APPENDIX O

Hydrogeological Study

FINAL REPORT

JOYCE LAKE AND AREA DSO PROJECT HYDROGEOLOGICAL STUDY

Submitted to:

LABEC CENTURY IRON ORE INC.
拉 贝 克 世 纪 铁 矿 公 司

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Submitted by:

WESA, a division of BluMetric Environmental Inc.
273 Elm Street
Sudbury, ON P3C 1V5

January 8th, 2015
S-B12738-00-00

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1. INTRODUCTION

WESA, a division of Blumetric Environmental, and LVM, a division of Englobe Corporation, were retained by Labec Century Iron Ore Inc. (LCIO) to conduct hydrogeological and geotechnical studies of the Joyce Lake Direct Shipping Ore (Joyce Lake DSO) Project, located in western Labrador, approximately 20 km northeast of Schefferville, Quebec. WESA conducted the hydrogeological work and LVM completed the geotechnical component of the project. The geotechnical component was in two parts: one part concerns the pit slope analysis and design, while the other one concerns the mine infrastructure in the surrounding areas. This report provides the objectives, methodology and results of the hydrogeological study.

The three stand-alone reports are as follows:

- Joyce Lake and Area DSO Project - Hydrogeological Study (current report);
- Joyce Lake and Area DSO Project – Geotechnical Feasibility Study – Open Pit Design (LVM, 2014a)
- Joyce Lake and Area DSO Project – Geotechnical Feasibility Study – Surrounding Areas (LVM, 2014b)

The Joyce Lake and Area DSO Project is part of the Attikamagen Project, which since September 2012 has been a joint venture between Century Iron Ore Inc. and WISCO Canada Attikamagen Resources Development and Investment Limited. The Joyce Lake property comprises four mineral licences that include a total of 564 mineral claims and cover an approximate area of 14,100 hectares. The orebody is located on a peninsula that juts out into Attikamagen Lake. The deposit is currently only accessible by air (helicopter) either directly from Schefferville or via road from Schefferville to Iron Arm Camp and then by helicopter. The deposit is bounded by Attikamagen Lake to the north, west and east, and by Joyce Lake to the southeast, as shown on Figure 1.1. The orebody extends beneath the northwestern portion of Joyce Lake. Current NI 43-101 compliant resource estimate at 50% Fe cutoff is 24.29 million tonnes in the measured and indicated categories at a grade of 58.55% iron and 0.84 million tonnes in the inferred category at a grade of 62% Fe.

1.1 OBJECTIVES

The objectives of the hydrogeological study were to obtain hydrogeological information to support the Bankable Feasibility Study and Environmental Impact Statement.

1.2 Scope of Work

The scope of work involved the following general tasks:

1. Review relevant background information pertaining to the study
2. Drill four vertical boreholes using a diamond drill (HQ) each to a depth of 170 m
3. Conduct packer testing of the four vertical boreholes to obtain information on hydraulic conductivity for various depth intervals
4. Install 50-mm diameter PVC monitoring wells in the four vertical boreholes as well as two inclined boreholes that were drilled for the geotechnical study
5. Determine bulk hydraulic properties by conducting short-term pumping tests and short-term injections tests in the six wells
6. Sample the six wells to acquire preliminary groundwater chemistry information
7. Construct a groundwater model of the site to determine groundwater flow conditions and to determine preliminary pit dewatering requirements. Run model simulations to allow a preliminary assessment of potential impacts to groundwater users and surface-water features as a result of pit dewatering
8. Prepare a report outlining the study objectives, methodology and results

1.3 Report Structure

This report contains eight sections. Section 1 contains the introduction, objectives and scope of work. Section 2 presents a summary of the proposed site development. A description of the project site and surrounding environment is provided in Section 3 along with the physiography and geology. The methodology for the hydrogeological study is provided in Section 4 and the results of the study are presented in Section 5. Section 6 contains a description of the preliminary pit dewatering requirements and potential impacts to the environment from pit dewatering. Preliminary measures to mitigate potential dewatering impacts are also provided in Section 6. Conclusions and recommendations are outlined in Section 7. Limiting conditions are provided in Section 8.

