25 YEARS 1985-2010

MTE

More Than Engineering

FREYMOND PROPOSED QUARRY

Final

Level 2 Hydrogeological Investigation

Project Location:
Lot 51 and 52, Concession WHR
Township of Faraday, County of Hastings

Prepared for:
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c/o Geological Investigations
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TABLE OF CONTENTS

FIGURES

TABLES

HYDROGRAPHS

APPENDICES

EXECUTIVE SUMMARY

MTE is working on behalf of Freymond Lumber Ltd. to prepare a Level 1 and Level 2 hydrogeological investigation for a proposed Category 2, Class 'A' quarry below-water-table. The proposed quarry is located on Lot 51 and 52, Concession WHR in the Township of Faraday, County of Hastings (hereby referred to as the "Site").

The purpose of this report is to assess geological, hydrogeological, and hydrological conditions at the Site and indentify any potential post-extraction adverse effects on water resources, water uses, and the natural environment.

As per the Provincial Standards, this report addresses the requirements for a Category 2 Class "A" license for quarry operations, which intends to extract aggregate material from below the established water table. The scope of work includes a review of published geological and water resources maps, and an examination of water well records on file with the Ontario Ministry of the Environment (MOE).

Reconnaissance, geological mapping, and natural features mapping on the Site and the adjacent lands were part of the field work. Field work also included drilling and construction of bedrock monitoring wells at six locations and on-going measurements of groundwater levels.

Based on the hydrogeological investigation, MTE Consultants Inc. offers the following conclusions and recommendations:

- 14 of the 15 private wells identified through MOE well records, have reported water depth found elevations below the floor of the proposed quarry. As such, proposed quarry operations are not interpreted to have the potential to interfere with the ability of these zones within the bedrock groundwater system to produce water to the private wells.
- The one well identified with a water found elevation above the floor of the proposed quarry lies up-gradient of the general bedrock groundwater flow pattern on the Site and is located on a separate topographic high which has been interpreted to be located in a separate local groundwater regime. Quarrying activities are not predicted to have the potential to cause an adverse effect at this well location.
- From the hydrogeological data collected through the preparation of this hydrogeological investigation, the local on-Site groundwater regime can be described as being predominately a low permeability recharge area.
- Groundwater flow in the shallow and deeper bedrock groundwater systems generally mimic each other and flow towards the northeast towards the York River.

- The predicated cone of influence that will be created by the extraction will extend to approximately 100 metres from the active quarry face. Based on the available mapping, no sensitive features have been identified within the predicated cone of influence.
- As an adaptive management action, in order to assess whether a major water bearing fracture or joint has been intersected, MTE recommends that fracture mapping occur on-Site after quarrying activities have commenced, and before the operation goes below the water table. This is expected to be several years after the start of the operation, when the bedrock has been fully exposed.

1.0 INTRODUCTION

Waterloo Geoscience Consultants Ltd. (WGC) merged with MTE Consultants Inc. (MTE) on June 1, 2009. WGC conducted the preliminary hydrogeological work associated with this project.

MTE is working on behalf of Freymond Lumber Ltd. to prepare a Level 1 and Level 2 hydrogeological investigation for a proposed Category 2, Class 'A' quarry below-water-table. The proposed quarry is located on Lot 51 and 52, Concession WHR in the Township of Faraday, County of Hastings (hereby referred to as the "Site"). The Site location is illustrated in Figure 1.

1.1 Scope and Methodology

The purpose of this report is to assess geological, hydrogeological, and hydrological conditions at the Site and indentify any potential post-extraction adverse effects on water resources, water uses, and the natural environment.

As per the Provincial Standards, this report addresses the requirements for a Category 2 Class "A" license for quarry operations, which intends to extract aggregate material from below the established water table. The scope of work includes a review of published geological and water resources maps, and an examination of water well records on file with the Ontario Ministry of the Environment (MOE).

Reconnaissance, geological mapping, and natural features mapping on the Site and the adjacent lands were part of the field work. Field work also included drilling and construction of bedrock monitoring wells at six locations and on-going measurements of groundwater levels.

2.0 SITE DESCRIPTION

The study area including the Site boundary, geological cross-section location, and the location of private water supply wells are illustrated on Figure 2. For the purposes of this investigation, the study area is defined as the area 500 metres beyond the Site boundary. The quarry has a proposed licensed area of 35 hectares (ha) and a proposed extraction area of 28 ha.

2.1 Surface Water and Drainage

Site topography consists of undulating bedrock knobs in the western portion of the Site. Topography peaks at 392 metres above mean sea level (mAMSL) at the northwestern corner of the Site before dipping to a valley at 380 mAMSL, which roughly bisects the central portion of the Site. Site topography rises steeply to the east from this central valley to approximately 389 mAMSL before topography falls sharply to 335 mAMSL at the eastern Site boundary.

While OBM mapping shows that there are no surface water bodies or courses on Site, Site reconnaissance, by Robin Craig (biologist), has identified a permanent surface water body in the north central portion of the Site and two semi-permanent ponds at or just beyond the south west Site boundary. There is an unnamed stream south and southeast of the Site (~50 m away) that drains the surrounding area and flows to the east where it joins the York River, which is the closest major surface water course to the Site. A stretch of the York River falls within the 500 m study area boundary, to the northeast. The closest mapped major surface water body to the Site is Spurr Lake which lies approximately 850 m south of the Site. OBM mapping shows a wetland complex northwest of the Site within the 500 m study area, associated with a small tributary of the York River.

3.0 GEOLOGY AND HYDROGEOLOGY

3.1 Quaternary Geology

Map sheets in publication (Barnett, 1985) regarding Quaternary geology of the Bancroft Area (Figure 3) describe the Site and surrounding area as containing:

1. Bedrock: exposed or with very thin drift cover.
2. Till: silty to sandy; stony.
3. Glaciofluvial outwash and deltaic deposits; gravelly sand, sand, gravel.
4. Bog and swamp deposits: muck, peat, marl.
5. Modern alluvium: unsubdivided-sand, silt, gravel, clay, muck.

3.2 Precambrian Geology

Map sheets in publication (Lumbers and Vertolli, 1998) regarding the Precambrian geology of the Bancroft Area (Figure 4) describe the Site and surrounding area as containing:

1. Rusty weathering, graphitic, pyrite and pyrrhotite-bearing schist.
2. Amphibole-rich metasedimentary rocks. Medium to high metamorphic grade calcareous mudstone and sandstone with a metamorphic fabric and mainly diopside-amphibole-plagioclase gneiss locally containing phases rich in potassium feldspar, quartz, biotite, scapolite, epidote, carbonate, titanite, pyrite and iron-titanium minerals; intercalated thin units of siliceous marble are common.
3. Calcitic Marble (Medium to High Metamorphic Grade). Medium- to coarse-grained, grey to white, gneissic calcitic marble containing up to 20% siliceous impurities; locally contains intercalated units of siliceous marble; Medium- to coarse-grained, gneissic, siliceous calcitic marble containing 20 to 60% siliceous impurities; commonly contains thin interlaced units of amphibole-rich metasedimentary rocks.

4. Dolomitic Marble; medium-to coarse-grained, white to greenish, dolomitic marble containing up to 20% siliceous impurities; local intercalations of tremolite-rich dolomitic marble. Medium- to coarse-grained, cherty, dolomitic marble containing numerous discontinuous layers of coarsely recrystallized chert, possibly in part derived from silicified stromatolites and algal mats.

A hand specimen collected at the Site (central location) appears to closely match the description of the calcitic marble from Unit 3 above.

While the above referenced mapping provided sufficient information regarding Precambrian rock types at the Site, the map did not provide detailed information on the structural geology (joints, fractures, etc.) at the Site. The Precambrian map (Lumbers and Vertolli, 1998) does show a series of regional fault lines north of the Site. These fault lines generally run east-west, so there may be minor faulting on the Site of similar orientation. As such, no detailed information regarding the localized fracture and joint orientation at the Site was available for this hydrogeological assessment.

3.3 Geological Cross-Section

Hydrogeological data related to private supply wells in the study area were obtained from water well records on file with the Ontario Ministry of the Environment (MOE) (Appendix A) and from boreholes constructed on-Site (Section 4.1) and used to construct geological cross-section A-A' through the Site (Figure 5). From the available MOE well records, a total of 15 private wells have been identified within 500 metres of the Site boundary. Based on MOE well records, the geology along the cross-section has been interpreted as being predominately Precambrian bedrock consisting of metasedimentary rock.

4.0 FIELD PROGRAM

4.1 Borehole Construction and Monitoring Well Installation

On April 27, 2009 and May 4, 2009 through May 6, 2009 a total of six nested boreholes were constructed by Freymond Lumber with MTE staff on-Site to monitor and record all drilling and monitoring well installations. Boreholes were constructed using a track-mounted air percussion drill rig. At each borehole location, two monitoring wells (MW) were installed at a relatively shallow (s) and deep (d) elevation in the bedrock to allow for comparison of groundwater levels and determination of hydrogeological characteristics.

The deep monitoring wells (MWd) were constructed with the intent that the bottom elevation of the monitoring well would roughly correspond to the proposed deeper elevations of the quarry floor at that location. The shallow monitoring wells (MWs) were constructed with the intent that the bottom elevation of the monitoring well would roughly correspond to an elevation that approximated the mid-way point of the proposed quarry excavation. The monitoring wells were not constructed to map flow in discrete fractures sets as this practice is most applicable to sedimentary rocks and the process of metamorphism practically reduces this practice. As such, groundwater levels and hydrogeological characteristics collected from MWs and MWd locations would therefore be reflective of the general hydraulic heads and dewatering needs of the Site and allow for greater characterization of the local groundwater system at these locations.

Borehole logs and monitoring well installation details are provided in Appendix B. Each monitoring well was developed using the Waterra™ system to purge any drill cuttings from the monitoring well. Monitoring well locations are illustrated on Figure 2.

During the construction of MW4s, the driller noted inputs of water at 3.05 metres below ground surface (mBGS), 12.2 mBGS, and 18.3 mBGS, with a "significant" (as reported by the driller) amount of water encountered at 18.3 mbGS (~352mAMSL). At MW4d, the driller noted water inputs at 3.04 mBGS, 9.75 mBGS and 16.8 mBGS, with "significant" inputs being encountered at 16.8 mBGS (~353 mAMSL). The elevations of where "significant" groundwater inputs were observed by the driller appear to be common and despite the heterogeneities due to metamorphism, MTE strived to map these common fractures where possible, while considering the approach discussed above. Significant amounts of groundwater inputs were not detected while drilling the other five boreholes.

4.2 Groundwater Levels

Following monitoring well installation in May 2009, MW1s, MW1d, MW2s, MW2d, MW5s, MW5d, MW6s, and MW6d were initially instrumented with a data logger programmed on a linear setting to collect a groundwater level every eight hours. Manually measured groundwater levels were collected on a regular basis to supplement the data logger data and to aid in the calibration of the data logger data. Manually measured groundwater levels and elevations are presented in Table 1 and Table 2 and illustrated on Hydrograph 1. Groundwater elevations generated from the data logger data are illustrated in Hydrograph 2.

By July 2009, no groundwater levels had been reliably collected from MW1d and MW5d and MTE realized that these wells were "dry" and not likely to produce enough groundwater to represent static conditions and could not be used for groundwater maps or for in-situ testing. As such, during the August 2009 monitoring session, the data loggers from MW1d and MW5d were removed from their respective wells, re-programmed, and installed in MW4s and MW4d. Two additional data loggers were installed in MW3s and MW3d during the December 2009 groundwater monitoring session.

Since installation, the data logger data shows that groundwater levels in MW5s, MW6s, and MW6d are representative of natural seasonal fluctuations. Groundwater levels at MW2s, as recorded by the data logger, show that recovery at this location, based on well performance testing (discussed in Section 4.6) took approximately 1 month before assuming natural fluctuations while groundwater levels at MW2d took approximately five months to recovery from the well performance testing before groundwater levels assumed natural seasonal fluctuations.

Groundwater levels as recorded by the data logger at MW1s, show that recovery at this location, from well performance testing (discussed in Section 4.6), took approximately 11 months before assuming natural seasonal fluctuations.

Groundwater levels at MW4s and MW4d, as recorded by the data logger, show that recovery at this location, from well development following installation, took approximately 11 months before assuming natural seasonal fluctuations.

4.2.1 Water Table Elevation

The Provincial Standards that govern Category 2, Class 'A' quarry below-water-table applications have defined the groundwater table in consolidated bedrock materials as:

The groundwater level, or potentiometric surface, is a level that represents the fluid pressure in the water bearing zone and is generally defined by the level to which water will rise in a well.

However, as defined by the American Geological Institute, this is NOT the water table, since the water table must be in equilibrium with atmospheric pressure. In deep fractured rock, this condition cannot exist and the pressures at depth represent a potentiometric surface.

MTE has been advised by the Ministry of Natural Resources (MNR) on previous quarry applications, that when determining the elevation of the water table in bedrock, MNR considers the elevation of the water level in a well to be the top of the water table. As such, MTE has applied this definition to determine the elevation of the "water table" at the Site. This approach has implications on determining potential groundwater inflows into the quarry (discussed in Section 6).

The groundwater elevation in the shallow bedrock groundwater flow system, as defined by the manually measured water levels obtained from MW1s through MW6s ranges from 355.40 mAMSL (MW2s) to 375.22 mAMSL (MW3s). The groundwater elevation in the deeper bedrock groundwater flow system, as defined by the manually measured water levels obtained from MW1d through MW6d ranges from 331.97mAMSL (MW1d) to 373.88 mAMSL (MW3d). The site plans have proposed a quarry floor elevation of 332 mAMSL.

Establishing the maximum depth below-water-table of the proposed quarry was necessary in order to estimate the amount of groundwater that may enter the quarry during active operations (discussed in Section 6). The highest elevation for the water table observed at on-Site monitoring well was 375.22 mAMSL (MW3s). Therefore with the proposed quarry floor of being 332 mAMSL, the maximum depth of the quarry below the observed groundwater level was calculated to be approximately 43 m.

However, the exact elevation at which groundwater will enter the operating quarry will vary across the Site as bedrock groundwater will actually come from fractures in the bedrock located at discrete elevations across the operating face. As detailed in Section 6, the vast majority of water that will need managing at the Site will come from precipitation, and that a sloped quarry floor (as detailed in the site plans) will direct this water away from the operating face so that there will be no stored water on-Site.

4.3 Vertical Gradients

Vertical gradients were calculated for all on-Site monitoring wells using the manually measured groundwater levels. The calculated vertical gradients are presented in Table 3.

Moderate to strong downward vertical gradients are present at all monitoring locations across the Site indicating that at these locations the groundwater system is acting as a recharge zone. At the time of data collection bedrock groundwater was migrating from the shallow bedrock groundwater system to the deeper bedrock groundwater system.

4.4 Groundwater Flow

Groundwater flow mapping was conducted for the shallow (s) and deep (d) wells at the Site using the October 6, 2010 groundwater elevation data. Groundwater contours and flow patterns for the shallower bedrock and deeper groundwater flow systems are illustrated in Figure 6 and Figure 7. Monitoring well MW5d was not used to create the groundwater map since the well was 'dry' at the time of data collection

On October 6, 2010, groundwater in the shallow bedrock flowed in a radial pattern to the North, Northeast, and East from an interpreted groundwater mound centered on MW3. A horizontal hydraulic gradient of 0.045m/m was calculated for the shallow bedrock groundwater system on this day. The unnamed stream to the south of the Site will not have any direct hydraulic connection with the groundwater on the Site since the stream flows over a bedrock surface, and the groundwater elevations are potentiometric, with water originating within the deep fractures of the bedrock. As both precipitation and groundwater are collected in the operating quarry, the water will be directed by gravity, along the quarry floor, towards the gravel deposit within the Site as described in Section 5.1. The unnamed stream and/or the York River may receive some of this water after it has migrated several hundred metres through the unconsolidated deposits. The rest of the quarry discharge water will be incorporated into the regional groundwater system.

On October 6, 2010, groundwater in the deeper bedrock groundwater system flowed in a predominately northeastern direction across the Site towards the York River. A horizontal hydraulic gradient of 0.12 m/m was calculated for the deeper bedrock groundwater system on this day.

4.5 Private Well Inventory

Who are the people?

On April 20, 2010, a questionnaire (well inventory form) was delivered by hand to each residence with 500 metres of the Site. The door to door survey was conducted along Bay Lake Road, Gaebel Road, Jeffery Lake Road, and Highway 62. Where possible, local residents were interviewed in person and a private well inventory form was completed. In addition to providing details regarding their well, residents were queried about any past water quality or quantity problems. When no resident was available, a well inventory and covering letter was left with the request that the inventory be completed to the best of the resident's knowledge and returned to MTE in a self-addressed stamped envelope.

No

A total of 20 well inventories were delivered with seven being returned to MTE at the time of writing. Completed private well inventories are provided in Appendix C and summarized in Table 4. A total of six drilled wells and one dug well were reported. Of the seven private wells identified through the private well inventory, four have been included in the groundwater monitoring program. In general, the response from the public to the private well inventory was positive and assisted in the hydrogeological assessment process.

4.6 Well Performance Testing

Recovery tests were conducted in the newly installed monitoring wells on May 7, 2009 to define the hydraulic conductivity of the bedrock groundwater system around each well. Each monitoring well was pumped 'dry' using Waterra™ tubing and foot valve. Once each well was 'dry', the tubing and foot valve were removed and the recovery was recorded using dedicated pressure transducers (data loggers). The data loggers recorded the recovery rates in the wells every minute until May 8, 2009. Following the recording and the initial recovery, the data loggers were programmed as described in Section 4.2. Recovery curves for MW1s, MW2s, MW2d, and MW6s are presented in Hydrograph 3 through Hydrograph 6.

Recovery data from MW1s, MW2s, MW2d, MW4s, MW4d, and MW6s was used to analyze bedrock hydraulic properties. The hydraulic conductivity of the bedrock surrounding each well was calculated using AquiferTest© software. Recovery curves using the Hvorslev and Bouwer-Rice analyses have been presented in Appendix D. Calculated hydraulic conductivities have been summarized in Table 5. A geometric mean of 4.5×10^{-10} m/sec was calculated from the hydraulic conductivities derived from the Hvorslev analysis of the shallower bedrock wells, while a geometric mean of 4.8×10^{-10} m/sec was calculated from the Bouwer-Rice analysis .

A geometric mean of 1.1×10^{-10} m/sec was calculated from the hydraulic conductivities derived from the Hvorslev analysis of the deeper bedrock wells, while a geometric mean of 1.1×10^{-10} m/sec was calculated from the Bouwer-Rice. The comparable hydraulic conductivities indicate that there is no significant difference in the hydraulic conductivity results of the methods employed.

5.0 PROPOSED QUARRY OPERATIONS

5.1 Proposed Water Diversion, Storage, and Drainage Facilities

Since the proposed quarry is for a below-water-table extraction, groundwater and precipitation accumulating in the quarry are to be diverted during the operation to maintain dry operating conditions. A collection sump will be constructed along the eastern boundaries of the Site to collect groundwater, runoff, and precipitation running off the extraction area. Each phase of the quarry will be excavated to a depth and graded such that groundwater and precipitation are directed to the collection sump. There will be no water storage on the Site other than what is collected in the sump.

Drainage and diversions of groundwater and precipitation in the active area of the Site will be via a gravity driven process. There will be no pumping to dewater the Site.

5.2 Discharge to Surface Water

Precipitation and groundwater collected in the collection sump (Section 5.1) will be discharged via a weir to the east of the Site, and allowed to infiltrate into the natural sand/gravel deposit to supplement the shallow groundwater. By collecting water in the sump prior to discharge, fine-grained materials suspended in the water will be allowed to settle out and chemicals (e.g. trace amounts of residual ammonia from blasting) that may be introduced to runoff water during blasting will have time to dissipate. There will be no direct discharge of precipitation or groundwater collected at the Site to surface water features as also described in Section 4.4.

Regular water samples will be collected from the overflow weir to ensure that discharge water meets the Provincial Water Quality Objectives (PWQO). A detailed monitoring program for weir discharge has been presented in Section 9.0.

6.0 WATER BALANCE

A water balance equation shows the natural processes that contribute water to the Site. An understanding of these processes provides:

1. An estimate of the amount of water that may drain under gravity from the quarry.
2. An understanding of how to maintain the overall water balance in order to minimize potential effects on the natural environment.

The intent of the water balance discussion is to evaluate pre- and post-aggregate extraction water inputs to the Site with the goal of assessing what affects the proposed quarry will have on the water balance and surrounding natural features.

During this discussion, several parameters remain constant and are discussed below. These include:

- Evaporation and evapotranspiration rates;
- The annual amount of precipitation (in millimetres);
- Hydraulic conductivity under the Site as determined in Section 4.6 (1.1×10^{-10} m/sec);
- Horizontal hydraulic gradient determined from Figure 7 (0.12 m/m); and
- Depth of the saturated rock face (assumed to be 43.2 metres to correspond with the maximum depth of the quarry below the piezometric surface, as discussed in Section 4.2)

Evaporative Losses and Evapotranspiration

The mean evaporative rate from lakes in the Bancroft area is 700 mm/year (MNR, 1984). MNR derived mean evaporative losses from lakes (excluding the Great Lakes) from isolines printed in the Hydrologic Atlas of Canada. The following excerpt from page 23 of the MNR publication details how mean lake evaporation and evapotranspiration were determined.

The isolines of mean annual lake evaporation were developed using pan evaporation data, as well as evaporative calculated from climatological data including air temperature, wind velocity, relative humidity, and amount of possible bright sunshine. The stations that currently measure pan evaporation are shown on the map [this map can be found on page 22 of the MNR publication].

The isolines for mean annual evapotranspiration were calculated by subtracting mean annual runoff from mean annual precipitation. Over a period of many years, average evapotranspiration is the difference between precipitation and runoff.

Mean annual evapotranspiration at the Site, as determined by MNR, is on the order of 500 mm/year.

Precipitation

The closest Environment Canada weather station to the Site with climate averages from 1971-2000 is located at the Peterborough Airport. The annual average precipitation used in this water balance discussion is 840.3 mm/year or 0.8403 m/year.

Prior to extraction, the Site covers an undisturbed area of 35 hectares (ha). A total of 294,105 m^3 of precipitation falls on the Site in an average year. Using the evapotranspiration rates presented above, a total 175,000 m^3 of water is lost through evapotranspiration.

The pre-extraction runoff volumes were calculated using the Rational Method. The Rational Method uses the following formulae to estimate runoff:

$Q(r) = A \times c \times P$

Where:
$Q(r)$ = peak runoff
A = drainage area – Site Area = 350,000 m^2
C = runoff coefficient = 0.2 (discussed below)
P = precipitation = 840.3 mm/year or 0.8403 m/year

The runoff coefficient (c) was determined using tabulated values by McCuen (1998). These values are based on variables including:

1. Hydrologic soil group.
2. Slope range.
3. Land use.

The overburden across the majority of the Site has been observed through drilling to be relatively thin and discontinuous with numerous bedrock exposures. The lack of significant overburden soils indicates a high runoff potential which corresponds to soil group D. The Site is steeply sloped and is covered primarily with forest. Therefore, a runoff coefficient of 0.2 was chosen for the rational method. The resulting peak runoff in the pre-extraction scenario has been calculated to be 58,821 m^3/year.

Bedrock groundwater crossed the part of the Site that is below the saturated zone. This component of flow was the volumetric discharge (Q) in m^3/year across the up gradient face. The thickness of the face is equal to the depth of extraction below the water table on the up gradient cut face. To calculate the volumetric discharge, the groundwater flux in the bedrock was required.

The groundwater flux (Darcy velocity) was calculated as follows:

$q=K \times i$

Where:
K = geometric mean of the hydraulic conductivity values for tested monitoring wells = 1.1×10^{-10} m/s;
i = is the horizontal hydraulic gradient (0.12m/m) estimated from the equipotential contours described by the on-Site deep observation wells (Figure 7).

Therefore: $q = 1.4x10^{-11}m/s$
$= 4.5x10^{-4}m/year$

The volumetric discharge was calculated from groundwater flux as:

$Q=q \times A = 10m^3/year$

Where: A = Lx b
And: b = thickness of the rock face = 43.2m
L = length of up gradient quarry face perpendicular to groundwater flow = 526 m
$A = 526 \text{ m} \times 43.2 \text{ m} = 22,723 \text{ m}^2$

Groundwater inputs (10m^3/year) to the Site are insignificant when compared to precipitation inputs.

Infiltration on the Site can be calculated using the formulae below and the water inputs and outputs described above. The following shows the calculation for the infiltration that occurs on the Site before extraction.

$I = P + Q_{gwin} – Q_r – ET- E - Q_{gwout}$

Where: P = precipitation
Q_{gwin} = groundwater underflow input
I = infiltration
Q_r = runoff
E = Evaporation
ET = Evapotranspiration
Q_{gwout} = groundwater underflow output

I = 294,105 m^3/year + 10 m^3/year – 58,821m^3/year -175, 000 m^3/year – 0 m^3/year – 10 m^3/year
I = 60,284 m^3/year

Under the pre-extraction water balance, of 294,105 m^3/year of precipitation that falls on the Site and 10 m^3/year contributed by groundwater underflow, 59.5% is lost to evapotranspiration (175,000 m^3/year) and 20% is runoff (58,821 m^3/year). Groundwater underflow accounts for less than 1% of total inputs. The remaining 20.5% of the inputs (60,284 m^3/year or 115 litres/minute) are available for infiltration to the groundwater system. Differences between percentages and actual numbers are due to rounding. The pre-extraction water balance details are summarized in Table 6.

Post-Aggregate Extraction Water Balance

At the conclusion of extraction, a total of 7 ha will remain undisturbed by quarrying operations. Precipitation (294,105 m^3/year) and groundwater inputs (10 m^3/year) to the Site will remain the same as calculated in pre-extraction water balance.

Under the post-aggregate extraction scenario, the area covered by the extracted quarry was assumed to be devoid of vegetation, so no evapotranspiration would occur. Evapotranspiration from the undisturbed area of the licensed property following quarrying was calculated to be 4 m^3/year.

The post-aggregate extraction runoff volumes were calculated using the Rational Method. The runoff coefficient was determined using the tabulated values by McCuen (1998). These values are based on variables including:

1. Hydrological soil group.
2. Slope range.
3. Land use.

In order to account for the two different land uses that will exist on the Site following extraction, a weighted runoff coefficient (c) was calculated. The disturbed area (quarried area) was assumed to have no overburden and therefore will have a high runoff potential which corresponds to soil group D. The disturbed portion of the Site will be graded to allow gravity to drain the quarry and is assumed to be relatively impervious which resulted in a runoff coefficient of 0.85 being chosen for this portion of the Site. The undisturbed area of the Site was assumed to have pre-aggregate extraction conditions which resulted in a runoff coefficient of 0.2 being chosen for this portion of the Site. The weighted runoff coefficient was calculated using the following:

$$
\begin{aligned}
c &= [(c_q \text{ x } A_q) + (c_{ud} \text{ x } A_{cu})]/A_t \\
&= [(0.85\text{x } 28) + (0.2 \text{ x } 7)]/35 \\
&= 0.72
\end{aligned}
$$

Where:
c_q = runoff coefficient of quarried area = 0.85
A_q = area of quarried area = 28 ha
c_{ud} = runoff coefficient of undisturbed area = 0.2
A_{ud} = undisturbed area = 7 ha
A_t = Total area of the Site = 35 ha

In addition to the runoff generated from precipitation events, groundwater entering the quarry from the up gradient operating face will contribute runoff exiting the quarried area. This component of flow is volumetric discharge (Q) in m^3/year across the up gradient face. The thickness of the face is equal to the depth of extraction below the water table on the up gradient cut face. To calculate the volumetric discharge, the groundwater flux in the bedrock is required.

The groundwater flux (Darcy velocity) was calculated as follows:

$q = K \times i$

Where: K = geometric mean of the hydraulic conductivity values calculated for tested monitoring wells = 1.1×10^{-10} m/sec
i = is the horizontal hydraulic gradient (0.12 m/m)

Therefore: $q = 1.4 \times 10^{-11}$ m/sec
$= 4.5 \times 10^{-4}$ m/year

The volumetric discharge of groundwater that becomes runoff was calculated from groundwater flux as:

$Q = q \times A = 8\ m^3$/year

Where: $A = L \times b$
And: b = thickness of the rock face = 43.2 m
L = length of the up gradient face perpendicular to groundwater flow = 430 m
$A = 430 \times 42.5 = 18{,}576\ m^2$

Therefore, the amount of runoff emanating from the Site under the post-aggregate extraction scenario was calculated as follows:

$Q_{(r)} = c \times [(A \times P) + Q_{gw}]$

Where: $Q_{(r)}$ = peak runoff = 211,762 m^3/yr
A = drainage area = Site area = 35 ha
c = runoff coefficient = 0.72
P = precipitation = 840.3 mm/year or 0.8403 m/year
Q_{gw} = groundwater becoming runoff = 8 m^3/year

Bedrock groundwater will continue to cross the part of the Site that is below the saturated zone and not part of the quarried area (as discussed above). This component of flow is the volumetric discharge (Q) in m^3/year across the up gradient face. The thickness of the rock face is equal to the depth of extraction below the water table on the up gradient cut face. To calculate the volumetric discharge, the groundwater flux in the bedrock is required.

Where: K = geometric mean of the hydraulic conductivity values calculated for tested monitoring wells = 1.1×10^{-10} m/sec
i = is the horizontal hydraulic gradient (0.125 m/m)

Therefore: $q = 1.43 \times 10^{-11}$ m/sec
$= 4.49 \times 10^{-4}$ m/year

The volumetric discharge was calculated from groundwater flux as:

$Q = q \times A = 2\ m^3/year$

Where: $A = L \times b$
And: b = thickness of the rock face = 43.2 m
L = length of the up gradient face perpendicular to groundwater flow = 96 m
$A = 96\ m \times 43.2\ m = 4{,}147 m^2$

Groundwater inputs across the undisturbed portion of the Site were calculated to be 2 m^3/year.

Infiltration (I) on the Site can be calculated using the formulae below and the water inputs and outputs described above. The following shows the calculation for the infiltration that occurs on the Site before and after extraction.

$I = P + Q_{gwin} – Q_r – ET- E - Q_{gwout}$

Where: P = precipitation
Q_{gwin} = groundwater underflow input
I = infiltration
Q_r = runoff
E = Evaporation
ET = Evapotranspiration
Q_{gwout} = groundwater underflow output

$I = 294{,}105\ m^3/year + 10\ m^3/year – 211{,}762 m^3/year - 4\ m^3/year – 0\ m^3/year – 2 m^3/year$
$I = 82{,}348\ m^3/year$

Under the post-aggregate extraction scenario water balance, 294,105 m^3/year of precipitation falls on the Site and 10 m^3/year of groundwater enters the up-gradient portion(s) of the Site. Of these inputs, less than 1% is lost to evaporation and evapotranspiration (4 m^3/year), 72% is lost to runoff (211,762m^3/year) and less than 1% (2 m^3/year) to groundwater underflow exiting the Site. The remaining 28% of the inputs (82,348 m^3/year) are available for infiltration to the groundwater system. Differences between percentages and actual numbers are due to rounding. The post-aggregate extraction water balance details are summarized in Table 7.

7.0 IMPACT ASSESSMENT

The following section identifies potential impacts that the proposed quarry operations have on surrounding private water uses, natural features, and on quarry operations. An assessment of each potential effect has been provided. Section 8 is dedicated to trigger mechanisms and mitigative measures for each potential adverse effect identified below.

7.1 Local Groundwater Use

A review of MOE well records has identified 15 private wells within 500 metres of the Site boundary (Figure 2). Of these wells, 14 have been reported to obtain water from the Precambrian bedrock while one has been reported to obtain water from glaciofluvial outwash deposits. Fourteen of the 15 wells identified in the MOE well records have been reported as having 'water found' elevations below the proposed quarry elevations of 332 mAMSL.

The elevation of 'water found' has provided an indication where the driller noted significant inputs of groundwater and were interpreted to be the primary source of groundwater for that particular well. With the proposed quarry floor located above the 'water found' elevation, the proposed quarry is interpreted to not have the potential to interfere with the ability of these zones in the bedrock groundwater systems to produce groundwater to the well.

One well (MOE Well 29-12953) has a 'water found' elevation above the proposed quarry floor. However, this well, based on MOE provided UTM co-ordinates, has been located up-gradient of the general groundwater flow direction on the Site. Additionally, Well 29-12953 has been located on a topographic high that is separated from the proposed extraction area by a valley and the unnamed stream south of the Site (Figure 2).

The elevation of the unnamed stream (~370 mAMSL) based on OBM mapping suggests that this stream may be connected to the deeper bedrock groundwater system, but it must be acknowledged that the Site groundwater contours represent a potentiometric surface, with the actual water source from deeper bedrock fractures. Therefore, the unnamed stream is not interpreted to be receiving any water from the shallow or deep groundwater regime within the bedrock. However, the stream could contribute to the groundwater in those areas where surface water could infiltrate into exposed bedrock fractures. This process has no relevance to the proposed quarry activities.

