =	6.03E-07	cm/sec
	3.62E-05	cm/min
	6.03E-09	m/sec
	1.42E-05	inch/min
	2.37E-07	inch/sec

Φ_m = 1.41E-04 (cm^2/min)

Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and α^* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	α^*(cm^{-1})	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_1/a}{2.102 + 0.118(H_1/a)}\right)^{0.655}$ $C_2 = \left(\frac{H_2/a}{2.102 + 0.118(H_2/a)}\right)^{0.655}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091(H_1/a)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091(H_2/a)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where R is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm^2/s), α^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm) , H_2 is the second head of water established in borehole (cm) and $C$is Shape factor (from Table 2).

One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{\alpha^*}\right)}$ $\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)\alpha^* + 2\pi H_1}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_2 = \frac{H_1 C_2}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $K_{fs} = G_2Q_2 - G_1Q_1$ $G_3 = \frac{(2H_2^2 + a^2C_2)C_1}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_4 = \frac{(2H_1^2 + a^2C_1)C_2}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $\Phi_m = G_3Q_1 - G_4Q_2$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	

GP6

Guelph Permeameter Calculations

Input

Result

Support: ali@soilmoisture.com

Head #1

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): 1
Enter water Head Height ("H" in cm): 10
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 2

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.4000

Res Type	35.22
H	10
a	3
H/a	3.333
a*	0.04
C0.01	1.218
C0.04	1.29
C0.12	1.288
C0.36	1.288
C	1.29
R	0.400
Q	0.235
pi	3.142

α^* = 0.04 (cm^{-1})

C = 1.290234
Q = 0.2348

K_{fs} = 1.36E-04 cm/sec
8.13E-03 cm/min
1.36E-06 m/sec
3.20E-03 inch/min
5.34E-05 inch/sec

Φ_m = 3.39E-03 (cm^2/min)

Head #2

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): 2
Enter water Head Height ("H" in cm): 10
Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 2

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

Steady State Rate of Water Level Change ("R" in cm/min): 0.2000

Res Type	2.16
H	10
a	3
H/a	3.33333
a*	0.04
C0.01	1.21841
C0.04	1.29023
C0.12	1.28754
C0.36	1.28754
C	1.29023
R	0.200
Q	0.0072
pi	3.1415

α^* = 0.04 (cm^{-1})

C = 1.290234
Q = 0.0072

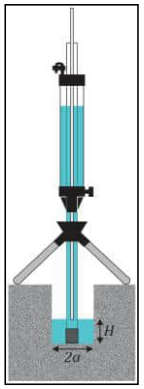
K_{fs} = 4.16E-06 cm/sec
2.49E-04 cm/min
4.16E-08 m/ses
9.82E-05 inch/min
1.64E-06 inch/sec

Φ_m = 1.04E-04 (cm^2/min)

Average

K_{fs} = 6.98E-05 cm/sec
4.19E-03 cm/min
6.98E-07 m/s
1.65E-03 inch/min
2.75E-05 inch/sec

Φ_m = 1.75E-03 (cm^2/min)



Two Head Method

Reservoir Type (enter "1" for Combined and "2" for Inner reservoir): 2

Enter the first water Head Height ("H1" in cm): 5
Enter the second water Head Height ("H2" in cm): 10

Enter the Borehole Radius ("a" in cm): 3

Enter the soil texture-structure category (enter one of the below numbers): 2

1. Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.
2. Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.
3. Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.
4. Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macropors, etc

α^* = 0.04 (cm^{-1})

Steady State Rate of Water Level Change ("R1" in cm/min): 0.1500

Steady State Rate of Water Level Change ("R2" in cm/min): 0.2000

Q_1 = 0.0054

Q_2 = 0.0072

C_1 = 0.842059

C_2 = 1.290234

Res Type:	2.16
H1/a:	1.666667
H2/a:	3.333333
C1-0.01:	0.809485
C2-0.01:	1.21841
C1-0.04:	0.842059
C2-0.04:	1.290234
C1-0.12:	0.803154
C2-0.12:	1.287543
C1-0.36:	0.803154
C2-0.36:	1.287543

G_1 = 0.005197

G_2 = 0.003981

G_3 = 0.058806

G_4 = 0.024517

K_{fs} = 6.03E-07 cm/sec
3.62E-05 cm/min
6.03E-09 m/sec
1.42E-05 inch/min
2.37E-07 inch/sec

Φ_m = 1.41E-04 (cm^2/min)

Calculation formulas related to shape factor (C). Where H_1 is the first water head height (cm), H_2 is the second water head height (cm), a is borehole radius (cm) and α^* is microscopic capillary length factor which is decided according to the soil texture-structure category. For one-head method, only C_1 needs to be calculated while for two-head method, C_1 and C_2 are calculated (Zang et al., 1998).

Soil Texture-Structure Category	$\alpha^*(cm^{-1})$	Shape Factor
Compacted, Structure-less, clayey or silty materials such as landfill caps and liners, lacustrine or marine sediments, etc.	0.01	$C_1 = \left(\frac{H_1/a}{2.102 + 0.118(H_1/a)}\right)^{0.655}$ $C_2 = \left(\frac{H_2/a}{2.102 + 0.118(H_2/a)}\right)^{0.655}$
Soils which are both fine textured (clayey or silty) and unstructured; may also include some fine sands.	0.04	$C_1 = \left(\frac{H_1/a}{1.992 + 0.091(H_1/a)}\right)^{0.683}$ $C_2 = \left(\frac{H_2/a}{1.992 + 0.091(H_2/a)}\right)^{0.683}$
Most structured soils from clays through loams; also includes unstructured medium and fine sands. The category most frequently applicable for agricultural soils.	0.12	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$
Coarse and gravely sands; may also include some highly structured soils with large and/or numerous cracks, macro pores, etc.	0.36	$C_1 = \left(\frac{H_1/a}{2.074 + 0.093(H_1/a)}\right)^{0.754}$ $C_2 = \left(\frac{H_2/a}{2.074 + 0.093(H_2/a)}\right)^{0.754}$

Calculation formulas related to one-head and two-head methods. Where R is steady-state rate of fall of water in reservoir (cm/s), K_{fs} is Soil saturated hydraulic conductivity (cm/s), Φ_m is Soil matric flux potential (cm^2/s), α^* is Macroscopic capillary length parameter (from Table 2), a is Borehole radius (cm), H_1 is the first head of water established in borehole (cm) , H_2 is the second head of water established in borehole (cm) and $C$is Shape factor (from Table 2).

One Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$	$K_{fs} = \frac{C_1 \times Q_1}{2\pi H_1^2 + \pi a^2 C_1 + 2\pi\left(\frac{H_1}{\alpha^*}\right)}$ $\Phi_m = \frac{C_1 \times Q_1}{(2\pi H_1^2 + \pi a^2 C_1)\alpha^* + 2\pi H_1}$
One Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$	
Two Head, Combined Reservoir	$Q_1 = \bar{R}_1 \times 35.22$ $Q_2 = \bar{R}_2 \times 35.22$	$G_1 = \frac{H_2 C_1}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_2 = \frac{H_1 C_2}{\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $K_{fs} = G_2Q_2 - G_1Q_1$ $G_3 = \frac{(2H_2^2 + a^2C_2)C_1}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $G_4 = \frac{(2H_1^2 + a^2C_1)C_2}{2\pi(2H_1H_2(H_2 - H_1) + a^2(H_1C_2 - H_2C_1))}$ $\Phi_m = G_3Q_1 - G_4Q_2$
Two Head, Inner Reservoir	$Q_1 = \bar{R}_1 \times 2.16$ $Q_2 = \bar{R}_2 \times 2.16$	

Appendix F

Certificates of Analysis (ALS 2023)

ALS Canada Ltd.

CERTIFICATE OF ANALYSIS

Work Order	: **WT2324845**	Page	: 1 of 5
Client	: **Palmer Environmental Consulting Group Inc.**	Laboratory	: ALS Environmental - Waterloo
Contact	: Tanvi Patel	Account Manager	: Andrew Martin
Address	: 74 Berkeley Street Toronto ON Canada M5V 1E3	Address	: 60 Northland Road, Unit 1 Waterloo ON Canada N2V 2B8
Telephone	: ----	Telephone	: +1 519 886 6910
Project	: 2200902	Date Samples Received	: 10-Aug-2023 17:31
PO	: 2200902	Date Analysis Commenced	: 10-Aug-2023
C-O-C number	: 20-1046873	Issue Date	: 01-Sep-2023 16:22
Sampler	: TP		
Site	: ----		
Quote number	: (Q88296) PALMER 2023 STANDING OFFER		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Walt Kippenhuck	Supervisor - Inorganic	Inorganics, Waterloo, Ontario
Walt Kippenhuck	Supervisor - Inorganic	Metals, Waterloo, Ontario

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Please refer to Quality Control Interpretive report (QCI) for information regarding Holding Time compliance.

Key : CAS Number: Chemical Abstracts Services number is a unique identifier assigned to discrete substances

LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	no units
%	percent
µS/cm	microsiemens per centimetre
CU	colour units (1 cu = 1 mg/l pt)
meq/L	milliequivalents per litre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

<: less than.

>: greater than.

Surrogate: An analyte that is similar in behavior to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.

Test results reported relate only to the samples as received by the laboratory.

UNLESS OTHERWISE STATED on SRN or QCI Report, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.

Qualifiers

Qualifier	*Description*
DLDS	*Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.*

Analytical Results

Sub-Matrix: **Water**
(Matrix: **Water**)

Analyte	CAS Number	Method/Lab	LOR	Unit	Client sample ID: BH23-2	----	----	----	----
					Client sampling date / time: 10-Aug-2023 10:00	----	----	----	----
					WT2324845-001	--------	--------	--------	--------
					Result	----	----	----	----
Physical Tests									
Alkalinity, bicarbonate (as HCO3)	71-52-3	E290/WT	1.0	mg/L	337	----	----	----	----
Alkalinity, carbonate (as CO3)	3812-32-6	E290/WT	1.0	mg/L	<1.0	----	----	----	----
Alkalinity, hydroxide (as OH)	14280-30-9	E290/WT	1.0	mg/L	<1.0	----	----	----	----
Alkalinity, total (as CaCO3)	----	E290/WT	1.0	mg/L	276	----	----	----	----
Colour, apparent	----	E330/WT	2.0	CU	78.7	----	----	----	----
Conductivity	----	E100/WT	1.0	µS/cm	552	----	----	----	----
Hardness (as CaCO3), from total Ca/Mg	----	EC100A/WT	0.50	mg/L	281	----	----	----	----
pH	----	E108/WT	0.10	pH units	7.96	----	----	----	----
Solids, total dissolved [TDS]	----	E162/WT	10	mg/L	396 DLDS	----	----	----	----
Solids, total dissolved [TDS], calculated	----	EC103A/WT	1.0	mg/L	359	----	----	----	----
Turbidity	----	E121/WT	0.10	NTU	11.0	----	----	----	----
Langelier index (@ 20°C)	----	EC105A/WT	0.010	-	0.858	----	----	----	----
Langelier index (@ 4°C)	----	EC105A/WT	0.010	-	0.611	----	----	----	----
pH, saturation (@ 20°C)	----	EC105A/WT	0.010	pH units	7.10	----	----	----	----
pH, saturation (@ 4°C)	----	EC105A/WT	0.010	pH units	7.35	----	----	----	----
Anions and Nutrients									
Ammonia, total (as N)	7664-41-7	E298/WT	0.0050	mg/L	<0.0050	----	----	----	----
Bromide	24959-67-9	E235.Br/WT	0.10	mg/L	<0.10	----	----	----	----
Chloride	16887-00-6	E235.Cl/WT	0.50	mg/L	11.6	----	----	----	----
Fluoride	16984-48-8	E235.F/WT	0.020	mg/L	0.187	----	----	----	----
Nitrate (as N)	14797-55-8	E235.NO3/WT	0.020	mg/L	0.034	----	----	----	----
Nitrate + Nitrite (as N)	----	EC235.N+N/WT	0.0032	mg/L	0.0340	----	----	----	----
Nitrite (as N)	14797-65-0	E235.NO2/WT	0.010	mg/L	<0.010	----	----	----	----
Phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U/WT	0.0010	mg/L	<0.0010	----	----	----	----
Sulfate (as SO4)	14808-79-8	E235.SO4/WT	0.30	mg/L	18.0	----	----	----	----
Organic / Inorganic Carbon									
Carbon, dissolved organic [DOC]	----	E358-L/WT	0.50	mg/L	1.48	----	----	----	----
Metals									

Analytical Results

Sub-Matrix: Water (Matrix: Water)					Client sample ID	BH23-2	----	----	----	----
					Client sampling date / time	10-Aug-2023 10:00	----	----	----	----
Analyte	CAS Number	Method/Lab	LOR	Unit		WT2324845-001	--------	--------	--------	--------
						Result	----	----	----	----
Metals										
Sodium adsorption ratio [SAR]	----	EC102/WT	0.10	-		0.39	----	----	----	----
Ion Balance										
Anion sum	----	EC101A/WT	0.10	meq/L		6.23	----	----	----	----
Cation sum (total)	----	EC101A/WT	0.10	meq/L		6.41	----	----	----	----
Ion balance (APHA)	----	EC101A/WT	0.010	%		1.42	----	----	----	----
Ion balance (cations/anions)	----	EC101A/WT	0.01	%		103	----	----	----	----
Total Metals										
Aluminum, total	7429-90-5	E420/WT	0.0030	mg/L		0.176	----	----	----	----
Antimony, total	7440-36-0	E420/WT	0.00010	mg/L		0.00017	----	----	----	----
Arsenic, total	7440-38-2	E420/WT	0.00010	mg/L		0.00064	----	----	----	----
Barium, total	7440-39-3	E420/WT	0.00010	mg/L		0.122	----	----	----	----
Beryllium, total	7440-41-7	E420/WT	0.000020	mg/L		<0.000020	----	----	----	----
Bismuth, total	7440-69-9	E420/WT	0.000050	mg/L		<0.000050	----	----	----	----
Boron, total	7440-42-8	E420/WT	0.010	mg/L		0.051	----	----	----	----
Cadmium, total	7440-43-9	E420/WT	0.0000050	mg/L		<0.0000050	----	----	----	----
Calcium, total	7440-70-2	E420/WT	0.050	mg/L		80.8	----	----	----	----
Cesium, total	7440-46-2	E420/WT	0.000010	mg/L		0.000030	----	----	----	----
Chromium, total	7440-47-3	E420/WT	0.00050	mg/L		<0.00050	----	----	----	----
Cobalt, total	7440-48-4	E420/WT	0.00010	mg/L		0.00090	----	----	----	----
Copper, total	7440-50-8	E420/WT	0.00050	mg/L		<0.00050	----	----	----	----
Iron, total	7439-89-6	E420/WT	0.010	mg/L		0.166	----	----	----	----
Lead, total	7439-92-1	E420/WT	0.000050	mg/L		0.000201	----	----	----	----
Lithium, total	7439-93-2	E420/WT	0.0010	mg/L		0.0074	----	----	----	----
Magnesium, total	7439-95-4	E420/WT	0.0050	mg/L		19.3	----	----	----	----
Manganese, total	7439-96-5	E420/WT	0.00010	mg/L		0.0342	----	----	----	----
Molybdenum, total	7439-98-7	E420/WT	0.000050	mg/L		0.00435	----	----	----	----
Nickel, total	7440-02-0	E420/WT	0.00050	mg/L		0.00134	----	----	----	----
Phosphorus, total	7723-14-0	E420/WT	0.050	mg/L		<0.050	----	----	----	----
Potassium, total	7440-09-7	E420/WT	0.050	mg/L		4.42	----	----	----	----
Rubidium, total	7440-17-7	E420/WT	0.00020	mg/L		0.00134	----	----	----	----

Analytical Results

Sub-Matrix: Water (Matrix: Water)					Client sample ID	BH23-2	----	----	----	----
					Client sampling date / time	10-Aug-2023 10:00	----	----	----	----
Analyte	CAS Number	Method/Lab	LOR	Unit		WT2324845-001	--------	--------	--------	--------
						Result	----	----	----	----
Total Metals										
Selenium, total	7782-49-2	E420/WT	0.000050	mg/L		<0.000050	----	----	----	----
Silicon (as SiO2), total	7631-86-9	EC420.SiO2/ WT	0.25	mg/L		20.9	----	----	----	----
Silicon, total	7440-21-3	E420/WT	0.10	mg/L		9.78	----	----	----	----
Silver, total	7440-22-4	E420/WT	0.000010	mg/L		<0.000010	----	----	----	----
Sodium, total	7440-23-5	E420/WT	0.050	mg/L		14.9	----	----	----	----
Strontium, total	7440-24-6	E420/WT	0.00020	mg/L		0.595	----	----	----	----
Sulfur, total	7704-34-9	E420/WT	0.50	mg/L		7.05	----	----	----	----
Tellurium, total	13494-80-9	E420/WT	0.00020	mg/L		<0.00020	----	----	----	----
Thallium, total	7440-28-0	E420/WT	0.000010	mg/L		0.000028	----	----	----	----
Thorium, total	7440-29-1	E420/WT	0.00010	mg/L		<0.00010	----	----	----	----
Tin, total	7440-31-5	E420/WT	0.00010	mg/L		0.00073	----	----	----	----
Titanium, total	7440-32-6	E420/WT	0.00030	mg/L		0.00783	----	----	----	----
Tungsten, total	7440-33-7	E420/WT	0.00010	mg/L		<0.00010	----	----	----	----
Uranium, total	7440-61-1	E420/WT	0.000010	mg/L		0.000590	----	----	----	----
Vanadium, total	7440-62-2	E420/WT	0.00050	mg/L		0.00074	----	----	----	----
Zinc, total	7440-66-6	E420/WT	0.0030	mg/L		0.0060	----	----	----	----
Zirconium, total	7440-67-7	E420/WT	0.00020	mg/L		<0.00020	----	----	----	----

Please refer to the General Comments section for an explanation of any result qualifiers detected.

Please refer to the Accreditation section for an explanation of analyte accreditations.

