



FINAL REPORT

**Hydrogeological Impact Assessment for
the Expansion of the Cruickshank
Elginburg Quarry**

Lot 12 to 15, Concession 5, City of Kingston, County
of Frontenac, Ontario

Presented to:

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EXECUTIVE SUMMARY

Morrison Hershfield Limited (MH) was retained by Cruickshank Construction Limited (Cruickshank) to assess the hydrogeological impacts of the expansion of the Cruickshank Elginburg Quarry.

The study included background data review, site and area inspections, drilling of eight boreholes using a variety of drilling methods over a three year period, hydraulic testing of open holes, installation of piezometers in select holes, hydraulic testing of the piezometers, groundwater level monitoring, and groundwater sampling and analysis. The study also included analysis of the collected field data to determine a conceptual hydrogeological model of the expansion lands and surrounding area, predictive analysis of drawdown cone propagation, impact assessment, and proposal of monitoring and contingency plans.

The results of the field work indicate that the bedrock, which is limestone of the upper and middle members of the Gull River Formation, is of very low permeability except within a few hundred metres of the south-facing escarpment at the south end of the expansion lands. Here, weathering and/or a different stress regime has resulted in enhanced permeability and a depressed water table.

Quarrying and dewatering of the quarry sump will lower the water table at the quarry itself. Analysis indicates that this lowering of the water table will not propagate more than 50 m from the quarry walls on the north side of the expansion, and will not propagate more than 100 m from the quarry walls on the west side of the expansion. Following rehabilitation, lakes are expected to form in the quarries on the north and south side of the pipeline which traverses the property. The north lake is expected to flow into the south lake, and the south lake is expected to equilibrate at approximately the elevation of the current water table at the south side of the property. Approximate lake elevations have been estimated.

Wells, aquifers, surface water and structures were all considered in the impact assessment, and the highest risk receptors are the two wells closest to the expansion lands at 2528 Unity Road and 2467 Unity Road. The very low permeability of the limestone bedrock in this vicinity will limit the propagation of drawdown from the dewatered quarry, and the wells should continue to be recharged locally by precipitation. A minor change in flow along the ditch on the south side of Unity Road where the expansion lands abut is anticipated.

Quarterly groundwater level monitoring in the perimeter open holes and piezometers and in the two closest domestic wells is recommended to provide ongoing information about the actual effects of the quarry on groundwater levels between the quarry face and the potential receptors, as the quarry develops over the years or decades.

A contingency plan is recommended to address the unlikely event of a water well interference complaint or if monitoring data suggests a potential impact to a receptor.

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1. INTRODUCTION

Cruickshank Construction Limited (Cruickshank) owns the Elginburg Quarry, Lots 13 and 14, Concession 5, City of Kingston, Ontario. The quarry is licensed under the Aggregate Resources Act (# 2901). Cruickshank intends to expand this quarry westward into Lots 12 and 13, Concession 5 (see Figure 1). These expansion lands are south of Unity Road and north of Burbrook Road, to the west of the existing quarry.

Morrison Hershfield Limited (MH) was retained by Cruickshank to assess the hydrogeological impacts of the expansion of the Cruickshank Elginburg Quarry in support of the following:

- an application for major site plan amendment under the Aggregate Resources Act (ARA) for the expansion to be made with Ministry of Natural Resources;
- City of Kingston zoning by-law amendment; and,
- an eventual Permit to Take Water application to be made for the expanded quarry with the Ministry of the Environment.

1.1 Study Area

The study area is approximately defined by the extents shown on Figure 1. The study area includes the area to be licensed and the existing and proposed extraction limits, as well as the area surrounding the quarry including the nearest water wells, wetlands, or other features potentially impacted by the project.

1.2 Scope of Work

The scope of work is defined by the Provincial Standards for a Hydrogeological Level 2 Technical Report, Category 2 - Class “A” Licence for quarrying below the water table. The scope includes field work and hydrogeological analysis deemed necessary to achieve the objective. All work is to be carried out in accordance with applicable industry standard practices.

1.3 Contents of Report

This section of the report provides information on the context for the study, the scope of work and the layout of the report. Section 2 describes the methods used in the study. Section 3 describes the results including background information, the results of field investigations, and any calculations necessary for the impact assessment. Section 4 describes the impact assessment including identification of Valued Ecosystem Components and assessment of the impacts of the project on all identified potential receptors. Section 5 presents a summary of the results and the potential impacts, describes any recommended monitoring, and contingency plans to be implemented in the event of certain occurrences. Section 6 provides closure notes and signatures of the report authors, and Section 7 presents the limitations and use of this report. References are provided in Section 8. Figures, tables, and supporting documents are provided in the appendices.

2. METHODS

This section describes the methods used in this study. Specifics to the project, including dates, specific data sources and specific details of the chosen methodology are included as part of the results.

2.1 Background Data Review

Background data review was conducted in accordance with industry standard practices using readily available information from federal, provincial, municipal and other sources of information. The following is a non-exhaustive list of key data sources:

- Cruickshank files and previous reports;
- Ministry of the Environment Water Well Information System (WWIS, MOE, 2012);
- Geology Ontario (maps published by the Ontario Geological Survey); and,
- Google Earth (for quick reference topographic and land use information).
- Land Information Ontario, for detailed topographic and hydrological mapping.

The background review included analysis as necessary to develop an overall understanding of the hydrogeological setting and potential impacts of the expansion. In this case, the analysis included the tabulation and plotting of site-specific borehole information; tabulation and use of (WWIS) water well information to determine depths and available drawdown in area wells; plan view plotting of surface water features such as streams, rivers, lakes and wetlands to assess groundwater and surface water interaction; and plan view plotting of surficial and bedrock geology to determine the likely occurrence of surficial deposits as well as the occurrence and thickness of sedimentary rocks.

2.2 Site Inspection

Site inspections were carried out on November 25, 2013 and on January 10, 2013, primarily to observe geological and hydrogeological conditions in the existing quarry. During these inspections, the quarry walls were inspected for variations in rock bedding and colour, and for signs of seepage. Photographs were taken of observed features.

2.3 Subsurface Investigation

Hydrogeological analysis and impact assessment requires that the properties of the soil, rock and groundwater be known in proximity to the area affected by the project. Unless it can be inferred entirely from existing sources, field work such as drilling and soil/rock sampling is required. In this case, subsurface investigations were carried

out by two separate consultants over a four year period, for the combined purpose of investigating the rock quality and the hydrogeology. The remainder of this section describes the methods used as it pertains to the subsurface properties.

2.3.1 Diamond Drilling, Core Recovery, Core Logging

Diamond drilling allows for the recovery of a piece of rock core, with diameter determined by the drill bit size. Core is recovered from the core barrel, inspected and placed in core boxes, labeled to indicate depth interval. Diamond drilling was carried out under Morrison Hershfield supervision. Each core was visually inspected for colour, texture and composition of the rocks, fractures in the core and evidence of fossils or bioturbation. The surface of the core was also scratch-tested for hardness using a pocket blade. The classification shown in Table 2.1 was used to determine the hardness of the rock.

Table 2.1: Rock hardness Classification

Classification	Description
Very Soft	Can be peeled with a knife.
Soft	Can be easily gouged or carved with a knife.
Medium soft	Can be readily scratched with a knife blade; scratch leaves heavy trace of dust and is readily visible after powder blown away.
Hard	Can be scratched with a knife with difficulty; scratch produces little powder and is often faintly visible.
Very Hard	Cannot be scratched with a knife or can barely be scratched with a knife.

Acid testing was also carried out on the core samples to distinguish between limestone and dolostone. Acid was prepared by mixing muriatic acid and water in a 1:7 ratio to form a diluted HCl acid. The HCl acid was transferred into a squeeze bottle fitted with a cap to enable precise application of small amounts of acid onto the core samples. When applied to limestone, acid reacts and fizzes vigorously as carbon dioxide is produced. When applied to dolostone, acid reacts to a lesser extent and fizzes very slightly. Dolostone surfaces typically need to be scratched prior to adding acid to facilitate a more visible reaction. It is noted that the reaction may also take place on other rock types if calcite is present (e.g. sandstone with calcite cement).

Diamond drilling had also been carried out in December, 2010 at DDH10-01 by Marathon Drilling Co. Ltd. under the supervision of Golder. The core had been split (apparently using a rotary rock saw) and the remaining half was available for inspection by MH.

2.3.2 Rock Drilling and Rock Chip Logging

The bit of a rock drill is pushed and hammered into the ground, while the crushed rock chips are brought to the surface using compressed air. Common types of rock drills at quarry sites include water well rigs and top-hammer rigs used in quarrying.

The drilling was carried out in intervals and rock chips from each interval were flushed out into piles near the drill. Rock chips samples at each interval were collected using a trowel and placed into zip-lock bags for later analysis. After samples were taken, the piles were cleared out to make room for the next rock chip sample interval so as to not mix two sample intervals.

The rock chips were later arranged into compartmentalized boxes for ease of storage and assessment. The rock chips were visually inspected for colour and tested for limestone and/or dolostone using HCl acid (as described in Section 2.2). All observations and field test results were noted down and used to produce borehole logs using Gint software.

2.3.3 Downhole Geophysical Logging

Downhole geophysics was carried out in all boreholes by Notra Inc. of Ottawa. It was carried out using a BMP06 probe which measures simultaneously the temperature, apparent conductivity, apparent resistivity, single point resistance, magnetic susceptibility and natural gamma at a rate of 2 readings per second recorded on a logging computer. The probe was lined up with the top of the casing and a depth of zero was entered in the logging computer. With the computer logging, the probe was lowered at approximately 5 meters per minute, resulting in one data point for all parameters recorded every 4 cm. The probe was stopped briefly at calibrated 10 meter intervals to confirm accuracy of the logged depth. After reaching the end of the hole, the probe was brought back up at a faster rate, while still logging data. The up data is compared to the down data to ensure proper operation of the unit.

Depth data in each borehole were calibrated using the 10 m calibration intervals and each parameter was extracted to an asc file. The files were then plotted in LogView from which the analysis was conducted. More detailed methodology and analysis can be seen in the report attached in Appendix D.

2.4 Water Investigation

In hydrogeological studies, especially at a regional scale, it is necessary to understand the interaction of groundwater and surface water.

2.4.1 Groundwater Level Monitoring and Hydraulic Testing

To provide information on the permeability of the subsurface, a rising head (bail) test was performed on all open holes, and on all installed piezometers. Open holes were pumped down using a 51 mm (2") submersible pump, while piezometers were pumped down using a hand-actuated inertial foot valve on the bottom of tubing installed to the bottom of piezometer. Water levels were monitored as the well or piezometer recovered using an electric water level tape. The hydraulic conductivity of the tested media was determined by applying the Hvorslev method to the measured water level recovery data.

To determine information on the variation in hydraulic conductivity with depth within the stratigraphy, packer testing was completed in one open hole. Packer testing is conducted in intervals of an open borehole, which are isolated from the remainder of the borehole using inflatable rubber "packers". The hydraulic conductivity of the test interval is calculated using the equation (Powers et al., 2007):

$$K = \frac{Q}{2\pi L \Delta H} \ln \left(\frac{L}{r_w} \right) \quad (1)$$

where,

K = Hydraulic conductivity of borehole interval [L/T]

L = Length of test section [L]

Q = Steady injection rate [L³/T]

ΔH = Differential pressure head [L]

r_w = Radius of borehole [L].

The differential pressure head is the gauge pressure converted into metres of water, plus the height of the gauge above the water table.

2.4.2 Piezometer Installation

The design of the piezometers was finalized based on observations of water bearing zones made during drilling. Piezometers were completed using 32 mm inside diameter PVC slotted screen and riser pipe, washed crushed stone for the gravel packs, and bentonite clay seals. The piezometers were installed in conformance with the requirements of Ontario Regulation 903 (Wells) by a licensed well driller.

2.4.3 Groundwater Sampling and Analysis

Groundwater sampling was conducted in open holes and/or piezometers where permeability allowed. The water sampling procedure involved purging three well volumes and then filling the sampling bottles provided by the

laboratory with the groundwater. Samples to be analyzed for metals were field filtered. The sampling bottles were returned to Caduceon Laboratories Ltd., in Ottawa, Ontario, for some or all of the following analyses, depending on setting:

- Inorganics and general chemistry (alkalinity, ammonia, chloride, conductivity, NO₂, NO₃, pH, TSS, sulphate, carbonate, bicarbonate, hardness, phenolics, turbidity);
- Metals (Al, B, Cd, Ca, Co, Cr, Cu, Fe, Pb, Mg, Ni, Ag, Si, K, Na & Zn);

Although there is no requirement to meet these standards, the results were compared to both the Ontario Drinking Water Quality Standards (ODWQS) (MOE, 2003) and the Provincial Water Quality Objectives (PWQO) (MOE, 1994) as a reference point.

2.4.4 Surface Water Inspection and Sampling

Surface water and storm water management features were inspected in the existing quarry and in the expansion area. Water samples were collected from strategic locations within and downstream of the existing quarry. Water samples were collected with a clean container which was used for measurement of field parameters (temperature, pH, electrical conductivity, and dissolved oxygen) and to decant the samples into bottles provided by the laboratory. Samples were kept refrigerated, and were shipped to the analytical laboratory under Chain of Custody. Samples were analysed for the following parameters:

- General chemistry including Alkalinity, Ammonia, Chloride, Conductivity, NO₂, NO₃, TP/TKN, TSS, pH, TDS, Sulphate, Carbonate, Bicarbonate, Phenols (4AAP)
- Metals (Hardness, Al, As, Ba, Be, B, Cd, Ca, Co, Cr, Cu, Fe, Pb, Mg, Mn, Mo, Ni, Ag, Si, Hg, K, Na, Sr, Tl, Ti, V & Zn)
- BOD, COD, DIC, DOC
- Oil and Grease (Total)
- PHC (F1-F4)

Field and laboratory measured parameters were compared to Provincial Water Quality Objectives (PWQO, being referenced as MOE, 1994) to further assess the water quality being discharged from the existing quarry.

2.5 Groundwater Flow Calculations

2.5.1 Drawdown during Operations Analysis

Drawdown analysis was conducted assuming steady state radial flow towards the extraction area at full development of the quarry, using a two-step process. In the first step, the radius of influence of the dewatering, r_0 , was estimated using a variety the method of Sichart and Kryieleis (see Powers et al., 2007):

$$r_0 = 3000s_{qry}\sqrt{K} \quad (2)$$

where

r_0	=	radius of influence of the quarry dewatering [L; metres]
s_{qry}	=	drawdown at the quarry face [L; metres]
K	=	Hydraulic conductivity of the bedrock [L; metres per second].

In the second step, the radial distance to the critical drawdown used in the impact assessment (i.e., to determine where to draw contours of drawdown) was calculated from a re-arrangement of the equation describing steady state radial flow in a confined aquifer (see Bear, 1979). That is,

$$r_{crit} = r_0 \left(\frac{r_0}{r_{qry}} \right)^{\frac{s_{crit}}{s_{qry}}} \quad (3)$$

where

r_0	=	radius of influence of the quarry dewatering [L; metres]
r_{crit}	=	radius to the critical drawdown s_{crit} [L; metres]
r_{qry}	=	radius of the quarry [L; metres].
s_{qry}	=	drawdown at quarry face [L; metres]
s_{crit}	=	critical drawdown between 0 and s_{qry} for the impact assessment [L; metres]

2.5.2 Lake Level Following Rehabilitation Analysis

Following final rehabilitation of the quarry, a lake will be established north and south of the pipeline in the quarries which will no longer be pumped. Lake levels were estimated using best judgment considering the existing water table elevation, rock permeability, estimates of how this rock permeability may change during quarrying, topography, and the influence of evaporation.

2.6 Storm Water Management Considerations

Management of storm water during operations of the expanded quarry was considered in a qualitative fashion, considering how the quarry is currently operated, and how it may operate in the future.

2.7 Impact Assessment

Groundwater impacts are generally assessed based on calculated or estimated drawdown of the water table/potentiometric surface, and on calculated or estimated changes in volumetric flow (such as loss of baseflow to local streams). The impact assessment is made by considering the impacts of these project-induced calculated or estimated hydrogeological effects on the following potential receptors:

- Wells and Aquifers;
- Surface water;
- Existing subsurface contamination;
- Structures; and,
- Ecology.

3. RESULTS

3.1 Background Data Review

This section describes the results of the background data review. Key documents found during the review were:

- Hydrogeological Investigation of Elginburg Quarry, Part Lots 14 & 15, Conc. V, Township of Kingston, County of Frontenac. Report No. 934000, Gorrell Resource Investigations, 1995.
- Hydrogeological Investigation of the Cruickshank Elginburg Quarry, Lot 14 and 15, Concession V, City of Kingston, County of Frontenac, by Morrison Hershfield, dated September, 2012.

3.1.1 Physiography and Topography

The Elginburg Quarry is located in the Napanee Plain physiographic region (Chapman and Putman, 1984). This region is characterized by the flat topography of the limestone formations. The defining feature of the study area is a north-east south-west trending escarpment which is approximately coincident with the south end of the existing and proposed expanded Cruickshank Elginburg quarry. The escarpment marks the edge of the limestone plain. At Unity Road the ground surface is essentially flat in the east west direction, at approximately 140 masl.

3.1.2 Drainage and Surface Water (Hydrology)

Figure 1 shows the surface water features in and around the existing Elginburg Quarry and the expansion area. The main branch of Collins Creek traverses the south east corner of the Figure 1 map area, flowing northeast to southwest and crossing Bur Brook Road approximately one kilometer west of Silvers Corners. South of existing quarry and expansion area, Collins Creek turns northerly and flows for approximately 0.5 km on the north side of Bur Brook Road. This section of the creek is joined by a tributary from the north carrying drainage from the existing quarry and Elginburg village area, and is also the receiver of overland flow from the south part of the expansion area. Drainage from the north part of the expansion area flows overland in the southwesterly direction, joining another tributary which joins Collins Creek in a wetland south of Burbrook Road. Collins Creek flows to the south approximately 12 km before draining into Lake Ontario at Collin's Bay.

3.1.3 Geology

Most of the expansion lands are underlain directly by bedrock, with very little overburden. In some low-lying upland areas (coincident with the drainage features), and at the base of the escarpment, there are massive to well-

laminated, fine-textured glaciolacustrine deposits of silt and clay with minor sand and gravel (Ontario Geological Survey, 2010).

Above the escarpment the ground surface is at approximately 126 masl and the bedrock is mapped as the upper member of the Gull River Formation (Carson, 1981). Below the escarpment the ground surface is at approximately 90 masl, and the rock is mapped as Precambrian. On the escarpment itself, the rock is mapped as the middle member of the Gull River Formation, which contains buff and green siltstone, and which appears from the mapping to be approximately 20 m thick. The geology from Carson (1981) is approximately shown on Figure 2.

The Ministry of the Environment water well database (Water Well Information System or WWIS, accessed June 2012) indicates overburden depths between 0.6 m to 1.8 m throughout the property, and limestone to at least 43 m depth on the northern side of the property and to at least 28 m depth on the western side of the property. The limestone is generally underlain directly by granite, but sometimes by sandstone being the arkosic sandstone, siltstone and shale of the Shadow Lake formation. The geology information from the WWIS is shown schematically on three cross-sections presented in Figures 3, 4 and 5. The locations of the cross-section lines are shown on Figure 1 and 2.

A HQ-sized rock core was collected to 36.4 m depth by Golder Associates Ltd. (2011) as part of an aggregate resource assessment for the expansion. The 100 mm diameter diamond-drilled borehole (DDH10-01) was cased at surface, and left as an open hole. The rock was determined to be Gull River Formation micritic limestone. The borehole log is included in Appendix B.

Three boreholes were advanced in 2011 to 36 m depth by Golder Associates Ltd. (2011). These 152 mm diameter air-rotary (water well rig) boreholes (BH11-02, BH11-03, and BH11-04) were cased at surface and left as an open hole. No borehole logs were available for these.

3.1.4 Hydrogeology

There are approximately 350 water wells in the study area. These vary in depth from less than one metre to 123 m, with an average depth of 29 m. The static levels vary from being at ground surface to 53 m depth, with an average depth of 10 m. Approximately ninety percent of the wells were completed in limestone, seven percent in granite, and two percent in sandstone (Shadow Lake Formation).

The locations of all houses/businesses observed in satellite imagery or in the area reconnaissance within 500 m of the existing or proposed extraction area are shown on Figure 1. The closest houses to the expansion area are at 2528 Unity Road, across Unity Road and to the west, and 2467 Unity Road, where the proposed extraction area is set back further from Unity Road. The wells are estimated to be approximately 60 m and 100 m from the proposed extraction area, at these two locations, respectively. An attempt was made to correlate these locations with the WWIS water wells. One-to-one correlation

between specific houses/businesses and specific wells was not possible, but clusters of houses/businesses could be correlated to clusters of wells in the WWIS. The closest Well

WWIS water well 2205740 in the northwest corner of the proposed extraction area (see Appendix H and Figure 5), can be correlated to the houses on Unity Road west of the proposed extraction area. This well was drilled to approximately 44 m depth, through less than a metre of clay and then through limestone. Water was found at approximately 23 m depth, and the static level was less than 2 m below ground. Other WWIS wells in this area include 2214366 and 2218761, further to the northwest. These wells were drilled through then, and then terminated very shallow (less than 7 m) in limestone.

WWIS water well 2215473 on the east side of Cordukes Road midway between Unity Road and Bur Brook Road (see Appendix H and Figure 4) is representative of wells in this area. This well was drilled to approximately 40 m depth, again through less than a metre of clay, and then through shale and limestone. Water was found at 11 m and 27 m depth, and the static level was at 9 m depth. Some of the wells in this area were drilled to over 100 m depth and into the underlying granite.

The hydrogeology of the existing quarry site is described in both the GRI (1995) and the MH (2012) reports. In 1994, four 6 inch diameter wells were drilled to between 86 to 98 masl, and water levels were measured and rising head tests were performed in open hole and installed piezometers. The well logs from Gorrell Resource Investigations' Hydrogeological Investigation (GRI, 1995) are provided in Appendix B. Hydraulic conductivities estimated from recovery data (i.e., rising head test, Hvorslev method of analysis) for the existing quarry open holes and piezometers is summarized in Table 1.

Table 1: Hydraulic Conductivities - Existing Quarry

ID	Hydraulic Conductivity (m/s)
MW-1 (Open Hole)	2% recovery in one month
MW-2-1	1×10^{-8}
MW-2-2	3% recovery in one hour
MW-2-3	1% recovery in one hour
MW-3-1	1×10^{-5}
MW-3-2	4×10^{-6}
MW-4-1	7×10^{-6}
MW-4-2	1×10^{-5}

These data suggest a very low rock permeability in and around the existing north extraction area, and a higher rock permeability in and around the south extraction area. This conceptual model is supported by the groundwater levels measured between 2007 and 2013 in the existing quarry monitoring wells, and in the residential wells approximately 150 m (2309 Unity Road) and 250 m (2296 Unity Road) east of the existing quarry. The time-series of

these data (Figure 6) indicates that only piezometers in MW-3, which is in the centre of the south extraction area, have been affected by rock extraction and dewatering.

3.2 Site Inspection

Site inspections were carried out on November 25, 2013, January 10, 2013, and May 29, 2014 (for surface water). The temperature was below freezing on both 2013 days, and frozen discharged groundwater could be observed at various point locations on the quarry walls. An apparently water-bearing fracture was observed at approximately 128 masl in both the north and south extraction areas. Photographs from the site inspection are included in Appendix C.

3.3 Subsurface Investigation

3.3.1 Diamond Drilling, Core Recovery, Core Logging

Diamond drilling was completed on December 9th and 10th, 2013 by George Downing Estate Drilling Ltd., under the supervision of Morrison Hershfield staff. A single core hole named BH13-01 was drilled to 35.05 m depth in the northwest corner of the property. The coring bit was HQ sized, leaving a 96 mm diameter borehole, and returning a 63 mm diameter core.

A total of twenty-four (24) core runs of between 0.5 m and 1.5 m were collected into 15 core boxes. Micritic limestone of the Gull River Formation was encountered that was generally medium-grained, moderately bedded, and moderately hard. Above 12.5 m depth, the limestone was occasionally interbedded with lime mudstone. Between 12.5 and 19 m depth the lime mudstone beds increased in frequency and thickness (up to 10 cm). Grey-green argillaceous lime mudstone was noted below 25 m depth.

Horizontal clay/shale filled fractures were noted in every core run, while vertical fractures were noted only twice: near the surface, and at approximately 21 m depth. Borehole logs are provided in Appendix B.

3.3.2 Rock Drilling and Rock Chip Logging

Rock drilling was carried out at BH12-01 to BH12-03 by Cruickshank Construction Ltd. using a Furukawa HCR1200 track mounted Rock Drill on December 14th, 2012 under the supervision of Morrison Hershfield staff.

All three (3) boreholes were terminated at approximately 40.2 m depth. Light to dark grey limestone was encountered in all three boreholes, underlain at various depths by light to greenish grey limestone. Borehole logs are provided in Appendix B.

3.3.3 Downhole Geophysical Logging

Downhole geophysics was carried out by Notra Inc. of Ottawa in DDH10-01, BH11-02, BH11-03, BH11-04, BH12-01, BH12-02, BH12-03, and BH13-01. The geophysical logging on all but BH13-01 and on BH13-01 was carried out on December 18th, 2012 and December 10, 2013, respectively. Natural gamma rays, temperature and resistivity were measured in the 2012 investigation, while only natural gamma rays were measured in the 2013 investigation.

Correlation of the natural gamma between all eight boreholes was conducted by NOTRA Inc., and the elevation of a marker location was determined in each borehole. The best fit plane through the marker locations, determined using a solver dips 3.6 m per kilometre to the north, and 2.2 m per kilometre to the east. This provides a useful sense of the strike and dip of the strata.

The results of the geophysical testing are provided in Appendix D.

3.4 Water Investigation

3.4.1 Groundwater Level and Hydraulic Testing of Open Holes

Ground water levels were measured and rising head tests were carried out in BH13-01 and in the existing open holes between December 11 and 18, 2013. The results of the water level monitoring are presented in Appendix E, while the results of the rising head tests are presented in Appendix F and summarized in Table 2.

Table 2: Hydraulic Conductivities Measured in Open Holes

BH	Hydraulic Conductivity (m/s)
DDH10-01	1×10^{-8}
BH11-02	3×10^{-8}
BH11-03	4×10^{-11}
BH11-04	3×10^{-6}
BH12-01	1×10^{-7}
BH12-02	2×10^{-5}
BH12-03	4×10^{-7}
BH13-01	6×10^{-8}

These hydraulic conductivity results indicate that the highest hydraulic conductivities were measured in the open holes closest to the escarpment (BH12-02 and BH11-04), and that the hydraulic conductivity can be said to decrease with distance northwards away from the escarpment. These results are consistent with the findings in the GRI (1995) report.

Packer testing was carried out in BH13-01 in 2.74 m (9 ft) intervals with no overlap from 33.64 m depth to 3.46 m depth and again from 4.26 m depth to

1.52 m depth. Gauge pressures of approximately 50 psi were measured in all tests, while injection flow rates in all tests but one were too small to be measurable (i.e., “no-flow”). All tests were performed with approximately five minutes duration.

In the test interval from 30.9 m to 28.16 m, a flow rate of 2.9 litres per minute was measured, which translates to a hydraulic conductivity of 4×10^{-8} m/s. This is consistent with the hydraulic conductivity measured in the open hole. The results of the packer testing are presented on the borehole log for BH13-01 in Appendix B.

3.4.2 Piezometer Installation

Based on the result of the open-hole hydraulic testing, it was decided to install three piezometers in each of BH11-02, BH12-02, BH12-03, and BH13-01. Piezometers were constructed as designed except at BH12-02, where the uppermost piezometer could not be installed due to a plug of bentonite pellets in the upper part of the hole. Details of the piezometer installations are included in Appendix B.

3.4.3 Groundwater Level and Hydraulic Testing of Piezometers

Groundwater levels were measured and rising head tests were carried out on all but one of the newly installed piezometers between December 18 and 19, 2013. Piezometer BH11-02C had become flooded to the top during installation (a sign of impermeable rock), and had frozen solid before the water level could be measured or the rising head test performed. The results of the water level monitoring are presented in Appendix E, while the results of the rising head tests are presented in Appendix F and summarized in Table 3.

Table 3: Hydraulic Conductivities Measured in Piezometers

BH	Hydraulic Conductivity (m/s)
BH11-02A	3×10^{-9}
BH11-02B	1×10^{-7}
BH11-03C	n/a (dry)
BH12-02A	8×10^{-7}
BH12-02B	4×10^{-10}
BH12-02C	n/a (dry)
BH12-03A	6×10^{-12}
BH12-03B	8×10^{-10}
BH13-01A	2×10^{-7}
BH13-01B	1×10^{-9}

3.4.4 Monthly Groundwater Monitoring / Static Levels

In order to determine static levels in the newly installed piezometers, and to observe seasonal variations in groundwater level, monthly groundwater level monitoring was carried out over a 3 month period. The results of the water level monitoring are summarized in Appendix E, which also indicates which levels are considered most representative of static conditions. The selected static levels are indicated on the borehole logs in Appendix B, and in the cross sections in Appendix A.

These static levels indicate high groundwater levels (i.e., close to ground surface) and low vertical hydraulic gradients in the wells the furthest north of the escarpment (BH11-02 and BH13-01). This and the hydraulic conductivity results tend to support the supposition that this rock mass contains no significant hydrostratigraphy, is of low permeability, and is not under-drained by the escarpment.

These static levels indicate reasonably high groundwater levels (i.e., close to ground surface) in the upper piezometers in the wells closest to the escarpment (BH12-02 and BH12-03), and much lower groundwater elevations in the lower piezometers. These strong upwards gradients¹, and the hydraulic conductivity results imply that there is a permeable zone at depth which is drained by the escarpment.

3.4.5 Groundwater Sampling Results

Based on the results of the hydraulic testing, the following open holes and piezometers were selected for analytical testing of groundwater: BH11-02B, BH11-04, BH12-02A, BH12-03A, and BH13-01A. The sampling was carried out on December 19, 2013. Table G1 in Appendix G presents the results from the groundwater chemistry analysis, and highlights exceedances of ODWQS or PWQO.

The water quality results indicate quality typical of water from a limestone aquifer, with several general or inorganic parameters (hardness, chloride, sulphate, dissolved organic carbon, turbidity, sodium, and iron) exceeding operational or aesthetic ODWQS, and several parameters (typically metals) exceeding PWQO. Dissolved metals in mineralized groundwater are natural, and the metals concentrations (aluminum, boron, cadmium, cobalt, copper, iron and zinc) above PWQO are expected. In a natural setting, these concentrations would be diluted below PWQO upon mixing of the discharging groundwater with surface water. The groundwater quality results indicate that metals concentrations should be monitored in the quarry discharge.

¹ Gradient is the amount of increase in groundwater elevation with elevation. An upwards gradient implies downwards flow.

3.4.6 Surface Water Inspection and Sampling Results

The surface water inspection was carried out on May 29, 2014. Drainage of the existing north quarry was observed to be via a pump with inlet set in a sump established in southeast corner. A sample of the discharge from this sump was collected, with sample ID “E-SW1”. The discharge line was directed southward through a culvert which traverses beneath the pipeline corridor and discharges into a drainage ditch established by Cruickshank.

Drainage of the existing south quarry has historically been via pumping and/or gravity drainage through a channel cut in the rock in the south east corner. On the day of the inspection there was no flow through this channel, although a sample was collected from the standing water, with sample ID, “E-SW-3”. There have been recent changes in the quarry which have changed the use and discharge of surface water in the south part of the quarry.

The first recent change to quarry operations was that the wash plant was moved from the north quarry to the south quarry. Two sedimentation ponds have been established for the wash plant with a pump for removal of excess water during storm events. The discharge from the pump is directed towards an overflow sedimentation pond which flows by gravity into the aforementioned drainage ditch on the east side of the quarry. On the day of the inspection, there was no water being pumped from the wash plant sedimentation ponds and no water flowing out of the overflow sedimentation pond, but a sample of ponded water from the drainage channel was collected, with sample ID “E-SW2”.

The second recent change to quarry operations was extraction of rock towards the southwest, creating a new low point below the level of the wash plant in the southwest corner of the quarry. This low point is below the level required for gravity drainage. There was no pump in this area on the day of the site inspection there was standing water on the low point of the quarry floor.

The drainage ditch which is the receiver of water from both the north and south quarries crosses the south east corner of the south quarry and continues southward over the escarpment. It crosses below the K&P trail (a former rail line) through a culvert (Culvert 1 in Figure 1), before being joined by the tributary of Collins Creek which drains the Elginburg village area. On the day of the inspection there was no flow in the culvert.

The only defined drainage feature of the expansion area is a very shallow ditch which appears to drain the most northerly part of the expansion area, and also to convey water from the municipal ditch on the south side of Unity Road. The drainage ditch appears to flow to the south, but becomes undefined approximately 160 m south of Unity Road. The land in this area is very flat, but the regional topographic gradient is towards the southwest.

The surface water quality results from the three collected samples are included in Table G2a (PHC and general chemistry) and G2b (metals) in Appendix G. The results indicate much lower concentration of general and

inorganic parameters than in the groundwater. Only aluminum (E-SW1 and E-SW3), boron (E-SW1) and zinc (E-SW1) were present in concentrations marginally above the PWQO.

3.5 Groundwater Flow Calculations

3.5.1 Results of the Conceptual Modelling

The bedrock potentially affected by the quarry operation, through extraction or through dewatering, is the upper and middle units of the Gull River Formation. The evidence suggests that within a few hundred metres of the escarpment, where these formations outcrop across their thickness (see cross section in Figure 3), weathering and/or a different stress regime has resulted in enhanced permeability. This permeability comes in the form of open horizontal bedding plan fractures, or more specifically channels within these horizontal fractures (see photos in Appendix C). Where this type of porosity is intersected by boreholes, moderate permeability is measured (BH12-03, BH11-04 and BH12-02). More than a few hundred metres from the escarpment, there appears to be very little permeability in the bedrock, manifested in very low yield wells (BH12-01, BH11-02, BH11-03, DDH10-01, and BH13-01).

The water table elevation interpreted from the groundwater elevations measured on site, and from the static levels recorded in the WWIS is shown in cross section in Figures 3, 4, and 5 and in plan view on Figure 7. Here, the water table is defined as the elevation to which water would rise in an open hole. Generally, speaking the water table is close to (within a few metres of) the ground surface in the low permeability zone away from the escarpment, and is deeper in the higher permeability zone close to the escarpment. The dip in the water table near BH 12-02 is the most striking example of this. Groundwater flow is towards the escarpment, where it may discharge at the toe of the escarpment, or further to the southeast in the wetlands at the low point of land.

3.5.2 Estimated Drawdowns and Inflows during Operations

Based on the conceptual model, the method of Sichart and Kryieleis (see Section 2.5) was applied at locations A, B, C, D, and E shown on Figure 7, on the west and north side quarry perimeter. The data contributing to the calculations and their results are summarized in Table 4.

Table 4: Radius of Influence Calculations

Point	Contributing Data			Averages		Calculated Values	
	Open Holes	K (m/s)	Water Levels (m)	K ¹ (m/s)	Water Level ² (masl)	Lowering at Quarry Wall ³ (m)	Radius of Influence ⁴ (m)
A	BH11-04	3E-06	105.81	3E-06	105.81	2.81	15

Point	Contributing Data			Averages		Calculated Values	
	Open Holes	K (m/s)	Water Levels (m)	K ¹ (m/s)	Water Level ² (masl)	Lowering at Quarry Wall ³ (m)	Radius of Influence ⁴ (m)
B	BH12-02, BH12-03	2E-05, 3E-07	109.81, 130.20	2E-06	120.01	17.01	79
C	BH12-02	2E-05	109.81	2E-05	109.81	6.81	90
D	BH12-01, BH11-03	9E-08, 3E-11	121.97, 131.23	2E-09	126.60	23.60	3
E	BH13-01, BH11-02, MW-2-1	6E-08, 3E-08, 1E-08	137.71, 134.52, 127.74	3E-08	133.32	30.32	15

¹ Hydraulic Conductivity, where the geometric mean is used to calculate the average

² Static Groundwater Level, where an ordinary average is used

³ The difference between the static groundwater level and 103 masl, the assumed quarry floor at full development

⁴ Calculated using the method of Sichart and Kryieleis

These results indicate that drawdown is expected to propagate well under 50 m everywhere except near points B and C, where the drawdown is expected to propagate near 100 m. The explanation for the low propagation distance on the north side is the extremely low permeability in this area. The explanation for the low propagation distance on the south side is fact that the much lower water table, drawn down already by the escarpment. At points B and C, the permeability is higher, and the water table is higher, leading to the higher propagation distance.

To be conservative and to consider the effect of non-radial flow, especially on Unity Road, the propagation distances have been rounded up: to 50 m north of point “D”, and to 100 m south of point D.

3.5.3 Estimated Lake Levels Following Rehabilitation

The level in the lake north of the pipeline was estimated to be 125 masl. This is the approximate elevation of the culvert which presently traverses beneath the pipeline on the east side of the quarry, and is approximately 5 m below the low point of the quarry rim. Even if the culvert becomes blocked, it is difficult to imagine the lake level rising above this level due to the presence of fractures and weathered rock in the upper part of the rock pillar holding up the pipeline which will separate the north and south quarries. Water from the north lake will flow through the culvert and/or the shallow weathered rock and into the south lake.

The level in the lake south of the pipeline was estimated to be 110 masl. This is approximately equal to the present day water table elevation at the south end of the quarry. According to this estimate, the water in the south lake will flow as groundwater through the pillar of bedrock which will remain between the quarry and the escarpment, and will discharge to the tributary of Collins Creek at the toe of the slope.