The location of Well 29-12953 in concert with the potential boundary condition presented by the unnamed stream south of the Site suggest that Well 29-12953 is located in a separate localized bedrock groundwater system. Therefore, there is no potential for quarrying activities to cause an adverse effect to this well.

7.2 Groundwater Seeps, Springs, and Wetlands

As discussed in Section 2.2, OBM mapping has identified an unnamed stream that drains lands south of the Site. The bedrock through which groundwater flows has been interpreted to have a low bulk permeability and has a groundwater radial flow pattern. Given the potentiometric conditions at depth described in the previous section, bedrock groundwater at the Site does not directly contribute water to this stream. Therefore, bedrock groundwater quantity reaching this unnamed stream from Site will not be measurably impacted. With respect to potential water quality, no impacts to the unnamed stream are anticipated as there will be no direct discharge to it.

Regardless, the proposed quarry operations will have significant portions of precipitation and groundwater captured in the active quarry to collect. The redirection of precipitation and captured groundwater, after any required treatment, will be infiltrated in the Site's sand and gravel deposits to the North and this water will sustain flows in down-gradient wetlands and streams given that runoff is expected to increase by approximately 52% (Section 6).

During field reconnaissance by MTE staff, no groundwater seeps or springs were observed on-Site.

7.3 Significant Drainage from a Vertical Fracture

The presence of a major vertical fracture in excavations could provide a pathway for a large quantity of water to flow into the quarry. Any significant fracture flow could alter the size and shape of the cone of influence in the direction that the fracture extends from the quarry. In order to further understand bedrock fracture patterns, fracture and joint mapping could be undertaken on-Site once quarrying operations commence to assess the potential of intersecting a major water bearing fracture during quarrying.

The network of observation wells will observe this change in the groundwater flow pattern as it develops over time. Such an event could also allow unacceptable amounts of water to flow into the excavation. High rates of seepage into the quarry would be readily observed (if it ever occurs) and actions to mitigate this condition will be implemented early in the process.

Fracture mapping is anticipated to be necessary before the quarry goes below the water table. This is anticipated to be several years into the quarry operation, when there is a sufficient exposure to the rock to allow for effective mapping.

7.4 Spills

As with any aggregate extraction operation, there exists the possibility of an accidental release of petroleum hydrocarbons from equipment operating on the Site. The release of petroleum hydrocarbons at the Site has the potential to enter groundwater and/or surface water courses and impact water quality.

7.5 Blasting

The proposed operation has the potential to introduce residual ammonia into the groundwater and surface water courses via runoff following blasting. Furthermore, there is the potential that blasting could also increase total suspended solids (TSS) in surface water bodies and courses. To avoid this, water collected in the quarry will be treated before leaving the Site.

7.6 Water Balance

Following quarrying, on-Site infiltration is predicted to increase from 20.5% of inputs to 28% inputs, while losses to evapotranspiration and evaporation (E+ET) are predicted to decrease from 59.5% to <1%. Runoff leaving the Site is predicted to increase from 20% to 72% over the life of the operation. Please note that the quarry phasing will be designed to collect runoff in a way that allows this water to passively drain from the active quarry, and the water will be discharged on-site into a natural sand/gavel deposit for infiltration.

The increase in runoff can be attributed to quarrying operations removing vegetation and topsoil that would normally reduce runoff and allow for infiltration/evaporation and exposing relatively impervious bedrock that would allow precipitation and any groundwater migrating on to the Site to run across the exposed bedrock surface.

Groundwater contributions in both pre- and post-aggregate extraction water balance scenarios account for less than 1% of total inputs and have been considered to be relatively insignificant to the overall water balance at the Site.

7.7 Zone of Influence

As the proposed quarry expands, the excavation will create a zone of influence on the bedrock groundwater system. To estimate the extent of the zone of influence that the proposed quarry may exert on the bedrock groundwater system, the Theis method (1935) was used. The proposed quarry was treated as an over-sized well.

The Theis method (1935) was given as:

$$s = \frac{Q\,W_{(u)}}{4\pi T}$$

where:

s = drawdown (m) at distance r from the Site
Q = pumping rate (m^3/day) = 0.027m^3/day (10m^3/year) – (Section 6)
T = Transmissivity (m^2/day) = 0.00043 m^2/day
W(u) = well function of u and is defined as:

$$u = \frac{r^2S}{4Tt}$$

where:

r = distance (m) from the centre of the pumped well (in this case the quarry)
S = Storage coefficient (unitless)
T = Transmissivity (m^2/day) = 0.00043 m^2/day
t = time since pumping started (d)

A number of assumptions have been made in order to calibrate the model. A description of these assumptions has been provided below:

Pumping Rate (Q)

Since the proposed quarry will be drained via gravity, the pumping rate (Q) used in the Theis (1935) would equal the rate at which groundwater flows into the quarry under gravity. In order to provide the most conservative estimate of Q, the pumping rate was assumed to equal the pre-extraction volumetric discharge as determined in Section 6. A pre-extraction Q of 10m^3/year or 0.027m^3/day was determined in Section 6.

Transmissivity (T)

A transmissivity (T) of 0.00043 m^2/day was determined based on the theoretical saturated thickness of the bedrock (43.2m) as defined in Section 4.2.1 and the calculated hydraulic conductivity for the deep bedrock groundwater system (Section 4.6).

Time (t)

Time periods of 1 day, 5 days, 10 days, 40 days, and 115 days where selected for the analysis. Since there will be no active pumping and groundwater will enter the quarry via gravity only, groundwater cannot be drawn down below the final floor elevation of the proposed quarry. As such, there will be a time – in this case 115 days - were the bedrock along the immediate up-gradient face will be drained of groundwater and the maximum drawdown will equal the saturated thickness of the bedrock (as defined in Section 4.2.1). At this time and assuming no recharge, the bedrock groundwater system will enter into a steady state and the zone of influence will stabilize around the proposed quarry.

Radial Distance (r)

Various distances were selected from the quarry face to define the predicated drawdown from the proposed quarry. To provide a very conservative estimate of the zone of influence, the area between the operating face and one metre into the un-quarried bedrock was assumed to be completely drained of groundwater. Using the Theis (1935) method and bedrock hydraulic parameters discussed in this section, the measurable zone of influence (0.1m) around the proposed quarry at the conclusion of the extraction is expected to extend no further than approximately 100 metres from the edge of the quarry face.

Storage Coefficient (S)

Conducting a long term pumping test on-Site to determine the storage coefficient of the bedrock groundwater system was not possible due to the low hydraulic conductivity of the bedrock. As such, a storage coefficient of 0.00005 was selected and was determined to be representative of a confined, bedrock groundwater system with little storage (Driscoll, 1986; Fetter, 2001; Freeze and Cherry, 1979).

The results for predicted drawdown around the proposed quarry using the Theis (1935) method have been summarized in Table 8. Detailed calculations have been provided in Appendix E

8.0 MITIGATIVE MEASURES

A limited number of potential detrimental adverse effects to the natural environment have been identified in Section 7. The following describes details for mitigative measures to those potential adverse effects.

8.1 Local Groundwater Use

All existing water wells are protected under the Ontario Water Resources Act, with the intent that groundwater is a resource to be shared by everyone. If a well experiences interference (i.e. an unacceptable reduction in groundwater quantity and/or a degradation in water quality), then the person (or organization) responsible for the interference is responsible for returning the groundwater supply to its former condition.

The following describes a contingency plan that will be executed should groundwater interference be observed during activities at the Freymond Quarry. In the event of a reported interference with a private water supply well, water levels within the well would be measured immediately to assess the degree of interference and the well interference compliant would be investigated by a qualified person. If necessary, the affected residence would be supplied with water by the quarry operator until a suitable resolution can be established.

If the observed well interference is a result of quarry operations and is proven to have an impact on the well then a replacement water supply well will be constructed immediately at the expense of the quarry owner. Drilling a replacement well (deeper and/or in a different set of bedrock fractures) is the most effective way to achieve this objective. Based on the proposed operation and the nature of private wells, there is a very low risk of any private well interference.

8.2 Groundwater, Seeps, Springs, and Wetlands.

Precipitation and groundwater collected in the quarry will be re-directed to a collection sump where fines, and other potential contaminants introduced during blasting and quarrying, will be allowed to settle or removed. The collected water will then be discharged into the sand/gravel deposit at the eastern side of the Site. Provided that the water quality exiting the sump is maintained, no impacts to any receiving water bodies are anticipated. Depending on the location of the settling pond, groundwater migration will be on the order of 150 metres before discharging into the unnamed stream. Groundwater migration to the York River is over 400 metres. Additionally, any increases to groundwater temperature caused by the incorporation of the water collected in the sump to groundwater are expected to be mitigated by the time that groundwater reaches the receiving water bodies.

8.3 Significant Drainage from a Vertical Fracture

The trigger mechanism for mitigative measures will be the direct observation of significant quantity of flow through a fracture or bedding plane into the quarry excavation. The recommended trigger criterion is a flow rate in excess of 200 litres per minute over a 24 hour duration. If there is no evidence of a measurable decrease in flow rate, then a licensed drilling contractor will be contacted in order to grout the vertical fractures at the edge of the quarry. This type of grouting is common practice for many geotechnical projects on fractured rock (e.g. dams).

8.4 Spills

Contingency measures regarding hydrocarbon spills over 20 litres are presented on the operational Site Plans and include the following preventative and release incident measures:

In case of an accidental spill of petroleum products, the contingency plan, as presented on the operational plans for the Site, shall be activated as follows:

1. The Ministry of the Environment shall be notified.
2. For a petroleum leakage, the owner of the quarry shall immediate action will be taken to stop it. At the same time, measures shall be taken to prevent the spread of the leak (i.e. construction of a berm, digging of a ditch). If it is a spill, similar measures as mentioned for preventing the spread of a leak shall be taken.

3. The owner of the quarry will commence recovery procedures by pumping the spilled liquid into containers. The spilled liquid may have to be recovered from the open water body or land or both. For the spill contained in the open water body, recovery may require pumping or skimming or both.
4. The soil in the area affected by the spill or leak will be removed.
5. The contaminated soil, the recovered spill and water will be disposed by the owner of the quarry to locations prescribed by the Ministry of the Environment.
6. The following equipment will be available at the Site:
    - A skimming device
    - A diesel operated pump
    - Portable containers

8.5 Blasting

Groundwater and surface water sampling for ammonia and total suspended solids (TSS) will be conducted seasonally for a two year period following the commencement of operations to monitor potential increases in ammonia and TSS that may occur as a result of blasting. Should elevated concentrations of either parameter be observed, controlling and treatment of water discharged from the Site will be required to reduce ammonia concentrations and allow for the settling of TSS.

8.6 Water Balance

A comprehensive groundwater monitoring plan has been proposed in Section 9.0 that will, in part, monitor local groundwater users that may potentially be affected by the changes in the water balance. Should the changes in the water balance affect existing users, then the contingency measures presented in Section 8.1 will take effect.

8.7 Zone of Influence

The maximum extent of the zone of influence presented in Section 7.7 is representative of conditions at the conclusion of extraction. Based on the maximum extent of the predicted zone of influence of approximately 72 metres and the best available mapping, there are no sensitive features within the predicted zone of influence. Beyond the predicted zone of influence, the natural groundwater flow pattern is expected to be maintained, while impacts to natural features (i.e. streams and/or wetlands) are expected to be minimal to non-existent.

Throughout the course of the life of the active quarry, there will be ample opportunity to monitor the actual zone of influence that the quarry may have to the surrounding groundwater regime through the existing groundwater monitoring network.

9.0 MONITORING PROGRAM

Groundwater Monitoring:

1. Well shall be monitored monthly during the operating season for two years after operations commence. After the first two years, wells shall be monitored seasonally (Spring, Summer, and Fall). Wells to be monitored shall include all on-Site observation wells via data loggers and the five off-Site private wells currently in the monitoring program. Private wells shall be monitored for a minimum of two years, so long as the private well remains readily and safely accessible, and that the owner of any private well currently in the monitoring program continues to grant permission to monitor their well.
2. After two years of operations, the groundwater monitoring program shall be reviewed on an annual basis and revised if necessary.

Effluent Monitoring

1. Effluent from the weir draining the collection sump shall be sampled monthly under non-freezing conditions, provided that there are sufficient volumes of water to be sampled, for a period of two years after operations commence. Samples are to be analyzed for the following parameters:
    a. Total suspended solids (TSS);
    b. Total Ammonia;
    c. Nitrate;
    d. Nitrite;
    e. Total Petroleum Hydrocarbons (F1 through F4)
2. During sampling, the pH and temperature of the water sample will be collected and recorded in-situ. The concentration of un-ionized ammonia shall be calculated using the total ammonia concentration, pH, and temperature using the methodology stipulated in "Ontario's Provincial Water Quality objectives" dated July 1994, as amended, for ammonia (un-ionized).
3. The quarry operator shall measure, record, and calculate the volume of flow discharging over the weir on each day of sampling.
4. After two years of operations, the effluent monitoring program shall be reviewed on an annual basis and revised if necessary.

10.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the hydrogeological investigation, MTE Consultants Inc. offers the following conclusions and recommendations:

- 14 of the 15 private wells identified through MOE well records, have "water found" elevations below the floor of the proposed quarry. As such, proposed quarry operations do not have the potential to interfere with the ability of these zones, within the bedrock groundwater system, to produce water to the private wells.

- The one well identified with a "water found" elevation above the floor of the proposed quarry lies up-gradient of the general bedrock groundwater flow pattern under the Site, and is located on a topographic high, which has be interpreted to be a separate local groundwater regime. Quarrying activities do not have the potential to cause an adverse effect at this well.
- From the hydrogeological data collected through the preparation of this hydrogeological investigation, the local on-Site groundwater regime can be described as being predominately a low permeable recharge area.
- Groundwater flow in the shallow and deep bedrock groundwater systems generally mimic each other and flow towards the northeast towards the York River.
- The predicated zone of influence that will be created by the extraction will extend to approximately 72 metres from the active quarry face. Based on the best available mapping, no sensitive features have been identified within the predicated zone of influence.
- As an adaptive management action, in order to assess whether a major water bearing fracture or joint has been intersected, MTE recommends that fracture mapping occur on-Site after quarrying activities have commenced, and before the operation goes below the water table. This is expected to be several years after the start of the operation, when the bedrock has been fully exposed.

11.0 LIMITATIONS

Services performed by **MTE Consultants Inc.** (MTE) were conducted in a manner consistent with the level of care and skill ordinarily exercised by members of the Environmental Engineering & Consulting profession. No other warranty or representation expressed or implied as to the accuracy of the information, conclusions or recommendations is included or intended in this report.

This report was completed for the sole use of MTE and the client. It was completed in accordance with the Scope of Work referred to in Section 1.1. As such, this report may not deal with all issues potentially applicable to the Site and may omit issues, which are or may be of interest to the reader. MTE makes no representation that the present report has dealt with any and all of the important features, including any or all important environmental features, except as provided in the Scope of Work. All findings and conclusions presented in this report are based on Site conditions as they existed during the time period of the investigation. This report is not intended to be exhaustive in scope or to imply a risk-free facility.

Any use which a third party makes of this report, or any reliance on, or decisions to be made based upon it, are the responsibility of such third parties. MTE accepts no responsibility for liabilities incurred by or damages, if any, suffered by any third party as a result of decisions made or actions taken, based upon this report. Others with interest in the Site should undertake their own investigations and studies to determine how or if the condition affects them or their plans.

It should be recognized that the passage of time may affect the views, conclusions and recommendations (if any) provided in this report because environmental conditions of a property can change. Should additional or new information become available, MTE recommends that it be brought to our attention in order that we may re-assess the contents of this report.

Respectfully Submitted,

MTE CONSULTANTS INC.

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PRACTISING MEMBER
0335

MDE:plw

12.0 REFERENCES

Barnett, P. J., 1985: *Quaternary Geology of the Bancroft Area;* Ontario Geological Survey, Map 2500, Quaternary Geology Series, scale 1:50 000, Geology 1978, 1979.

Driscoll, F.G., 1986: *Groundwater and Wells, 2nd ed.,* Johnson Division, St. Paul, Minnesota, 55112

Fetter, C.W., 2001: *Applied Hydrogeology 4th ed.,* Prentice Hall, Upper Saddle River, New Jersey, 07458

Freeze, R.A., and Cherry, J.A., 1979: *Groundwater*, Prentice Hall Inc., Englewood Cliffs, N.J., 07632

Lumbers, S.B., and Vertolli, V. M., 1998: *Geology of the Bancroft Area;* Ontario Geological Survey, Preliminary Map P.3385, scale 1:50 000

McCuen, R.H., 1998. Hydrologic Analysis and Design, 2nd ed., Prentice Hall, Upper Saddle River, New Jersey, 07458

Ontario Ministry of Natural Resources, 1984. Water Quantity Resources of Ontario.

FIGURES

Project: 33886-100 CAD: P:\P\33886\EV\33886-100-EV1.DWG

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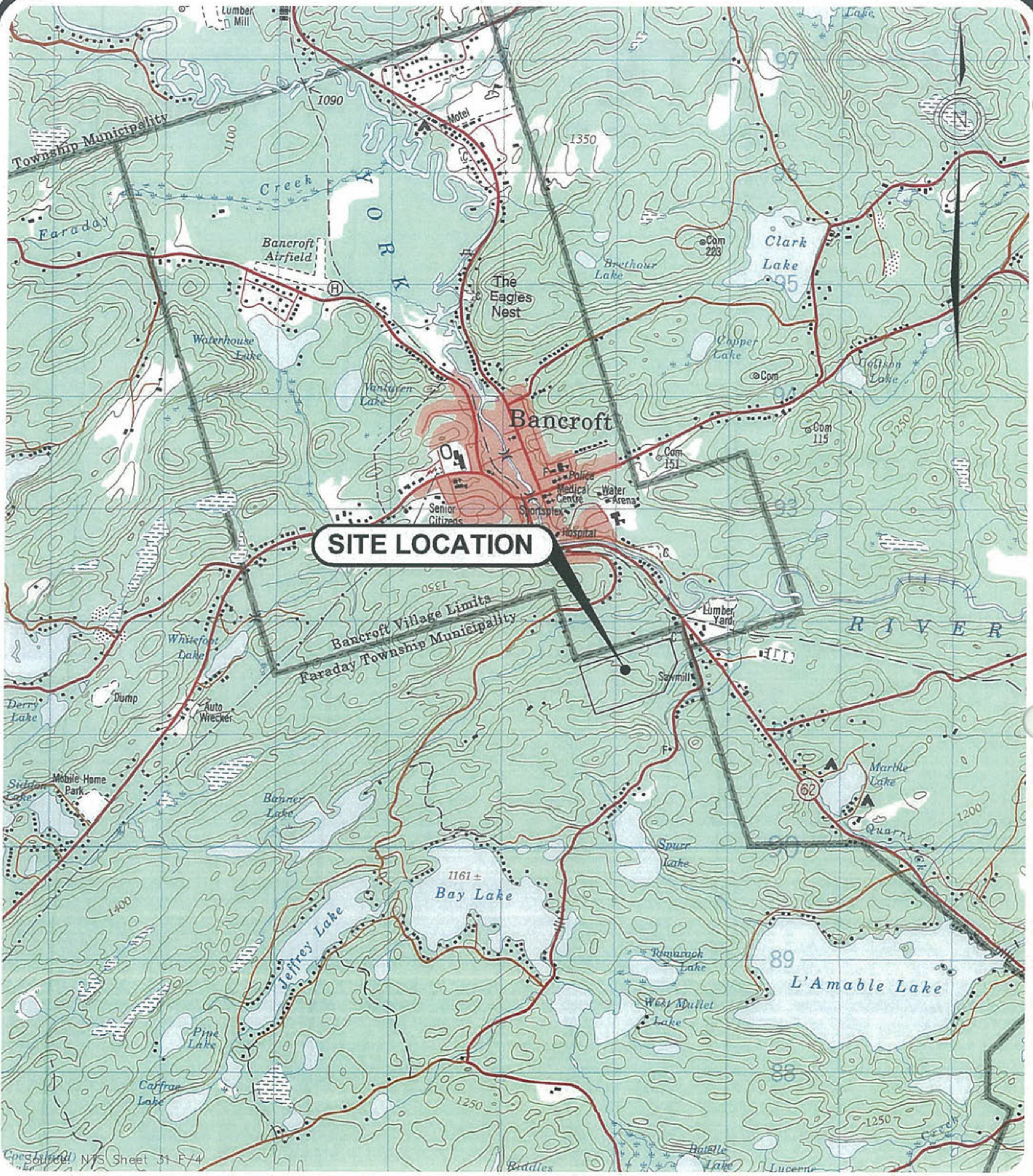

Source: NTS Sheet 31 F/4

Figure 1 KEY MAP

MTE
ENVIRONMENTAL DIVISION

Project Name
Fowler Freymond Proposed Quarry

Site	Client
Bancroft, Ontario	Freymond Lumber Limited

Scale.	MTE Project No.	Date	Layout No.
1:50,000	33886-100	May 2013	EV1.1

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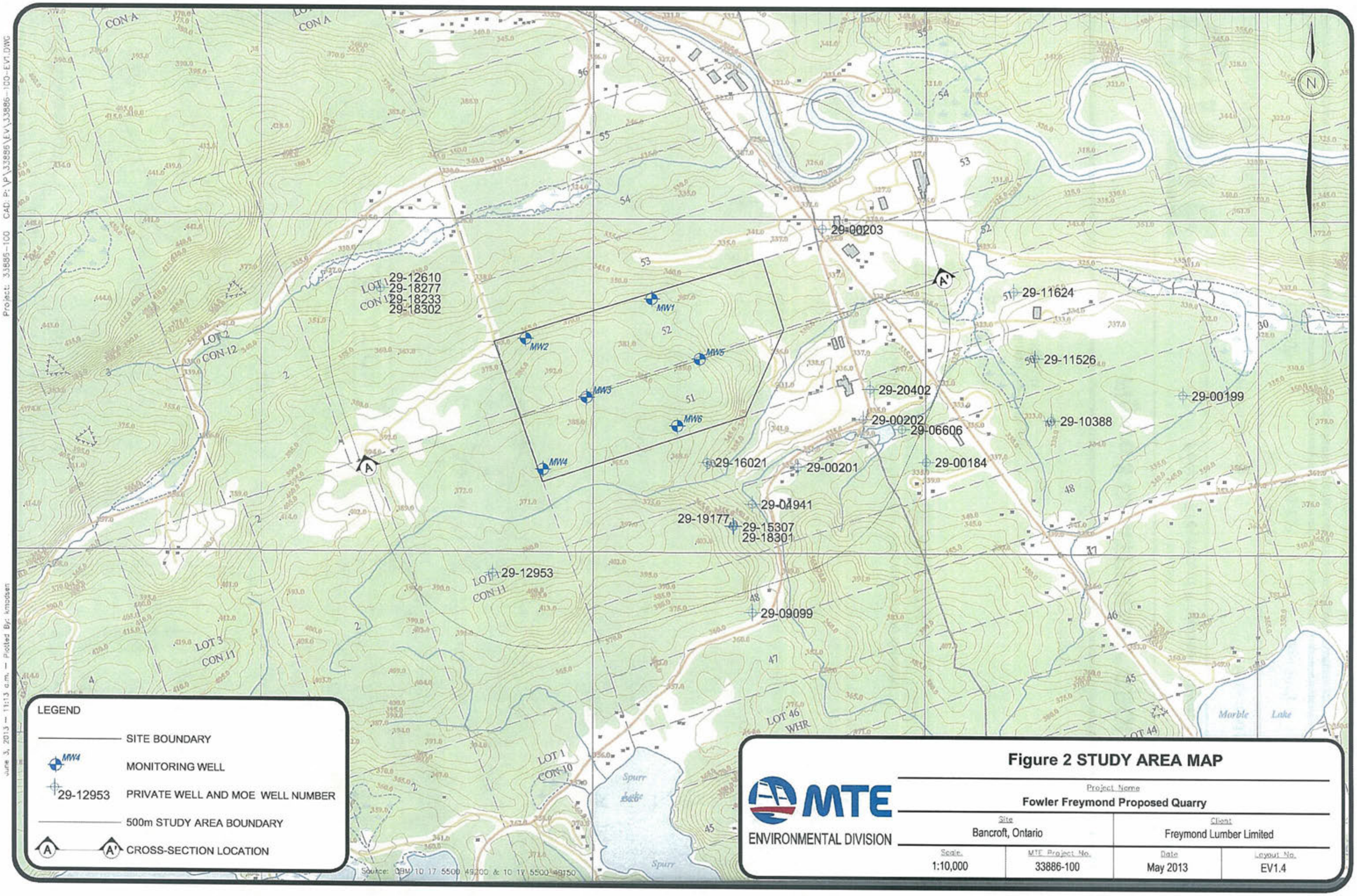
Project: 33886-100 CAD: P:\P\33886\EV\33886-100-EV1.DWG



LEGEND

SITE BOUNDARY

MW4 MONITORING WELL

29-12953 PRIVATE WELL AND MOE WELL NUMBER

500m STUDY AREA BOUNDARY

A A' CROSS-SECTION LOCATION

Source: OBM 10 17 5500 49200 & 10 17 5500 49150

MTE

ENVIRONMENTAL DIVISION

Figure 2 STUDY AREA MAP

Project Name Fowler Freymond Proposed Quarry	
Site Bancroft, Ontario	Client Freymond Lumber Limited

Scale	MTE Project No.	Date	Layout No.
1:10,000	33886-100	May 2013	EV1.4

Project: 33886-100 CAD: P:\P\33886\EV\33886-100-EV1.DWG

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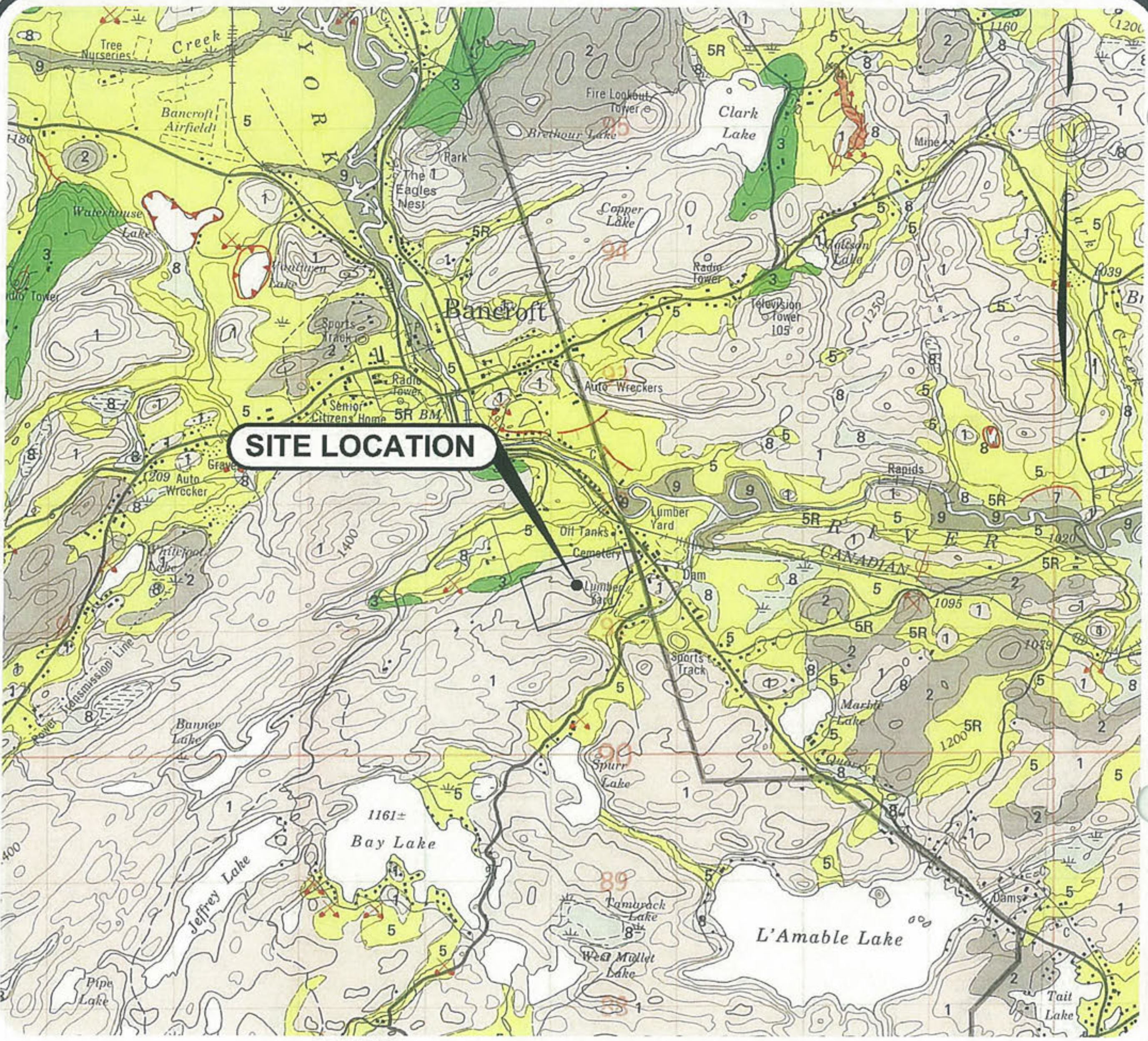

LEGEND

1	Pre-Cambrian Bedrock
2	Drift - Bedrock Complex
3	Till: Silty to sandy; Stony
4	Glaciofluvial ice contact Deposits
5	Glaciofluvial outwash and deltaic deposits
8	Bog and swamp deposits
9	Modern Alluvium

For symbol definitions refer to OGS Map 2500 or 1: 50 000 National Topographic System. For subgroup descriptions, refer to OGS Map 2500

Figure 3 QUATERNARY GEOLOGY

MTE
ENVIRONMENTAL DIVISION

Project Name
Fowler Freymond Proposed Quarry

Site	Client
Bancroft, Ontario	Freymond Lumber Limited

Scale.	MTE Project No.	Date	Layout No.
1:50,000	33886-100	May 2013	EV1.2

Project: 33886-100 CAD: P:\P\33886\EV\33886-100-EV1.DWG

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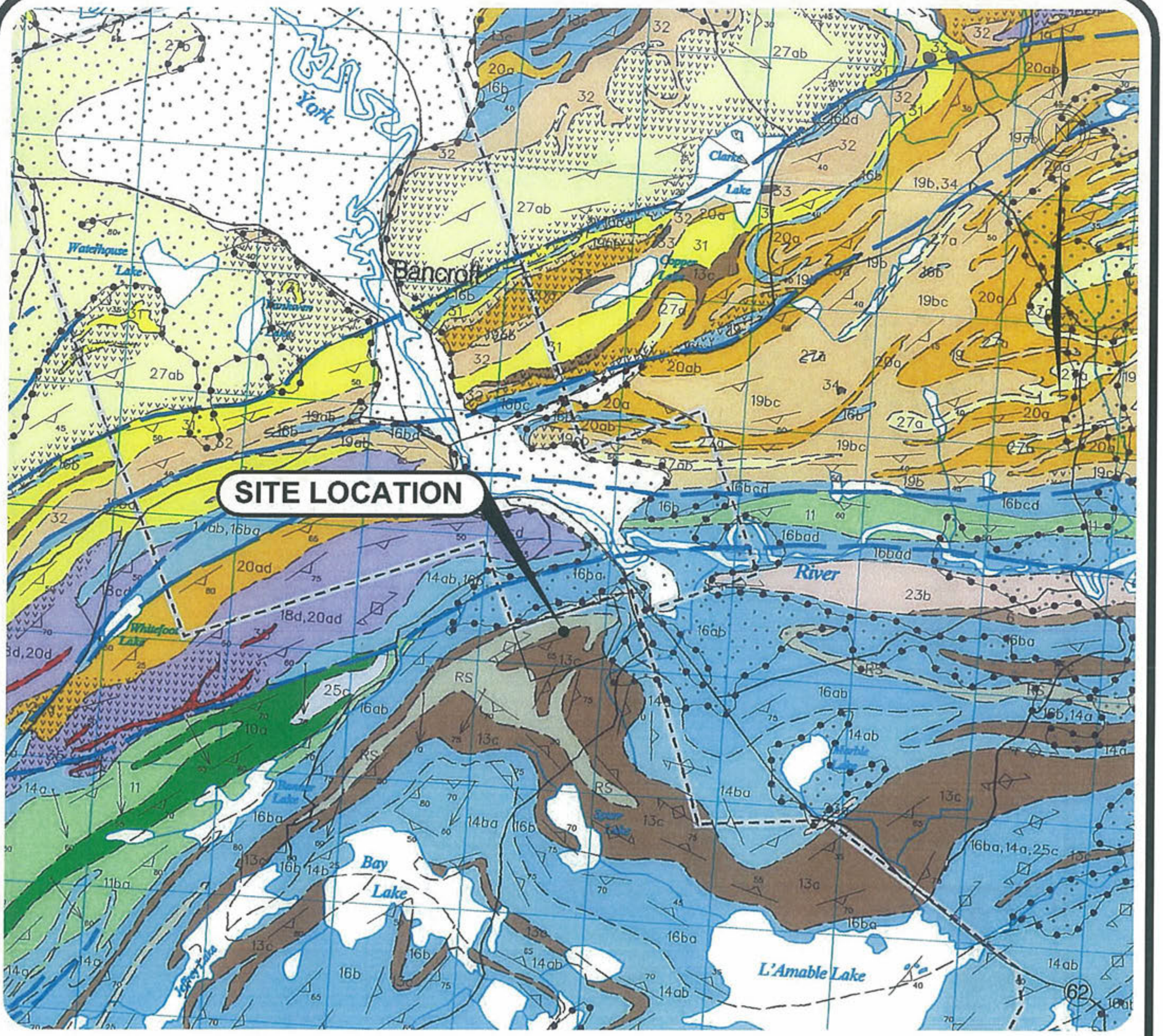