ALS Canada Ltd.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **WT2324845**	Page	: 1 of 11
Client	: **Palmer Environmental Consulting Group Inc.**	Laboratory	: ALS Environmental - Waterloo
Contact	: Tanvi Patel	Account Manager	: Andrew Martin
Address	: 74 Berkeley Street Toronto ON Canada M5V 1E3	Address	: 60 Northland Road, Unit 1 Waterloo, Ontario Canada N2V 2B8
Telephone	: ----	Telephone	: +1 519 886 6910
Project	: 2200902	Date Samples Received	: 10-Aug-2023 17:31
PO	: 2200902	Issue Date	: 01-Sep-2023 16:23
C-O-C number	: 20-1046873		
Sampler	: TP		
Site	: ----		
Quote number	: (Q88296) PALMER 2023 STANDING OFFER		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Service number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Workorder Comments

Holding times are displayed as "---" if no guidance exists from CCME, Canadian provinces, or broadly recognized international references.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- Matrix Spike outliers occur - please see following pages for full details.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- No Analysis Holding Time Outliers exist.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **Water**

Analyte Group	Laboratory sample ID	Client/Ref Sample ID	Analyte	CAS Number	Method	Result	Limits	Comment
Matrix Spike (MS) Recoveries								
Total Metals	Anonymous	Anonymous	Chromium, total	7440-47-3	E420	135 % K	70.0-130%	Recovery greater than upper data quality objective
Total Metals	Anonymous	Anonymous	Phosphorus, total	7723-14-0	E420	202 % K	70.0-130%	Recovery greater than upper data quality objective
Total Metals	Anonymous	Anonymous	Thorium, total	7440-29-1	E420	62.0 % K	70.0-130%	Recovery less than lower data quality objective

Result Qualifiers

Qualifier	Description
K	*Matrix Spike recovery outside ALS DQO due to sample matrix effects.*

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid) [ON MECP]										
BH23-2	E298	10-Aug-2023	14-Aug-2023	28 days	4 days	✓	15-Aug-2023	28 days	5 days	✓
Anions and Nutrients : Bromide in Water by IC										
HDPE [ON MECP]										
BH23-2	E235.Br	10-Aug-2023	11-Aug-2023	28 days	1 days	✓	11-Aug-2023	28 days	1 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE [ON MECP]										
BH23-2	E235.Cl	10-Aug-2023	11-Aug-2023	28 days	1 days	✓	11-Aug-2023	28 days	1 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level 0.001										
HDPE [ON MECP]										
BH23-2	E378-U	10-Aug-2023	11-Aug-2023	7 days	1 days	✓	14-Aug-2023	7 days	4 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE [ON MECP]										
BH23-2	E235.F	10-Aug-2023	11-Aug-2023	28 days	1 days	✓	11-Aug-2023	28 days	1 days	✓
Anions and Nutrients : Nitrate in Water by IC										
HDPE [ON MECP]										
BH23-2	E235.NO3	10-Aug-2023	11-Aug-2023	7 days	1 days	✓	11-Aug-2023	7 days	1 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Nitrite in Water by IC										
HDPE [ON MECP]										
BH23-2	E235.NO2	10-Aug-2023	11-Aug-2023	7 days	1 days	✓	11-Aug-2023	7 days	1 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE [ON MECP]										
BH23-2	E235.SO4	10-Aug-2023	11-Aug-2023	28 days	1 days	✓	11-Aug-2023	28 days	1 days	✓
Organic / Inorganic Carbon : Dissolved Organic Carbon by Combustion (Low Level)										
Amber glass dissolved (sulfuric acid) [ON MECP]										
BH23-2	E358-L	10-Aug-2023	15-Aug-2023	28 days	5 days	✓	18-Aug-2023	28 days	8 days	✓
Physical Tests : Alkalinity Species by Titration										
HDPE [ON MECP]										
BH23-2	E290	10-Aug-2023	11-Aug-2023	14 days	1 days	✓	11-Aug-2023	14 days	1 days	✓
Physical Tests : Colour (Apparent) by Spectrometer										
HDPE [ON MECP]										
BH23-2	E330	10-Aug-2023	----	----	----		11-Aug-2023	48 hrs	27 hrs	✓
Physical Tests : Conductivity in Water										
HDPE [ON MECP]										
BH23-2	E100	10-Aug-2023	11-Aug-2023	28 days	1 days	✓	11-Aug-2023	28 days	1 days	✓
Physical Tests : pH by Meter										
HDPE [ON MECP]										
BH23-2	E108	10-Aug-2023	11-Aug-2023	14 days	1 days	✓	11-Aug-2023	14 days	1 days	✓
Physical Tests : TDS by Gravimetry										
HDPE [ON MECP]										
BH23-2	E162	10-Aug-2023	----	----	----		11-Aug-2023	7 days	1 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE [ON MECP]										
BH23-2	E121	10-Aug-2023	----	----	----		11-Aug-2023	48 hrs	24 hrs	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Total Metals : Total Metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BH23-2	E420	10-Aug-2023	10-Aug-2023	180 days	1 days	✓	11-Aug-2023	180 days	1 days	✓

Legend & Qualifier Definitions

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Alkalinity Species by Titration	E290	1080369	1	11	9.0	5.0	✓
Ammonia by Fluorescence	E298	1083324	1	20	5.0	5.0	✓
Bromide in Water by IC	E235.Br	1080372	1	10	10.0	5.0	✓
Chloride in Water by IC	E235.Cl	1080376	1	14	7.1	5.0	✓
Colour (Apparent) by Spectrometer	E330	1080959	1	14	7.1	5.0	✓
Conductivity in Water	E100	1080370	1	14	7.1	5.0	✓
Dissolved Organic Carbon by Combustion (Low Level)	E358-L	1086536	1	11	9.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level 0.001 mg/L)	E378-U	1080975	1	20	5.0	5.0	✓
Fluoride in Water by IC	E235.F	1080373	1	15	6.6	5.0	✓
Nitrate in Water by IC	E235.NO3	1080374	1	15	6.6	5.0	✓
Nitrite in Water by IC	E235.NO2	1080375	1	14	7.1	5.0	✓
pH by Meter	E108	1080371	1	19	5.2	5.0	✓
Sulfate in Water by IC	E235.SO4	1080377	1	11	9.0	5.0	✓
TDS by Gravimetry	E162	1080788	1	19	5.2	5.0	✓
Total Metals in Water by CRC ICPMS	E420	1079898	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	1080450	1	18	5.5	5.0	✓
Laboratory Control Samples (LCS)							
Alkalinity Species by Titration	E290	1080369	1	11	9.0	5.0	✓
Ammonia by Fluorescence	E298	1083324	1	20	5.0	5.0	✓
Bromide in Water by IC	E235.Br	1080372	1	10	10.0	5.0	✓
Chloride in Water by IC	E235.Cl	1080376	1	14	7.1	5.0	✓
Colour (Apparent) by Spectrometer	E330	1080959	1	14	7.1	5.0	✓
Conductivity in Water	E100	1080370	1	14	7.1	5.0	✓
Dissolved Organic Carbon by Combustion (Low Level)	E358-L	1086536	1	11	9.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level 0.001 mg/L)	E378-U	1080975	1	20	5.0	5.0	✓
Fluoride in Water by IC	E235.F	1080373	1	15	6.6	5.0	✓
Nitrate in Water by IC	E235.NO3	1080374	1	15	6.6	5.0	✓
Nitrite in Water by IC	E235.NO2	1080375	1	14	7.1	5.0	✓
pH by Meter	E108	1080371	1	19	5.2	5.0	✓
Sulfate in Water by IC	E235.SO4	1080377	1	11	9.0	5.0	✓
TDS by Gravimetry	E162	1080788	1	19	5.2	5.0	✓
Total Metals in Water by CRC ICPMS	E420	1079898	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	1080450	1	18	5.5	5.0	✓
Method Blanks (MB)							
Alkalinity Species by Titration	E290	1080369	1	11	9.0	5.0	✓

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Method Blanks (MB) - Continued							
Ammonia by Fluorescence	E298	1083324	1	20	5.0	5.0	✓
Bromide in Water by IC	E235.Br	1080372	1	10	10.0	5.0	✓
Chloride in Water by IC	E235.Cl	1080376	1	14	7.1	5.0	✓
Colour (Apparent) by Spectrometer	E330	1080959	1	14	7.1	5.0	✓
Conductivity in Water	E100	1080370	1	14	7.1	5.0	✓
Dissolved Organic Carbon by Combustion (Low Level)	E358-L	1086536	1	11	9.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level 0.001 mg/L)	E378-U	1080975	1	20	5.0	5.0	✓
Fluoride in Water by IC	E235.F	1080373	1	15	6.6	5.0	✓
Nitrate in Water by IC	E235.NO3	1080374	1	15	6.6	5.0	✓
Nitrite in Water by IC	E235.NO2	1080375	1	14	7.1	5.0	✓
Sulfate in Water by IC	E235.SO4	1080377	1	11	9.0	5.0	✓
TDS by Gravimetry	E162	1080788	1	19	5.2	5.0	✓
Total Metals in Water by CRC ICPMS	E420	1079898	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	1080450	1	18	5.5	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	1083324	1	20	5.0	5.0	✓
Bromide in Water by IC	E235.Br	1080372	1	10	10.0	5.0	✓
Chloride in Water by IC	E235.Cl	1080376	1	14	7.1	5.0	✓
Dissolved Organic Carbon by Combustion (Low Level)	E358-L	1086536	1	11	9.0	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level 0.001 mg/L)	E378-U	1080975	1	20	5.0	5.0	✓
Fluoride in Water by IC	E235.F	1080373	1	15	6.6	5.0	✓
Nitrate in Water by IC	E235.NO3	1080374	1	15	6.6	5.0	✓
Nitrite in Water by IC	E235.NO2	1080375	1	14	7.1	5.0	✓
Sulfate in Water by IC	E235.SO4	1080377	1	11	9.0	5.0	✓
Total Metals in Water by CRC ICPMS	E420	1079898	1	20	5.0	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Conductivity in Water	E100 ALS Environmental - Waterloo	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 ALS Environmental - Waterloo	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 ALS Environmental - Waterloo	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TDS by Gravimetry	E162 ALS Environmental - Waterloo	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC	E235.Br ALS Environmental - Waterloo	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl ALS Environmental - Waterloo	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F ALS Environmental - Waterloo	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrite in Water by IC	E235.NO2 ALS Environmental - Waterloo	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC	E235.NO3 ALS Environmental - Waterloo	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Sulfate in Water by IC	E235.SO4 ALS Environmental - Waterloo	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Alkalinity Species by Titration	E290 ALS Environmental - Waterloo	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 ALS Environmental - Waterloo	Water	Method Fialab 100, 2018	Ammonia in water is determined by automated continuous flow analysis with membrane diffusion and fluorescence detection, after reaction with OPA (ortho-phthalaldehyde). This method is approved under US EPA 40 CFR Part 136 (May 2021)
Colour (Apparent) by Spectrometer	E330 ALS Environmental - Waterloo	Water	APHA 2120 C (mod)	Colour (Apparent) is measured in an unfiltered sample spectrophotometrically using the single wavelength method. The colour contribution of settleable solids are not included in the result. This method is intended for potable waters. Colour measurements can be highly pH dependent, and apply to the pH of the sample as received (at time of testing), without pH adjustment.
Dissolved Organic Carbon by Combustion (Low Level)	E358-L ALS Environmental - Waterloo	Water	APHA 5310 B (mod)	Dissolved Organic Carbon (Non-Purgeable), also known as NPOC (dissolved), is a direct measurement of DOC after a filtered (0.45 micron) sample has been acidified and purged to remove inorganic carbon (IC). Analysis is by high temperature combustion with infrared detection of CO_2. NPOC does not include volatile organic species that are purged off with IC. For samples where the majority of DC (dissolved carbon) is comprised of IC (which is common), this method is more accurate and more reliable than the DOC by subtraction method (i.e. DC minus DIC).
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level 0.001 mg/L)	E378-U ALS Environmental - Waterloo	Water	APHA 4500-P F (mod)	Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total Metals in Water by CRC ICPMS	E420 ALS Environmental - Waterloo	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Hardness (Calculated) from Total Ca/Mg	EC100A ALS Environmental - Waterloo	Water	APHA 2340B	"Hardness (as $CaCO_3$), from total Ca/Mg" is calculated from the sum of total Calcium and Magnesium concentrations, expressed in $CaCO_3$ equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.
Ion Balance using Total Metals	EC101A ALS Environmental - Waterloo	Water	APHA 1030E	Cation Sum (using total metals), Anion Sum, and Ion Balance are calculated based on guidance from APHA Standard Methods (1030E Checking Correctness of Analysis). Minor ions are included where data is present. Ion Balance cannot be calculated accurately for waters with very low electrical conductivity (EC).

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Sodium Adsorption Ratio [SAR] from Total Metals	EC102 ALS Environmental - Waterloo	Water	CCME Sodium Adsorption Ratio (SAR)	The Sodium Adsorption Ratio (SAR) for a water sample is calculated from the Sodium, Calcium, and Magnesium concentrations of the water, using the same calculations as would be used for a sediment paste extract.
TDS calculated from conductivity	EC103A ALS Environmental - Waterloo	Water	APHA 1030 E	Total dissolved solids (as mg/L) can be estimated by multiplying electrical conductance (in umhos/cm) by 0.65.
Saturation Index using Laboratory pH (Ca-T)	EC105A ALS Environmental - Waterloo	Water	APHA 2330B	Langelier Index provides an indication of scale formation potential at a given pH and temperature, and is calculated as per APHA 2330B Saturation Index. Positive values indicate oversaturation with respect to CaCO3. Negative values indicate undersaturation of CaCO3. This calculation uses laboratory pH measurements and provides estimates of Langelier Index at temperatures of 4, 15, 20, 25, 66, and 77°C. Ryznar Stability Index is an alternative index used for scale formation and corrosion potential.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N ALS Environmental - Waterloo	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Silicon as Silica (Calculation)	EC420.SiO2 ALS Environmental - Waterloo	Water	N/A	Total Silicon (as SiO2) is a calculated parameter. Total Silicon (as SiO2 mg/L) = 2.139 x Total Silicon (mg/L).

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 ALS Environmental - Waterloo	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.
Preparation for Dissolved Organic Carbon for Combustion	EP358 ALS Environmental - Waterloo	Water	APHA 5310 B (mod)	Preparation for Dissolved Organic Carbon

ALS Canada Ltd.

QUALITY CONTROL REPORT

Work Order	: **WT2324845**	Page	: 1 of 13
Client	: Palmer Environmental Consulting Group Inc.	Laboratory	: ALS Environmental - Waterloo
Contact	: Tanvi Patel	Account Manager	: Andrew Martin
Address	: 74 Berkeley Street Toronto ON Canada M5V 1E3	Address	: 60 Northland Road, Unit 1 Waterloo, Ontario Canada N2V 2B8
Telephone	:	Telephone	: +1 519 886 6910
Project	: 2200902	Date Samples Received	: 10-Aug-2023 17:31
PO	: 2200902	Date Analysis Commenced	: 10-Aug-2023
C-O-C number	: 20-1046873	Issue Date	: 01-Sep-2023 16:28
Sampler	: TP ----		
Site	: ----		
Quote number	: (Q88296) PALMER 2023 STANDING OFFER		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percent Difference (RPD) and Data Quality Objectives
- Matrix Spike (MS) Report; Recovery and Data Quality Objectives
- Method Blank (MB) Report; Recovery and Data Quality Objectives
- Laboratory Control Sample (LCS) Report; Recovery and Data Quality Objectives

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Walt Kippenhuck	Supervisor - Inorganic	Waterloo Inorganics, Waterloo, Ontario
Walt Kippenhuck	Supervisor - Inorganic	Waterloo Metals, Waterloo, Ontario

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Service number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percent Difference
# = Indicates a QC result that did not meet the ALS DQO.

Workorder Comments

Holding times are displayed as "---" if no guidance exists from CCME, Canadian provinces, or broadly recognized international references.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test-specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	LOR	Unit	Original Result	Duplicate Result	RPD(%) or Difference	Duplicate Limits	Qualifier
Physical Tests (QC Lot: 1080369)											
WT2324479-001	Anonymous	Alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	297	286	3.77%	20%	----
Physical Tests (QC Lot: 1080370)											
WT2324479-001	Anonymous	Conductivity	----	E100	1.0	µS/cm	576	580	0.692%	10%	----
Physical Tests (QC Lot: 1080371)											
WT2324479-001	Anonymous	pH	----	E108	0.10	pH units	7.83	7.86	0.382%	4%	----
Physical Tests (QC Lot: 1080450)											
WT2324479-001	Anonymous	Turbidity	----	E121	0.10	NTU	0.52	0.51	0.005	Diff <2x LOR	----
Physical Tests (QC Lot: 1080788)											
WT2324479-001	Anonymous	Solids, total dissolved [TDS]	----	E162	20	mg/L	298	295	1.18%	20%	----
Physical Tests (QC Lot: 1080959)											
HA2300497-001	Anonymous	Colour, apparent	----	E330	4.0	CU	243	244	0.316%	20%	----
Anions and Nutrients (QC Lot: 1080372)											
WT2324479-001	Anonymous	Bromide	24959-67-9	E235.Br	0.10	mg/L	<0.10	<0.10	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 1080373)											
WT2324479-001	Anonymous	Fluoride	16984-48-8	E235.F	0.020	mg/L	0.057	0.054	0.003	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 1080374)											
WT2324479-001	Anonymous	Nitrate (as N)	14797-55-8	E235.NO3	0.020	mg/L	0.074	0.073	0.001	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 1080375)											
WT2324479-001	Anonymous	Nitrite (as N)	14797-65-0	E235.NO2	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 1080376)											
WT2324479-001	Anonymous	Chloride	16887-00-6	E235.Cl	0.50	mg/L	13.9	13.8	0.352%	20%	----
Anions and Nutrients (QC Lot: 1080377)											
WT2324479-001	Anonymous	Sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	4.62	4.61	0.381%	20%	----
Anions and Nutrients (QC Lot: 1080975)											
HA2300497-002	Anonymous	Phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 1083324)											
BF2300216-003	Anonymous	Ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0173	0.0164	0.0009	Diff <2x LOR	----
Organic / Inorganic Carbon (QC Lot: 1086536)											
WT2324845-001	BH23-2	Carbon, dissolved organic [DOC]	----	E358-L	0.50	mg/L	1.48	1.63	0.14	Diff <2x LOR	----
Total Metals (QC Lot: 1079898)											

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Total Metals (QC Lot: 1079898) - continued											
WT2324742-001	Anonymous	Aluminum, total	7429-90-5	E420	0.0300	mg/L	0.708	0.717	1.23%	20%	----
		Antimony, total	7440-36-0	E420	0.00100	mg/L	0.00153	0.00161	0.00008	Diff <2x LOR	----
		Arsenic, total	7440-38-2	E420	0.00100	mg/L	0.00454	0.00473	0.00019	Diff <2x LOR	----
		Barium, total	7440-39-3	E420	0.00100	mg/L	0.0121	0.0125	3.63%	20%	----
		Beryllium, total	7440-41-7	E420	0.000200	mg/L	<0.000200	<0.000200	0	Diff <2x LOR	----
		Bismuth, total	7440-69-9	E420	0.000500	mg/L	<0.000500	<0.000500	0	Diff <2x LOR	----
		Boron, total	7440-42-8	E420	0.100	mg/L	0.138	0.137	0.001	Diff <2x LOR	----
		Cadmium, total	7440-43-9	E420	0.0000500	mg/L	<0.0000500	<0.0000500	0	Diff <2x LOR	----
		Calcium, total	7440-70-2	E420	0.500	mg/L	12.5	12.5	0.332%	20%	----
		Cesium, total	7440-46-2	E420	0.000100	mg/L	0.00231	0.00236	2.18%	20%	----
		Chromium, total	7440-47-3	E420	0.00500	mg/L	0.0930	0.0953	2.40%	20%	----
		Cobalt, total	7440-48-4	E420	0.00100	mg/L	<0.00100	<0.00100	0	Diff <2x LOR	----
		Copper, total	7440-50-8	E420	0.00500	mg/L	0.0178	0.0187	0.00087	Diff <2x LOR	----
		Iron, total	7439-89-6	E420	0.100	mg/L	0.419	0.435	0.015	Diff <2x LOR	----
		Lead, total	7439-92-1	E420	0.000500	mg/L	0.000857	0.000878	0.000021	Diff <2x LOR	----
		Lithium, total	7439-93-2	E420	0.0100	mg/L	0.125	0.124	0.659%	20%	----
		Magnesium, total	7439-95-4	E420	0.0500	mg/L	2.58	2.67	3.47%	20%	----
		Manganese, total	7439-96-5	E420	0.00100	mg/L	0.0105	0.0116	9.89%	20%	----
		Molybdenum, total	7439-98-7	E420	0.000500	mg/L	0.0157	0.0159	0.918%	20%	----
		Nickel, total	7440-02-0	E420	0.00500	mg/L	0.0109	0.0111	0.00028	Diff <2x LOR	----
		Phosphorus, total	7723-14-0	E420	0.500	mg/L	<0.500	<0.500	0	Diff <2x LOR	----
		Potassium, total	7440-09-7	E420	0.500	mg/L	203	209	2.88%	20%	----
		Rubidium, total	7440-17-7	E420	0.00200	mg/L	0.477	0.488	2.39%	20%	----
		Selenium, total	7782-49-2	E420	0.000500	mg/L	0.000725	0.000636	0.000088	Diff <2x LOR	----
		Silicon, total	7440-21-3	E420	1.00	mg/L	19.2	19.2	0.179%	20%	----
		Silver, total	7440-22-4	E420	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		Sodium, total	7440-23-5	E420	0.500	mg/L	84.5	86.5	2.32%	20%	----
		Strontium, total	7440-24-6	E420	0.00200	mg/L	0.0874	0.0894	2.38%	20%	----
		Sulfur, total	7704-34-9	E420	5.00	mg/L	46.4	46.9	0.54	Diff <2x LOR	----
		Tellurium, total	13494-80-9	E420	0.00200	mg/L	<0.00200	<0.00200	0	Diff <2x LOR	----
		Thallium, total	7440-28-0	E420	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		Thorium, total	7440-29-1	E420	0.00100	mg/L	<0.00100	<0.00100	0	Diff <2x LOR	----
		Tin, total	7440-31-5	E420	0.00100	mg/L	0.00230	0.00240	0.00010	Diff <2x LOR	----
		Titanium, total	7440-32-6	E420	0.00300	mg/L	0.0172	0.0183	0.00105	Diff <2x LOR	----