3.6 Storm Water Management Considerations

Based on discussions with Cruickshank, the following storm water management options are proposed:

- 1) A berm will be constructed in the 30 m offset south of Unity Road where the northerly part of the expansion area abuts Unity Road. This berm will prevent the southwards flow of water from the municipally-owned ditch (there is presently a very shallow southwards-running ditch on the expansion lands, see Section 3.4.6), and will force the water to flow either west or east. Ideally, the ditching would be adjusted to encourage the water to flow west, which will allow it to discharge to a southwards-running ditch on the south side of Unity Road approximately 260 m west of the western property line of the expansion area. This ditch connects to the tributary of Collins Creek, effectively taking the drainage the same point that it currently arrives at, via a different route.
- 2) Storm water from the northern quarry will continue to be directed to a sump in the southeast corner of the existing quarry, where it will be pumped through the culvert below the pipeline and into the drainage ditch. Depending on the levels of the quarry floor, an intermediate pumping step may be required. Expansion of the quarry footprint is not anticipated to change the quality of the water being discharged to the ditch.
- 3) Storm water from the southern quarry will continue to be discharged via pumping, of overflow from the wash plant area, and/or pumping from the low point in the south end of the quarry.
- 4) Cruickshank is considering the option of a large self-draining sump in the southwest corner of the existing quarry. This would consist of an excavation in the rock down to the approximately 110 masl, with sufficient volume to capture storm flows of a specified size/return period. The sump would be self-draining over extended periods as the water table in this area will be approximately coincident with the elevation of the sump floor. The sump would act as a place for sedimentation, and the discharge from the sump would travel briefly southward through the rock before discharging to the surface water feature at the toe of the escarpment.\
- 5) An Environmental Compliance Approval (ECA) will be required for the treatment and disposal of industrial process wastewater from the quarry. Conditions of the ECA will almost certainly include a requirement for ongoing monitoring of contaminant levels in the discharge.

4. IMPACT ASSESSMENT

4.1 Impact on Wells and Aquifers

All wells in the area are outside of the radius of influence, (area of zero drawdown) conservatively estimated for the quarry dewatering in this study. Even at the closest wells, at 2528 Unity Road and 2467 Unity Road, the very low permeability of the bedrock will protect them drawdown propagating from the quarry, and these wells should continue to be recharged locally by precipitation. This conclusion is supported by the lack of drawdown effects observed over a six year period in monitoring wells and domestic wells adjacent to the existing Elginburg Quarry.

In addition, monitoring of the water level in BH11-02 and BH13-01 will provide accurate information about the actual groundwater table lowering between the quarry face and the domestic wells, as the quarry develops over the coming years and decades.

Industrial use of the expansion lands presents a risk of accidental release of fuel, and/or other potential contaminants. However, since the quarry will be the topographic low point (causing a hydraulic trap) and since the rock is of very low permeability, migration of spilled contaminants in groundwater is considered virtually impossible. The risk of contamination of aquifers and local water wells due to spilled fuel is considered negligible.

4.2 Impact on Surface Water

4.2.1 Flow Routing

A berm will be constructed in the 30 m offset south of Unity Road where the northerly part of the expansion area abuts Unity Road. This berm will prevent the southwards flow of water from the municipally-owned ditch (there is presently a very shallow southwards-running ditch on the expansion lands, see Section 3.4.6), and will force the water to flow either west or east. Ideally, the ditching would be adjusted to encourage the water to flow west, which will allow it to discharge to a southwards-running ditch on the south side of Unity Road approximately 260 m west of the western property line of the expansion area. This ditch connects to the tributary of Collins Creek, effectively taking the drainage the same point that it currently arrives at, via a different route.

4.2.2 Flow Amounts

The very low permeability of the bedrock ensures that the upland portions (i.e., above the escarpment) of the two north-to-south flowing tributaries of Collin's Creek flows are not significantly fed by groundwater, and thus will not experience reductions in baseflow due to operation of the quarry sump. Groundwater discharge at the base of the escarpment may be reduced by the quarrying and pumping of the quarry sump, although the pumped water will be discharged back into the same ultimate receiver. Conversely, if a self-

draining sump is incorporated into the design of the quarry, this will enhance groundwater discharge to the receiver at the base of the escarpment. No impacts in terms of the quantity of water present in surface water features are anticipated.

4.2.3 Water Quality

The quarry is currently dewatered using sumps and sedimentation ponds, and the water quality was acceptable on the day of the inspection. The expansion of the quarry is not anticipated to change the quality of the water being discharged, and no impacts to the surface water quality are anticipated. Cruickshank is considering options for a self-draining sump at the southwest corner of the existing quarry that will allow for pump-free discharge of storm water from the south quarry through a natural bedrock filter.

Industrial use of the expansion lands presents a risk of accidental release of fuel, and/or other potential contaminants. Spilled contaminants may migrate to the quarry sump, where there is potential for them to be discharged to surface water. This risk is low, and is mitigated by implementing prevention measures discussed in Section 5.

An Environmental Compliance Approval (ECA) will be required for the treatment and disposal of industrial process wastewater from the quarry. Conditions of the ECA will almost certainly include a requirement for ongoing monitoring of contaminant levels in the discharge.

4.3 Impact on Contamination

There are no existing groundwater contamination issues within the radius of influence of dewatering. No impacts on contamination are identified.

4.4 Impact on Structures

Dewatering of the bedrock is not anticipated to result in significant consolidation of soils. No impact on structures is anticipated.

4.5 Impact on Ecology

According to the natural environment technical report for the quarry expansion (Ecological Services, 2012), ecological receptors include a Sugar Maple dominated woodland and a potential reptile hibernacula (fractured exposed bedrock on a south facing slope, with field habitat further south), both on the escarpment.

It was confirmed by Rob Snetsinger of Ecological Services (personal communication, February 24, 2014) that neither of these receptors will be impacted by any potential reduction in volume of groundwater discharge resulting from quarrying and pumping of the quarry sump. Therefore, no impacts to ecological receptors are anticipated.

5. ENVIRONMENTAL PROTECTION / MITIGATION

5.1 Summary of the Results and Impact Assessment

The results of this hydrogeological assessment indicate that westward expansion of the Cruickshank Elginburg Quarry will have minimal hydrogeological impacts. Wells, aquifers, surface water and structures were all considered in the impact assessment, and the highest risk receptors are the two wells closest to the expansion lands at 2528 Unity Road and 2467 Unity Road. The very low permeability of the limestone bedrock in this vicinity will limit the propagation of drawdown from the dewatered quarry, and the wells should continue to be recharged locally by precipitation. A minor change in flow along the ditch on the south side of Unity Road where the expansion lands abut is anticipated.

5.2 Recommended Monitoring Plan

Quarterly groundwater level monitoring in BH 12-02, BH 12-03, BH 11-03, BH 13-01, and BH 11-02 and in domestic wells at 2528 and 2467 Unity Road is recommended. This monitoring will provide data to verify the predicted groundwater level lowering; will provide useful data to address water well interference complaints, if any; and will allow for mitigation of impacts to receptors in case groundwater level lowering is greater than estimated.

Monitoring of contaminant levels in the quarry discharge should be addressed through an Environmental Compliance Approval for industrial sewage works.

5.3 Recommended Contingency Plan

The impact assessment found that it is highly unlikely that the key receptors will be negatively affected by the quarry dewatering. Notwithstanding this finding, groundwater level monitoring is recommended in strategically-located monitoring wells. This section provides a contingency plan to respond to specific events.

5.3.1 A Water Well Interference Complaint

If a water well interference complaint is received by Cruickshank, either directly or through other channels (i.e., the Ministry of Natural Resources or Ministry of the Environment), and the complaint concerns a water well within 500 m of the licensed area, then Cruickshank will:

1. Immediately provide an interim potable water supply (within 12 hours);
2. Notify the MOE of the complaint (if they are not already aware);
3. Retain a qualified professional to conduct a site investigation, determine the cause and provide recommendations to correct the problem; and,

4. If it is found that the water well interference resulted from Cruickshank dewatering and quarry operations, the water supply will be restored to its original condition, or better.

5.3.2 Monitoring Data Which Suggests a Potential Impact to a Receptor

If groundwater level monitoring data suggests greater-than-expected groundwater level lowering which is quarry-related, and if, based on the judgment of a qualified professional, there is a potential for this lowering to impact a receptor, then Cruickshank will:

1. Modify quarry operations;
2. Consult with the potentially affected party;
3. Make provisions to mitigate the potential impact.

6. CLOSURE

We trust the information presented in this report meets your requirements. If you have any further questions or need addition details, please do not hesitate to contact our office.

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7. LIMITATIONS AND USE

This report has been prepared for the exclusive use of Cruickshank Construction Limited, by Morrison Hershfield Limited (Morrison Hershfield). Morrison Hershfield hereby disclaims any liability or responsibility to any person or party, other than Cruickshank Construction Limited, for any loss, damage, expense, fines, or penalties which may arise from the use of any information or recommendations contained in this report by a third party.

The report, which specifically includes all tables, figures and appendices is based on data and information collected during investigations conducted by Morrison Hershfield and is based solely on the conditions of the site at the time of the investigation, supplemented by historical information and data obtained by Morrison Hershfield as described in this report.

Morrison Hershfield has exercised professional judgment in collecting and analyzing the information and formulating recommendations based on the results of the study. The services performed as described in this report were conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to this study. No other warranty or representation, either expressed or implied, as to the accuracy of the information or recommendations included or intended in this report.

8. REFERENCES

Carson, D.M., 1981. Paleozoic Geology of the Tichborne-Sydenham Area, Southern Ontario; Ontario Geological Survey Preliminary Map P. 2413, Geological Series. Scale 1:50,000, Geology, 1980.

Chapman, L.J. and Putnam, D.F., 1984. The Physiography of Southern Ontario, Ontario Geological Survey, Special Volume 2.

Ecological Services, 2012. Natural Environment, Technical Report: Level I And II, Elginburg Quarry, City Of Kingston, dated October.

Golder Associates Ltd., 2011. Preliminary Aggregate Resource Evaluation, Cruickshank Construction Limited, Proposed Expansion of Elginburg Quarry, Elginburg, Ontario, June 20.

Gorrell Resource Investigations, 1995. Hydrogeological Investigation of Elginburg Quarry, Part Lots 14 & 15, Conc. V, Township of Kingston, County of Frontenac. Report No. 934000.

Morrison Hershfield, 2012. Hydrogeological Investigation of the Cruickshank Elginburg Quarry, Lot 14 and 15, Concession V, City of Kingston, County of Frontenac, September.

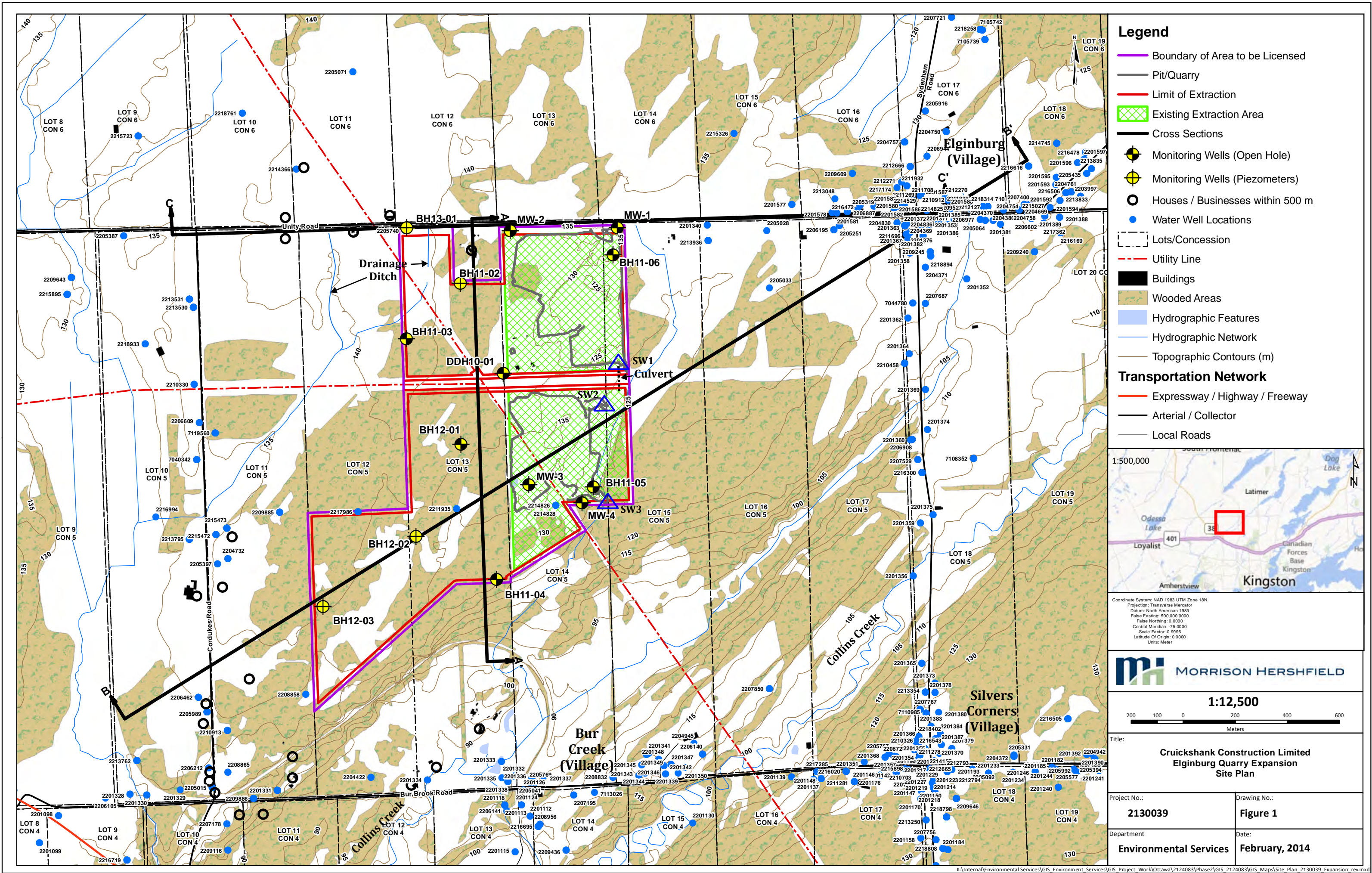
Ontario Geological Survey 2010. Surficial geology of Southern Ontario; Ontario Geological Survey, Miscellaneous Release--Data 128-REV

Ontario Ministry of the Environment, 2012. Well Record Data, downloaded in June 2012, Queen's Printer.

Powers, J.P., Corwin, A.B., Schmall, P.C. and Kaeck, W.E., 2007. Construction Dewatering and Groundwater Control, John Wiley and Sons.

Snetsinger, Rob, 2014. Verbal communication regarding water needs of woodlot and potential reptile hibernacula, February 24.

APPENDIX A: Figures



Legend

- Boundary of Area to be Licensed
- Pit/Quarry
- Limit of Extraction
- Existing Extraction Area
- Cross Sections
- Monitoring Wells (Open Hole)
- Monitoring Wells (Piezometers)
- Houses / Businesses within 500 m
- Water Well Locations
- Lots/Concession
- Utility Line
- Buildings
- Wooded Areas
- Hydrographic Features
- Hydrographic Network
- Topographic Contours (m)

Transportation Network

- Expressway / Highway / Freeway
- Arterial / Collector
- Local Roads

1:500,000

Coordinate System: NAD 1983 UTM Zone 18N
Projection: Transverse Mercator
Datum: North American 1983
False Easting: 500,000.0000
False Northing: 0.0000
Central Meridian: -75.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

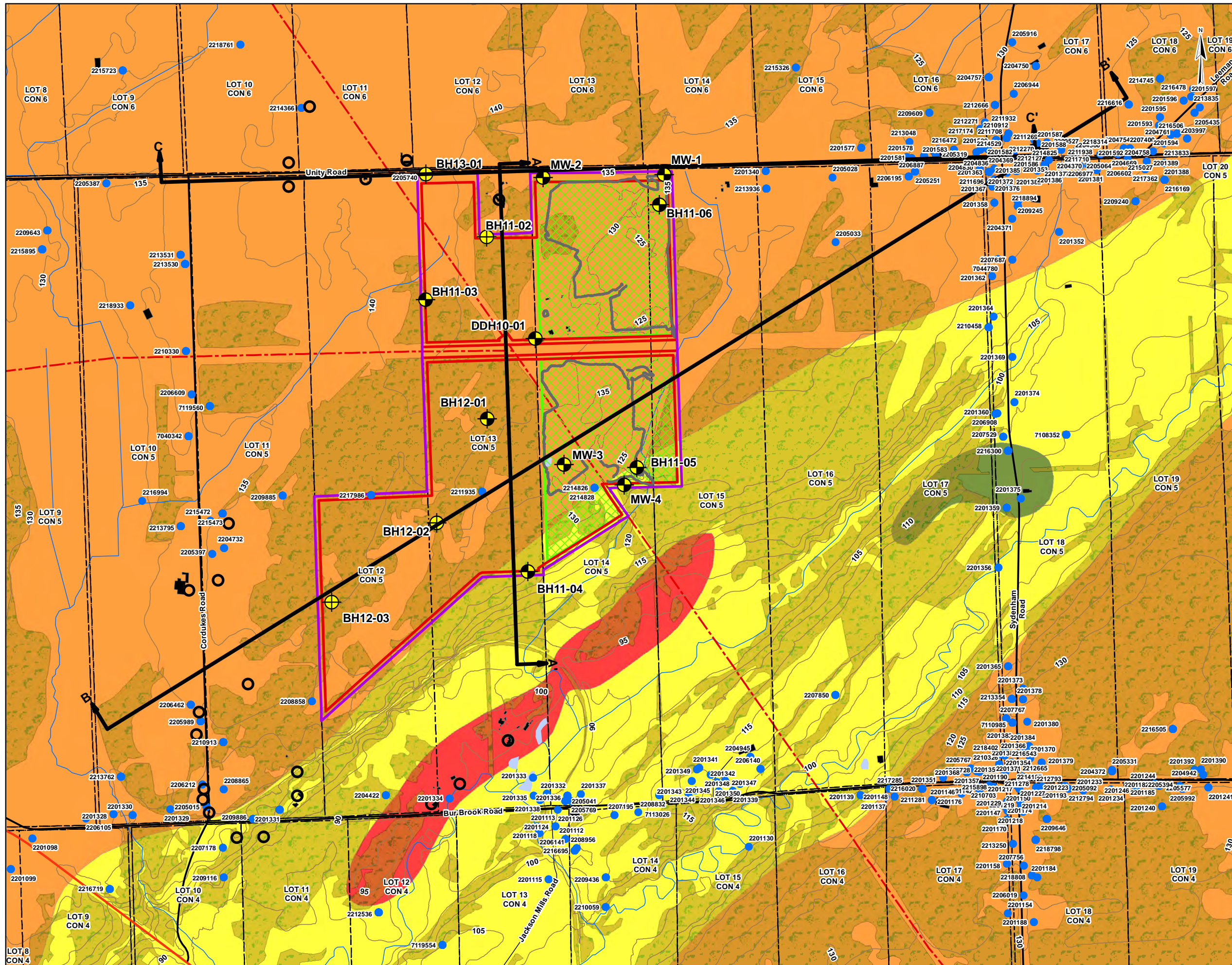
MORRISON HERSHFIELD

1:12,500

Title:

**Cruikshank Construction Limited
Elginburg Quarry Expansion
Site Plan**

Project No.:	Drawing No.:
2130039	Figure 1
Department	Date:
Environmental Services	February, 2014



Legend

- Boundary of Area to be Licensed
- Pit/Quarry
- Limit of Extraction
- Existing Extraction Area
- Cross Sections
- Monitoring Wells (Open Hole)
- Monitoring Wells (Piezometers)
- Water Well Locations
- Houses / Businesses within 500 m

Ontario Geological Survey

FORMATION, MEMBER

- Gull River, upper member
- Gull River, middle member
- Gull River, lower member
- Precambrian

Lots/Concession

- Utility Line
- Buildings
- Wooded Areas
- Hydrographic Features
- Hydrographic Network
- Topographic Contours (m)

Transportation Network

- Expressway / Highway / Freeway
- Arterial / Collector
- Local Roads

1:500,000

Coordinate System: NAD 1983 UTM Zone 18N
Projection: Transverse Mercator
Datum: North American 1983
False Easting: 500,000.0000
False Northing: 0.0000
Central Meridian: -75.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter

MORRISON HERSHFIELD

1:12,500

200 100 0 200 400 600
Meters

Title:

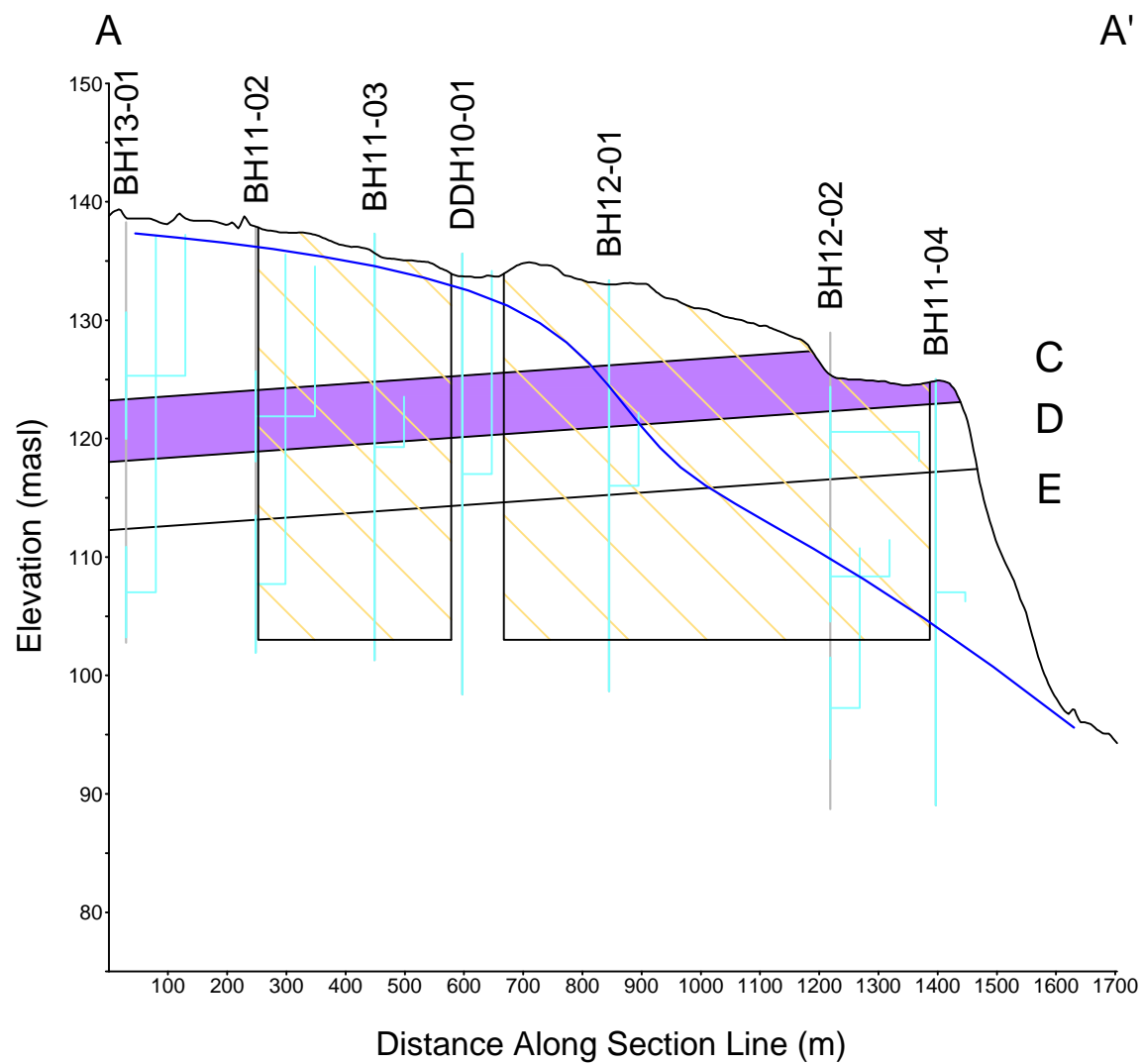
**Cruikshank Construction Limited
Elginburg Quarry Expansion
Bedrock Geology**

Project No.: **2130039**

Drawing No.: **Figure 2**

Department: **Environmental Services**

Date: **February, 2014**



Legend

- Limestone
- Water Table
- Monitoring Well Interval
- Head Elevations
- To be Licensed Extraction Area
- Thicker Lime Mudstone Interbeds (Shows stratigraphic model only)



Scale:

See Axes

Title:

Cruickshank Construction Limited
Elginburg Quarry Expansion -
Hydrogeological Cross Section AA'

Project No.:

2130039

Drawing No.:

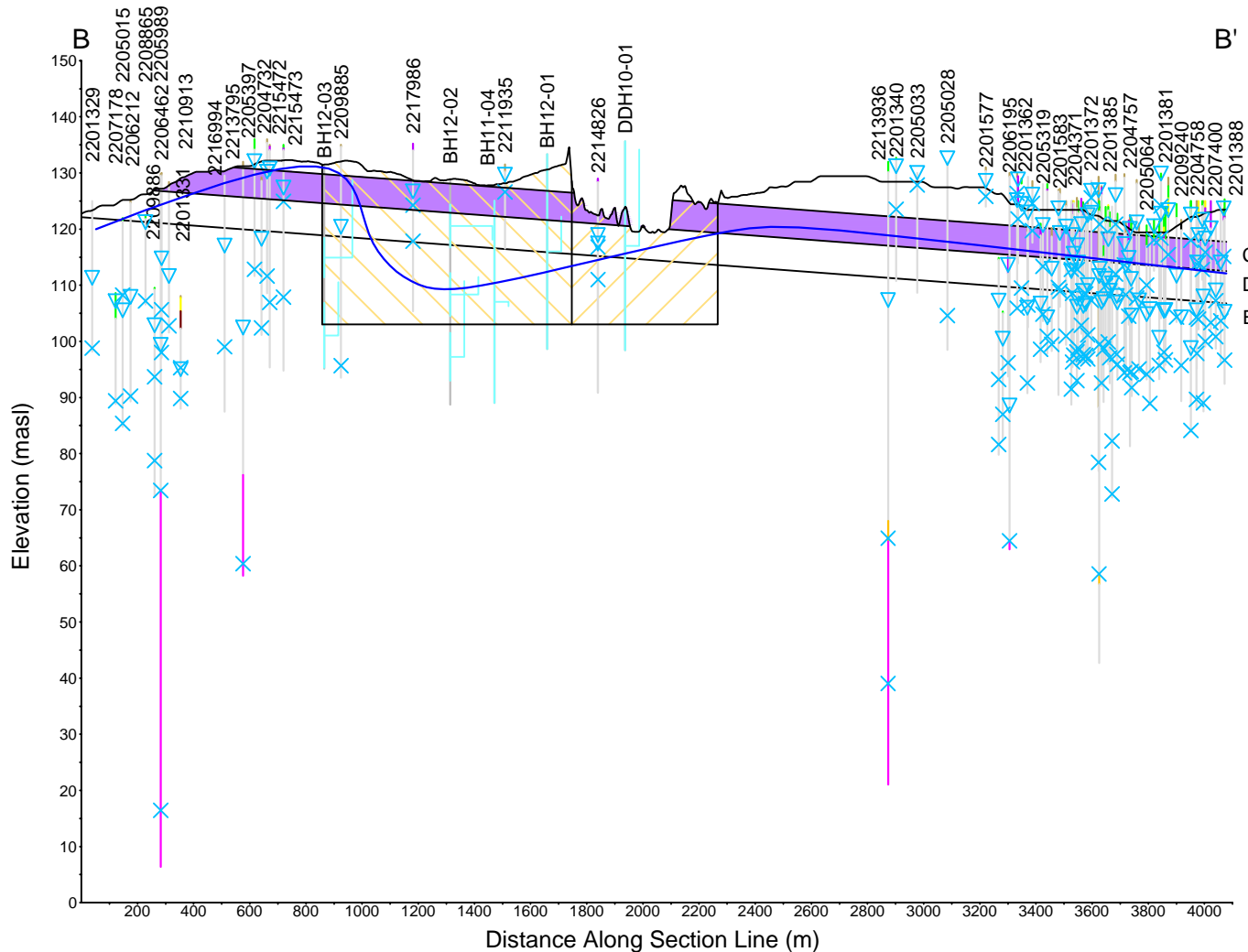
Figure 3

Department:

Environmental
Services

Date:

February 10, 2014



Legend

- Silt and/or Clay
- Sand and/or Gravel
- Overburden
- Shale
- Limestone
- Sandstone
- Granite
- Water Table
- ▽ Groundwater Elevation
- × Elevation of Water Found
- | Monitoring Well Interval
- | Head Elevations
- Licensed Extraction Area
- To be Licensed Extraction Area
- Thicker Lime Mudstone Interbeds (Shows stratigraphic model only)



MORRISON HERSHFIELD

Scale:

See Axes

Title:

Cruickshank Construction Limited
Elginburg Quarry Expansion -
Hydrogeological Cross Section BB'

Project No.:

2130039

Drawing No.:

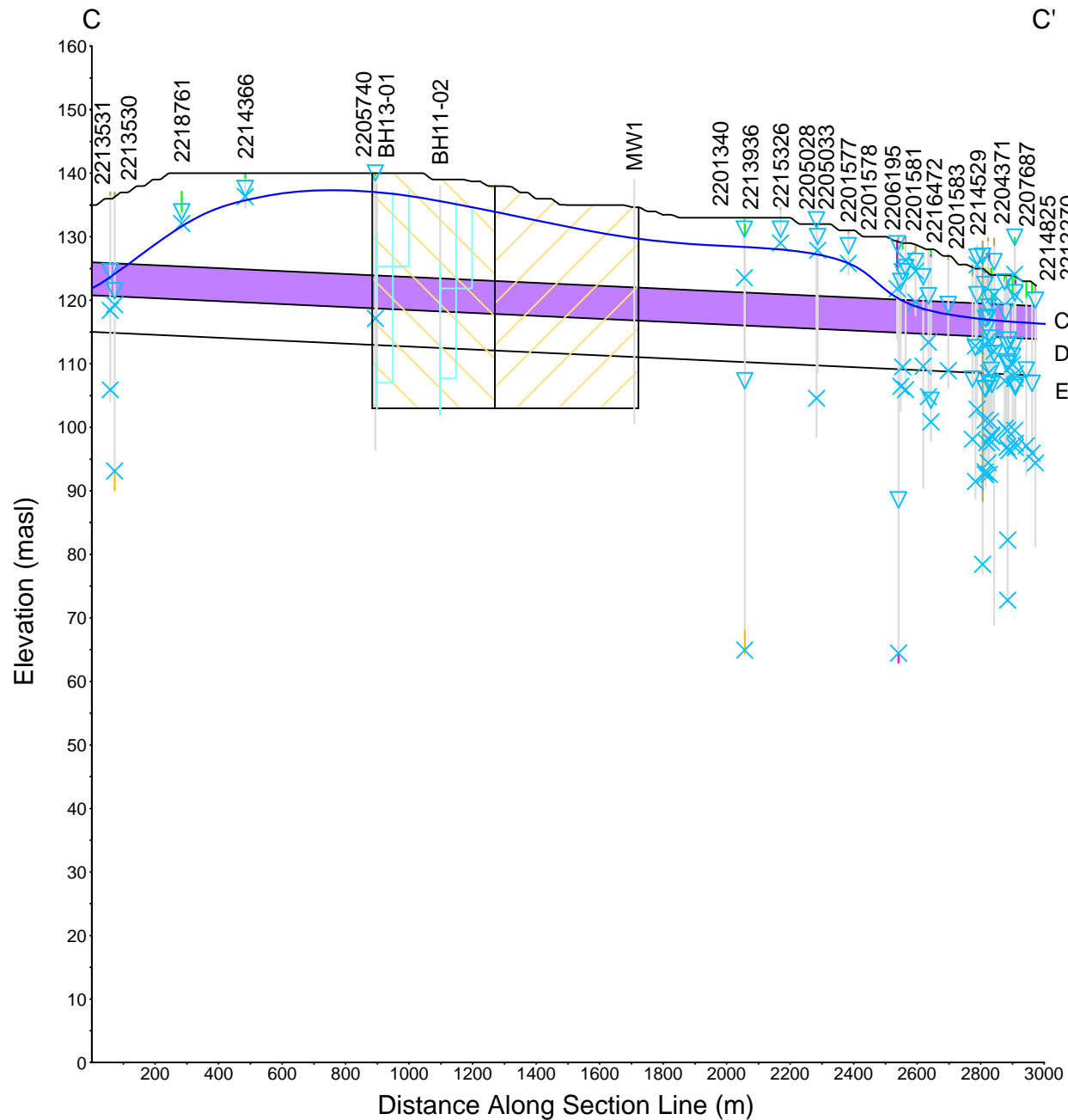
Figure 4

Department:

Environmental
Services

Date:

February 10, 2014



Legend

- Silt and/or Clay
- Sand and/or Gravel
- Overburden
- Shale
- Limestone
- Sandstone
- Granite
- Water Table
- ▽ Groundwater Elevation
- × Elevation of Water Found
- Monitoring Well Interval
- Head Elevations
- Licensed Extraction Area
- To be Licensed Extraction Area
- Thicker Lime Mudstone Interbeds (Shows stratigraphic model only)



MORRISON HERSHFIELD

Scale:

See Axes

Title:

Cruickshank Construction Limited
Elginburg Quarry Expansion -
Hydrogeological Cross Section CC'

Project No.:

2130039

Drawing No.:

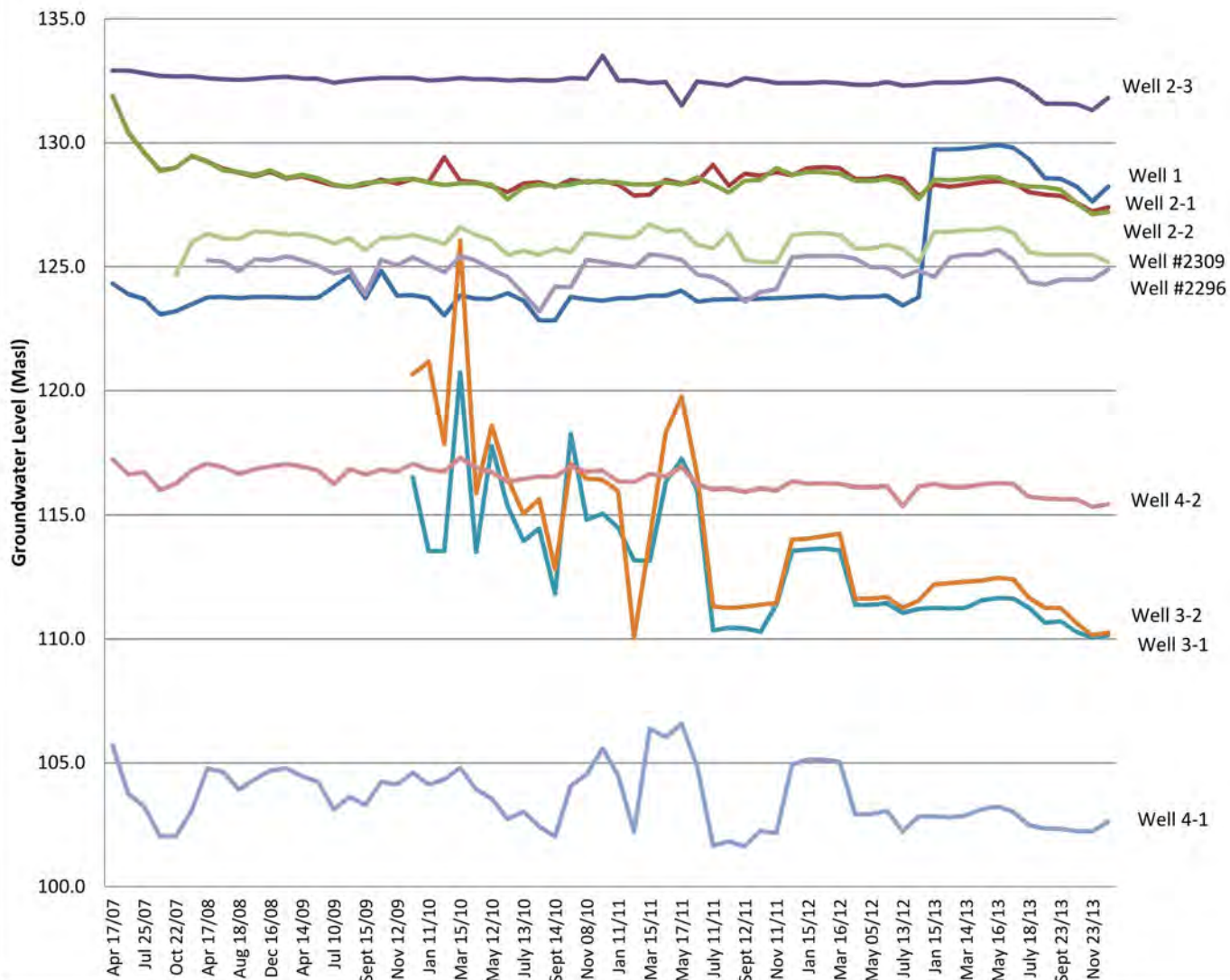
Figure 5

Department:

Environmental
Services

Date:

February 10, 2014



Legend

- Well 1
- Well 2-1
- Well 2-2
- Well 2-3
- Well 3-1
- Well 3-2
- Well 4-1
- Well 4-2
- Well #2309
- Well #2296



MORRISON HERSHFIELD

Scale:

See Axes

Title:

Cruickshank Construction Limited
Elginburg Quarry Expansion -
Groundwater Levels at Existing Quarry,
2007-2013

Project No.:

2130039

Drawing No.:

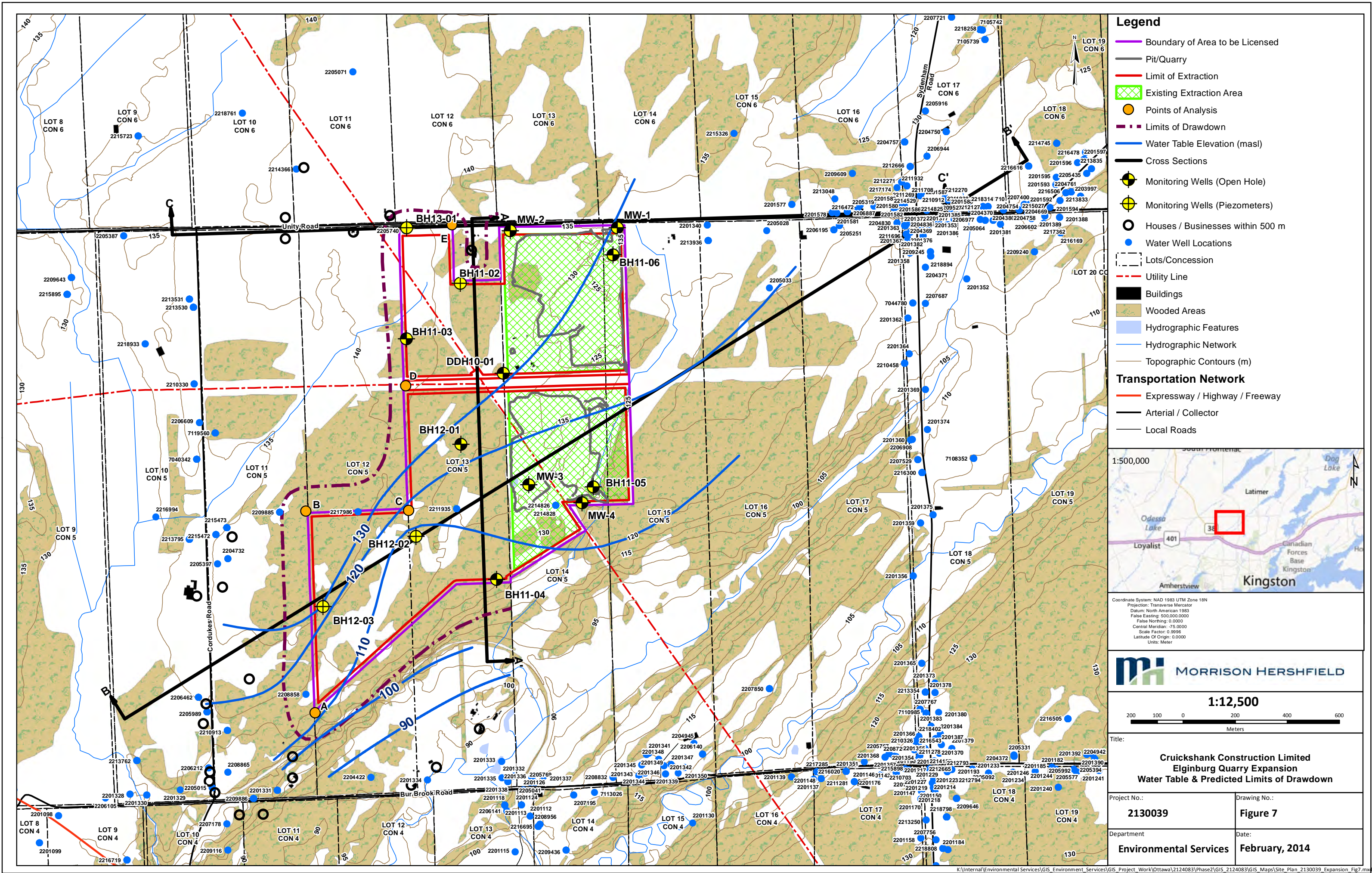
Figure 6

Department:

Environmental
Services

Date:

February 10, 2014



Legend

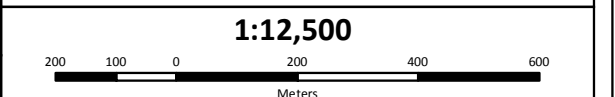
- Boundary of Area to be Licensed
- Pit/Quarry
- Limit of Extraction
- Existing Extraction Area
- Points of Analysis
- Limits of Drawdown
- Water Table Elevation (masl)
- Cross Sections
- Monitoring Wells (Open Hole)
- Monitoring Wells (Piezometers)
- Houses / Businesses within 500 m
- Water Well Locations
- Lots/Concession
- Utility Line
- Buildings
- Wooded Areas
- Hydrographic Features
- Hydrographic Network
- Topographic Contours (m)

Transportation Network

- Expressway / Highway / Freeway
- Arterial / Collector
- Local Roads



Coordinate System: NAD 1983 UTM Zone 18N
Projection: Transverse Mercator
Datum: North American 1983
False Easting: 500,000.0000
False Northing: 0.0000
Central Meridian: -75.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter



Title:
**Cruickshank Construction Limited
Elginburg Quarry Expansion
Water Table & Predicted Limits of Drawdown**

Project No.: 2130039	Drawing No.: Figure 7
Department: Environmental Services	Date: February, 2014

APPENDIX B: Well Records, Well Logs, Well Completions



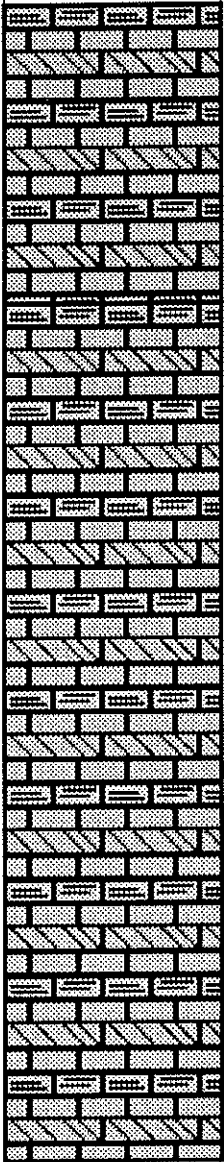
PROJECT: 934000

DRILL TYPE: Rotary with water

HOLE NUMBER: 1

DATE: June 2, 1994

LOCATION: northeast corner of site, just east of old access road

DEPTH (m)	STRATIGRAPHIC SECTION	PIEZ.	ELEVATION (m asl)	Major Bedding Plane	Estimated Cumulative Yield (L./min)	MATERIAL DESCRIPTION
0			131.2			0 to 9.75 UPPER GULL RIVER FORMATION
5				2.44, 3.66	0	-dark grey, fine crystalline limestones, thinly bedded (5 to 10 cm) with shale between limestones -noticeable drops at 2.44, 3.66, 8.53, and 9.75 -no water present
10			121.45	8.53 9.75		
15					0	9.75 TO 38.10 m - LOWER GULL RIVER FORMATION
20					0	-interbedded limestone, silty dolostone, quartz sandstone and shale -first thick green dolostone bed which was noticed was at 20.73 m -small drops at 27.13 to 28.04, 29.87, 30.18 and 35.97 -calcite-rich areas which may be the characteristic vugs of the Formation were encountered at 27.13 to 28.04 m
25					0	-below 35.97 the amount of green dolostone appears to increase
30				27.13 28.04 29.87 30.18	0	-there is virtually no water in well, after 5 days the static water level was greater than 36 m below the surface -what water there is in the well appears to be mineralized
35				36.97		after 1 month there was less than 0.7 m of water in the drill hole
40			92.89		0	

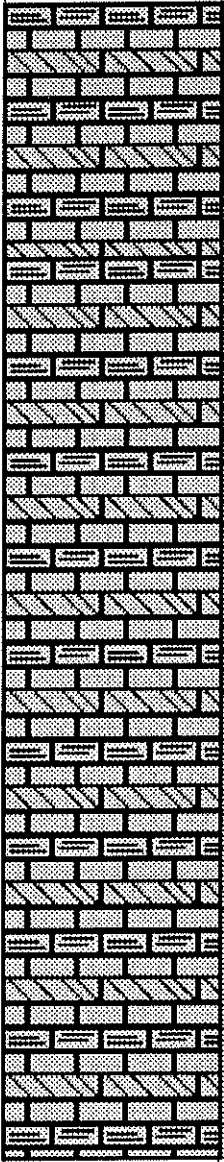

PROJECT: 934000

DRILL TYPE: Rotary with water

HOLE NUMBER: 2

DATE: June 2, 1994

LOCATION: northwest corner of property, where new office
is to be constructed

DEPTH (m)	STRATIGRAPHIC SECTION	PIEZ.	ELEVATION (m asl)	Major Bedding Plane	Estimated Cumulative Yield (L/min)	MATERIAL DESCRIPTION
0			136.8			0 to 8.53 UPPER GULL RIVER FORMATION
				3.66		-dark grey to black, fine crystalline limestones,
				4.57		-thinly bedded (5 to 10 cm) with shale between limestones
5			129.31	5.49, 5.79	0	- noticable drops at 3.66, 4.57, 5.49, 5.79 and 8.53
			128.27	8.53 to 9.75		- very black cuttings; shale
						-no water present
10				11.58	0	8.53 TO 38.10 m - LOWER GULL RIVER FORMATION
						-interbedded limestone, silty dolostone, quartz sandstone and shale
15				19.51	0	-first thick green dolostone bed which was noticed was at 25.6 to 26.21 m
			117.24	20.73 to 21.34		-small drops at 8.53 to 9.75, 11.58, 19.51, 20.73 to 21.34, 25.60 to 26.21 and 32.0
20					0	-calcite-rich areas which may be the characteristic vugs of the Formation were encountered at 18.29 and 23.32 m
						-below 14.63 m the colour of the limestone changed to light grey to fine grained; changed to dark grey to black at 23.32
25				25.60 to 26.21	0	-below 32 m started to encounter very fine grained grey/brown thinly bedded limestones
30					0	
35				32.0		
			98.55		0	
40						

PROJECT: 934000

DRILL TYPE: Rotary with water

HOLE NUMBER: 3

DATE: June 2, 1994

LOCATION: southwest corner of property, in area
of small test quarry

DEPTH (m)	STRATIGRAPHIC SECTION	PIEZ.	ELEVATION (m asl)	Major Bedding Plane	Estimated Cumulative Yield (L/min)	MATERIAL DESCRIPTION
0			128.4	0.91		0 to 7.92 UPPER GULL RIVER FORMATION
				2.44		-dark grey to black, fine crystalline limestones,
				3.66		-thinly bedded (5 to 10 cm) with shale between limestones
5				4.88, 5.19	0	- noticable drops at 0.91, 2.44, 3.66, 4.88 and 5.19 m - very black cuttings; shale
			120.48			-no water present
				8.53		7.92 TO 38.10 m - LOWER GULL RIVER FORMATION
10				10.36 to 14.63	18.18	-interbedded limestone, silty dolostone, quartz sandstone and shale -first thick green dolostone bed which was noticed was at 11.28 to 12.19 m
15					18.18	-small drops at 8.53, 10.36 to 14.63, 21.95, 23.77, 26.21 and 28.04 m
20			109.50			-calcite-rich areas which may be the characteristic vugs of the Formation were encountered at 10.36 to 12.19 and 21.95
				21.95		-below 15.24 m the colour of the limestone changed to light grey to fine grained;
				23.77	20.45**	-below 23.77 m started to encounter very fine grained grey/brown thinly bedded limestones
25						-occurrence of greenish dolostone increases below 26.21 m
				26.21		
				28.04		
30					29.54**	-the well has a yield estimated to be on the order of 40.9 L/min -all of this water is from the 10.36 to 14.63 m zone and cascading was noted until the static water level rose above this level
35						
			90.17		40.90**	
40						

** the increase was due to the development of the 11.28 to 14.63 zone and does not reflect the interception of additional water bearing zones

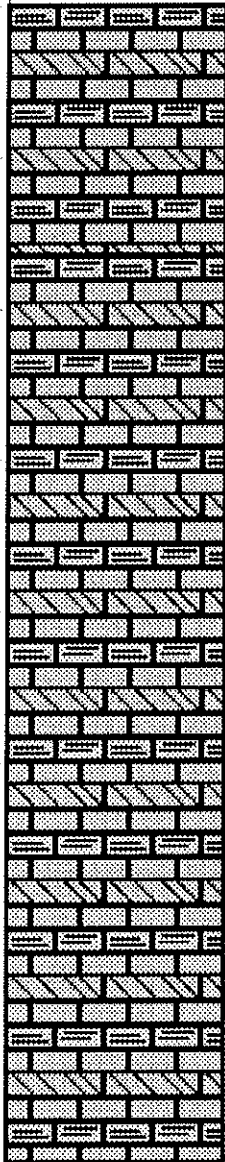

PROJECT: 934000

DRILL TYPE: Rotary with water

HOLE NUMBER: 4

DATE: June 3, 1994

LOCATION: southeast corner of property, east of hydro-line and just south of existing quarry; between quarry and berm

DEPTH (m)	STRATIGRAPHIC SECTION	PIEZ.	ELEVATION (m asl)	Major Bedding Plane	Estimated Cumulative Yield (L/min)	MATERIAL DESCRIPTION	
0			124.8	1.23, 1.83 2.44	0	0 to 8.23 UPPER GULL RIVER FORMATION -dark grey to black, fine crystalline limestones, -thinly bedded (5 to 10 cm) with shale between limestones - noticable drops at 1.22, 1.83, 2.44 and 8.23 m - very black cuttings; shale -no water present	
5			116.57	8.23		8.23 TO 38.10 m - LOWER GULL RIVER FORMATION	
10						-interbedded limestone, silty dolostone, quartz sandstone and shale -first thick green dolostone bed which was noticed was at 17.98 m	
15				17.23		-small drops at 8.23, 17.98, 28.04, 35.97 and 37.19 to 37.49 m	
20					9.09	-calcite-rich areas which may be the characteristic vugs of the Formation were encountered at 35.97 m	
25					9.09	-below 35.97 m started to encounter very fine grained grey/brown thinly bedded limestones	
30				28.04	-occurrence of greenish dolostone increases below 26.21 m		
35				35.97	- there is less than 9 L/min (2 IGPM) cumulative from the well, all this water was being derived from the 17.98 m level		
40				86.45	37.19 to 37.49	9.09	

LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

I. SAMPLE TYPE		III. SOIL DESCRIPTION	
AS	Auger sample	(a)	Cohesionless Soils
BS	Block sample	Density Index	N
CS	Chunk sample	(Relative Density)	<u>Blows/300 mm</u>
DO	Drive open		<u>Or Blows/ft.</u>
DS	Denison type sample	Very loose	0 to 4
FS	Foil sample	Loose	4 to 10
RC	Rock core	Compact	10 to 30
SC	Soil core	Dense	30 to 50
ST	Slotted tube	Very dense	over 50
TO	Thin-walled, open		
TP	Thin-walled, piston	(b)	Cohesive Soils
WS	Wash sample	Consistency	C_u or S_u
DT	Dual Tube sample		
II. PENETRATION RESISTANCE			
Standard Penetration Resistance (SPT), N:			
The number of blows by a 63.5 kg. (140 lb.)			
hammer dropped 760 mm (30 in.) required			
to drive a 50 mm (2 in.) drive open			
Sampler for a distance of 300 mm (12 in.)			
DD- Diamond Drilling			
Dynamic Penetration Resistance; N_a:			
The number of blows by a 63.5 kg (140 lb.)			
hammer dropped 760 mm (30 in.) to drive			
Uncased a 50 mm (2 in.) diameter, 60° cone			
attached to "A" size drill rods for a distance			
of 300 mm (12 in.).			
PH:	Sampler advanced by hydraulic pressure	IV. SOIL TESTS	
PM:	Sampler advanced by manual pressure	w	water content
WH:	Sampler advanced by static weight of hammer	w_p	plastic limited
WR:	Sampler advanced by weight of sampler and rod	w_l	liquid limit
		C	consolidation (oedometer) test
		CHEM	chemical analysis (refer to text)
		CID	consolidated isotropically drained triaxial test ¹
		CIU	consolidated isotropically undrained triaxial test
			with porewater pressure measurement ¹
		D_R	relative density (specific gravity, G_s)
		DS	direct shear test
		M	sieve analysis for particle size
		MH	combined sieve and hydrometer (H) analysis
		MPC	modified Proctor compaction test
		SPC	standard Proctor compaction test
		OC	organic content test
		SO_4	concentration of water-soluble sulphates
		UC	unconfined compression test
		UU	unconsolidated undrained triaxial test
		V	field vane test (LV-laboratory vane test)
		γ	unit weight

Note:

1. Tests which are anisotropically consolidated prior shear are shown as CAD, CAU.

LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

I. GENERAL		(a) Index Properties (cont'd.)	
π	= 3.1416	w	water content
$\ln x$	natural logarithm of x	w_l	liquid limit
$\log_{10} x$ or $\log x$	logarithm of x to base 10	w_p	plastic limit
g	Acceleration due to gravity	I_p	plasticity Index= $(w_l - w_p)$
t	time	w_s	shrinkage limit
F	factor of safety	I_L	liquidity index= $(w - w_p)/I_p$
V	volume	I_c	consistency index= $(w_l - w)/I_p$
W	weight	e_{max}	void ratio in loosest state
II. STRESS AND STRAIN		e_{min}	void ratio in densest state
γ	shear strain	I_D	density index= $(e_{max} - e)/(e_{max} - e_{min})$ (formerly relative density)
Δ	change in, e.g. in stress: $\Delta \sigma'$	(b) Hydraulic Properties	
ϵ	linear strain	h	hydraulic head or potential
ϵ_v	volumetric strain	q	rate of flow
η	coefficient of viscosity	v	velocity of flow
ν	Poisson's ratio	i	hydraulic gradient
σ	total stress	k	hydraulic conductivity (coefficient of permeability)
σ'	effective stress ($\sigma' = \sigma - u$)	j	seepage force per unit volume
σ'_{vo}	initial effective overburden stress	(c) Consolidation (one-dimensional)	
$\sigma_1 \sigma_2 \sigma_3$	principal stresses (major, intermediate, minor)	C_c	compression index (normally consolidated range)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$	C_r	recompression index (overconsolidated range)
τ	shear stress	C_s	swelling index
u	porewater pressure	C_α	coefficient of secondary consolidation
E	modulus of deformation	m_v	coefficient of volume change
G	shear modulus of deformation	c_v	coefficient of consolidation
K	bulk modulus of compressibility	T_v	time factor (vertical direction)
III. SOIL PROPERTIES		U	degree of consolidation
(a) Index Properties		σ'_p	pre-consolidation pressure
$\rho(\gamma)$	bulk density (bulk unit weight*)	OCR	Overconsolidation ratio= σ'_p/σ'_{vo}
$\rho_d(\gamma_d)$	dry density (dry unit weight)	(d) Shear Strength	
$\rho_w(\gamma_w)$	density (unit weight) of water	τ_p, τ_r	peak and residual shear strength
$\rho_s(\gamma_s)$	density (unit weight) of solid particles	ϕ'	effective angle of internal friction
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)	δ	angle of interface friction
D_R	relative density (specific gravity) of solid particles ($D_R = p_s/p_w$) formerly (G_s)	μ	coefficient of friction= $\tan \delta$
e	void ratio	c'	effective cohesion
n	porosity	c_u, s_u	undrained shear strength ($\phi=0$ analysis)
S	degree of saturation	p	mean total stress $(\sigma_1 + \sigma_3)/2$
*	Density symbol is ρ . Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density x acceleration due to gravity)	p'	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
		q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
		q_u	compressive strength $(\sigma_1 - \sigma_3)$
		S_l	sensitivity

Notes: 1. $\tau = c' + \sigma' \tan \phi'$

2. Shear strength = (Compressive strength)/2

PROJECT: 10-1127-0091

GEOPHYSICAL LOG OF: DDH10-01

SHEET 1 OF 4

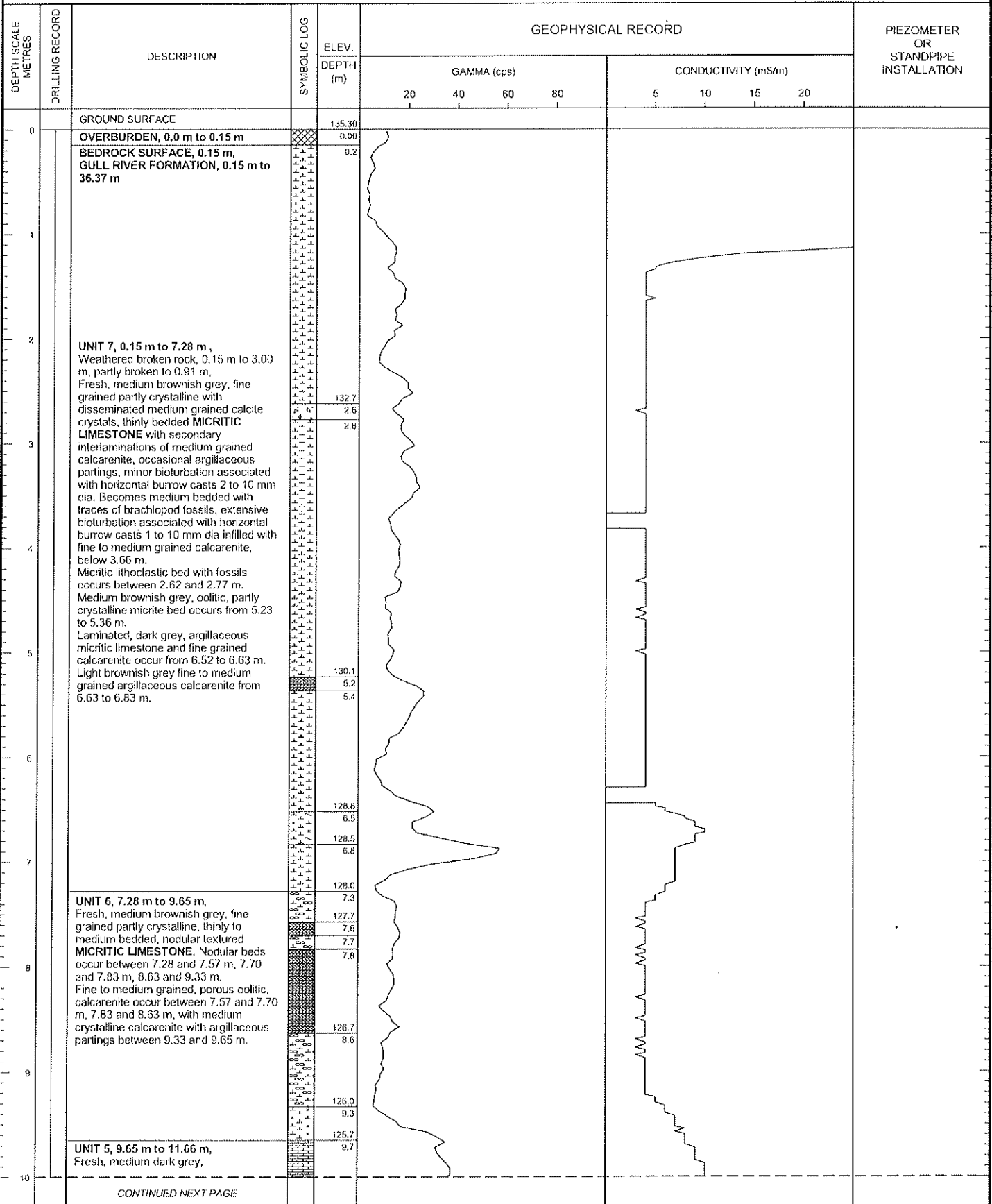
LOCATION: See Site Plan

DRILLING DATE: Dec. 13, 2010

DATUM:

DRILL RIG: CME 55

DRILLING CONTRACTOR: Marathon Drilling Co. Ltd.



MIS-GEO 008 1011270091.GPJ GAL-MISS.GDT 2016/11

DEPTH SCALE

1 : 50



LOGGED: RDB

CHECKED: RDB

PROJECT: 10-1127-0091

GEOPHYSICAL LOG OF: DDH10-01

SHEET 2 OF 4

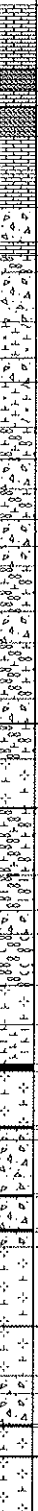
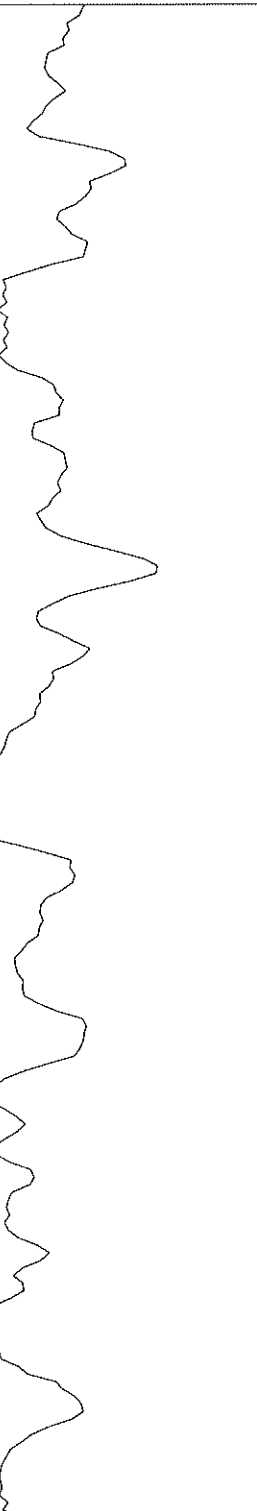
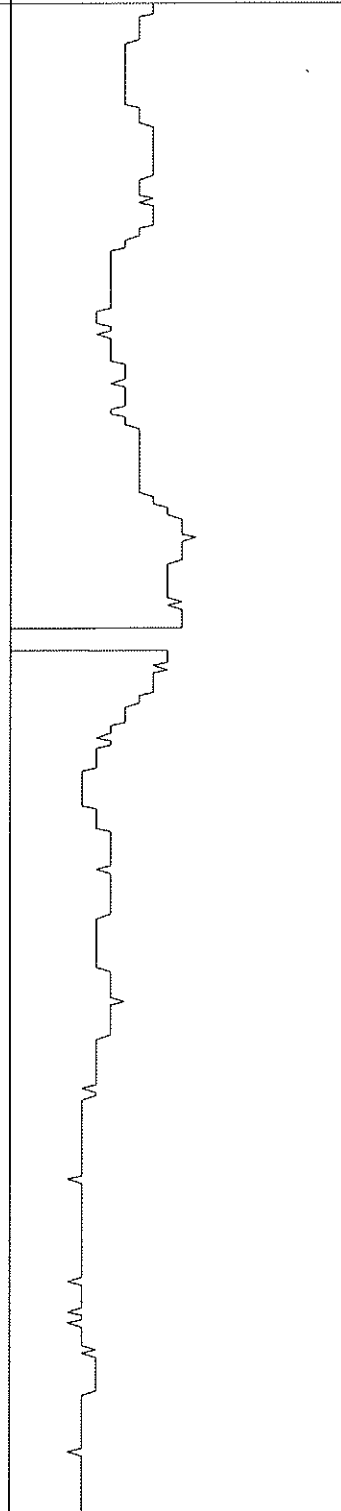
LOCATION: See Site Plan

DRILLING DATE: Dec. 13, 2010

DATUM:

DRILL RIG: CME 55

DRILLING CONTRACTOR: Marathon Drilling Co. Ltd.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. DEPTH (m)	GEOPHYSICAL RECORD								PIEZOMETER OR STANDPIPE INSTALLATION
					GAMMA (cps)				CONDUCTIVITY (mS/m)				
					20	40	60	80	5	10	15	20	
10		--- CONTINUED FROM PREVIOUS PAGE ---											
		interfaminated to very thinly interbedded very fine to medium grained micritic and calcarenitic LIMESTONE with argillaceous partings and minor bioturbation, Partly crystalline oolitic micrite beds occur between 10.42 and 10.57 m, 10.67 and 10.87 m, Poorly developed lithoclastic argillaceous micritic limestone bed occurs between 11.34 and 11.57 m,		124.9 10.4 10.6 10.7 124.4 10.9 124.0 11.3 123.7 11.6 11.7 11.8 123.2 12.1 123.0 12.3 12.5 122.5 12.8 122.3 13.0 122.1 13.2 121.9 13.4 13.6 13.7 121.3 14.0 121.1 14.2 120.7 14.6 14.8 120.3 15.0 120.0 15.3 119.5 15.8 119.3 15.0 16.0 16.2 118.8 16.5 118.5 16.8 118.3 17.1 117.9 17.5 117.4 17.9 117.2 18.1 18.2 116.6 18.8 116.2 19.1 19.2 115.9 19.4 115.7 19.6									
11													
12		UNIT 4, 11.66 m to 16.50 m, Fresh, light to medium brownish grey, interbedded sequence of fine to medium grained, medium bedded lithoclastic CALCARENITIC LIMESTONE and medium bedded argillaceous, laminar to nodular textured MICRITIC LIMESTONE , transitional contact with overlying unit marked by change from argillaceous micrite to laminated micrite and calcarenite. Lithoclastic calcarenite beds comprised of 1 to 10 mm dia, subrounded micrite clasts in calcarenite matrix occur between 11.77 and 12.10 m (first well developed lithoclastic bed), 12.34 and 12.50 m (argillaceous calcarenite), 13.01 and 13.21 m, 13.41 and 13.59 m (fossiliferous), 13.59 and 13.72 m (bioturbated), 14.02 and 14.23 m (argillaceous calcarenite), 14.60 and 14.76 m, 15.00 and 16.16 m. Argillaceous calcarenite beds occur between 12.10 and 12.34 m (porous, oolitic), 12.50 and 12.80 m (partly oolitic). Argillaceous, laminar to nodular textured micrite beds occur between 11.66 and 11.77 m, 13.21 and 13.41 m (lithoclastic), 13.72 and 14.02 m (dark grey), 14.23 and 14.60 m (nodular, bioturbated), 14.77 and 15.00 m, 15.00 and 15.32 m (first lithographic bed with fine stylolites and burrow casts), 15.33 and 15.77 m (nodular, bioturbated), 15.77 and 16.00 m (medium to dark grey with Lithoclasts), 16.16 and 16.50 (bioturbated). Black argillaceous to shaley bedding partings occur between 14.76 and 14.77 m, 15.32 and 15.33 m.											
13													
14													
15													
16													
17		Unit 3, 16.50 m to 20.60 m, Fresh, medium brownish grey, very fine to fine grained with disseminated calcite crystals, medium to thickly bedded, massive textured LITHOGRAPHIC LIMESTONE with black argillaceous to shaley bedding partings and interbedded layers of lithoclastic calcarenite and argillaceous micritic limestone. Individual lithographic beds occur between 16.50 and 16.76 m, 17.07 and 17.43 m, 18.23 and 19.08 m, 19.42 and 20.60 m. Lithoclastic calcarenite beds with shaley partings occur between 17.52 and 18.23 m. Lithoclastic micrite beds occur between 17.45 and 17.52 m, 19.08 and 19.20 m, 19.20 and 19.40 (argillaceous). Dark grey laminar textured, argillaceous to shaley micrite bed occurs between 16.76 and 17.02 m. Black, very thin shaley bedding partings occur between 17.02 and .07 m, 17.43 and .45 m, 17.88 and .90 m, 18.11 and .13 m, 18.75 and .76 m, 19.40 and .42 m, 19.61 and .62 m, 20.04 and .06 m, 20.21 and .23 m, 20.37 and 39 m.											
18													
19													
20													
		CONTINUED NEXT PAGE											

DEPTH SCALE

1 : 50

LOGGED: RDB

CHECKED: RDB

MIS-GEO 008 1011270091.GPJ GAL-MISS.GDT 20/6/11

PROJECT: 10-1127-0091

GEOPHYSICAL LOG OF: DDH10-01

SHEET 3 OF 4

LOCATION: See Site Plan

DRILLING DATE: Dec. 13, 2010

DATUM:

DRILL RIG: CME 55

DRILLING CONTRACTOR: Marathon Drilling Co. Ltd.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	GEOPHYSICAL RECORD								PIEZOMETER OR STANDPIPE INSTALLATION	
				ELEV.	GAMMA (cps)				CONDUCTIVITY (mS/m)				
				DEPTH (m)	20	40	60	80	5	10	15		20
20		--- CONTINUED FROM PREVIOUS PAGE ---											
				20.1									
				20.2									
				20.4									
				114.7									
				20.6									
				114.4									
21		Unit 2, 20.60 m to 25.88 m, Fresh, light to medium grey, fine grained, medium to thickly bedded, massive textured to bioturbated MICRITIC LIMESTONE with interbeds of micrite and calcarenite, lithoclastic micrite and calcarenite and shaley partings. Distinct medium grey, fine crystalline, massive textured, thick dolostone bed occurs between 23.04 and 23.83 m with a 1 cm grey shale bottom overlying dolomitic limestone between 23.84 and 24.35 m. Lithoclastic calcarenite with fining upward clasts occurs between 20.60 and 20.93 m, 21.95 and 22.35 m (tabular clasts, partly oolitic). Lithoclastic micrite bed occurs between 20.93 and 21.03 m, 24.84 and 25.07 m. Light grey, fine to medium grained, massive textured calcarenite between 22.35 and 22.86 m. Black, shaley argillaceous partings occur between 20.93 and 20.94 m, 21.43 and 21.44 m. Medium grey, fissile, clayey, calcareous shale beds occur between 23.84 and 23.85 m, 25.68 and 25.71 m, 25.86 and 25.88 m.		20.9									
				21.0									
				113.9									
				21.4									
				113.4									
22				22.0									
				113.0									
				22.4									
				112.4									
				112.3									
23				23.0									
				111.5									
				23.9									
				111.0									
				24.4									
				110.5									
				24.8									
25				110.2									
				25.1									
				109.6									
				25.7									
26		UNIT 1, 25.88 m to 36.37 m, Fresh, light to medium grey, fine grained partly crystalline, medium to thickly bedded, non fossiliferous, massive textured, MICRITIC LIMESTONE with well developed fine stylolites and occasional interbeds of darker grey micritic dolomitic limestone and numerous 1 to 5 mm thick argillaceous bedding partings. Top of unit marked by light grey, partly crystalline, lithoclastic micritic limestone between 25.88 and 26.06 m. Dolomitic limestone beds occur between 28.59 and 28.82 m, 29.29 and 29.49 m (argillaceous, fossiliferous), 33.83 and 34.23 m, 35.63 and 36.37 m. Dark grey, laminar textured argillaceous micrite beds occur between 33.51 and 33.59 m, 34.93 and 35.20 m. Light grey lithographic micrite bed occurs between 32.03 and 32.31 m. Argillaceous bedding partings 1 to 5 mm thick occur at 26.62 m, 27.42 m, 27.52 m, 27.89 m, 28.45 m, 28.59 m, 30.01 m, 30.18 m, 30.51 m, 31.68 m, 32.31 m, 32.84 m, 33.12 m, 34.23 m. Limestone breccia infilled with vuggy coarse grained calcite occurs between 35.57 and 35.63 m.		25.9									
				109.2									
				26.1									
				108.7									
				26.6									
				107.9									
				27.6									
				107.4									
28				27.9									
				106.9									
				28.5									
				28.6									
				106.5									
				28.8									
				106.0									
				29.3									
				105.8									
				29.5									
				105.3									
30		CONTINUED NEXT PAGE											

DEPTH SCALE

1:50

LOGGED: RDB

CHECKED: RDB

PROJECT: 10-1127-0091

GEOPHYSICAL LOG OF: DDH10-01

SHEET 4 OF 4

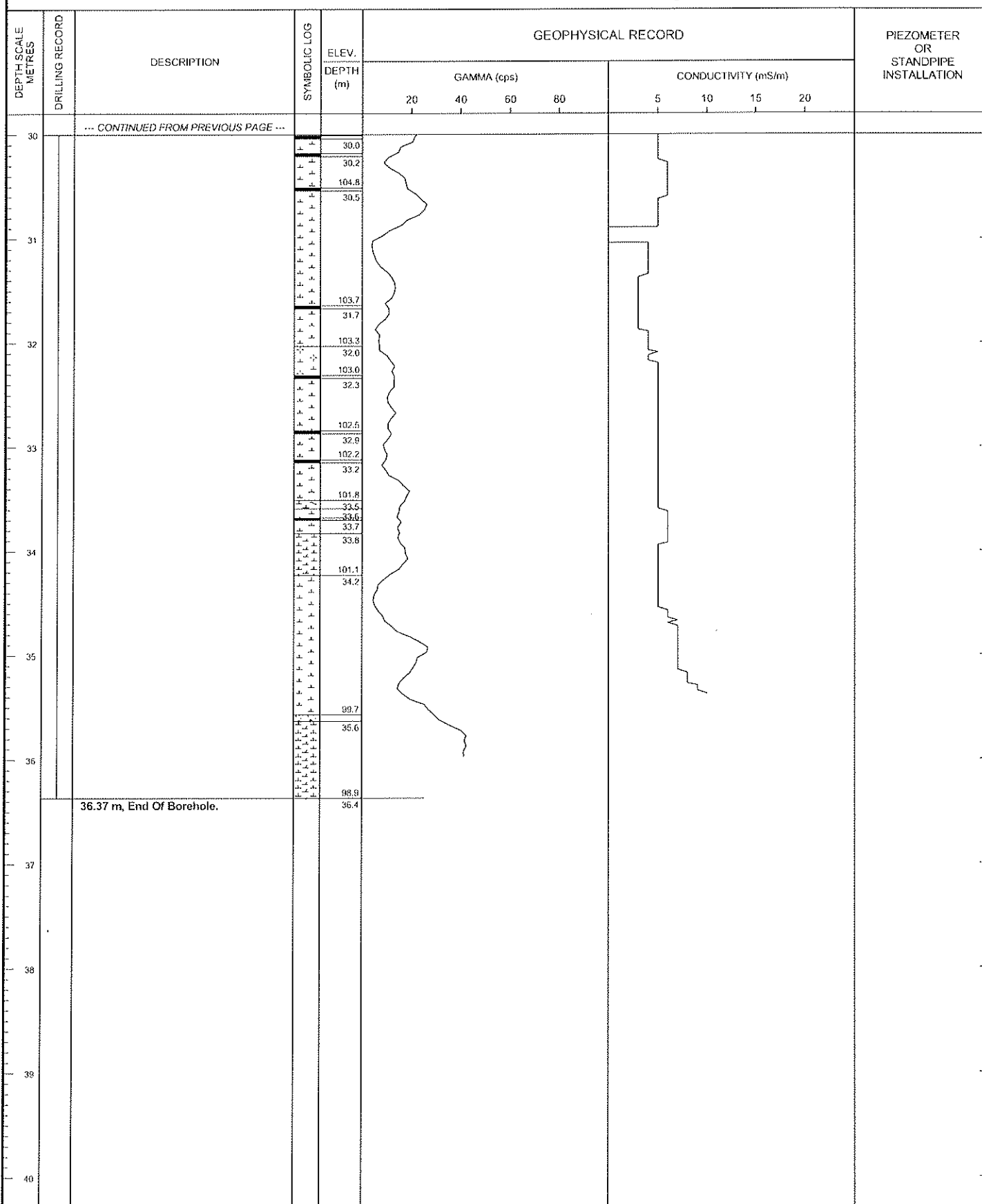
LOCATION: See Site Plan

DRILLING DATE: Dec. 13, 2010

DATUM:

DRILL RIG: CME 55

DRILLING CONTRACTOR: Marathon Drilling Co. Ltd.