LEGEND

10	Mafic Metavolcanic Rocks
11	Felsic Metavolcanic Rocks
13	Amphibole rich Metasedimentary Rocks
14	Dolomitic Marble
16	Calcitic Marble Medium to High Metamorphic Grade
18	Mafic Alkalic Rocks
19	Nepheline Syenite
20	Alkalic Syenite
23	Trondhjemite and Granodiorite
27	Felsic Intrusive Rocks
31	Fenite
32	Fenite
35	Late Pegmatite
RS	Rusty-weathering, graphitic pyrite and pyrrhotite -bearing schist

For symbol definitions refer to OGS Map 3385 or 1: 50 000 National Topographic System. For subgroup descriptions, refer to OGS Map P. 3385

Figure 4 PRECAMBRIAN GEOLOGY

MTE
ENVIRONMENTAL DIVISION

Project Name
Fowler Freymond Proposed Quarry

Site	Client
Bancroft, Ontario	Freymond Lumber Limited

Scale.	MTE Project No.	Date	Layout No.
1:50,000	33886-100	May 2013	EV1.3

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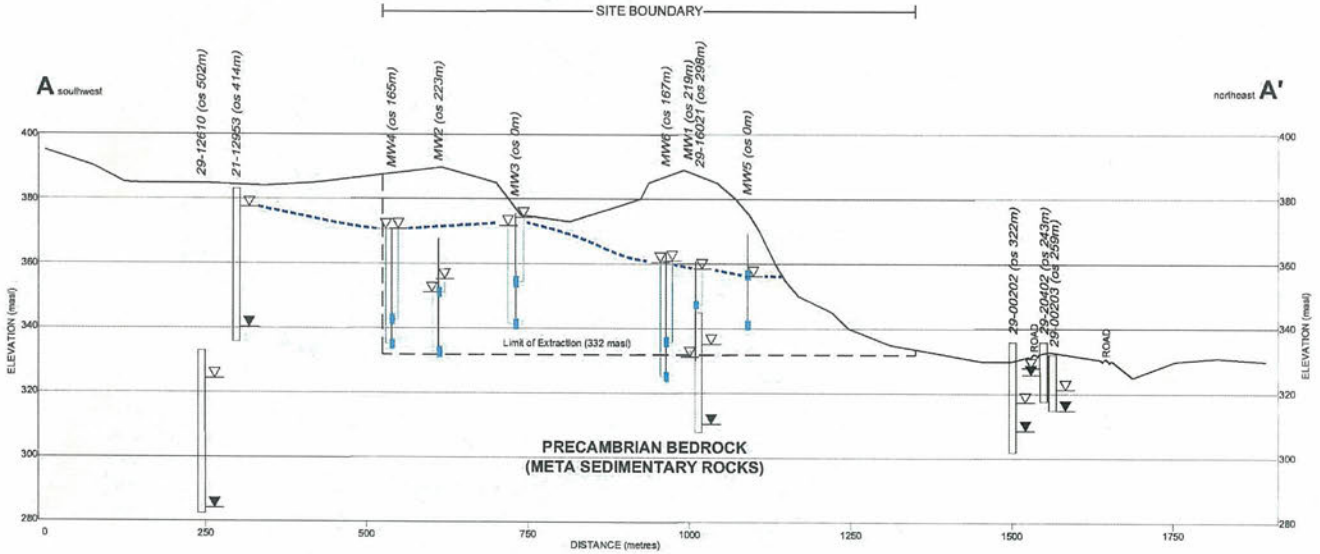

LEGEND

- Ground Surface
- Geological Contact Observed
- Geological Contact Inferred
- Potentiometric Surface
- Drilled Borehole/Well
- ▽ Static Water Level
- ▼ Depth of Water Found

00000 (os 10m)

Offset Distance in metres From Cross-Section

Private Well, Drilled (MOE Well Number)

MTE
ENVIRONMENTAL DIVISION

Figure 5 GEOLOGICAL CROSS-SECTION A-A'

Project Name Freymond Quarry			
Site Township of Faraday, County of Hastings		Client Freymond Lumber Limited	
Scale 1:7500	MTE Project No. 33886-100	Date May 2013	Layout No. EV1.7

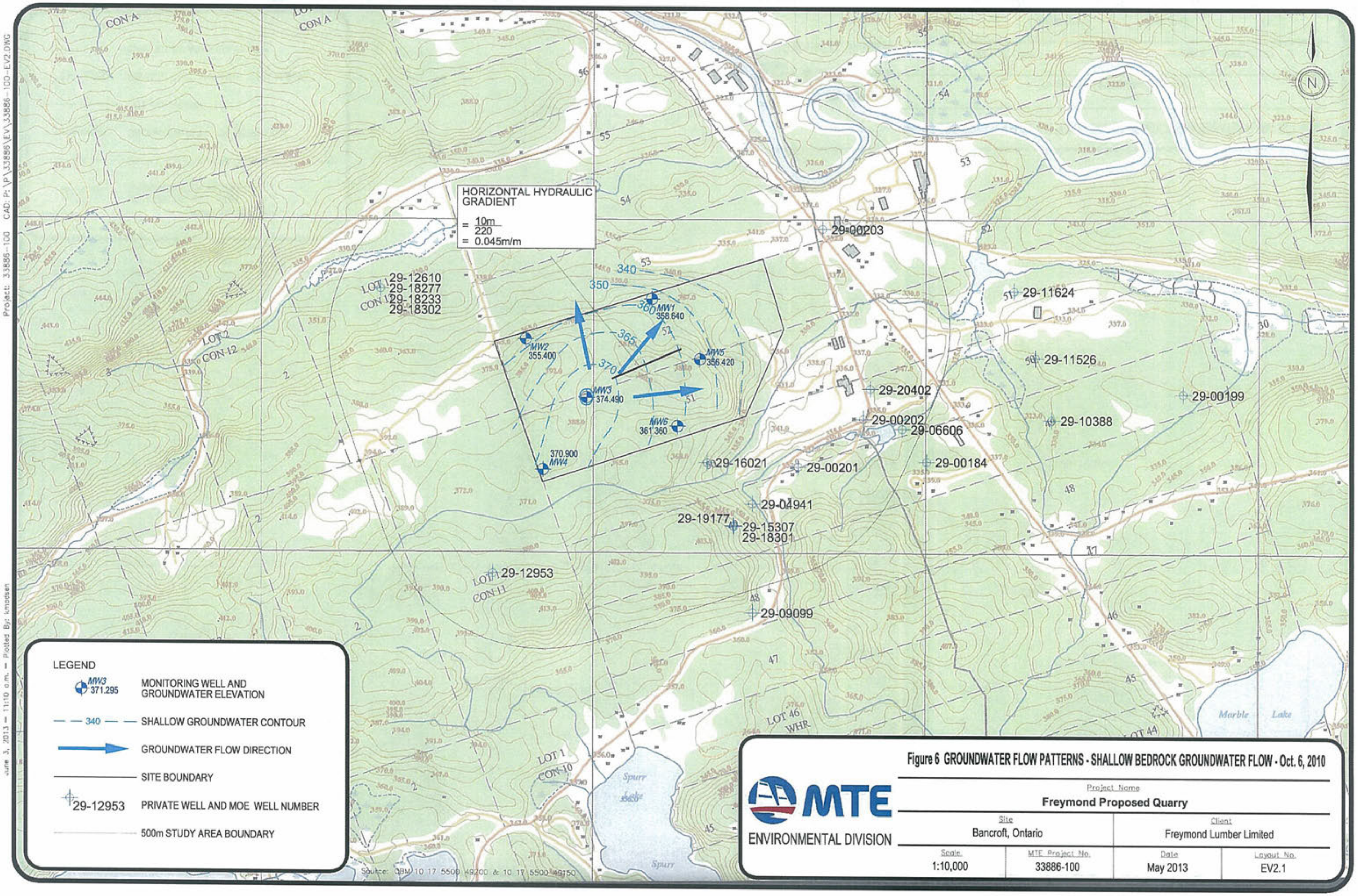

Figure 6 GROUNDWATER FLOW PATTERNS - SHALLOW BEDROCK GROUNDWATER FLOW - Oct. 6, 2010

MTE
ENVIRONMENTAL DIVISION

Project Name			
Freymond Proposed Quarry			
Site		Client	
Bancroft, Ontario		Freymond Lumber Limited	
Scale	MTE Project No.	Date	Layout No.
1:10,000	33886-100	May 2013	EV2.1

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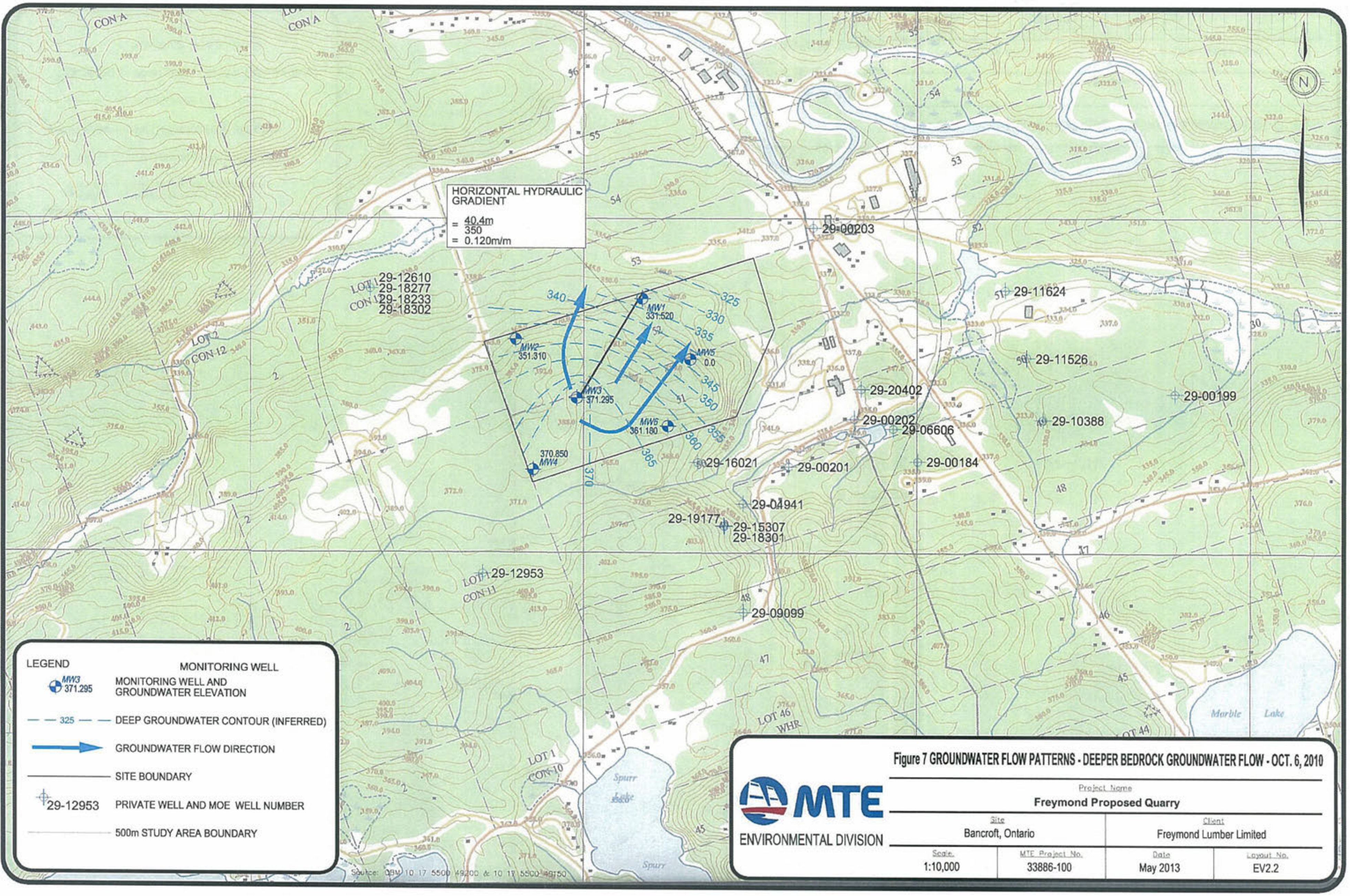


LEGEND

MONITORING WELL

MW3 371.295 MONITORING WELL AND GROUNDWATER ELEVATION

— — 325 — — DEEP GROUNDWATER CONTOUR (INFERRED)

GROUNDWATER FLOW DIRECTION

SITE BOUNDARY

29-12953 PRIVATE WELL AND MOE WELL NUMBER

500m STUDY AREA BOUNDARY

Source: OBM 10 17 5500 49200 & 10 17 5500 49150

MTE

ENVIRONMENTAL DIVISION

Figure 7 GROUNDWATER FLOW PATTERNS - DEEPER BEDROCK GROUNDWATER FLOW - OCT. 6, 2010

Project Name
Freymond Proposed Quarry

Site
Bancroft, Ontario

Client
Freymond Lumber Limited

Scale	MTE Project No.	Date	Layout No.
1:10,000	33886-100	May 2013	EV2.2

TABLES

TABLE 1: GROUNDWATER LEVELS (MBTOC) – MANUALLY MEASURED – 2009 – 2012

DATE	SHALLOW BEDROCK WELLS						DEEPER BEDROCK WELLS					
	MW1S	MW2S	MW3S	MW4S	MW5S	MW6S	MW1D	MW2D	MW3D	MW4D	MW5D	MW6D
21-May-09	12.83	14.70	2.00	26.35	12.93	3.35	31.24	29.83	3.29	35.18	*	3.60
1-Jul-09	9.88	13.06	2.80	18.61	13.05	3.66	31.20	21.66	3.40	25.93	*	3.84
24-Aug-09	6.27	13.32	3.74	10.41	13.18	3.75	*	17.70	4.10	15.57	*	3.78
22-Sep-09	5.09	13.53	3.87	7.41	*	3.94	*	17.25	4.45	12.69	*	3.86
30-Nov-09	3.11	12.85	2.13	2.84	13.30	3.40	30.83	17.04	3.63	5.96	30.22	3.42
19-Apr-10	1.81	11.00	1.32	0.12	13.38	3.33	30.53	16.63	2.77	1.65	30.21	3.31
21-Jun-10	1.73	11.40	1.70	0.86	13.40	3.53	30.38	16.51	3.40	1.08	30.24	3.40
6-Oct-10	1.75	12.68	2.05	0.14	13.48	3.15	30.18	17.28	4.28	0.39	*	3.20
29-Apr-11	1.40	9.70	**	0.66	13.47	2.72	29.73	16.26	2.35	**	*	2.99
15-Aug-11	1.68	11.11	2.95	0.21	13.50	3.55	*	16.22	4.11	0.05	*	3.80
30-Sep-11	2.16	11.65	3.65	0.04	13.56	3.81	29.36	16.77	4.84	0.10	*	4.00
4-May-12	1.50	9.35	1.37	0.20	13.55	2.52	28.90	17.19	2.82	0.12	*	3.41
20-Jul-12	1.72	10.34	3.23	0.05	13.55	3.07	*	17.10	4.00	0.10	*	3.90
29-Oct-12	1.41	11.01	3.90	0.01	13.61	3.13	28.52	17.61	5.13	0.22	*	3.72

*mbTOC = metres below top of casing; * = well was dry at the time of measurement; ** = well was flowing at the time of measurement*

TABLE 2: GROUNDWATER ELEVATIONS (MAMSL) – MANUALLY MEASURED – 2009 – 2012

DATE	SHALLOW BEDROCK WELLS						DEEPER BEDROCK WELLS					
	MW1S	MW2S	MW3S	MW4S	MW5S	MW6S	MW1D	MW2D	MW3D	MW4D	MW5D	MW6D
21-May-09	347.56	353.38	374.53	344.09	356.97	361.34	330.46	338.76	372.94	336.06	*	360.78
1-Jul-09	350.51	355.02	373.73	351.83	356.85	361.03	330.50	346.93	372.83	345.31	*	360.54
24-Aug-09	354.12	354.76	372.79	360.03	356.72	360.94	*	350.89	372.13	355.67	*	360.60
22-Sep-09	355.30	354.55	372.66	363.03	*	360.75	*	351.34	371.78	358.55	*	360.52
30-Nov-09	357.28	355.23	374.40	367.60	356.60	361.29	330.87	351.55	372.60	365.28	339.88	360.96
19-Apr-10	358.58	357.08	375.21	370.32	356.52	361.36	331.17	351.96	373.46	369.59	339.89	361.07
21-Jun-10	358.66	356.68	374.83	370.39	356.50	361.16	331.32	352.08	372.83	370.16	339.86	360.98
6-Oct-10	358.64	355.40	374.49	370.92	356.42	361.54	331.52	351.31	371.95	370.85	*	361.18
29-Apr-11	358.99	358.38	**	370.40	356.43	361.97	331.92	352.34	373.88	**	*	361.39
15-Aug-11	358.71	356.97	373.58	370.85	356.40	361.14	*	325.37	372.12	371.19	*	360.58
30-Sep-11	358.23	356.43	372.88	371.02	356.34	360.88	332.34	351.82	371.39	371.14	*	360.38
4-May-12	358.89	358.73	375.16	370.86	356.34	362.17	332.80	351.41	373.41	371.13	*	360.98
20-Jul-12	358.67	357.74	373.30	371.01	356.35	361.62	*	351.49	372.23	371.14	*	360.48
29-Oct-12	358.98	357.07	372.63	371.05	356.29	361.56	333.18	350.98	371.10	371.02	*	360.66

*mAMSL = metres mean sea level; * = well was dry at the time of measurement; ** = well was flowing at the time of measurement*

TABLE 3: VERTICAL GRADIENTS

Date	MW1	MW2	MW3	MW4	MW5	MW6
21-May-09	-1.11	*	-0.12	†	*	-0.03
1-Jul-09	-1.30	*	-0.07	†	*	-0.03
24-Aug-09	*	-0.21	-0.05	†	*	-0.02
22-Sep-09	*	-0.17	-0.07	†	*	-0.01
30-Nov-09	-1.72	-0.20	-0.14	†	-1.08	-0.02
19-Apr-10	-1.78	-0.28	-0.14	-0.09	-1.07	-0.02
6-Oct-10	-1.76	-0.22	-0.20	-0.01	*	-0.02
29-Apr-11	-1.76	-0.33	-	-	*	-0.03
15-Aug-11		-0.25	-0.11	0.04		-0.03
30-Sep-11	-1.68	-0.25	-0.12	0.02		-0.03
4-May-12	-1.70	-0.39	-0.14	0.03		-0.06
20-Jul-12		-0.34	-0.08	0.02		-0.06
29-Oct-12	-1.68	-0.33	-0.12	0.00		-0.05

*Negative values equal downward vertical gradient; Positive values equal upward vertical gradient; * = deep monitoring well was dry; † = wells still recovering at time of measurement.*

Table 4: Private Well Inventory Summary

ID	Type	Diameter (m)	Depth (m)	Water Source	In Use
PW1	Drilled	0.15*	91.44*	Bedrock*	Yes
PW2	Drilled	0.20*	67.05*	Bedrock*	Yes
PW3	Drilled	0.15*	55.47*	Bedrock*	Yes
PW4	Dug	0.90*	4.57*	Overburden*	Yes
PW5	Drilled	0.15*	Unknown	Unknown	Yes
PW6	Drilled	0.20*	Unknown	Overburden*	Yes
PW7	Drilled	0.15*	44.2*	Bedrock	Yes

** = reported by homeowner*

Table 5a: Bedrock Hydraulic Properties Summary – Shallow Bedrock Wells

Location	Test Type	Test Date	Maximum Drawdown (m)	Slug Test Analysis	Hydraulic Conductivity (m/s)
MW1s	Slug	May 7, 2009	14.15	Hvorslev	7.19x10^{-11}
MW2s	Slug	May 7, 2009	17.24	Hvorslev	2.56x10^{-10}
MW4s	Slug	May 7, 2009	24.47	Hvorslev	1.83x10^{-10}
MW6s	Slug	May 7, 2009	21.53	Hvorslev	1.21x10^{-8}
Geometric Mean					4.49x10^{-10}
MW1s	Slug	May 7, 2009	14.15	Bouwer & Rice	7.11x10^{-11}
MW2s	Slug	May 7, 2009	17.24	Bouwer & Rice	2.13x10^{-10}
MW4s	Slug	May 7, 2009	24.47	Bouwer & Rice	1.94x10^{-10}
MW6s	Slug	May 7, 2009	21.53	Bouwer & Rice	1.76x10^{-8}
Geometric Mean					4.77x10^{-10}

Table 5b: Bedrock Hydraulic Properties Summary – Deeper Bedrock Wells

Location	Test Type	Test Date	Maximum Drawdown (m)	Slug Test Analysis	Hydraulic Conductivity (m/s)
MW2d	Slug	May 7, 2009	30.20	Hvorslev	6.48x10^{-11}
MW4d	Slug	May 7, 2009	36.88	Hvorslev	2.02x10^{-10}
Geometric Mean					1.14x10^{-10}
MW2d	Slug	May 7, 2009	30.20	Bouwer & Rice	5.29x10^{-11}
MW4d	Slug	May 7, 2009	36.88	Bouwer & Rice	2.24x10^{-10}
Geometric Mean					1.09x10^{-10}

TABLE 6: PRE-AGGREGATE EXTRACTION WATER BALANCE SUMMARY

Inputs		
Precipitation (P)	294,105	m^3/yr
Groundwater (Q_{gwin})	10	m^3/yr
Outputs		
Runoff (Qr)	58,821	m^3/yr
Groundwater (Q_{gwout})	10	m^3/yr
Evaporation (E)	0	m^3/yr
Evapotranspiration (ET)	175,000	m^3/yr
Pre-extraction		
$I = P + Q_{gwin} - Q_r - ET - E - Q_{gwout}$	**60,284**	m^3/yr
Pre-extraction		
Infiltration (I)%		20.50
E + ET %		59.50
Groundwater		0.00
Runoff (Qr)%		20.00
		100

TABLE 7: POST-AGGREGATE EXTRACTION WATER BALANCE SUMMARY

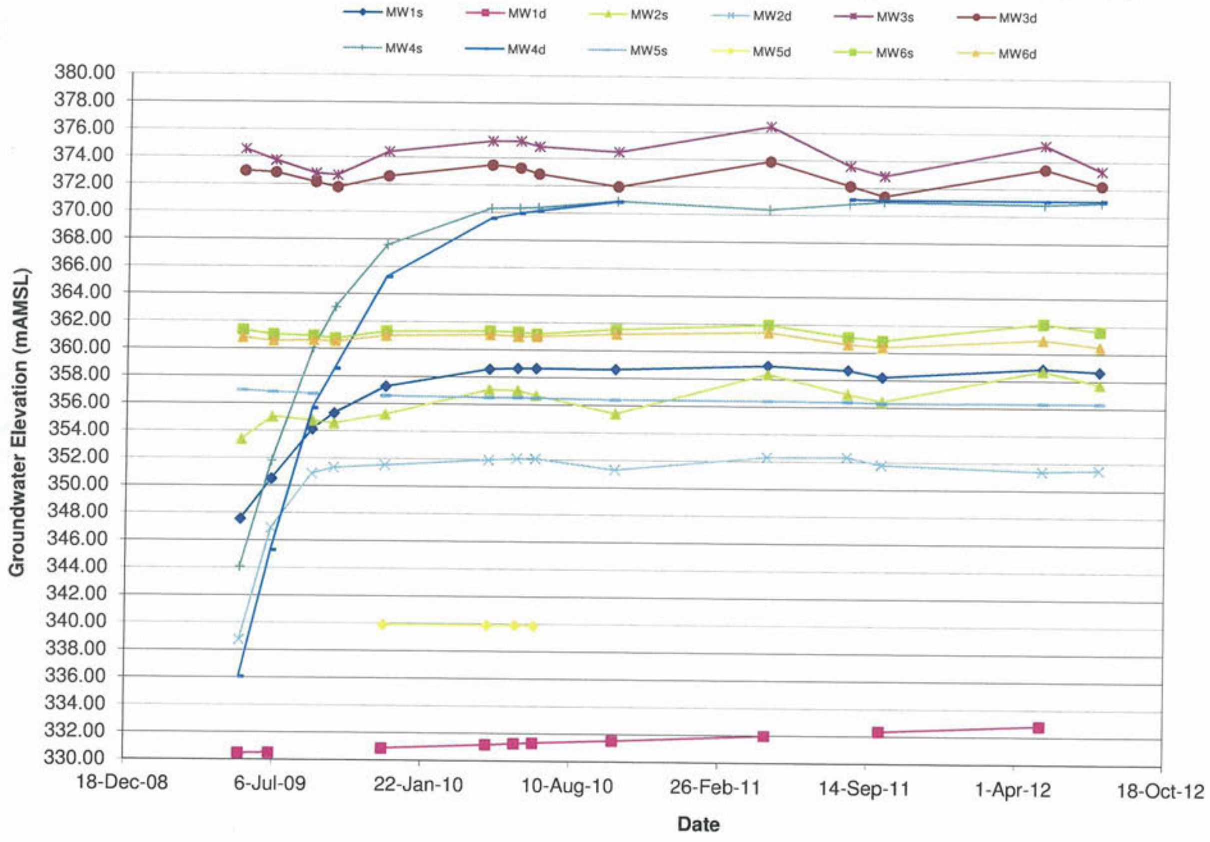
Inputs		
Precipitation (P)	294,105	m^3/yr
Groundwater (Q_{gwin})	10	m^3/yr
Outputs		
Runoff (Qr)	211,762	m^3/yr
Groundwater (Q_{gwout})	2	m^3/yr
Evaporation (E)	0	m^3/yr
Evapotranspiration (ET)	4	m^3/yr
Pre-extraction		
$I = P + Q_{gwin} - Q_r - ET - E - Q_{gwout} =$	**82,348**	m^3/yr
Pre-extraction		
Infiltration (I)%		28.00
E + ET %		0.00
Groundwater		0.00
Runoff (Qr)%		72.00
		100

TABLE 8: ZONE OF INFLUENCE PREDICTION SUMMARY – THEIS METHOD

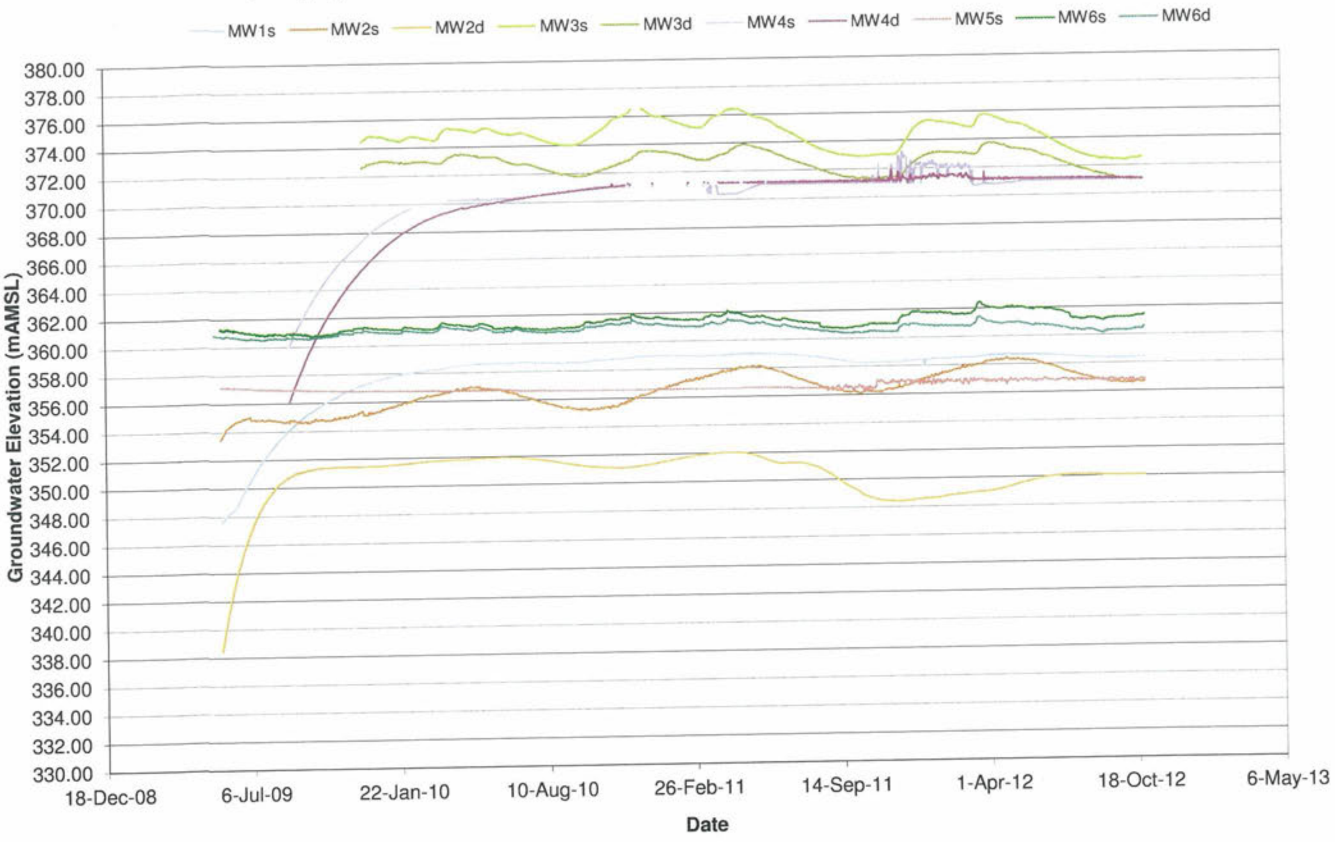
Values for drawdown s(r,t) (m)						
t (days)	**r(m)--->**	**1**	**10**	**50**	**100**	**195**
1		16.73	0.08	0.00	0.00	0.00
5		25.63	2.62	0.00	0.00	0.00
10		29.50	5.17	0.0004	0.00	0.00
30		35.66	10.34	0.14	3.16E-05	0.00
40		37.27	11.82	0.57	4.30E-04	0.00
115		43.20	17.49	2.36	1.30E-01	3.19E-05

HYDROGRAPHS

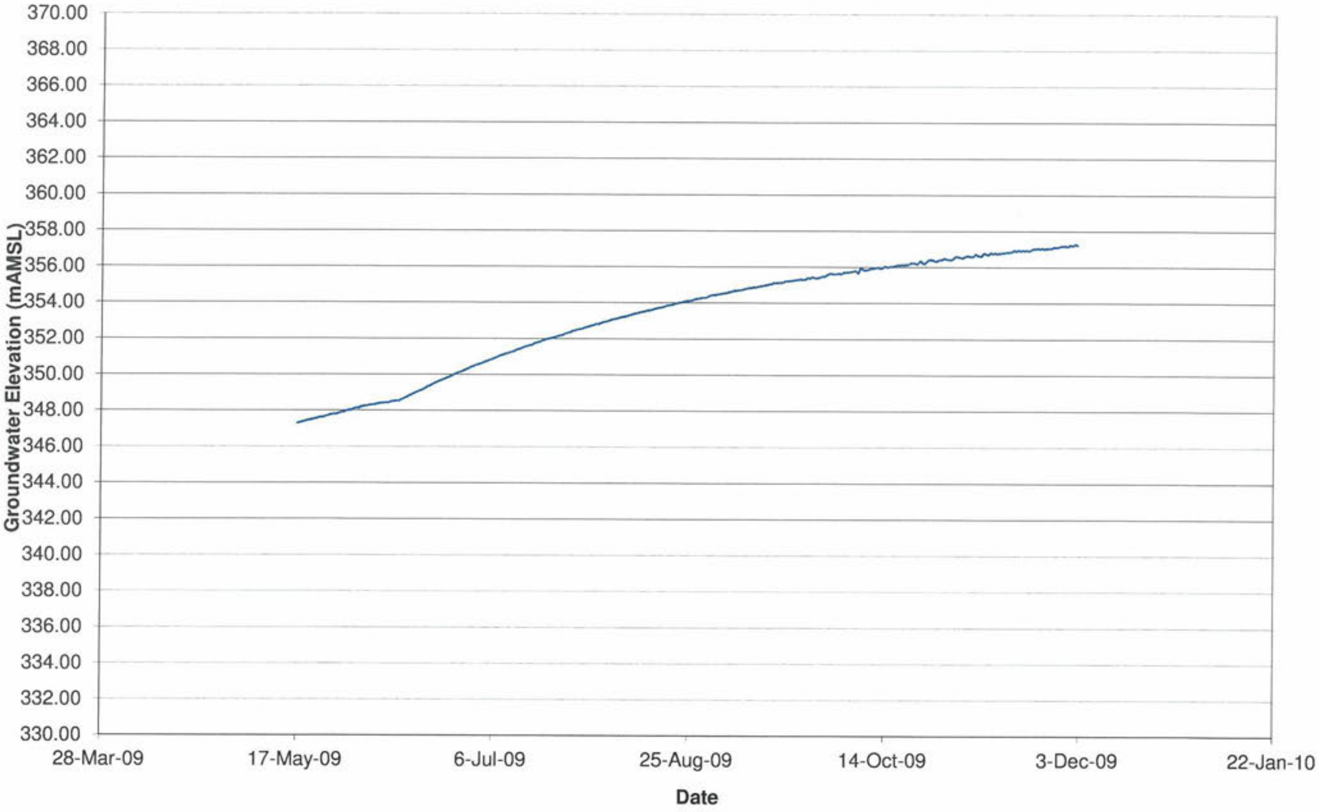
Hydrograph 1: Groundwater Elevations (mAMSL) - Manually Measured - 2009 - 2012