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Total Metals (QC Lot: 1079898) - continued											
WT2324742-001	Anonymous	Tungsten, total	7440-33-7	E420	0.00100	mg/L	0.00206	0.00208	0.00002	Diff <2x LOR	----
		Uranium, total	7440-61-1	E420	0.000100	mg/L	0.000342	0.000360	0.000017	Diff <2x LOR	----
		Vanadium, total	7440-62-2	E420	0.00500	mg/L	0.0716	0.0734	2.58%	20%	----
		Zinc, total	7440-66-6	E420	0.0300	mg/L	0.0399	0.0409	0.0010	Diff <2x LOR	----
		Zirconium, total	7440-67-7	E420	0.00200	mg/L	<0.00200	<0.00200	0	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 1080369)						
Alkalinity, total (as CaCO3)	----	E290	1	mg/L	1.2	----
Physical Tests (QCLot: 1080370)						
Conductivity	----	E100	1	µS/cm	1.2	----
Physical Tests (QCLot: 1080450)						
Turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 1080788)						
Solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Physical Tests (QCLot: 1080959)						
Colour, apparent	----	E330	2	CU	<2.0	----
Anions and Nutrients (QCLot: 1080372)						
Bromide	24959-67-9	E235.Br	0.1	mg/L	<0.10	----
Anions and Nutrients (QCLot: 1080373)						
Fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 1080374)						
Nitrate (as N)	14797-55-8	E235.NO3	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 1080375)						
Nitrite (as N)	14797-65-0	E235.NO2	0.01	mg/L	<0.010	----
Anions and Nutrients (QCLot: 1080376)						
Chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 1080377)						
Sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 1080975)						
Phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 1083324)						
Ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Organic / Inorganic Carbon (QCLot: 1086536)						
Carbon, dissolved organic [DOC]	----	E358-L	0.5	mg/L	<0.50	----
Total Metals (QCLot: 1079898)						
Aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
Antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
Arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
Barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 1079898) - continued						
Beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
Bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
Boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
Cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
Calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
Cesium, total	7440-46-2	E420	0.00001	mg/L	<0.000010	----
Chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
Cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
Copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
Iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
Lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
Lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
Magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
Manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
Molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
Nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
Phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
Potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
Rubidium, total	7440-17-7	E420	0.0002	mg/L	<0.00020	----
Selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
Silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
Silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
Sodium, total	7440-23-5	E420	0.05	mg/L	<0.050	----
Strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
Sulfur, total	7704-34-9	E420	0.5	mg/L	<0.50	----
Tellurium, total	13494-80-9	E420	0.0002	mg/L	<0.00020	----
Thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
Thorium, total	7440-29-1	E420	0.0001	mg/L	<0.00010	----
Tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
Titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
Tungsten, total	7440-33-7	E420	0.0001	mg/L	<0.00010	----
Uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
Vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
Zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Zirconium, total	7440-67-7	E420	0.0002	mg/L	<0.00020	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 1080369)									
Alkalinity, total (as CaCO3)	----	E290	1	mg/L	150 mg/L	104	85.0	115	----
Physical Tests (QCLot: 1080370)									
Conductivity	----	E100	1	µS/cm	1409 µS/cm	101	90.0	110	----
Physical Tests (QCLot: 1080371)									
pH	----	E108	----	pH units	7 pH units	100	98.0	102	----
Physical Tests (QCLot: 1080450)									
Turbidity	----	E121	0.1	NTU	200 NTU	97.0	85.0	115	----
Physical Tests (QCLot: 1080788)									
Solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	86.9	85.0	115	----
Physical Tests (QCLot: 1080959)									
Colour, apparent	----	E330	2	CU	25 CU	99.6	70.0	130	----
Anions and Nutrients (QCLot: 1080372)									
Bromide	24959-67-9	E235.Br	0.1	mg/L	0.5 mg/L	99.8	85.0	115	----
Anions and Nutrients (QCLot: 1080373)									
Fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	99.0	90.0	110	----
Anions and Nutrients (QCLot: 1080374)									
Nitrate (as N)	14797-55-8	E235.NO3	0.02	mg/L	2.5 mg/L	98.7	90.0	110	----
Anions and Nutrients (QCLot: 1080375)									
Nitrite (as N)	14797-65-0	E235.NO2	0.01	mg/L	0.5 mg/L	97.8	90.0	110	----
Anions and Nutrients (QCLot: 1080376)									
Chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	98.9	90.0	110	----
Anions and Nutrients (QCLot: 1080377)									
Sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	100	90.0	110	----
Anions and Nutrients (QCLot: 1080975)									
Phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.0212 mg/L	105	80.0	120	----
Anions and Nutrients (QCLot: 1083324)									
Ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	100	85.0	115	----
Organic / Inorganic Carbon (QCLot: 1086536)									
Carbon, dissolved organic [DOC]	----	E358-L	0.5	mg/L	8.57 mg/L	105	80.0	120	----

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Total Metals (QCLot: 1079898)									
Aluminum, total	7429-90-5	E420	0.003	mg/L	0.1 mg/L	102	80.0	120	----
Antimony, total	7440-36-0	E420	0.0001	mg/L	0.05 mg/L	103	80.0	120	----
Arsenic, total	7440-38-2	E420	0.0001	mg/L	0.05 mg/L	106	80.0	120	----
Barium, total	7440-39-3	E420	0.0001	mg/L	0.0125 mg/L	105	80.0	120	----
Beryllium, total	7440-41-7	E420	0.00002	mg/L	0.005 mg/L	106	80.0	120	----
Bismuth, total	7440-69-9	E420	0.00005	mg/L	0.05 mg/L	99.9	80.0	120	----
Boron, total	7440-42-8	E420	0.01	mg/L	0.05 mg/L	102	80.0	120	----
Cadmium, total	7440-43-9	E420	0.000005	mg/L	0.005 mg/L	101	80.0	120	----
Calcium, total	7440-70-2	E420	0.05	mg/L	2.5 mg/L	102	80.0	120	----
Cesium, total	7440-46-2	E420	0.00001	mg/L	0.0025 mg/L	102	80.0	120	----
Chromium, total	7440-47-3	E420	0.0005	mg/L	0.0125 mg/L	104	80.0	120	----
Cobalt, total	7440-48-4	E420	0.0001	mg/L	0.0125 mg/L	103	80.0	120	----
Copper, total	7440-50-8	E420	0.0005	mg/L	0.0125 mg/L	102	80.0	120	----
Iron, total	7439-89-6	E420	0.01	mg/L	0.05 mg/L	104	80.0	120	----
Lead, total	7439-92-1	E420	0.00005	mg/L	0.025 mg/L	103	80.0	120	----
Lithium, total	7439-93-2	E420	0.001	mg/L	0.0125 mg/L	107	80.0	120	----
Magnesium, total	7439-95-4	E420	0.005	mg/L	2.5 mg/L	109	80.0	120	----
Manganese, total	7439-96-5	E420	0.0001	mg/L	0.0125 mg/L	104	80.0	120	----
Molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.0125 mg/L	101	80.0	120	----
Nickel, total	7440-02-0	E420	0.0005	mg/L	0.025 mg/L	102	80.0	120	----
Phosphorus, total	7723-14-0	E420	0.05	mg/L	0.5 mg/L	113	80.0	120	----
Potassium, total	7440-09-7	E420	0.05	mg/L	2.5 mg/L	106	80.0	120	----
Rubidium, total	7440-17-7	E420	0.0002	mg/L	0.005 mg/L	105	80.0	120	----
Selenium, total	7782-49-2	E420	0.00005	mg/L	0.05 mg/L	98.1	80.0	120	----
Silicon, total	7440-21-3	E420	0.1	mg/L	0.5 mg/L	111	80.0	120	----
Silver, total	7440-22-4	E420	0.00001	mg/L	0.005 mg/L	102	80.0	120	----
Sodium, total	7440-23-5	E420	0.05	mg/L	2.5 mg/L	106	80.0	120	----
Strontium, total	7440-24-6	E420	0.0002	mg/L	0.0125 mg/L	101	80.0	120	----
Sulfur, total	7704-34-9	E420	0.5	mg/L	2.5 mg/L	111	80.0	120	----
Tellurium, total	13494-80-9	E420	0.0002	mg/L	0.005 mg/L	98.0	80.0	120	----
Thallium, total	7440-28-0	E420	0.00001	mg/L	0.05 mg/L	103	80.0	120	----
Thorium, total	7440-29-1	E420	0.0001	mg/L	0.005 mg/L	94.3	80.0	120	----
Tin, total	7440-31-5	E420	0.0001	mg/L	0.025 mg/L	101	80.0	120	----
Titanium, total	7440-32-6	E420	0.0003	mg/L	0.0125 mg/L	102	80.0	120	----
Tungsten, total	7440-33-7	E420	0.0001	mg/L	0.005 mg/L	103	80.0	120	----
Uranium, total	7440-61-1	E420	0.00001	mg/L	0.00025 mg/L	102	80.0	120	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
					Concentration	LCS	Low	High	Qualifier
Total Metals (QCLot: 1079898) - continued									
Vanadium, total	7440-62-2	E420	0.0005	mg/L	0.025 mg/L	105	80.0	120	----
Zinc, total	7440-66-6	E420	0.003	mg/L	0.025 mg/L	103	80.0	120	----
Zirconium, total	7440-67-7	E420	0.0002	mg/L	0.005 mg/L	104	80.0	120	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 1080372)										
WT2324479-001	Anonymous	Bromide	24959-67-9	E235.Br	0.48 mg/L	0.5 mg/L	96.5	75.0	125	----
Anions and Nutrients (QCLot: 1080373)										
WT2324479-001	Anonymous	Fluoride	16984-48-8	E235.F	0.952 mg/L	1 mg/L	95.2	75.0	125	----
Anions and Nutrients (QCLot: 1080374)										
WT2324479-001	Anonymous	Nitrate (as N)	14797-55-8	E235.NO3	2.34 mg/L	2.5 mg/L	93.7	75.0	125	----
Anions and Nutrients (QCLot: 1080375)										
WT2324479-001	Anonymous	Nitrite (as N)	14797-65-0	E235.NO2	0.486 mg/L	0.5 mg/L	97.2	75.0	125	----
Anions and Nutrients (QCLot: 1080376)										
WT2324479-001	Anonymous	Chloride	16887-00-6	E235.Cl	96.9 mg/L	100 mg/L	96.9	75.0	125	----
Anions and Nutrients (QCLot: 1080377)										
WT2324479-001	Anonymous	Sulfate (as SO4)	14808-79-8	E235.SO4	94.9 mg/L	100 mg/L	94.9	75.0	125	----
Anions and Nutrients (QCLot: 1080975)										
HA2300497-002	Anonymous	Phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0156 mg/L	0.0196 mg/L	79.6	70.0	130	----
Anions and Nutrients (QCLot: 1083324)										
BF2300216-003	Anonymous	Ammonia, total (as N)	7664-41-7	E298	0.106 mg/L	0.1 mg/L	106	75.0	125	----
Organic / Inorganic Carbon (QCLot: 1086536)										
WT2324845-001	BH23-2	Carbon, dissolved organic [DOC]	----	E358-L	6.03 mg/L	5 mg/L	121	70.0	130	----
Total Metals (QCLot: 1079898)										
WT2324765-001	Anonymous	Aluminum, total	7429-90-5	E420	0.119 mg/L	0.1 mg/L	119	70.0	130	----
		Antimony, total	7440-36-0	E420	0.0530 mg/L	0.05 mg/L	106	70.0	130	----
		Arsenic, total	7440-38-2	E420	0.0521 mg/L	0.05 mg/L	104	70.0	130	----
		Barium, total	7440-39-3	E420	ND mg/L	0.0125 mg/L	ND	70.0	130	----
		Beryllium, total	7440-41-7	E420	0.00515 mg/L	0.005 mg/L	103	70.0	130	----
		Bismuth, total	7440-69-9	E420	0.0490 mg/L	0.05 mg/L	97.9	70.0	130	----
		Boron, total	7440-42-8	E420	0.051 mg/L	0.05 mg/L	102	70.0	130	----
		Cadmium, total	7440-43-9	E420	0.00463 mg/L	0.005 mg/L	92.6	70.0	130	----
		Calcium, total	7440-70-2	E420	ND mg/L	2.5 mg/L	ND	70.0	130	----
		Cesium, total	7440-46-2	E420	0.00257 mg/L	0.0025 mg/L	103	70.0	130	----
		Chromium, total	7440-47-3	E420	0.0169 mg/L	0.0125 mg/L	135	70.0	130	K

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Total Metals (QCLot: 1079898) - continued										
WT2324765-001	Anonymous	Cobalt, total	7440-48-4	E420	0.0127 mg/L	0.0125 mg/L	102	70.0	130	----
		Copper, total	7440-50-8	E420	0.0138 mg/L	0.0125 mg/L	110	70.0	130	----
		Iron, total	7439-89-6	E420	ND mg/L	0.05 mg/L	ND	70.0	130	----
		Lead, total	7439-92-1	E420	0.0249 mg/L	0.025 mg/L	99.7	70.0	130	----
		Lithium, total	7439-93-2	E420	ND mg/L	0.0125 mg/L	ND	70.0	130	----
		Magnesium, total	7439-95-4	E420	ND mg/L	2.5 mg/L	ND	70.0	130	----
		Manganese, total	7439-96-5	E420	ND mg/L	0.0125 mg/L	ND	70.0	130	----
		Molybdenum, total	7439-98-7	E420	ND mg/L	0.0125 mg/L	ND	70.0	130	----
		Nickel, total	7440-02-0	E420	ND mg/L	0.025 mg/L	ND	70.0	130	----
		Phosphorus, total	7723-14-0	E420	1.01 mg/L	0.5 mg/L	202	70.0	130	K
		Potassium, total	7440-09-7	E420	ND mg/L	2.5 mg/L	ND	70.0	130	----
		Rubidium, total	7440-17-7	E420	0.00532 mg/L	0.005 mg/L	106	70.0	130	----
		Selenium, total	7782-49-2	E420	0.0422 mg/L	0.05 mg/L	84.3	70.0	130	----
		Silicon, total	7440-21-3	E420	ND mg/L	0.5 mg/L	ND	70.0	130	----
		Silver, total	7440-22-4	E420	0.00518 mg/L	0.005 mg/L	104	70.0	130	----
		Sodium, total	7440-23-5	E420	ND mg/L	2.5 mg/L	ND	70.0	130	----
		Strontium, total	7440-24-6	E420	ND mg/L	0.0125 mg/L	ND	70.0	130	----
		Sulfur, total	7704-34-9	E420	ND mg/L	2.5 mg/L	ND	70.0	130	----
		Tellurium, total	13494-80-9	E420	0.00464 mg/L	0.005 mg/L	92.8	70.0	130	----
		Thallium, total	7440-28-0	E420	0.0500 mg/L	0.05 mg/L	100	70.0	130	----
		Thorium, total	7440-29-1	E420	0.00310 mg/L	0.005 mg/L	62.0	70.0	130	K
		Tin, total	7440-31-5	E420	0.0244 mg/L	0.025 mg/L	97.6	70.0	130	----
		Titanium, total	7440-32-6	E420	0.0106 mg/L	0.0125 mg/L	85.2	70.0	130	----
		Tungsten, total	7440-33-7	E420	0.00549 mg/L	0.005 mg/L	110	70.0	130	----
		Uranium, total	7440-61-1	E420	ND mg/L	0.00025 mg/L	ND	70.0	130	----
		Vanadium, total	7440-62-2	E420	0.0290 mg/L	0.025 mg/L	116	70.0	130	----
		Zinc, total	7440-66-6	E420	0.0289 mg/L	0.025 mg/L	116	70.0	130	----
		Zirconium, total	7440-67-7	E420	0.00476 mg/L	0.005 mg/L	95.2	70.0	130	----

Qualifiers

Qualifier	Description
K	*Matrix Spike recovery outside ALS DQO due to sample matrix effects.*

Chain of Custody (COC) / Analytical Request Form

ALS www.alsglobal.com

Canada Toll Free: 1 800 668 9878

COC Number: 2

Page

Environmental Division Waterloo

Work Order Reference WT2324845

Telephone : +1 519 886 6910

Report To	Contact and company name below will appear on the final report
Company:	PALMER
Contact:	TANVI PATEL
Phone:	647 688 2538
	Company address below will appear on the final report
Street:	871 EQUESTRIAN CT
City/Province:	OAKVILLE
Postal Code:	L6L 6L7
Invoice To	Same as Report To ☒ YES ☐ NO
	Copy of Invoice with Report ☐ YES ☒ NO
Company:	PALMER
Contact:	accounting@pecg.ca

Reports / Recipients

Select Report Format: ☒ PDF ☒ EXCEL ☐ EDD (DIGITAL)

Merge QC/QCI Reports with COA ☐ YES ☒ NO ☐ N/A

☒ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☒ EMAIL ☒ MAIL ☐ FAX

Email 1 or Fax: tanvi.patel@pecg.ca

Email 2: frank.liu@pecg.ca

Email 3:

Invoice Recipients

Select Invoice Distribution: ☒ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax: accounting@pecg.ca

Email 2:

Turnaround Time (TAT) Requested

☒ Routine [R] if received by 3pm M-F - no surcharges apply

☐ 4 day [P4] if received by 3pm M-F - 20% rush surcharge minim

☐ 3 day [P3] if received by 3pm M-F - 25% rush surcharge mini

☐ 2 day [P2] if received by 3pm M-F - 50% rush surcharge mini

☐ 1 day [E] if received by 3pm M-F - 100% rush surcharge mini

☐ Same day [E2] if received by 10am M-S - 200% rush surcharge... may apply to rush requests on weekends, statutory holidays and o

For all tests with rush TATs requested, please contact your AM to confirm availability.

Project Information

ALS Account # / Quote #: ~~WT~~ 24400

Job #: 2200902

PO / AFE: 2200902

LSD:

Oil and Gas Required Fields (client use)

AFE/Cost Center: PO#

Major/Minor Code: Routing Code:

Requisitioner:

Location:

ALS Lab Work Order # (ALS use only):

ALS Contact: Andrew Martin

Sampler: TP

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (ALS use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	NUMBER OF CONTAINERS	General chem 3	SAMPLES ON HOLD	EXTENDED STORAGE REQUIRED	SUSPECTED HAZARD (see notes)
	BH23-2	10-Aug-23	10:00	water	5	✓			

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System?

☐ YES ☒ NO

Are samples for human consumption/ use?

☐ YES ☒ NO

Notes / Specify Limits for result evaluation by selecting from drop-down below (Excel COC only)

General chemistry 3

SHIPMENT RELEASE (client use)

Released by: TP Date: 10/Aug/23 Time: 2pm

INITIAL SHIPMENT RECEPTION (ALS use only)

Received by: Date: Time:

FINAL SHIPMENT RECEPTION (ALS use only)

Received by: Date: 10-AUG-23 Time: 19:00

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user ... and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW

GC-490 MM-366 EC
N-105

ALS Canada Ltd.

CERTIFICATE OF ANALYSIS (GUIDELINE EVALUATION)

Work Order	: **WT2324847**	Page	: 1 of 9
Client	: **Palmer Environmental Consulting Group Inc.**	Laboratory	: ALS Environmental - Waterloo
Contact	: Tanvi Patel	Account Manager	: Andrew Martin
Address	: 74 Berkeley Street Toronto ON Canada M5V 1E3	Address	: 60 Northland Road, Unit 1 Waterloo, Ontario Canada N2V 2B8
Telephone	: ----	Telephone	: +1 519 886 6910
Project	: 2200902	Date Samples Received	: 10-Aug-2023 17:38
PO	: 2200902	Date Analysis Commenced	: 10-Aug-2023
C-O-C number	: 20-950513	Issue Date	: 17-Aug-2023 12:17
Sampler	: TP		
Site	: ----		
Quote number	: (Q88296) PALMER 2023 STANDING OFFER		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Guideline Comparison

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QC Interpretive report to assist with Quality Review and Sample Receipt Notification (SRN).