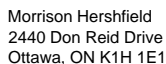


DEPTH SCALE

1 : 50

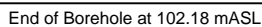
LOGGED: RDB

CHECKED: RDB



Client Cruickshank Construction Limited
Project Number 2130039.00
Well Location 375321 mE, 4908199 mN (UTM Zone 18 NAD 83)
Date Completed 12/12/2013
Hole Size 6 inch

Project Name Elginburg Quarry Expansion ARA Application
Project Location Elginburg Quarry
Ground Surface Elevation 138.14 mASL
Casing Top Elevation 138.94 mASL
Static Water Level See Well Diagram



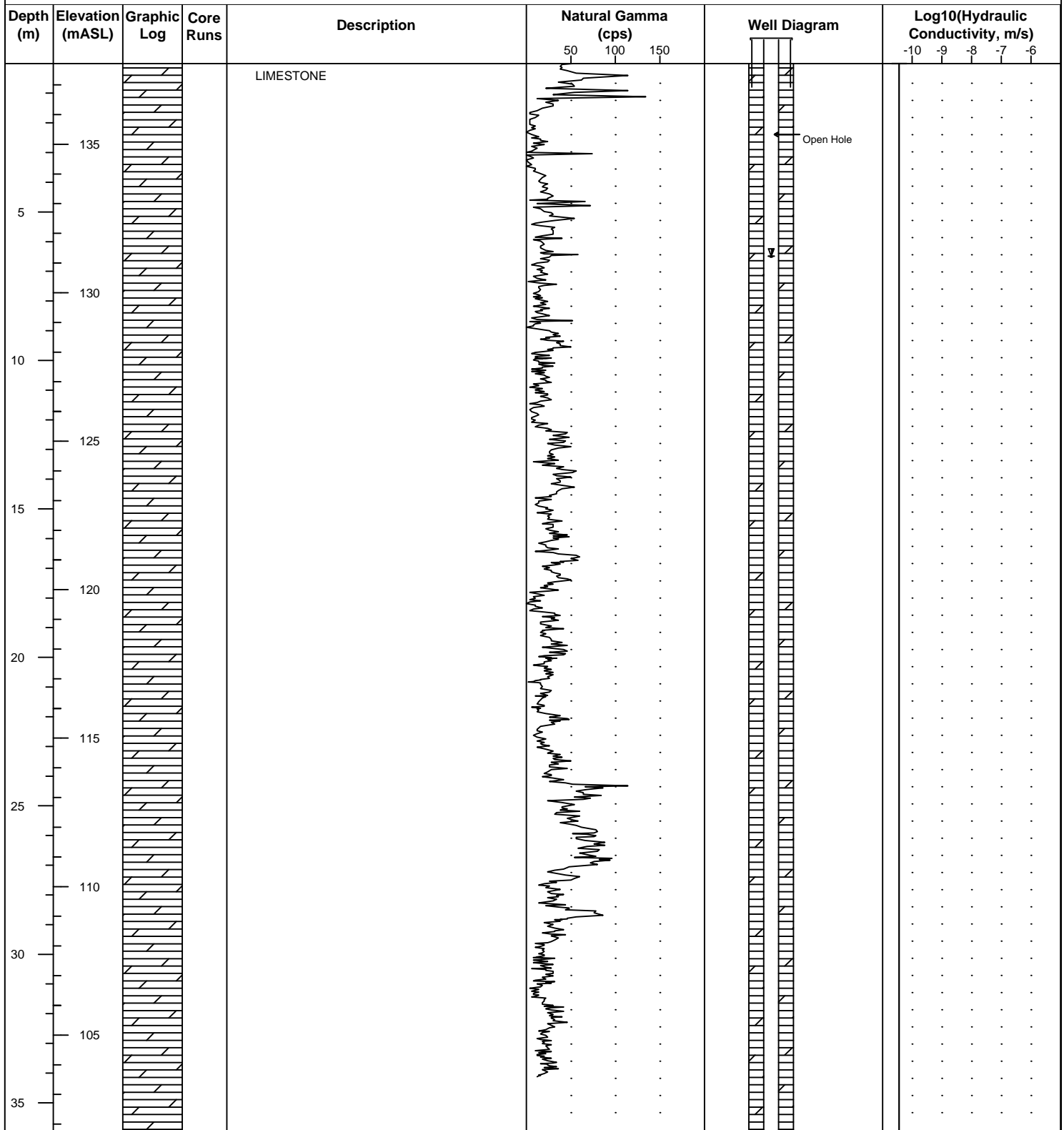


Morrison Hershfield
2440 Don Reid Drive
Ottawa, ON K1H 1E1

BORING NUMBER BH11-03

Client Cruickshank Construction Limited
Project Number 2130039.00
Well Location 375109 mE, 4907991 mN (UTM Zone 18 NAD 83)
Date Completed 2011
Hole Size 6 inch

Project Name Elginburg Quarry Expansion ARA Application
Project Location Elginburg Quarry
Ground Surface Elevation 137.72 mASL
Casing Top Elevation 138.52 mASL
Static Water Level See Well Diagram



End of Borehole at 101.72 mASL

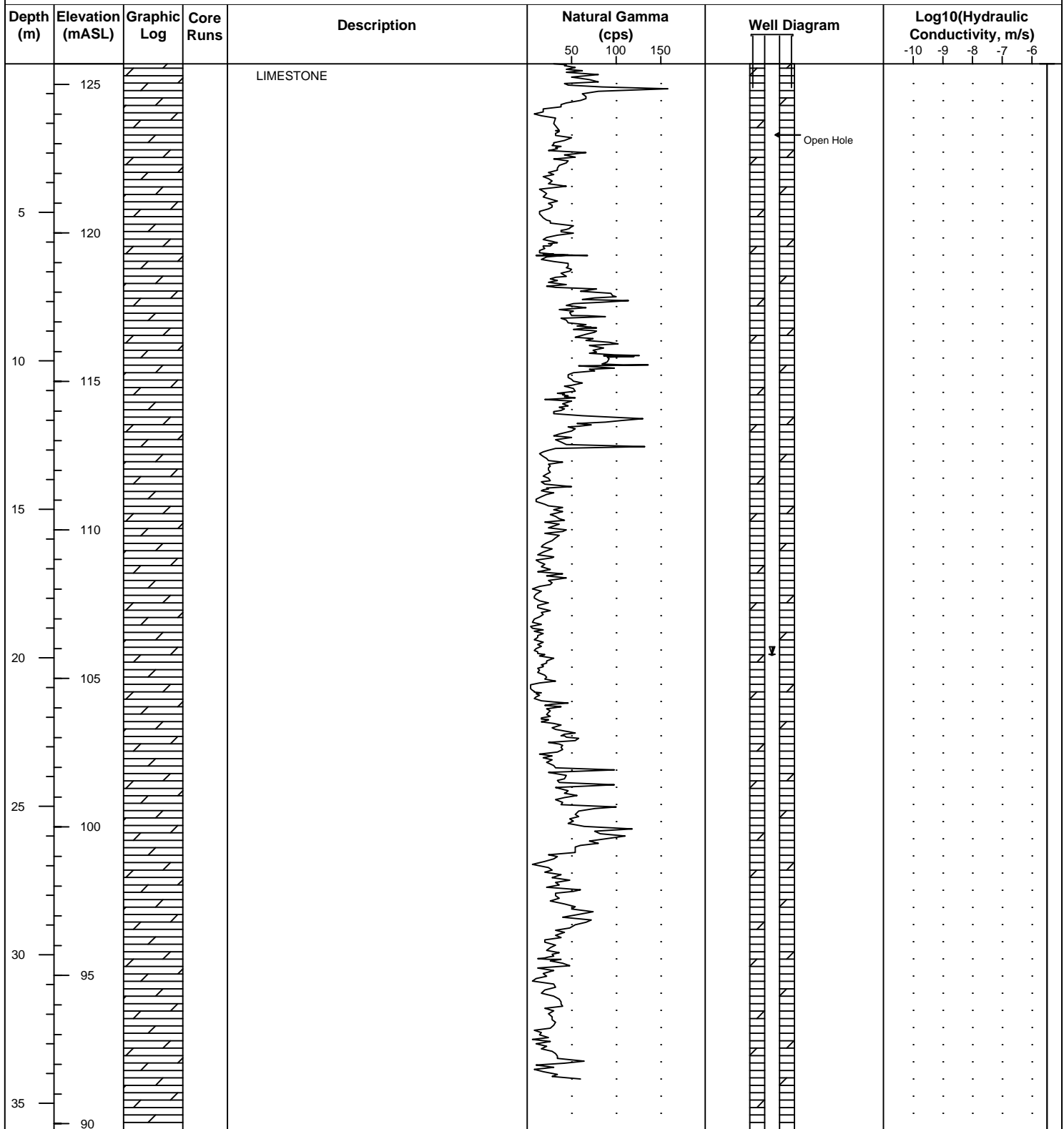


Morrison Hershfield
2440 Don Reid Drive
Ottawa, ON K1H 1E1

BORING NUMBER BH11-04

Client Cruickshank Construction Limited
Project Number 2130039.00
Well Location 375437 mE, 4907054 mN (UTM Zone 18 NAD 83)
Date Completed 2011
Hole Size 6 inch

Project Name Elginburg Quarry Expansion ARA Application
Project Location Elginburg Quarry
Ground Surface Elevation 125.69 mASL
Casing Top Elevation 126.63 mASL
Static Water Level See Well Diagram



End of Borehole at 89.69 mASL

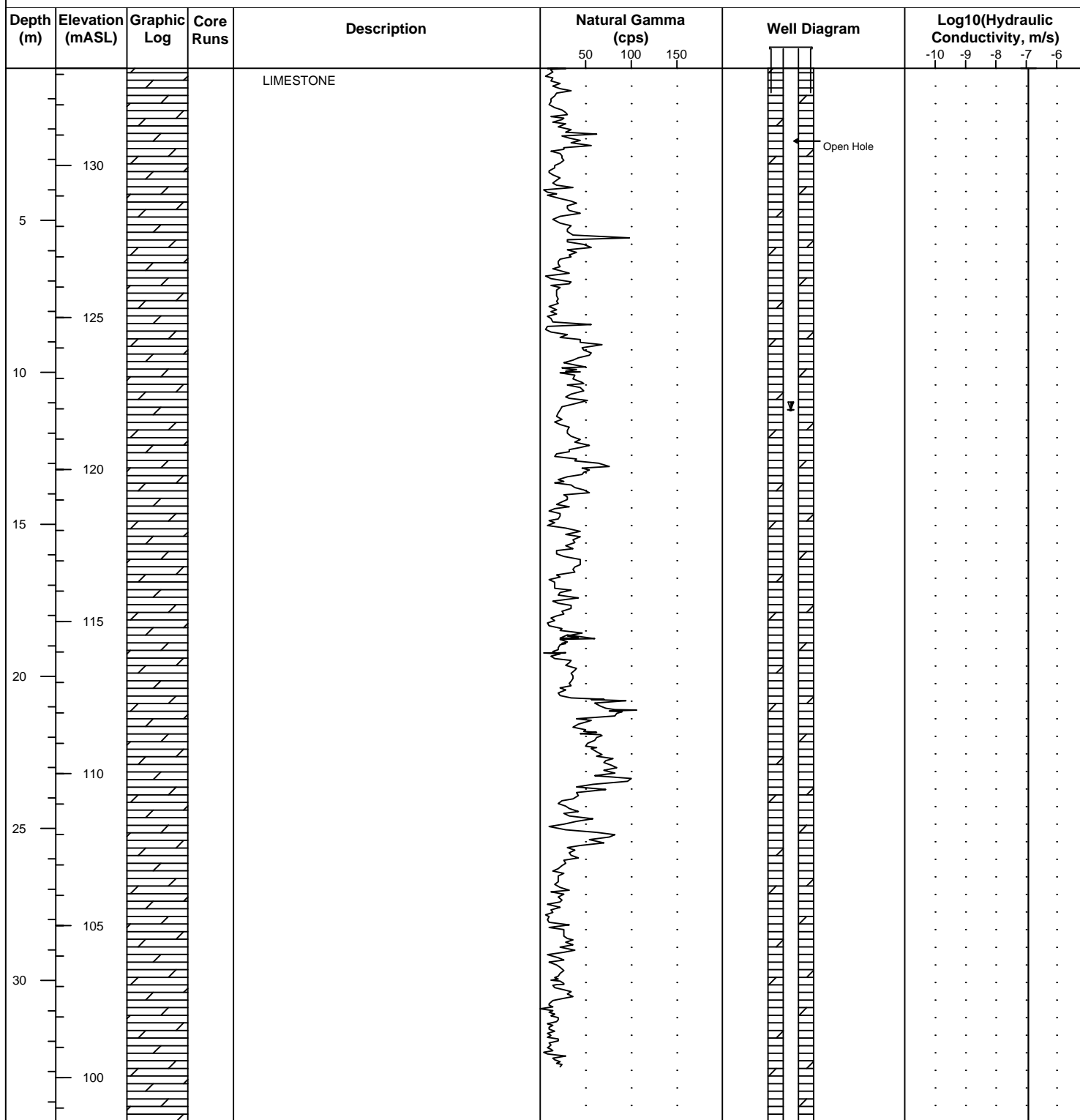


Morrison Hershfield
2440 Don Reid Drive
Ottawa, ON K1H 1E1

BORING NUMBER BH12-01

Client Cruickshank Construction Limited
Project Number 2130039.00
Well Location 375319 mE, 4907602 mN (UTM Zone 18 NAD 83)
Date Completed 12/14/2012
Hole Size 4 inch

Project Name Elginburg Quarry Expansion ARA Application
Project Location Elginburg Quarry
Ground Surface Elevation 133.20 mASL
Casing Top Elevation 133.84 mASL
Static Water Level See Well Diagram



End of Borehole at 98.50 mASL

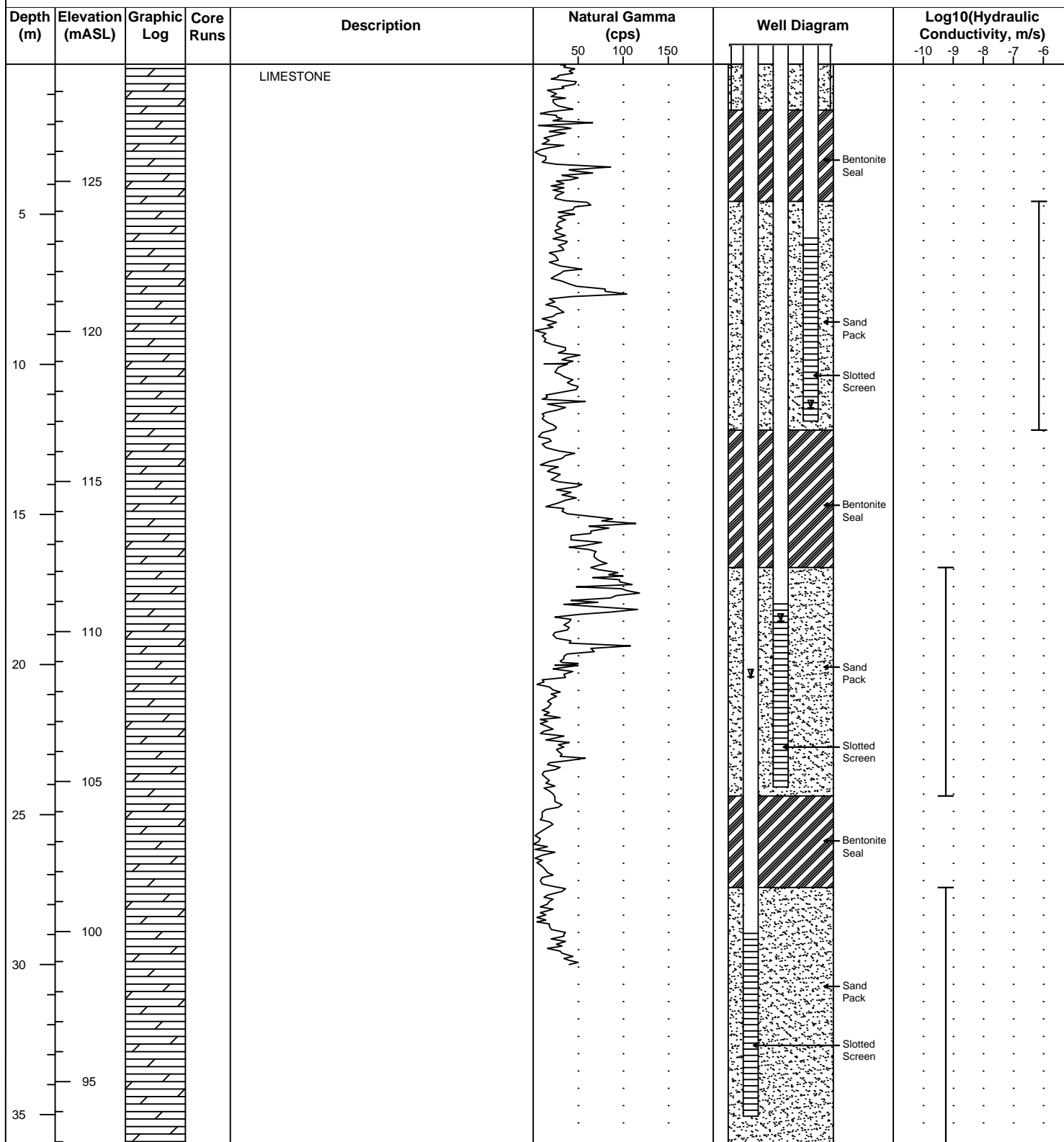


Morrison Hershfield
2440 Don Reid Drive
Ottawa, ON K1H 1E1

BORING NUMBER BH12-02

Client Cruickshank Construction Limited
Project Number 2130039.00
Well Location 375148 mE, 4907222 mN (UTM Zone 18 NAD 83)
Date Completed 12/12/2013
Hole Size 6 inch

Project Name Elginburg Quarry Expansion ARA Application
Project Location Elginburg Quarry
Ground Surface Elevation 128.90 mASL
Casing Top Elevation 129.51 mASL
Static Water Level See Well Diagram



End of Borehole at 92.94 mASL

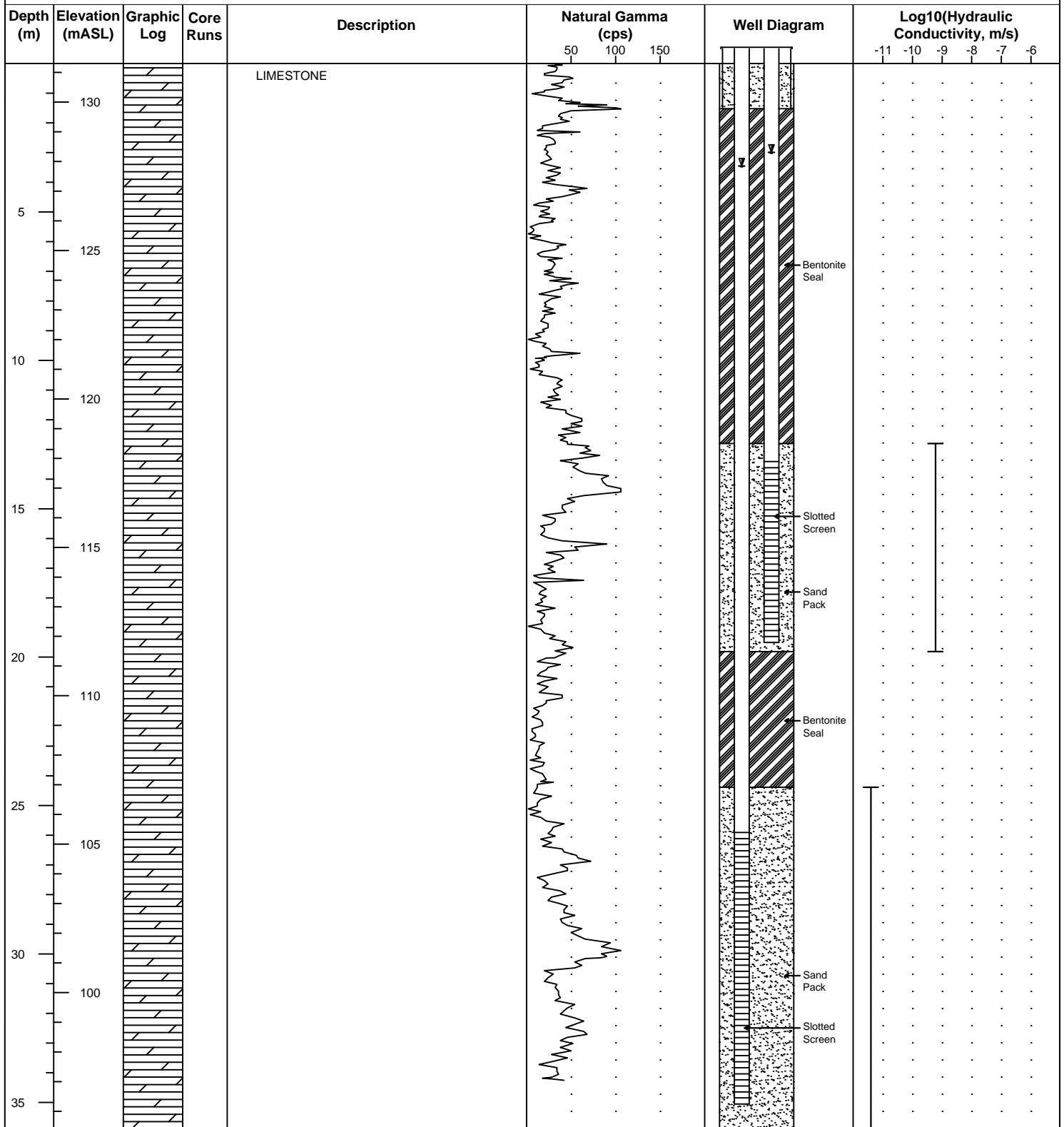


Morrison Hershfield
2440 Don Reid Drive
Ottawa, ON K1H 1E1

BORING NUMBER BH12-03

Client Cruickshank Construction Limited
Project Number 2130039.00
Well Location 374786 mE, 4906954 mN (UTM Zone 18 NAD 83)
Date Completed 12/12/2013
Hole Size 6 inch

Project Name Elginburg Quarry Expansion ARA Application
Project Location Elginburg Quarry
Ground Surface Elevation 131.30 mASL
Casing Top Elevation 131.80 mASL
Static Water Level See Well Diagram



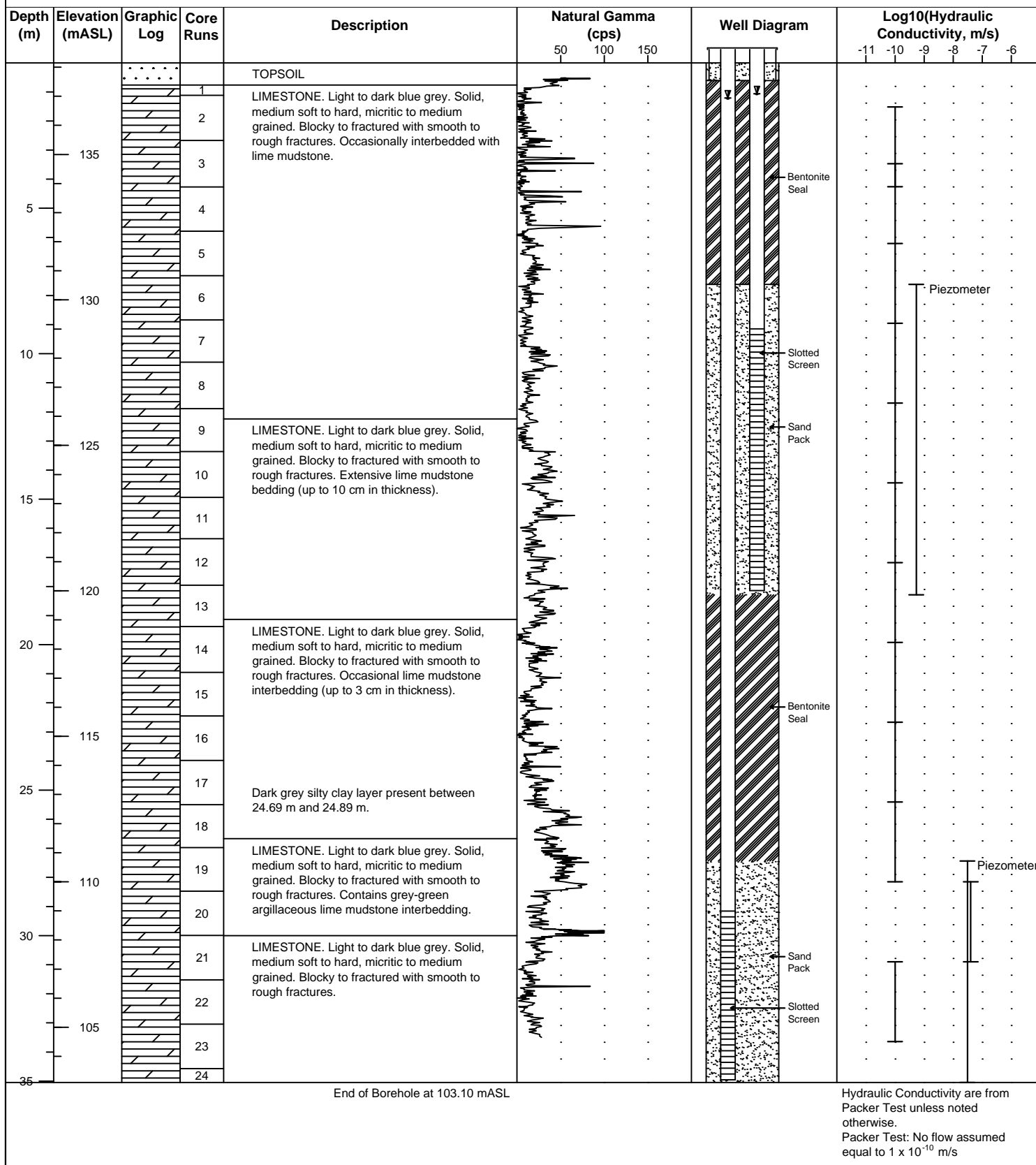


Morrison Hershfield
2440 Don Reid Drive
Ottawa, ON K1H 1E1

BORING NUMBER BH13-01

Client Cruickshank Construction Limited
Project Number 2130039.00
Well Location 375115 mE, 4908411 mN (UTM Zone 18 NAD 83)
Date Completed 12/12/2013
Hole Size 6 inch

Project Name Elginburg Quarry Expansion ARA Application
Project Location Elginburg Quarry
Ground Surface Elevation 138.15 mASL
Casing Top Elevation 138.61 mASL
Static Water Level See Well Diagram



APPENDIX C: Photographs from Site Inspection





Photo 1: Ice on west wall of south existing quarry, approx. elevation 128 masl, taken Nov. 25, 2013



Photo 2: Same location, on January 10, 2014



Photo 3: North quarry, looking north.
Note the same ice production at approximately 128 masl.



Photo 4: South quarry, looking south.
Note the ice at various locations, at approximately 120 masl.



Photo 5: South wall of south quarry. Note the ice at approximately 120 masl.



Photo 6: Close up of rust staining and ice at point groundwater discharge location.



Photo 7: Pumping from the sump of north excavation



Photo 8: North pump junction. Black pipe goes to culvert and to south quarry (SW1)



Photo 9: Wash plant sediment ponds in south quarry



Photo 10: Wash plant pond with pump for flood events



Photo 11: Overflow sediment pond (SW2)



Photo 12: Southwest corner of south quarry, with ponded water



Photo 13: Drainage ditch exiting quarry at the south end (SW3)



Photo 14: Rectangular culvert under K&P trail (taken from upstream end)

APPENDIX D: Downhole Geophysics Report



NOTRA

***SUMMARY OF THE
PHYSICAL PROPERTY BOREHOLE
GEOPHYSICAL SURVEYS CONDUCTED AT
ELGINBURG, ONTARIO***

Submitted To:

Morrison Hershfield

Date

29 January 2013

Prepared By:

NOTRA Inc.

Dennis Gamble, P.Geo.

DISCLOSURE RESTRICTIONS

This document contains information which has been developed by NOTRA at its expense, and is subject to Section 19, 20 and 21 of the Access to Information Act of the Government of Canada. Any use or disclosure of this information, other than the specific purpose for which it is intended, is expressly prohibited, except as NOTRA may otherwise agree in writing.

EXECUTIVE SUMMARY

A potential quarry expansion has been identified along the west and south west side of the current operations near Elginburg, ON, north of Kingston, Ontario.

In order to determine if suitable rock materials are sufficient and shallow enough to make a quarry operation feasible, a series of three (3) additional bore holes were commissioned throughout the property (in addition to 3 previously drilled). One hole, DDH10-01 (2010) was cored using a diamond drill borehole rig, allowing for a core log to be determined as well as additional chemical analysis. The geologic sections determined from DDH10-01 served as a reference log of the local geology and other boreholes.

An additional three (3) holes were drilled using reverse circulation techniques in 2012, holes BH1201, BH1202 and BH1203, which result in only rock dust being retrieved from the holes. Three other holes drilled in 2011 were also surveyed (BH1102, BH1103 and BH1104). In order to determine the lithology in these holes, borehole physical property surveys were conducted and the results compared to the reference log of DDH10-01.

Morrison Hershfield contracted NOTRA Inc. to conduct the seven (7) borehole physical property surveys. The Instruments for Geophysics (IFG) BMP06 multi-parameter probe was used along with the IFG 100 meter winch with optical depth encoder. The BMP06 simultaneously measures six (6) parameters at a rate of two (2) readings per second. The site was large; with limited access to the holes that were distributed over an area of approximately 1.2 km x 500m. A Side by Side ATV was used to transport the equipment from hole to hole.

Following analysis of the data it was determined that the natural gamma displayed a very close resemblance between all seven (7) boreholes. Using the DDH10-01 results, marker locations for the other 6 holes were projected using the natural gamma and resistivity data.

At the time of this report the results of the core and chemical analysis were not provided, however, the geophysical markers can be used to interpolate the relative depths any zones of interest from DDH10-01 to the other holes.

The overall trend indicates that the sedimentary rock sequences dip linearly to the south relative to the ground surface (elevation data has not been collected or provided). Over approximately 1100 meters from north to south, the top of DDH10-01 is found to have an additional 13 meters of sedimentary rock above it, implying a dip of approximately 0.6 Degrees.

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5.0 Statement of Limitations.....	7
 Annex A Equipment Description	
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• 100m Winch	
 Annex B Completed Logs (DDH10-01, BH1102, BH1103, BH1104, BH1201, BH1202 and BH1203)	
 Annex C Pictures	

1.0 Introduction

On 18 December 2012, NOTRA conducted a physical property borehole survey of seven (7) Boreholes that were approximately 35m in depth. Borehole DDH10-01 was a cored hole from which geophysical markers were identified. The other six (6) holes were drilled using reverse circulation and no core logs were produced.

The purpose of the borehole survey was to provide a manner to compare the geology sequences and depths between the cored hole and the six non-cored holes. An IFG BMP06 multi-parameter borehole tool was used to log data at approximately 5 cm intervals in all seven (7) holes.

The water table was found to be relatively deep, between 8 to 20 meters for the five (5) holes. The Apparent Resistivity and Single Point Resistance can only work within the water column and were deleted in the dry section of each hole. The Magnetic Susceptibility and Apparent Conductivity reacted only to the casing and were not used otherwise. The temperature data is presented, but only provides information of possible porous fractures.

The natural gamma data works within casing, dry sections of holes and within the water column with no variation. It was this parameter that was reproducible from hole to hole and can be used to imply the depths of any sequence relative to the sequences present in DDH10-01.

2.0 Methodology and Approach

BMP06

The BMP06 measures simultaneously the temperature (T), apparent conductivity (AC), apparent resistivity (AR), single point resistance (SPR), magnetic susceptibility (MS) and natural gamma (NG) at a rate of 2 reading per second. The depth is also measured using an optical depth encoder that is part of the pulley mechanism affixed to the casing.

During the survey a 5 mA current is transmitted into the electrode from the control unit (remotely placed 25 meters from the borehole). This is used for the apparent resistivity measurements.

Upon placing the borehole probe in the hole, the depth of Zero is entered in the logging computer after the top of the probe has been lined up with the top of the casing. All depth references are to the top of the casing.

With the computer logging, the probe is lowered at approximately 5 meters per minute, resulting in one data point for all parameters being recorded every 4 cm. The probe is stopped briefly at 10 meter intervals (to confirm the accuracy of the optical depth encoder). Following completion of the hole, data is then collected while bringing the probe up, although at a faster rate. This up data is compared to the down run data to ensure proper operation of the unit. In the event there is a depth dispute when the probe reaches the top of the casing, the hole is resurveyed.

From each file the depth values are also confirmed (using the 10 m calibration points) and each parameter is extracted to an asc file. These files were then plotted in LogView from which analysis can be conducted.

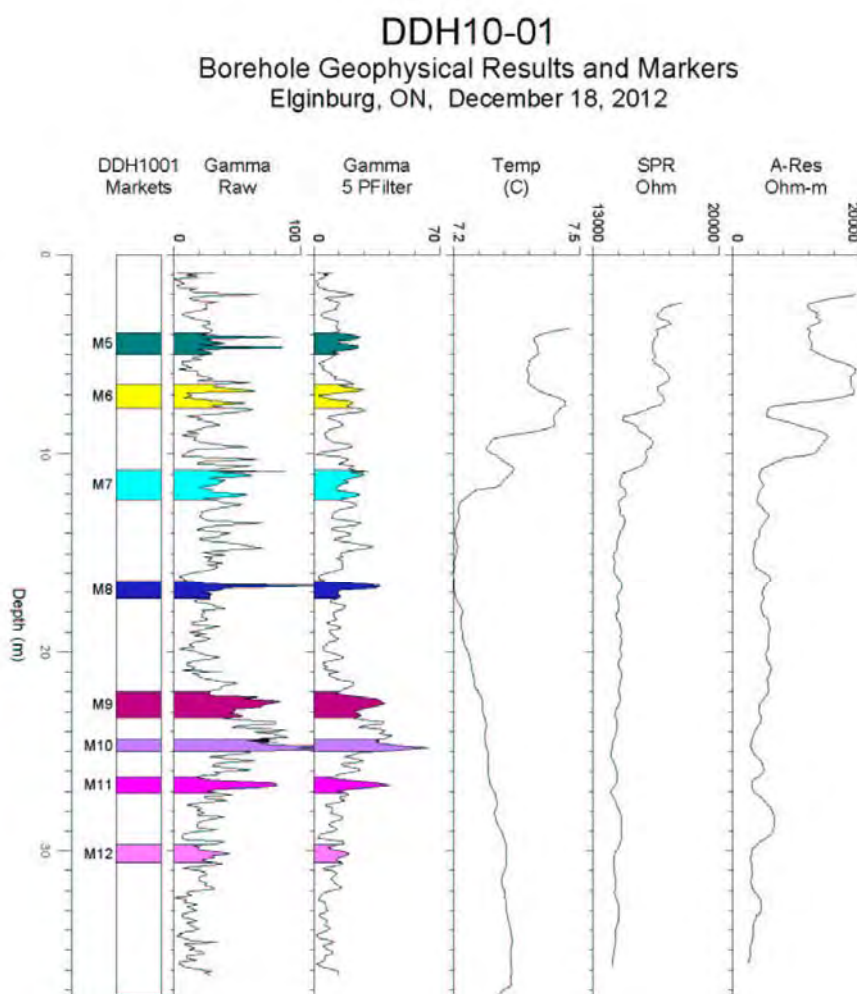
Annex A has a complete description of the BMP06 probe and winch used during this survey.

Annex B has a description of the portable, manual 100m winch.