2. PROPOSED SITE DEVELOPMENT

The Joyce Lake deposit is located approximately 20 km northeast of Schefferville on a peninsula in Attikamagen Lake (Figure 1.1). The proposed open pit will be approximately 21 hectares in area and is located on a part of the peninsula where the surface topography varies from approximately 540 masl down to the surface of Joyce Lake at approximately 505 masl. The deposit (and Joyce Lake itself) is located between two northwest/southeast trending ridges. The surface topography in the proposed open pit area generally slopes to the southeast toward Joyce Lake. The surface of Attikamagen Lake is at an elevation of approximately 472 masl, and therefore Joyce Lake is approximately 33 m higher than Attikamagen Lake.

The main features of the Joyce Lake project will be the open pit, the waste rock and low-grade ore stockpiles, the beneficiation plant, the causeway across Iron Arm, the haul road to Astray Lake, and the rail loop ore loading area (Figure 1.1).

The proposed open pit will be developed to a maximum depth of 150 m below ground surface and will be approximately 650 m long by 400 m wide. Mining will be conducted using a conventional drill-blast-load-haul approach, although some parts of the deposit will probably be sufficiently leached to allow excavation without drilling or blasting. The ramp will enter the pit in the northwest portion of the pit at an elevation of approximately 530 masl. The ramp will descend along the north wall of the pit and then will switchback at an elevation of approximately 432 masl. The floor of the pit will be at elevation 380 masl. The orebody extends beneath Joyce Lake, and therefore the pit will also extend beneath the current lake footprint. The two options for mining beneath the lake include:

i. Drain the lake entirely, which is considered the base case;
ii. Construct a dam across the lake and drain the pit footprint area plus a 100 to 200-m buffer.

The waste rock dump will be located north of the pit and will have a total capacity of 28.6 million m^3, a maximum elevation of 580 masl, and will cover an area of 60 ha. Stripped overburden will be stockpiled southeast of the waste rock dump and will cover an area of 4 ha and have a capacity of 1.3 million m^3. This overburden and topsoil will be stockpiled for future reclamation work. Low-grade ore will be stockpiled south of the pit and will have a capacity of 3.2 million m^3.

Ore will be hauled to a beneficiation plant which will be located south of the site, near Iron Arm. This plant will consist of mobile crushers and screening units in a dry process operation.

After beneficiation, the ore will be hauled over a proposed causeway across Iron Arm and 43 km southward along a proposed haul road to a rail loop and loading facility that will be developed near Astray Lake. The ore will be placed in ore cars and will be hauled by rail to Sept Iles, QC for ocean transport.

The targeted DSO production rate is 2.5 million tonnes per year.

3. SITE DESCRIPTION, PHYSIOGRAPHY AND GEOLOGY

3.1 SITE DESCRIPTION AND PHYSIOGRAPHY

As mentioned in Section 1, the Joyce Lake deposit is located on a peninsula that juts out into Attikamagen Lake. The width of the peninsula is approximately 4 km. The peninsula is oriented in a northwest/southeast direction, which parallels most of the small lake and stream orientations and the major ridges in the area, all of which are manifestations of the underlying geological structure of this portion of the Labrador Trough. Joyce Lake is located between two northwest/southeast trending ridges that are composed of more resistant rock.

Joyce Lake is the dominant feature on the peninsula. The drainage area of the lake is 1.82 km^2 and the water surface area is 0.371 km^2 (Stassinu Stantec, 2013a).