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Walt Kippenhuck	Supervisor - Inorganic	Inorganics, Waterloo, Ontario
Walt Kippenhuck	Supervisor - Inorganic	Metals, Waterloo, Ontario
Zeba Patel		Microbiology, Waterloo, Ontario

Summary of Guideline Breaches by Sample

SampleID/Client ID	Matrix	Analyte	Analyte Summary	Guideline	Category	Result	Limit
BH23-10	Water	Alkalinity, total (as CaCO3)		ONDWS	AO/OG	631 mg/L	30-500 mg/L
	Water	Colour, apparent	May interfere with disinfection; removal is important to ensure effective treatment.	ONDWS	AO/OG	40.2 CU	5 CU
	Water	Hardness (as CaCO3), from total Ca/Mg	Hardness levels between 80 and 100 mg/L (as CaCO3) provide acceptable balance between corrosion and incrustation; where a water softener is used, a separate unsoftened supply for cooking and drinking purposes is recommended.	ONDWS	AO/OG	669 mg/L	80-100 mg/L
	Water	Solids, total dissolved [TDS]	Based on taste; TDS above 500 mg/L results in excessive scaling in water pipes, water heaters, boilers and appliances; TDS is composed of calcium, magnesium, sodium, potassium, carbonate, bicarbonate, chloride, sulphate and nitrate.	ONDWS	AO/OG	648 mg/L	500 mg/L
	Water	Turbidity	Filtration systems should be designed and operated to reduce turbidity levels as low as reasonably achievable and strive to achieve a treated water turbidity target from individual filters of less than 0.1 NTU. Particles can harbour microorganisms, protecting them from disinfection, and can entrap heavy metals and biocides; elevated or fluctuating turbidity in filtered water can indicate a problem with the water treatment process and a potential increased risk of pathogens in treated water.	ONDWS	AO/OG	5.22 NTU	5 NTU
	Water	Aluminum, total	There is no consistent, convincing evidence that aluminum in drinking water causes adverse health effects in humans. The operational guideline applies to treatment plants using aluminum-based coagulants; it does not apply to naturally occurring aluminum found in groundwater. For treatment plants using aluminum-based coagulants, monthly samples should be taken of the water leaving the plant; the OGs are based on a running annual average of monthly samples.	ONDWS	AO/OG	0.142 mg/L	0.1 mg/L
	Water	Manganese, total	Based on taste and staining of laundry and plumbing fixtures.	ONDWS	AO/OG	0.0758 mg/L	0.05 mg/L

General Comments

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Refer to the ALS Quality Control Interpretive report (QCI) for applicable references and methodology summaries. Reference methods may incorporate modifications to improve performance.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.
Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Application of guidelines is provided "as is" without warranty of any kind, either expressed or implied, including, but not limited to fitness for a particular purpose, or non-infringement. ALS assumes no responsibility for errors or omissions in the information. Guidelines are not adjusted for the hardness, pH or temperature of the sample (the most conservative values are used). Measurement uncertainty is not applied to test results prior to comparison with specified criteria values.

Key : LOR: Limit of Reporting (detection limit).

Unit	*Description*
-	no units
%	percent
µS/cm	microsiemens per centimetre
CFU/100mL	colony forming units per hundred millilitres
CU	colour units (1 cu = 1 mg/l pt)
meq/L	milliequivalents per litre
mg/L	milligrams per litre
NTU	nephelometric turbidity units
pH units	pH units

>: greater than.
<: less than.
Red shading is applied where the result or the LOR is greater than the Guideline Upper Limit (or lower than the Guideline Lower Limit, if applicable).
For drinking water samples, Red shading is applied where the result for E.coli, fecal or total coliforms is greater than or equal to the Guideline Upper Limit.

Qualifiers

Qualifier	*Description*
DLDS	*Detection Limit Raised: Dilution required due to high Dissolved Solids / Electrical Conductivity.*
NDOGTC	*No Data-Total Coliform overgrown.*

Analytical Results Evaluation

Matrix: **Water**

Analyte	CAS Number	Method/Lab	Unit	Client sample ID	BH23-10	----	----	----	----	----	----
				Sampling date/time	10-Aug-2023 10:00	----	----	----	----	----	----
				Sub-Matrix	Water	----	----	----	----	----	----
					WT2324847-001	--------	--------	--------	--------	--------	--------
Physical Tests											
Alkalinity, bicarbonate (as HCO3)	71-52-3	E290/WT			770	----	----	----	----	----	----
Alkalinity, carbonate (as CO3)	3812-32-6	E290/WT	mg/L		<1.0	----	----	----	----	----	----
Alkalinity, hydroxide (as OH)	14280-30-9	E290/WT			<1.0	----	----	----	----	----	----
Alkalinity, total (as CaCO3)	----	E290/WT	mg/L		631	----	----	----	----	----	----
Colour, apparent	----	E330/WT			40.2	----	----	----	----	----	----
Conductivity	----	E100/WT	µS/cm		1130	----	----	----	----	----	----
Hardness (as CaCO3), from total Ca/Mg	----	EC100A/WT			669	----	----	----	----	----	----
pH	----	E108/WT	pH units		7.43	----	----	----	----	----	----
Solids, total dissolved [TDS]	----	E162/WT			648 DLDS	----	----	----	----	----	----
Solids, total dissolved [TDS], calculated	----	EC103A/WT	mg/L		734	----	----	----	----	----	----
Turbidity	----	E121/WT			5.22	----	----	----	----	----	----
Langelier index (@ 20°C)	----	EC105A/WT	-		1.01	----	----	----	----	----	----
Langelier index (@ 4°C)	----	EC105A/WT			0.761	----	----	----	----	----	----
pH, saturation (@ 20°C)	----	EC105A/WT	pH units		6.42	----	----	----	----	----	----
pH, saturation (@ 4°C)	----	EC105A/WT			6.67	----	----	----	----	----	----
Anions and Nutrients											
Ammonia, total (as N)	7664-41-7	E298/WT	mg/L		0.0056	----	----	----	----	----	----
Bromide	24959-67-9	E235.Br/WT			0.12	----	----	----	----	----	----
Chloride	16887-00-6	E235.Cl/WT	mg/L		2.82	----	----	----	----	----	----
Fluoride	16984-48-8	E235.F/WT			0.050	----	----	----	----	----	----
Nitrate (as N)	14797-55-8	E235.NO3/WT	mg/L		<0.020	----	----	----	----	----	----
Nitrate + Nitrite (as N)	----	EC235.N+N/WT			<0.0224	----	----	----	----	----	----
Nitrite (as N)	14797-65-0	E235.NO2/WT	mg/L		<0.010	----	----	----	----	----	----
Phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U/WT			0.0046	----	----	----	----	----	----
Sulfate (as SO4)	14808-79-8	E235.SO4/WT	mg/L		29.4	----	----	----	----	----	----
Microbiological Tests											
Coliforms, Escherichia coli [E. coli]	----	E012A.EC/WT			Not Detected	----	----	----	----	----	----

Analytical Results Evaluation

Matrix: **Water**

Analyte	CAS Number	Method/Lab	Unit	Client sample ID: BH23-10	----	----	----	----	----	----
				Sampling date/time: 10-Aug-2023 10:00	----	----	----	----	----	----
				Sub-Matrix: Water	----	----	----	----	----	----
				WT2324847-001	--------	--------	--------	--------	--------	--------
Microbiological Tests										
Coliforms, total	----	E012.TC/WT	CFU/100 mL	NR NDOGTC	----	----	----	----	----	----
coliforms, total background	----	E012.BG.TC/WT		NR NDOGTC	----	----	----	----	----	----
Metals										
Sodium adsorption ratio [SAR]	----	EC102/WT	-	0.22	----	----	----	----	----	----
Ion Balance										
Anion sum	----	EC101A/WT	meq/L	13.3	----	----	----	----	----	----
Cation sum (total)	----	EC101A/WT		14.1	----	----	----	----	----	----
Ion balance (APHA)	----	EC101A/WT		2.92	----	----	----	----	----	----
Ion balance (cations/anions)	----	EC101A/WT	%	106	----	----	----	----	----	----
Total Metals										
Aluminum, total	7429-90-5	E420/WT	mg/L	0.142	----	----	----	----	----	----
Antimony, total	7440-36-0	E420/WT		<0.00010	----	----	----	----	----	----
Arsenic, total	7440-38-2	E420/WT		0.00035	----	----	----	----	----	----
Barium, total	7440-39-3	E420/WT	mg/L	0.164	----	----	----	----	----	----
Beryllium, total	7440-41-7	E420/WT		<0.000020	----	----	----	----	----	----
Bismuth, total	7440-69-9	E420/WT	mg/L	<0.000050	----	----	----	----	----	----
Boron, total	7440-42-8	E420/WT		0.048	----	----	----	----	----	----
Cadmium, total	7440-43-9	E420/WT	mg/L	<0.0000050	----	----	----	----	----	----
Calcium, total	7440-70-2	E420/WT		189	----	----	----	----	----	----
Cesium, total	7440-46-2	E420/WT	mg/L	0.000019	----	----	----	----	----	----
Chromium, total	7440-47-3	E420/WT		<0.00050	----	----	----	----	----	----
Cobalt, total	7440-48-4	E420/WT	mg/L	0.00046	----	----	----	----	----	----
Copper, total	7440-50-8	E420/WT		0.00082	----	----	----	----	----	----
Iron, total	7439-89-6	E420/WT	mg/L	0.129	----	----	----	----	----	----
Lead, total	7439-92-1	E420/WT		0.000099	----	----	----	----	----	----
Lithium, total	7439-93-2	E420/WT	mg/L	0.0122	----	----	----	----	----	----
Magnesium, total	7439-95-4	E420/WT		47.8	----	----	----	----	----	----

Analytical Results Evaluation

Matrix: **Water**

Analyte	CAS Number	Method/Lab	Unit	Client sample ID	BH23-10	----	----	----	----	----	----
				Sampling date/time	10-Aug-2023 10:00	----	----	----	----	----	----
				Sub-Matrix	Water	----	----	----	----	----	----
				WT2324847-001	--------	--------	--------	--------	--------	--------	
Total Metals											
Manganese, total	7439-96-5	E420/WT	mg/L	0.0758	----	----	----	----	----	----	
Molybdenum, total	7439-98-7	E420/WT		0.00101	----	----	----	----	----	----	
Nickel, total	7440-02-0	E420/WT	mg/L	0.00214	----	----	----	----	----	----	
Phosphorus, total	7723-14-0	E420/WT		<0.050	----	----	----	----	----	----	
Potassium, total	7440-09-7	E420/WT	mg/L	4.32	----	----	----	----	----	----	
Rubidium, total	7440-17-7	E420/WT		0.00067	----	----	----	----	----	----	
Selenium, total	7782-49-2	E420/WT	mg/L	<0.000050	----	----	----	----	----	----	
Silicon (as SiO2), total	7631-86-9	EC420.SiO2/WT		30.8	----	----	----	----	----	----	
Silicon, total	7440-21-3	E420/WT	mg/L	14.4	----	----	----	----	----	----	
Silver, total	7440-22-4	E420/WT		<0.000010	----	----	----	----	----	----	
Sodium, total	7440-23-5	E420/WT	mg/L	13.1	----	----	----	----	----	----	
Strontium, total	7440-24-6	E420/WT		0.554	----	----	----	----	----	----	
Sulfur, total	7704-34-9	E420/WT	mg/L	11.9	----	----	----	----	----	----	
Tellurium, total	13494-80-9	E420/WT		<0.00020	----	----	----	----	----	----	
Thallium, total	7440-28-0	E420/WT	mg/L	<0.000010	----	----	----	----	----	----	
Thorium, total	7440-29-1	E420/WT		<0.00010	----	----	----	----	----	----	
Tin, total	7440-31-5	E420/WT	mg/L	0.00093	----	----	----	----	----	----	
Titanium, total	7440-32-6	E420/WT		0.00786	----	----	----	----	----	----	
Tungsten, total	7440-33-7	E420/WT	mg/L	0.00080	----	----	----	----	----	----	
Uranium, total	7440-61-1	E420/WT		0.00160	----	----	----	----	----	----	
Vanadium, total	7440-62-2	E420/WT	mg/L	0.00156	----	----	----	----	----	----	
Zinc, total	7440-66-6	E420/WT		0.0046	----	----	----	----	----	----	
Zirconium, total	7440-67-7	E420/WT	mg/L	0.00035	----	----	----	----	----	----	

Please refer to the General Comments section for an explanation of any result qualifiers detected.

Please refer to the Accreditation section for an explanation of analyte accreditations.

Summary of Guideline Limits

Analyte	CAS Number	Unit	ONDWS AO/OG	ONDWS MAC					
Physical Tests									
Alkalinity, bicarbonate (as HCO3)	71-52-3	mg/L	--	--					
Alkalinity, carbonate (as CO3)	3812-32-6	mg/L	--	--					
Alkalinity, hydroxide (as OH)	14280-30-9	mg/L	--	--					
Alkalinity, total (as CaCO3)	----	mg/L	**30 - 500 mg/L**	--					
Colour, apparent	----	CU	**5 CU**	--					
Conductivity	----	µS/cm	--	--					
Hardness (as CaCO3), from total Ca/Mg	----	mg/L	**80 - 100 mg/L**	--					
Langelier index (@ 20°C)	----	-	--	--					
Langelier index (@ 4°C)	----	-	--	--					
pH, saturation (@ 20°C)	----	pH units	--	--					
pH, saturation (@ 4°C)	----	pH units	--	--					
pH	----	pH units	**6.5 - 8.5 pH units**	--					
Solids, total dissolved [TDS], calculated	----	mg/L	--	--					
Solids, total dissolved [TDS]	----	mg/L	**500 mg/L**	--					
Turbidity	----	NTU	**5 NTU**	--					
Anions and Nutrients									
Ammonia, total (as N)	7664-41-7	mg/L	--	--					
Bromide	24959-67-9	mg/L	--	--					
Chloride	16887-00-6	mg/L	**250 mg/L**	--					
Fluoride	16984-48-8	mg/L	--	**1.5 mg/L**					
Nitrate (as N)	14797-55-8	mg/L	--	**10 mg/L**					
Nitrate + Nitrite (as N)	----	mg/L	--	**10 mg/L**					
Nitrite (as N)	14797-65-0	mg/L	--	**1 mg/L**					
Phosphate, ortho-, dissolved (as P)	14265-44-2	mg/L	--	--					
Sulfate (as SO4)	14808-79-8	mg/L	**500 mg/L**	--					
Microbiological Tests									
Coliforms, Escherichia coli [E. coli]	----	CFU/100mL	--	**1 CFU/100mL**					
coliforms, total background	----	CFU/100mL	--	--					
Coliforms, total	----	CFU/100mL	--	**1 CFU/100mL**					
Metals									
Sodium adsorption ratio [SAR]	----	-	--	--					
Ion Balance									
Anion sum	----	meq/L	--	--					
Cation sum (total)	----	meq/L	--	--					
Ion balance (APHA)	----	%	--	--					
Ion balance (cations/anions)	----	%	--	--					

Analyte	CAS Number	Unit	ONDWS AO/OG	ONDWS MAC					
Total Metals									
Aluminum, total	7429-90-5	mg/L	**0.1 mg/L**	--					
Antimony, total	7440-36-0	mg/L	--	**0.006 mg/L**					
Arsenic, total	7440-38-2	mg/L	--	**0.01 mg/L**					
Barium, total	7440-39-3	mg/L	--	**1 mg/L**					
Beryllium, total	7440-41-7	mg/L	--	--					
Bismuth, total	7440-69-9	mg/L	--	--					
Boron, total	7440-42-8	mg/L	--	**5 mg/L**					
Cadmium, total	7440-43-9	mg/L	--	**0.005 mg/L**					
Calcium, total	7440-70-2	mg/L	--	--					
Cesium, total	7440-46-2	mg/L	--	--					
Chromium, total	7440-47-3	mg/L	--	**0.05 mg/L**					
Cobalt, total	7440-48-4	mg/L	--	--					
Copper, total	7440-50-8	mg/L	**1 mg/L**	--					
Iron, total	7439-89-6	mg/L	**0.3 mg/L**	--					
Lead, total	7439-92-1	mg/L	--	**0.01 mg/L**					
Lithium, total	7439-93-2	mg/L	--	--					
Magnesium, total	7439-95-4	mg/L	--	--					
Manganese, total	7439-96-5	mg/L	**0.05 mg/L**	--					
Molybdenum, total	7439-98-7	mg/L	--	--					
Nickel, total	7440-02-0	mg/L	--	--					
Phosphorus, total	7723-14-0	mg/L	--	--					
Potassium, total	7440-09-7	mg/L	--	--					
Rubidium, total	7440-17-7	mg/L	--	--					
Selenium, total	7782-49-2	mg/L	--	**0.05 mg/L**					
Silicon (as SiO2), total	7631-86-9	mg/L	--	--					
Silicon, total	7440-21-3	mg/L	--	--					
Silver, total	7440-22-4	mg/L	--	--					
Sodium, total	7440-23-5	mg/L	**200 mg/L**	**20 mg/L**					
Strontium, total	7440-24-6	mg/L	--	--					
Sulfur, total	7704-34-9	mg/L	--	--					
Tellurium, total	13494-80-9	mg/L	--	--					
Thallium, total	7440-28-0	mg/L	--	--					
Thorium, total	7440-29-1	mg/L	--	--					
Tin, total	7440-31-5	mg/L	--	--					
Titanium, total	7440-32-6	mg/L	--	--					
Tungsten, total	7440-33-7	mg/L	--	--					
Uranium, total	7440-61-1	mg/L	--	**0.02 mg/L**					
Vanadium, total	7440-62-2	mg/L	--	--					
Zinc, total	7440-66-6	mg/L	**5 mg/L**	--					

Analyte	CAS Number	Unit	ONDWS AO/OG	ONDWS MAC					
Total Metals - Continued									
Zirconium, total	7440-67-7	mg/L	--	--					

Please refer to the General Comments section for an explanation of any qualifiers detected.

Key:

ONDWS	Ontario Drinking Water Regulation (JAN, 2020)
AO/OG	Aesthetic Objective/Operational Guideline
MAC	Schedule 1 (Microbiological) and 2 (Chemical) Standards (JAN,2020)

ALS Canada Ltd.

QUALITY CONTROL INTERPRETIVE REPORT

Work Order	: **WT2324847**	Page	: 1 of 11
Client	: **Palmer Environmental Consulting Group Inc.**	Laboratory	: ALS Environmental - Waterloo
Contact	: Tanvi Patel	Account Manager	: Andrew Martin
Address	: 74 Berkeley Street Toronto ON Canada M5V 1E3	Address	: 60 Northland Road, Unit 1 Waterloo, Ontario Canada N2V 2B8
Telephone	: ----	Telephone	: +1 519 886 6910
Project	: 2200902	Date Samples Received	: 10-Aug-2023 17:38
PO	: 2200902	Issue Date	: 17-Aug-2023 12:17
C-O-C number	: 20-950513		
Sampler	: TP		
Site	: ----		
Quote number	: (Q88296) PALMER 2023 STANDING OFFER		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report is automatically generated by the ALS LIMS (Laboratory Information Management System) through evaluation of Quality Control (QC) results and other QA parameters associated with this submission, and is intended to facilitate rapid data validation by auditors or reviewers. The report highlights any exceptions and outliers to ALS Data Quality Objectives, provides holding time details and exceptions, summarizes QC sample frequencies, and lists applicable methodology references and summaries.

Key

Anonymous: Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number: Chemical Abstracts Service number is a unique identifier assigned to discrete substances.
DQO: Data Quality Objective.
LOR: Limit of Reporting (detection limit).
RPD: Relative Percent Difference.

Workorder Comments

Holding times are displayed as "---" if no guidance exists from CCME, Canadian provinces, or broadly recognized international references.

Summary of Outliers

Outliers : Quality Control Samples

- No Method Blank value outliers occur.
- No Duplicate outliers occur.
- No Laboratory Control Sample (LCS) outliers occur
- Matrix Spike outliers occur - please see following pages for full details.
- No Test sample Surrogate recovery outliers exist.

Outliers: Reference Material (RM) Samples

- No Reference Material (RM) Sample outliers occur.

Outliers : Analysis Holding Time Compliance (Breaches)

- No Analysis Holding Time Outliers exist.

Outliers : Frequency of Quality Control Samples

- No Quality Control Sample Frequency Outliers occur.

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **Water**

Analyte Group	Laboratory sample ID	Client/Ref Sample ID	Analyte	CAS Number	Method	Result	Limits	Comment
Matrix Spike (MS) Recoveries								
Total Metals	Anonymous	Anonymous	Chromium, total	7440-47-3	E420	135 % K	70.0-130%	Recovery greater than upper data quality objective
Total Metals	Anonymous	Anonymous	Phosphorus, total	7723-14-0	E420	202 % K	70.0-130%	Recovery greater than upper data quality objective
Total Metals	Anonymous	Anonymous	Thorium, total	7440-29-1	E420	62.0 % K	70.0-130%	Recovery less than lower data quality objective

Result Qualifiers

Qualifier	Description
K	*Matrix Spike recovery outside ALS DQO due to sample matrix effects.*

Analysis Holding Time Compliance

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times, which are selected to meet known provincial and /or federal requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by organizations such as CCME, US EPA, APHA Standard Methods, ASTM, or Environment Canada (where available). Dates and holding times reported below represent the first dates of extraction or analysis. If subsequent tests or dilutions exceeded holding times, qualifiers are added (refer to COA).

If samples are identified below as having been analyzed or extracted outside of recommended holding times, measurement uncertainties may be increased, and this should be taken into consideration when interpreting results.

Where actual sampling date is not provided on the chain of custody, the date of receipt with time at 00:00 is used for calculation purposes.

Where only the sample date without time is provided on the chain of custody, the sampling date at 00:00 is used for calculation purposes.