3.0 Results

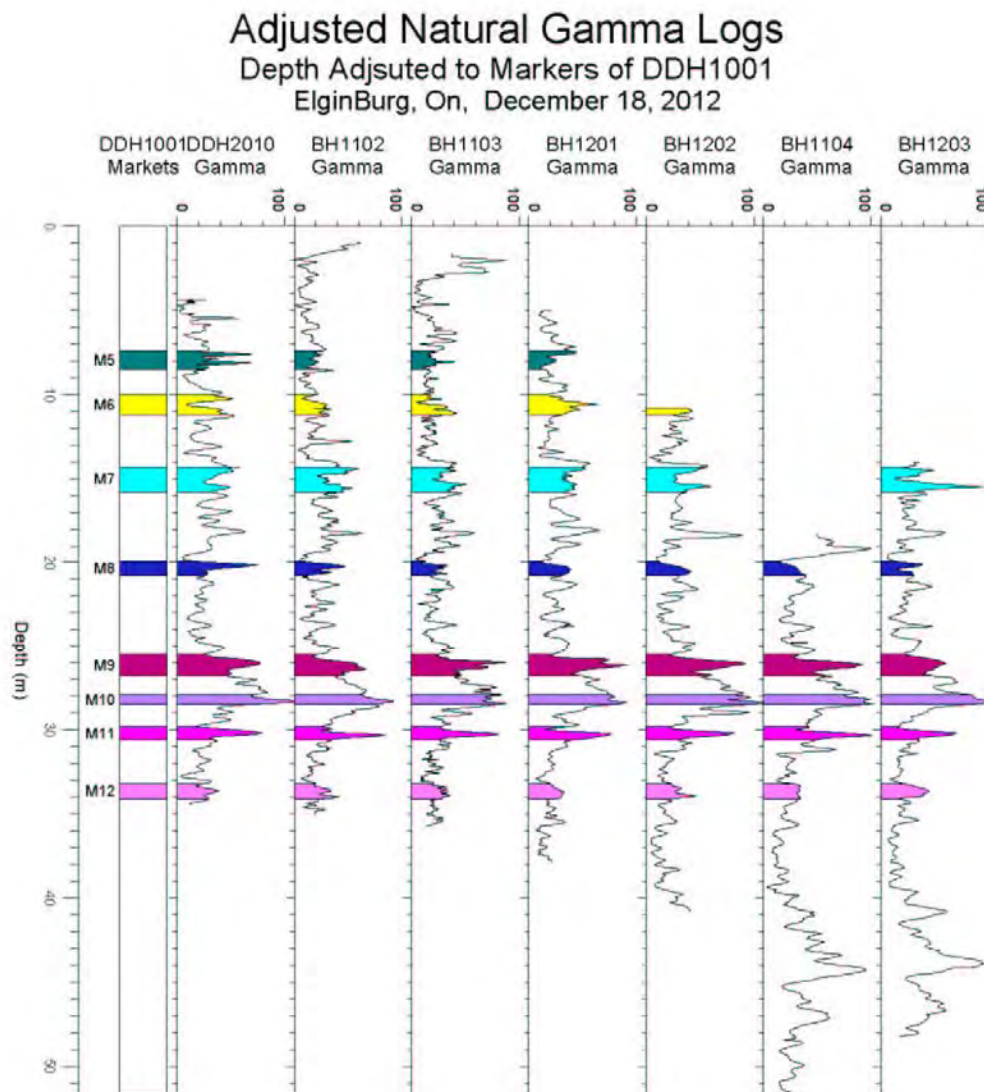
DDH10-01 was surveyed and divided into the eight markers (8) units based on the natural gamma profiles starting at marker 5 (marker 1 to 4 to be attributed to markers higher in the sedimentary sequence than present at the ground level of DDH10-01).

Figure 1 – DDH10-01 with Markers



After determining location of these markers depths for the remaining 6 holes, the relative depth was adjusted until they matched that of the natural gamma markers (M5 to M12), the Natural Gamma data was plotted for all the holes and adjusted to line up (on BH1102 – the highest). - The complete logs for BH1102-BH1104, to BH1201-BH1203 are contained in Annex B.

Figure 2 - Natural Gamma Data – Levelled to Markers



The natural gamma data maps profiles for each hole are very similar when adjusted by a vertical shift and aligned to specific features in the profiles.

The following table summarizes the depth of each hole surveyed, the water table depth and the relative shift to the natural gamma profiles to align the markers to BH1102.

Table 1 - Borehole Summary

	Depth in meters		
Borehole	Water	Hole Length	Shift to Align Markers
DDH1001	3.7	37.2	4.4
BH1102	4.9	35.9	0.9
BH1103	8.8	36.0	1.6
BH1104	19.8	36.0	18.3
BH1201	11.4	34.7	5.0
BH1202	17.6	39.1	10.8
BH1203	2.0	36.1	14.0

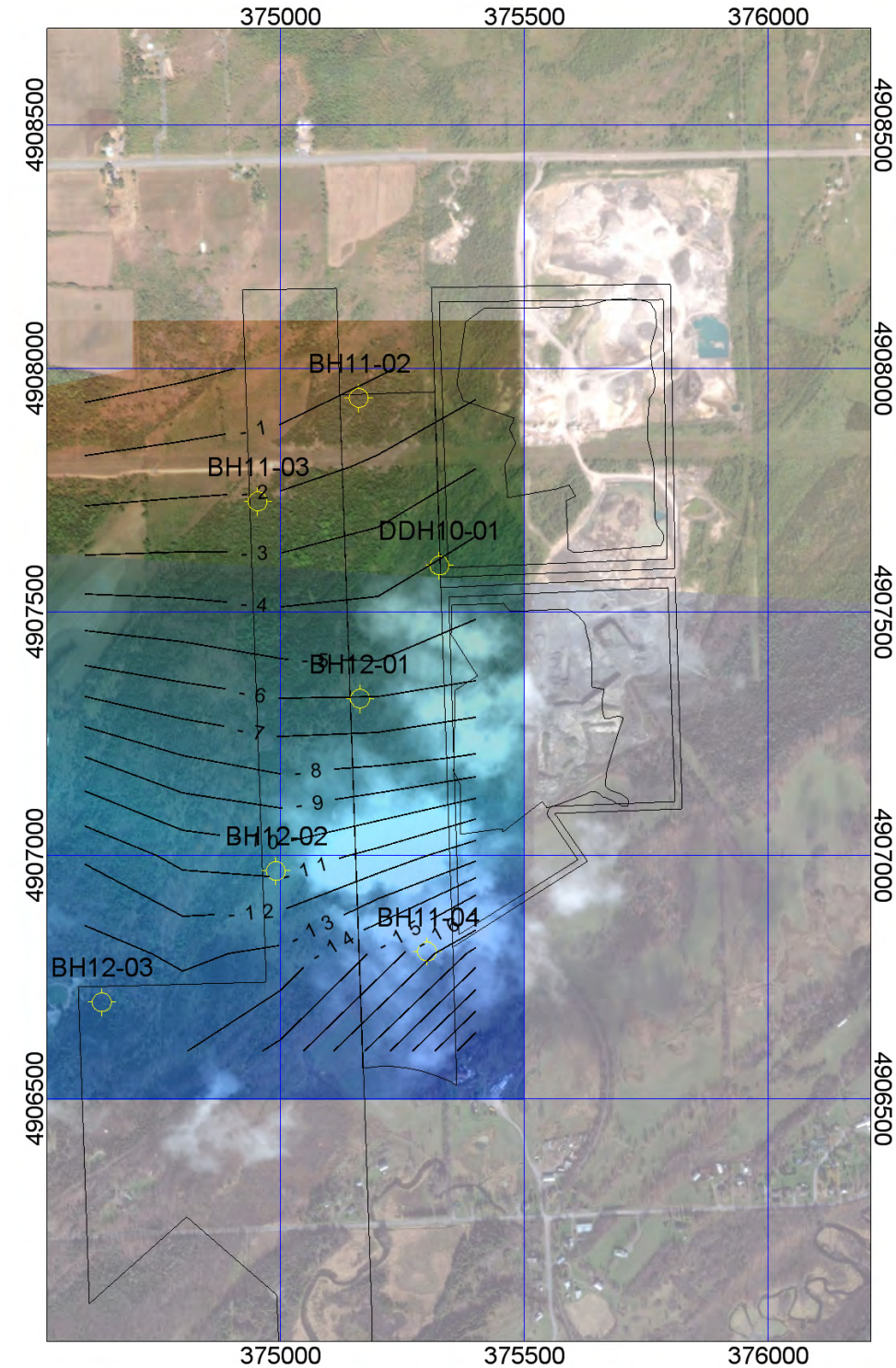
By plotting the location of each hole and the shift required to align the Natural Gamma data, the relative dip and strike of the sedimentary rocks can be plotted relative to the top of the borehole casing (the reference for each profile). Table 2 below has the locations (provided by Morrison Hershfield) and the shift.

Table 2 - Borehole Locations and Shift to Align Markers

<u>Name</u>	<u>X</u>	<u>Y</u>	<u>Shift to Align Gamma</u>
DDH10-01	375326.5	4907596.0	4.4
BH11-02	375161.1	4907940.2	0.9
BH11-03	374953.6	4907727.6	1.6
BH11-04	375301.2	4906803.1	18.3
BH12-01	375163.5	4907322.5	5.0
BH12-02	374990.9	4906968.5	10.8
BH12-03	374634.1	4906698.8	14.0

Figure 3 is a contour map of the borehole locations and the shift applied to match the markers identified in the natural gamma data.

Figure 3 – Contour Map of Shift applied to Alien Natural Gamma Data



4.0 Conclusions

At the Elginburg Site, natural gamma (NG) data can be used to determine the locations of lithology between all seven (7) Boreholes.

Markers relating to Natural Gamma data can be identified and located on all of the holes surveyed. Markers M5 to M12 were located on the reference hole, DDH10-01 and located on the additional six (6) boreholes

By shifting the elevation of each hole, the Natural Gamma and markers were aligned. A plot of this shift value for each hole using the provided borehole location indicates a dip of less than 1 degree to the south relative to ground surface (top of casings for each hole).

This implies a significant additional amount of rock of over 10 meters is above the beginning sedimentary rock units present at the top of DDH10-01 at a distance of 1 km to the south, increasing to 18m at a distance of 1200m.

The locations of fractures can be obtained from the temperature and temperature gradient data; however, at this time this information is not required.

5.0 Statement of Limitations

This Geophysical Survey Report has been prepared exclusively for Morrison Hershfield. The purpose of this report is to provide them with an assessment of the lithology of six (6) Boreholes relative to one (1) Diamond Drill Hole. This report is neither an endorsement nor a condemnation of the subject property.

The borehole geophysical techniques employed typically produce methods to map and differentiate structure in bed rock. However, each technique has limitations, especially in areas in which there is little magnetic changes, conductivity changes or in dry portions of wells.

The results and conclusions documented in this report have been prepared for a specific application to this project and have been developed in a manner with that level of skill normally exercised by qualified professionals currently practicing in this area of geophysical surveying. No other warranty, expressed or implied, is made.

Reports or memoranda resulting from this assignment are not to be used in whole or in part outside Morrison Hershfield without prior written permission.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. NOTRA Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.

If new information is developed in future work (which may include the survey in of borehole locations and elevations or changes to the diamond drill logs), NOTRA should be contacted to re-evaluate the conclusions of this report and to provide amendments as required.

Dennis Gamble

Dennis Gamble, P.Geo, P.Geoph.
Senior Geophysicist, NOTRA Inc.
January 29, 2013

***ANNEX A
EQUIPMENT DESCRIPTION***

- BMP06 Multi-Component Probe
- 100m Winch

Instruments for Geophysics (IFG) - BMP06 Multi-Component Probe

General Description

The BMP-06 is a multi-component probe designed by the IFG Corporation in Brampton, Ontario. It simultaneously measures temperature (T), Relative Conductivity (RC), Magnetic Susceptibility (MS), Natural Gamma (NG), Single Point Resistance (SPR) and Apparent Resistivity (AR).

The probe is a total length of 196 cm (from cable head to tip). The parameters measured are located along the full probe length.

Parameter Description

Temperature

A temperature sensor is located 182 cm below the cable head. The temperature sensor is resilient to drift and measurements are repeatable to within 0.01 of a degree Celsius. For additional calculations such as gradient or differential temperature, the temperature data is interpolated to a fixed depth interval.

As the probe goes down the hole it disturbs the static water column. For this reason the initial down run is used for presentation and interpretation. It is also preferable to conduct the survey when the water within the hole has been allowed to settle following drilling, purging or other actions.

Temperature is effective at detecting water-flowing fractures. When water from the surrounding rock enters or leaves the borehole, it may be evident as a rapid change in temperature that may be enhanced with temperature gradient calculations. To enhance water leaving the column, the borehole column can be heated and the temperature resurveyed.

Relative Conductivity

The RC sensor is located 120 cm below the cable head. The sensor, coincident loop coil, is tuned for relatively conductive environments (sulfide differentiation) and is susceptible to drift due to temperature changes, especially in low conductivity environments (0.1 to 20 mS/m).

The RC may be used to measure large conductivity contrasts in the borehole.

Magnetic Susceptibility

The MS sensor is located 150 cm below the cable head. The coincident loop coil is tuned to measure the in phase response that may be related to magnetic materials in the borehole. This relationship may breakdown in highly conductive environments (sulfides) and the MS response is susceptible to drift due to temperature changes.

Rock units that have contrasting iron content may be mapped with the MS.

Natural Gamma

The natural gamma sensor is located 92 cm below the cable head. The natural gamma measures gamma rays in the spectrum between 0.1 and 3 MeV in counts per second.

In most rock units it is the variations in potassium content that results in variations in the gamma values (ranging from 30 to 500 cps). This technique is the most successful at differentiating changes in lithology, especially in a multi-hole project in which subtle variations may be related from hole to hole.

The introduction of concentrations of uranium (and to some degree thorium) may result in a significant increase in count rate of well over 1000 cps. As the energies of the gamma rays are not measured, it is not possible to attribute a high gamma count rate to a specific element.

The natural gamma sensor is not sensitive to temperature changes and can be used in the presence of borehole casing.

Single Point and Apparent Resistivity

The single point resistance (SPR) is the electrical resistance measured between the cable head and the casing or grounded electrode at surface. The SPR may be used to differentiate rock units that have large resistivity variations.

For the Ares, a constant 5 mA current is applied between the grounded electrode (or casing) and the cable head and the voltage measured between two additional electrodes below the cable head. The scale factor used to calculate the apparent resistivity (AR) is;

$$AR = \pi (V/i) / 0.406 \quad \text{where } V \text{ is the measured voltage} \\ \text{and } i \text{ is the constant current}$$

Although the AR closely matches the SPR, it is a more precise measurement of the rock resistivity. For both AR and SPR, the probe must be submerged in water.

Instruments for Geophysics (IFG) - 100 m Winch - General Description

The borehole winch used is the IFG 100 meter manual winch with external controller. The system is ideal for shallow environmental surveys due to its relative portability.

The basic system includes a winch with a geared hand crank and 100 m of 4-conductor cable. A pulley placed on the borehole casing or affixed to the winch has a laser counter built in to measure cable motion (depth).

A controller box is used to power the various probes that may be attached to the winch, to digitize the analog signal from the probes and to digitize the counter signal. A stream of digital data is transmitted from the controller to a laptop computer at a rate of 1 complete data set/second. The controller requires 200 Watts of power and can be powered by portable 12 volt battery with and a small inverter (12v DC to 110 v AC).

The IFG DAS software is used to control data acquisition and monitor data quality.

Field Procedures

During each survey the zero depth is established as the location of the cable head (to the probe) relative to the top of the casing. As the probe is lowered at a rate of 4cm/sec data is stored to a *down run file*. As there is the possibility of pulley slippage or dirt and ice interference, the borehole cable has markings at 10 meter intervals. At each 10 meter marking the digitized depth is noted. Any deviation between measured depth and actual depth is corrected during post processing.

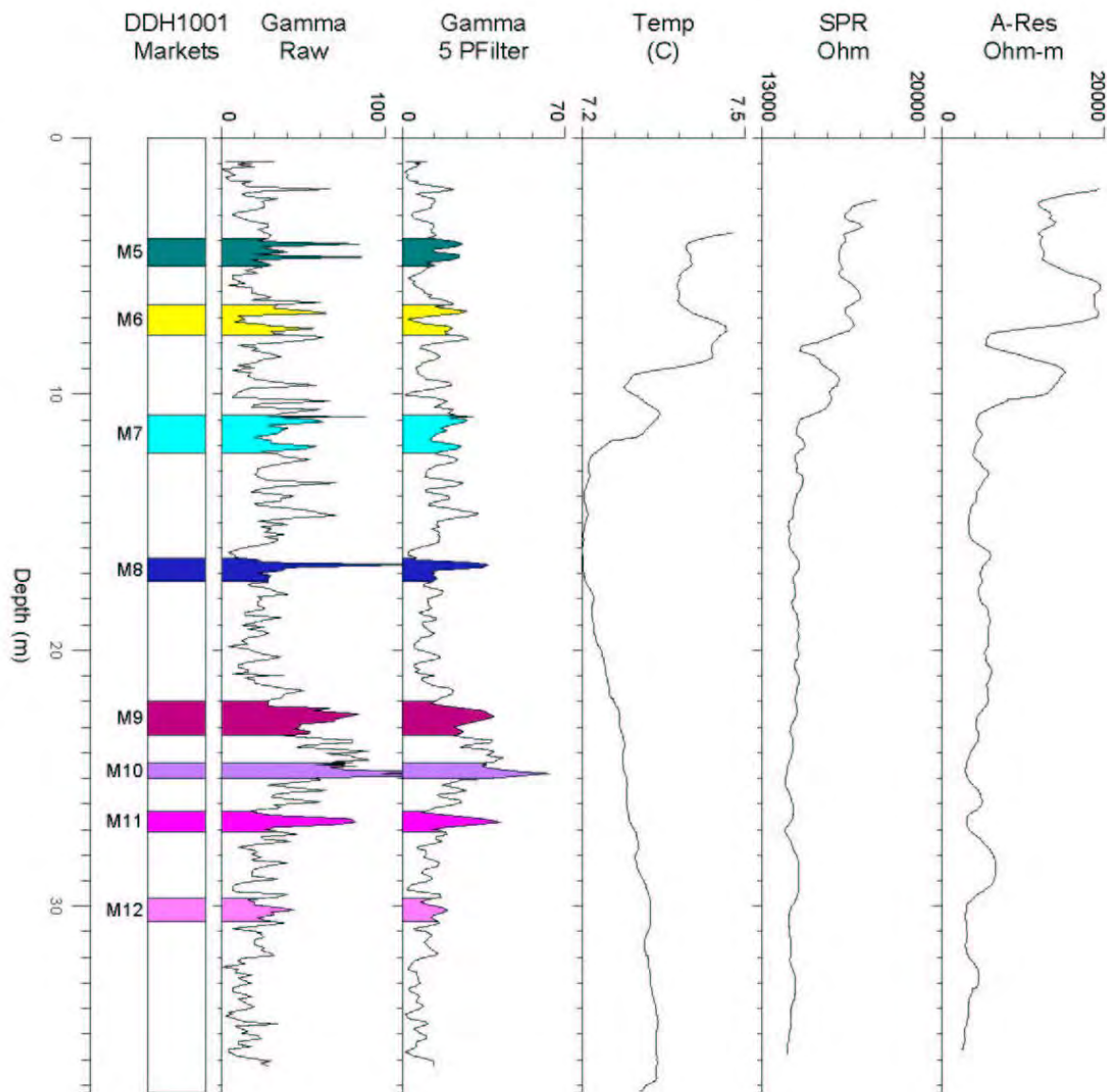
When the end of hole is encountered the down run file is closed and an up run file is opened. The up run is collected as a check against probe operation. Provided there is no deviation between runs for a particular parameter, only one run is presented in profiles.