The ore deposit is located in the northwest portion of the peninsula, at the northwest end of Joyce Lake and extending beneath the lake. The topography of the ore body area is influenced by the underlying geological structure, which consists of a syncline that is dipping to the southeast. The "nose" of the fold is located approximately 250 m northwest of the proposed pit location and forms a topographic high point because of the expression of the more resistant Wishart Formation. More detailed information regarding the site geology and this structural feature is provided in Section 3.2.

The topography of the northwest portion of the peninsula, where the pit, waste rock stockpiles, overburden stockpiles, and low-grade ore stockpiles will be located, ranges between 472 masl at Iron Arm of Attikamagen Lake, up to a maximum of approximately 580 masl northwest of the pit area. The surface topography of the pit area ranges from approximately 505 masl (Joyce Lake to 530 masl. The ground elevation in the proposed waste rock and overburden stockpile areas ranges between approximately 530 to 575 masl, while the surface topography in the proposed low-grade ore area is approximately 550 masl. The topography slopes sharply down to the shore of Joyce Lake.

Most of the proposed development area is tree covered with the exception of areas that have been cleared for site work related to the development (exploration drilling and trenching, hydrogeological and geotechnical drilling).

There is a small isolated wetland located in the western portion of the proposed pit area (between JGW-3 and JGW-4 – Figure 3.1). A very small stream flows to the southeast from this wetland to Joyce Lake. There is a small pond (Pond A on Figure 3.1) located approximately

250 m east of the proposed pit. These features and Joyce Lake are the only surface-water features within 500 m of the proposed pit.

3.2 GEOLOGY

The regional geology of the Joyce Lake Area is documented in several reports including the Hayot Lake Mineral Resource Estimate (SRK, 2012) and the Joyce Lake Preliminary Economic Analysis (CIMA+, 2013).

In general, the Joyce Lake Iron Ore Project is located on the western margin of the Labrador Trough, a Proterozoic volcano-sedimentary sequence wedged between Archean basement gneisses. The Labrador Trough extends for more than 1,000 kilometres along the eastern margin of the Superior craton from the Ungava Bay to Lake Pletipi, located in central Quebec. The elongated lobe-shaped belt is about 100 kilometres wide in its central part and narrows considerably to the north and south.

The Labrador Trough is a sequence of Proterozoic sedimentary rocks including iron formation, volcanic rocks and mafic intrusions forming the Kaniapiskau Supergroup. The Kaniapiskau Supergroup comprises the Knob Lake Group in the western part and the Doublet Group, which is primarily volcanic, in the eastern part.

To the west of Schefferville, rocks of the Knob Lake Group lie unconformably on Archean gneisses, and to the east, they pass into the eugeosynclinal facies of the Labrador Trough. The Kaniapiskau Supergroup has been intruded by numerous diabase dikes known as the Montagnais Intrusive Suite. These dikes, along with the Nimish volcanic rocks, are the only rock types representing igneous activity in the western part of the central Labrador Trough.

The Knob Lake Group includes the Sokoman Formation, which is the principal target of the Joyce Lake Iron Ore Project. The Sokoman Formation forms a continuous stratigraphic sequence of rock units varying in thickness as a result of folding and fault repetition.

Metamorphic grade increases from sub-greenschist assemblages in the west to upper amphibolite through granulite assemblages in the eastern part of the Labrador Trough. Thrusting and metamorphism occurred between 1,840 and 1,829 million years ago.

In the vicinity of the Joyce Lake Iron Ore Project, the Knob Lake Group is subdivided into eight formal geological units. The lowermost unit rests unconformably over Archean gneisses of the Ashuanipi Complex. Figure 3.2 shows the bedrock geology in the project vicinity. In order from oldest to youngest, the rock units include the Seward, Lac Le Fer, Denault, Fleming, Dolly, Wishart, Sokoman and Menihek Formations. The Knob Lake Group can be divided into two sedimentary cycles:

Cycle 1 (the Attikamagen Subgroup) is a shallow marine shelf comprising the Lac Le Fer, Denault, Dolly and Fleming Formations.