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Ammonia by Fluorescence										
Amber glass total (sulfuric acid) [ON MECP]										
BH23-10	E298	10-Aug-2023	14-Aug-2023	28 days	4 days	✓	15-Aug-2023	28 days	5 days	✓
Anions and Nutrients : Bromide in Water by IC										
HDPE [ON MECP]										
BH23-10	E235.Br	10-Aug-2023	11-Aug-2023	28 days	1 days	✓	11-Aug-2023	28 days	1 days	✓
Anions and Nutrients : Chloride in Water by IC										
HDPE [ON MECP]										
BH23-10	E235.Cl	10-Aug-2023	11-Aug-2023	28 days	1 days	✓	11-Aug-2023	28 days	1 days	✓
Anions and Nutrients : Dissolved Orthophosphate by Colourimetry (Ultra Trace Level 0.001										
HDPE [ON MECP]										
BH23-10	E378-U	10-Aug-2023	11-Aug-2023	7 days	1 days	✓	14-Aug-2023	7 days	4 days	✓
Anions and Nutrients : Fluoride in Water by IC										
HDPE [ON MECP]										
BH23-10	E235.F	10-Aug-2023	11-Aug-2023	28 days	1 days	✓	11-Aug-2023	28 days	1 days	✓
Anions and Nutrients : Nitrate in Water by IC										
HDPE [ON MECP]										
BH23-10	E235.NO3	10-Aug-2023	11-Aug-2023	7 days	1 days	✓	11-Aug-2023	7 days	1 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Anions and Nutrients : Nitrite in Water by IC										
HDPE [ON MECP]										
BH23-10	E235.NO2	10-Aug-2023	11-Aug-2023	7 days	1 days	✓	11-Aug-2023	7 days	1 days	✓
Anions and Nutrients : Sulfate in Water by IC										
HDPE [ON MECP]										
BH23-10	E235.SO4	10-Aug-2023	11-Aug-2023	28 days	1 days	✓	11-Aug-2023	28 days	1 days	✓
Microbiological Tests : E. coli (MF-mFC-BCIG)										
Sterile HDPE (Sodium thiosulphate) [ON MECP]										
BH23-10	E012A.EC	10-Aug-2023	----	----	----		11-Aug-2023	48 hrs	23 hrs	✓
Microbiological Tests : Total Coliforms (MF-mEndo)										
Sterile HDPE (Sodium thiosulphate) [ON MECP]										
BH23-10	E012.TC	10-Aug-2023	----	----	----		11-Aug-2023	48 hrs	23 hrs	✓
Microbiological Tests : Total Coliforms Background (MF-mEndo)										
Sterile HDPE (Sodium thiosulphate) [ON MECP]										
BH23-10	E012.BG.TC	10-Aug-2023	----	----	----		11-Aug-2023	48 hrs	23 hrs	✓
Physical Tests : Alkalinity Species by Titration										
HDPE [ON MECP]										
BH23-10	E290	10-Aug-2023	11-Aug-2023	14 days	1 days	✓	11-Aug-2023	14 days	1 days	✓
Physical Tests : Colour (Apparent) by Spectrometer										
HDPE [ON MECP]										
BH23-10	E330	10-Aug-2023	----	----	----		11-Aug-2023	48 hrs	27 hrs	✓
Physical Tests : Conductivity in Water										
HDPE [ON MECP]										
BH23-10	E100	10-Aug-2023	11-Aug-2023	28 days	1 days	✓	11-Aug-2023	28 days	1 days	✓
Physical Tests : pH by Meter										
HDPE [ON MECP]										
BH23-10	E108	10-Aug-2023	11-Aug-2023	14 days	1 days	✓	11-Aug-2023	14 days	1 days	✓

Matrix: **Water**

Evaluation: × = Holding time exceedance ; ✓ = Within Holding Time

Analyte Group / Container / Client Sample ID(s)	Method	Sampling Date	Extraction / Preparation				Analysis			
			Preparation Date	Holding Times Rec	Holding Times Actual	Eval	Analysis Date	Holding Times Rec	Holding Times Actual	Eval
Physical Tests : TDS by Gravimetry										
HDPE [ON MECP]										
BH23-10	E162	10-Aug-2023	----	----	----		14-Aug-2023	7 days	4 days	✓
Physical Tests : Turbidity by Nephelometry										
HDPE [ON MECP]										
BH23-10	E121	10-Aug-2023	----	----	----		11-Aug-2023	48 hrs	24 hrs	✓
Total Metals : Total metals in Water by CRC ICPMS										
HDPE total (nitric acid)										
BH23-10	E420	10-Aug-2023	10-Aug-2023	180 days	1 days	✓	11-Aug-2023	180 days	1 days	✓

Legend & Qualifier Definitions

Rec. HT: ALS recommended hold time (see units).

Quality Control Parameter Frequency Compliance

The following report summarizes the frequency of laboratory QC samples analyzed within the analytical batches (QC lots) in which the submitted samples were processed. The actual frequency should be greater than or equal to the expected frequency.

Matrix: **Water**

Evaluation: × = *QC frequency outside specification*; ✓ = *QC frequency within specification.*

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Laboratory Duplicates (DUP)							
Alkalinity Species by Titration	E290	1080369	1	11	9.0	5.0	✓
Ammonia by Fluorescence	E298	1083324	1	20	5.0	5.0	✓
Bromide in Water by IC	E235.Br	1080372	1	10	10.0	5.0	✓
Chloride in Water by IC	E235.Cl	1080376	1	14	7.1	5.0	✓
Colour (Apparent) by Spectrometer	E330	1080959	1	14	7.1	5.0	✓
Conductivity in Water	E100	1080370	1	14	7.1	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level 0.001 mg/L)	E378-U	1080975	1	20	5.0	5.0	✓
E. coli (MF-mFC-BCIG)	E012A.EC	1080610	1	20	5.0	5.0	✓
Fluoride in Water by IC	E235.F	1080373	1	15	6.6	5.0	✓
Nitrate in Water by IC	E235.NO3	1080374	1	15	6.6	5.0	✓
Nitrite in Water by IC	E235.NO2	1080375	1	14	7.1	5.0	✓
pH by Meter	E108	1080371	1	19	5.2	5.0	✓
Sulfate in Water by IC	E235.SO4	1080377	1	11	9.0	5.0	✓
TDS by Gravimetry	E162	1083888	1	14	7.1	5.0	✓
Total Coliforms (MF-mEndo)	E012.TC	1080599	1	20	5.0	5.0	✓
Total Coliforms Background (MF-mEndo)	E012.BG.TC	1080600	1	20	5.0	5.0	✓
Total metals in Water by CRC ICPMS	E420	1079898	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	1080450	1	18	5.5	5.0	✓
Laboratory Control Samples (LCS)							
Alkalinity Species by Titration	E290	1080369	1	11	9.0	5.0	✓
Ammonia by Fluorescence	E298	1083324	1	20	5.0	5.0	✓
Bromide in Water by IC	E235.Br	1080372	1	10	10.0	5.0	✓
Chloride in Water by IC	E235.Cl	1080376	1	14	7.1	5.0	✓
Colour (Apparent) by Spectrometer	E330	1080959	1	14	7.1	5.0	✓
Conductivity in Water	E100	1080370	1	14	7.1	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level 0.001 mg/L)	E378-U	1080975	1	20	5.0	5.0	✓
Fluoride in Water by IC	E235.F	1080373	1	15	6.6	5.0	✓
Nitrate in Water by IC	E235.NO3	1080374	1	15	6.6	5.0	✓
Nitrite in Water by IC	E235.NO2	1080375	1	14	7.1	5.0	✓
pH by Meter	E108	1080371	1	19	5.2	5.0	✓
Sulfate in Water by IC	E235.SO4	1080377	1	11	9.0	5.0	✓
TDS by Gravimetry	E162	1083888	1	14	7.1	5.0	✓
Total metals in Water by CRC ICPMS	E420	1079898	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	1080450	1	18	5.5	5.0	✓
Method Blanks (MB)							

Matrix: **Water**

Evaluation: × = QC frequency outside specification; ✓ = QC frequency within specification.

Quality Control Sample Type			Count		Frequency (%)		
Analytical Methods	*Method*	*QC Lot #*	*QC*	*Regular*	*Actual*	*Expected*	*Evaluation*
Method Blanks (MB) - Continued							
Alkalinity Species by Titration	E290	1080369	1	11	9.0	5.0	✓
Ammonia by Fluorescence	E298	1083324	1	20	5.0	5.0	✓
Bromide in Water by IC	E235.Br	1080372	1	10	10.0	5.0	✓
Chloride in Water by IC	E235.Cl	1080376	1	14	7.1	5.0	✓
Colour (Apparent) by Spectrometer	E330	1080959	1	14	7.1	5.0	✓
Conductivity in Water	E100	1080370	1	14	7.1	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level 0.001 mg/L)	E378-U	1080975	1	20	5.0	5.0	✓
E. coli (MF-mFC-BCIG)	E012A.EC	1080610	1	20	5.0	5.0	✓
Fluoride in Water by IC	E235.F	1080373	1	15	6.6	5.0	✓
Nitrate in Water by IC	E235.NO3	1080374	1	15	6.6	5.0	✓
Nitrite in Water by IC	E235.NO2	1080375	1	14	7.1	5.0	✓
Sulfate in Water by IC	E235.SO4	1080377	1	11	9.0	5.0	✓
TDS by Gravimetry	E162	1083888	1	14	7.1	5.0	✓
Total Coliforms (MF-mEndo)	E012.TC	1080599	1	20	5.0	5.0	✓
Total Coliforms Background (MF-mEndo)	E012.BG.TC	1080600	1	20	5.0	5.0	✓
Total metals in Water by CRC ICPMS	E420	1079898	1	20	5.0	5.0	✓
Turbidity by Nephelometry	E121	1080450	1	18	5.5	5.0	✓
Matrix Spikes (MS)							
Ammonia by Fluorescence	E298	1083324	1	20	5.0	5.0	✓
Bromide in Water by IC	E235.Br	1080372	1	10	10.0	5.0	✓
Chloride in Water by IC	E235.Cl	1080376	1	14	7.1	5.0	✓
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level 0.001 mg/L)	E378-U	1080975	1	20	5.0	5.0	✓
Fluoride in Water by IC	E235.F	1080373	1	15	6.6	5.0	✓
Nitrate in Water by IC	E235.NO3	1080374	1	15	6.6	5.0	✓
Nitrite in Water by IC	E235.NO2	1080375	1	14	7.1	5.0	✓
Sulfate in Water by IC	E235.SO4	1080377	1	11	9.0	5.0	✓
Total metals in Water by CRC ICPMS	E420	1079898	1	20	5.0	5.0	✓

Methodology References and Summaries

The analytical methods used by ALS are developed using internationally recognized reference methods (where available), such as those published by US EPA, APHA Standard Methods, ASTM, ISO, Environment Canada, BC MOE, and Ontario MOE. Reference methods may incorporate modifications to improve performance (indicated by "mod").

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Total Coliforms Background (MF-mEndo)	E012.BG.TC ALS Environmental - Waterloo	Water	APHA 9222B (mod)	Noncoliform bacteria observed on Total Coliform plates are enumerated.
Total Coliforms (MF-mEndo)	E012.TC ALS Environmental - Waterloo	Water	APHA 9222B (mod)	Following filtration (0.45 µm), and incubation at 35.0 ±0.5°C for 24 hours, colonies exhibiting characteristic morphology of the target organism are enumerated and confirmed.
E. coli (MF-mFC-BCIG)	E012A.EC ALS Environmental - Waterloo	Water	ON E3433 (mod)	Following filtration (0.45 µm), and incubation at 44.5±0.2°C for 24 hours, colonies exhibiting characteristic morphology of the target organism are enumerated.
Conductivity in Water	E100 ALS Environmental - Waterloo	Water	APHA 2510 (mod)	Conductivity, also known as Electrical Conductivity (EC) or Specific Conductance, is measured by immersion of a conductivity cell with platinum electrodes into a water sample. Conductivity measurements are temperature-compensated to 25°C.
pH by Meter	E108 ALS Environmental - Waterloo	Water	APHA 4500-H (mod)	pH is determined by potentiometric measurement with a pH electrode, and is conducted at ambient laboratory temperature (normally 20 ± 5°C). For high accuracy test results, pH should be measured in the field within the recommended 15 minute hold time.
Turbidity by Nephelometry	E121 ALS Environmental - Waterloo	Water	APHA 2130 B (mod)	Turbidity is measured by the nephelometric method, by measuring the intensity of light scatter under defined conditions.
TDS by Gravimetry	E162 ALS Environmental - Waterloo	Water	APHA 2540 C (mod)	Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, with evaporation of the filtrate at 180 ± 2°C for 16 hours or to constant weight, with gravimetric measurement of the residue.
Bromide in Water by IC	E235.Br ALS Environmental - Waterloo	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Chloride in Water by IC	E235.Cl ALS Environmental - Waterloo	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Fluoride in Water by IC	E235.F ALS Environmental - Waterloo	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Nitrite in Water by IC	E235.NO2 ALS Environmental - Waterloo	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Nitrate in Water by IC	E235.NO3 ALS Environmental - Waterloo	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Sulfate in Water by IC	E235.SO4 ALS Environmental - Waterloo	Water	EPA 300.1 (mod)	Inorganic anions are analyzed by Ion Chromatography with conductivity and/or UV detection.
Alkalinity Species by Titration	E290 ALS Environmental - Waterloo	Water	APHA 2320 B (mod)	Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.
Ammonia by Fluorescence	E298 ALS Environmental - Waterloo	Water	Method Fialab 100, 2018	Ammonia in water is determined by automated continuous flow analysis with membrane diffusion and fluorescence detection, after reaction with OPA (ortho-phthalaldehyde). This method is approved under US EPA 40 CFR Part 136 (May 2021)
Colour (Apparent) by Spectrometer	E330 ALS Environmental - Waterloo	Water	APHA 2120 C (mod)	Colour (Apparent) is measured in an unfiltered sample spectrophotometrically using the single wavelength method. The colour contribution of settleable solids are not included in the result. This method is intended for potable waters. Colour measurements can be highly pH dependent, and apply to the pH of the sample as received (at time of testing), without pH adjustment.
Dissolved Orthophosphate by Colourimetry (Ultra Trace Level 0.001 mg/L)	E378-U ALS Environmental - Waterloo	Water	APHA 4500-P F (mod)	Dissolved Orthophosphate is determined colourimetrically on a sample that has been lab or field filtered through a 0.45 micron membrane filter. Field filtration is recommended to ensure test results represent conditions at time of sampling.
Total metals in Water by CRC ICPMS	E420 ALS Environmental - Waterloo	Water	EPA 200.2/6020B (mod)	Water samples are digested with nitric and hydrochloric acids, and analyzed by Collision/Reaction Cell ICPMS. Method Limitation (re: Sulfur): Sulfide and volatile sulfur species may not be recovered by this method.
Hardness (Calculated) from Total Ca/Mg	EC100A ALS Environmental - Waterloo	Water	APHA 2340B	"Hardness (as CaCO3), from total Ca/Mg" is calculated from the sum of total Calcium and Magnesium concentrations, expressed in CaCO3 equivalents. "Total Hardness" refers to the sum of Calcium and Magnesium Hardness. Hardness is normally or preferentially calculated from dissolved Calcium and Magnesium concentrations, because it is a property of water due to dissolved divalent cations. Hardness from total Ca/Mg is normally comparable to Dissolved Hardness in non-turbid waters.

Analytical Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Ion Balance using Total Metals	EC101A ALS Environmental - Waterloo	Water	APHA 1030E	Cation Sum (using total metals), Anion Sum, and Ion Balance are calculated based on guidance from APHA Standard Methods (1030E Checking Correctness of Analysis). Minor ions are included where data is present. Ion Balance cannot be calculated accurately for waters with very low electrical conductivity (EC).
Sodium Adsorption Ratio [SAR] from Total Metals	EC102 ALS Environmental - Waterloo	Water	CCME Sodium Adsorption Ratio (SAR)	The Sodium Adsorption Ratio (SAR) for a water sample is calculated from the Sodium, Calcium, and Magnesium concentrations of the water, using the same calculations as would be used for a sediment paste extract.
TDS calculated from conductivity	EC103A ALS Environmental - Waterloo	Water	APHA 1030 E	Total dissolved solids (as mg/L) can be estimated by multiplying electrical conductance (in umhos/cm) by 0.65.
Saturation Index using Laboratory pH (Ca-T)	EC105A ALS Environmental - Waterloo	Water	APHA 2330B	Langelier Index provides an indication of scale formation potential at a given pH and temperature, and is calculated as per APHA 2330B Saturation Index. Positive values indicate oversaturation with respect to CaCO3. Negative values indicate undersaturation of CaCO3. This calculation uses laboratory pH measurements and provides estimates of Langelier Index at temperatures of 4, 15, 20, 25, 66, and 77°C. Ryznar Stability Index is an alternative index used for scale formation and corrosion potential.
Nitrate and Nitrite (as N) (Calculation)	EC235.N+N ALS Environmental - Waterloo	Water	EPA 300.0	Nitrate and Nitrite (as N) is a calculated parameter. Nitrate and Nitrite (as N) = Nitrite (as N) + Nitrate (as N).
Total Silicon as Silica (Calculation)	EC420.SiO2 ALS Environmental - Waterloo	Water	N/A	Total Silicon (as SiO2) is a calculated parameter. Total Silicon (as SiO2 mg/L) = 2.139 x Total Silicon (mg/L).

Preparation Methods	Method / Lab	Matrix	Method Reference	Method Descriptions
Preparation for Ammonia	EP298 ALS Environmental - Waterloo	Water		Sample preparation for Preserved Nutrients Water Quality Analysis.

ALS Canada Ltd.

QUALITY CONTROL REPORT

Work Order	: **WT2324847**	Page	: 1 of 13
Client	: Palmer Environmental Consulting Group Inc.	Laboratory	: ALS Environmental - Waterloo
Contact	: Tanvi Patel	Account Manager	: Andrew Martin
Address	: 74 Berkeley Street Toronto ON Canada M5V 1E3	Address	: 60 Northland Road, Unit 1 Waterloo, Ontario Canada N2V 2B8
Telephone	:	Telephone	: +1 519 886 6910
Project	: 2200902	Date Samples Received	: 10-Aug-2023 17:38
PO	: 2200902	Date Analysis Commenced	: 10-Aug-2023
C-O-C number	: 20-950513	Issue Date	: 17-Aug-2023 12:17
Sampler	: TP ----		
Site	: ----		
Quote number	: (Q88296) PALMER 2023 STANDING OFFER		
No. of samples received	: 1		
No. of samples analysed	: 1		

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percent Difference (RPD) and Data Quality Objectives
- Matrix Spike (MS) Report; Recovery and Data Quality Objectives
- Method Blank (MB) Report; Recovery and Data Quality Objectives
- Laboratory Control Sample (LCS) Report; Recovery and Data Quality Objectives

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is conducted in accordance with US FDA 21 CFR Part 11.

Signatories	*Position*	*Laboratory Department*
Walt Kippenhuck	Supervisor - Inorganic	Waterloo Inorganics, Waterloo, Ontario
Walt Kippenhuck	Supervisor - Inorganic	Waterloo Metals, Waterloo, Ontario
Zeba Patel		Waterloo Microbiology, Waterloo, Ontario

General Comments

The ALS Quality Control (QC) report is optionally provided to ALS clients upon request. ALS test methods include comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against predetermined Data Quality Objectives (DQOs) to provide confidence in the accuracy of associated test results. This report contains detailed results for all QC results applicable to this sample submission. Please refer to the ALS Quality Control Interpretation report (QCI) for applicable method references and methodology summaries.

Key :

Anonymous = Refers to samples which are not part of this work order, but which formed part of the QC process lot.
CAS Number = Chemical Abstracts Service number is a unique identifier assigned to discrete substances.
DQO = Data Quality Objective.
LOR = Limit of Reporting (detection limit).
RPD = Relative Percent Difference
# = Indicates a QC result that did not meet the ALS DQO.

Workorder Comments

Holding times are displayed as "---" if no guidance exists from CCME, Canadian provinces, or broadly recognized international references.

Laboratory Duplicate (DUP) Report

A Laboratory Duplicate (DUP) is a randomly selected intralaboratory replicate sample. Laboratory Duplicates provide information regarding method precision and sample heterogeneity. ALS DQOs for Laboratory Duplicates are expressed as test-specific limits for Relative Percent Difference (RPD), or as an absolute difference limit of 2 times the LOR for low concentration duplicates within ~ 4-10 times the LOR (cut-off is test-specific).