<p><i>ANNEX B COMPLETED LOGS</i></p>

DDH10-01

Borehole Geophysical Results and Markers

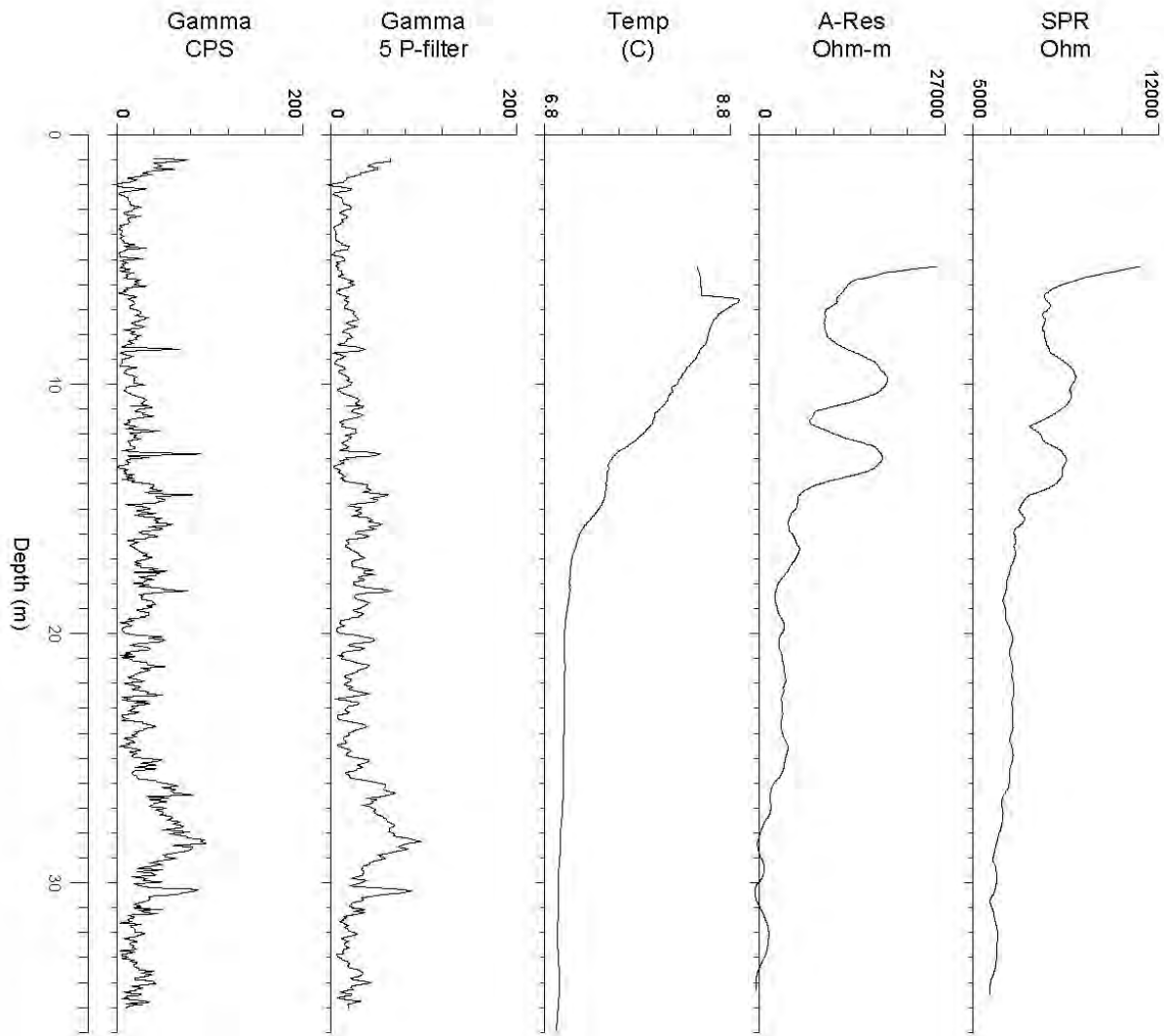
Elginburg, ON, December 18, 2012



BH1102

Borehole Geophysical Results

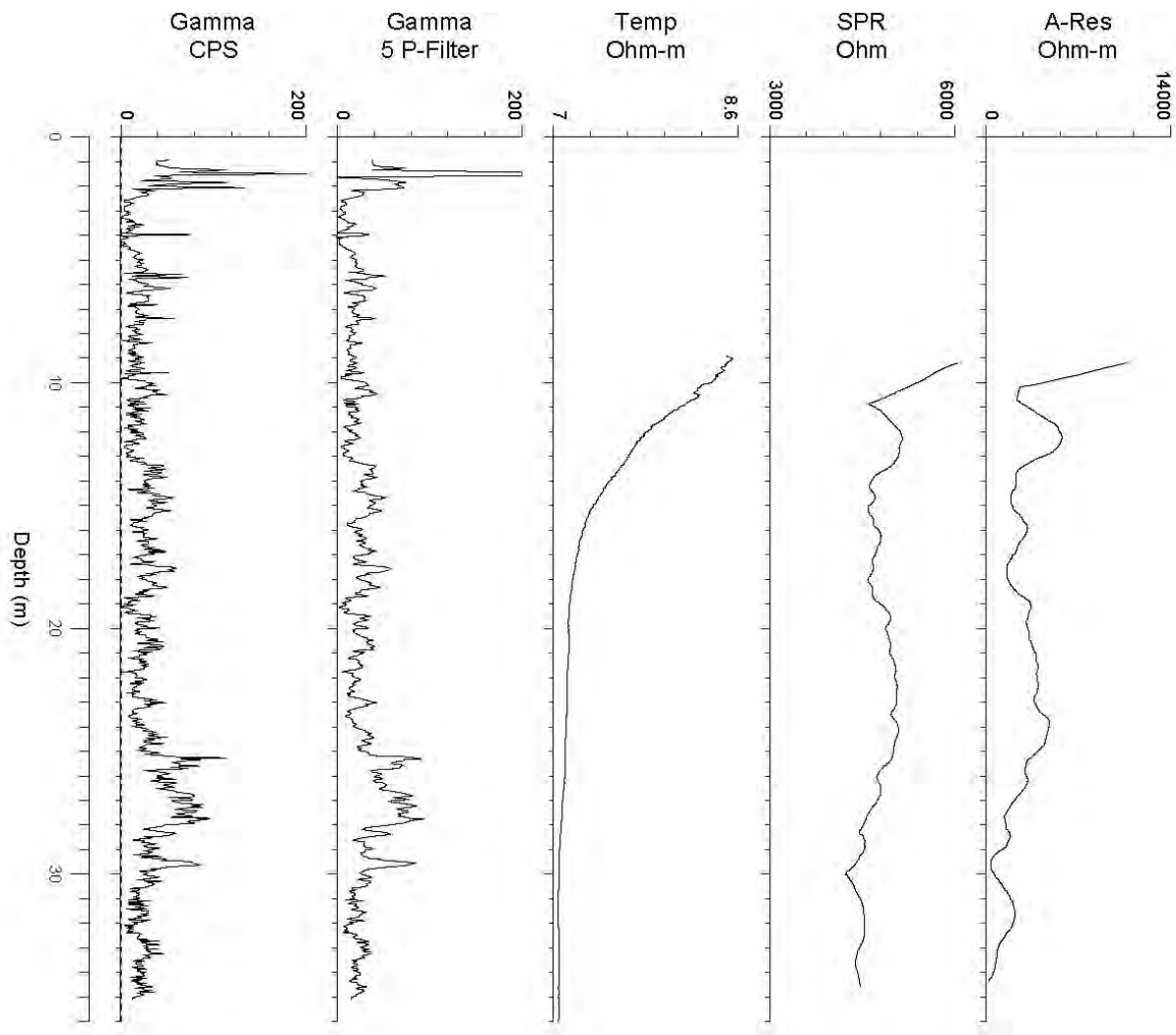
Elginburg, ON, December 18, 2012



BH1103

Borehole Geophysical Results

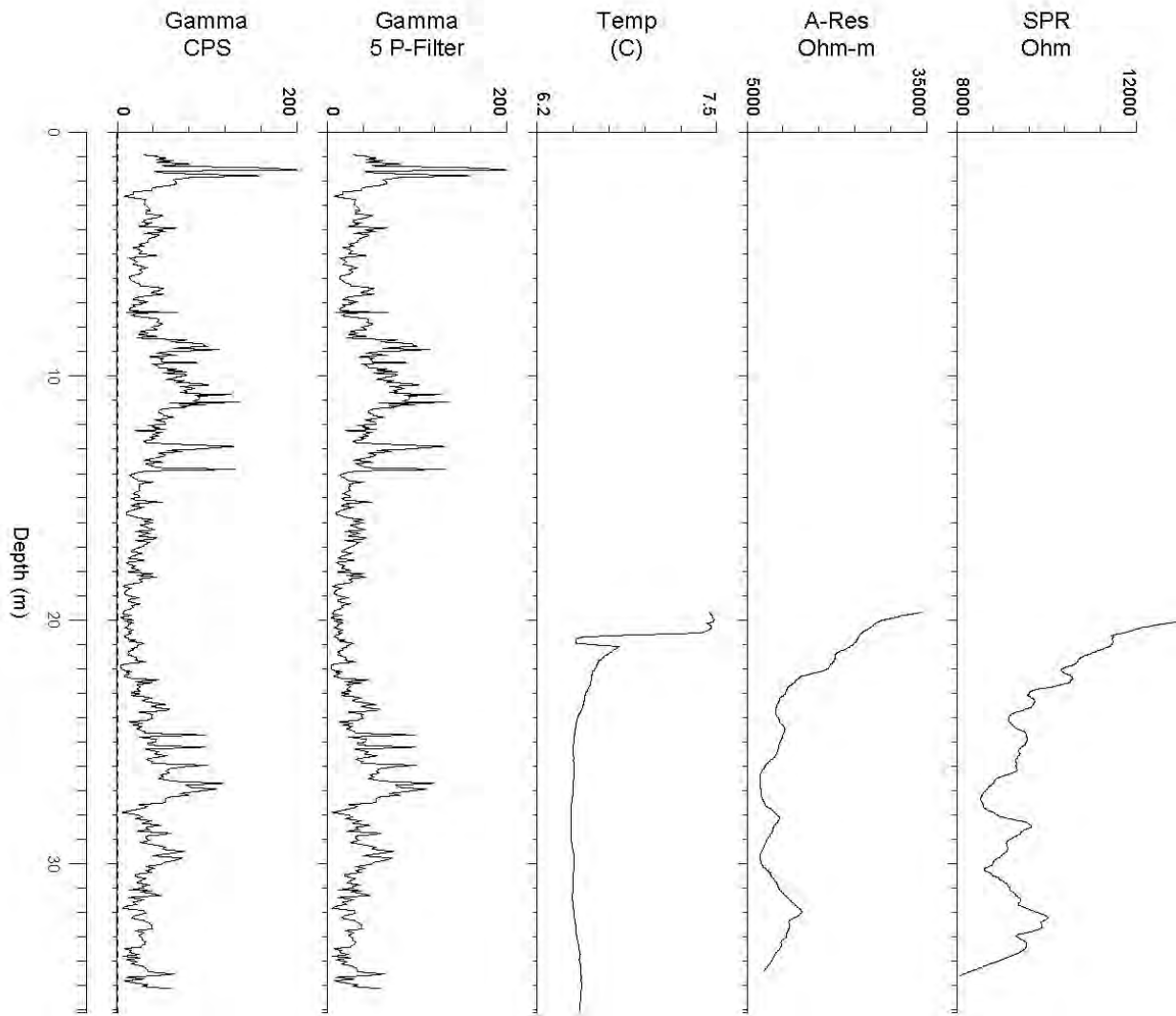
Elginburg, ON, December 18, 2012



BH1104

Borehole Physical Property Log

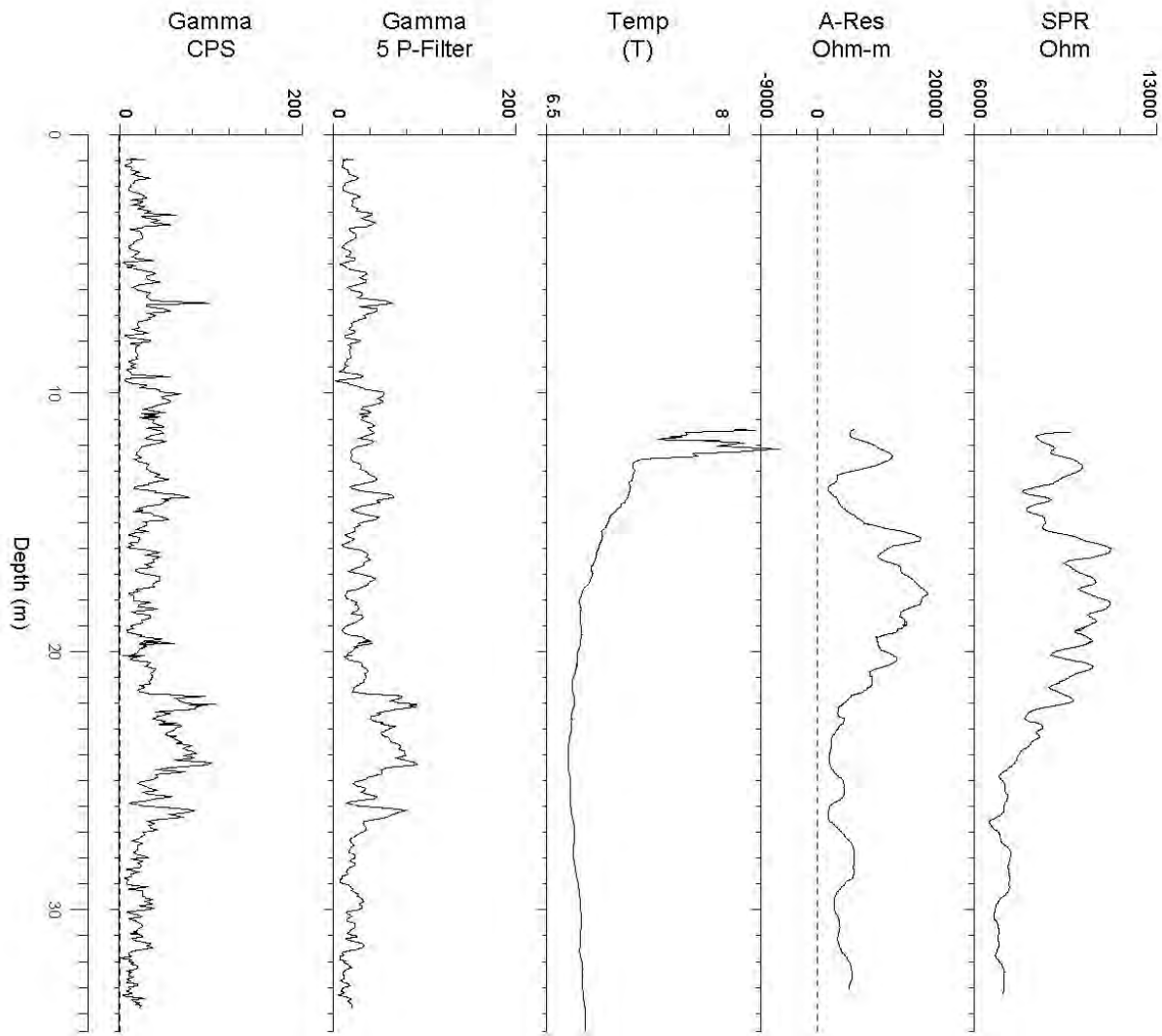
Elginburg, ON, December 18, 2012



BH1201

Borehole Geophysical Results

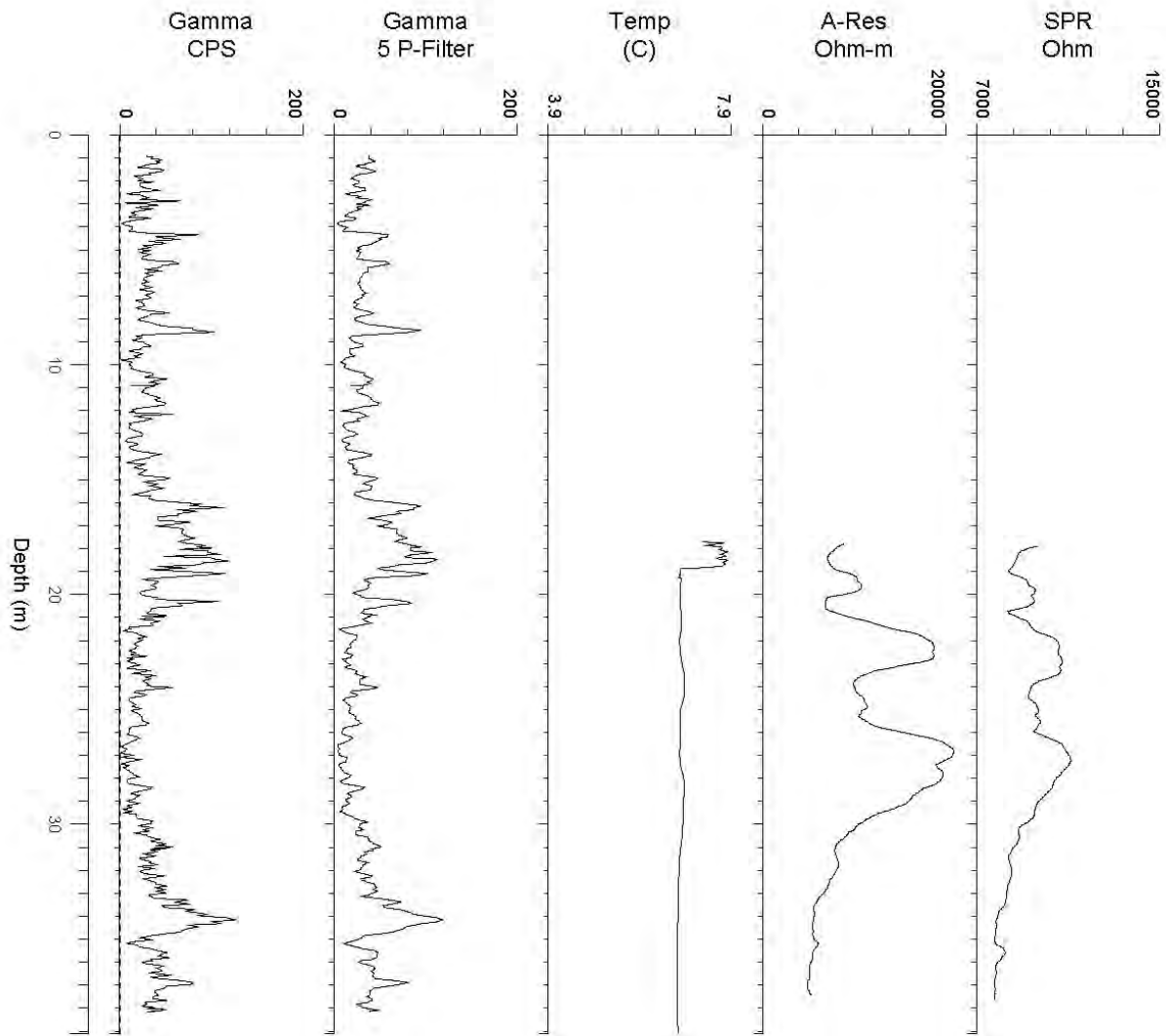
Elginburg, ON, December 18, 2012



BH1202

Borehole Geophysical Results

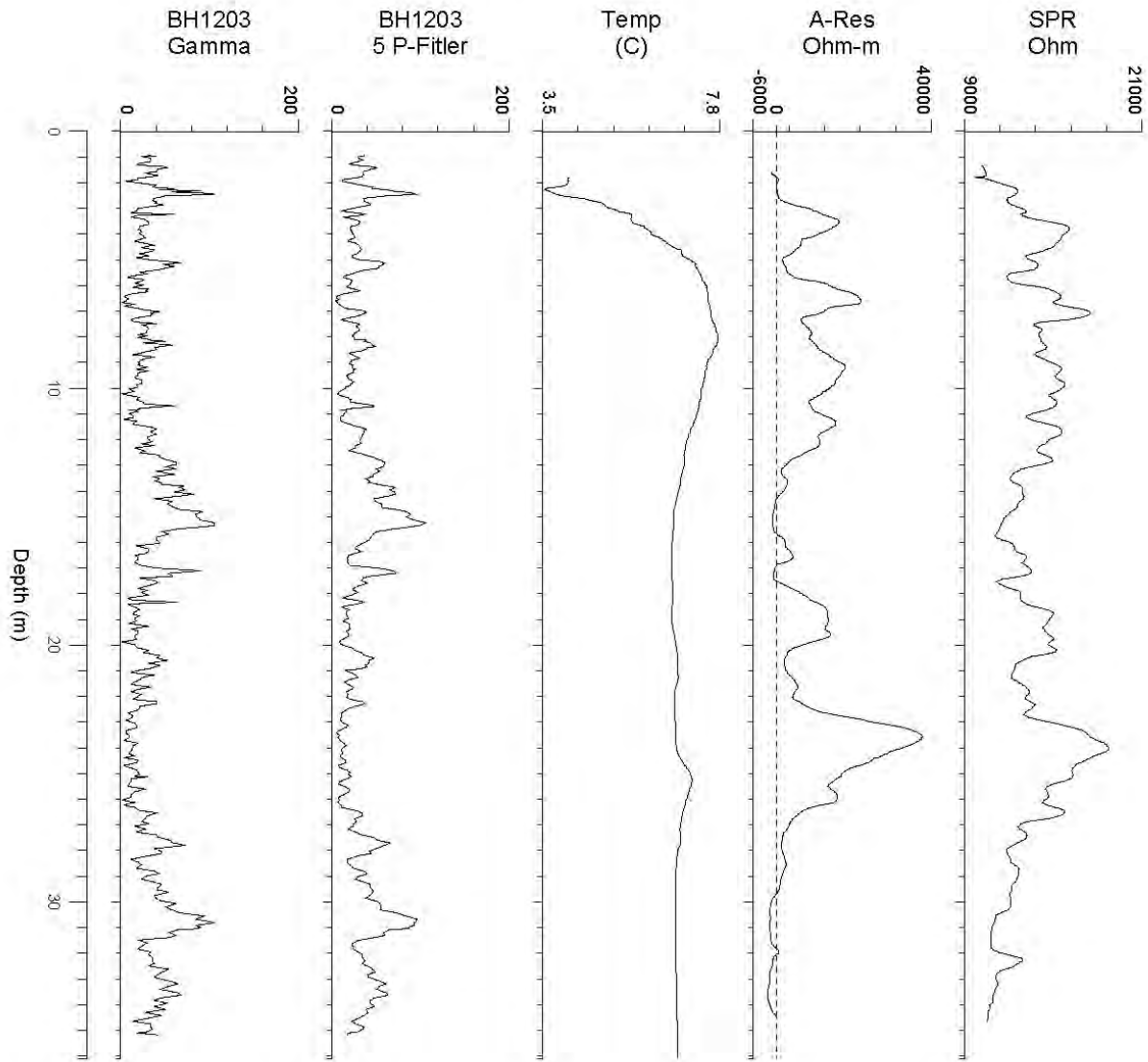
Elginburg, ON, December 18, 2012



BH1203

Borehole Geophysical Results

Elginburg, ON, December 18, 2012



***ANNEX C
PICTURES***

System Logging –DDH10-01



Setting Up System – BH1203



The IFG BMP06 Probe – BH1102

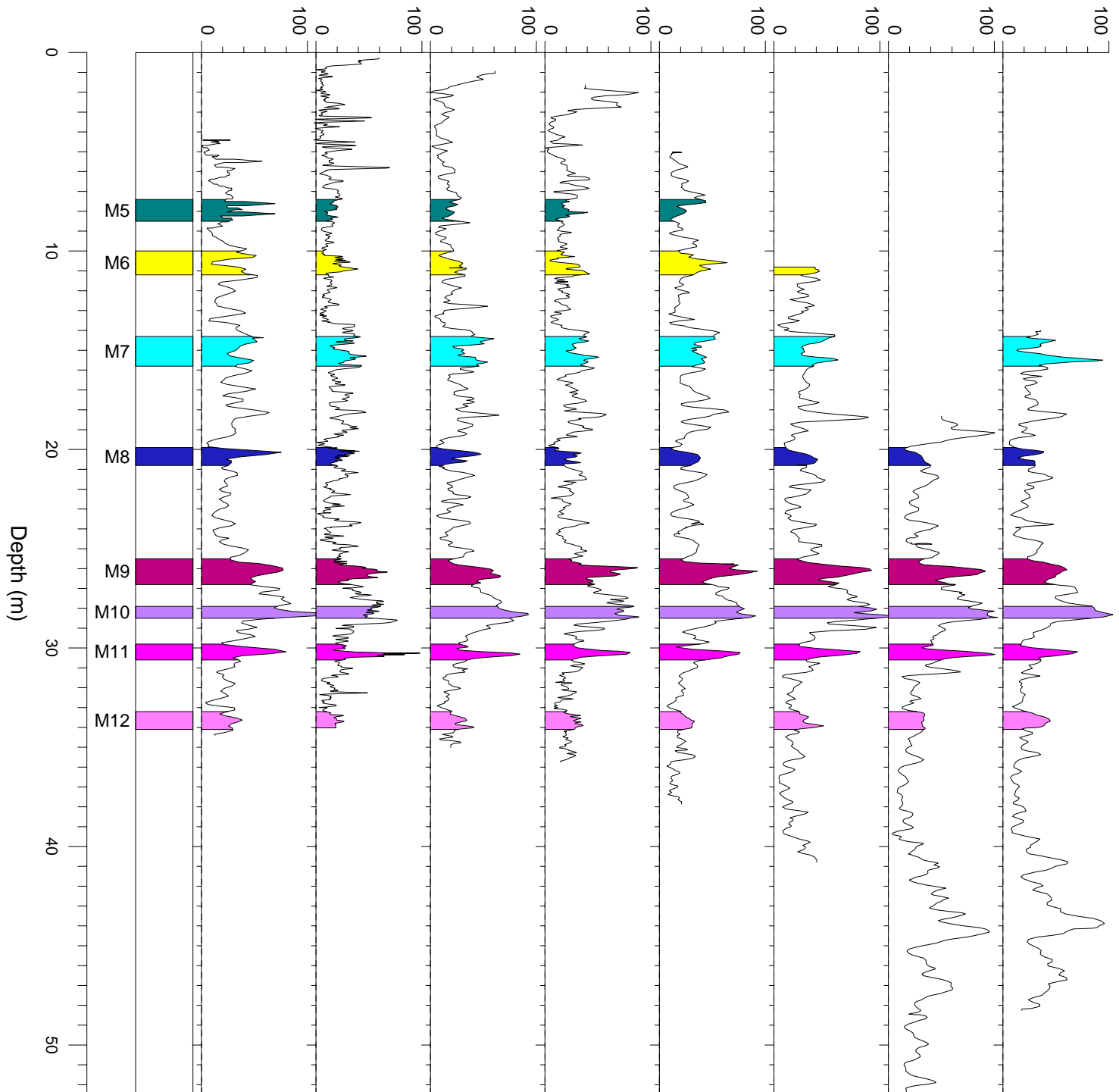


Adjusted Natural Gamma Logs

Depth Adjusted to Markers of DDH1001

ElginBurg, On, December 10, 2013

DDH2010 BH1301 BH1102 BH1103 BH1201 BH1202 BH1104 BH1203
Markets Gamma Gamma Gamma Gamma Gamma Gamma Gamma Gamma



APPENDIX E: Groundwater Level Monitoring Data

Table E1 - Well Installation Information

BH	Easting	Northing	Ground Surface (masl)	Casing Height (m)	Casing Top Elev. (masl)	Depth to Bot of Hole (mbgs)	Elev. of Bot of Hole	Depth of Top of Interval (mbgs)	Depth of Bottom of Interval (mbgs)	Interval Top Elev. (masl)	Interval Bot. Elev. (masl)
DDH10-01	375488	4907856	135.37	0.84	136.21	37.20	98.17	-	-	135.37	98.17
BH11-02	375321	4908199	138.14	0.80	138.94	35.90	102.24	-	-	138.14	102.24
BH11-03	375109	4907991	137.72	0.80	138.52	36.00	101.72	-	-	137.72	101.72
BH11-04	375437	4907054	125.69	0.94	126.63	36.00	89.69	-	-	125.69	89.69
BH12-01	375319	4907602	133.20	0.64	133.84	34.70	98.50	-	-	133.20	98.50
BH12-02	375148	4907222	128.90	0.61	129.51	40.23	88.67	-	-	128.90	88.67
BH12-03	374786	4906954	131.30	0.50	131.80	36.10	95.20	-	-	131.30	95.20
BH13-01	375115	4908411	138.15	0.46	138.61	35.51	102.64	-	-	138.15	102.64
BH11-02A	375321	4908199	138.14	0.80	138.94	35.96	102.18	24.38	35.96	113.76	102.18
BH11-02B	375321	4908199	138.14	0.80	138.94	35.96	102.18	12.19	19.81	125.95	118.33
BH11-02C	375321	4908199	138.14	0.80	138.94	35.96	102.18	4.57	9.14	133.57	129.00
BH12-02A	375148	4907222	128.90	0.61	129.51	35.96	92.94	27.43	35.96	101.47	92.94
BH12-02B	375148	4907222	128.90	0.61	129.51	35.96	92.94	16.76	24.38	112.14	104.52
BH12-02C	375148	4907222	128.90	0.61	129.51	35.96	92.94	4.57	12.19	124.33	116.71
BH12-03A	374786	4906954	131.30	0.50	131.80	35.96	95.34	24.38	35.96	106.92	95.34
BH12-03B	374786	4906954	131.30	0.50	131.80	19.51	111.79	12.80	19.81	118.50	111.49
BH13-01A	375115	4908411	138.15	0.46	138.61	35.05	103.10	27.43	35.05	110.72	103.10
BH13-01B	375115	4908411	138.15	0.46	138.61	18.29	119.86	7.62	18.29	130.53	119.86
MW-1-1	375926	4908412	131.20	-	-	38.31	92.89	-	-	-	-
MW-2-1	-	-	136.80	-	-	38.25	98.55	22.50	38.25	114.30	98.55
MW-2-2	-	-	136.80	-	-	19.56	117.24	9.40	20.30	127.40	116.50
MW-2-3	-	-	136.80	-	-	7.49	129.31	5.90	7.30	130.90	129.50
MW-3-1	-	-	128.40	-	-	38.23	90.17	22.10	38.23	106.30	90.17
MW-3-2	-	-	128.40	-	-	18.90	109.50	6.50	19.60	121.90	108.80
MW-4-1	-	-	124.80	-	-	38.35	86.45	23.20	38.35	101.60	86.45
MW-4-2	-	-	124.80	-	-	20.67	104.13	7.70	20.80	117.10	104.00

Prepared by: AC

Reviewed by: AW

Date: 2/11/2014

Elginburg Boreholes 6-1-14



Table E2 - Static Groundwater Levels

BH	Ground water Level (mbgs)	Ground water Elev. (masl)	Ground water Level (mbct)	Ground water Elev. (masl)	Ground water Level (mbct)	Ground water Elev. (masl)	Ground water Level (mbct)	Ground water Elev. (masl)	Ground water Level (mbct)	Ground water Elev. (masl)	Ground water Level (mbct)	Ground water Elev. (masl)	Static Level (masl)
	Prior to Dec/13		11/12/2013		12/12/2013		13/12/2013		18/12/2013		10/1/2014		
DDH10-01	-	-	-	-	2.36	133.85	-	-	-	-	2.28	133.93	133.85
BH11-02	-	-	4.42	134.52	-	-	-	-	-	-	-	-	134.52
BH11-03	-	-	-	-	-	-	7.29	131.23	-	-	14.54	123.98	131.23
BH11-04	-	-	-	-	-	-	20.82	105.81	-	-	19.71	106.92	105.81
BH12-01	-	-	-	-	-	-	11.87	121.97	-	-	11.80	122.04	121.97
BH12-02	-	-	-	-	19.70	109.81	-	-	-	-	-	-	109.81
BH12-03	-	-	-	-	1.60	130.20	-	-	-	-	-	-	130.20
BH13-01	-	-	0.90	137.71	-	-	-	-	-	-	-	-	137.71
BH11-02A	-	-	-	-	-	-	-	-	3.05	135.89	3.13	135.81	135.89
BH11-02B	-	-	-	-	-	-	-	-	4.91	134.03	4.14	134.80	134.03
BH11-02C	-	-	-	-	-	-	-	-	-	-	-	-	-
BH12-02A	-	-	-	-	-	-	-	-	20.41	109.10	18.81	110.70	109.10
BH12-02B	-	-	-	-	-	-	-	-	18.56	110.95	18.10	111.41	110.95
BH12-02C	-	-	-	-	-	-	-	-	-	-	11.45	118.06	118.06
BH12-03A	-	-	-	-	-	-	-	-	3.95	127.85	21.20	110.60	127.85
BH12-03B	-	-	-	-	-	-	-	-	3.49	128.31	2.92	128.88	128.31
BH13-01A	-	-	-	-	-	-	-	-	1.62	136.99	1.67	136.94	136.99
BH13-01B	-	-	-	-	-	-	-	-	2.91	135.70	1.52	137.09	135.70
MW-1-1	7.93	123.50	-	-	-	-	-	-	-	-	-	-	123.50
MW-2-1	9.47	127.74	-	-	-	-	-	-	-	-	-	-	127.74
MW-2-2	9.43	127.78	-	-	-	-	-	-	-	-	-	-	127.78
MW-2-3	4.82	132.39	-	-	-	-	-	-	-	-	-	-	132.39
MW-3-1	19.75	109.50	-	-	-	-	-	-	-	-	-	-	109.50
MW-3-2	17.82	111.43	-	-	-	-	-	-	-	-	-	-	111.43
MW-4-1	25.30	99.93	-	-	-	-	-	-	-	-	-	-	99.93
MW-4-2	9.49	115.74	-	-	-	-	-	-	-	-	-	-	115.74

Prepared by: AC

Reviewed by: AW

Date: 2/11/2014

Elginburg Boreholes 6-1-14



APPENDIX F: Hvorslev Analysis



Hvorslev Analysis of Slug or Bail Test

Elginburgh Quarry DDH10-01-01

Top of Individual

Well Casing

Elevation 109.03 masl

H 106.67 masl

H₀ 101.38 masl

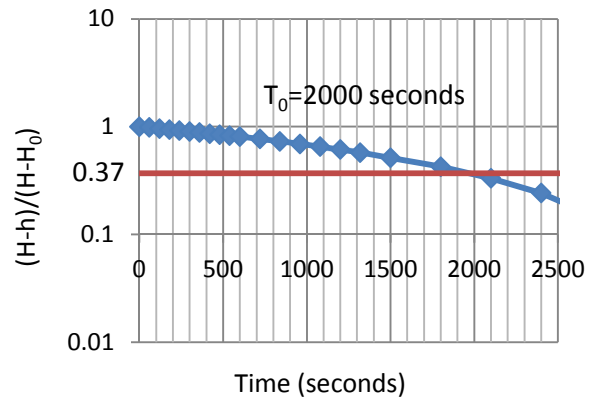
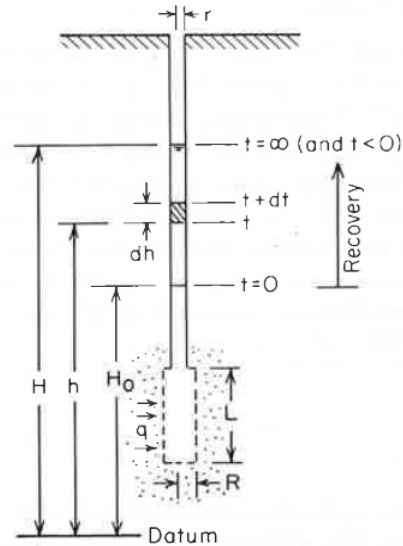
R (screen radius) 0.05 m

r (riser radius) 0.05 m

L (screen length) 35.68 m

T₀ 20000 seconds

time (seconds)	h(t)	(H-h)/(H-H ₀)
0	101.38	1
60	101.48	0.981096408
120	101.59	0.960302457
180	101.69	0.941398866
240	101.8	0.920604915
300	101.92	0.897920605
360	102.01	0.880907372
420	102.12	0.860113422
480	102.22	0.84120983
540	102.31	0.824196597
600	102.4	0.807183365
720	102.61	0.767485822
840	102.81	0.729678639
960	103.02	0.689981096
1080	103.22	0.652173913
1200	103.43	0.612476371
1320	103.63	0.574669187
1500	103.96	0.512287335
1800	104.42	0.425330813
2100	104.92	0.330812854
2400	105.39	0.241965974
2700	105.87	0.151228733
3000	106.25	0.079395085
3300	106.46	0.039697543
3600	106.56	0.020793951



Hvorslev Formula (see Freeze and Cherry, 1979)

$$K = \frac{r^2 \ln L/R}{2LT_0}$$

K= 1.2E-08 m/seconds

Hvorslev Analysis of Slug or Bail Test

Elginburgh Quarry BH11-02

Top of Individual

Well Casing

Elevation 109.03 masl

H 104.61 masl

H₀ 102.61 masl

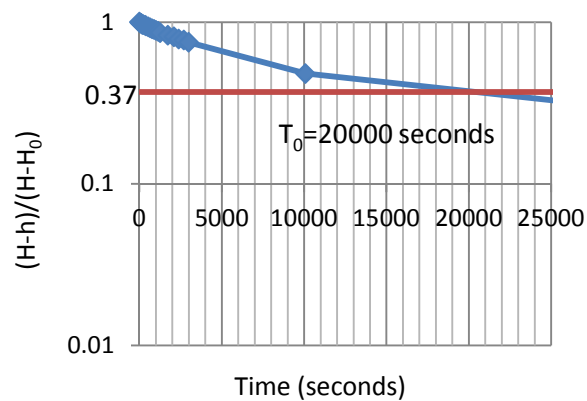
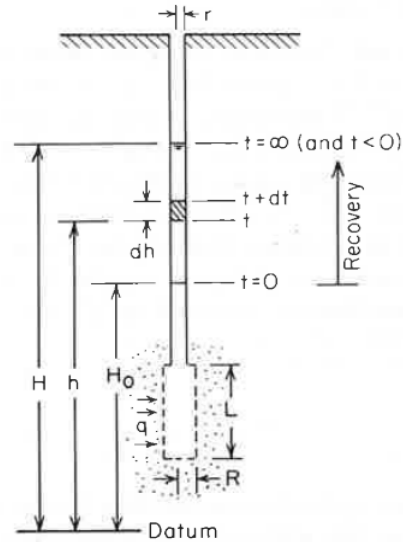
R (screen radius) 0.08 m

r (riser radius) 0.08 m

L (screen length) 32.28 m

T₀ 20000 seconds

time (seconds)	h(t)	(H-h)/(H-H ₀)
0	102.61	1
60	102.64	0.985
120	102.65	0.98
180	102.67	0.97
240	102.68	0.965
360	102.7	0.955
420	102.72	0.945
540	102.74	0.935
660	102.77	0.92
780	102.79	0.91
900	102.81	0.9
1020	102.83	0.89
1140	102.86	0.875
1260	102.89	0.86
1740	102.95	0.83
2100	102.99	0.81
2400	103.04	0.785
2700	103.06	0.775
3000	103.11	0.75
10080	103.65	0.48
64500	104.37	0.12
96480	104.45	0.08



Hvorslev Formula (see Freeze and Cherry, 1979)

$$K = \frac{r^2 \ln L/R}{2LT_0}$$

K= 2.7E-08 m/seconds

Hvorslev Analysis of Slug or Bail Test

Elginburgh Quarry BH11-02A

Top of Individual

Well Casing

Elevation 109.03 masl

H 106.05 masl

H₀ 87.23 masl

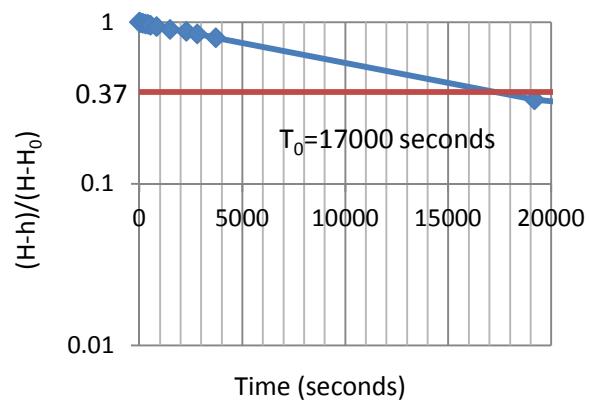
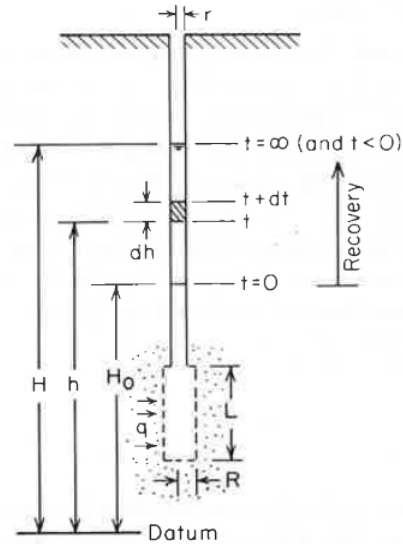
R (screen radius) 0.08 m

r (riser radius) 0.02 m

L (screen length) 11.58 m

T₀ 17000 seconds

time (seconds)	h(t)	(H-h)/(H-H ₀)
0	87.23	1
60	87.38	0.992029756
180	87.55	0.982996812
300	87.73	0.973432519
420	87.86	0.966524973
540	88.03	0.95749203
840	88.39	0.938363443
1500	89.14	0.898512221
2280	89.53	0.877789586
2820	90.12	0.846439957
3720	91.01	0.799149841
19200	99.83	0.330499469
81960	104.97	0.05738576



Hvorslev Formula (see Freeze and Cherry, 1979)

$$K = \frac{r^2 \ln L/R}{2LT_0}$$

K= 3.2E-09 m/seconds

Hvorslev Analysis of Slug or Bail Test

Elginburgh Quarry BH11-02B

Top of Individual

Well Casing

Elevation 109.03 masl

H 104.16 masl

H₀ 95.39 masl

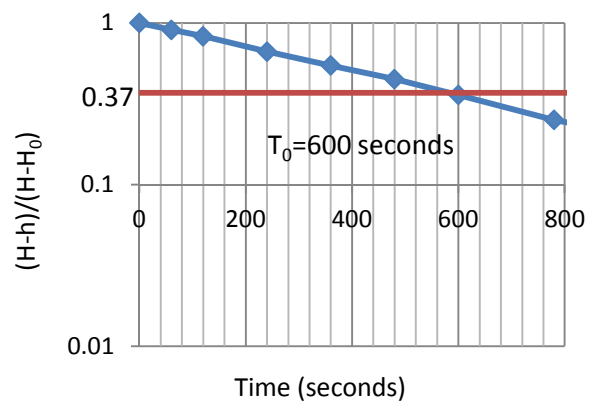
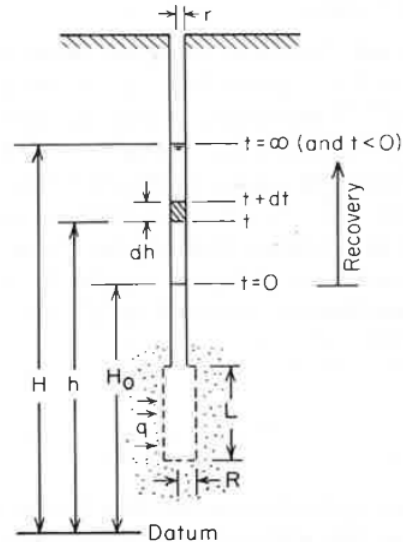
R (screen radius) 0.08 m

r (riser radius) 0.02 m

L (screen length) 7.62 m

T₀ 600 seconds

time (seconds)	h(t)	(H-h)/(H-H ₀)
0	95.39	1
60	96.21	0.90649943
120	96.91	0.82668187
240	98.33	0.664766249
360	99.38	0.545039909
480	100.22	0.449258837
600	101.02	0.358038769
780	101.96	0.250855188
1020	102.59	0.179019384
1140	102.98	0.134549601
1320	103.21	0.108323831
1560	103.44	0.082098062
2520	103.85	0.035347777
18060	104.37	-0.023945268
80760	104.39	-0.02622577



Hvorslev Formula (see Freeze and Cherry, 1979)

$$K = \frac{r^2 \ln L/R}{2LT_0}$$

K= 1.3E-07 m/seconds

Hvorslev Analysis of Slug or Bail Test

Elginburgh Quarry BH11-03

Top of Individual

Well Casing

Elevation 109.03 masl

H 101.74 masl

H₀ 93.33 masl

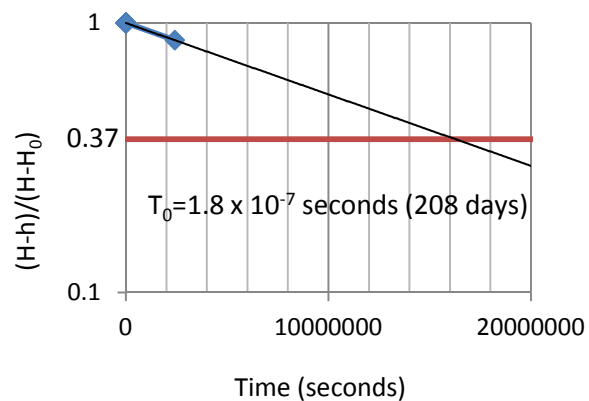
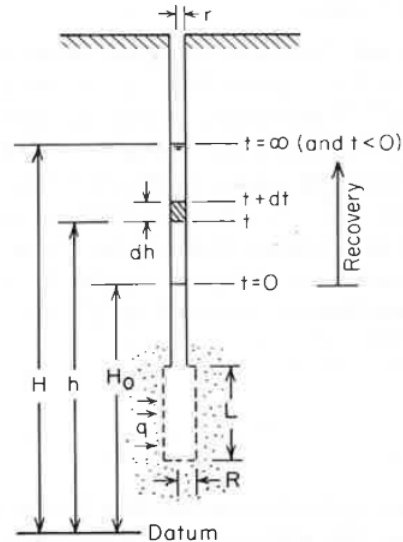
R (screen radius) 0.08 m

r (riser radius) 0.08 m

L (screen length) 29.51 m

T₀ 16000000 seconds

time (seconds)	h(t)	(H-h)/(H-H ₀)
0	93.33	1
60	93.34	0.998810939
120	93.34	0.998810939
180	93.34	0.998810939
240	93.34	0.998810939
540	93.34	0.998810939
840	93.34	0.998810939
1740	93.34	0.998810939
2940	93.34	0.998810939
7140	93.34	0.998810939
2419200	94.49	0.862068966



Hvorslev Formula (see Freeze and Cherry, 1979)

$$K = \frac{r^2 \ln L/R}{2LT_0}$$

K= 4E-11 m/seconds

Hvorslev Analysis of Slug or Bail Test

Elginburgh Quarry BH11-04

Top of Individual

Well Casing

Elevation 109.03 masl

H 88.21 masl

H₀ 86.03 masl

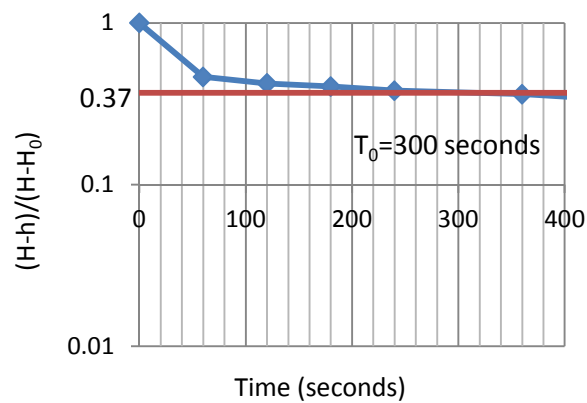
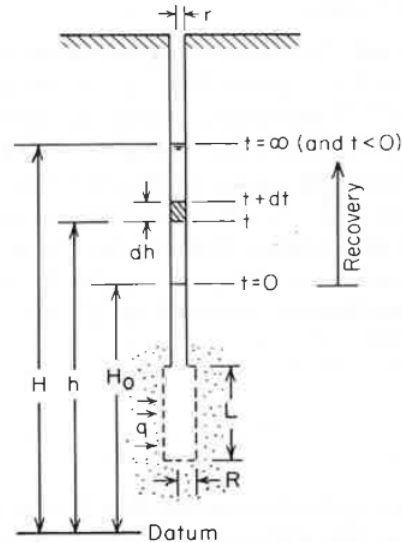
R (screen radius) 0.08 m

r (riser radius) 0.08 m

L (screen length) 16.12 m

T₀ 300 seconds

time (seconds)	h(t)	(H-h)/(H-H ₀)
0	86.03	1
60	87.2	0.463302752
120	87.29	0.422018349
180	87.33	0.403669725
240	87.38	0.380733945
360	87.42	0.362385321
420	87.46	0.344036697
480	87.49	0.330275229
540	87.51	0.321100917
600	87.54	0.30733945
660	87.56	0.298165138
780	87.61	0.275229358
960	87.68	0.243119266
1140	87.75	0.211009174
1560	87.86	0.160550459
1860	87.93	0.128440367
2160	87.97	0.110091743
2760	88.06	0.068807339
3840	88.13	0.036697248



Hvorslev Formula (see Freeze and Cherry, 1979)

$$K = \frac{r^2 \ln L/R}{2LT_0}$$

K= 3.2E-06 m/seconds

Hvorslev Analysis of Slug or Bail Test

Elginburgh Quarry BH12-01

Top of Individual

Well Casing

Elevation 109.03 masl

H 97.16 masl

H₀ 93.49 masl

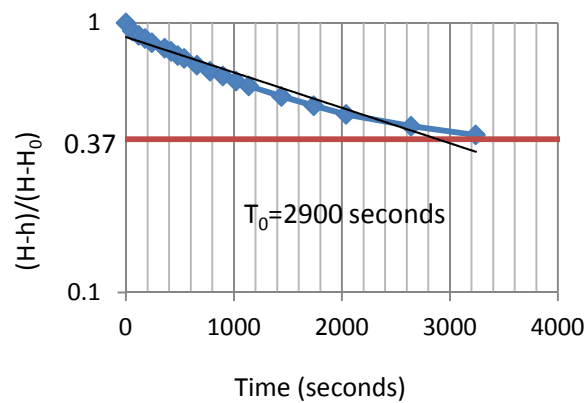
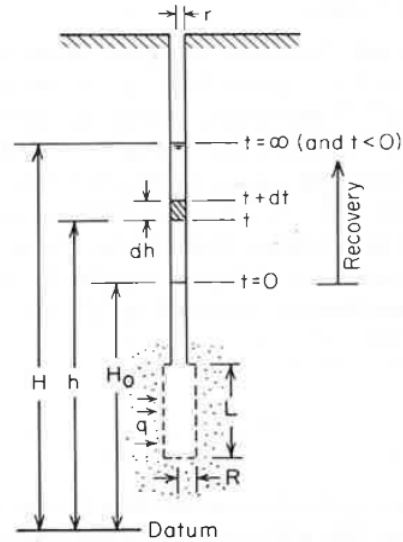
R (screen radius) 0.05 m

r (riser radius) 0.05 m

L (screen length) 23.47 m

T₀ 2900 seconds

time (seconds)	h(t)	(H-h)/(H-H ₀)
0	93.49	1
60	93.73	0.934604905
120	93.86	0.899182561
180	93.95	0.874659401
240	94.06	0.844686649
360	94.2	0.80653951
420	94.28	0.784741144
480	94.38	0.757493188
540	94.45	0.738419619
660	94.6	0.697547684
780	94.73	0.662125341
900	94.83	0.634877384
1020	94.93	0.607629428
1140	95.02	0.583106267
1440	95.2	0.534059946
1740	95.35	0.493188011
2040	95.48	0.457765668
2640	95.64	0.414168937
3240	95.75	0.384196185
7800	96.06	0.29972752
16140	96.25	0.247956403
285840	96.44	0.196185286
446160	96.43	0.198910082



Hvorslev Formula (see Freeze and Cherry, 1979)

$$K = \frac{r^2 \ln L/R}{2LT_0}$$

K= 1.2E-07 m/seconds

Hvorslev Analysis of Slug or Bail Test

Elginburgh Quarry BH12-02

Top of Individual

Well Casing

Elevation 109.03 masl

H 89.33 masl

H₀ 86.03 masl

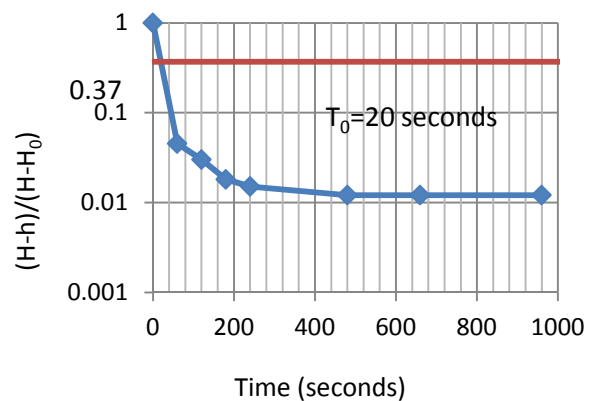
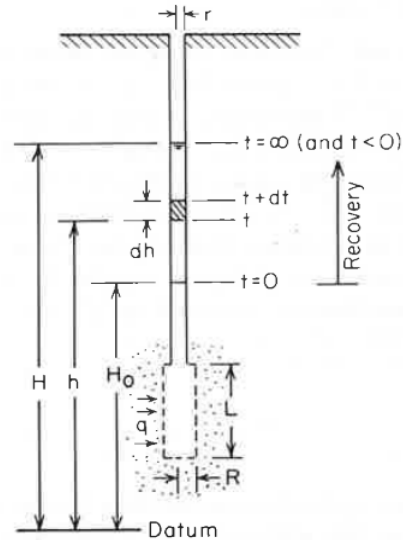
R (screen radius) 0.05 m

r (riser radius) 0.05 m

L (screen length) 21.14 m

T₀ 20 seconds

time (seconds)	h(t)	(H-h)/(H-H ₀)
0	86.03	1
60	89.18	0.045454545
120	89.23	0.03030303
180	89.27	0.018181818
240	89.28	0.015151515
480	89.29	0.012121212
660	89.29	0.012121212
960	89.29	0.012121212



Hvorslev Formula (see Freeze and Cherry, 1979)

$$K = \frac{r^2 \ln L/R}{2LT_0}$$

K= 1.8E-05 m/seconds

Hvorslev Analysis of Slug or Bail Test

Elginburgh Quarry BH12-02A

Top of Individual

Well Casing

Elevation 109.03 masl

H 88.73 masl

H_0 88.67 masl

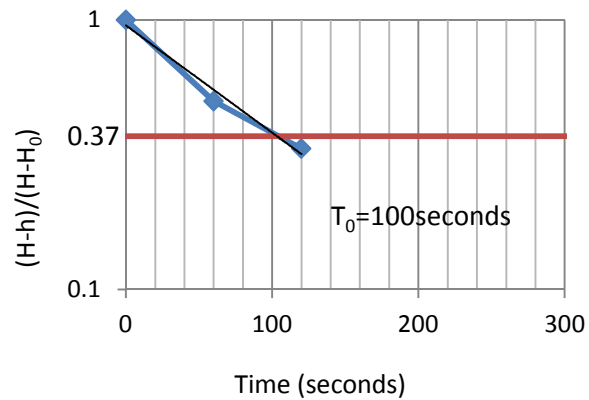
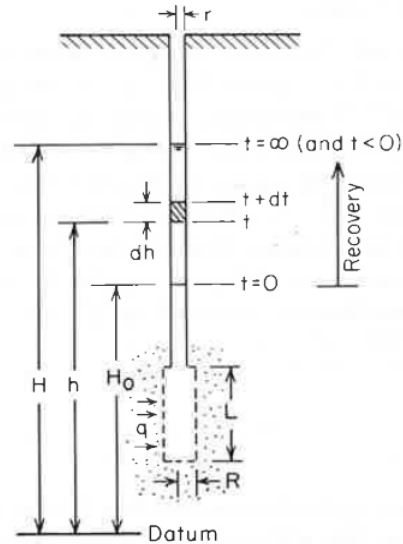
R (screen radius) 0.05 m

r (riser radius) 0.02 m

L (screen length) 8.53 m

T_0 100 seconds

time (seconds)	$h(t)$	$(H-h)/(H-H_0)$
0	88.67	1
60	88.7	0.5
120	88.71	0.333333333
180	88.71	0.333333333
300	88.71	0.333333333