Cycle 2 (the Ferriman Subgroup) is a deeper water slope-rise environment beginning with a transgressive quartz arenite (Wishart Formation) followed by shale (the Ruth Shale) and banded-iron-formation of the Sokoman Formation. Finally, the Sokoman Formation is conformably overlain by clastic shale, slate and siltstone of the Menihek Formation.

The iron formations of the Sokoman Formation mapped on the Joyce Lake Property are classified as Lake Superior type and display a banded character of iron formations resulting from interlayering of thin chert beds with other thin beds in which iron-bearing minerals predominate. Based on current nomenclature and results from recent exploration drilling, the Joyce Lake Project recognises four iron-bearing subunits within the Sokoman Formation depending on the concentration of chert and iron-rich beds. In order from youngest to oldest, they consist of the Upper Massive Hematite (UMH), the Red Chert (RC), the Lower Massive Hematite (LMH) and the Lower Red Chert (LRC) Formations. The chert occurs in variable proportions depending on the subunit. It consists essentially of microgranular quartz, although it is generally ferruginous and contains minor amounts of the associated iron-bearing minerals. The iron-bearing units constitute anhydrous hematite and magnetite in variable proportions with some hydrous oxide goethite and limonite commonly associated with alteration phases. A detailed treatment of these subunits will be presented in Section 5.1 of this report.

Field mapping conducted by LCIO indicates that the stratigraphic units of the Ferriman Subgroup in the Joyce Lake Area form a synclinal fold structure trending northwest/southeast. Based on their structural interpretation, the fold trends at approximately 135^{0}Az with a plunge of 42^{0}SE.

4. GROUNDWATER STUDY METHODOLOGY

4.1 Background Review

At contract award WESA was provided with a number of technical reports related to the project for review prior to mobilisation to the site. These reports included the following key documents, among others:

- Preliminary Economic Assessment Study Report (CIMA+, 2013)
- NI43-101 Technical Report (SGS, 2013)-
- Baseline Hydrogeology Scoping Study (Stassinu Stantec, 2013a)
- Site Wide Water Balance Analysis (Stassinu Stantec, 2013b)
- Surface Water Baseline Study (Stassinu Stantec, 2013c)

- Geological Mapping, Exploration Drill Hole Data and Block Model, Labec Century Iron Ore

In addition to the background document review, a meeting was held with Labec Century geologists on September 10, 2014 to discuss site geology and potential drilling locations.

4.2 Drilling, Packer Testing, and Well Installation

The drilling work for the hydrogeological study was conducted by Downing Drilling of Grenville Sur La Rouge, Quebec using an LF70 diamond drill. This type of drill rig is made for fly-in camp operations and can be taken apart and slung by helicopter to each drilling location. Given the site access constraints, this was determined to be the only feasible method of drilling and well installation at this stage of development at the project site. Four vertical drill holes were diamond drilled to approximately 170 m below ground surface using the wireline method and HQ tooling. The drilling program operated 24 hours a day and seven days a week starting September 18 until the fourth and final hydrogeological hole was completed October 11, 2014. Field observations and core samples were analysed and logged. Besides logging core sample characteristics, field observations including an appreciation for the rate of advancement drilling, water intake and drilling efficiency over the length of the borehole were noted. Rock quality designation (RQD), a qualitative evaluation of fracture intensity, general fracture characteristics, core sample condition, petrological description of the core, colour patterns, structural features, textures and fabric were examined over the entire length of the core.