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Physical Tests (QC Lot: 1080369)											
WT2324479-001	Anonymous	Alkalinity, total (as CaCO3)	----	E290	1.0	mg/L	297	286	3.77%	20%	----
Physical Tests (QC Lot: 1080370)											
WT2324479-001	Anonymous	Conductivity	----	E100	1.0	µS/cm	576	580	0.692%	10%	----
Physical Tests (QC Lot: 1080371)											
WT2324479-001	Anonymous	pH	----	E108	0.10	pH units	7.83	7.86	0.382%	4%	----
Physical Tests (QC Lot: 1080450)											
WT2324479-001	Anonymous	Turbidity	----	E121	0.10	NTU	0.52	0.51	0.005	Diff <2x LOR	----
Physical Tests (QC Lot: 1080959)											
HA2300497-001	Anonymous	Colour, apparent	----	E330	4.0	CU	243	244	0.316%	20%	----
Physical Tests (QC Lot: 1083888)											
WT2324851-004	Anonymous	Solids, total dissolved [TDS]	----	E162	20	mg/L	320	330	3.23%	20%	----
Anions and Nutrients (QC Lot: 1080372)											
WT2324479-001	Anonymous	Bromide	24959-67-9	E235.Br	0.10	mg/L	<0.10	<0.10	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 1080373)											
WT2324479-001	Anonymous	Fluoride	16984-48-8	E235.F	0.020	mg/L	0.057	0.054	0.003	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 1080374)											
WT2324479-001	Anonymous	Nitrate (as N)	14797-55-8	E235.NO3	0.020	mg/L	0.074	0.073	0.001	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 1080375)											
WT2324479-001	Anonymous	Nitrite (as N)	14797-65-0	E235.NO2	0.010	mg/L	<0.010	<0.010	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 1080376)											
WT2324479-001	Anonymous	Chloride	16887-00-6	E235.Cl	0.50	mg/L	13.9	13.8	0.352%	20%	----
Anions and Nutrients (QC Lot: 1080377)											
WT2324479-001	Anonymous	Sulfate (as SO4)	14808-79-8	E235.SO4	0.30	mg/L	4.62	4.61	0.381%	20%	----
Anions and Nutrients (QC Lot: 1080975)											
HA2300497-002	Anonymous	Phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0010	mg/L	<0.0010	<0.0010	0	Diff <2x LOR	----
Anions and Nutrients (QC Lot: 1083324)											
BF2300216-003	Anonymous	Ammonia, total (as N)	7664-41-7	E298	0.0050	mg/L	0.0173	0.0164	0.0009	Diff <2x LOR	----
Microbiological Tests (QC Lot: 1080599)											
WT2324777-003	Anonymous	Coliforms, total	----	E012.TC	1	CFU/100mL	<1	<1	0	Diff <2x LOR	----
Microbiological Tests (QC Lot: 1080600)											

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Microbiological Tests (QC Lot: 1080600) - continued											
WT2324777-003	Anonymous	coliforms, total background	----	E012.BG.TC	1	CFU/100mL	1	1	0	Diff <2x LOR	----
Microbiological Tests (QC Lot: 1080610)											
WT2324826-002	Anonymous	Coliforms, Escherichia coli [E. coli]	----	E012A.EC	1	CFU/100mL	2	1	1	Diff <2x LOR	----
Total Metals (QC Lot: 1079898)											
WT2324742-001	Anonymous	Aluminum, total	7429-90-5	E420	0.0300	mg/L	0.708	0.717	1.23%	20%	----
		Antimony, total	7440-36-0	E420	0.00100	mg/L	0.00153	0.00161	0.00008	Diff <2x LOR	----
		Arsenic, total	7440-38-2	E420	0.00100	mg/L	0.00454	0.00473	0.00019	Diff <2x LOR	----
		Barium, total	7440-39-3	E420	0.00100	mg/L	0.0121	0.0125	3.63%	20%	----
		Beryllium, total	7440-41-7	E420	0.000200	mg/L	<0.000200	<0.000200	0	Diff <2x LOR	----
		Bismuth, total	7440-69-9	E420	0.000500	mg/L	<0.000500	<0.000500	0	Diff <2x LOR	----
		Boron, total	7440-42-8	E420	0.100	mg/L	0.138	0.137	0.001	Diff <2x LOR	----
		Cadmium, total	7440-43-9	E420	0.0000500	mg/L	<0.0000500	<0.0000500	0	Diff <2x LOR	----
		Calcium, total	7440-70-2	E420	0.500	mg/L	12.5	12.5	0.332%	20%	----
		Cesium, total	7440-46-2	E420	0.000100	mg/L	0.00231	0.00236	2.18%	20%	----
		Chromium, total	7440-47-3	E420	0.00500	mg/L	0.0930	0.0953	2.40%	20%	----
		Cobalt, total	7440-48-4	E420	0.00100	mg/L	<0.00100	<0.00100	0	Diff <2x LOR	----
		Copper, total	7440-50-8	E420	0.00500	mg/L	0.0178	0.0187	0.00087	Diff <2x LOR	----
		Iron, total	7439-89-6	E420	0.100	mg/L	0.419	0.435	0.015	Diff <2x LOR	----
		Lead, total	7439-92-1	E420	0.000500	mg/L	0.000857	0.000878	0.000021	Diff <2x LOR	----
		Lithium, total	7439-93-2	E420	0.0100	mg/L	0.125	0.124	0.659%	20%	----
		Magnesium, total	7439-95-4	E420	0.0500	mg/L	2.58	2.67	3.47%	20%	----
		Manganese, total	7439-96-5	E420	0.00100	mg/L	0.0105	0.0116	9.89%	20%	----
		Molybdenum, total	7439-98-7	E420	0.000500	mg/L	0.0157	0.0159	0.918%	20%	----
		Nickel, total	7440-02-0	E420	0.00500	mg/L	0.0109	0.0111	0.00028	Diff <2x LOR	----
		Phosphorus, total	7723-14-0	E420	0.500	mg/L	<0.500	<0.500	0	Diff <2x LOR	----
		Potassium, total	7440-09-7	E420	0.500	mg/L	203	209	2.88%	20%	----
		Rubidium, total	7440-17-7	E420	0.00200	mg/L	0.477	0.488	2.39%	20%	----
		Selenium, total	7782-49-2	E420	0.000500	mg/L	0.000725	0.000636	0.000088	Diff <2x LOR	----
		Silicon, total	7440-21-3	E420	1.00	mg/L	19.2	19.2	0.179%	20%	----
		Silver, total	7440-22-4	E420	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		Sodium, total	7440-23-5	E420	0.500	mg/L	84.5	86.5	2.32%	20%	----
		Strontium, total	7440-24-6	E420	0.00200	mg/L	0.0874	0.0894	2.38%	20%	----
		Sulfur, total	7704-34-9	E420	5.00	mg/L	46.4	46.9	0.54	Diff <2x LOR	----
		Tellurium, total	13494-80-9	E420	0.00200	mg/L	<0.00200	<0.00200	0	Diff <2x LOR	----

Sub-Matrix: **Water**

					Laboratory Duplicate (DUP) Report						
Laboratory sample ID	*Client sample ID*	*Analyte*	*CAS Number*	*Method*	*LOR*	*Unit*	*Original Result*	*Duplicate Result*	*RPD(%) or Difference*	*Duplicate Limits*	*Qualifier*
Total Metals (QC Lot: 1079898) - continued											
WT2324742-001	Anonymous	Thallium, total	7440-28-0	E420	0.000100	mg/L	<0.000100	<0.000100	0	Diff <2x LOR	----
		Thorium, total	7440-29-1	E420	0.00100	mg/L	<0.00100	<0.00100	0	Diff <2x LOR	----
		Tin, total	7440-31-5	E420	0.00100	mg/L	0.00230	0.00240	0.00010	Diff <2x LOR	----
		Titanium, total	7440-32-6	E420	0.00300	mg/L	0.0172	0.0183	0.00105	Diff <2x LOR	----
		Tungsten, total	7440-33-7	E420	0.00100	mg/L	0.00206	0.00208	0.00002	Diff <2x LOR	----
		Uranium, total	7440-61-1	E420	0.000100	mg/L	0.000342	0.000360	0.000017	Diff <2x LOR	----
		Vanadium, total	7440-62-2	E420	0.00500	mg/L	0.0716	0.0734	2.58%	20%	----
		Zinc, total	7440-66-6	E420	0.0300	mg/L	0.0399	0.0409	0.0010	Diff <2x LOR	----
		Zirconium, total	7440-67-7	E420	0.00200	mg/L	<0.00200	<0.00200	0	Diff <2x LOR	----

Method Blank (MB) Report

A Method Blank is an analyte-free matrix that undergoes sample processing identical to that carried out for test samples. Method Blank results are used to monitor and control for potential contamination from the laboratory environment and reagents. For most tests, the DQO for Method Blanks is for the result to be < LOR.

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Physical Tests (QCLot: 1080369)						
Alkalinity, total (as CaCO3)	----	E290	1	mg/L	1.2	----
Physical Tests (QCLot: 1080370)						
Conductivity	----	E100	1	µS/cm	1.2	----
Physical Tests (QCLot: 1080450)						
Turbidity	----	E121	0.1	NTU	<0.10	----
Physical Tests (QCLot: 1080959)						
Colour, apparent	----	E330	2	CU	<2.0	----
Physical Tests (QCLot: 1083888)						
Solids, total dissolved [TDS]	----	E162	10	mg/L	<10	----
Anions and Nutrients (QCLot: 1080372)						
Bromide	24959-67-9	E235.Br	0.1	mg/L	<0.10	----
Anions and Nutrients (QCLot: 1080373)						
Fluoride	16984-48-8	E235.F	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 1080374)						
Nitrate (as N)	14797-55-8	E235.NO3	0.02	mg/L	<0.020	----
Anions and Nutrients (QCLot: 1080375)						
Nitrite (as N)	14797-65-0	E235.NO2	0.01	mg/L	<0.010	----
Anions and Nutrients (QCLot: 1080376)						
Chloride	16887-00-6	E235.Cl	0.5	mg/L	<0.50	----
Anions and Nutrients (QCLot: 1080377)						
Sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	<0.30	----
Anions and Nutrients (QCLot: 1080975)						
Phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	<0.0010	----
Anions and Nutrients (QCLot: 1083324)						
Ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	<0.0050	----
Microbiological Tests (QCLot: 1080599)						
Coliforms, total	----	E012.TC	1	CFU/100mL	<1	----
Microbiological Tests (QCLot: 1080600)						
coliforms, total background	----	E012.BG.TC	1	CFU/100mL	<1	----
Microbiological Tests (QCLot: 1080610)						
Coliforms, Escherichia coli [E. coli]	----	E012A.EC	1	CFU/100mL	<1	----
Total Metals (QCLot: 1079898)						

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 1079898) - continued						
Aluminum, total	7429-90-5	E420	0.003	mg/L	<0.0030	----
Antimony, total	7440-36-0	E420	0.0001	mg/L	<0.00010	----
Arsenic, total	7440-38-2	E420	0.0001	mg/L	<0.00010	----
Barium, total	7440-39-3	E420	0.0001	mg/L	<0.00010	----
Beryllium, total	7440-41-7	E420	0.00002	mg/L	<0.000020	----
Bismuth, total	7440-69-9	E420	0.00005	mg/L	<0.000050	----
Boron, total	7440-42-8	E420	0.01	mg/L	<0.010	----
Cadmium, total	7440-43-9	E420	0.000005	mg/L	<0.0000050	----
Calcium, total	7440-70-2	E420	0.05	mg/L	<0.050	----
Cesium, total	7440-46-2	E420	0.00001	mg/L	<0.000010	----
Chromium, total	7440-47-3	E420	0.0005	mg/L	<0.00050	----
Cobalt, total	7440-48-4	E420	0.0001	mg/L	<0.00010	----
Copper, total	7440-50-8	E420	0.0005	mg/L	<0.00050	----
Iron, total	7439-89-6	E420	0.01	mg/L	<0.010	----
Lead, total	7439-92-1	E420	0.00005	mg/L	<0.000050	----
Lithium, total	7439-93-2	E420	0.001	mg/L	<0.0010	----
Magnesium, total	7439-95-4	E420	0.005	mg/L	<0.0050	----
Manganese, total	7439-96-5	E420	0.0001	mg/L	<0.00010	----
Molybdenum, total	7439-98-7	E420	0.00005	mg/L	<0.000050	----
Nickel, total	7440-02-0	E420	0.0005	mg/L	<0.00050	----
Phosphorus, total	7723-14-0	E420	0.05	mg/L	<0.050	----
Potassium, total	7440-09-7	E420	0.05	mg/L	<0.050	----
Rubidium, total	7440-17-7	E420	0.0002	mg/L	<0.00020	----
Selenium, total	7782-49-2	E420	0.00005	mg/L	<0.000050	----
Silicon, total	7440-21-3	E420	0.1	mg/L	<0.10	----
Silver, total	7440-22-4	E420	0.00001	mg/L	<0.000010	----
Sodium, total	7440-23-5	E420	0.05	mg/L	<0.050	----
Strontium, total	7440-24-6	E420	0.0002	mg/L	<0.00020	----
Sulfur, total	7704-34-9	E420	0.5	mg/L	<0.50	----
Tellurium, total	13494-80-9	E420	0.0002	mg/L	<0.00020	----
Thallium, total	7440-28-0	E420	0.00001	mg/L	<0.000010	----
Thorium, total	7440-29-1	E420	0.0001	mg/L	<0.00010	----
Tin, total	7440-31-5	E420	0.0001	mg/L	<0.00010	----
Titanium, total	7440-32-6	E420	0.0003	mg/L	<0.00030	----
Tungsten, total	7440-33-7	E420	0.0001	mg/L	<0.00010	----

Sub-Matrix: **Water**

Analyte	CAS Number	Method	LOR	Unit	Result	Qualifier
Total Metals (QCLot: 1079898) - continued						
Uranium, total	7440-61-1	E420	0.00001	mg/L	<0.000010	----
Vanadium, total	7440-62-2	E420	0.0005	mg/L	<0.00050	----
Zinc, total	7440-66-6	E420	0.003	mg/L	<0.0030	----
Zirconium, total	7440-67-7	E420	0.0002	mg/L	<0.00020	----

Laboratory Control Sample (LCS) Report

A Laboratory Control Sample (LCS) is an analyte-free matrix that has been fortified (spiked) with test analytes at known concentration and processed in an identical manner to test samples. LCS results are expressed as percent recovery, and are used to monitor and control test method accuracy and precision, independent of test sample matrix.

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Physical Tests (QCLot: 1080369)									
Alkalinity, total (as CaCO3)	----	E290	1	mg/L	150 mg/L	104	85.0	115	----
Physical Tests (QCLot: 1080370)									
Conductivity	----	E100	1	µS/cm	1409 µS/cm	101	90.0	110	----
Physical Tests (QCLot: 1080371)									
pH	----	E108	----	pH units	7 pH units	100	98.0	102	----
Physical Tests (QCLot: 1080450)									
Turbidity	----	E121	0.1	NTU	200 NTU	97.0	85.0	115	----
Physical Tests (QCLot: 1080959)									
Colour, apparent	----	E330	2	CU	25 CU	99.6	70.0	130	----
Physical Tests (QCLot: 1083888)									
Solids, total dissolved [TDS]	----	E162	10	mg/L	1000 mg/L	101	85.0	115	----
Anions and Nutrients (QCLot: 1080372)									
Bromide	24959-67-9	E235.Br	0.1	mg/L	0.5 mg/L	99.8	85.0	115	----
Anions and Nutrients (QCLot: 1080373)									
Fluoride	16984-48-8	E235.F	0.02	mg/L	1 mg/L	99.0	90.0	110	----
Anions and Nutrients (QCLot: 1080374)									
Nitrate (as N)	14797-55-8	E235.NO3	0.02	mg/L	2.5 mg/L	98.7	90.0	110	----
Anions and Nutrients (QCLot: 1080375)									
Nitrite (as N)	14797-65-0	E235.NO2	0.01	mg/L	0.5 mg/L	97.8	90.0	110	----
Anions and Nutrients (QCLot: 1080376)									
Chloride	16887-00-6	E235.Cl	0.5	mg/L	100 mg/L	98.9	90.0	110	----
Anions and Nutrients (QCLot: 1080377)									
Sulfate (as SO4)	14808-79-8	E235.SO4	0.3	mg/L	100 mg/L	100	90.0	110	----
Anions and Nutrients (QCLot: 1080975)									
Phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.001	mg/L	0.0212 mg/L	105	80.0	120	----
Anions and Nutrients (QCLot: 1083324)									
Ammonia, total (as N)	7664-41-7	E298	0.005	mg/L	0.2 mg/L	100	85.0	115	----
Total Metals (QCLot: 1079898)									
Aluminum, total	7429-90-5	E420	0.003	mg/L	0.1 mg/L	102	80.0	120	----
Antimony, total	7440-36-0	E420	0.0001	mg/L	0.05 mg/L	103	80.0	120	----

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Total Metals (QCLot: 1079898) - continued									
Arsenic, total	7440-38-2	E420	0.0001	mg/L	0.05 mg/L	106	80.0	120	----
Barium, total	7440-39-3	E420	0.0001	mg/L	0.0125 mg/L	105	80.0	120	----
Beryllium, total	7440-41-7	E420	0.00002	mg/L	0.005 mg/L	106	80.0	120	----
Bismuth, total	7440-69-9	E420	0.00005	mg/L	0.05 mg/L	99.9	80.0	120	----
Boron, total	7440-42-8	E420	0.01	mg/L	0.05 mg/L	102	80.0	120	----
Cadmium, total	7440-43-9	E420	0.000005	mg/L	0.005 mg/L	101	80.0	120	----
Calcium, total	7440-70-2	E420	0.05	mg/L	2.5 mg/L	102	80.0	120	----
Cesium, total	7440-46-2	E420	0.00001	mg/L	0.0025 mg/L	102	80.0	120	----
Chromium, total	7440-47-3	E420	0.0005	mg/L	0.0125 mg/L	104	80.0	120	----
Cobalt, total	7440-48-4	E420	0.0001	mg/L	0.0125 mg/L	103	80.0	120	----
Copper, total	7440-50-8	E420	0.0005	mg/L	0.0125 mg/L	102	80.0	120	----
Iron, total	7439-89-6	E420	0.01	mg/L	0.05 mg/L	104	80.0	120	----
Lead, total	7439-92-1	E420	0.00005	mg/L	0.025 mg/L	103	80.0	120	----
Lithium, total	7439-93-2	E420	0.001	mg/L	0.0125 mg/L	107	80.0	120	----
Magnesium, total	7439-95-4	E420	0.005	mg/L	2.5 mg/L	109	80.0	120	----
Manganese, total	7439-96-5	E420	0.0001	mg/L	0.0125 mg/L	104	80.0	120	----
Molybdenum, total	7439-98-7	E420	0.00005	mg/L	0.0125 mg/L	101	80.0	120	----
Nickel, total	7440-02-0	E420	0.0005	mg/L	0.025 mg/L	102	80.0	120	----
Phosphorus, total	7723-14-0	E420	0.05	mg/L	0.5 mg/L	113	80.0	120	----
Potassium, total	7440-09-7	E420	0.05	mg/L	2.5 mg/L	106	80.0	120	----
Rubidium, total	7440-17-7	E420	0.0002	mg/L	0.005 mg/L	105	80.0	120	----
Selenium, total	7782-49-2	E420	0.00005	mg/L	0.05 mg/L	98.1	80.0	120	----
Silicon, total	7440-21-3	E420	0.1	mg/L	0.5 mg/L	111	80.0	120	----
Silver, total	7440-22-4	E420	0.00001	mg/L	0.005 mg/L	102	80.0	120	----
Sodium, total	7440-23-5	E420	0.05	mg/L	2.5 mg/L	106	80.0	120	----
Strontium, total	7440-24-6	E420	0.0002	mg/L	0.0125 mg/L	101	80.0	120	----
Sulfur, total	7704-34-9	E420	0.5	mg/L	2.5 mg/L	111	80.0	120	----
Tellurium, total	13494-80-9	E420	0.0002	mg/L	0.005 mg/L	98.0	80.0	120	----
Thallium, total	7440-28-0	E420	0.00001	mg/L	0.05 mg/L	103	80.0	120	----
Thorium, total	7440-29-1	E420	0.0001	mg/L	0.005 mg/L	94.3	80.0	120	----
Tin, total	7440-31-5	E420	0.0001	mg/L	0.025 mg/L	101	80.0	120	----
Titanium, total	7440-32-6	E420	0.0003	mg/L	0.0125 mg/L	102	80.0	120	----
Tungsten, total	7440-33-7	E420	0.0001	mg/L	0.005 mg/L	103	80.0	120	----
Uranium, total	7440-61-1	E420	0.00001	mg/L	0.00025 mg/L	102	80.0	120	----
Vanadium, total	7440-62-2	E420	0.0005	mg/L	0.025 mg/L	105	80.0	120	----
Zinc, total	7440-66-6	E420	0.003	mg/L	0.025 mg/L	103	80.0	120	----

Sub-Matrix: **Water**

					Laboratory Control Sample (LCS) Report				
					Spike	Recovery (%)	Recovery Limits (%)		
Analyte	CAS Number	Method	LOR	Unit	Concentration	LCS	Low	High	Qualifier
Total Metals (QCLot: 1079898) - continued									
Zirconium, total	7440-67-7	E420	0.0002	mg/L	0.005 mg/L	104	80.0	120	----

Matrix Spike (MS) Report

A Matrix Spike (MS) is a randomly selected intra-laboratory replicate sample that has been fortified (spiked) with test analytes at known concentration, and processed in an identical manner to test samples. Matrix Spikes provide information regarding analyte recovery and potential matrix effects. MS DQO exceedances due to sample matrix may sometimes be unavoidable; in such cases, test results for the associated sample (or similar samples) may be subject to bias. ND – Recovery not determined, background level >= 1x spike level.