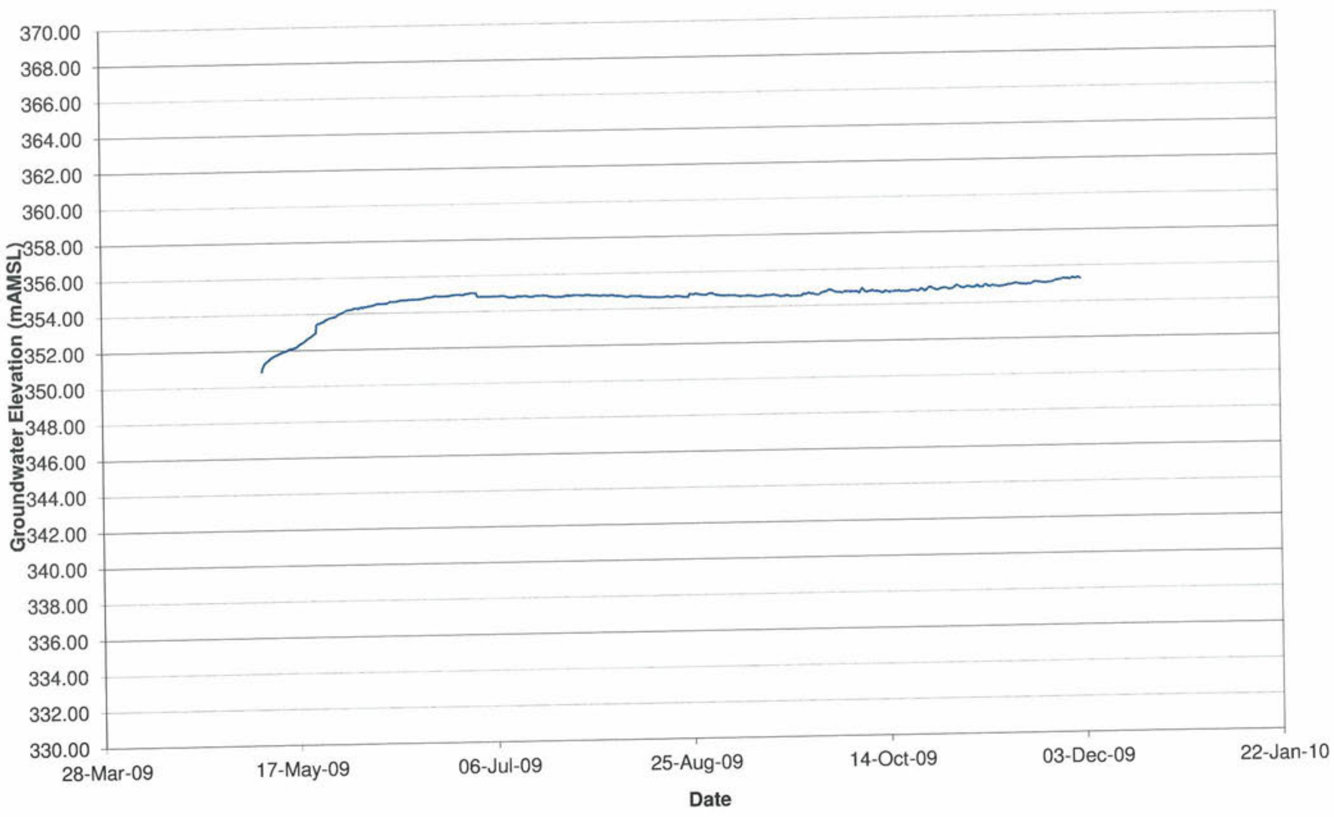
Hydrograph 2: Groundwater Elevations (mAMSL) - Data Logger - 2009 - 2012



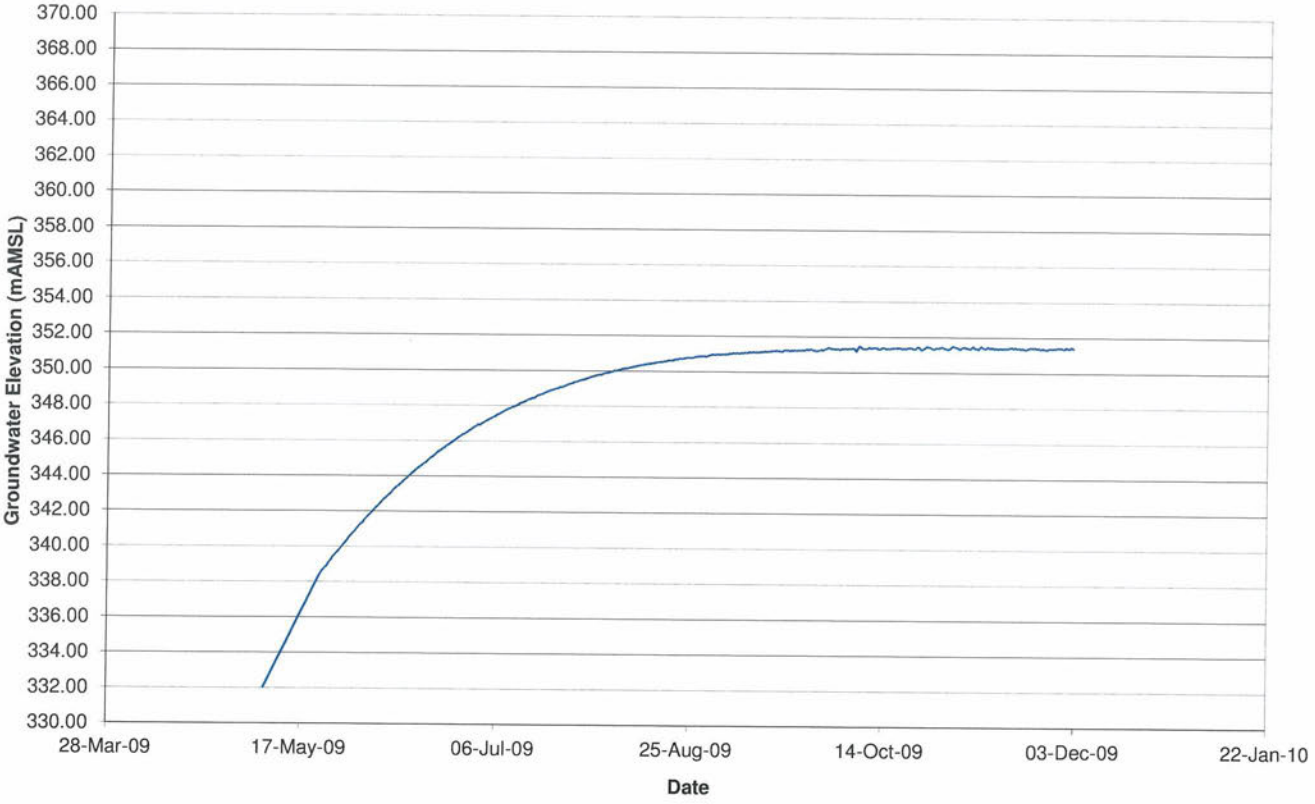
Hydrograph 3: Groundwater Elevations (mAMSL) - MW1s - Recovery



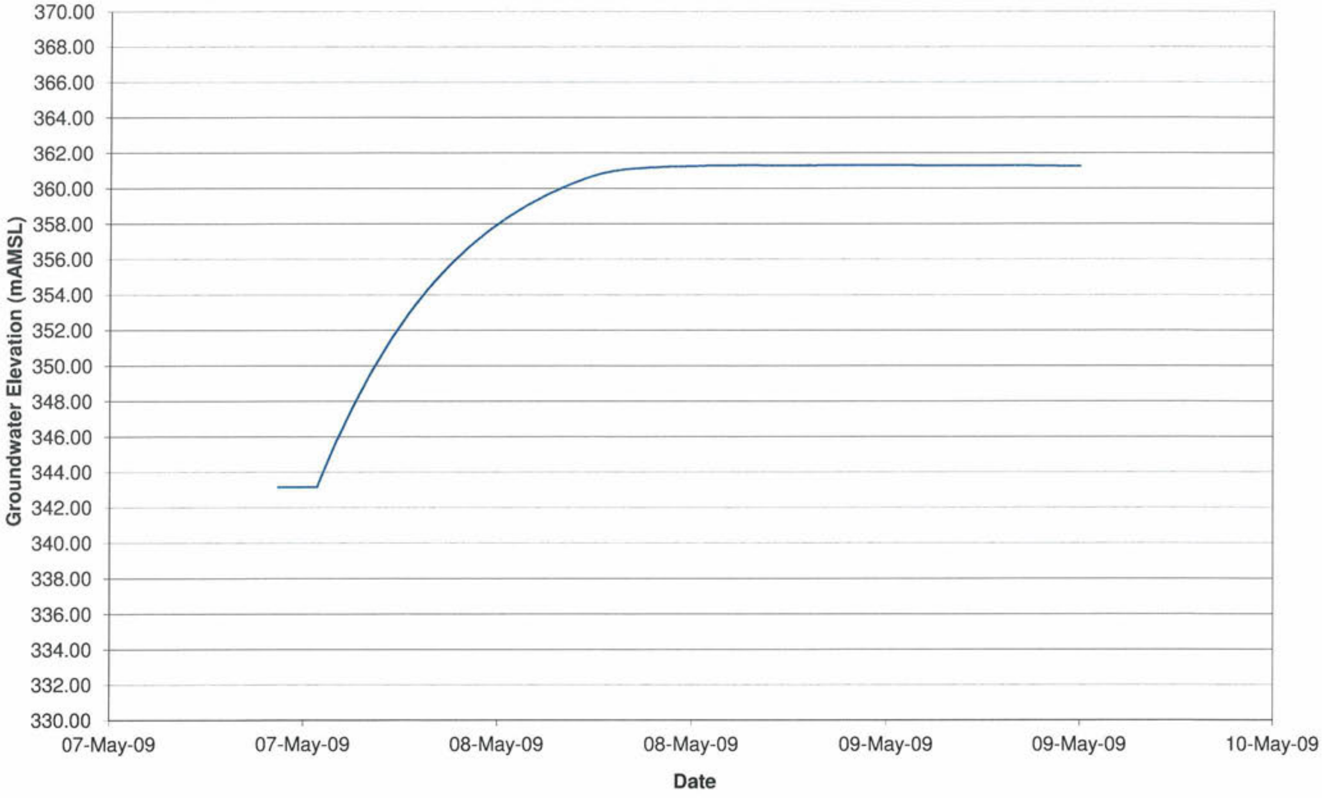
Hydrograph 4: Groundwater Elevations (mAMSL) - MW2s - Recovery



Hydrograph 5: Groundwater Elevations (mAMSL) - MW2d - Recovery



Hydrograph 6: Groundwater Elevations (mAMSL) - MW6s - Recovery



APPENDIX A

MINISTRY OF THE ENVIRONMENT WELL DATA SHEETS

Well Computer Print Out Data as of May 30 2008

TOWNSHIP CONCESSION (LOT)	UTM[1]	DATE[2] CNTR[3]	CASING DIA[4]	WATER[5,6] DETAIL	STAT LVL/PUMP LVL[7] RATE[8]/TIME HR:MIN	WATER USE[9]	SCREEN INFO[10]	WELL # (AUDIT#) WELL TAG # DEPTHS TO WHICH FORMATIONS EXTEND5,11
DUNGANNON TOWNSHIP HR E (049)	18 277003 4991274^{W}	1958/02 1821	06	FR 0040	040 / / :0	NU		2900184 () FSND 0020 QSND 0075 GREY GRNT 0140
DUNGANNON TOWNSHIP HR E (049)	18 277379 4991399^{L}	1983/05 3668	06		024 / 329 / 2:0	CO		2910388 () BRWN FSND 0071 GREY GRNT HARD 0329
DUNGANNON TOWNSHIP HR E (049)	18 276929 4991372^{W}	1974/10 1805	06	FR 0147	130 / / :0	IN		2906606 () BRWN SAND 0006 GRNT 0395
DUNGANNON TOWNSHIP HR E (049)	18 277774 4991476^{W}	1961/04 4513	02 02	FR 0085	022 / 030 002 / 2:0	PS		2900199 () GRNT 0003 GREY GRNT 0090
DUNGANNON TOWNSHIP HR E (050)	18 277330 4991584^{L}	1987/04 1748	06	FR 0050 FR 0108	018 / 120 002 / 1:0	DO		2911526 (09229) SAND STNS 0029 GREY GRNT 0120
DUNGANNON TOWNSHIP HR E (050)	18 276812 4991401^{W}	1958/08 3532	06 06	FR 0090 FR 0082	037 / 100 002 / 2:0	IN		2900202 () FILL MSND 0003 GREY GRNT 0100
DUNGANNON TOWNSHIP HR E (050)	18 276616 4991258^{W}	1961/04 4513	02 02	FR 0061	061 / 072 001 / 3:0	DO		2900201 () RED MSND BLDR 0017 GRNT 0020 RED GRNT 0112
DUNGANNON TOWNSHIP HR E (050)	18 276833 4991491^{W}	2004/08 3611	06	FR 0033	026 / 090 045 / 1:0	DO		2920402 (Z08181) A008101 BRWN SAND 0011 WHIT MRBL HARD 0028 WHIT MRBL SOFT FCRD 0032 WHIT MRBL 0060
DUNGANNON TOWNSHIP HR E (051)	18 277265 4991785^{L}	1987/05 3651	06 06	FR 0065 FR 0098 FR 0047	016 / 105 005 / 2:0	DO		2911624 (1643) BRWN LOAM 0008 GREY GRNT 0105
DUNGANNON TOWNSHIP HR E (052)	18 276689 4991972^{W}	1952/02 3532	06	FR 0056	035 / 035 010 / :0	IN		2900203 () MSND GRVL 0056
DUNGANNON TOWNSHIP HR E (059)	18 276744 4993390^{L}	1989/08 3651	06 06	FR 0255	025 / 256 009 / 1:0	DO		2912945 (59926) BRWN HPAN BLDR 0006 RED GRNT 0087 WHIT GRNT 0095 GREY GRNT 0124 RED GRNT 0145 GREY GRNT 0253 GREN ROCK 0268
DUNGANNON TOWNSHIP HR E (060)	18 276690 4993586^{L}	2001/06 3651	06 06	FR 0245	001 / 275 010 / 1:0	DO		2919096 (227851) BLCK LOAM 0004 BRWN GRVL SAND HARD 0039 GREY HPAN BLDR 0097 GREY GRNT MRBL 0239 BLCK GRNT 0245 GREY GRNT MRBL 0282
DUNGANNON TOWNSHIP HR E (061)	18 276644 4993766^{L}	1999/10 3651	06 06	FR 0200	/ 235 005 / 1:0	DO		2918433 (211104) BRWN SAND FGVL 0012 BRWN GRVL CLAY 0025 GREY HPAN BLDR 0043 RED GRNT 0240
DUNGANNON TOWNSHIP HR E (061)	18 276644 4993766^{L}	1994/02 3651	06 06	FR 0140 FR 0230	009 / 260 002 / 3:0	DO		2916154 (138155) BRWN LOAM 0010 GREY HPAN BLDR 0050 GREY CLAY 0065 GREY HPAN BLDR 0129 GREY GRNT 0138 BRWN GRNT FCRD 0141 GREY LMSN 0215 GREY GRNT 0240 GREY GRNT 0260
DUNGANNON TOWNSHIP HR E (061)	18 276644 4993766^{L}	1994/05 2664	05					2916135 (138877)

Well Computer Print Out Data as of May 30 2008

TOWNSHIP CONCESSION (LOT)	UTM^{1}	DATE ^{2} CNTR ^{3}	CASING DIA ^{4}	WATER^{5,6} DETAIL	STAT LVL/PUMP LVL^{7} RATE^{8}/TIME HR:MIN	WATER USE^{9}	SCREEN INFO^{10}	WELL # (AUDIT#) WELL TAG # DEPTHS TO WHICH FORMATIONS EXTEND5,11
FARADAY TOWNSHIP CON 10(029)	18 265129 4986421^{W}	1981/04 3668	06 06	FR 0047	008 / 052 040 / 1:30	DO		2909868 () BRWN SAND FGVL 0031 GREY LMSN LTCL 0052
FARADAY TOWNSHIP CON 10(029)	18 265443 4986111^{W}	2003/09 3611	05 06	UK 0079	008 / 009 050 / :0	DO		2920030 (263302) BRWN SAND 0046 GREY SAND SILT 0065 GREY LMSN 0081
FARADAY TOWNSHIP CON 10(029)	18 265281 4986133^{W}	2004/05 7052	06	FR 0056	012 / 030 / 2:40	DO		2920260 (Z13206) A013110 BRWN FSND 0034 WHIT DLMT ROCK 0065
FARADAY TOWNSHIP CON 10(029)	18 265429 4986111^{W}	2003/09 3611				NU		2920029 (263310)
FARADAY TOWNSHIP CON 10(072)		1987/05 3651	06 05	FR 0240 FR 0090	003 / 248 001 / 1:0	DO		2911620 (10605) BRWN LOAM STNS 0011 BRWN QSND CLAY 0028 GREY ROCK SOFT FCRD 0083 GREY GRNT 0248
FARADAY TOWNSHIP CON 10()		1984/08 3668	06 06	FR 0278 FR 0245	/ 005 / 3:0	DO		2910739 () BRWN GRVL FSND DRY 0020 GREY QSND WBRG 0140 BRWN SAND BLDR HARD 0185 RED CLAY 0200 RED ROCK QTZ SOFT 0221 RED ROCK QTZ SOFT 0290
FARADAY TOWNSHIP CON 11(001)	18 275698 4990937^{L}	1989/08 3651	06 06	FR 0140	018 / 155 010 / 1:0	DO		2912953 (59932) BRWN HPAN 0010 GREY GRNT 0084 GREY GRNT 0138 GREY GRNT 0141 GREY GRNT 0155
FARADAY TOWNSHIP CON 11(005)	18 274119 4990352^{W}	1974/10 3610	06 06	UK 0069	034 / 064 007 / 3:0	DO		2906688 () BRWN LOAM 0004 GRNT PORS 0007 GREY GRNT 0070
FARADAY TOWNSHIP CON 11(005)	18 274122 4990406^{L}	2003/10 3651	06 05	FR 0130 FR 0255	019 / 264 012 / 2:0	DO		2920068 (267251) BRWN LOAM 0005 GREY GRNT HARD 0189 GREY GRNT SOFT 0235 BRWN GRNT 0269
FARADAY TOWNSHIP CON 11(007)	18 273351 4990142^{L}	1996/08 3651	06 06	FR 0122	013 / 016 010 / 1:30	DO		2917238 (171075) BRWN FSND 0045 GREY QSND 0095 BRWN CGVL 0110 GREY GRNT 0142
FARADAY TOWNSHIP CON 11(008)	18 272981 4990017^{L}	1990/09 3651	06 06	FR 0038	024 / 200 001 / 1:0	DO		2914022 (80658) BRWN SAND 0010 GREY GRNT 0200
FARADAY TOWNSHIP CON 11(008)	18 272784 4989912^{W}	1965/04 4603	02 02	FR 0083	010 / 022 002 / 1:0	DO		2900296 () CSND GRVL 0016 GREY GRNT 0090
FARADAY TOWNSHIP CON 11(009)	18 272417 4987641^{W}	2006/05 3651	06	FR 0035 FR 0095	027 / 059 020 / 1:0	DO		2921151 (Z33919) A031221 BRWN SAND LOOS BLDR 0002 GREY GRNT LTCL 0120
FARADAY TOWNSHIP CON 11(012)	18 271379 4989684^{L}	1994/04 3611	06 01 06	MN 0055 UK 0084 UK 0091	021 / 040 035 / 10:0	DO		2916112 (138847) BRWN SAND GRVL 0021 GREY FSND 0055 GREY GRNT GRVL WBRG 0076 BRWN GRNT FCRD 0081 WHIT LMSN SOFT 0084 BLCK GRNT SHST CGRD 0091 GREN ROCK CGRD 0095
FARADAY TOWNSHIP CON 11(012)	18 271279 4990372^{W}	1975/10 3610	06 06	FR 0200 FR 0122	020 / 195 011 / 5:0	CO		2907365 () FSND 0118 GREY GRNT 0210

Well Computer Print Out Data as of May 30 2008

TOWNSHIP CONCESSION (LOT)	UTM^1	DATE ^{2} CNTR ^{3}	CASING DIA ^{4}	WATER^{5,6} DETAIL	STAT LVL/PUMP LVL^7 RATE^8/TIME HR:MIN	WATER USE^9	SCREEN INFO^{10}	WELL # (AUDIT#) WELL TAG # DEPTHS TO WHICH FORMATIONS EXTENDS,11
FARADAY TOWNSHIP CON 11(017)	18 269279 4988772^W	1975/09 2104	06	FR 0037	005 / 010 049 / 12:0	MN	0032 04	2907146 () BRWN STNS SAND FILL 0001 BRWN FSND CLAY LOOS 0005 BRWN SAND GRVL LOOS 0037 RED GRVL WBRG LOOS 0042 RED GRVL SAND LOOS 0048
FARADAY TOWNSHIP CON 11(018)	18 269129 4988822^W	1976/11 3668	06	FR 0057	012 / 022 025 / 2:0	IN		2907793 () HPAN 0055 GRVL 0057
FARADAY TOWNSHIP CON 11(025)	18 266354 4987964^L	1992/10 1748	06 06	FR 0057 FR 0026 FR 0063	021 / 070 005 / 1:0	DO		2915433 (123861) BRWN SAND GRVL LOOS 0001 WHIT GRNT ROCK 0018 BLCK GRNT 0070
FARADAY TOWNSHIP CON 11(027)		1988/09 1748	06	FR 0095	025 / 105 008 / 1:0	DO		2912233 (41906) LOAM 0003 BLCK GRNT 0105
FARADAY TOWNSHIP CON 11(030)		1986/07 1748	06	FR 0080	010 / 084 008 / 1:0	DO		2911494 (01058) LOAM STNS 0006 WHIT GRNT 0084
FARADAY TOWNSHIP CON 11(032)		1981/07 1748	06	FR 0025	020 / 040 015 / 1:0	DO		2910824 () BRWN SAND STNS LOAM 0004 BLCK GRNT QTZ 0040
FARADAY TOWNSHIP CON 12(001)	18 275360 4991790^L	1999/07 3611	06 06	UK 0155	016 / 060 020 / 1:0	DO		2918277 (193993) BRWN SAND STNS PCKD 0038 WHIT LMSN 0130 GREY GRNT 0145 GREY GRNT 0162
FARADAY TOWNSHIP CON 12(001)	18 275360 4991790^L	1999/05 6016	06 06	UK 0093	007 / 100 007 / 2:0	DO		2918233 (200335) BRWN LOAM 0004 BRWN SAND 0016 WHIT DLMT 0100
FARADAY TOWNSHIP CON 12(001)	18 275360 4991790^L	1999/08 3611	06 06	UK 0222	011 / 230 018 / 1:0	DO		2918302 (205829) BRWN SAND CLAY HPAN 0052 GREY LMSN 0180 WHIT LMSN 0230
FARADAY TOWNSHIP CON 12(001)	18 275360 4991790^L	1989/04 3611	06 06	FR 0160	028 / 166 004 / 1:0	DO		2912610 () BRWN FSND 0051 GREY SAND PCKD 0057 GREY MRBL 0115 BLCK GRNT 0136 WHIT MRBL 0166
FARADAY TOWNSHIP CON 12(002)	18 275021 4991797^W	1960/09 4513	02 02	FR 0082	020 / 030 003 / 2:0	DO		2900298 () PRDG 0014 HPAN 0016 GREY GRNT 0087
FARADAY TOWNSHIP CON 12(003)	18 274536 4991524^L	2000/04 3611	06 06	UK 0218 UK 0180	021 / 240 003 / 1:0	DO		2918617 (205914) BRWN SAND FILL 0008 BRWN FSND 0053 WHIT LMSN 0062 GREY GRNT 0242
FARADAY TOWNSHIP CON 12(009)	18 272335 4990701^L	1988/07 3651	06 06	FR 0096 FR 0071	014 / 130 006 / 1:0	CO		2912159 (29741) BRWN SAND FGVL 0009 GREY GRNT 0015 WHIT LMSN 0025 GREY GRNT 0061 WHIT LMSN 0078 GREY GRNT 0094 GREY GRNT LMSN 0110 GREY GRNT 0115 WHIT LMSN 0130
FARADAY TOWNSHIP CON 12(010)	18 271828 4990521^W	1981/08 3668	06 06	FR 0170	030 / 240 001 / 2:0	DO		2909867 () BRWN SAND 0004 WHIT LMSN 0040 GREY GRNT 0160 WHIT LMSN 0200 GREY GRNT 0249
FARADAY TOWNSHIP CON 12(011)	18 271611 4990338^L	1996/11 3651	06 06	FR 0162	018 / 160 005 / 1:0	DO		2917280 (175133) BRWN GRVL CGRD 0030 BRWN GRVL FSND 0080 BRWN SAND BLDR 0095 BRWN SAND FGVL 0101 WHIT ROCK SOFT 0110 BLCK GRNT LYRD 0162 BRWN GRNT 0164 BLCK GRNT 0182

Well Computer Print Out Data as of May 30 2008

TOWNSHIP CONCESSION (LOT)	UTM^{1}	DATE ^{2} CNTR ^{3}	CASING DIA ^{4}	WATER^{5,6} DETAIL	STAT LVL/PUMP LVL^{7} RATE^{8}/TIME HR:MIN	WATER USE^{9}	SCREEN INFO^{10}	WELL # (AUDIT#) WELL TAG # DEPTHS TO WHICH FORMATIONS EXTEND5,11
FARADAY TOWNSHIP HR W (039)	18 278785 4989728^{W}	1966/12 3611	05 05	FR 0130	015 / 100 010 / 1:0	DO		2900306 () LOAM MSND 0005 GREY GRNT 0132
FARADAY TOWNSHIP HR W (039)	18 277778 4989496^{L}	2001/04 3651	06 06	FR 0149 FR 0039	026 / 137 004 / 1:0	DO		2919022 (227795) BRWN SAND GRVL 0004 GREY GRNT 0160
FARADAY TOWNSHIP HR W (039)	18 277781 4989494^{L}	1991/11 3651	06 06	FR 0104 FR 0112	015 / 122 007 / 1:0	DO		2914964 (113108) BRWN LOAM 0002 GREY GRNT SOFT 0008 GREY GRNT HARD 0050 GREY GRNT 0122
FARADAY TOWNSHIP HR W (039)	18 277781 4989494^{L}	1987/08 1748	06	FR 0060 FR 0180	009 / 200 001 / 1:0	DO		2911632 (17926) SAND 0018 GREY GRNT 0200
FARADAY TOWNSHIP HR W (040)	18 277662 4989587^{L}	1991/05 3651	06 06	FR	028 / 200 002 / 1:0	DO		2914422 (90190) GREY HPAN 0006 GREY GRNT HARD 0060 GREY GRNT HARD 0170 GREY GRNT HARD 0200
FARADAY TOWNSHIP HR W (045)	18 276709 4990350^{L}	1994/08 3611	06 06	UK 0206	045 / 220 002 / 2:0	DO		2916313 (138890) BRWN SAND 0001 GREY GRNT 0220
FARADAY TOWNSHIP HR W (046)	18 276642 4990531^{L}	1995/11 3611	06 06		014 / 180 005 / 1:0	DO		2916913 (138825) BRWN LOAM 0002 GREY MRBL 0180
FARADAY TOWNSHIP HR W (046)	18 276079 4990422^{W}	1974/08 3610	06 06	FR 0072	039 / 060 008 / 2:0	DO		2906700 () SAND 0066 GRNT 0073
FARADAY TOWNSHIP HR W (046)	18 276642 4990531^{L}	1995/09 3611	06 06	UK 0159	014 / 162 020 / 1:0	DO		2916805 (153724) BLCK LOAM 0007 BRWN GRVL LOOS 0016 GREY MRBL HARD 0162
FARADAY TOWNSHIP HR W (047)	18 276563 4990703^{L}	1987/11 3651	06 06	FR 0040	010 / 044 020 / 1:0	DO		2911801 (10556) BRWN SAND BLDR 0015 GREY GRNT HARD 0040 BLUE GRNT SOFT 0042 GREY GRNT HARD 0044
FARADAY TOWNSHIP HR W (048)	18 276479 4990822^{W}	1979/06 3668	06 06	FR 0150	004 / 322 001 / 1:0	DO		2909099 () PRDG 0007 STNS 0008 GREY GRNT 0322
FARADAY TOWNSHIP HR W (049)	18 276423 4991079^{L}	1992/07 3611	06 06	FR 0184 FR 0193	032 / 195 020 / 2:15	DO		2915307 (102949) BRWN FSND SHRP 0035 GREY QSND 0057 GREY CLAY SAND SOFT 0086 GREY CLAY SAND PCKD 0135 WHIT GRNT 0169 BLCK GRNT SHST 0184 BLCK GRNT SHST 0193 GREY GRNT 0201
FARADAY TOWNSHIP HR W (049)	18 276423 4991079^{L}	1999/07 3611	06 05	UK 0196	027 / 202 007 / 1:0	DO		2918301 (193983) BRWN SAND QSND FSND 0110 GREY GRVL STNS 0125 GREY LMSN 0202
FARADAY TOWNSHIP HR W (049)	18 276479 4991147^{W}	1971/06 3610	06 06	FR 0068	040 / 050 020 / 2:0	CO		2904941 () BRWN FSND 0062 GREY GRNT 0070
FARADAY TOWNSHIP HR W (049)	18 276421 4991081^{L}	2001/08 3651	06 06	FR 0170	023 / 048 010 / 1:0	DO		2919177 (227899) BRWN SAND GRVL BLDR 0080 GREY GRNT QTZ 0180
FARADAY TOWNSHIP HR W (050)	18 276342 4991271^{L}	1993/12 3611	06 06	UK 0113	035 / 110 080 / 1:30	DO		2916021 (138845) BRWN SAND PCKD 0052 BRWN SAND GRVL 0103 GREY LMSN MRBL 0122

Well Computer Print Out Data as of May 30 2008

TOWNSHIP CONCESSION (LOT)	UTM[1]	DATE[2] CNTR[3]	CASING DIA[4]	WATER[5,6] DETAIL	STAT LVL/PUMP LVL[7] RATE[8]/TIME HR:MIN	WATER USE[9]	SCREEN INFO[10]	WELL # (AUDIT#) WELL TAG # DEPTHS TO WHICH FORMATIONS EXTEND5,11
FARADAY TOWNSHIP HR W (056)	18 275962 4992445^{L}	1989/01 3611	06 06	FR 0122	038 / 145 005 / 2:0	DO		2912611 () BRWN SAND CGVL 0045 BRWN FSND 0080 GREY SAND CLAY PCKD 0105 GREY GRNT 0118 BRWN SNDS LYRD 0122 GREY GRNT 0145
FARADAY TOWNSHIP HR W (057)	18 275899 4992638^{L}	1999/10 3651	06 06	FR 0085 FR 0095	021 / 098 007 / 1:0	DO		2918434 (211110) BRWN LOAM 0004 GREY HPAN BLDR 0030 BLCK GRNT 0038 BLCK GRNT QTZ 0084 BLCK GRNT 0095 BLCK GRNT 0100
FARADAY TOWNSHIP HR W (057)	18 275896 4992639^{L}	2003/07 3611	05 06	UK 0160 UK 0225	066 / 240 003 / 1:0	DO		2919950 (263296) UNKN 0009 BLCK GRNT HARD 0241
FARADAY TOWNSHIP HR W (058)	18 276105 4992713^{W}	1956/10 2801	10	FR 0040	015 / 021 063 / 40:0	PS	0032 11	2900312 () LOAM 0002 GRVL MSND BLDR 0011 MSND GRVL 0030 MSND GRVL BLDR 0040 GRVL BLDR MSND 0044
FARADAY TOWNSHIP HR W (058)	18 276107 4992713^{W}	1956/08 2801	10					2900311 () LOAM 0001 GRVL BLDR 0007 GRVL CLAY BLDR 0012 GRVL BLDR 0018 FSND GRVL 0028 HPAN 0049 LMSN 0052
FARADAY TOWNSHIP HR W (058)	18 276113 4992722^{W}	1956/08 2801	10		015 / 024 066 / 8:0	NU		2900310 () LOAM 0002 GRVL BLDR 0007 GRVL CLAY BLDR 0013 GRVL 0017 HPAN 0023 CSND GRVL 0035 FSND CSND GRVL 0043 CLAY MSND GRVL 0062 LMSN 0063
FARADAY TOWNSHIP HR W (058)	18 275834 4992828^{L}	2001/08 3651	06 05	FR 0165	015 / 164 004 / 1:0	DO		2919175 (227892) BRWN SAND BLDR GRVL 0127 GREY GRNT 0180
FARADAY TOWNSHIP HR W (058)	18 276120 4992741^{W}	1956/08 2801	10					2900308 () GRVL BLDR 0002 FSND 0020 CSND 0027 FSND 0030 GRVL BLDR 0034 CLAY MSND BLDR 0045 LMSN 0050
FARADAY TOWNSHIP HR W (058)	18 276120 4992741^{W}	1956/08 2801	08					2900309 () GRVL BLDR 0002 FSND 0020 CSND 0027 FSND 0030 GRVL BLDR 0034 CLAY BLDR 0045 LMSN 0050
FARADAY TOWNSHIP HR W (066)	18 275626 4994486^{W}	2004/06 3651	06	FR 0072	013 / 052 036 / 1:0	DO		2920337 (Z07731) A007637 BRWN LOAM 0004 GREY GRNT 0071 WHIT MRBL 0073 GREY GRNT 0080
FARADAY TOWNSHIP HR W (070)	18 274702 4995079^{W}	1955/09 1651	04	FR 0020	016 / 019 002 / :0	DO		2900313 () BRWN LOAM 0018 GRVL 0020
FARADAY TOWNSHIP HR W (070)	18 274657 4995130^{W}	1956/08 1821	06	FR 0023	010 / 010 002 / 2:0	DO		2900314 () GRVL 0025
FARADAY TOWNSHIP HR W (071)	18 275054 4995258^{L}	2001/04 3611	06 05		045 / 374 004 / 1:45	DO		2919059 (222182) BRWN LOAM 0002 GREY GRNT 0012 GREY GRNT HARD 0480
FARADAY TOWNSHIP HR W (074)	18 274843 4996062^{W}	1957/12 2402	10 10	FR 0192	032 / 140 015 / 12:0	DO		2900316 () LOAM 0001 MSND 0011 FSND 0048 RED GRNT 0194
FARADAY TOWNSHIP HR W (074)	18 274601 4996063^{W}	1956/07 1806	06	FR 0063	053 / / :0	DO		2900315 () CSND 0063

APPENDIX B

BOREHOLE LOGS

Client: Freymond Lumber Ltd.