The four hole/well locations drilled for the hydrogeological study were selected based on the proposed pit outline and underlying geology. Labec Century geologists indicated that preliminary data suggested the potential presence of two parallel faults striking northwest-southeast along the flanks of a synclinal structural fold observed in the area. One potential fault was aligned approximately parallel with the northeast shore of Joyce Lake while the other was aligned approximately parallel with the southwest shore. Drill holes JGW-1 and JGW-2 were located near the alignment of the potential northeast fault while holes JGW-3 and JGW-4 were located near the alignment of the potential southwest fault. Taking into consideration that the projected fold is plunging southeast, drill holes JGW-2 and JGW-4 were located near the northwest rim of the proposed pit to intercept the lower units of the Ferriman Subgroup. Drill holes JGW-1 and JGW-3, situated along near the north shore of Joyce Lake, were positioned to intercept the upper units of this Subgroup. Appendix A includes detailed logs of hydrogeological drill holes JGW-1 through JGW-4.

Packer testing was conducted in each hole as the drilling progressed using a wireline based, drilling activated packer system (SWiPS) from Inflatable Packers International LLC (IPI) of Red

Lodge, Montana. This system is completely hydraulic and uses the drill's wireline system to lower and raise the packer assembly and the overshot is used to deflate the packer at the end of a test. The drill rig pump is used to inflate the packer and to inject water. A single packer system was used during this study because the rock quality was expected to be poor. As a result, it was expected that the holes would not remain open sufficiently long following completion of drilling to complete packer testing with a double packer (also called straddle packer) assembly and subsequent installation of a monitoring well.

The SWiPS system was used to measure flow rate and pressure build-up/decay in a test interval over a period of time. The upper range of measurements taken with the SWiPS system was limited by the hydraulics of the injection system (rate and pressure output limit of pump, supply line (friction losses) and water availability).

The injection testing method otherwise known as Lugeon tests was carried out in the four hydrogeological holes JGW-1 to JGW-4 from September 22nd to October 10th 2014. Table B-1 in Appendix B lists the details of each test performed in the hydrogeological drilling and packer testing campaign. As noted above, a single-packer system was used for this study. The packer was inflated to isolate a test interval defined by the length of an open borehole from the upper packer (bladder) to the base of the open borehole. Under these circumstances, the test intervals were selected during drilling and as analyses of core characteristics progressed. Upon selection of a relevant test interval, drilling was temporarily halted to conduct the packer test. The core barrel was removed from the drill hole and the base of the borehole flushed to disengage and remove residue and drilling muds. The drill casing was then retracted to expose the length of the targeted test interval and the SWiPS assembly was installed to conduct the packer test. Drilling resumed following completion of the packer test. A packer test generally lasted anywhere from two to four hours depending on the flushing time and permeability of the rock.

During the packer test, water was injected at pre-determined pressures or "steps" and the resulting pressures were recorded when flow reached a quasi-"steady-state" condition. Steps were "ramped" up and down through the expected pressure ranges. The behaviour of the system to increasing and recovery injection provided information on the rock mass characteristics and fracture behaviour.

The SWiPS system is composed of two main components including an adapted installation tool assembly and the SWiPS assembly itself.

The adapted installation tool assembly is used to latch, lower, raise and set the SWiPS system in the test interval with the wireline system of the LF70 drilling rig in HQ format. The installation tool comprises a modified spearhead and an extension rod adaptor.

The SWiPS assembly consists of five main components including, the packer element, the injection valve assembly, an internal mandrel, the memory gauge carrier and the end cap. A datalogger (model Level-Troll 700 from In-Situ Inc.) was placed in the memory gauge carrier to record water level, temperature and pressure throughout the duration of the Lugeon Injection Testing Program.

The installation tool and each component of the SWiPS system were fastened together along tailored threaded components. The mandrel, set within the packer assembly, ran over the length of the SWiPS system up to the injection valve assembly. The mandrel functioned to secure, set and release the water pressures used to inflate the packer and allow water flow through test interval over a test sequence. Operating pressures directed to the packer system were achieved by sealing the interface between open borehole and the drill rods past a landing ring seated at the base of the drill rods at the drill bit.