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Anions and Nutrients (QCLot: 1080372)										
WT2324479-001	Anonymous	Bromide	24959-67-9	E235.Br	0.48 mg/L	0.5 mg/L	96.5	75.0	125	----
Anions and Nutrients (QCLot: 1080373)										
WT2324479-001	Anonymous	Fluoride	16984-48-8	E235.F	0.952 mg/L	1 mg/L	95.2	75.0	125	----
Anions and Nutrients (QCLot: 1080374)										
WT2324479-001	Anonymous	Nitrate (as N)	14797-55-8	E235.NO3	2.34 mg/L	2.5 mg/L	93.7	75.0	125	----
Anions and Nutrients (QCLot: 1080375)										
WT2324479-001	Anonymous	Nitrite (as N)	14797-65-0	E235.NO2	0.486 mg/L	0.5 mg/L	97.2	75.0	125	----
Anions and Nutrients (QCLot: 1080376)										
WT2324479-001	Anonymous	Chloride	16887-00-6	E235.Cl	96.9 mg/L	100 mg/L	96.9	75.0	125	----
Anions and Nutrients (QCLot: 1080377)										
WT2324479-001	Anonymous	Sulfate (as SO4)	14808-79-8	E235.SO4	94.9 mg/L	100 mg/L	94.9	75.0	125	----
Anions and Nutrients (QCLot: 1080975)										
HA2300497-002	Anonymous	Phosphate, ortho-, dissolved (as P)	14265-44-2	E378-U	0.0156 mg/L	0.0196 mg/L	79.6	70.0	130	----
Anions and Nutrients (QCLot: 1083324)										
BF2300216-003	Anonymous	Ammonia, total (as N)	7664-41-7	E298	0.106 mg/L	0.1 mg/L	106	75.0	125	----
Total Metals (QCLot: 1079898)										
WT2324765-001	Anonymous	Aluminum, total	7429-90-5	E420	0.119 mg/L	0.1 mg/L	119	70.0	130	----
		Antimony, total	7440-36-0	E420	0.0530 mg/L	0.05 mg/L	106	70.0	130	----
		Arsenic, total	7440-38-2	E420	0.0521 mg/L	0.05 mg/L	104	70.0	130	----
		Barium, total	7440-39-3	E420	ND mg/L	0.0125 mg/L	ND	70.0	130	----
		Beryllium, total	7440-41-7	E420	0.00515 mg/L	0.005 mg/L	103	70.0	130	----
		Bismuth, total	7440-69-9	E420	0.0490 mg/L	0.05 mg/L	97.9	70.0	130	----
		Boron, total	7440-42-8	E420	0.051 mg/L	0.05 mg/L	102	70.0	130	----
		Cadmium, total	7440-43-9	E420	0.00463 mg/L	0.005 mg/L	92.6	70.0	130	----
		Calcium, total	7440-70-2	E420	ND mg/L	2.5 mg/L	ND	70.0	130	----
		Cesium, total	7440-46-2	E420	0.00257 mg/L	0.0025 mg/L	103	70.0	130	----
		Chromium, total	7440-47-3	E420	0.0169 mg/L	0.0125 mg/L	135	70.0	130	K
		Cobalt, total	7440-48-4	E420	0.0127 mg/L	0.0125 mg/L	102	70.0	130	----
		Copper, total	7440-50-8	E420	0.0138 mg/L	0.0125 mg/L	110	70.0	130	----

Sub-Matrix: **Water**

					Matrix Spike (MS) Report					
					Spike		Recovery (%)	Recovery Limits (%)		
Laboratory sample ID	Client sample ID	Analyte	CAS Number	Method	Concentration	Target	MS	Low	High	Qualifier
Total Metals (QCLot: 1079898) - continued										
WT2324765-001	Anonymous	Iron, total	7439-89-6	E420	ND mg/L	0.05 mg/L	ND	70.0	130	----
		Lead, total	7439-92-1	E420	0.0249 mg/L	0.025 mg/L	99.7	70.0	130	----
		Lithium, total	7439-93-2	E420	ND mg/L	0.0125 mg/L	ND	70.0	130	----
		Magnesium, total	7439-95-4	E420	ND mg/L	2.5 mg/L	ND	70.0	130	----
		Manganese, total	7439-96-5	E420	ND mg/L	0.0125 mg/L	ND	70.0	130	----
		Molybdenum, total	7439-98-7	E420	ND mg/L	0.0125 mg/L	ND	70.0	130	----
		Nickel, total	7440-02-0	E420	ND mg/L	0.025 mg/L	ND	70.0	130	----
		Phosphorus, total	7723-14-0	E420	1.01 mg/L	0.5 mg/L	202	70.0	130	K
		Potassium, total	7440-09-7	E420	ND mg/L	2.5 mg/L	ND	70.0	130	----
		Rubidium, total	7440-17-7	E420	0.00532 mg/L	0.005 mg/L	106	70.0	130	----
		Selenium, total	7782-49-2	E420	0.0422 mg/L	0.05 mg/L	84.3	70.0	130	----
		Silicon, total	7440-21-3	E420	ND mg/L	0.5 mg/L	ND	70.0	130	----
		Silver, total	7440-22-4	E420	0.00518 mg/L	0.005 mg/L	104	70.0	130	----
		Sodium, total	7440-23-5	E420	ND mg/L	2.5 mg/L	ND	70.0	130	----
		Strontium, total	7440-24-6	E420	ND mg/L	0.0125 mg/L	ND	70.0	130	----
		Sulfur, total	7704-34-9	E420	ND mg/L	2.5 mg/L	ND	70.0	130	----
		Tellurium, total	13494-80-9	E420	0.00464 mg/L	0.005 mg/L	92.8	70.0	130	----
		Thallium, total	7440-28-0	E420	0.0500 mg/L	0.05 mg/L	100	70.0	130	----
		Thorium, total	7440-29-1	E420	0.00310 mg/L	0.005 mg/L	62.0	70.0	130	K
		Tin, total	7440-31-5	E420	0.0244 mg/L	0.025 mg/L	97.6	70.0	130	----
		Titanium, total	7440-32-6	E420	0.0106 mg/L	0.0125 mg/L	85.2	70.0	130	----
		Tungsten, total	7440-33-7	E420	0.00549 mg/L	0.005 mg/L	110	70.0	130	----
		Uranium, total	7440-61-1	E420	ND mg/L	0.00025 mg/L	ND	70.0	130	----
		Vanadium, total	7440-62-2	E420	0.0290 mg/L	0.025 mg/L	116	70.0	130	----
		Zinc, total	7440-66-6	E420	0.0289 mg/L	0.025 mg/L	116	70.0	130	----
		Zirconium, total	7440-67-7	E420	0.00476 mg/L	0.005 mg/L	95.2	70.0	130	----

Qualifiers

Qualifier	Description
K	*Matrix Spike recovery outside ALS DQO due to sample matrix effects.*

Chain of Custody (COC) / Analytical Request Form

ALS www.alsglobal.com

Canada Toll Free: 1 800 668 9878

COC Number: 1

Page 1

Environmental Division Waterloo

Work Order Reference **WT2324847**

Telephone : +1 519 886 6910

Report To	Contact and company name below will appear on the final report
Company:	PALMER
Contact:	Tanvi Patel
Phone:	647 688 2538
	Company address below will appear on the final report
Street:	871 EQUESTRIAN CT
City/Province:	OAKVILLE
Postal Code:	L6L 6L7
Invoice To	Same as Report To ☑ YES ☐ NO
	Copy of Invoice with Report ☐ YES ☑ NO
Company:	Palmer
Contact:	accounting@pcg.ca

Reports / Recipients

Select Report Format: ☑ PDF ☑ EXCEL ☐ EDD (DIGITAL)

Merge QC/QCI Reports with COA ☑ YES ☐ NO ☐ N/A

☑ Compare Results to Criteria on Report - provide details below if box checked

Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax: tanvi.patel@pcg.ca

Email 2: frank.liu@pcg.ca

Email 3:

Invoice Recipients

Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX

Email 1 or Fax: accounting@pcg.ca

Email 2:

Turnaround Time (TAT) Requested

☑ Routine [R] if received by 3pm M-F - no surcharges apply

☐ 4 day [P4] if received by 3pm M-F - 20% rush surcharge minimum

☐ 3 day [P3] if received by 3pm M-F - 25% rush surcharge minimum

☐ 2 day [P2] if received by 3pm M-F - 50% rush surcharge minimum

☐ 1 day [E] if received by 3pm M-F - 100% rush surcharge minimum

☐ Same day [E2] if received by 10am M-S - 200% rush surcharge. Additional fees may apply to rush requests on weekends, statutory holidays and non-standard hours.

Date and Time Required for all E&P TATs:

For all tests with rush TATs requested, please contact your AM to confirm availability.

Project Information

ALS Account # / Quote #: 2 4400

Job #: 2200902

PO / AFE: 2200902

LSD:

Oilfield Gas Required Fields (client use)

AFE/Cost Center: PO#:

Major/Minor Code: Routing Code:

Requisitioner:

Location:

ALS Lab Work Order # (ALS use only):

ALS Contact: Andrew Martin

Sampler: TP

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (ALS use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	NUMBER OF CONTAINERS	Ben Chem Potability	SAMPLES ON HOLD	EXTENDED STORAGE REQUIRED	SUSPECTED HAZARD (see notes)
	BH23-10	10-AUG-22	10:00	Water	5	X			

Drinking Water (DW) Samples[1] (client use)

Are samples taken from a Regulated DW System?

☐ YES ☑ NO

Are samples for human consumption/ use?

☐ YES ☑ NO

Notes / Specify Limits for result evaluation by selecting from drop-down below (Excel COC only)

ODWS

SAMPLE RECEIPT DETAILS (ALS use only)

Cooling Method: ☐ NONE ☑ ICE ☐ ICE PACKS ☐ FROZEN ☐ COOLING INITIATED

Submission Comments identified on Sample Receipt Notification: ☐ YES ☐ NO

Cooler Custody Seals Present: ☐ YES ☐ NO | Cooler Custody Seals Intact: ☐ YES ☐ NO | Sample Custody Seals Intact: ☐ YES ☐ NO

INITIAL COOLER TEMPERATURES (°C)	FINAL COOLER TEMPERATURES (°C)
1.2	

SHIPMENT RELEASE (client use)

Released by: TP | Date: 10-Aug-22 | Time: 2pm

INITIAL SHIPMENT RECEPTION (ALS use only)

Received by: | Date: 10-Aug-22 | Time: 14:36

FINAL SHIPMENT RECEPTION (ALS use only)

Received by: | Date: | Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

WHITE - LABORATORY COPY YELLOW - CLIENT COPY

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

1. If any water samples are taken from a Regulated Drinking Water (DW) System, please submit using an Authorized DW COC form.

N - 105
MM - 366
GC - 490

EC

Appendix G

MECP Well Records

(Well Records within Site)

(Well Records within 500 m Buffer from Site Boundary)

WELL_ID	COMPLETED	DEPTH	DP_BEDROCK	STATIC_LEV	WELL_USE	WATER	SCREEN	CASING_DIA	PUMP_TEST	FORMATION
2920485	2004-10-08	29.30	21.30	8.30	CO	FR 0070 FR 0074		6.11	27/57/2/1:0	BRWN LOAM 0001 BRWN CLAY GRVL STNS 0010 BRWN CLAY HARD 0019 GREY CLAY BLDR HARD 0024 GREY CLAY GRVL HPAN 0054 GREY CLAY BLDR 0070 GREY LMSN 0096
2903193	1959-11-03	14.90	11.90	3.40	DO	FR 0040			11/20/10/1:0	CLAY 0035 GRVL 0039 LMSN 0049
2903195	1960-06-22	15.20	11.30	4.60	DO	FR 0045			15/20/20/1:0	CLAY 0005 GRVL 0037 LMSN 0050
2903199	1965-09-28	22.90	11.30	0.00						GRVL MSND BLDR 0037 GREY LMSN 0075
2903200	1965-09-30	12.50	11.30	4.60	DO	FR 0039			15/30/10/2:0	GRVL MSND BLDR 0037 GREY LMSN 0041
2905402	1971-08-18	13.40	11.30	6.10	DO	FR			20/32/20/1:0	BRWN CLAY GRVL BLDR 0037 GREY LMSN 0044
2903196	1962-07-10	15.50	11.00	4.60	DO	FR 0040			15/30/33/2:0	MSND BLDR 0036 GREY LMSN 0051
2903197	1963-11-22	14.60	11.00	6.10	DO	FR 0038			20/20/20/2:0	CLAY BLDR 0036 GREY LMSN 0048
2903198	1963-11-28	18.30	11.00	6.10	DO	FR 0055			20/20/20/2:0	CLAY BLDR 0036 GREY LMSN 0060
2905311	1972-05-01	12.20	8.80	3.00	DO	FR 0030 FR 0036		6	10/10/40/4:0	LOAM 0002 GREY CLAY GRVL 0026 GREY GRVL 0029 GREY LMSN 0036 YLLW LMSN 0040
2904011	1968-04-23	10.10	8.20	3.00	DO	FR 0029			10/20/10/2:0	LOAM 0002 GRVL BLDR 0027 LMSN 0033
2903191	1967-08-08	12.20	0.00	6.10	DO	FR 0035			20/25/15/2:0	LMSN 0010 GRVL 0030 BRWN LMSN 0040
2903192	1951-09-18	10.10	0.00	3.00	ST DO	FR 0030			10/30/1/1:0	MSND GRVL CLAY 0033
2903194	1960-06-17	9.10	0.00	6.70	DO	FR 0030		6	22/28/20/1:0	CLAY STNS 0028 GRVL 0030
2904004	1968-12-06	6.70	0.00	1.80	DO	FR 0018		6	6/15/25/1:0	LOAM 0003 GRVL BLDR 0022
2904006	1968-06-28	8.50	0.00	4.90	DO	FR 0028		6	16/27/4/1:0	CLAY 0012 CLAY MSND 0018 HPAN CLAY 0024 GRVL
2904449	1970-03-05	10.70	0.00	5.50	DO	FR 0033		6	18/28/8/3:0	GREY CLAY 0005 GREY GRVL 0035
2909173	1979-08-10	10.70	0.00	6.10	DO	FR 0029		6	20/29/10/1:0	CLAY BLDR 0028 GRVL 0035
7137686	2010-01-06	0.00	0.00	0.00						
7150671	2010-08-26	13.40	0.00	2.70	DO	UT 0021			9/19/7/1:0	BRWN CLAY STNS HARD 0008 GREY CLAY BLDR 0016 GREY CLAY 0018 GREY LMSN 0044
7152519	2010-09-15	12.20	0.00	2.40	DO	UT 0020 OT 0030			8/14/20/1:0	BRWN LOAM STNS 0001 BRWN CLAY BLDR STNS 0012 GREY CLAY STNS HARD 0016 GREY LMSN 0040
7152520	2010-09-07	26.50	0.00	0.00	NU					BRWN LOAM STNS 0001 BRWN CLAY STNS BLDR 0016 GREY CLAY GRVL BLDR 0040 GREY SHLE 0041 GREY LMSN 0087
7154171	2010-10-28	12.50	0.00	4.60	DO TH	UT 0024			15/20/8/1:0	BRWN LOAM 0001 BRWN CLAY STNS GRVL 0016 GREY CLAY GRVL 0021 GREY LMSN 0041
7154173	2010-10-18	16.20	0.00	0.00	NU					BRWN CLAY GRVL STNS 0018 BRWN GRVL BLDR CLAY 0026 BRWN SAND GRVL 0030 GREY CLAY STNS HARD 0038 GREY LMSN 0053
7155672	2010-11-16	12.20	0.00	3.40	DO	UT 0022 SU 0030			11/19/5/1:	BRWN LOAM 0001 BRWN CLAY STNS GRVL 0016 GREY CLAY STNS HARD 0018 GREY LMSN 0040
7155673	2010-11-08	12.50	0.00	0.90	DO	UT 0013			3/10/18/1:	BRWN LOAM 0001 BRWN CLAY DNSE 0008 GREY LMSN ROCK FCRD 0011 GREY LMSN 0041
7159891	2011-02-24	12.50	0.00	3.50	DO	UT 0021			12/13/10/1:0	BLCK LOAM 0001 BRWN CLAY GRVL STNS 0013 GREY CLAY GRVL STNS 0020 GREY ROCK SHLE FCRD 0021 GREY LMSN 0041
7159892	2011-01-11	11.30	0.00	0.60	DO	UT 0013			2/9/20/1:0	BRWN LOAM 0001 BRWN CLAY BLDR 0003 BRWN CLAY GRVL STNS 0010 GREY LMSN FCRD 0012 GREY LMSN 0037
7167154	2011-07-14	21.30	0.00	9.40	DO	UT 0061 UT 0064			31/55/2/1:	BRWN LOAM 0001 BRWN CLAY STNS 0014 BRWN CLAY GRVL BLDR 0024 GREY CLAY GRVL STNS 0050 GREY LMSN 0070
7167155	2011-07-14	15.50	0.00	6.20	DO	UT 0033			20/39/2/1:	BRWN LOAM 0001 BRWN CLAY STNS BLDR 0010 BRWN CLAY GRVL HARD 0016 GREY CLAY GRVL 0031 GREY LMSN 0051