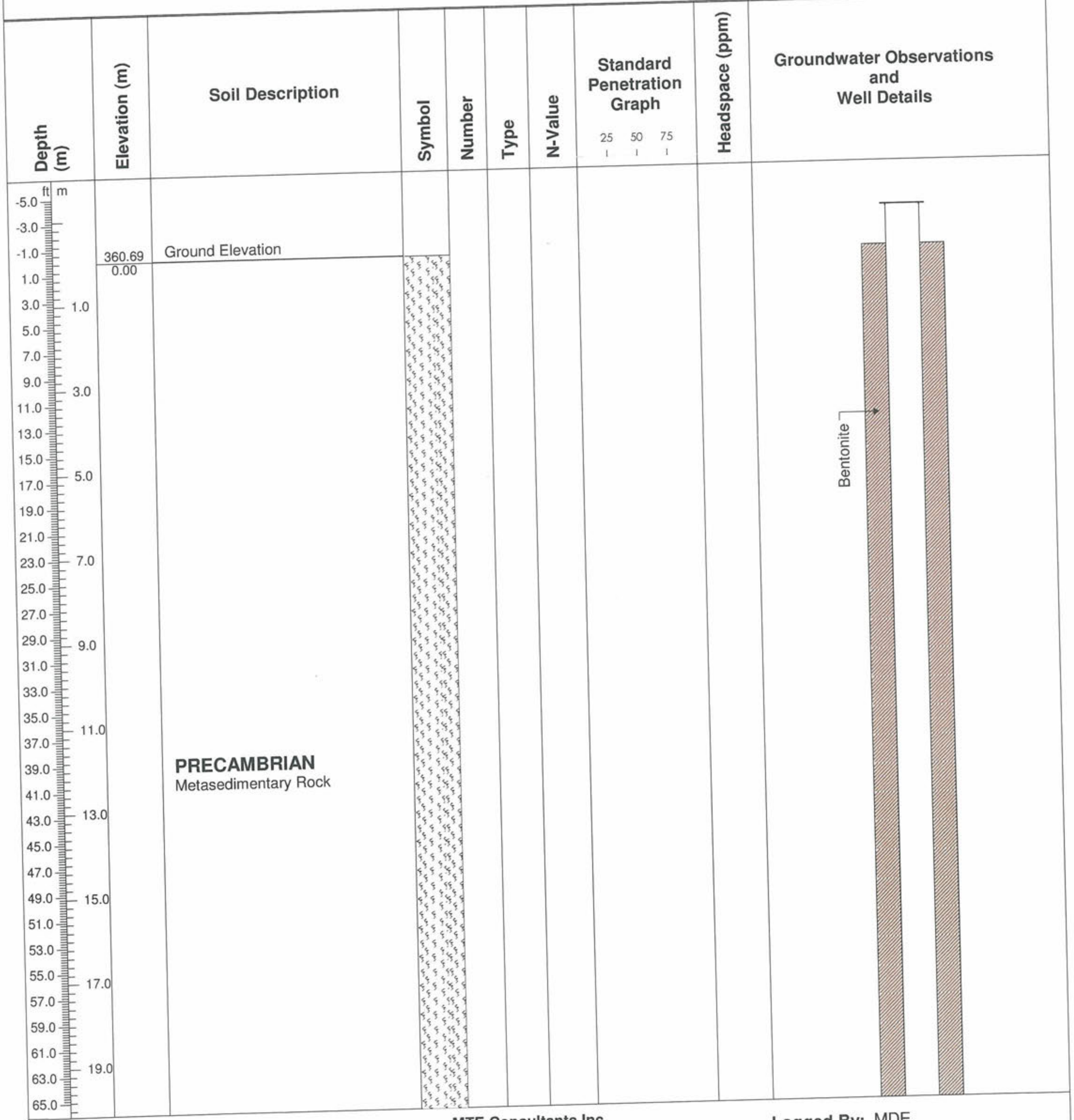
Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW1d

Job Number: 33886-100

Drill Date: April 27, 2009



Elevation (m)	Soil Description
360.69 0.00	Ground Elevation
	PRECAMBRIAN Metasedimentary Rock

Reviewed By: WSC

Method: Air Percussion

Notes:

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Sheet: 1 of 2

Client: Freymond Lumber Ltd.

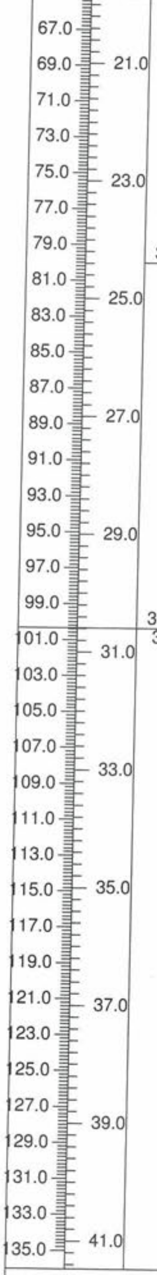
Project: Freymond Quarry

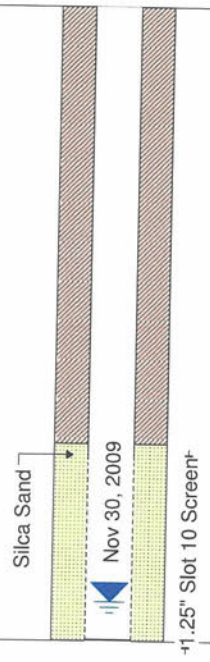
Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW1d

Job Number: 33886-100

Drill Date: April 27, 2009



Elevation (m)	Soil Description	Symbol	Number	Type	N-Value	Standard Penetration Graph 25 50 75	Headspace (ppm)	Groundwater Observations and Well Details
336.31 24.38	**PRECAMBRIAN** Metasedimentary Rock							
330.11 30.58								

Reviewed By: WSC

Method: Air Percussion

Notes:

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Sheet: 2 of 2

Client: Freymond Lumber Ltd.

Project: Freymond Quarry

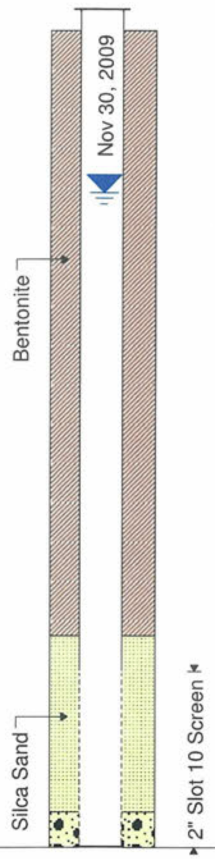
Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW1s

Job Number: 33886-100

Drill Date: April 27, 2009

Depth (m)	Elevation (m)	Soil Description	Symbol	Number	Type	N-Value	Standard Penetration Graph 25 50 75	Headspace (ppm)	Groundwater Observations and Well Details
ft: -5.0, -3.0, -1.0, 1.0, 3.0, 5.0, 7.0, 9.0, 11.0, 13.0, 15.0, 17.0, 19.0, 21.0, 23.0, 25.0, 27.0, 29.0, 31.0, 33.0, 35.0, 37.0, 39.0, 41.0, 43.0, 45.0, 47.0, 49.0, 51.0, 53.0, 55.0, 57.0, 59.0, 61.0, 63.0, 65.0 m: 1.0, 3.0, 5.0, 7.0, 9.0, 11.0, 13.0, 15.0, 17.0, 19.0	359.64 0.00	Ground Elevation							
		PRECAMBRIAN Metasedimentary Rock							
	345.49 14.15								



Reviewed By: WSC

Method: Air Percussion

Notes:

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Sheet: 1 of 1

Client: Freymond Lumber Ltd.

Project: Freymond Quarry

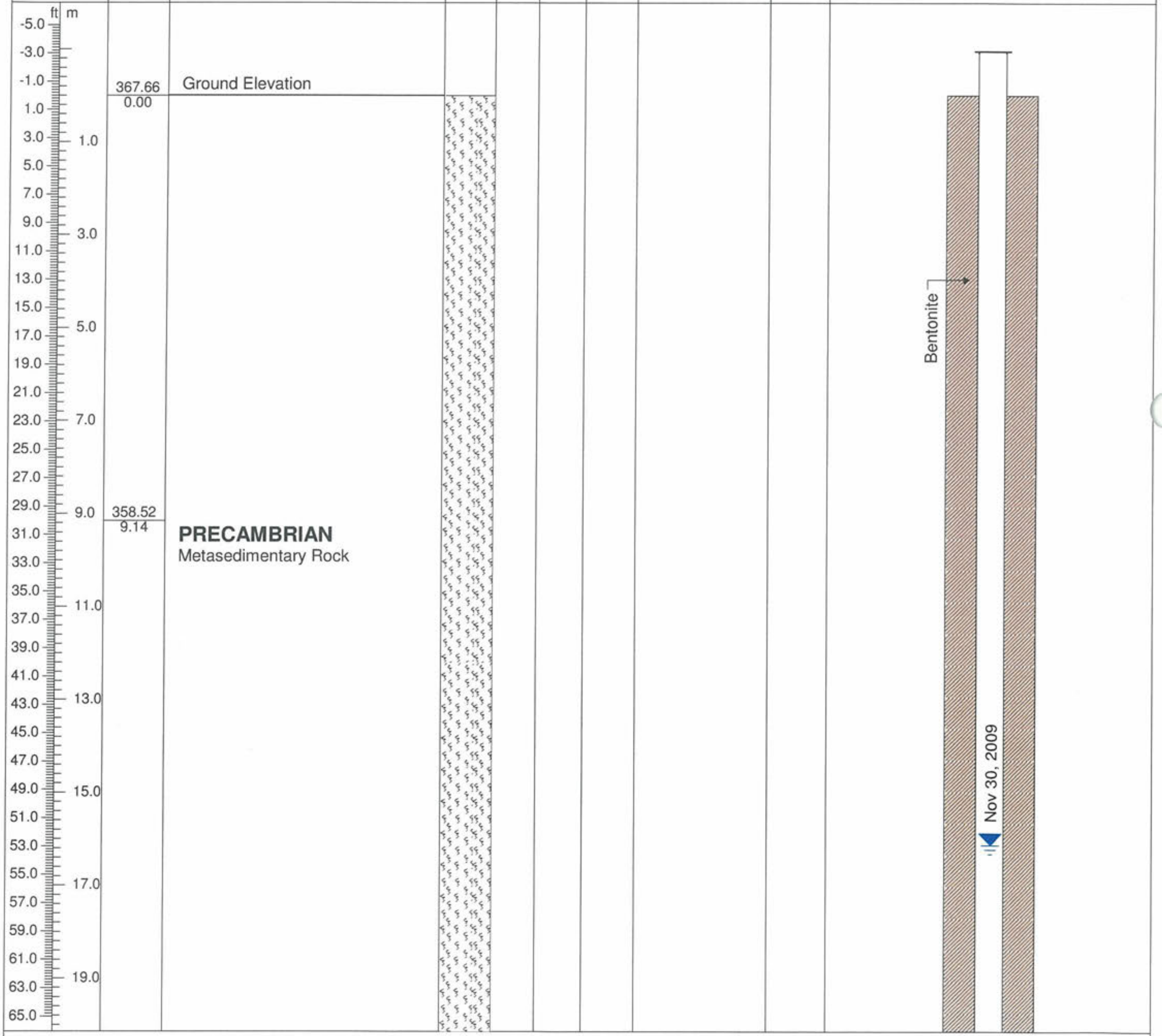
Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW2d

Job Number: 33886-100

Drill Date: May 5, 2009

Depth (m)	Elevation (m)	Soil Description	Symbol	Number	Type	N-Value	Standard Penetration Graph 25 50 75	Headspace (ppm)	Groundwater Observations and Well Details
	367.66 0.00	Ground Elevation							
	358.52 9.14	**PRECAMBRIAN** Metasedimentary Rock							



Reviewed By: WSC

Method: Air Percussion

Notes:

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Sheet: 1 of 2

Client: Freymond Lumber Ltd.

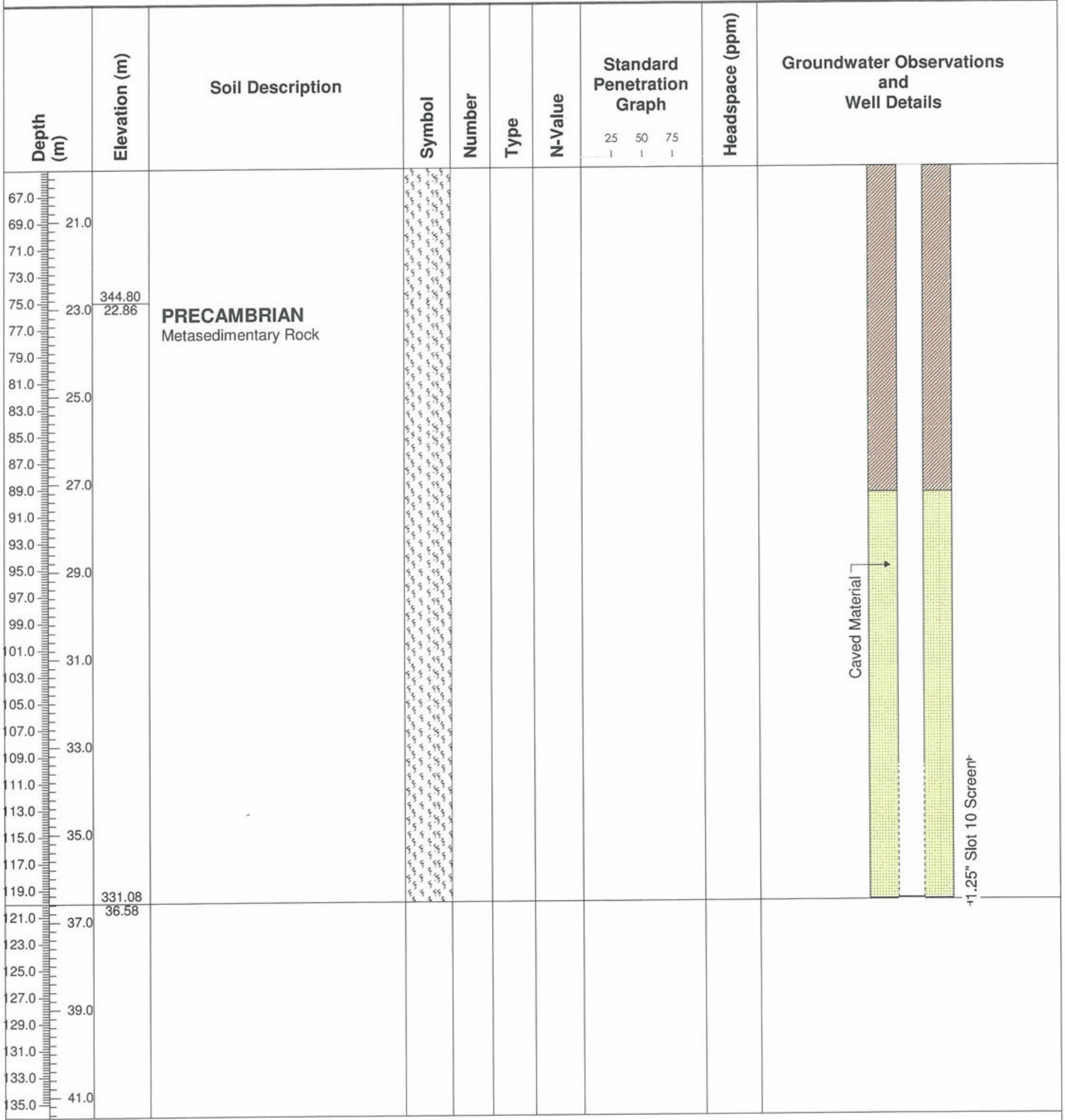
Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW2d

Job Number: 33886-100

Drill Date: May 5, 2009



Reviewed By: WSC

Method: Air Percussion

Notes:

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Sheet: 2 of 2

Client: Freymond Lumber Ltd.

Project: Freymond Quarry

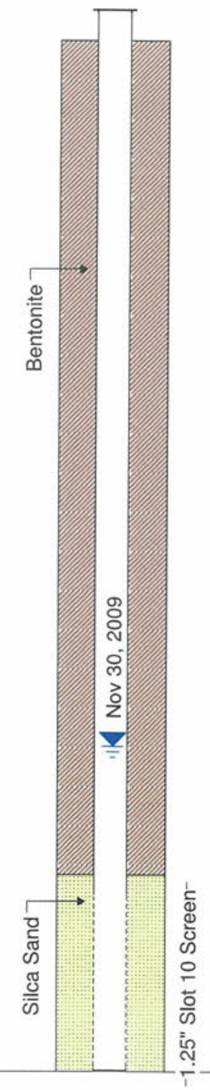
Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW2s

Job Number: 33886-100

Drill Date: May 4, 2009

Depth (m)	Elevation (m)	Soil Description	Symbol	Number	Type	N-Value	Standard Penetration Graph 25 50 75	Headspace (ppm)	Groundwater Observations and Well Details
0.00	367.53	Ground Elevation							
		PRECAMBRIAN Metasedimentary Rock							
17.88	349.65								



Depth scale: ft -5.0 to 65.0; m 1.0 to 19.0

Reviewed By: WSC

Method: Air Percussion

Notes:

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Sheet: 1 of 1

Client: Freymond Lumber Ltd.

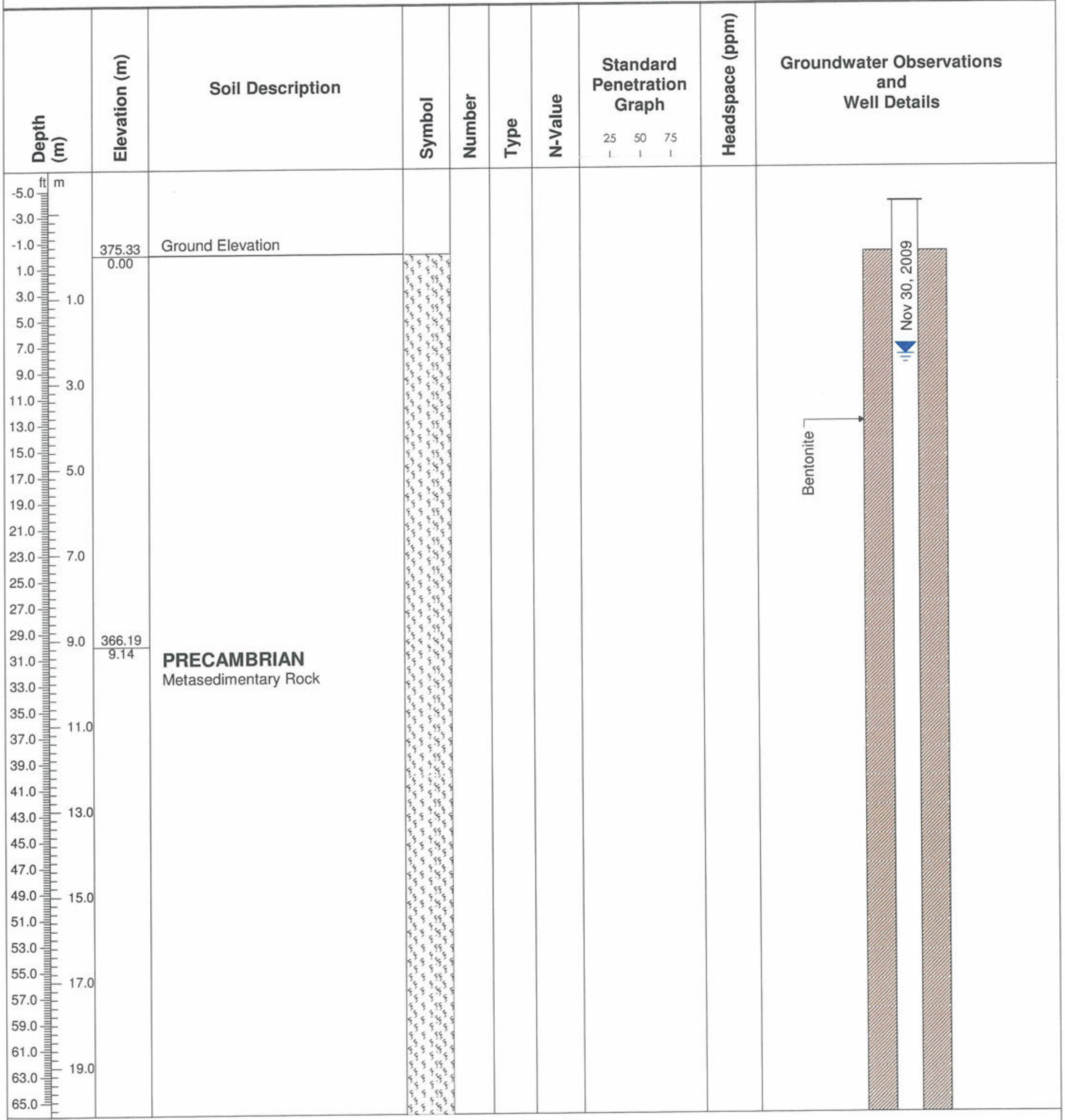
Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW3d

Job Number: 33886-100

Drill Date: May 4, 2009



Reviewed By: WSC

Method: Air Percussion

Notes:

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Sheet: 1 of 2

Client: Freymond Lumber Ltd.

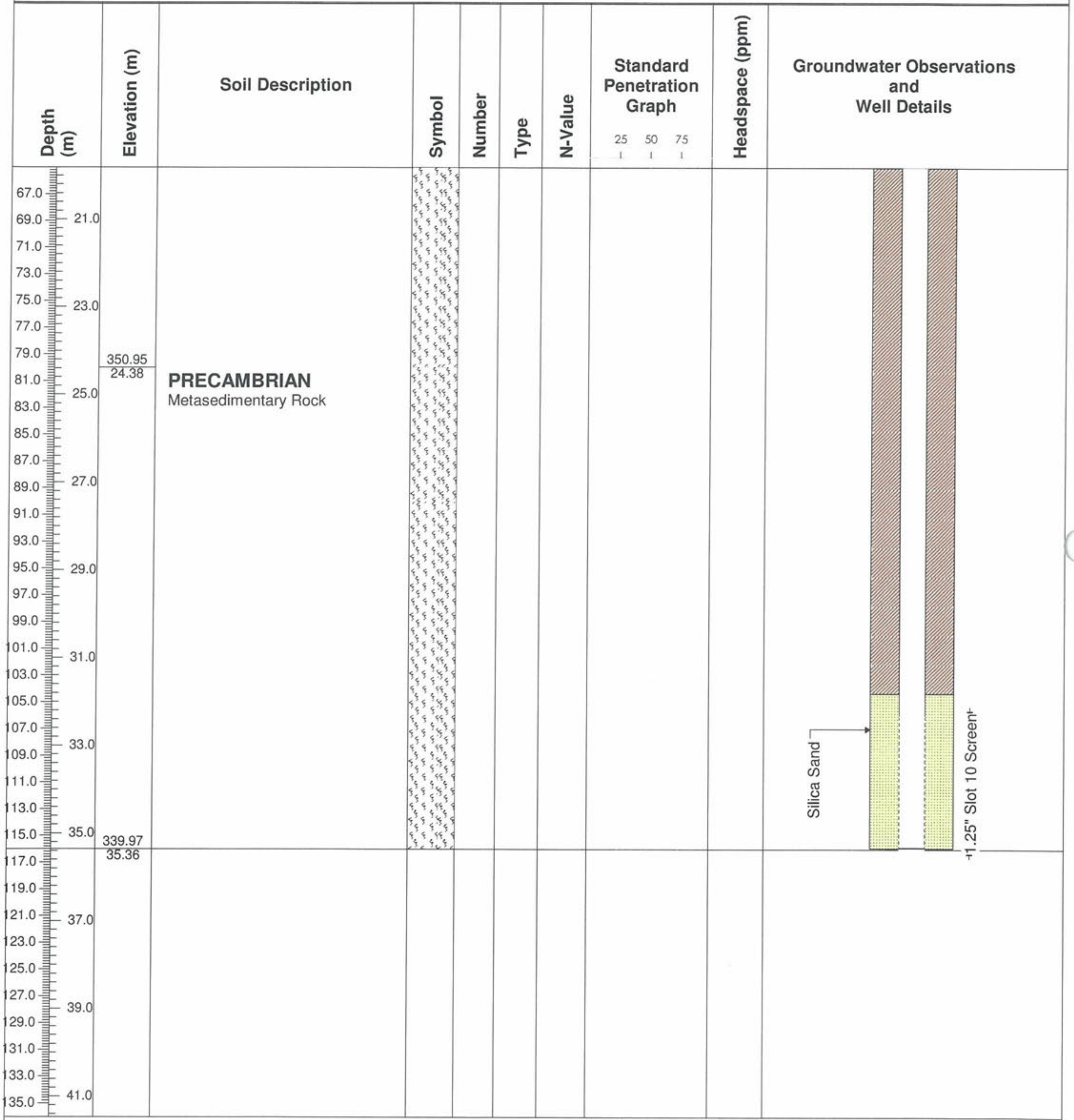
Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW3d

Job Number: 33886-100

Drill Date: May 4, 2009



Reviewed By: WSC

Method: Air Percussion

Notes:

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Sheet: 2 of 2

Client: Freymond Lumber Ltd.

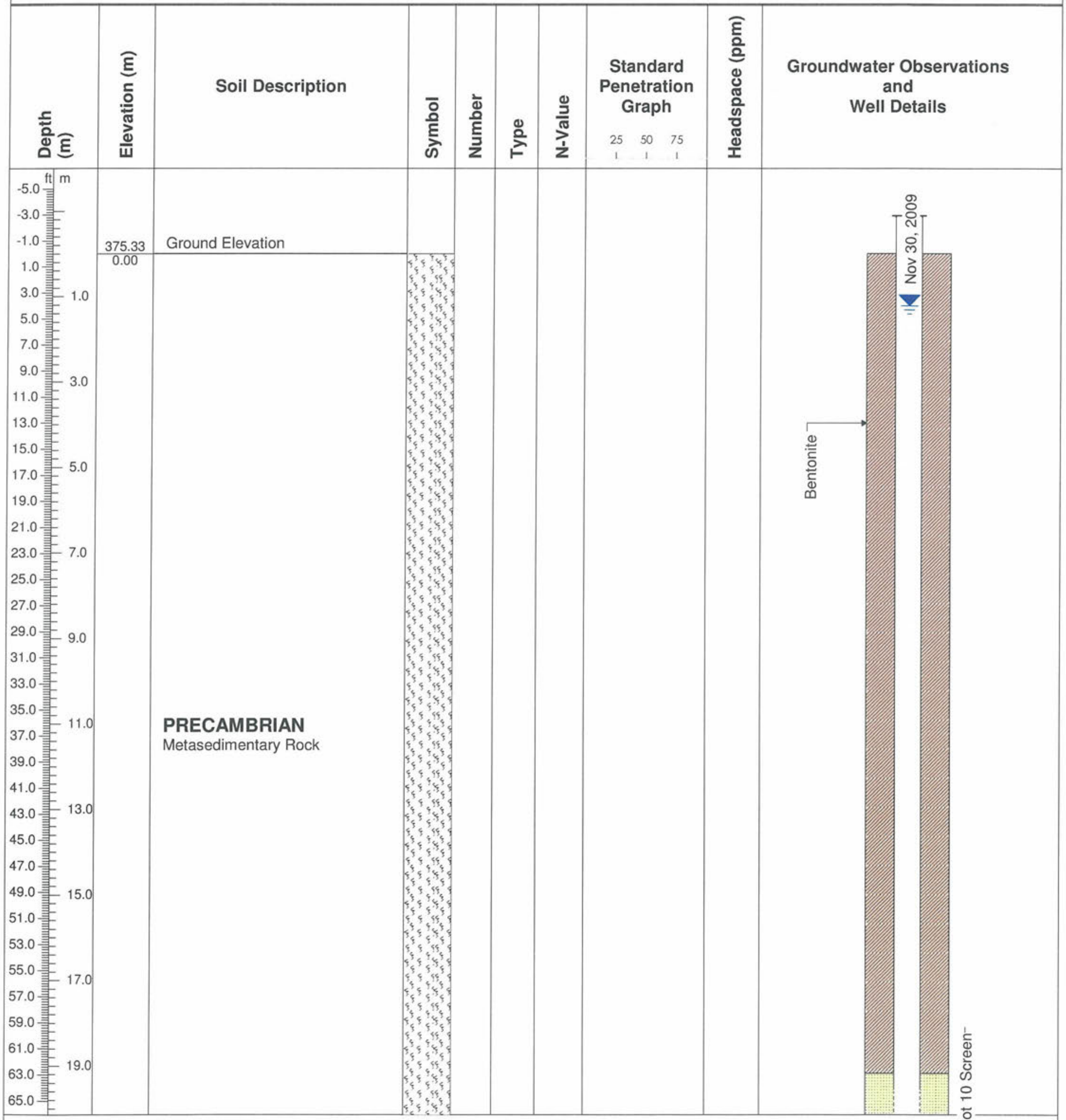
Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW3s

Job Number: 33886-100

Drill Date: May 4, 2009



Reviewed By: WSC

Method: Air Percussion

Notes:

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Sheet: 1 of 2

Client: Freymond Lumber Ltd.