Hvorslev Formula (see Freeze and Cherry, 1979)

$$K = \frac{r^2 \ln L/R}{2LT_0}$$

$K = 7.7E-07$ m/seconds

Hvorslev Analysis of Slug or Bail Test

Elginburgh Quarry BH12-02B

Top of Individual

Well Casing

Elevation 109.03 masl

H 90.53 masl

H_0 88.26 masl

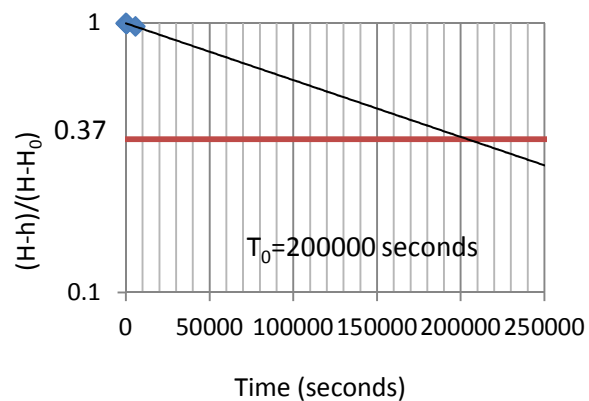
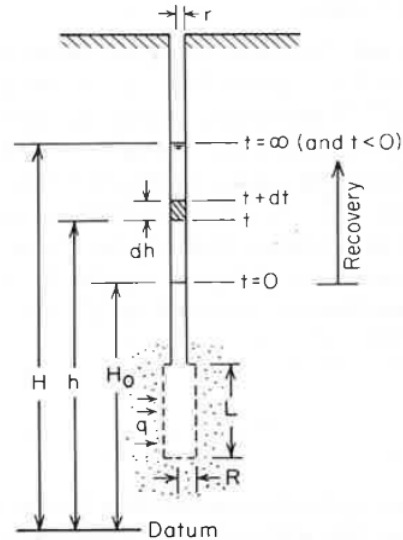
R (screen radius) 0.05 m

r (riser radius) 0.02 m

L (screen length) 7.62 m

T_0 200000 seconds

time (seconds)	$h(t)$	$(H-h)/(H-H_0)$
0	88.26	1
60	88.27	0.995594714
120	88.27	0.995594714
180	88.27	0.995594714
240	88.27	0.995594714
420	88.28	0.991189427
720	88.28	0.991189427
5760	88.33	0.969162996



Hvorslev Formula (see Freeze and Cherry, 1979)

$$K = \frac{r^2 \ln L/R}{2LT_0}$$

$K = 4.2E-10$ m/seconds

Hvorslev Analysis of Slug or Bail Test

Elginburgh Quarry BH12-03

Top of Individual

Well Casing

Elevation 109.03 masl

H 107.43 masl

H_0 103.03 masl

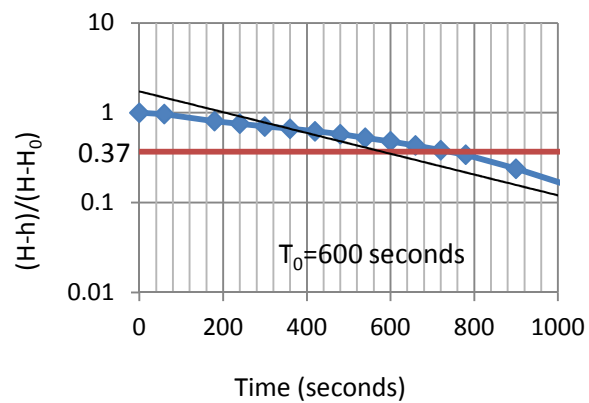
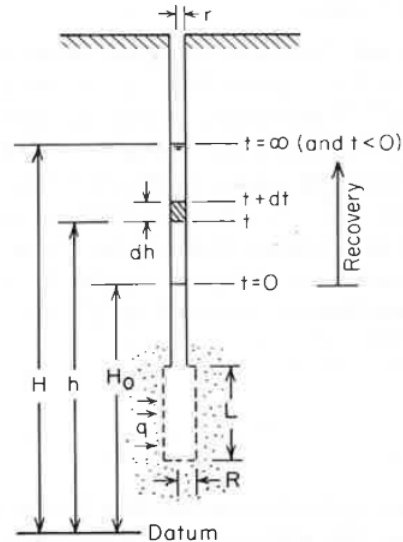
R (screen radius) 0.05 m

r (riser radius) 0.05 m

L (screen length) 35.00 m

T_0 600 seconds

time (seconds)	h(t)	$(H-h)/(H-H_0)$
0	103.03	1
60	103.18	0.965909091
180	103.88	0.806818182
240	104.11	0.754545455
300	104.33	0.704545455
360	104.5	0.665909091
420	104.69	0.622727273
480	104.88	0.579545455
540	105.11	0.527272727
600	105.31	0.481818182
660	105.53	0.431818182
720	105.74	0.384090909
780	105.93	0.340909091
900	106.38	0.238636364
1020	106.73	0.159090909
1140	107.06	0.084090909
1260	107.23	0.045454545
1380	107.29	0.031818182
1500	107.32	0.025
1620	107.35	0.018181818
1740	107.37	0.013636364



Hvorslev Formula (see Freeze and Cherry, 1979)

$$K = \frac{r^2 \ln L/R}{2LT_0}$$

$K = 4.0E-07$ m/seconds

Hvorslev Analysis of Slug or Bail Test

Elginburgh Quarry BH12-03A

Top of Individual

Well Casing

Elevation 109.03 masl

H 105.11 masl

H_0 83.8 masl

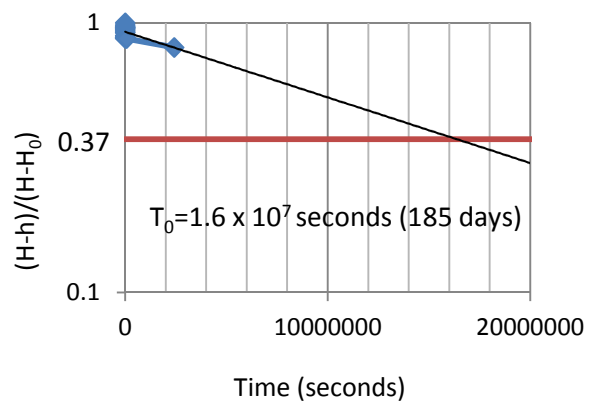
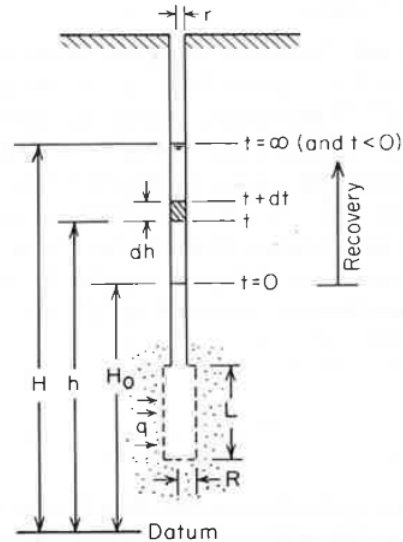
R (screen radius) 0.05 m

r (riser radius) 0.02 m

L (screen length) 11.58 m

T_0 16000000 seconds

time (seconds)	h(t)	$(H-h)/(H-H_0)$
0	83.8	1
240	84.18	0.982167996
300	84.48	0.968090099
360	84.58	0.963397466
420	84.69	0.95823557
480	84.79	0.953542938
600	85	0.943688409
720	85.23	0.932895354
840	85.42	0.923979352
1020	85.55	0.91787893
1620	86.03	0.895354294
2280	86.26	0.884561239
2820	86.32	0.881745659
4080	86.4	0.877991553
5040	86.43	0.876583763
74040	86.47	0.87470671
2419200	87.83	0.810886908



Hvorslev Formula (see Freeze and Cherry, 1979)

$$K = \frac{r^2 \ln L/R}{2LT_0}$$

$K = 5.9E-12$ m/seconds

Hvorslev Analysis of Slug or Bail Test

Elginburgh Quarry BH12-03B

Top of Individual

Well Casing

Elevation 109.03 masl

H 105.56 masl

H₀ 100.63 masl

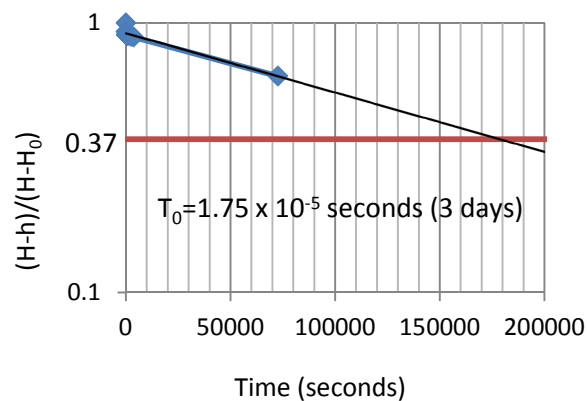
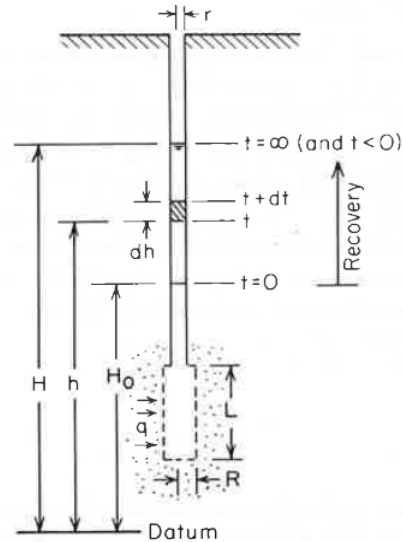
R (screen radius) 0.05 m

r (riser radius) 0.02 m

L (screen length) 7.01 m

T₀ 175000 seconds

time (seconds)	h(t)	(H-h)/(H-H ₀)
0	100.63	1
60	100.98	0.929006085
240	101.09	0.906693712
420	101.11	0.902636917
540	101.13	0.898580122
720	101.13	0.898580122
900	101.13	0.898580122
1320	101.13	0.898580122
2520	101.16	0.892494929
3660	101.19	0.886409736
72660	102.43	0.634888438



Hvorslev Formula (see Freeze and Cherry, 1979)

$$K = \frac{r^2 \ln L/R}{2LT_0}$$

K= 8.1E-10 m/seconds

Hvorslev Analysis of Slug or Bail Test

Elginburgh Quarry BH13-01

Top of Individual

Well Casing

Elevation 109.03 masl

H 108.13 masl

H_0 107.5 masl

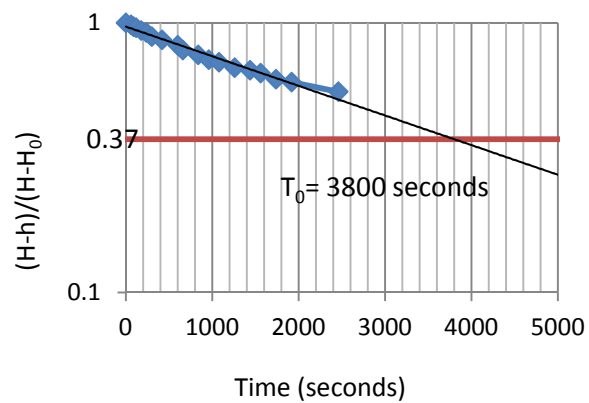
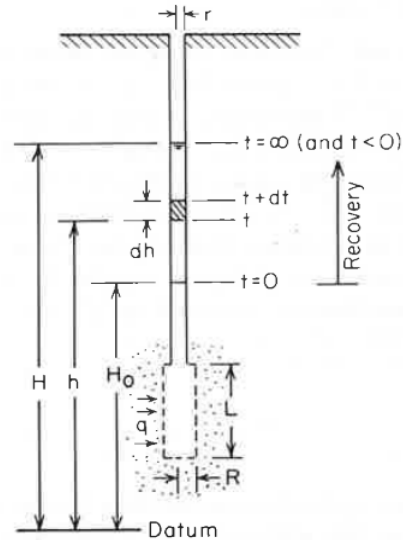
R (screen radius) 0.05 m

r (riser radius) 0.05 m

L (screen length) 35.07 m

T_0 3800 seconds

time (seconds)	h(t)	$(H-h)/(H-H_0)$
0	107.5	1
60	107.51	0.984126984
90	107.52	0.968253968
120	107.525	0.96031746
180	107.54	0.936507937
240	107.55	0.920634921
300	107.57	0.888888889
420	107.585	0.865079365
600	107.61	0.825396825
660	107.63	0.793650794
840	107.65	0.761904762
960	107.67	0.73015873
1080	107.68	0.714285714
1260	107.7	0.682539683
1440	107.71	0.666666667
1560	107.72	0.650793651
1740	107.74	0.619047619
1920	107.75	0.603174603
2460	107.78	0.555555556



Hvorslev Formula (see Freeze and Cherry, 1979)

$$K = \frac{r^2 \ln L/R}{2LT_0}$$

$K = 6.1E-08$ m/seconds

Hvorslev Analysis of Slug or Bail Test

Elginburgh Quarry BH13-01A

Top of Individual

Well Casing

Elevation 109.03 masl

H 107.48 masl

H_0 99.25 masl

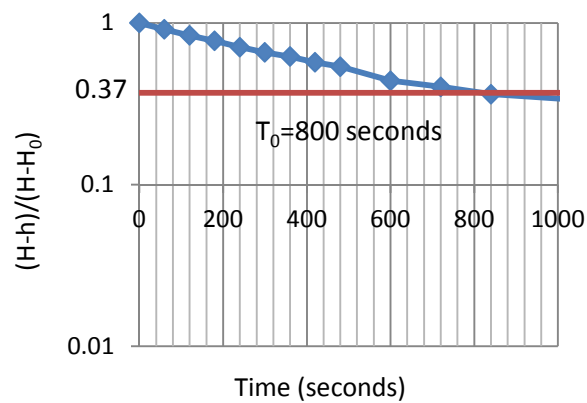
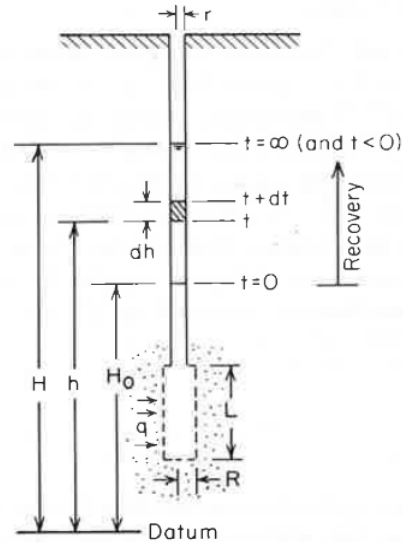
R (screen radius) 0.05 m

r (riser radius) 0.02 m

L (screen length) 7.62 m

T_0 800 seconds

time (seconds)	h(t)	$(H-h)/(H-H_0)$
0	99.25	1
60	99.98	0.911300122
120	100.6	0.835965978
180	101.11	0.77399757
240	101.65	0.708383961
300	102.07	0.657351154
360	102.39	0.618469016
420	102.79	0.569866343
480	103.07	0.535844471
600	103.87	0.438639125
720	104.17	0.40218712
840	104.5	0.362089915
1080	104.77	0.329283111
1680	105.24	0.27217497
2280	105.72	0.213851762
2880	105.95	0.185905225
3480	106.16	0.160388821
5520	106.38	0.133657351
11580	106.54	0.114216282
27240	106.83	0.078979344
88440	106.92	0.068043742



Hvorslev Formula (see Freeze and Cherry, 1979)

$$K = \frac{r^2 \ln L/R}{2LT_0}$$

$$K = 1.6E-07 \text{ m/seconds}$$

Hvorslev Analysis of Slug or Bail Test

Elginburgh Quarry BH13-01B

Top of Individual

Well Casing

Elevation 109.03 masl

H 106.23 masl

H_0 96.53 masl

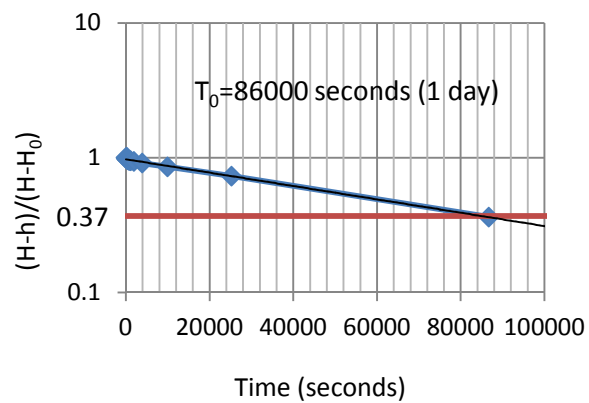
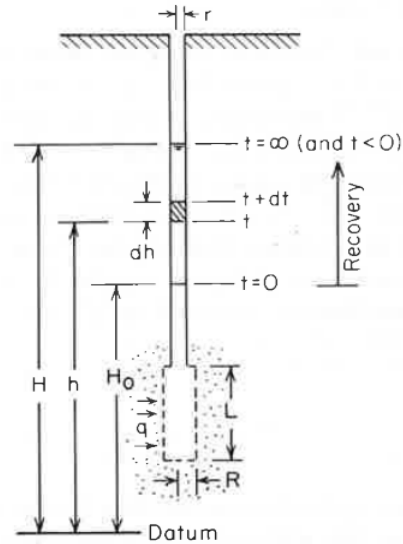
R (screen radius) 0.05 m

r (riser radius) 0.02 m

L (screen length) 10.67 m

T_0 84000 seconds

time (seconds)	$h(t)$	$(H-h)/(H-H_0)$
0	96.53	1
120	96.68	0.984536082
240	96.45	1.008247423
360	96.82	0.970103093
480	96.88	0.963917526
720	96.93	0.958762887
900	96.97	0.954639175
1200	97.02	0.949484536
1920	97.12	0.939175258
3900	97.37	0.913402062
9960	97.92	0.856701031
25260	99.13	0.731958763
86760	102.71	0.362886598



Hvorslev Formula (see Freeze and Cherry, 1979)

$$K = \frac{r^2 \ln L/R}{2LT_0}$$

$K = 1.2E-09$ m/seconds

APPENDIX G: Groundwater and Surface Water Analytical Results

Table G1 - Groundwater Metals and General Chemistry

Parameter	Units	M.D.L.	PWQO ²	ODWQS ¹	BH11-02B	BH11-04	BH12-02A	BH12-03A	BH13-01A
Electrical Conductivity (EC) umho/cm		1	NV	NV	2250	560	3570	804	22800
pH*		NA	6.5-8.5	6.5-8.5	7.47	7.79	7.41	8.87	7.56
Total Hardness (as CaCO ₃)*	mg/L	1	NV	80-100	272	378	2210	19	3200
Total Suspended Solids	mg/L	2	NV	NV	2500	198	330	13800	1370
Alkalinity (as CaCO ₃)**	mg/L	3	NV	30-500	296	232	202	330	99
Chloride**	mg/L	0.50	NV	250	391	9.3	396	3.6	5030
Nitrate as N	mg/L	0.1	NV	10	0.1	0.2	0.2	0.4	0.3
Nitrite as N	mg/L	0.1	NV	1	<0.1	<0.1	<0.1	<0.1	<0.1
Sulphate	mg/L	1	NV	500	269	49	1250	79	156
Ammonia (N) - Total	mg/L	0.005	NV	NV	1.01	0.033	0.598	0.789	5.31
Ammonia (unionized)	mg/L	NA	0.02	NV	0.0034	0.0002	0.0018	0.0620	0.0221
Dissolved Organic Carbon**	mg/L	0.2	NV	5	8.9	4.5	3.1	228	92.9
Dissolved Inorganic Carbon	mg/L	0.2	NV	NV	56.3	43	34.3	91	13.3
Phenolics	mg/L	0.001	0.001	NV	0.003	<0.001	0.002	<0.001	<0.001
Carbonate (as CaCO ₃)	mg/L	3	NV	NV	<3	<3	<3	37	<3
Bicarbonate (as CaCO ₃)	mg/L	3	NV	NV	296	232	202	294	99
Turbidity**	NTU	0.2	NV	5	970	127	438	7830	1270
Calcium	mg/L	0.02	NV	NV	60	126	718	6.66	603
Magnesium	mg/L	0.01	NV	NV	29.8	15.4	100	0.68	411
Sodium**	mg/L	0.2	NV	200	350	8.1	496	197	3450
Potassium	mg/L	0.1	NV	NV	8	1.6	16.9	0.6	47.2
Aluminum***	mg/L	0.01	0.075	0.1/0.2	0.13	0.28	0.19	0.54	0.16
Boron	mg/L	0.005	0.2	5	1.87	0.082	0.602	0.096	1.26
Cadmium	mg/L	0.00002	0.0002	0.005	5E-05	3E-05	0.0003	8E-05	0.0002
Chromium	mg/L	0.002	0.0089	0.05	<0.002	0.004	<0.002	<0.002	<0.002
Cobalt	mg/L	0.0001	0.0009	NV	0.0081	0.0274	0.0121	0.0157	0.0067
Copper**	mg/L	0.0001	0.005	1	0.0022	0.0032	0.004	0.003	0.0264
Iron**	mg/L	0.005	0.3	0.3	0.214	1.25	0.107	0.402	0.067
Lead	mg/L	0.00002	0.025	0.01	9E-05	0.0039	3E-05	0.0025	0.0013
Nickel	mg/L	0.01	0.025	NV	<0.01	<0.01	0.02	<0.01	<0.01
Silicon	mg/L	0.01	NV	NV	4.55	2.85	3.22	3.72	1.91
Silver	mg/L	0.00002	0.0001	NV	<0.0000	<0.0000	<0.0000	<0.0000	5E-05
Zinc**	mg/L	0.005	0.03	5	0.006	0.023	0.009	0.008	0.088
Temperature (field)	°C	NA	NV	NV	6	8.6	8.1	5.9	5.6
pH (field)		NA	NV	NV	7.26	8	7.72	10.03	8.1
EC (field)	umho/cm	10	6.5-8.5	6.5-8.5	3095	672	3363	1046	3999

Notes:

(1) Ontario Drinking Water Quality Standards, O.Reg 169/03, Safe Drinking Water Act, 2002.

(2) Water Management Policies, Guidelines, Provincial Water Quality Objectives of the Ministry of the Environment and Energy, July 1994.

* Standards based on ODWQS **Operational Guideline**, Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines, June 2006.

** Standards based on ODWQS **Aesthetic Objective**, Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines, June 2006.

*** Standard based on Guidelines for Canadian Drinking Water Quality, March 2006. This is an **operational guidance** value, designed to apply only to drinking water treatment plants using aluminum-based coagulants. The value of 0.1 mg/L applies to conventional treatment plants, and 0.2 mg/L applies to other types of treatment systems

MDL - Method Detection Limit

Values shaded exceed PWQO Standards	Values in bold exceed ODWQS Standards
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Analyses completed by Caduceon Environmental Laboratories of Ottawa

Table G2a - Surface Water PHC and General Chemistry

			Sample ID:	E-SW1	E-SW2	E-SW3
			Date Collected:	29-May-14	29-May-14	29-May-14
Parameter	Units	M.D.L.	PWQO Criteria ⁽¹⁾			
Hardness (as CaCO3)	mg/L	1	NV	405	276	280
Alkalinity(CaCO3) to pH4.5	mg/L	5	NV	138	182	146
Bicarbonate(as CaCO3)	mg/L	5	NV	138	182	146
Carbonate (as CaCO3)	mg/L	5	NV	< 5	< 5	< 5
pH @25°C	pH Units		6.5-8.5	8.21	8.26	8.27
Conductivity @25°C	µmho/cm	1	NV	886	577	627
Field Dissolved Oxygen			NV	7.16	8.47	9.57
Field Temperature	°C		NV	19.7	17.1	17.2
Field pH	pH Units		NV	7.01	7.02	7.42
Field Conductivity	µmho/cm		NV	715	591	623
Total Suspended Solids	mg/L	3		< 3	7	12
Chloride	mg/L	0.5	NV	52.1	23.5	25.9
Nitrite (N)	mg/L	0.1	1	< 0.1	< 0.1	< 0.1
Nitrate (N)	mg/L	0.1	10	0.3	0.2	0.2
Sulphate	mg/L	1	NV	254	90	148
Calcium	mg/L	0.02	NV	114	89.9	87
Ammonia (N)-Total	mg/L	0.01	NV	< 0.01	0.03	0.01
Ammonia (unionized) ⁽²⁾	mg/L		0.02	< 0.00004	0.00010	0.00008
Total Kjeldahl Nitrogen	mg/L	0.05	NV	0.25	0.47	0.41
Phosphorus-Total	mg/L	0.01	0.03	< 0.01	< 0.01	0.02
Phenolics	mg/L	0.001	NV	< 0.001	< 0.001	< 0.001
BOD	mg/L	3	NV	< 3	< 3	< 3
COD	mg/L	5	NV	35	38	36
Dissolved Organic Carbon	mg/L	0.2	NV	4.1	4.2	3.6
Dissolved Inorganic Carbon	mg/L	0.2	NV	33.1	43.7	35
PHC F1 (C6-C10)	µg/L	20	NV	< 20	< 20	< 20
PHC F2 (>C10-C16)	µg/L	50	NV	< 50	< 50	< 60
PHC F3 (>C16-C34)	µg/L	400	NV	< 400	< 400	< 500
PHC F4 (>C34-C50)	µg/L	400	NV	< 400	< 400	< 500
Oil & Grease-Total	mg/L	1	NV	< 1.0	< 1.0	< 1.0

Notes:

(1) Water Management Policies, Guidelines, Provincial Water Quality Objectives of the Ministry of the Environment and Energy July, 1994

(2) Calculated based on field measurements of pH and temperature

Table G2b - Surface Water Metals

			Sample ID:	E-SW1	E-SW2	E-SW3
			Date Collected:	29-May-14	29-May-14	29-May-14
Parameter	Units	M.D.L.	PWQO Criteria ⁽¹⁾			
Magnesium	mg/L	0.01	NV	29.1	12.5	15.1
Sodium	mg/L	0.2	NV	41.3	21.6	25
Potassium	mg/L	0.1	NV	8.2	3.7	6.4
Aluminum (total)	mg/L	0.01	0.075	0.08	0.06	0.09
Arsenic	mg/L	0.0001	0.1	0.0004	0.0003	0.0003
Barium	mg/L	0.001	NV	0.042	0.038	0.04
Beryllium	mg/L	0.002	1.1	< 0.002	< 0.002	< 0.002
Boron	mg/L	0.005	0.2	0.258	0.119	0.174
Cadmium	mg/L	0.00002	0.0002	< 0.00002	< 0.00002	< 0.00002
Chromium	mg/L	0.002	0.0089	< 0.002	0.003	< 0.002
Cobalt	mg/L	0.0001	0.0009	0.0008	0.0002	0.0003
Copper	mg/L	0.0001	0.005	0.0014	0.0011	0.0009
Iron (Total)	mg/L	0.005	0.3	0.136	0.106	0.131
Lead	mg/L	0.00002	0.025	0.00005	0.00005	0.00016
Manganese (Total)	mg/L	0.001	NV	0.051	0.051	0.024
Mercury	mg/L	0.00002	0.0002	< 0.00002	< 0.00002	< 0.00002
Molybdenum	mg/L	0.0001	0.04	0.0072	0.0023	0.0035
Nickel	mg/L	0.0005	0.025	0.0067	0.0043	0.0059
Silicon	mg/L	0.01	NV	1.53	1.67	0.55
Silver	mg/L	0.00002	0.0001	< 0.00002	< 0.00002	< 0.00002
Strontium	mg/L	0.001	NV	2.48	0.999	1.47
Thallium	mg/L	0.00005	0.0003	0.00008	< 0.00005	< 0.00005
Titanium	mg/L	0.005	NV	< 0.005	0.005	0.006
Vanadium	mg/L	0.005	0.006	< 0.005	< 0.005	< 0.005
Zinc	mg/L	0.005	0.03	0.032	0.009	0.009

Notes:

(1) Water Management Policies, Guidelines, Provincial Water Quality Objectives of the Ministry of the Environment and Energy July, 1994

APPENDIX H: Water Well Information System (Well Records)



Table H1 - MOE Water Well Record Query Results

BH ID	Easting	Northing	Ground Surface (masl)	Total Depth (m)	# of Formation	Formation Mat1 Codes*	Formation Contact Elevations (masl)	# Water Found	Water Found Elevations (masl)	Heads (masl)
2201087	373135	4906139	128.66	20.73	2	5 15	128.66 127.44 107.94	1	108.55	111.9
2201088	373224	4906048	125.66	20.73	2	5 15	125.66 124.45 104.94	1	107.38	123.84
2201090	373290	4906137	126	43.28	3	2 5 15	126.00 125.70 125.09 82.72	3	119.90 103.14 83.94	119.6
2201094	373401	4906161	126	14.02	3	2 5 15	126.00 125.70 123.56 111.98	2	114.42 113.20	115.03
2201096	373441	4906155	126.87	19.81	2	17 15	126.87 122.29 107.05	1	113.76	122.29
2201098	373779	4906155	125.03	18.29	2	2 15	125.03 124.42 106.74	1	109.79	122.9
2201099	373705	4906049	126.98	35.36	1	15	126.98 91.62	3	116.31 102.59 94.97	116.31
2201103	374778	4905199	90	29.87	2	17 15	90.00 83.29 60.13	1	66.84	77.81
2201105	374974	4905641	95.48	12.8	2	5 15	95.48 93.65 82.68	1	85.73	90
2201106	375035	4905253	93.04	27.13	2	5 15	93.04 89.99 65.92	1	70.18	85.73
2201108	375172	4905371	90.41	12.5	1	15	90.41 77.91	1	78.22	87.06
2201112	375591	4906152	101.6	22.86	2	5 15	101.60 100.99 78.74	1	83.32	86.36
2201113	375494	4906196	90.37	24.69	2	17 15	90.37 87.33 65.68	1	65.99	83.97
2201115	375534	4906015	96.36	23.47	2	5 15	96.36 94.53 72.89	1	74.72	82.95
2201118	375494	4906194	90.39	19.81	3	2 17 15	90.39 89.78 83.38 70.58	1	72.1	78.2
2201124	375557	4906195	95.93	15.24	3	2 15 15	95.93 95.01 89.53 80.69	1	82.52	85.87
2201126	375565	4906253	93.43	14.63	1	15	93.43 78.80	1	83.98	83.98
2201130	376215	4906126	97.32	18.29	1	15	97.32 79.03	1	82.08	86.65
2201137	376680	4906294	115.77	28.65	1	15	115.77 87.12	1	104.19	108.46
2201139	376595	4906302	107.4	17.98	3	2 17 15	107.40 104.96 103.74 89.41	1	97.64	100.08
2201142	376998	4906316	130	23.47	2	5 15	130.00 128.48 106.53	1	116.28	120.86
2201146	376938	4906307	130	43.59	1	15	130.00 86.41	1	111.71	111.71
2201147	377094	4906249	130	14.02	2	5 15	130.00 126.95 115.98	1	117.81	128.17
2201148	376710	4906296	117.35	31.7	2	9 15	117.35 116.75 85.66	1	89.92	112.48
2201150	377088	4906262	130	16.76	2	5 15	130.00 126.34 113.24	1	116.89	116.89
2201154	377095	4905900	130	13.41	1	15	130.00 116.59	1	117.81	127.56
2201158	377092	4906068	130	12.8	2	2 15	130.00 129.70 117.20	1	118.42	126.65
2201170	377092	4906218	130	19.81	2	5 15	130.00 128.78 110.19	1	118.42	119.03
2201174	377093	4906280	130	21.95	2	5 15	130.00 128.17 108.05	1	111.1	114.76
2201176	376939	4906311	130	59.74	3	5 15 21	130.00 128.17 71.48 70.26	1	71.48	99.52

Table H1 - MOE Water Well Record Query Results

BH ID	Easting	Northing	Ground Surface (masl)	Total Depth (m)	# of Form-ation	Form-ation Mat1 Codes*	Formation Contact Elevations (masl)	# Water Found	Water Found Elevations (masl)	Heads (masl)
2201182	377598	4906338	131	15.24	2	5 15	131.00 130.39 115.76	1	117.28	121.25
2201183	377205	4905705	130	19.51	2	9 15	130.00 128.78 110.49	1	112.32	120.25
2201184	377196	4906023	130	23.47	2	17 15	130.00 126.95 106.53	1	108.66	122.38
2201185	377596	4906341	131	15.24	1	15	131.00 115.76	1	120.33	128.56
2201188	377184	4905869	130	26.82	2	17 15	130.00 127.87 103.18	1	107.14	122.99
2201190	377031	4906334	130	25.91	2	5 15	130.00 126.95 104.09	1	114.76	114.76
2201193	377212	4906331	131	20.42	2	17 15	131.00 125.82 110.58	1	124.6	124.6
2201214	377142	4906295	130	19.51	2	5 15	130.00 128.48 110.49	1	111.71	120.86
2201217	377135	4906323	130.21	21.03	2	5 15	130.21 129.30 109.18	1	113.45	125.64
2201218	377147	4906245	130.02	20.42	2	5 15	130.02 129.10 109.60	1	113.25	119.35
2201219	377140	4906262	130	20.73	2	5 15	130.00 128.78 109.27	1	117.81	118.11
2201223	377194	4906322	131	20.12	2	1 15	131.00 130.39 110.88	1	123.68	127.95
2201226	377183	4905220	130	15.24	3	2 15 15	130.00 129.39 123.90 114.76	2	126.95 119.33	129.09
2201227	377137	4906279	130	17.37	2	5 15	130.00 128.48 112.63	1	114.15	123.6
2201229	377095	4906282	130	28.04	2	2 15	130.00 129.70 101.96	1	102.87	116.28
2201232	377171	4905353	130	9.75	2	2 15	130.00 129.70 120.25	1	124.21	128.48
2201233	377352	4906318	132	13.11	3	2 17 15	132.00 131.09 129.87 118.89	1	120.42	130.48
2201234	377446	4906321	132	17.37	2	17 15	132.00 129.26 114.63	1	124.99	129.56
2201235	377185	4905242	130	20.73	1	15	130.00 109.27	1	110.49	120.86
2201237	377179	4905498	130	20.42	2	24 15	130.00 116.28 109.58	1	112.32	124.51
2201238	377165	4905217	130	22.86	2	17 15	130.00 124.21 107.14	1	108.36	117.5
2201240	377620	4906264	131	24.99	3	2 17 15	131.00 130.70 129.78 106.01	1	107.23	121.86
2201241	377777	4906328	129.41	22.56	3	2 17 15	129.41 128.80 126.97 106.86	1	108.69	125.15
2201244	377598	4906338	131	24.38	3	2 17 15	131.00 130.39 129.48 106.62	1	107.84	125.51
2201246	377531	4906325	131	22.56	2	24 15	131.00 115.15 108.44	1	112.71	126.73
2201316	373468	4906265	128	22.25	2	2 15	128.00 127.70 105.75	1	108.19	118.86
2201317	373214	4906409	130.8	20.42	2	2 15	130.80 129.89 110.38	1	112.51	126.53
2201318	373261	4906386	130	67.06	3	5 15 15	130.00 129.09 127.26 62.94	1	62.94	76.66
2201319	373590	4908218	129.55	21.64	2	2 15	129.55 129.25 107.91	1	110.35	119.8
2201321	372988	4906537	135	22.25	2	17 15	135.00 133.17 112.75	1	116.71	120.67

Table H1 - MOE Water Well Record Query Results

BH ID	Easting	Northing	Ground Surface (masl)	Total Depth (m)	# of Form-ation	Form-ation Mat1 Codes*	Formation Contact Elevations (masl)	# Water Found	Water Found Elevations (masl)	Heads (masl)
2201324	373081	4906544	135.16	15.85	3	2 17 15	135.16 134.85 132.11 119.31	1	130.89	133.63
2201325	373608	4906253	128	18.59	2	17 15	128.00 127.39 109.41	1	120.38	125.56
2201326	372923	4906581	136	15.24	2	5 15	136.00 135.70 120.76	1	126.55	135.09
2201328	374054	4906237	116.14	25.91	3	5 17 15	116.14 115.83 113.70 90.23	1	91.75	112.48
2201329	374247	4906254	125	26.82	1	15	125.00 98.18	1	98.79	110.06
2201330	374119	4906233	123.14	30.48	3	2 17 15	123.14 122.83 121.61 92.66	1	113.99	113.99
2201331	374620	4906251	108.1	20.12	4	2 12 14 15	108.10 107.79 105.35 102.31 87.98	2	95.30 89.81	93.77
2201332	375528	4906306	89.17	15.85	2	5 18	89.17 75.75 73.32	1	73.93	89.17
2201333	375481	4906362	89	13.72	2	2 21	89.00 87.17 75.28	1	76.81	83.51
2201334	375197	4906291	89.05	16.15	2	5 21	89.05 88.13 72.89	1	74.42	85.39
2201335	375483	4906299	89	28.65	2	5 21	89.00 66.75 60.35	1	61.87	88.7
2201336	375598	4906300	91.89	22.25	2	5 21	91.89 73.60 69.64	2	72.08 70.55	86.4
2201337	375643	4906305	93.76	26.52	1	15	93.76 67.24	1	68.76	80.04
2201338	375505	4906286	89.08	26.21	3	2 15 21	89.08 88.16 64.70 62.87	1	70.79	79.94
2201339	376160	4906317	113.75	23.47	1	15	113.75 90.28	1	96.99	103.09
2201340	376272	4908423	132.69	21.95	2	5 15	132.69 132.39 110.75	1	123.55	129.95
2201341	376046	4906394	114.43	29.26	2	5 15	114.43 114.13 85.17	1	87	104.07
2201342	376105	4906346	114.86	28.35	2	5 15	114.86 113.64 86.52	1	87.43	104.5
2201343	376009	4906309	115	25.6	2	5 15	115.00 113.78 89.40	1	90.62	101.59
2201344	376032	4906317	115.6	26.21	2	5 15	115.60 114.38 89.38	1	90.6	101.58
2201345	376020	4906349	115.49	27.43	2	5 15	115.49 113.96 88.05	1	88.97	101.77
2201346	376112	4906315	115	26.52	2	5 15	115.00 113.78 88.48	1	89.7	103.72
2201347	376133	4906350	115	28.96	2	5 15	115.00 113.48 86.04	1	87.57	99.76
2201348	376085	4906371	114.18	24.38	2	5 15	114.18 112.96 89.79	1	90.71	101.99
2201349	376038	4906389	114.99	25.3	2	5 15	114.99 113.46 89.69	1	90.6	101.88
2201350	376185	4906339	112.83	26.52	2	5 15	112.83 111.61 86.31	1	87.23	101.55
2201351	376875	4906360	125.64	19.81	1	15	125.64 105.83	1	106.75	113.45
2201352	377269	4908216	116.93	27.74	2	5 15	116.93 115.11 89.20	1	98.65	106.27
2201353	377124	4908424	123.9	25.6	2	5 15	123.90 123.59 98.29	2	120.85 99.51	111.71
2201354	377066	4906407	130	20.73	2	5 15	130.00 128.78 109.27	1	110.19	122.38