WELL_ID	COMPLETED	DEPTH	DP_BEDROCK	STATIC_LEV	WELL_USE	WATER	SCREEN	CASING_DIA	PUMP_TEST	FORMATION
2903091	1961-04-12	7.60	7.30	4.30	IN	FR 0025			14/22/60/3:0	LOAM 0001 BRWN CLAY STNS 0010 GREY BLDR CLAY 0024 GREY LMSN SHLE 0025
2903092	1961-11-03	10.10	0.00	4.90	DO	FR 0033		6	16/16/5/1:0	CLAY STNS 0018 GRVL 0033
2903096	1960-07-15	19.50	11.60	4.60	PS	FR 0060			15/30/33/3:0	CLAY GRVL MSND 0038 LMSN 0064
2903106	1962-07-06	15.80	10.70	9.10	CO	FR 0040			30/43/33/2:0	MSND BLDR 0035 GREY LMSN 0052
2903113	1967-01-23	21.30	0.00	6.10	PS	UK 0049 FR 0065			20/60/25/2:0	CLAY 0008 HPAN GRVL BLDR 0041 UNKN UNKN UNKN 0070
2903114	1951-08-27	7.30	5.80	0.90	DO	UK 0024			3/3/5/0:30	GREY CLAY MSND STNS 0019 GREY LMSN 0024
2903116	1964-11-19	13.70	0.00	4.60	DO	FR 0045			15/45/5/1:0	PRDR 0012 GRVL 0045
2903117	1965-09-23	11.60	7.30	6.10	DO	FR 0034			20/30/33/1:0	CLAY 0004 GRVL BLDR 0024 GREY LMSN 0038
2903118	1951-06-01	14.60	8.80	2.70	DO	FR 0029		6	9///:	PRDR 0019 HPAN CLAY 0029 LMSN 0048
2903119	1956-09-27	6.70	0.00	2.10	DO	FR 0020		6	7/12/3/1:0	CLAY 0018 GRVL 0022
2903120	1964-04-14	12.50	0.00	3.70	DO	FR 0038		6	12/25/10/3:0	CLAY 0020 GRVL 0041
2903121	1964-06-20	12.20	0.00	3.70	DO	FR 0038		6	12/30/15/2:0	CLAY GRVL 0010 GRVL BLDR 0025 FSND GRVL 0040
2903185	1962-09-13	13.70	7.00	1.80	DO	FR 0035			6/35/13/1:0	CLAY BLDR 0012 MSND GRVL 0023 GREY LMSN 0045
2903186	1959-08-21	10.70	0.00	4.30	DO	FR 0028		6	14/24/6/1:0	CLAY 0025 GRVL 0035
2903187	1959-08-23	10.70	8.80	6.10	DO	FR 0031			20/35/4/1:0	CLAY 0029 LMSN 0035
2903188	1959-08-27	14.30	13.10	5.50	DO	FR 0045			18/18/8/1:0	CLAY 0043 LMSN 0047
2903189	1966-11-09	13.40	0.00	5.20	DO	FR 0040		6	17/34/10/2:0	LOAM 0005 GRVL 0020 FSND 0025 GREY CLAY 0035 GRVL 0044
2903190	1965-03-15	12.20	11.00	3.00	DO	FR 0036			10/20/50/1:0	CLAY 0002 GRVL 0025 QSND 0033 GRVL 0036 LMSN
2903201	1955-08-10	24.40	12.20	6.10	DO	FR 0064			20/80/10/1:0	BLDR GRVL 0040 GREY LMSN 0080
2904013	1968-05-14	5.50	3.00	0.90	DO	FR 0016		6	3/12/10/1:0	CLAY 0003 GRVL 0010 LMSN 0016 GRVL 0018
2904148	1969-03-06	8.80	0.00	2.40	DO	FR 0025		6	8/15/25/1:0	CLAY 0002 GRVL 0029
2904225	1968-07-10	22.90	11.60	6.70	PS	FR 0067			22/50/25/3:0	CLAY 0010 MSND GRVL BLDR 0038 GREY LMSN 0075
2904305	1969-08-14	11.90	9.80	3.70	DO	FR 0036			12/30/25/:	BRWN LOAM 0005 GREY GRVL BLDR 0032 GREY SHLE LMSN 0036 GREY LMSN 0039
2904453	1970-02-07	8.50	0.00	5.50	DO	FR 0025		6	18/20/8/4:0	GREY CLAY GRVL 0009 GRVL 0028
2904514	1969-07-11	10.40	0.00	3.40	DO	FR 0034		6	11/18/25/2:0	CLAY 0005 BRWN MSND 0012 GREY STNS 0034
2905095	1971-11-24	12.20	3.70	0.00				6		CLAY BLDR 0012 GREY LMSN 0040
2905096	1971-11-24	21.90	4.60	0.00				6		CLAY BLDR 0015 GREY LMSN 0072
2905170	1971-08-09	18.30	7.00	3.70	DO	FR 0045 FR 0055			12/35/20/1:0	BRWN CLAY BLDR 0021 BRWN MSND GRVL 0023 GREY SHLE 0041 GREY LMSN 0060
2905370	1972-07-10	10.10	0.00	7.00	MN CO	FR 0030			23/23/30/2:0	SHLE LMSN 0005 LMSN 0032 GRVL LMSN 0033
2905892	1973-06-20	6.10	0.00	2.40	DO	FR 0018		6	8/20/30/0:30	BRWN CLAY SAND BLDR 0010 GREY GRVL 0020
2906477	1974-07-04	6.10	0.00	2.40	DO	FR 0020		6	8/8/30/1:45	BRWN LOAM 0002 GREY GRVL BLDR 0010 GREY GRVL 0020
2907328	1976-01-07	14.60	0.00	7.00	DO	FR 0046		6	23/38/18/5:30	GREY LMSN 0048
2909296	1979-11-06	15.20	0.00	9.10	ST	FR 0048		6	30/48/10/1:0	CLAY 0018 HPAN 0045 CGVL 0050
2911409	1986-10-14	26.80	25.00	2.70	DO	FR 0082			9/88/7/1:30	BRWN LOAM LOOS 0001 BRWN HPAN BLDR HARD 0032 GREY HPAN HARD PCKD 0082 GREY LMSN HARD 0088
2911842	1987-11-12	28.70	15.50	4.60	DO	FR 0051			15/94/2/1:0	BRWN SAND CLAY LOOS 0003 BRWN CLAY BLDR PCKD 0017 GREY CLAY HPAN GRVL 0051 GREY LMSN HARD 0094
2911845	1987-12-14	32.30	22.60	9.10	DO	FR 0075			30/106/2/2:0	BRWN CLAY BLDR PCKD 0030 GREY HPAN PCKD 0060 GREY CLAY GRVL PCKD 0074 GREY LMSN HARD 0106
2911864	1987-09-01	10.10	6.40	3.40	DO	FR 0040		6	11/35/10/1:0	CLAY GRVL 0021 LMSN 0033
2911977	1988-04-13	13.10	9.40	2.40	DO	FR 0034			8/40/3/1:30	BRWN CLAY BLDR 0009 GREY GRVL BLDR 0017 GREY CLAY GRVL STNS 0031 GREY LMSN 0043
2915694	1993-06-23	10.70	2.10	0.60	NU	FR 0011 FR 0018			2/16/3/1:0	BRWN LOAM CLAY 0001 BRWN CLAY 0007 GREY SHLE FCRD 0011 GREY LMSN 0035

2917714	1998-02-17	13.70	2.40	0.60	DO	FR 0010 SU 0033			2/30/20/1:30	BRWN CLAY DNSE 0005 BRWN CLAY BLDR FCRD 0008 GREY SHLE 0010 GREY LMSN 0045
2917715	1998-02-10	11.60	0.00	0.00	NU					BRWN CLAY 0005 BRWN CLAY BLDR 0011 GREY CLAY STNS 0017 GREY HPAN 0024 BRWN SAND 0028 GREY CLAY BLDR FCRD 0038
2917716	1998-02-03	14.00	6.40	4.60	DO	FR 0024			15/30/15/1:0	BRWN CLAY GRVL STNS 0001 GREY CLAY HPAN 0019 GREY CLAY BLDR HPAN 0021 GREY LMSN 0046
2918005	1998-12-16	11.00	3.70	1.80	DO	FR 0016 FR 0020			6/9/25/1:0	BRWN CLAY STNS 0004 BRWN CLAY BLDR 0009 GREY CLAY GRVL BLDR 0012 GREY LMSN 0036
2916901	1995-10-06	11.90	11.90	3.40	DO	FR 0036			11/32/8/1:0	BRWN LOAM 0001 BRWN CLAY DNSE 0004 BRWN CLAY GRVL STNS 0016 GREY CLAY GRVL STNS 0023 GREY GRVL CLAY 0028 GREY GRVL 0031 GREY CLAY BLDR 0039 GREY LMSN 0039
2916902	1995-10-03	12.50	9.40	3.40	DO	FR 0038			11/26/25/1:0	BRWN LOAM 0001 BRWN CLAY DNSE 0003 BRWN CLAY GRVL STNS 0015 GREY CLAY GRVL BLDR 0022 GREY GRVL CLAY HARD 0031 GREY GRVL LMSN FCRD 0036 GREY LMSN 0041
2916930	1995-11-09	24.10	24.10	19.50	DO	FR 0079			64/70/15/1:0	BRWN LOAM 0001 BRWN CLAY STNS 0018 BRWN CLAY GRVL BLDR 0023 GREY CLAY GRVL BLDR 0038 GREY CLAY GRVL HARD 0079 GREY LMSN 0079
2917673	1997-11-14	30.80	12.20	7.60	DO	FR 0058 SU 0095			25/101/1/1:0	BRWN CLAY PCKD 0002 BRWN HPAN BLDR HARD 0024 GREY HPAN GRVL PCKD 0040 GREY LMSN HARD 0101
2917674	1997-11-27	21.30	2.70	0.00	NU					BRWN CLAY PCKD 0002 BRWN HPAN GRVL BLDR 0009 GREY LMSN HARD 0070
2917675	1997-11-12	25.90	14.60	4.60	DO	FR 0052			15/84/4/2:0	BRWN CLAY PCKD 0004 BRWN HPAN BLDR PCKD 0025 GREY HPAN GRVL PCKD 0042 GREY HPAN HARD PCKD 0048 GREY LMSN HARD 0085
2917676	1997-11-11	25.90	12.80	7.30	DO	FR 0042 FR 0063			24/85/6/3:0	BRWN CLAY PCKD 0003 BRWN CLAY STNS PCKD 0018 BRWN CLAY SAND GRVL 0042 GREY LMSN HARD 0085
2917677	1997-11-07	30.50	24.40	18.30	NU	SU 0095			60/100/1/0:30	BRWN CLAY PCKD 0002 BRWN HPAN BLDR PCKD 0030 GREY HPAN GRVL PCKD 0080 GREY LMSN HARD 0100
2917678	1997-11-05	12.20	11.00	4.90	DO	FR 0037			16/25/25/2:0	BRWN CLAY PCKD 0002 BRWN CLAY HPAN STNS 0016 GREY CLAY HPAN BLDR 0019 GREY GRVL LOOS 0036 GREY SHLE LMSN FCRD 0037 GREY LMSN HARD 0040
2917679	1997-11-04	9.10	6.70	0.00	DO	FR 0022			0/25/15/2:0	BRWN CLAY PCKD 0005 BRWN HPAN BLDR PCKD 0008 GREY GRVL BLDR LOOS 0022 GREY LMSN HARD 0030
2917680	1997-10-29	11.30	11.30	1.80	DO	UK 0037		6	6/25/30/2:30	BRWN CLAY PCKD 0006 BRWN CLAY HPAN GRVL 0017 GREY CLAY PCKD 0020 GREY CLAY HPAN PCKD 0036 GREY GRVL LOOS 0037 GREY LMSN HARD 0037
2917701	1998-01-16	15.20	6.70	0.90	DO	FR 0024			3/45/5/1:0	BRWN CLAY BLDR 0018 GREY CLAY 0022 GREY LMSN 0050
2917702	1998-01-28	39.60	14.60	2.40	DO	FR 0048 FR 0073			8/126/2/1:0	BRWN CLAY STNS BLDR 0009 BRWN CLAY BLDR 0012 GREY CLAY BLDR HARD 0025 GREY CLAY HARD 0048 GREY LMSN 0110 WHIT LMSN 0130
2917796	1998-06-02	22.90	1.50	1.20	DO	FR 0008 FR 0010			4/72/2/1:0	BLCK LOAM WDFR STNS 0001 BRWN CLAY STNS WDFR 0005 GREY SHLE FCRD 0008 GREY LMSN 0075
2917797	1998-06-05	12.20	1.50	1.80	DO	FR 0008 FR 0011			6/7/25/1:0	BLCK LOAM STNS WDFR 0001 BRWN CLAY STNS WDFR 0005 GREY SHLE FCRD 0007 GREY LMSN 0040
2917798	1998-06-10	15.20	2.70	5.80	DO	FR 0023 SU 0034			19//10/1:0	BLCK LOAM SAND WDFR 0001 BRWN CLAY BLDR 0005 GREY BLDR 0009 GREY LMSN 0050
2917799	1998-06-16	12.50	2.40	3.70	DO	FR 0017			12/33/12/1:0	BRWN LOAM 0001 BRWN CLAY STNS 0005 GREY CLAY BLDR 0008 GREY LMSN 0041

2917800	1998-06-22	19.80	6.70	2.10	DO	FR 0022			7/56/12/1:0	BLCK LOAM 0001 BRWN SAND 0002 BRWN CLAY DNSE 0009 BRWN CLAY GRVL DNSE 0014 BRWN CLAY BLDR 0018 GREY CLAY STNS GRVL 0022 GREY LMSN 0065
2917873	1998-08-17	19.80	4.90	3.70	DO	FR 0017 FR 0058			12/60/4/1:0	BRWN CLAY WDFR DNSE 0004 BRWN CLAY BLDR 0009 BRWN CLAY GRVL 0016 GREY SHLE FCRD 0017 GREY LMSN 0065
2917874	1998-08-28	16.80	3.40	3.70	DO	FR 0018 SU 0029			12/40/9/1:0	BRWN CLAY STNS DNSE 0008 BRWN CLAY GRVL STNS 0011 GREY LMSN 0055
2917875	1998-08-24	30.50	4.30	2.70	DO	FR 0018 FR 0041 FR 0072			9/96/3/1:0	BRWN CLAY WDFR 0005 BRWN CLAY GRVL STNS 0008 BRWN CLAY BLDR STNS 0010 GREY CLAY HARD 0014 GREY LMSN 0072 WHIT LMSN 0100
2917914	1998-09-07	18.60	5.80	8.50	DO	FR 0028 FR 0030			28/48/15/1:0	BRWN CLAY 0006 BRWN CLAY GRVL STNS 0019 GREY CLAY FCRD ROCK 0025 GREY LMSN 0061
2918486	1999-11-17	39.60	14.60	0.00	NU	FR 0048 SA 0073				BRWN CLAY STNS BLDR 0009 BRWN CLAY BLDR 0012 GREY CLAY BLDR HARD 0025 GREY CLAY HARD 0048 GREY LMSN 0110 WHIT LMSN 0130
2918837	2000-02-21	12.20	7.90	0.00	NU	UK 0026		6		BRWN SAND LOOS 0014 GREY SAND GRVL LOOS 0019 GREY CLAY SAND PCKD 0026 GREY LMSN HARD 0040
2918838	2000-01-26	10.70	3.40	1.20		UK 0016 UK 0028			4/35/50/9:0	BRWN CLAY TILL BLDR 0011 GREY LMSN HARD 0035
2918839	2000-01-20	5.80	3.40	1.20		UK 0016		6	4/9/30/1:0	BRWN CLAY PCKD 0004 BRWN CLAY SAND PCKD 0011 GREY LMSN HARD 0019
2918843	2000-02-25	12.20	8.20	0.60		UK 0027			2/6/30/1:40	BRWN CLAY PCKD 0016 GREY CLAY PCKD 0020 BRWN SAND CLAY PCKD 0026 BRWN SAND GRVL LOOS 0027 GREY LMSN HARD 0040
2918891	2000-08-09	0.00	0.00	0.00	NU					
2919709	2002-12-12	13.40	13.10	4.00	DO	FR 0043			13/22/25/1:0	BRWN CLAY 0002 GREY CLAY GRVL STNS 0019 GREY CLAY 0023 GREY CLAY GRVL 0039 GREY CLAY GRVL BLDR 0043 GREY LMSN 0044
2919824	2003-04-23	0.00	0.00	0.00						
2919825	2003-05-23	0.00	0.00	0.00						
2920726	2005-06-09	14.00	10.10	2.30	DO	FR 0043		6.11	7/21/7/1:0	BRWN LOAM 0001 BRWN CLAY 0008 BRWN CLAY GRVL STNS 0015 GREY CLAY GRVL STNS 0033 GREY SHLE ROCK FCRD 0036 GREY LMSN 0046
2921054	2005-11-25	0.00	0.00	0.00						
7050008	2007-08-20	0.00	0.00	7.50	PS			6.21	25/28/8/1:0	
7050044	2007-08-20	0.00	0.00	6.10	PS			6.21	20/21/8/1:0	
7126261	2009-04-17	13.40	0.00	7.20	CO	UT 0044		6.25	24/27/10/1:0	BRWN CLAY STNS PCKD 0012 BRWN SHLE LMSN FCRD 0024 GREY SHLE LMSN FCRD 0044
7144259	2010-04-29	14.60	0.00	3.30	DO MO	FR 0039			11//20/1:	BRWN LOAM 0001 BRWN CLAY DNSE 0005 BRWN CLAY GRVL BLDR 0018 GREY CLAY GRVL BLDR 0036 GREY SHLE 0037 GREY LMSN 0048
7144282	2010-04-22	12.20	0.00	1.50	DO	FR 0029			5/12/20/1:	BRWN LOAM 0001 BRWN CLAY DNSE 0009 BRWN CLAY GRVL STNS 0012 GREY CLAY BLDR 0020 GREY GRVL 0027 GREY SHLE 0028 GREY LMSN 0040
7144796	2010-05-11	0.00	0.00	7.10				6.25	23/25/10/1:0	
7167151	2011-07-22	14.00	0.00	2.30	DO	UT 0038 UT 0041			7/37/10/1:	BRWN CLAY DNSE 0009 BRWN CLAY GRVL STNS 0016 GREY CLAY GRVL STNS 0035 GREY GRVL BLDR ROCK 0038 GREY LMSN 0046
7167152	2011-07-11	14.00	0.00	2.30	DO	UT 0041			7/15/12/1:	BRWN CLAY STNS 0010 BRWN CLAY GRVL STNS 0017 GREY CLAY GRVL STNS 0035 GREY GRVL BLDR 0038 GREY LMSN 0046

7168720	2011-08-26	13.40	0.00	3.50	DO	UT 0041			11/16/20/1:0	BRWN CLAY GRVL STNS 0017 GREY CLAY GRVL STNS 0028 GREY CLAY GRVL HARD 0031 GREY GRVL 0033 GREY SHLE 0036 GREY LMSN 0044
7168721	2011-08-18	13.10	0.00	3.10	DO	UT 0038			10/14/22/1:0	BRWN CLAY GRVL STNS 0017 GREY CLAY GRVL BLDR 0025 GREY CLAY GRVL HARD 0031 GREY GRVL 0032 GREY SHLE 0033 GREY LMSN 0043
7168722	2011-08-09	12.50	0.00	3.30	DO	UT 0036 UT 0040			11/15/20/1:0	BRWN CLAY GRVL BLDR 0017 GREY CLAY GRVL BLDR 0032 GREY GRVL 0033 GREY SHLE 0036 GREY LMSN 0041
7169615	2011-09-15	14.30	0.00	3.90	DO	UT 0042			13/16/20/1:	BRWN CLAY GRVL STNS 0016 GREY CLAY GRVL BLDR 0039 GREY LMSN 0047
7169616	2011-09-07	14.30	0.00	4.30	DO	UT 0045			14/18/20/1:	BRWN LOAM 0001 BRWN CLAY GRVL STNS 0019 GREY CLAY GRVL STNS 0033 GREY GRVL 0036 GREY CLAY GRVL STNS 0039 GREY SHLE 0041 GREY LMSN 0047
7173694	2011-07-29	12.80	0.00	3.40	DO	UT 0040			11//20/1:	BRWN CLAY GRVL STNS 0014 GREY CLAY GRVL STNS 0034 GREY GRVL 0035 GREY SHLE LMSN FCRD 0038 GREY LMSN 0042
7192218	2012-08-09	8.20	0.00	1.10	DO	UT 0027		6.25	4/7/12/1:	BRWN CLAY PCKD 0008 BRWN CLAY SAND PCKD 0016 GREY LMSN FCRD 0027
7224636	2014-02-26	0.00	0.00	0.00						
7234404		0.00	0.00	0.00						
7262830	2016-03-01	0.00	0.00	0.00						
7262831	2016-03-15	0.00	0.00	0.00						
7266817	2016-06-07	10.50	0.00	0.00	MO		0034 10	2		BRWN CLAY BLDR PCKD 0016 GREY CLAY PCKD 0031 GREY GRVL LOOS 0034
7266747	2016-05-13	0.00	0.00	0.00	MO			2		
7278389	2016-12-15	0.00	0.00	0.00						
7278390	2016-12-15	0.00	0.00	0.00						
7282661		0.00	0.00	0.00	PS					
7301528	2017-10-06	15.20	0.00	4.10	DO	UT 0038		6.25	13/28/12/1:0	BRWN CLAY TILL PCKD 0019 GREY CLAY TILL PCKD 0037 GREY LMSN FCRD 0038 GREY LMSN HARD 0050
7314333	2018-06-11	14.00	0.00	4.20	DO	UT 0040		6.25	14/16/11/1:0	BRWN CLAY TILL PCKD 0016 GREY CLAY TILL PCKD 0030 GREY GRVL LOOS 0032 GREY CLAY GRVL PCKD 0036 GREY LMSN HARD 0046
7317849	2018-06-12	9.80	0.00	1.40	DO	UT 0030		6.25	5/9/11/1:	BRWN CLAY BLDR PCKD 0013 GREY CLAY BLDR PCKD 0020 GREY GRVL LOOS 0027 GREY LMSN HARD 0032
7317869	2018-06-11	14.00	0.00	4.00	DO	UT 0040		6.25	13/15/11/1:	BRWN CLAY TILL PCKD 0016 GREY CLAY TILL PCKD 0030 GREY GRVL LOOS 0038 GREY LMSN HARD 0046
7341597	2019-09-04	0.00	0.00	0.00				2.35	/25/1/1:	
7374923	2020-12-08	0.00	0.00	0.00						