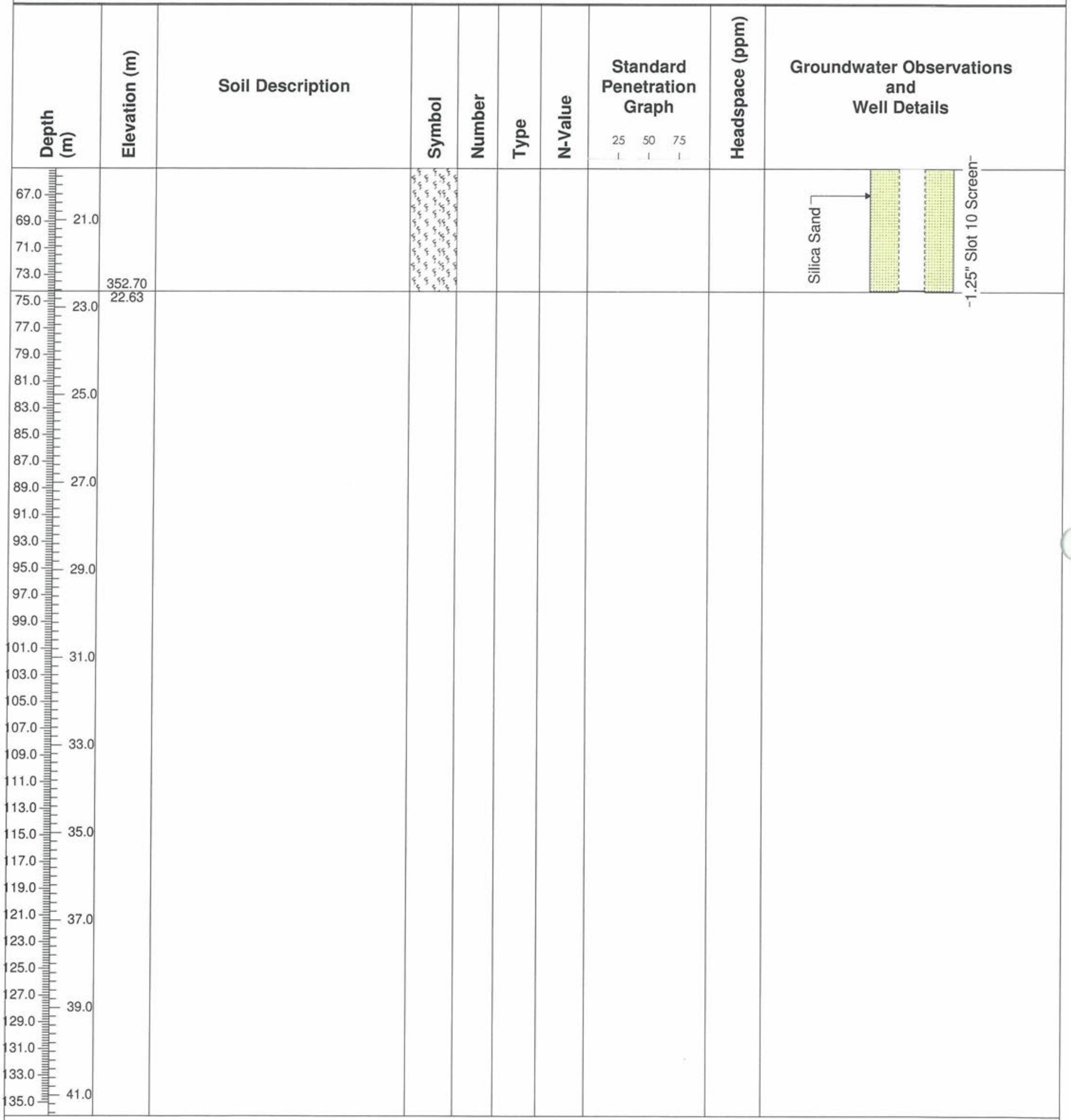
Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW3s

Job Number: 33886-100

Drill Date: May 4, 2009



Reviewed By: WSC

Method: Air Percussion

Notes:

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Logged By: MDE

Sheet: 2 of 2

Client: Freymond Lumber Ltd.

Project: Freymond Quarry

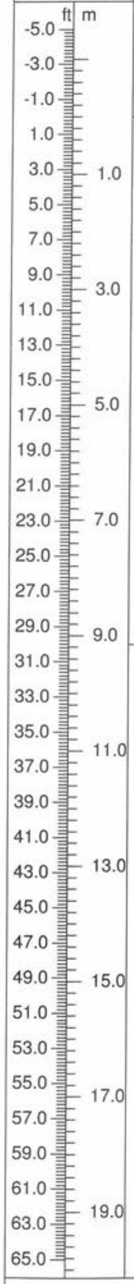
Location: Lot 51 & 52, Township of Faraday, Hastings County

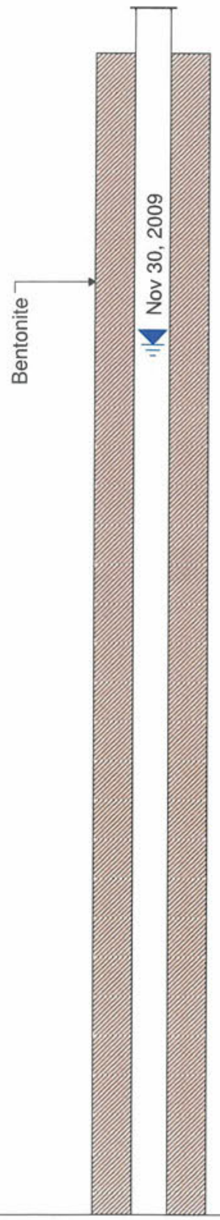
Borehole Number: MW4d

Job Number: 33886-100

Drill Date: May 5, 2009

Depth (m)	Elevation (m)	Soil Description	Symbol	Number	Type	N-Value	Standard Penetration Graph 25 50 75	Headspace (ppm)	Groundwater Observations and Well Details
	370.44 0.00	Ground Elevation							
	361.30 9.14	**PRECAMBRIAN** Metasedimentary Rock							





Reviewed By: WSC

Method: Air Percussion

Notes:

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Sheet: 1 of 3

Client: Freymond Lumber Ltd.

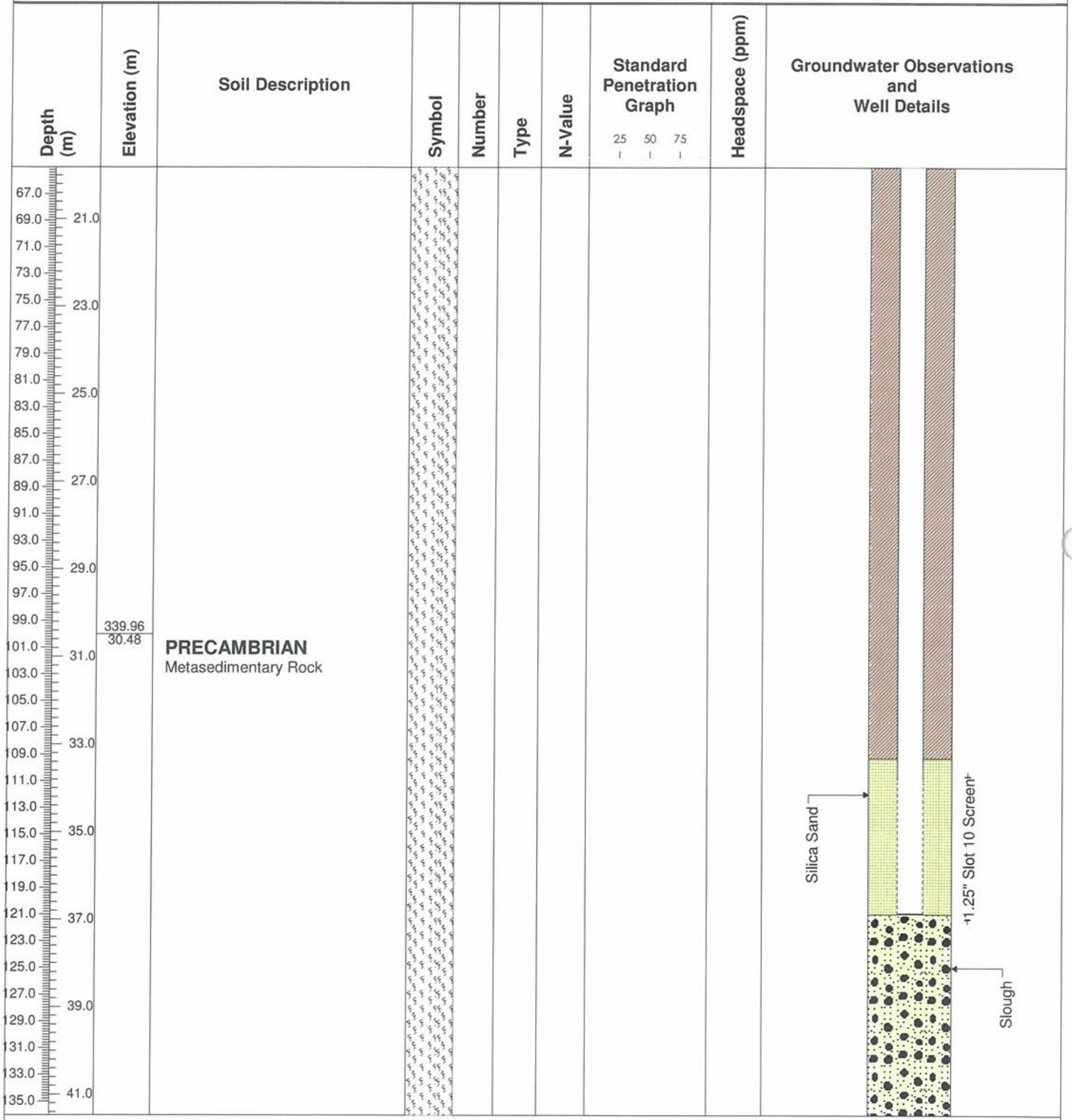
Borehole Number: MW4d

Project: Freymond Quarry

Job Number: 33886-100

Location: Lot 51 & 52, Township of Faraday, Hastings County

Drill Date: May 5, 2009



Reviewed By: WSC

Method: Air Percussion

Notes:

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Sheet: 2 of 3

Client: Freymond Lumber Ltd.

Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW4d

Job Number: 33886-100

Drill Date: May 5, 2009

Depth (m)	Elevation (m)	Soil Description	Symbol	Number	Type	N-Value	Standard Penetration Graph 25 50 75	Headspace (ppm)	Groundwater Observations and Well Details
137.0 139.0	327.77 42.67		▨						▨
141.0 – 43.0 143.0 145.0 147.0 – 45.0 149.0 151.0 153.0 – 47.0 155.0 157.0 159.0 161.0 – 49.0 163.0 165.0 167.0 – 51.0 169.0 171.0 173.0 – 53.0 175.0 177.0 179.0 181.0 – 55.0 183.0 185.0 187.0 – 57.0 189.0 191.0 193.0 – 59.0 195.0 197.0 199.0 – 61.0 201.0 203.0 205.0									

Reviewed By: WSC

Method: Air Percussion

Notes:

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Logged By: MDE

Sheet: 3 of 3

Client: Fowler Construction Company Limited

Project: Freymond Quarry

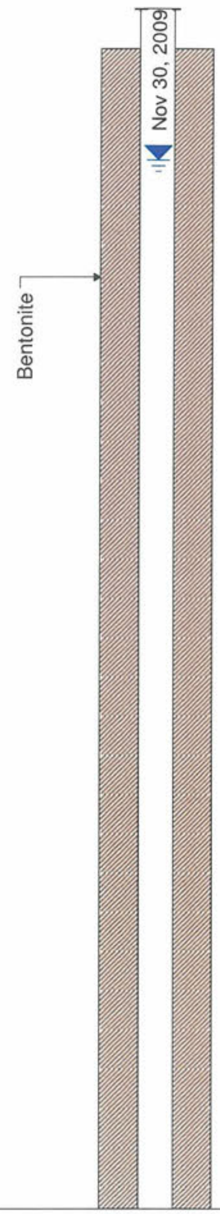
Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW4s

Job Number: 33886-100

Drill Date: May 5, 2009

Depth (m)	Elevation (m)	Soil Description	Symbol	Number	Type	N-Value	Standard Penetration Graph 25 50 75	Headspace (ppm)	Groundwater Observations and Well Details
	369.74 0.00	Ground Elevation							
	360.60 9.14	**PRECAMBRIAN** Metasedimentary Rock							



Reviewed By: WSC

Method: Air Percussion

Notes:

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Logged By: MDE

Sheet: 1 of 2

Client: Fowler Construction Company Limited

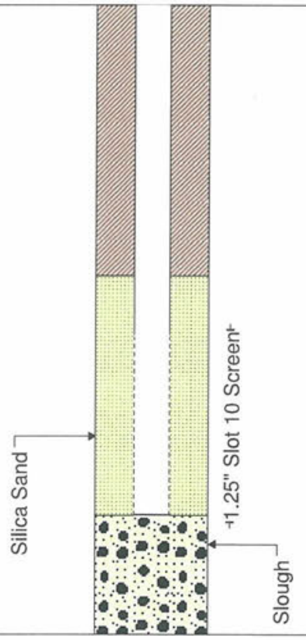
Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW4s

Job Number: 33886-100

Drill Date: May 5, 2009

Depth (m)	Elevation (m)	Soil Description	Symbol	Number	Type	N-Value	Standard Penetration Graph 25 50 75	Headspace (ppm)	Groundwater Observations and Well Details
67.0 69.0 – 21.0 71.0 73.0 75.0 – 23.0 77.0 79.0 81.0 – 25.0 83.0 85.0 87.0 89.0 – 27.0 91.0 93.0 95.0 – 29.0 97.0 99.0	348.40 21.34 339.26 30.48	**PRECAMBRIAN** Metasedimentary Rock							
101.0 – 31.0 103.0 105.0 107.0 109.0 – 33.0 111.0 113.0 115.0 – 35.0 117.0 119.0 121.0 – 37.0 123.0 125.0 127.0 129.0 – 39.0 131.0 133.0 135.0 – 41.0									

Reviewed By: WSC

Method: Air Percussion

Notes:

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Kitchener, Ontario
N2B 3X9
(519) 743-6500

Logged By: MDE

Sheet: 2 of 2

Client: Freymond Lumber Ltd.

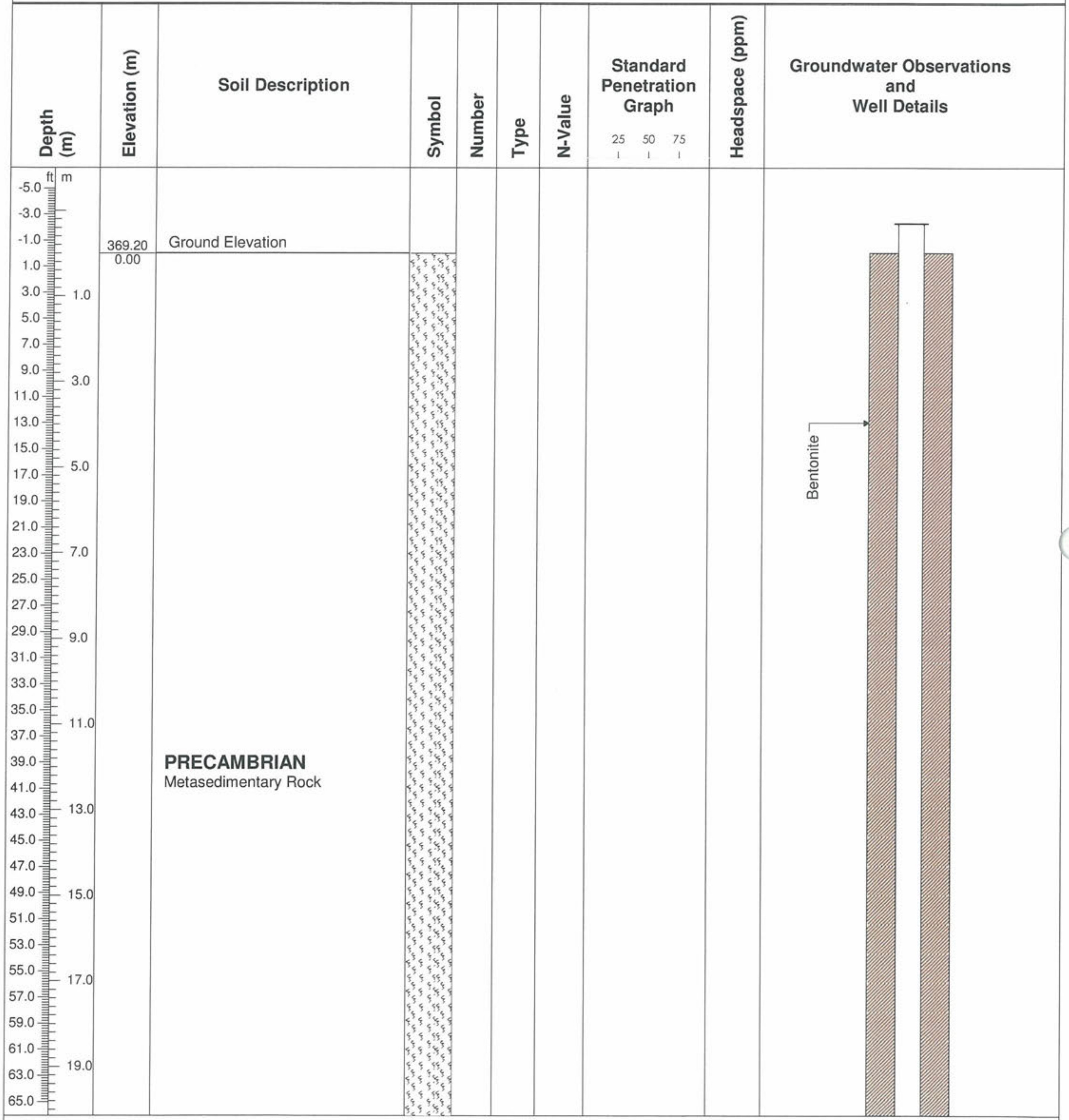
Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW5d

Job Number: 33886-100

Drill Date: May 5, 2009



Reviewed By: WSC

Method: Air Percussion

Notes:

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520 Bingemans Centre Drive
Kitchener, Ontario
N2B 3X9
(519) 743-6500

Logged By: MDE

Sheet: 1 of 2

Client: Freymond Lumber Ltd.

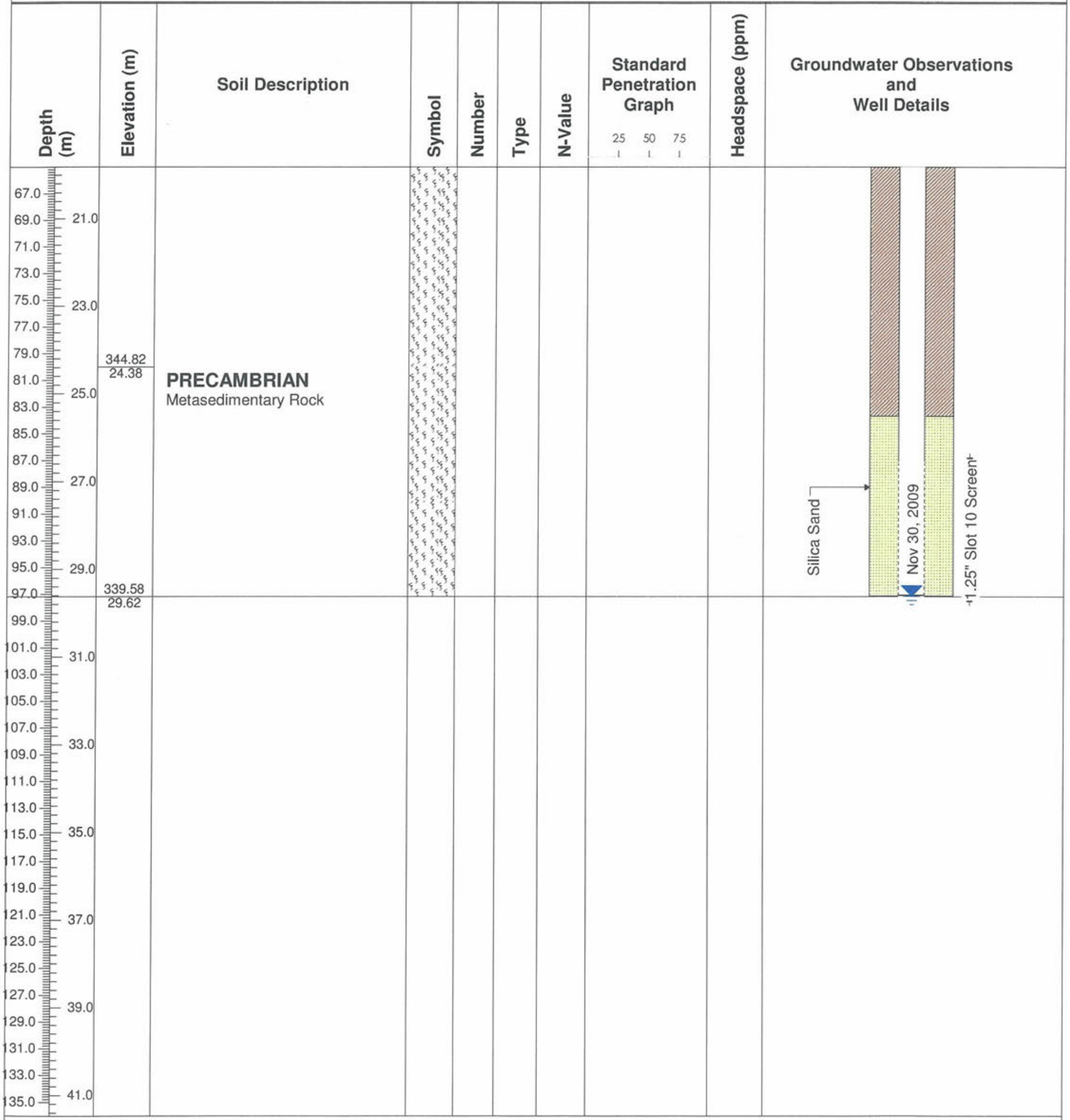
Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW5d

Job Number: 33886-100

Drill Date: May 5, 2009



Reviewed By: WSC

Method: Air Percussion

Notes:

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Kitchener, Ontario
N2B 3X9
(519) 743-6500

Logged By: MDE

Sheet: 2 of 2

Client: Freymond Lumber Ltd.

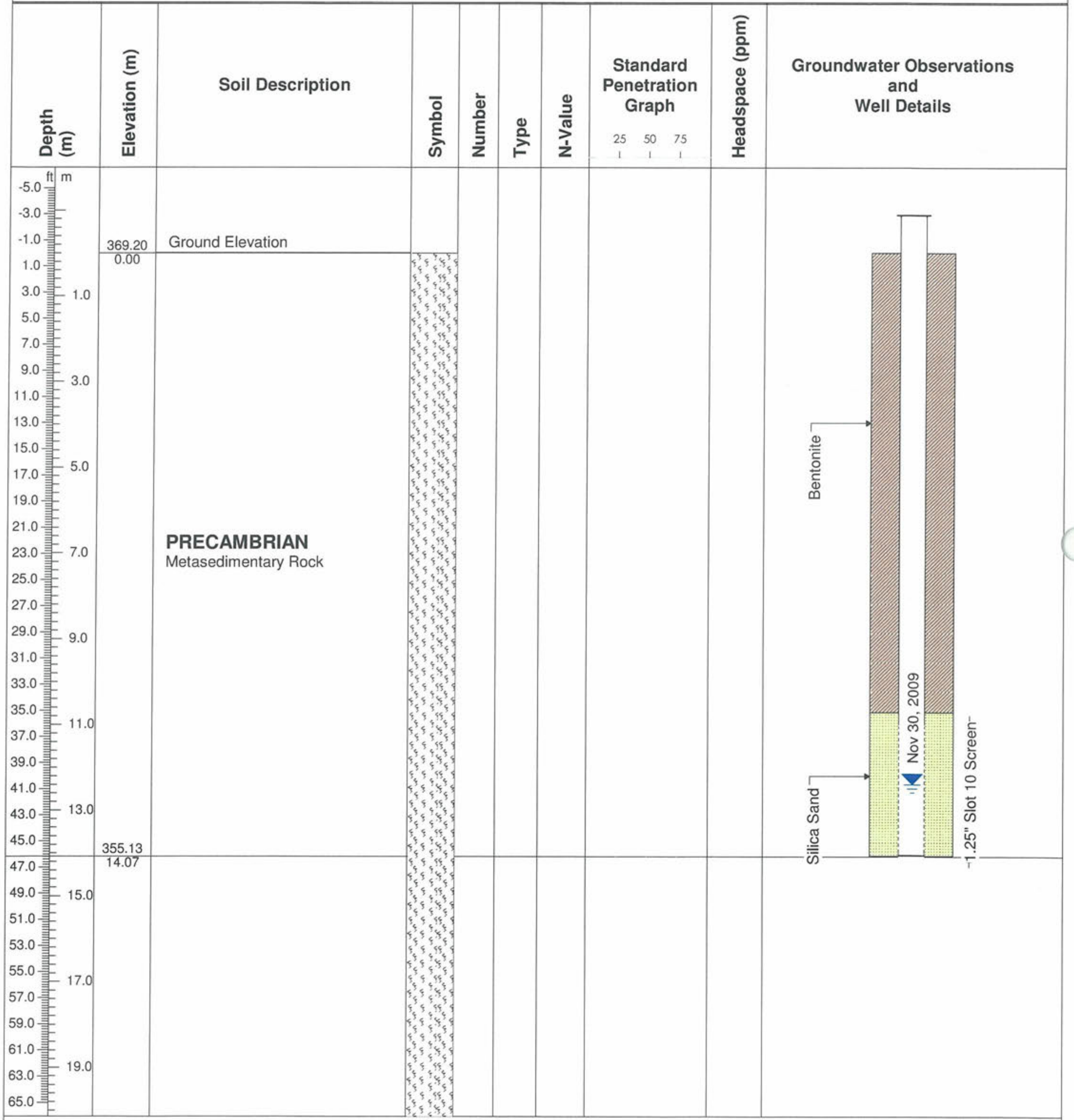
Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW5s

Job Number: 33886-100

Drill Date: May 6, 2009



Reviewed By: WSC

Method: Air Percussion

Notes:

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Logged By: MDE

Sheet: 1 of 1

Client: Freymond Lumber Ltd.

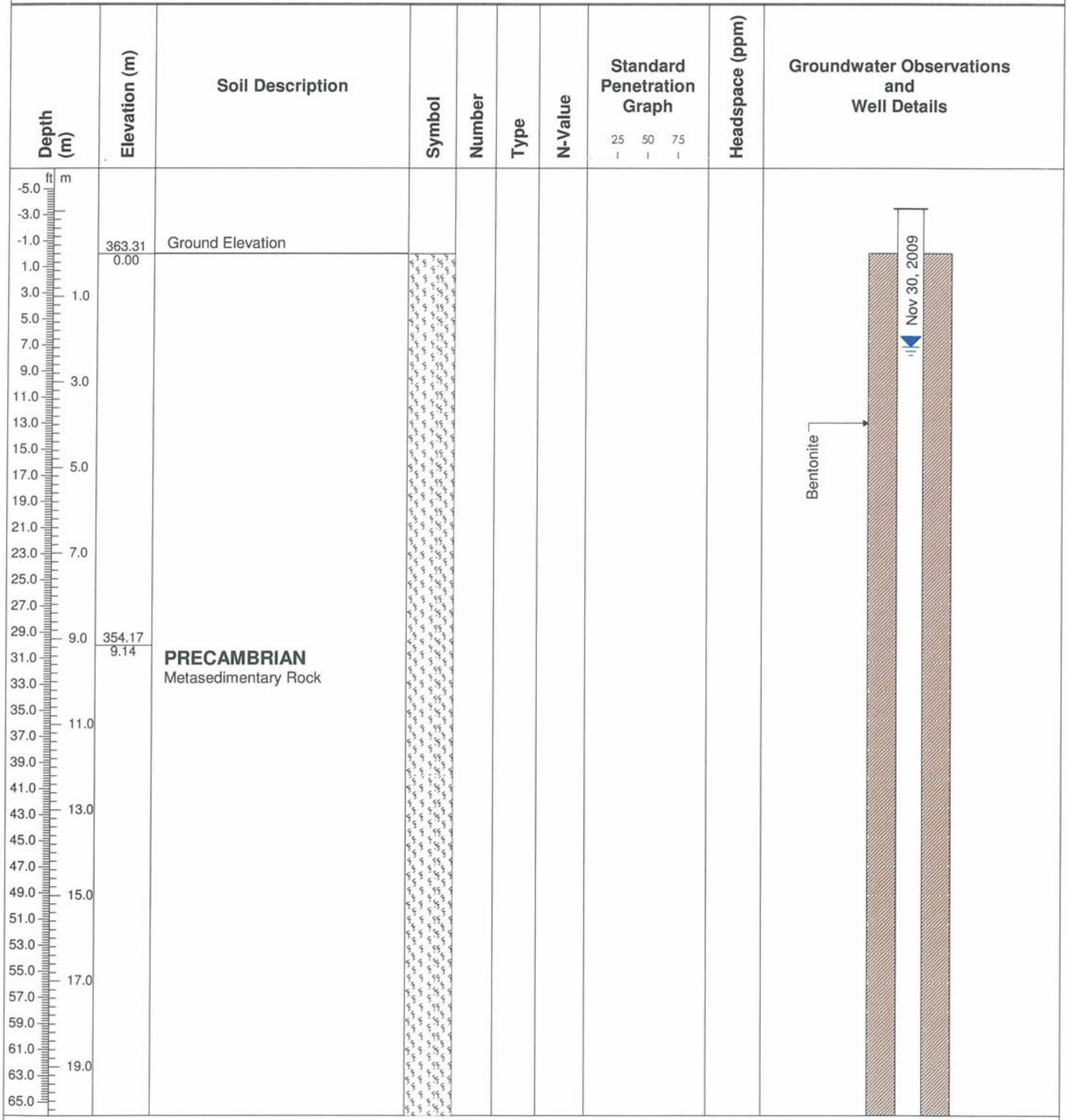
Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW6d

Job Number: 33886-100

Drill Date: May 6, 2009



Reviewed By: WSC

Method: Air Percussion

Notes:

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Kitchener, Ontario
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(519) 743-6500

Logged By: MDE

Sheet: 1 of 3

Client: Freymond Lumber Ltd.

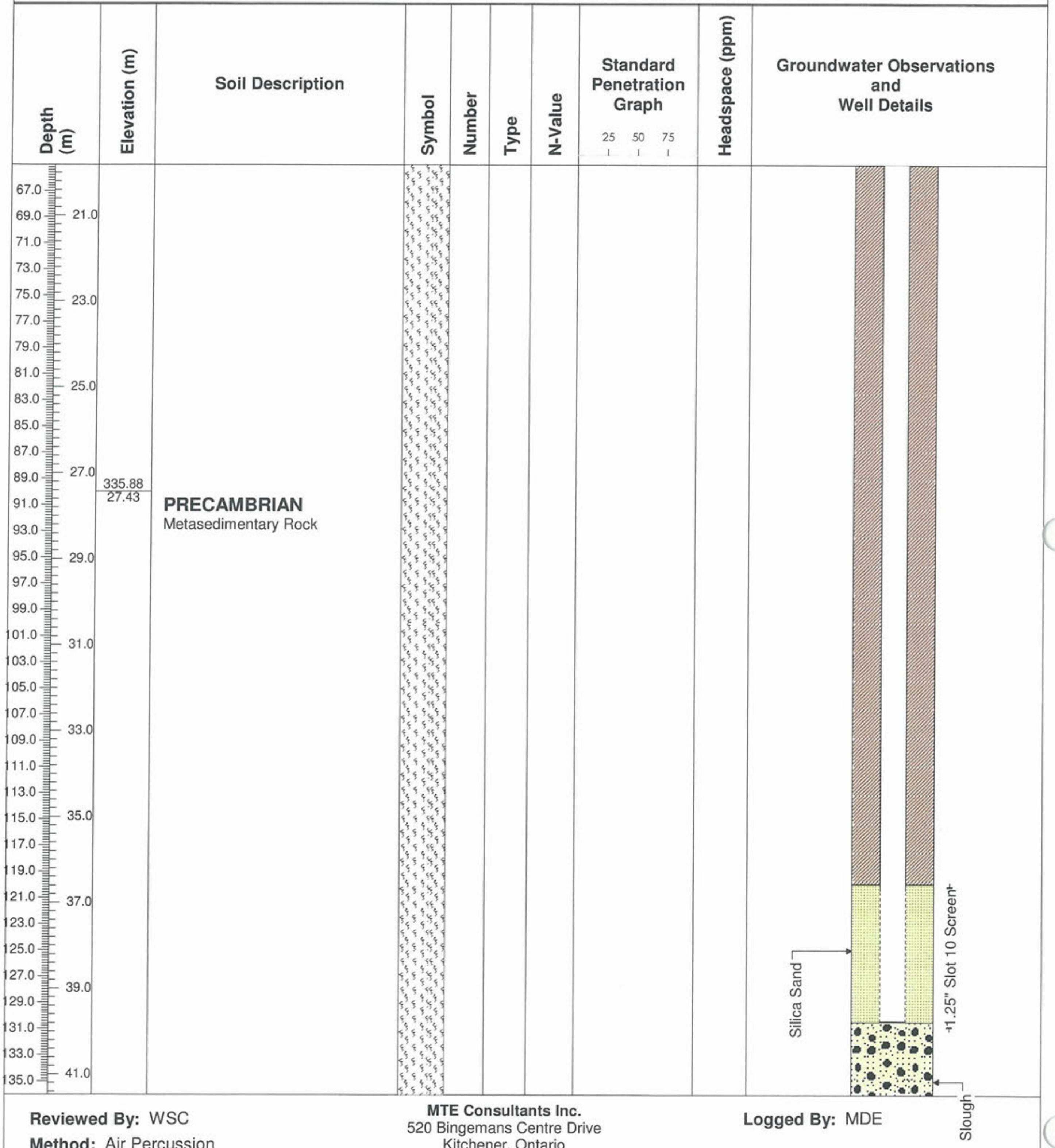
Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW6d

Job Number: 33886-100

Drill Date: May 6, 2009



Reviewed By: WSC

Method: Air Percussion

Notes:

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Logged By: MDE

Sheet: 2 of 3

Client: Freymond Lumber Ltd.