Prepared by: AC
Reviewed by: AW
Date: 2/24/2014
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Table H1 - MOE Water Well Record Query Results

BH ID	Easting	Northing	Ground Surface (masl)	Total Depth (m)	# of Formation	Form-ation Mat1 Codes*	Formation Contact Elevations (masl)	# Water Found	Water Found Elevations (masl)	Heads (masl)
2201355	377088	4906384	130	22.86	2	5 15	130.00 129.09 107.14	1	108.66	120.86
2201356	377063	4907076	97.17	17.07	3	5 17 15	97.17 95.95 94.12 80.10	1	81.01	94.73
2201357	376998	4906381	129.37	21.03	2	9 15	129.37 128.46 108.34	1	110.17	119.92
2201358	377050	4908317	125	25.6	2	2 15	125.00 124.09 99.40	1	100.92	119.21
2201359	377091	4907279	109.52	19.51	3	5 17 15	109.52 108.30 106.48 90.02	1	92.76	104.95
2201360	377053	4907598	105.34	22.25	2	5 15	105.34 104.73 83.09	1	83.4	96.81
2201362	377042	4908067	120	29.26	2	2 15	120.00 119.39 90.74	1	92.57	104.76
2201363	377032	4908420	125	24.38	2	5 15	125.00 123.78 100.62	1	112.81	115.86
2201364	377047	4907929	115.1	21.34	2	17 15	115.10 112.05 93.76	1	96.2	112.35
2201365	377096	4906740	118.1	56.08	3	17 15 15	118.10 114.44 65.07 62.02	1	63.54	93.72
2201366	377071	4906440	130.99	26.21	2	5 15	130.99 129.77 104.78	1	110.57	121.85
2201367	377043	4908370	125	17.37	3	2 17 15	125.00 124.39 122.56 107.63	1	108.54	117.68
2201368	376955	4906379	128.77	43.59	2	17 15	128.77 123.28 85.18	2	108.95 85.79	100.11
2201369	377110	4907792	105.3	22.86	2	5 15	105.30 105.00 82.44	1	87.01	99.21
2201370	377171	4906428	131	22.56	2	5 15	131.00 128.56 108.44	1	111.19	124.9
2201371	377163	4906393	131	21.34	2	5 15	131.00 127.95 109.66	1	112.71	124.9
2201372	377092	4908419	124.08	26.52	2	5 15	124.08 122.86 97.56	1	107.32	121.64
2201373	377147	4906664	127.12	25.6	2	5 15	127.12 124.98 101.51	1	109.74	121.02
2201374	377118	4907639	108.27	28.96	2	5 15	108.27 107.36 79.31	1	88.46	105.22
2201375	377139	4907311	109.3	31.39	3	5 17 15	109.30 108.39 107.17 77.91	1	98.63	105.03
2201376	377051	4908395	125	27.13	2	5 15	125.00 122.87 97.87	1	98.79	112.81
2201377	377220	4908445	121.08	27.43	2	2 15	121.08 119.25 93.65	1	108.28	112.24
2201378	377147	4906627	128.57	28.96	3	2 17 15	128.57 127.96 126.44 99.61	1	107.23	122.47
2201379	377211	4906413	131.54	15.24	2	9 15	131.54 129.10 116.30	1	122.4	130.02
2201380	377161	4906551	130.82	27.13	1	15	130.82 103.69	1	106.43	122.28
2201381	377398	4908427	123.85	28.04	2	5 15	123.85 118.06 95.81	1	96.73	104.35
2201382	377101	4908381	124	27.74	3	5 17 15	124.00 123.39 122.48 96.26	1	96.87	108.76
2201383	377132	4906499	130.79	22.86	2	5 15	130.79 129.57 107.93	1	108.84	121.03
2201384	377167	4906468	131	20.73	2	5 15	131.00 129.78 110.27	1	111.49	118.81
2201385	377160	4908433	123	30.48	2	5 15	123.00 120.26 92.52	1	97.09	107.76

Table H1 - MOE Water Well Record Query Results

BH ID	Easting	Northing	Ground Surface (masl)	Total Depth (m)	# of Formation	Formation Mat1 Codes*	Formation Contact Elevations (masl)	# Water Found	Water Found Elevations (masl)	Heads (masl)
2201386	377195	4908425	122.07	25.6	2	5 15	122.07 119.02 96.47	1	97.69	106.83
2201387	377149	4906451	131	69.49	3	17 15 21	131.00 124.90 73.39 61.51	1	73.39	101.43
2201388	377626	4908452	123.68	18.59	3	2 17 15	123.68 122.77 121.55 105.09	1	115.15	122.46
2201389	377568	4908458	125	22.86	2	17 15	125.00 120.12 102.14	1	103.36	118.9
2201390	377752	4906390	130	21.64	2	2 15	130.00 129.39 108.36	1	109.58	126.65
2201392	377730	4906388	130	23.77	2	17 15	130.00 128.78 106.23	1	115.37	124.51
2201577	376597	4908504	131	7.01	3	2 15 15	131.00 130.39 124.90 123.99	1	125.82	127.34
2201578	376752	4908472	129.45	15.54	2	17 15	129.45 124.57 113.90	1	121.83	127.62
2201580	377028	4908498	124.91	25.91	2	2 15	124.91 124.30 99.00	1	101.13	121.25
2201581	376769	4908469	129.01	0.91	1	5	129.01 128.10	1	109.51	123.22
2201582	377003	4908496	125.42	24.08	2	17 15	125.42 122.98 101.34	1	102.87	119.63
2201583	376912	4908497	127.21	21.03	2	2 15	127.21 126.30 106.18	1	108.92	118.07
2201586	377115	4908479	123.94	27.43	2	5 15	123.94 121.19 96.51	1	109.92	109.92
2201587	377196	4908520	122.03	30.48	2	5 15	122.03 119.90 91.55	1	94.6	109.84
2201588	377208	4908485	121.55	18.59	2	17 15	121.55 117.90 102.96	1	104.49	113.63
2201589	377182	4910014	125	17.37	2	5 15	125.00 120.43 107.63	1	108.54	120.12
2201590	377323	4910082	125	13.11	2	12 15	125.00 124.39 111.89	2	115.25 113.42	123.17
2201591	377256	4909612	125	21.03	3	2 17 15	125.00 124.39 121.65 103.97	1	113.42	118.29
2201592	377511	4908493	125	14.02	2	5 15	125.00 124.09 110.98	1	112.81	120.43
2201593	377610	4908580	125.92	28.65	1	15	125.92 97.27	1	103.06	118.3
2201594	377589	4908492	125	28.96	1	15	125.00 96.04	1	103.66	112.81
2201595	377613	4908607	126	31.09	2	2 15	126.00 125.39 94.91	1	96.43	107.71
2201596	377694	4908664	127	32	2	5 15	127.00 124.56 95.00	1	95.61	120.9
2201597	377719	4908676	127	41.15	2	5 15	127.00 125.17 85.85	1	85.85	117.86
2203997	377705	4908534	122.89	20.42	3	2 15 15	122.89 122.28 120.76 102.47	1	104.91	114.36
2204369	377050	4908432	124.8	28.65	2	5 15	124.80 122.67 96.15	1	97.67	107.73
2204370	377370	4908442	122.4	18.29	4	2 5 9 15	122.40 121.49 118.44 118.13 104.11	1	118.44	121.49
2204371	377110	4908262	123.14	27.74	2	5 15	123.14 121.92 95.40	1	96.32	112.47
2204372	377450	4906382	132	29.26	2	2 15	132.00 131.39 102.74	2	117.37 112.19	128.95
2204380	377410	4908482	124.47	21.03	2	5 15	124.47 122.03 103.44	1	104.35	110.45

Prepared by: AC
Reviewed by: AW
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Table H1 - MOE Water Well Record Query Results

BH ID	Easting	Northing	Ground Surface (masl)	Total Depth (m)	# of Formation	Form-ation Mat1 Codes*	Formation Contact Elevations (masl)	# Water Found	Water Found Elevations (masl)	Heads (masl)
2204422	374980	4906302	89.23	10.67	3	5 17 15	89.23 87.40 86.18 78.56	1	82.53	87.71
2204668	372990	4908302	131.89	14.02	3	2 17 15	131.89 130.98 126.41 117.87	1	125.8	128.24
2204669	377470	4908482	125	41.15	2	5 15	125.00 122.56 83.85	1	84.16	97.57
2204732	374430	4907142	136	27.43	3	2 15 15	136.00 135.39 133.56 108.57	1	111.62	128.99
2204750	377190	4908782	129.16	14.02	6	2 5 9 15 15 15	129.16 127.64 125.50 121.84 116.05 115.44 115.14	1	115.44	122.15
2204754	377490	4908502	125	22.86	2	9 15	125.00 122.26 102.14	2	114.03 103.97	117.68
2204757	377030	4908742	129.78	35.66	6	2 15 15 15 15 15	129.78 129.17 113.62 112.71 95.03 94.42 94.12	2	113.62 94.42	116.06
2204758	377470	4908482	125	17.07	2	5 15	125.00 123.78 107.93	1	117.99	121.34
2204761	377670	4908552	124.14	31.7	2	5 15	124.14 123.22 92.44	3	102.49 96.09 92.74	102.19
2204830	377000	4908432	125	36.27	1	15	125.00 88.73	2	112.81 91.47	111.28
2204836	377030	4908422	125	32.61	2	5 15	125.00 124.09 92.39	1	93	104.88
2204942	377760	4906372	130	25.6	3	2 15 15	130.00 129.09 126.34 104.40	1	106.84	119.03
2204945	376220	4906432	114.96	29.87	2	2 15	114.96 114.05 85.09	1	86.92	99.42
2204963	373230	4906402	130.52	14.94	2	2 15	130.52 130.22 115.59	1	128.69	128.08
2205015	374370	4906262	121.95	37.19	2	5 15	121.95 121.34 84.77	2	108.24 85.38	104.27
2205028	376500	4908402	132	33.53	1	15	132.00 98.47	1	104.57	131.39
2205033	376510	4908182	130	21.34	1	15	130.00 108.66	1	127.87	128.78
2205041	375590	4906282	92.29	15.24	2	5 15	92.29 91.07 77.05	1	77.96	86.8
2205064	377340	4908442	121.7	9.14	3	5 11 15	121.70 118.35 118.04 112.56	1	118.04	119.26
2205071	374910	4909012	142	26.82	2	15 15	142.00 137.43 115.18	1	116.09	135.6
2205092	377290	4906332	132	23.16	2	2 15	132.00 131.70 108.84	2	115.24 109.75	129.56
2205139	373480	4906162	127	19.2	2	15 15	127.00 125.78 107.80	2	117.86 108.71	124.56
2205251	376780	4908422	130	24.38	2	2 15	130.00 129.09 105.62	2	126.34 105.92	123.9
2205265	373420	4906252	127.57	21.34	3	2 15 15	127.57 127.27 125.44 106.24	1	114.77	122.39
2205319	376850	4908482	128	24.38	2	15 15	128.00 124.95 103.62	2	113.37 104.84	119.47
2205331	377450	4906387	132	28.35	2	2 15	132.00 131.09 103.65	1	115.85	127.12
2205332	375290	4905617	90.21	14.02	2	5 15	90.21 88.99 76.19	1	77.11	80.77
2205387	374030	4908382	135	22.25	2	2 15	135.00 134.70 112.75	1	113.66	130.12

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Table H1 - MOE Water Well Record Query Results

BH ID	Easting	Northing	Ground Surface (masl)	Total Depth (m)	# of Formation	Formation Mat1 Codes*	Formation Contact Elevations (masl)	# Water Found	Water Found Elevations (masl)	Heads (masl)
2205394	377680	4906332	130	21.95	3	2 15 15	130.00 128.78 125.12 108.05	1	109.27	127.56
2205397	374390	4907122	136	24.38	2	5 15	136.00 134.17 111.62	1	112.84	130.82
2205435	377730	4908622	125.91	28.35	3	2 5 15	125.91 125.60 124.69 97.56	1	98.48	106.71
2205568	375310	4905652	91.81	21.64	2	5 15	91.81 90.89 70.17	1	71.08	81.14
2205569	375324	4905680	92.46	28.65	2	5 15	92.46 91.55 63.81	1	64.72	81.79
2205570	375348	4905707	94.25	27.13	2	5 15	94.25 93.33 67.12	1	67.73	83.58
2205577	377610	4906332	130.67	33.53	2	2 15	130.67 130.06 97.14	1	98.66	122.44
2205740	375110	4908402	140	43.59	2	5 15	140.00 139.39 96.41	1	117.14	138.78
2205767	376970	4906392	128.85	22.86	2	2 15	128.85 127.93 105.99	1	106.9	117.26
2205769	375610	4906282	93.08	17.68	2	2 15	93.08 91.56 75.40	1	76.32	86.38
2205916	377110	4908862	129.89	12.8	2	5 15	129.89 128.98 117.09	1	124.1	128.67
2205989	374350	4906552	129.84	123.44	5	2 15 15 21 21	129.84 129.53 78.02 73.45 16.15 6.39	2	73.45 16.45	98.14
2205992	377690	4906322	130	35.97	2	2 15	130.00 129.70 94.03	2	112.63 94.64	125.73
2206019	377150	4905962	130	13.11	1	15	130.00 116.89	1	122.08	128.48
2206063	375210	4905442	91	18.59	1	15	91.00 72.41	1	74.24	81.86
2206105	373960	4906222	120.72	16.15	1	15	120.72 104.57	1	109.45	120.42
2206140	376254	4906391	111.3	21.34	2	5 15	111.30 110.39 89.97	2	97.89 91.19	101.85
2206141	375502	4906173	92.21	19.81	3	5 17 15	92.21 91.30 87.95 72.40	1	76.06	84.29
2206180	377360	4905422	130	21.64	2	17 15	130.00 128.78 108.36	1	126.95	126.95
2206195	376758	4908406	130	67.06	4	2 15 15 21	130.00 129.39 70.56 64.47 62.94	1	64.47	87.33
2206212	374356	4906338	124.98	35.66	2	2 15	124.98 124.68 89.32	1	90.24	106.7
2206462	374317	4906610	130	32.92	2	2 15	130.00 129.70 97.08	2	105.62 98.00	113.54
2206602	377517	4908447	125	29.87	2	1 15	125.00 123.78 95.13	1	97.87	112.81
2206609	374320	4907665	135.81	20.73	2	1 15	135.81 134.59 115.09	1	116.31	131.24
2206887	376810	4908475	128.54	10.97	2	1 15	128.54 127.32 117.57	2	124.58 119.70	124.88
2206908	377059	4907600	105.45	15.24	2	2 15	105.45 103.31 90.21	2	96.61 93.86	97.52
2206944	377116	4908688	128.76	22.25	2	2 15	128.76 128.15 106.51	1	107.73	119.92
2206977	377321	4908445	120.94	32.31	2	2 15	120.94 120.64 88.63	1	88.94	104.48
2207178	374426	4906123	108.62	19.81	2	5 15	108.62 104.05 88.81	1	89.42	105.88

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Table H1 - MOE Water Well Record Query Results

BH ID	Easting	Northing	Ground Surface (masl)	Total Depth (m)	# of Formation	Formation Mat1 Codes*	Formation Contact Elevations (masl)	# Water Found	Water Found Elevations (masl)	Heads (masl)
2207195	375758	4906234	103.16	22.25	2	2 15	103.16 102.55 80.91	1	89.44	90.05
2207400	377510	4908502	125	37.49	2	2 15	125.00 124.39 87.51	1	89.03	106.71
2207529	377080	4907522	110.02	31.7	2	5 15	110.02 109.41 78.32	2	96.00 80.15	103.62
2207545	374830	4905422	90.8	35.66	3	2 15 21	90.80 90.19 59.71 55.14	1	55.75	74.03
2207687	377110	4908122	120.21	21.95	2	2 15	120.21 118.68 98.26	1	99.48	111.67
2207721	377210	4909222	125	27.13	2	5 15	125.00 123.48 97.87	2	108.24 103.05	118.6
2207756	377150	4906062	130	13.41	2	12 15	130.00 128.48 116.59	1	117.5	128.78
2207767	377090	4906562	129.78	68.28	5	2 15 15 15 21	129.78 129.48 126.12 80.40 77.66 61.51	1	77.36	120.03
2207804	375130	4905322	88.74	44.2	3	5 15 15	88.74 86.91 49.42 44.54	1	46.68	79.59
2207850	376510	4906642	110.46	59.13	5	1 28 15 18 21	110.46 108.94 107.11 65.35 59.56 51.33	1	52.55	96.75
2208206	374790	4905322	90	32.31	3	2 15 18	90.00 89.09 61.04 57.69	1	59.52	79.33
2208298	373510	4906222	127.54	77.72	4	15 15 21 21	127.54 75.73 72.37 60.49 49.82	1	69.94	113.52
2208513	374890	4905322	93.37	46.33	5	2 15 15 15 21	93.37 93.07 92.15 62.28 58.02 47.04	1	55.88	77.83
2208635	374990	4905142	94.83	37.8	3	5 15 15	94.83 92.70 58.87 57.04	1	58.26	87.52
2208636	374930	4905282	95	60.05	4	5 15 15 21	95.00 92.56 56.90 55.38 34.95	1	35.26	86.47
2208728	376990	4906382	129.27	34.75	2	23 15	129.27 108.54 94.52	1	95.74	111.59
2208832	375910	4906302	110.88	33.22	2	1 15	110.88 110.27 77.66	1	77.96	94.73
2208858	374729	4906621	129.21	28.04	2	2 15	129.21 128.60 101.17	1	102.39	117.02
2208865	374429	4906321	122.42	15.85	2	5 15	122.42 121.81 106.57	1	107.18	119.98
2208895	377229	4905621	130	29.57	1	15	130.00 100.43	1	101.96	120.86
2208956	375629	4906121	105	21.95	3	2 15 21	105.00 104.39 88.24 83.05	1	88.54	88.54
2209099	377329	4905521	130	27.43	1	23	130.00 102.57	1	104.4	120.25
2209116	374429	4906021	98.53	37.19	2	2 15	98.53 97.61 61.34	1	62.56	81.46
2209240	377529	4908321	121.65	32.31	3	2 26 15	121.65 121.04 119.82 89.34	1	95.74	103.06
2209245	377129	4908321	123.7	27.13	2	2 15	123.70 123.39 96.57	2	108.46 97.49	105.41
2209314	373255	4909472	135	14.33	3	5 15 15	135.00 134.09 132.56 120.67	2	124.33 121.59	129.82
2209436	375729	4906021	109.75	27.43	2	17 15	109.75 108.53 82.32	2	88.11 83.54	97.56

Table H1 - MOE Water Well Record Query Results

BH ID	Easting	Northing	Ground Surface (masl)	Total Depth (m)	# of Form-ation	Form-ation Mat1 Codes*	Formation Contact Elevations (masl)	# Water Found	Water Found Elevations (masl)	Heads (masl)
2209527	377229	4908521	121	26.52	2	2 15	121.00 119.48 94.48	1	95.09	106.06
2209609	376829	4908621	127	36.58	2	2 15	127.00 126.70 90.42	1	109.63	122.43
2209643	373829	4908221	128.39	79.25	4	2 15 18 21	128.39 127.48 56.76 53.71 49.14	2	64.38 50.67	107.05
2209646	377229	4906221	131	33.53	6	5 15 15 15 46 15	131.00 130.39 110.27 109.05 99.00 98.69 97.47	2	115.15 99.00	119.42
2209880	377329	4909621	125	18.59	3	2 15 15	125.00 124.09 121.34 106.41	1	110.06	117.68
2209885	374629	4907321	135	41.45	5	2 15 15 15 15	135.00 134.70 126.16 97.20 95.07 93.55	1	95.68	119.15
2209886	374529	4906221	109.56	37.19	5	5 15 15 15 15	109.56 109.25 87.61 84.26 79.69 72.37	2	93.71 78.77	101.63
2210059	375729	4905921	106.58	20.42	2	2 15	106.58 105.67 86.16	1	89.82	89.82
2210264	374977	4905105	95.36	20.12	2	5 15	95.36 89.88 75.25	1	78.6	89.27
2210265	373147	4906194	128.42	29.26	2	2 15	128.42 128.11 99.16	1	121.41	122.32
2210326	377085	4906437	130.96	62.18	8	2 15 15 15 15 15 15 18	130.96 130.66 129.74 104.75 97.43 79.14 74.57 70.30 68.78	2	111.15 73.96	111.15
2210330	374300	4907812	136	22.86	2	5 15	136.00 134.48 113.14	2	118.02 115.27	129.9
2210332	373007	4907272	138.97	16.76	3	2 15 15	138.97 138.36 123.73 122.20	2	128.30 123.12	136.22
2210458	377030	4907892	114.87	35.05	5	5 15 15 15 15	114.87 114.56 111.21 93.53 91.09 79.81	2	93.23 81.64	106.03
2210703	376992	4906331	130	60.35	2	2 15	130.00 127.87 69.65	1	70.56	99.52
2210766	377219	4909420	125	15.54	3	2 15 15	125.00 124.39 120.73 109.46	2	115.25 110.98	119.82
2210912	377098	4908551	124	51.82	5	15 15 15 15 15	124.00 82.55 81.94 75.54 74.01 72.18	2	82.24 72.79	109.06
2210913	374428	4906481	128.39	26.82	6	2 15 15 15 15 15	128.39 127.47 116.19 114.37 108.57 106.44 101.56	1	102.78	110.4
2211269	377091	4908536	124.26	28.35	5	11 5 15 15 15	124.26 123.96 123.35 100.49 99.88 95.92	1	99.88	116.95
2211278	377084	4906371	130	47.85	5	5 15 15 15 15	130.00 129.09 105.62 103.48 85.50 82.15	1	83.06	104.09
2211279	373298	4906354	129.12	26.21	2	2 15	129.12 128.51 102.90	1	121.8	121.8

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Table H1 - MOE Water Well Record Query Results

BH ID	Easting	Northing	Ground Surface (masl)	Total Depth (m)	# of Form-ation	Form-ation Mat1 Codes*	Formation Contact Elevations (masl)	# Water Found	Water Found Elevations (masl)	Heads (masl)
2211281	376837	4906286	128.69	40.84	5	5 17 15 15 15	128.69 127.78 127.17 101.26 99.13 87.85	1	92.73	100.04
2211429	372867	4909452	136	34.14	1	15	136.00 101.86	1	103.39	115.27
2211432	377317	4905277	130	54.86	3	23 15 21	130.00 103.18 79.10 75.14	1	76.96	105.62
2211696	377037	4908389	125	28.65	2	11 15	125.00 124.70 96.35	1	97.57	114.33
2211708	377056	4908530	125	82.3	7	5 15 15 15 15 18 15	125.00 123.17 90.86 89.03 68.92 58.55 56.72 42.70	1	58.55	110.37
2211710	377331	4908494	121.33	28.04	5	5 28 15 15 15	121.33 118.28 117.67 100.91 95.73 93.29	1	95.73	99.38
2211932	377039	4908574	127.66	35.66	3	2 17 15	127.66 127.36 126.14 92.00	1	92.61	105.72
2211935	375308	4907334	131.49	14.94	3	2 15 15	131.49 130.28 126.62 116.56	1	126.62	128.45
2211938	377277	4908496	120.66	27.43	4	5 15 15 15	120.66 117.01 104.20 102.38 93.23	2	110.00 94.15	103.59
2212127	377235	4908462	121	30.78	3	5 15 15	121.00 120.70 93.87 90.22	1	91.74	103.32
2212270	377186	4908530	122.44	41.15	2	2 15	122.44 121.22 81.29	1	94.4	118.79
2212271	377018	4908588	129.34	52.43	2	24 15	129.34 88.19 76.91	1	78.44	125.68
2212536	374957	4905903	95.84	27.43	6	2 5 18 21 21 21	95.84 95.54 95.23 87.31 71.76 71.15 68.41	2	71.76 70.85	91.27
2212665	377145	4906364	130.93	37.49	6	5 5 15 15 15 15	130.93 130.01 129.71 105.93 103.19 94.66 93.44	2	111.42 94.66	114.16
2212666	377052	4908648	129.69	20.12	4	2 15 15 15	129.69 128.47 127.25 121.77 109.57	2	120.85 112.01	124.81
2212793	377192	4906328	131	37.49	4	5 15 15 15	131.00 130.39 116.67 116.06 93.51	1	96.86	111.49
2212794	377302	4906322	132	28.04	1	15	132.00 103.96	1	107.31	118.59
2213048	376762	4908524	129.32	26.82	1	15	129.32 102.50	1	106.46	121.7
2213126	377704	4905266	130	28.04	1	15	130.00 101.96	1	103.18	114.76
2213250	377113	4906137	130	33.83	2	23 15	130.00 101.65 96.17	1	98	109.58
2213354	377110	4906629	126.48	51.51	4	2 15 15 15	126.48 125.87 120.99 76.80 74.97	2	114.29 75.58	116.11
2213530	374298	4908108	137	46.94	7	2 15 15 15 15 18 18	137.00 136.39 134.56 98.90 94.33 92.80 90.06 90.06	2	119.32 93.11	120.24
2213531	374283	4908139	137	32.92	3	2 15 15	137.00 136.39 135.48 104.08	2	118.41 105.91	123.28

Table H1 - MOE Water Well Record Query Results

BH ID	Easting	Northing	Ground Surface (masl)	Total Depth (m)	# of Form-ation	Form-ation Mat1 Codes*	Formation Contact Elevations (masl)	# Water Found	Water Found Elevations (masl)	Heads (masl)
2213578	377317	4905277	130	67.06	3	2 15 21	130.00 129.09 65.38 62.94	4	112.32 108.66 105.62 64.77	117.5
2213632	373189	4906505	135.14	30.48	1	15	135.14 104.66	1	105.87	130.56
2213674	373440	4906163	127	22.56	5	2 17 15 15 15	127.00 126.39 125.78 114.81 113.89 104.44	1	113.89	113.59
2213760	374600	4909546	139.63	31.39	2	5 15	139.63 138.41 108.24	1	109.15	135.97
2213762	374080	4906365	125.94	35.36	5	2 15 15 15 15	125.94 125.63 121.98 105.82 95.15 90.58	2	94.24 91.80	106.74
2213795	374283	4907217	132	73.76	10	2 15 15 15 15 15 15 21 21 21	132.00 131.09 130.17 121.94 87.20 85.98 81.10 76.22 63.73 60.07 58.24	1	60.37	101.22
2213833	377627	4908517	124.83	39.93	1	15	124.83 84.90	2	94.96 85.20	111.11
2213835	377748	4908641	126.34	36.58	2	15 15	126.34 92.51 89.77	1	92.51	106.23
2213837	377317	4905277	130	19.51	2	5 21	130.00 123.29 110.49	2	121.16 113.54	126.95
2213936	376275	4908364	132	110.95	5	5 15 15 18 21	132.00 130.17 74.09 67.99 64.33 21.05	2	64.94 39.04	106.09
2214187	377126	4906335	130.15	21.34	2	2 15	130.15 128.32 108.81	3	112.77 110.94 109.72	117.95
2214332	375790	4905220	108.99	49.38	3	2 21 21	108.99 107.16 72.11 59.61	2	79.12 62.05	94.97
2214366	374693	4908638	140	5.49	2	5 15	140.00 139.09 134.51	1	136.34	136.34
2214529	376989	4908488	125.56	28.35	2	2 15	125.56 123.73 97.21	1	98.12	106.35
2214651	373413	4908500	130	24.38	5	2 17 15 15 15	130.00 129.70 129.09 112.93 111.10 105.62	2	111.71 106.23	119.94
2214745	377614	4908739	126	35.36	6	2 15 15 15 15 15	126.00 124.48 115.33 114.11 96.74 95.22 90.64	1	95.22	105.58
2214825	377178	4908457	122.76	29.26	3	5 15 15	122.76 120.93 96.55 93.50	1	95.94	105.69
2214826	375690	4907346	128.97	38.1	4	17 15 15 15	128.97 128.36 116.78 116.17 90.87	1	116.78	117.7
2214828	375690	4907346	128.97	38.1	2	17 15	128.97 128.36 90.87	1	110.99	116.17
2215027	377503	4908467	125	36.88	1	15	125.00 88.12	2	104.27 89.64	104.27
2215326	376375	4908776	134.5	6.1	2	2 15	134.50 134.20 128.41	1	129.02	129.93

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Table H1 - MOE Water Well Record Query Results

BH ID	Easting	Northing	Ground Surface (masl)	Total Depth (m)	# of Form-ation	Form-ation Mat1 Codes*	Formation Contact Elevations (masl)	# Water Found	Water Found Elevations (masl)	Heads (masl)
2215472	374384	4907235	135	39.62	7	2 17 15 15 15 15 15	135.00 134.70 134.09 123.11 122.20 107.26 106.96 95.38	1	106.96	129.51
2215473	374426	4907260	135	40.23	5	5 17 15 15 15	135.00 134.39 134.09 125.25 124.03 94.77	2	124.94 107.87	126.16
2215723	374086	4908766	135	27.43	5	5 15 15 15 15	135.00 134.39 119.15 117.93 108.79 107.57	1	108.48	131.65
2215868	376776	4909600	123.75	42.67	1	15	123.75 81.08	3	115.52 107.29 99.97	122.83
2215895	373812	4908158	130	15.85	8	5 17 15 15 15 15 15 15	130.00 129.70 128.78 125.12 124.82 118.42 118.11 114.76 114.15	2	118.42 114.46	129.39
2215898	377047	4906330	130	51.82	6	5 15 15 15 15 15	130.00 127.87 114.76 113.54 91.90 90.38 78.18	2	90.68 81.23	102.57
2216020	376805	4906324	123.15	39.93	6	5 17 15 15 15 15	123.15 122.85 122.24 92.37 87.80 83.53 83.23	2	86.27 85.05	97.25
2216169	377629	4908394	121.25	22.56	6	2 15 15 15 15 15	121.25 120.95 110.89 109.97 101.14 100.83 98.70	2	107.23 100.83	107.84
2216300	377097	4907472	111	23.16	7	5 17 15 15 15 15 15	111.00 109.17 108.56 97.59 96.98 89.66 88.75 87.84	3	103.68 102.16 96.98	103.99
2216472	376858	4908499	128	30.18	6	5 17 15 15 15 15	128.00 127.09 126.78 114.28 101.18 100.87 97.82	1	100.87	103.01
2216478	377725	4908703	127	35.36	1	15	127.00 91.64	2	94.69 92.25	108.71
2216505	377657	4906527	131	44.5	6	5 15 15 15 15 15	131.00 130.70 115.15 112.71 110.27 109.05 86.50	2	124.60 112.71	126.73
2216506	377650	4908548	124.64	35.97	3	5 17 15	124.64 124.03 123.42 88.67	2	97.81 90.50	100.86
2216543	377108	4906413	130.98	74.37	11	5 15 15 15 15 15 18 18 18 18 18	130.98 129.15 126.41 125.19 85.87 85.56 84.95 71.54 67.27 62.09 61.18 56.61	2	106.59 71.85	108.42
2216560	375216	4909560	140	6.1	3	2 5 15	140.00 139.70 138.17 133.90	2	138.17 134.82	135.12
2216616	377507	4908651	125.33	32.92	7	5 17 15 15 15 15 15	125.33 122.29 121.98 117.10 112.84 106.44 99.12 92.41	1	96.68	104

Table H1 - MOE Water Well Record Query Results

BH ID	Easting	Northing	Ground Surface (masl)	Total Depth (m)	# of Form-ation	Form-ation Mat1 Codes*	Formation Contact Elevations (masl)	# Water Found	Water Found Elevations (masl)	Heads (masl)
2216672	373536	4906172	127.11	31.09	6	5 15 15 15 15 15	127.11 126.20 115.23 114.92 114.01 113.40 96.02	1	105.78	108.22
2216695	375623	4906113	105	32.31	3	2 17 15	105.00 104.39 103.48 72.69	2	80.92 75.13	88.24
2216719	374042	4905983	124.42	28.04	6	15 15 15 15 15 15	124.42 123.51 114.97 111.62 98.82 98.51 96.38	1	98.51	108.27
2216821	372843	4905108	88	20.42	8	5 15 15 15 15 15 15 15	88.00 86.17 85.87 77.94 77.03 71.54 69.71 69.10 67.58	2	77.33 69.71	84.34
2216863	377561	4909621	125	37.49	3	2 17 15	125.00 124.39 123.78 87.51	2	105.80 89.64	110.98
2216930	373572	4905130	126	24.69	1	15	126.00 101.31	1	104.05	106.19
2216931	374321	4905160	109.37	26.52	4	5 17 15 15	109.37 108.76 104.80 85.60 82.85	2	90.47 85.60	90.47
2216961	374321	4905160	109.37	18.59	7	5 17 15 15 15 15 15	109.37 108.76 106.93 99.92 98.70 93.21 92.30 90.78	2	99.62 92.61	101.75
2216994	374153	4907302	129.51	42.06	1	15	129.51 87.45	1	99.03	115.8
2217174	377001	4908567	128.62	7.01	1	15	128.62 121.61	1	125.57	125.57
2217187	372828	4906013	130	35.05	2	15 15	130.00 127.56 94.95	2	119.33 109.27	129.39
2217285	376694	4906323	113.15	57.91	9	5 17 15 15 15 15 15 15 21	113.15 112.54 110.10 99.43 94.56 84.50 79.62 60.72 56.15 55.24	1	56.15	82.97
2217362	377563	4908430	124.98	25.91	3	28 17 15	124.98 123.76 122.85 99.08	2	115.84 99.99	117.06
2217381	373033	4906456	134	6.71	2	2 15	134.00 133.70 127.29	1	130.34	131.87
2217986	374930	4907322	135.22	29.87	2	17 15	135.22 134.00 105.35	2	124.24 117.84	125.46
2218258	377329	4909173	125	22.4	6	5 28 17 15 15 15	125.00 124.10 122.90 122.30 107.10 104.90 102.60	2	114.40 106.80	121.35
2218313	375177	4905408	90.6	29.1	6	5 17 15 15 15 15	90.60 90.30 89.70 83.00 76.30 75.10 61.50	2	79.90 75.60	85.4
2218314	377350	4908494	122.08	27.1	7	5 28 17 15 15 15 15	122.08 120.28 119.08 118.18 114.78 112.68 102.28 94.98	1	98.08	104.18
2218317	376999	4905262	130.89	20.1	2	15 15	130.89 113.49 110.79	1	113.49	118.09
2218402	377085	4906458	131	36.6	3	28 17 15	131.00 130.40 129.20 94.40	1	100.2	110.9
2218761	374486	4908854	137.09	6.09	2	5 15	137.09 133.79 131.00	1	132.09	132.65

Table H1 - MOE Water Well Record Query Results

BH ID	Easting	Northing	Ground Surface (masl)	Total Depth (m)	# of Formation	Form-ation Mat1 Codes*	Formation Contact Elevations (masl)	# Water Found	Water Found Elevations (masl)	Heads (masl)
2218798	377191	4906150	130	74.4	8	5 15 15 15 15 15 18 18	130.00 129.70 78.80 72.10 71.80 67.50 66.90 65.70 55.60	2	118.40 71.80	123.9
2218808	377178	4906029	130	74.4	5	5 17 15 18 18	130.00 127.90 127.00 116.30 60.50 55.60	2	122.40 58.00	128.4
2218894	377130	4908304	123.65	27.4	4	5 17 15 15	123.65 123.05 122.45 96.85 96.25	1	96.85	105.05
2218933	374112	4907968	133.93	18.3	3	17 15 15	133.93 132.73 119.33 115.63	1	117.53	131.13
2219208	372987	4908510	139.15	23.2	4	5 15 15 15	139.15 138.85 129.45 128.45 115.95	1	129.15	132.75
7040342	374310	4907523	135	24.1	7	5 17 15 15 15 15 15	135.00 134.50 132.00 124.30 122.80 119.80 116.70 110.90	1	113	128.2
7044780	377062	4908124	121	24.7	3	5 17 15	121.00 120.00 118.90 96.30	1	98.6	105.5
7105739	377339	4909136	125	24.4	3	5 17 15	125.00 124.70 123.80 100.60	2	108.60 103.10	120.6
7105742	377320	4909174	125	35.7	5	5 17 15 15 15	125.00 124.70 122.00 117.40 112.20 89.30	1	101	121.6
7108352	377295	4907527	110.02	24.4	3	5 17 15	110.02 109.12 107.92 85.62	2	98.02 89.02	102.22
7110985	377112	4906547	130	87.17	5	5 15 15 18 21	130.00 128.17 74.53 69.04 64.77 42.83	2	99.82 64.77	100.13
7113026	375839	4906244	108.58	23.47	1	15	108.58 85.11	1	86.03	94.8
7119554	375173	4905792	90.44	28.65	3	5 17 15	90.44 90.13 89.52 61.79	2	72.15 63.01	72.88
7119560	374382	4907625	135.96	21.64	7	15 15 15 15 15 15 15	135.96 133.82 124.37 123.76 119.80 119.19 117.67 114.32	1	117.67	131.32
7119565	375049	4905691	92	29.57	3	5 17 15	92.00 91.69 89.86 62.43	1	89.16	77.15

Note:

*Legend of Mat1 Codes can be seen in Table H2 in Appendix H

All data obtained from Ministry of Environment of Ontario Water Well Information System Database updated November 2012