Water pressure used to inflate the packer and produce pressurised flow for each test was achieved by pumping water through the drill rods with the rig's hydraulic pump. Water pressure was controlled using a manifold system equipped with flow control valves, flow meters and pressure gauges.

Each test was initiated by retracting drill rods to expose the targeted portion of the borehole. The packer system was then lowered into this interval, sealed and pressurised to inflate the packer. As soon as the packer touched the borehole wall, pressure began to build up rapidly and continued to increase until a preset level was reached. A shear pin mechanism located in the injection valve assembly sheared at the preset level allowing the tool (mandrel) to lock in the pressurised packer and allow for water to flow past the injection valve assembly through perforations of the SWiPS system and into the open borehole. The system was now set to perform a Lugeon injection test.

During the Lugeon injection test, water was hydraulically pumped into the exposed borehole through the SWiPS system, and ramped up and down to its predetermined pressures. The pressure was regulated on surface with control valves on the manifold system.

Upon completion of the test, an overshot was used to deflate the packer of the SWiPS system. The action of pulling on the coupled spearhead activated a release chamber along the SWiPS assembly to depressurise the packer.

Six to seven tests were conducted at various depths and over varying test interval lengths for each of the four hydrogeological drill holes and two geotechnical holes.

The packer tests were performed to assess the hydrogeological characteristics of the geological formations present in the future pit area. The data recorded during the test consisted of the flow rate and the corresponding pressure when "steady-state" conditions were achieved.

Observations of flow at predetermined pressures were made at 30-second intervals until three consecutive and consistent readings were taken. This condition should represent steady-state flow. The duration to reach "steady-state" conditions is dependent on the permeability of the rockmass. The tighter the rockmass (i.e., low permeability), the longer it took to attain "steady-state" conditions. In contrast, steady-state conditions were achieved rapidly in test zones with extremely high fracture density (i.e., very high permeability).

Each test consisted of five pressure steps. After the initial step was completed, the pressure was then subsequently increased for two additional and equal increments, followed by two decreasing pressure increments. The pressure of the fourth step was set equal to the second step, and the pressure of the fifth step was set equal to the first step. The steady-state flow at each pressure step was recorded.

Pressure ranges (steps) were determined prior to performing the Lugeon test and were based on estimated permeability of the rocks referenced from published literature, the expected intake of injected water and on test results obtained from earlier tests as drilling progressed from one drill hole to the next.

Results derived from testing were initially plotted on graphs (Step Pressure vs. Flow and Step Pressure vs. Lugeon Values) and assessed on their trends. Comparisons of trends between different stepped pressures were used to initially assess permeability characteristics of the test interval.

In addition, the hydraulic conductivity and Lugeon values from each test was calculated and compared to the geological characteristics intercepting the test interval including, lithology, structural features (bedding, cleavage, fractures), RQD and fracture frequency. A comprehensive treatment of data analyses and results are presented in Section 5 of this report.

Monitoring wells were installed in the four hydrogeological holes (JGW-1, JGW-2, JGW-3, JGW-4) as well as two of the geotechnical holes installed by LVM (BH-P-03, BH-P-04). Each well consists of 50-mm diameter PVC slot-10 screen attached to riser pipe. This is the largest diameter screen and riser pipe that could be installed in the HQ holes. The majority of each well consists of screen, with 5 to 6 metres of riser near surface. Each hole was allowed to collapse around the screened interval. A bentonite seal was placed near and at surface at each well. Table 4-1 summarises monitoring well construction details. Appendix A includes monitoring well logs.