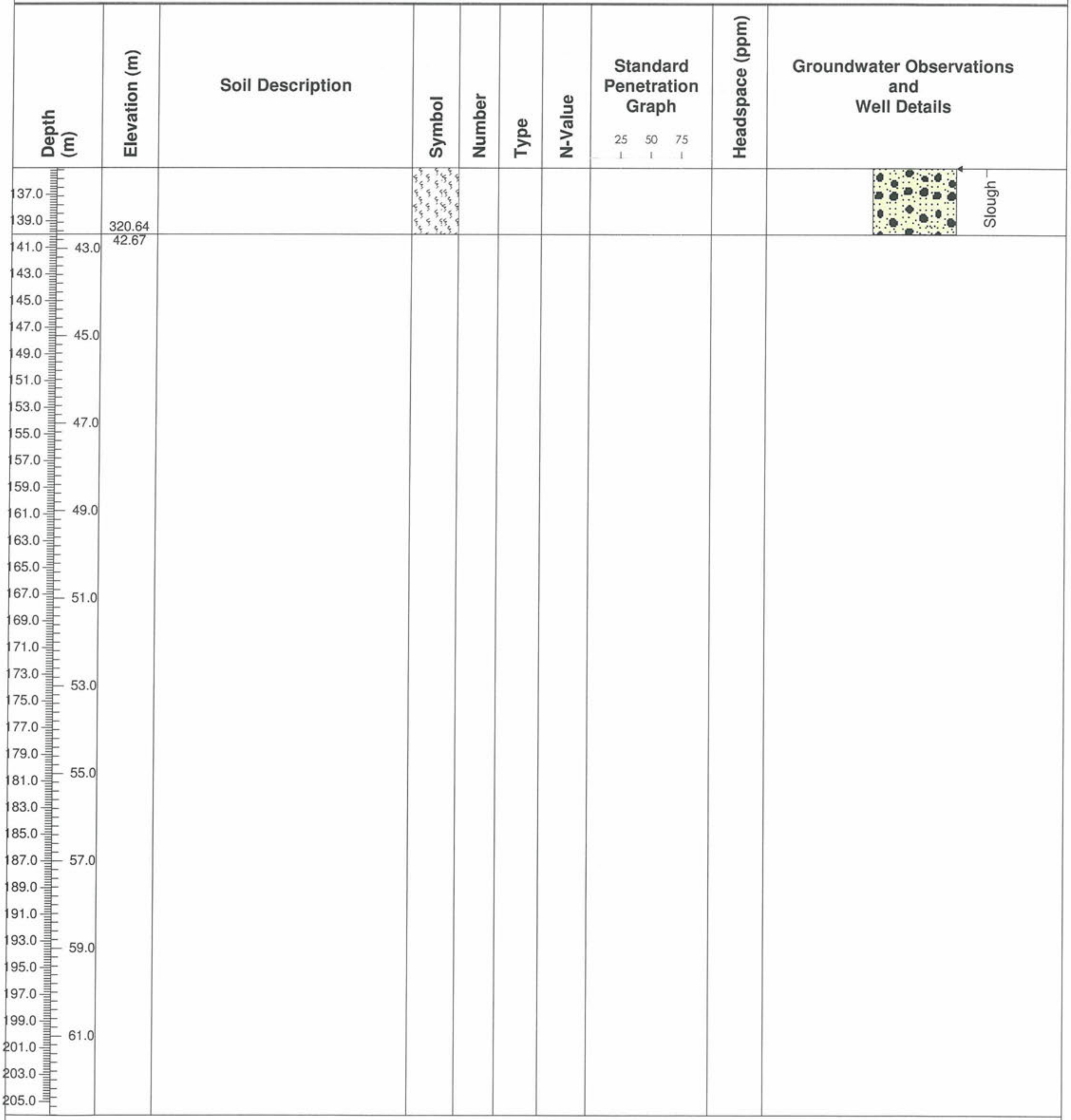
Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW6d

Job Number: 33886-100

Drill Date: May 6, 2009



Reviewed By: WSC

Method: Air Percussion

Notes:

MTE Consultants Inc.
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Kitchener, Ontario
N2B 3X9
(519) 743-6500

Logged By: MDE

Sheet: 3 of 3

Client: Freymond Lumber Ltd.

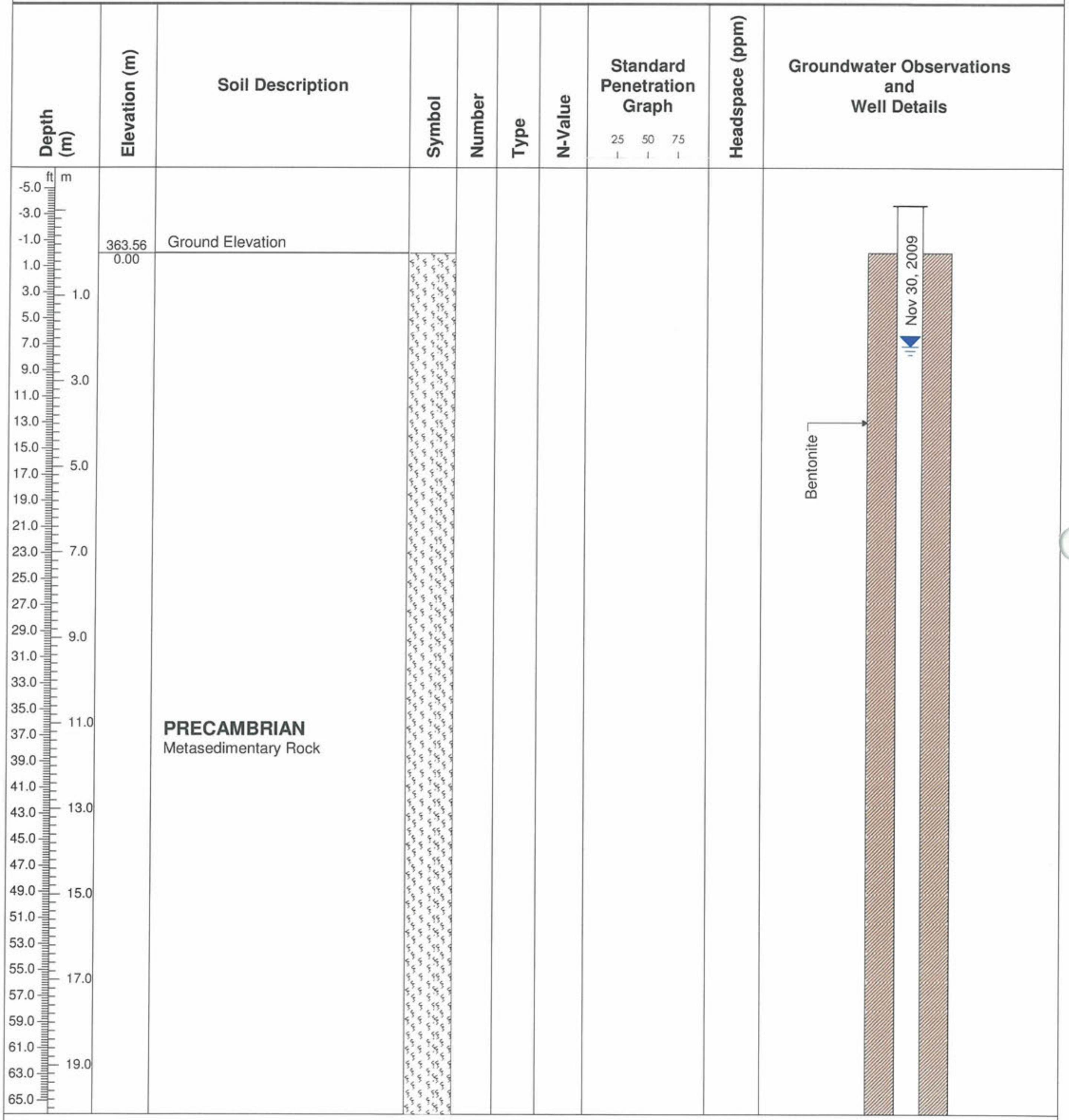
Project: Freymond Quarry

Location: Lot 51 & 52, Township of Faraday, Hastings County

Borehole Number: MW6s

Job Number: 33886-100

Drill Date: May 6, 2009



Reviewed By: WSC

Method: Air Percussion

Notes:

MTE Consultants Inc.
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Kitchener, Ontario
N2B 3X9
(519) 743-6500

Logged By: MDE

Sheet: 1 of 2

Client: Freymond Lumber Ltd.

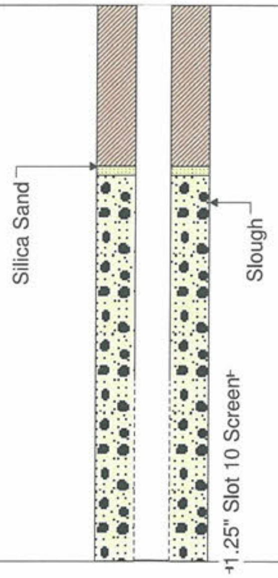
Borehole Number: MW6s

Project: Freymond Quarry

Job Number: 33886-100

Location: Lot 51 & 52, Township of Faraday, Hastings County

Drill Date: May 6, 2009

Depth (m)	Elevation (m)	Soil Description	Symbol	Number	Type	N-Value	Standard Penetration Graph 25 50 75	Headspace (ppm)	Groundwater Observations and Well Details
67.0 69.0 – 21.0 71.0 73.0 75.0 – 23.0	340.70 22.86	**PRECAMBRIAN** Metasedimentary Rock							
77.0 79.0 81.0 – 25.0 83.0 85.0 87.0 89.0 – 27.0 91.0 93.0 95.0 – 29.0	334.30 29.26								
97.0 99.0 101.0 – 31.0 103.0 105.0 107.0 109.0 – 33.0 111.0 113.0 115.0 – 35.0 117.0 119.0 121.0 – 37.0 123.0 125.0 127.0 129.0 – 39.0 131.0 133.0 135.0 – 41.0									

Reviewed By: WSC

Method: Air Percussion

Notes:

MTE Consultants Inc.
520 Bingemans Centre Drive
Kitchener, Ontario
N2B 3X9
(519) 743-6500

Logged By: MDE

Sheet: 2 of 2

APPENDIX C

PRIVATE WELL INVENTORIES

Water Well Inventory – Page 1

33886-100

Resident Name PW1

911 Number ________ Road ________

Address ________

Phone Number ________ email ________

Property Owner: ☒ Yes ☐ No If No, Property Owner's Name ________

Previous Property Owners ________

Number of Wells on property 1 ☐ Don't Know

Type of Well: ☒ Drilled ☐ Dug ☐ Sand Point ☐ Other ________ ☐ Don't Know

Diameter of Well: ☐ 2 inches ☐ 4 inches ☒ 6 inches ☐ 8 inches ☐ 3 feet ☐ Don't Know

Depth of Well 300 ft ☐ Don't Know

Depth to Water 37 ft ☐ Don't Know

Pump Depth 200 ☐ Don't Know

Pump Type Submersible ☐ Don't Know

Water Source: ☒ Bedrock ☐ Sand/Gravel/Overburden ☐ Don't Know

Name of Well Driller Earl V. Marquardt & Son Inc. ☐ Don't Know

Date Installed Nov. 25, 2005 ☐ Don't Know

I have the MOE Water Well Record ☒ Yes ☐ No ☐ Don't Know

MOE Water Well Record Number A032653 ☐ Don't Know

Type of Water Use: ☒ Domestic ☐ Farm ☐ Irrigation ☐ Industrial ☐ Other ________

Water Treatment: ☐ Softener ☐ Sand Filter ☐ Carbon Filter ☒ Fiber Filter ☐ Aluminum Oxide

☐ UV ☐ Reverse Osmosis ☐ Distillation ☐ Ion Exchange ☐ Ozonation

Other Water Treatment ________ ☐ Don't Know

Water Well Inventory – Page 2

33886-100

Condition of Well Casing ☒Good ☐Buried ☐Corroded ☐Seized ☐Broken ☐Don't Know

Other

Any problems with water quantity in the past? ☐Yes ☒No

Any problems with water quality in the past? ☐ Yes ☒No

If yes, what type ? ☐Sulphur smell ☐Iron taste ☐Brown water ☐Bacteria

Other

Location of Septic Bed West end of house

Potential Sources of Contamination: ☐barn ☐manure pile ☐gas tanks ☐heating oil tank

Other

Is the well easily accessible? ☒Yes ☐No

If Yes, may we measure the water level in this well? ☒Yes ☐ No

Describe Well Location East end of house

Sketch a diagram to show the location of well(s), house, buildings, road(s), and septic bed:

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www.wellaware.ca

Water Well Inventory – Page 1

33886-100

Resident Name PW2

911 Number ____________ Road ____________

Address ____________

____

Phone Number ____________ email ____________

Property Owner: ☒ Yes ☐ No If No, Property Owner's Name ____________

Previous Property Owners ____________

Number of Wells on property 2 ☐ Don't Know

Type of Well: ☒ Drilled ☐ Dug ☐ Sand Point ☐ Other and dug ☐ Don't Know

Diameter of Well: ☐ 2 inches ☐ 4 inches ☐ 6 inches ☒ 8 inches ☐ 3 feet ☐ Don't Know

Depth of Well 220 ft ☐ Don't Know

Depth to Water 200 ft ☐ Don't Know

Pump Depth 150 ☐ Don't Know

Pump Type submersible ☐ Don't Know

Water Source: ☒ Bedrock ☐ Sand/Gravel/Overburden ☐ Don't Know

Name of Well Driller Terry Marquardt ☐ Don't Know

Date Installed 1997 ☐ Don't Know

I have the MOE Water Well Record ☐ Yes ☒ No ☐ Don't Know

MOE Water Well Record Number ____________ ☐ Don't Know

Type of Water Use: ☒ Domestic ☐ Farm ☐ Irrigation ☐ Industrial ☐ Other ____________

Water Treatment: ☐ Softener ☐ Sand Filter ☐ Carbon Filter ☐ Fiber Filter ☐ Aluminum Oxide

☐ UV ☐ Reverse Osmosis ☐ Distillation ☐ Ion Exchange ☐ Ozonation

Other Water Treatment ____________ ☐ Don't Know

Water Well Inventory – Page 2

33886-100

Condition of Well Casing ☒Good ☐Buried ☐Corroded ☐Seized ☐Broken ☐Don't Know

Other

Any problems with water quantity in the past? ☐Yes ☒No

Any problems with water quality in the past? ☐ Yes☒No

If yes, what type ? ☐Sulphur smell ☐Iron taste ☐Brown water ☐Bacteria

Other

Location of Septic Bed `north side of house`

Potential Sources of Contamination: ☐barn ☐manure pile ☐gas tanks ☐heating oil tank

Other

Is the well easily accessible? ☒Yes ☐No

If Yes, may we measure the water level in this well? ☒Yes ☐ No

Describe Well Location `south side of house`

Sketch a diagram to show the location of well(s), house, buildings, road(s), and septic bed:

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www.wellaware.ca

Water Well Inventory – Page 1

33886-100

Resident Name PW3

911 Number ______ Road ______

Address ______

Phone Number ______ email ______

Property Owner: ☒ Yes ☐ No If No, Property Owner's Name ______

Previous Property Owners ______

Number of Wells on property 3 ☐ Don't Know

Type of Well: ☒ Drilled ☐ Dug ☐ Sand Point ☐ Other and dug ☐ Don't Know

Diameter of Well: ☐ 2 inches ☐ 4 inches ☒ 6 inches ☐ 8 inches ☐ 3 feet ☐ Don't Know

Depth of Well 182 ft ☐ Don't Know

Depth to Water ______ ☐ Don't Know

Pump Depth ______ ☒ Don't Know

Pump Type ______ ☒ Don't Know

Water Source: ☒ Bedrock ☐ Sand/Gravel/Overburden ☐ Don't Know

Name of Well Driller Marquardt Well Drilling ☐ Don't Know

Date Installed 1991 ☐ Don't Know

I have the MOE Water Well Record ☐ Yes ☐ No ☒ Don't Know

MOE Water Well Record Number ______ ☒ Don't Know

Type of Water Use: ☒ Domestic ☐ Farm ☐ Irrigation ☐ Industrial ☐ Other ______

Water Treatment: ☐ Softener ☐ Sand Filter ☐ Carbon Filter ☐ Fiber Filter ☐ Aluminum Oxide

☐ UV ☐ Reverse Osmosis ☐ Distillation ☐ Ion Exchange ☐ Ozonation

Other Water Treatment ______ ☒ Don't Know

Water Well Inventory – Page 2

33886-100

Condition of Well Casing ☒Good ☐Buried ☐Corroded ☐Seized ☐Broken ☐Don't Know

Other

Any problems with water quantity in the past? ☒Yes ☐No

Any problems with water quality in the past? ☒ Yes ☐No

If yes, what type ? ☐ Sulphur smell ☐ Iron taste ☐Brown water ☒Bacteria

Other from road (oil)

Location of Septic Bed side of house at front on East side

Potential Sources of Contamination: ☐barn ☐manure pile ☐gas tanks ☐heating oil tank

Other

Is the well easily accessible? ☒Yes ☐No

If Yes, may we measure the water level in this well? ☒Yes ☐ No

Describe Well Location well is at the back west side of house

Sketch a diagram to show the location of well(s), house, buildings, road(s), and septic bed:

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www.wellaware.ca

Water Well Inventory – Page 1

33886-100

Resident Name PW4

911 Number ______ Road ______

Address ______

Phone Number ______ email ______

Property Owner: ☒ Yes ☐ No If No, Property Owner's Name ______

Previous Property Owners ______

Number of Wells on property 1 ☐ Don't Know

Type of Well: ☐ Drilled ☐ Dug ☒ Sand Point ☐ Other dug wellpit ☐ Don't Know

Diameter of Well: ☐ 2 inches ☐ 4 inches ☐ 6 inches ☐ 8 inches ☒ 3 feet ☐ Don't Know

Depth of Well 15 ft ☐ Don't Know

Depth to Water 6 ft ☐ Don't Know

Pump Depth 15 ☐ Don't Know

Pump Type ______ ☐ Don't Know

Water Source: ☐ Bedrock ☒ Sand/Gravel/Overburden ☐ Don't Know

Name of Well Driller Charly Hannah (deceased) ☐ Don't Know

Date Installed ~May 1975 ☐ Don't Know

I have the MOE Water Well Record ☐ Yes ☒ No ☐ Don't Know

MOE Water Well Record Number ______ ☐ Don't Know

Type of Water Use: ☒ Domestic ☐ Farm ☐ Irrigation ☐ Industrial ☒ Other no drinking

Water Treatment: ☐ Softener ☐ Sand Filter ☐ Carbon Filter ☐ Fiber Filter ☐ Aluminum Oxide

☐ UV ☐ Reverse Osmosis ☐ Distillation ☐ Ion Exchange ☐ Ozonation

Other Water Treatment treated yearly with chlorine ☐ Don't Know

Water Well Inventory – Page 2

33886-100

Condition of Well Casing ☐Good ☒Buried ☐Corroded ☐Seized ☐Broken ☐Don't Know

Other 1/4 above ground tile

Any problems with water quantity in the past? ☐Yes ☒No

Any problems with water quality in the past? ☐ Yes ☒No

If yes, what type ? ☐ Sulphur smell ☐ Iron taste ☐ Brown water ☒ Bacteria

Other vegitation Tree roots?

Location of Septic Bed 10 feet behind house on the right side

Potential Sources of Contamination: ☐ barn ☐ manure pile ☐ gas tanks ☐ heating oil tank

Other put in legally (Hawley)

Is the well easily accessible? ☒ Yes ☐ No

If Yes, may we measure the water level in this well? ☒ Yes ☐ No

Describe Well Location left hand of cottage in line of pump about 30 feet from house.

Sketch a diagram to show the location of well(s), house, buildings, road(s), and septic bed:

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Water Well Inventory – Page 1

33886-100

Resident Name PW5

911 Number ______ Road ______

Address ______

Phone Number ______ email ______

Property Owner: ☒ Yes ☐ No If No, Property Owner's Name ______

Previous Property Owners ______

Number of Wells on property 1 ☐ Don't Know

Type of Well: ☒ Drilled ☐ Dug ☐ Sand Point ☐ Other ______ ☐ Don't Know

Diameter of Well: ☐ 2 inches ☐ 4 inches ☒ 6 inches ☐ 8 inches ☐ 3 feet ☐ Don't Know

Depth of Well ______ ☒ Don't Know

Depth to Water ______ ☒ Don't Know

Pump Depth ______ ☒ Don't Know

Pump Type ______ ☒ Don't Know

Water Source: ☐ Bedrock ☒ Sand/Gravel/Overburden ☐ Don't Know

Name of Well Driller Terry Marquardt ☐ Don't Know

Date Installed 2001? ☐ Don't Know

I have the MOE Water Well Record ☐ Yes ☒ No ☐ Don't Know

MOE Water Well Record Number ______ ☒ Don't Know

Type of Water Use: ☒ Domestic ☐ Farm ☐ Irrigation ☐ Industrial ☐ Other ______

Water Treatment: ☐ Softener ☒ Sand Filter ☐ Carbon Filter ☐ Fiber Filter ☐ Aluminum Oxide

☐ UV ☐ Reverse Osmosis ☐ Distillation ☐ Ion Exchange ☐ Ozonation

Other Water Treatment ______ ☐ Don't Know

Water Well Inventory – Page 2

33886-100

Condition of Well Casing ☒Good ☐Buried ☐Corroded ☐Seized ☐Broken ☐Don't Know

Other ____________________

Any problems with water quantity in the past? ☐Yes ☒No

Any problems with water quality in the past? ☐ Yes ☒No

If yes, what type ? ☐Sulphur smell ☐Iron taste ☐Brown water ☐Bacteria

Other ____________________

Location of Septic Bed ____________________

Potential Sources of Contamination: ☐barn ☐manure pile ☐gas tanks ☐heating oil tank

Other ____________________

Is the well easily accessible? ☒Yes ☐No

If Yes, may we measure the water level in this well? ☒Yes ☐ No

Describe Well Location `Lower driveway next to lawn`

Sketch a diagram to show the location of well(s), house, buildings, road(s), and septic bed:

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Water Well Inventory – Page 1

33886-100

Resident Name PW6

911 Number ____________ Road ____________

Address ____________

____

Phone Number ____________ email ____________

Property Owner: ☒ Yes ☐ No If No, Property Owner's Name ____________

Previous Property Owners ____________

Number of Wells on property 1 ☐ Don't Know

Type of Well: ☒ Drilled ☐ Dug ☐ Sand Point ☐ Other ____________ ☐ Don't Know

Diameter of Well: ☐ 2 inches ☐ 4 inches ☐ 6 inches ☒ 8 inches ☐ 3 feet ☐ Don't Know

Depth of Well ____________ ☒ Don't Know

Depth to Water ____________ ☒ Don't Know

Pump Depth ____________ ☒ Don't Know

Pump Type ____________ ☒ Don't Know

Water Source: ☐ Bedrock ☒ Sand/Gravel/Overburden ☐ Don't Know

Name of Well Driller ____________ ☒ Don't Know

Date Installed ____________ ☒ Don't Know

I have the MOE Water Well Record ☐ Yes ☒ No ☐ Don't Know

MOE Water Well Record Number ____________ ☐ Don't Know

Type of Water Use: ☒ Domestic ☐ Farm ☐ Irrigation ☐ Industrial ☐ Other ____________

Water Treatment: ☐ Softener ☐ Sand Filter ☐ Carbon Filter ☐ Fiber Filter ☐ Aluminum Oxide

☐ UV ☐ Reverse Osmosis ☐ Distillation ☐ Ion Exchange ☐ Ozonation

Other Water Treatment Sand Filter ☐ Don't Know

Water Well Inventory – Page 2

33886-100

Condition of Well Casing ☒ Good ☐ Buried ☐ Corroded ☐ Seized ☐ Broken ☐ Don't Know

Other ______

Any problems with water quantity in the past? ☐ Yes ☒ No

Any problems with water quality in the past? ☐ Yes ☒ No

If yes, what type ? ☐ Sulphur smell ☐ Iron taste ☐ Brown water ☐ Bacteria

Other ______

Location of Septic Bed ______

Potential Sources of Contamination: ☐ barn ☐ manure pile ☐ gas tanks ☐ heating oil tank

Other ______

Is the well easily accessible? ☒ Yes ☐ No

If Yes, may we measure the water level in this well? ☒ Yes ☐ No

Describe Well Location Behind house, next to pool house

Sketch a diagram to show the location of well(s), house, buildings, road(s), and septic bed:

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APPENDIX D

AQUIFER TEST DATA SHEETS

MTE Consultants Inc.
520 Bingemans Centre Dr.
Kitchener, ON N2B 3X9

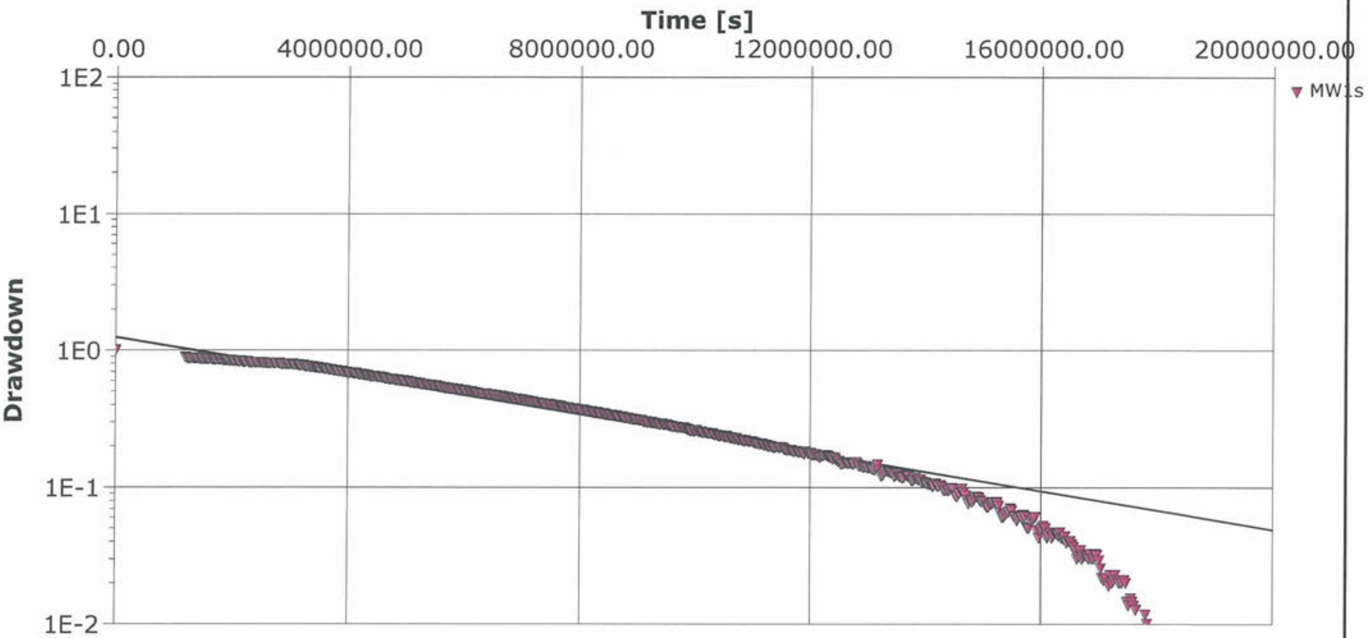
Slug Test Analysis Report

Project: Freymond Quarry

Number: 33886-100

Client: Freymond Quarry

Location: Lot 51&52, Con.WHR, Twn.Faraday	Slug Test: MW1s	Test Well: MW1s
Test Conducted by:		Test Date: 2/2/2010
Analysis Performed by:	Hvorslev	Analysis Date: 2/2/2010
Aquifer Thickness: 11.03 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW1s	7.19×10^{-11}	

MTE Consultants Inc.
520 Bingemans Centre Dr.
Kitchener, ON N2B 3X9

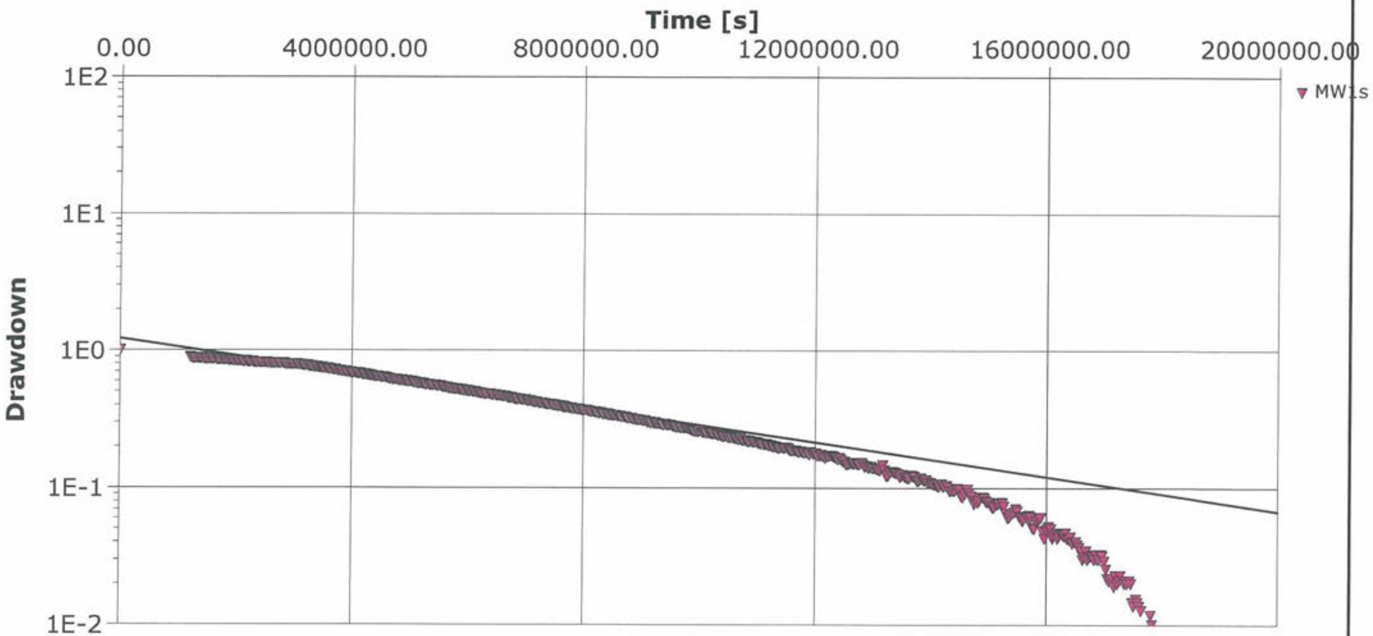
Slug Test Analysis Report

Project: Freymond Quarry

Number: 33886-100

Client: Freymond Quarry

Location: Lot 51&52, Con.WHR, Twn.Faraday	Slug Test: MW1s	Test Well: MW1s
Test Conducted by:		Test Date: 2/2/2010
Analysis Performed by:	Bouwer & Rice	Analysis Date: 2/2/2010
Aquifer Thickness: 11.03 m		



Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/s]	
MW1s	4.90×10^{-11}	

MTE Consultants Inc.
520 Bingemans Centre Dr.
Kitchener, ON N2B 3X9

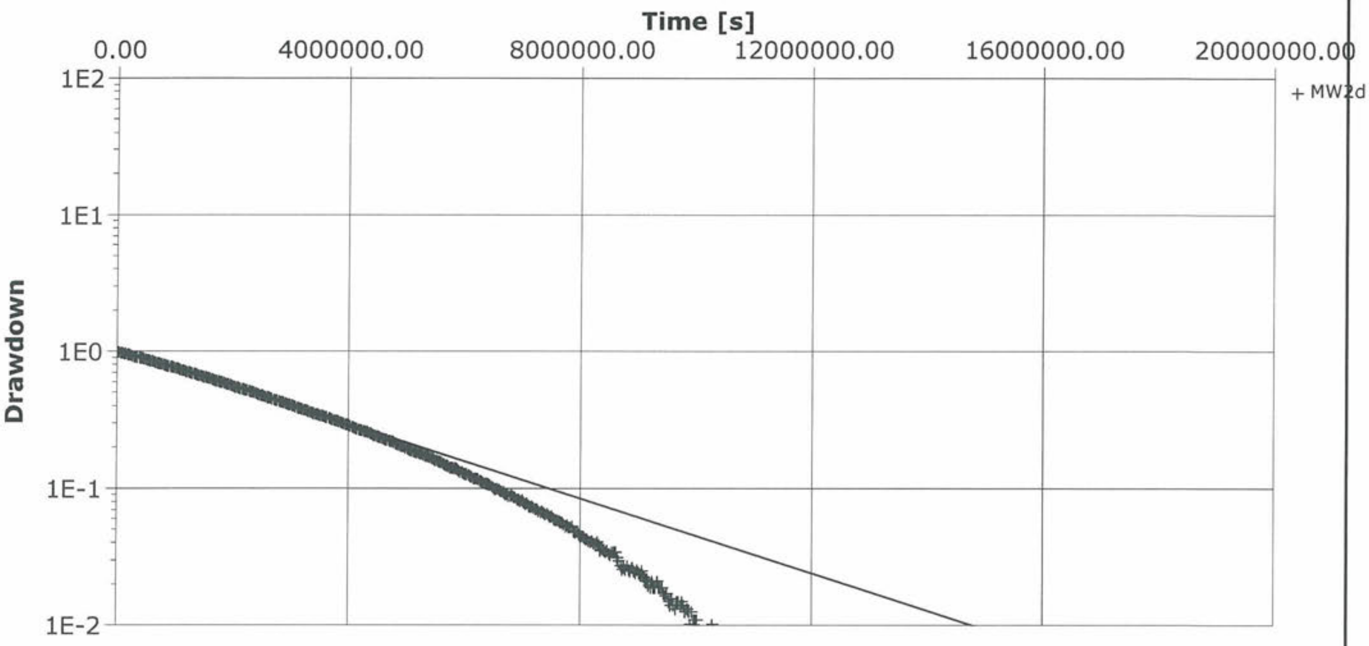
Slug Test Analysis Report

Project: Freymond Quarry

Number: 33886-100

Client: Freymond Quarry

Location: Lot 51&52, Con.WHR, Twn.Faraday	Slug Test: MW2d Recovery	Test Well: MW2d
Test Conducted by: MDE		Test Date: 2/2/2010
Analysis Performed by:	Bouwer & Rice	Analysis Date: 2/2/2010
Aquifer Thickness: 19.28 m		



Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/s]	
MW2d	5.04×10^{-11}	

MTE Consultants Inc.
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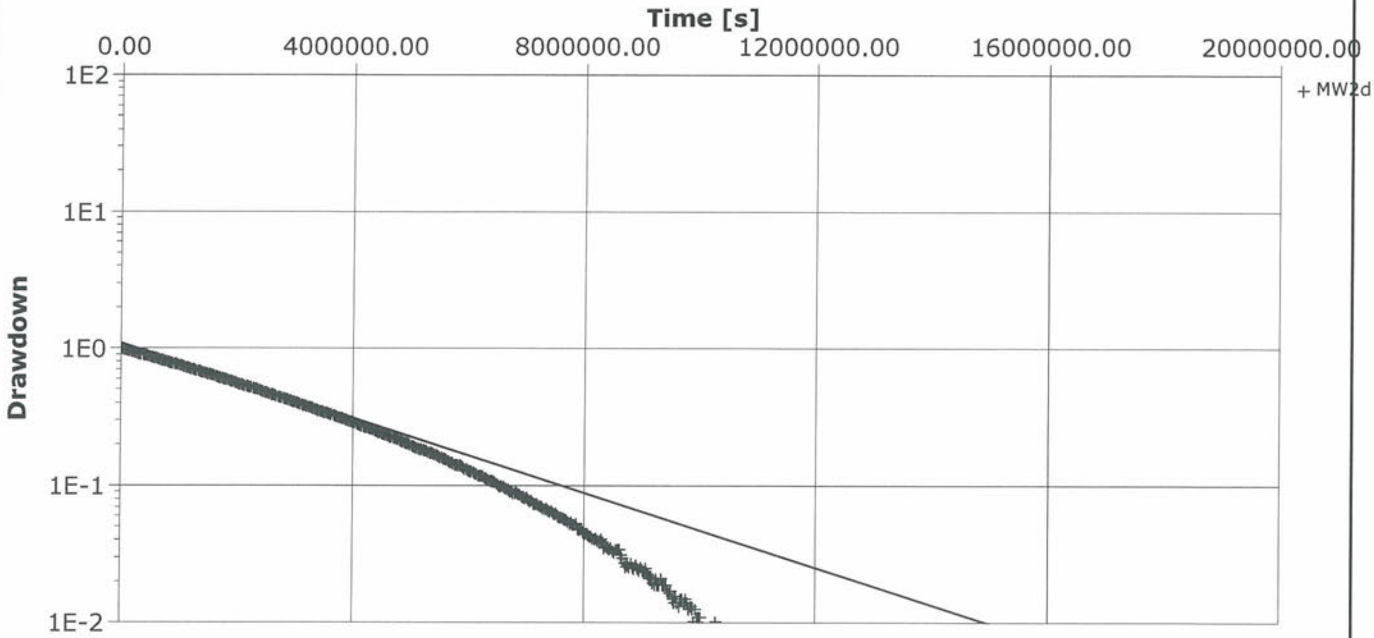
Slug Test Analysis Report

Project: Freymond Quarry

Number: 33886-100

Client: Freymond Quarry

Location: Lot 51&52, Con.WHR, Twn.Faraday	Slug Test: MW2d Recovery	Test Well: MW2d
Test Conducted by: MDE		Test Date: 2/2/2010
Analysis Performed by:	Hvorslev	Analysis Date: 5/26/2010
Aquifer Thickness: 19.28 m		



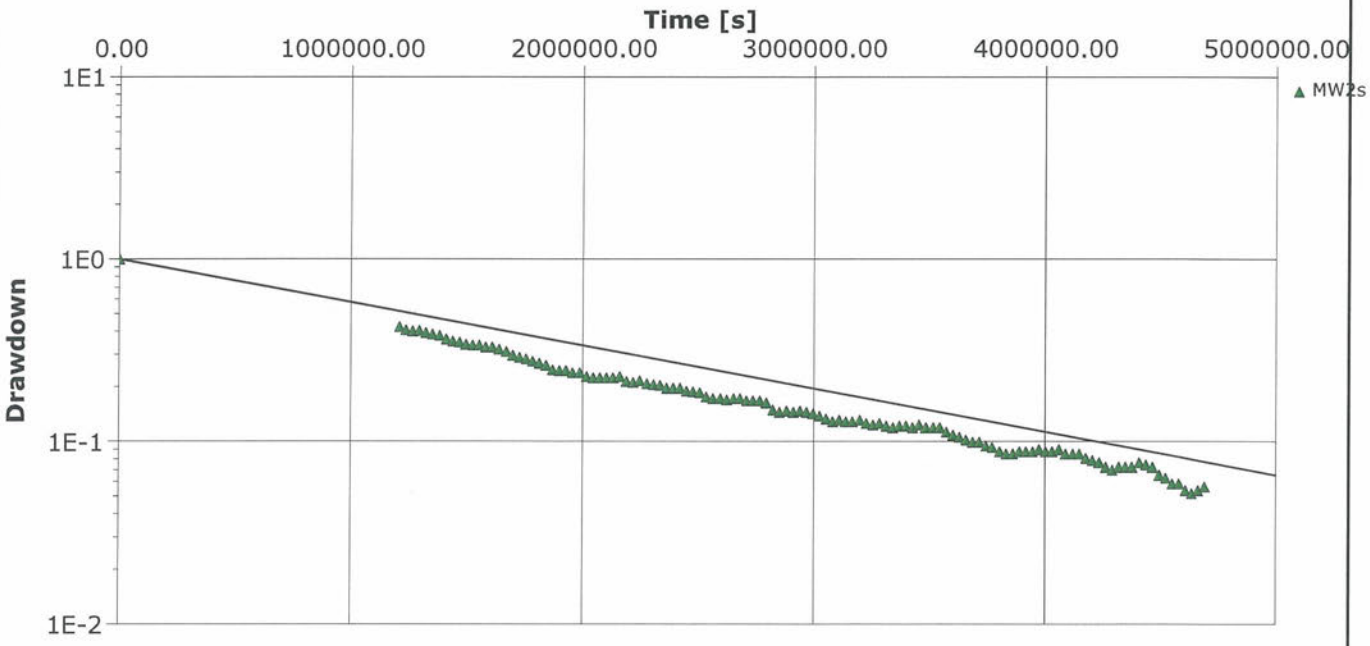
Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW2d	6.53×10^{-11}	

MTE Consultants Inc.
520 Bingemans Centre Dr.
Kitchener, ON N2B 3X9

Slug Test Analysis Report	
Project: Freymond Quarry	
Number: 33886-100	
Client: Freymond Quarry	

Location: Lot 51&52, Con.WHR, Twn.Faraday	Slug Test: MW2s (long)	Test Well: MW2s
Test Conducted by:		Test Date: 2/4/2010
Analysis Performed by:	Hvorslev	Analysis Date: 2/4/2010
Aquifer Thickness: 5.07 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW2s	2.56×10^{-10}	

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Slug Test Analysis Report

Project: Freymond Quarry

Number: 33886-100

Client: Freymond Quarry

Location: Lot 51&52, Con.WHR, Twn.Faraday

Slug Test: MW2s (long)

Test Well: MW2s

Test Conducted by:

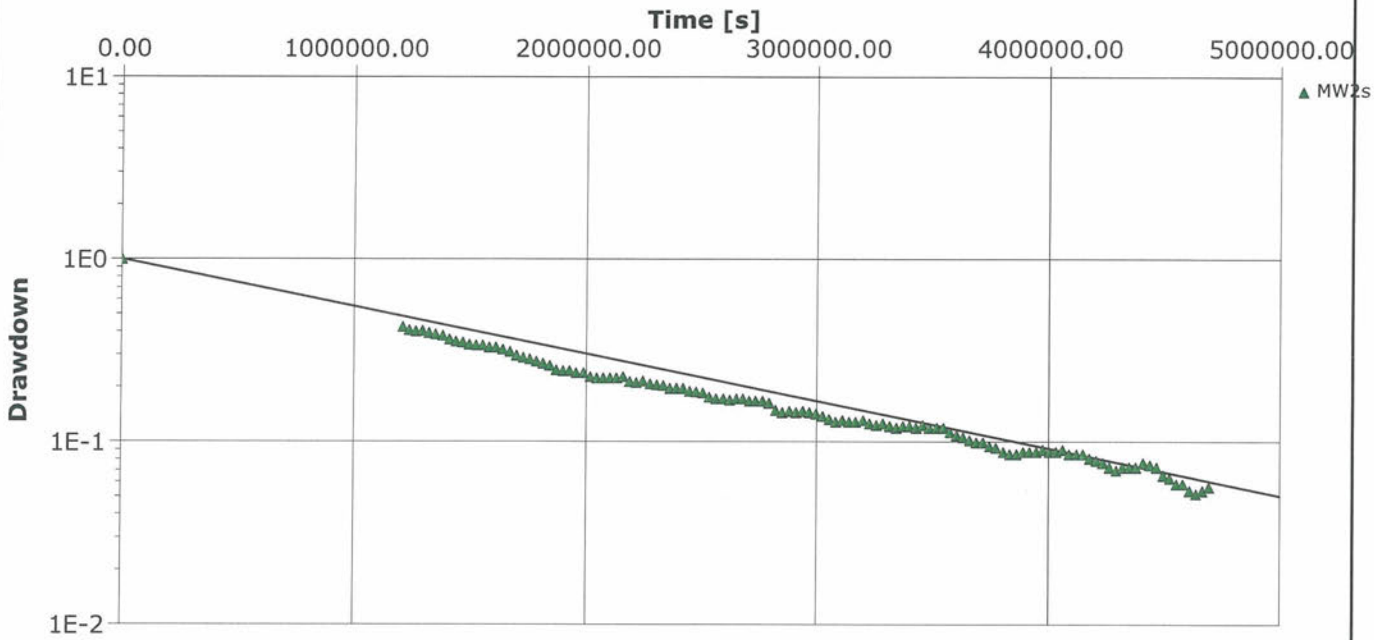
Test Date: 2/4/2010

Analysis Performed by:

Bouwer & Rice

Analysis Date: 2/4/2010

Aquifer Thickness: 5.07 m



Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/s]
MW2s	2.13×10^{-10}

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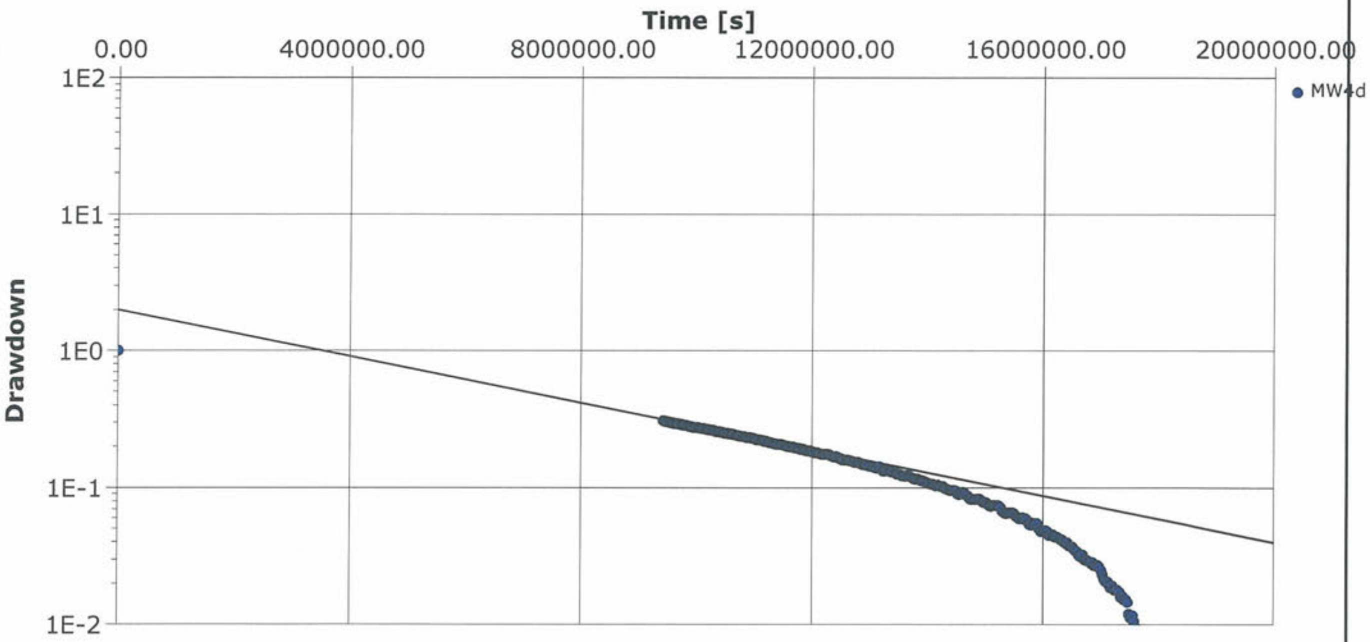
Slug Test Analysis Report

Project: Freymond Quarry

Number: 33886-100

Client: Freymond Quarry

Location: Lot 51&52, Con.WHR, Twn.Faraday	Slug Test: MW4d Recovery	Test Well: MW4d
Test Conducted by:		Test Date: 2/2/2010
Analysis Performed by:	Hvorslev	Analysis Date: 2/2/2010
Aquifer Thickness: 30.38 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]
MW4d	8.91×10^{-11}

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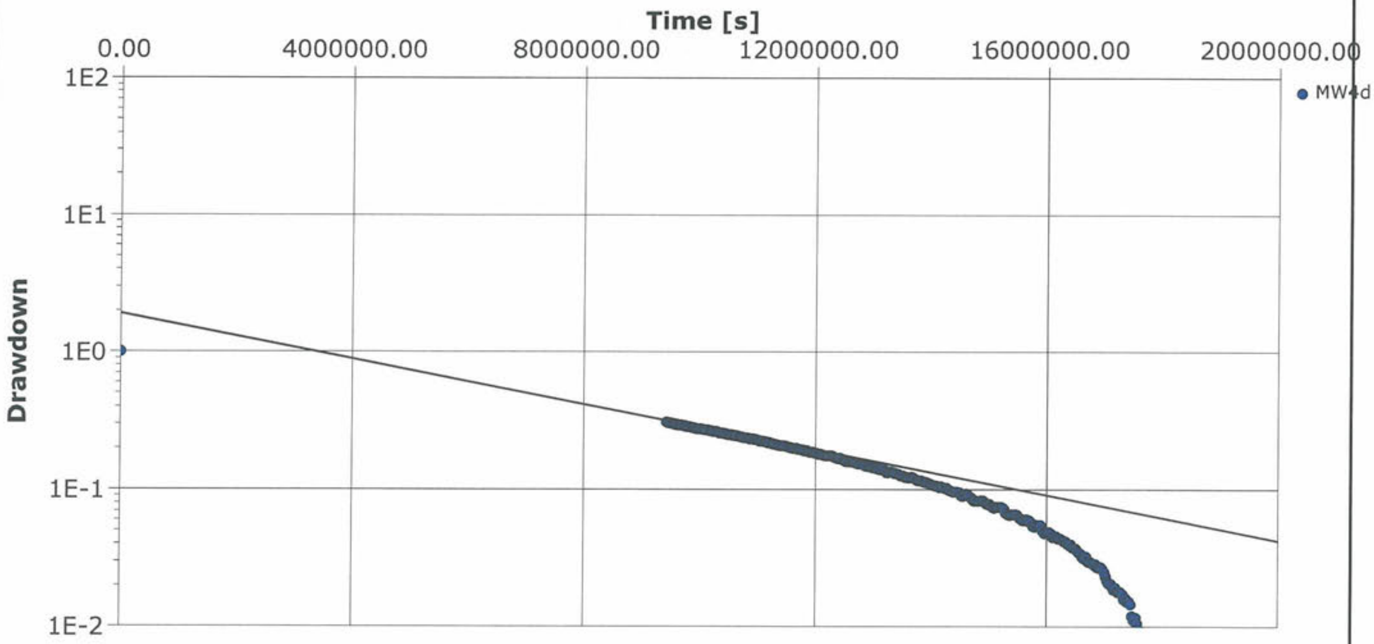
Slug Test Analysis Report	
Project: Freymond Quarry	
Number: 33886-100	
Client: Freymond Quarry	

Location: Lot 51&52, Con.WHR, Twn.Faraday	Slug Test: MW4d Recovery	Test Well: MW4d
Test Conducted by:		Test Date: 2/2/2010
Analysis Performed by:	Bouwer & Rice	Analysis Date: 2/2/2010
Aquifer Thickness: 30.38 m		



Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/s]	
MW4d	6.61×10^{-11}	

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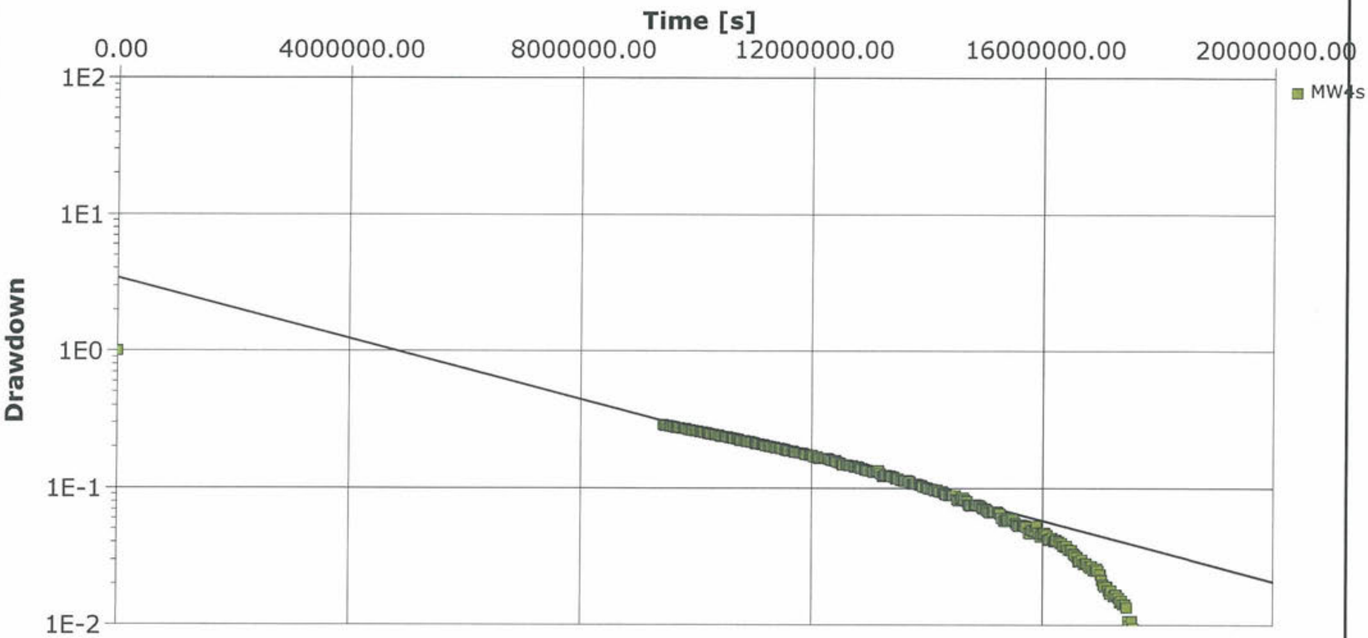
Slug Test Analysis Report

Project: Freymond Quarry

Number: 33886-100

Client: Freymond Quarry

Location: Lot 51&52, Con.WHR, Twn.Faraday	Slug Test: MW4s	Test Well: MW4s
Test Conducted by:		Test Date: 2/2/2010
Analysis Performed by:	Hvorslev	Analysis Date: 2/2/2010
Aquifer Thickness: 25.39 m		

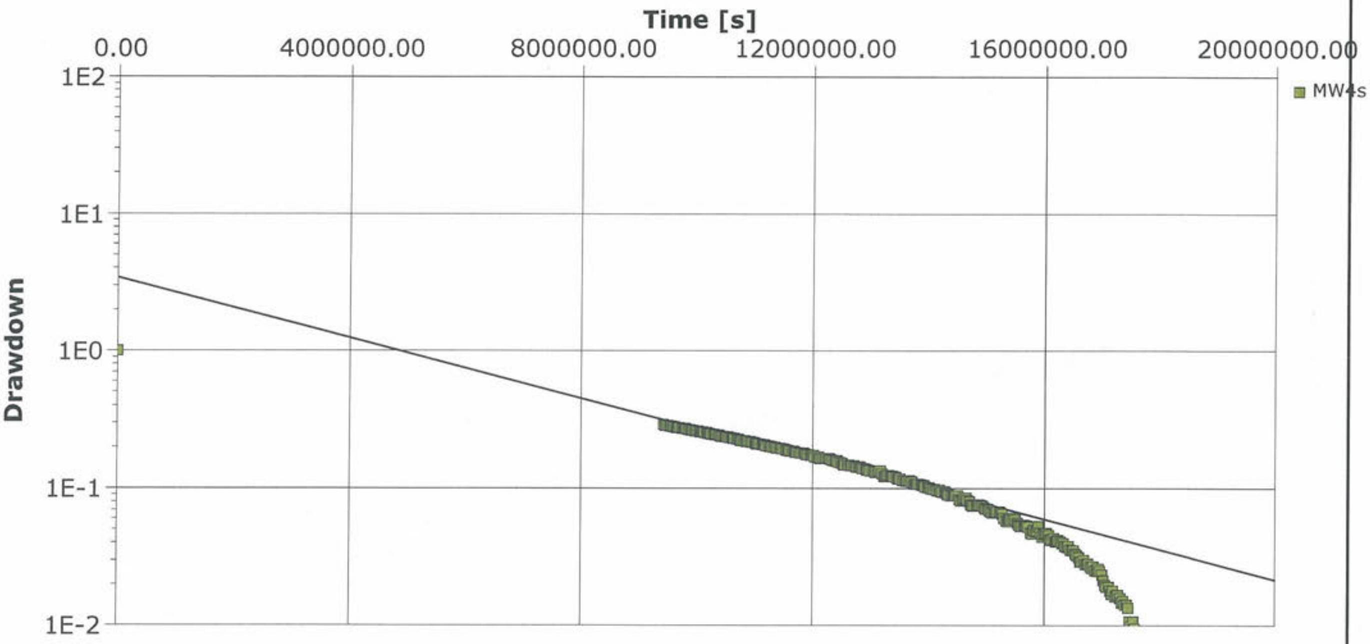


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW4s	1.06×10^{-10}	

MTE Consultants Inc. 520 Bingemans Centre Dr. Kitchener, ON N2B 3X9	**Slug Test Analysis Report**
	Project: Freymond Quarry
	Number: 33886-100
	Client: Freymond Quarry

Location: Lot 51&52, Con.WHR, Twn.Faraday	Slug Test: MW4s	Test Well: MW4s
Test Conducted by:		Test Date: 2/2/2010
Analysis Performed by:	Bouwer & Rice	Analysis Date: 2/2/2010
Aquifer Thickness: 25.39 m		

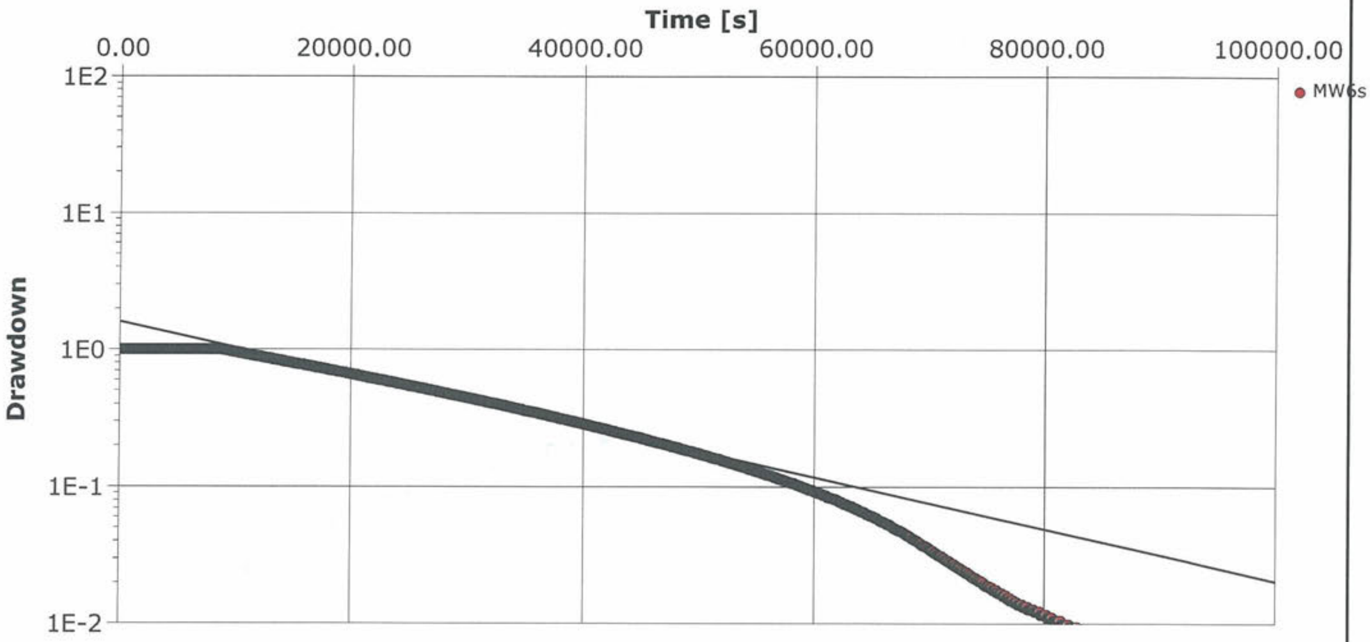


Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/s]	
MW4s	8.02×10^{-11}	

MTE Consultants Inc. 520 Bingemans Centre Dr. Kitchener, ON N2B 3X9	**Slug Test Analysis Report**
	Project: Freymond Quarry
	Number: 33886-100
	Client: Freymond Quarry

Location: Lot 51&52, Con.WHR, Twn.Faraday	Slug Test: MW6s Rcvry	Test Well: MW6s
Test Conducted by: ME/BC		Test Date: 6/3/2009
Analysis Performed by:	Hvorslev	Analysis Date: 6/3/2009
Aquifer Thickness: 26.25 m		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [m/s]	
MW6s	1.21×10^{-8}	

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Slug Test Analysis Report

Project: Freymond Quarry

Number: 33886-100

Client: Freymond Quarry

Location: Lot 51&52, Con.WHR, Twn.Faraday

Slug Test: MW6s Rcvry

Test Well: MW6s

Test Conducted by: ME/BC

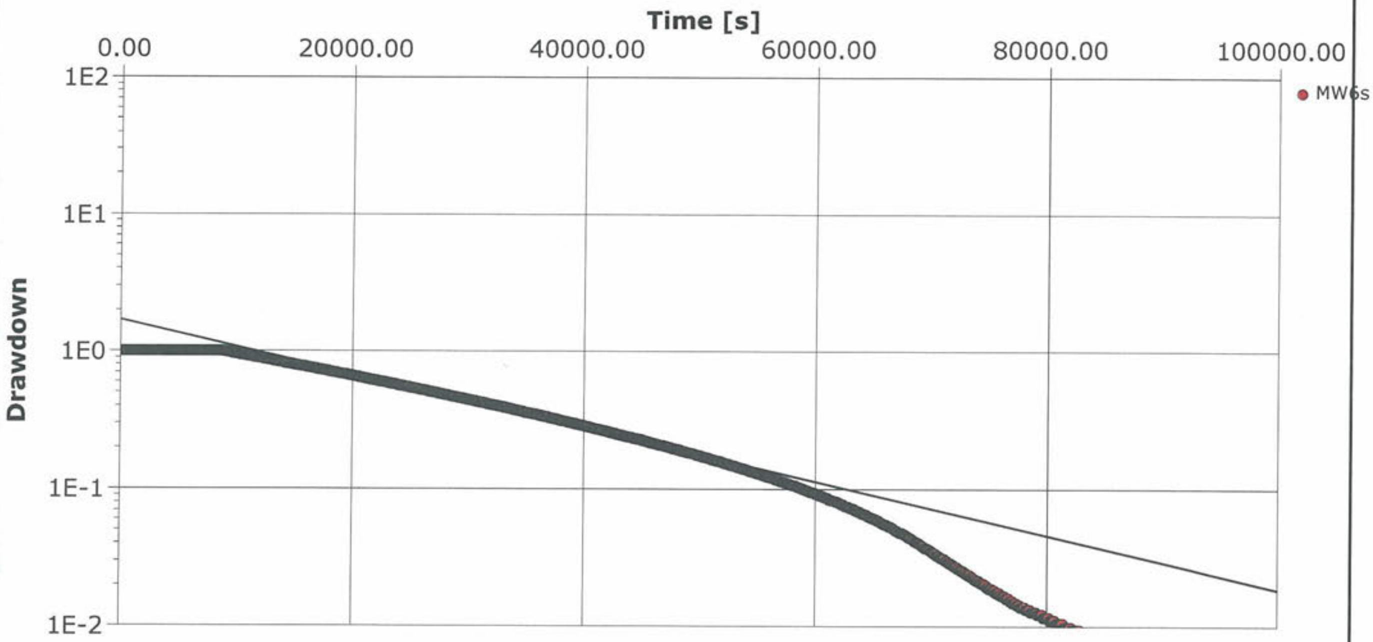
Test Date: 6/3/2009

Analysis Performed by:

Bouwer & Rice

Analysis Date: 2/2/2010

Aquifer Thickness: 26.25 m



Calculation using Bouwer & Rice

Observation Well	Hydraulic Conductivity [m/s]
MW6s	9.64×10^{-9}

APPENDIX E

THEIS CALCULATIONS

Table E1: Theis Calculations - Freymond Proposed Quarry

Aquifer parameters and Pumping Rate

K	1.14E-10	m/s
S	0.00005	
b	43.2	m
Q	3.47E-07	m^3/sec
Q	0.03	m^3/day
T	4.26E-04	m^3/day

Values of u (r,t)						
t (days)	r(m)--->	1	10	50	100	195
1		0.029377015	2.93770155	73.44253875	293.770	1117.061
5		0.005875403	0.58754031	14.68850775	58.754	223.412
10		0.002937702	0.293770155	7.34425387	29.377	111.706
30		0.000979234	0.097923385	2.44808462	9.792	37.235
40		0.000734425	0.073442539	1.83606347	7.344	27.927
115		0.000255452	0.025545231	0.63863077	2.555	9.714

Values of Well Function W[u(r,t)]						
t (days)	r(m)--->	1	10	50	100	195
1		2.98	0.01	0.00	0.00	0.00
5		4.57	0.47	0.00	0.00	0.00
10		5.26	0.92	7.85E-05	0.00	0.00
30		6.35	1.84	2.56E-02	5.63E-06	0.00
40		6.64	2.11	1.02E-01	7.67E-05	0.00
115		7.70	3.12	4.21E-01	2.32E-02	5.69E-06

Values for drawdown s(r,t) (m)						
t (days)	r(m)--->	1	10	50	100	195
1		16.73	0.08	0.00	0.00	0.00
5		25.63	2.62	0.00	0.00	0.00
10		29.50	5.17	0.0004	0.00	0.00
30		35.66	10.34	0.14	3.16E-05	0.00
40		37.27	11.82	0.57	4.30E-04	0.00
115		43.20	17.49	2.36	1.30E-01	3.19E-05