Table 4-1: Summary of Monitoring Well Details

Location	Easting (NAD 83)	Northing (NAD 83)	Ground Elevation (masl)	Top of Casing Elevation (masl)	Well Depth (mbtop)	Screen Interval (mbgs)	Stick-up (mags)	Angle from Horizontal (degrees)	Groundwater Elevation (Oct. 13/14) (masl)
JGW-01	658432.573	6086427.91	517.311	517.447	129.48†	6.00-129.48	0.917‡	90	506.04
JGW-02	658260.976	6086579.63	532.779	532.962	169.65	5.74-169.65	0.823	90	509.52
JGW-03	658213.384	6086282.807	517.008	518.306	172.66	7.01-172.66	1.298	90	507.39
JGW-04	657993.235	6086507.424	529.491	529.547	172.66	8.32-172.66	0.914	90	511.02
BH-P-03	658422.619	6086562.697	526.333	526.402	161.87	7.62-161.87	0.792	70	509.79
BH-P-04	658602.944	6086397.635	518.844	519.26	161.01	13.71-161.01	0.745	70	507.49
BH-P-01	658114.121	6086486.969	527.853	NA	NA	NA	NA	70	NA
BH-P-02	658177.634	6086299.006	522.179	NA	NA	NA	NA	70	NA

Notes:

masl – metres above sea level

mbtop – metres below top of casing

mbgs – metres below ground surface

mags – metres above ground surface

NA - Not applicable - no well installed

BH-P-04 water measured on Oct. 18/14

† Final Well Depth - Well Depth during testing was 128.73 mbtop

‡ Final Stick-up -Stick-up during testing was 0.177mags

4.3 Short-Term Pumping and Injection Testing

Short-term pumping and injection tests were performed on each of the six wells between October 15 and October 23, 2014. Pumping tests were performed first followed by injection tests after each well had recovered.

Pumping tests were conducted using a Solinst RediFlo2 submersible pump attached to Waterra tubing and the pump was powered by a portable generator. Pumping tests ranged in duration from 112 to 240 minutes. Pumping rates ranged from 23.0 to 27.3 LPM. The tests were ended when groundwater elevations in the pumped well stabilised. Solinst Levelogger™ dataloggers were used to record water levels during pumping and recovery. Water levels were recorded until they recovered at least 90% from the maximum drawdown.

Injection tests were conducted using a surface pump attached to a well header. Water was pumped from Joyce Lake to a 900-litre equalising tote tank and then from the tank to the well. Injection rates ranged from 27 to 158.7 LPM. Solinst Levelogger™ dataloggers recorded water levels during injection and recovery. Water levels were recorded until they recovered at least 90% from the maximum rise.

4.4 Water Levels and Groundwater Sampling

A synoptic round of water levels of five of the six wells was conducted on October 13, 2014 using a Solinst water level tape. The sixth well, BH-P-04 had not been completed on this date, but was measured on October 18, 2014. Table 4-1 summarises the measured groundwater elevations.

A groundwater sample was collected at the end of each pumping test from each well. The samples were collected in laboratory-supplied bottles from Testmark Laboratories of Sudbury, Ontario. Samples were analysed for the metals and general chemistry parameters listed in Table 4-2. The metals samples were field filtered and placed in metals sample bottles containing preservative.

Table 4-2: List of Chemical Analyses

Dissolved Metals		General Chemistry
Aluminum	Antimony	Acidity
Arsenic	Barium	Ammonia
Beryllium	Bismuth	Chloride
Boron	Cadmium	Conductivity
Calcium	Cerium	Hardness
Cesium	Chromium	Alkalinity
Cobalt	Copper	Nitrate
Europium	Gallium	Nitrite
Iron	Lanthanum	pH
Lead	Lithium	Sulphate
Magnesium	Manganese	Total Dissolved Solids
Mercury	Molybdenum	
Nickel	Niobium	
Potassium	Rubidium	
Scandium	Selenium	
Silicon	Silver	
Sodium	Strontium	
Sulfur	Tellurium	
Thallium	Thorium	
Tin	Titanium	
Tungsten	Uranium	
Vanadium	Yttrium	
Zinc	Zirconium	

4.5 Packer Test Analysis

Data derived from packer testing included flow rate with corresponding pressure (step) values generated in each series of packer tests. Five sets of readings were obtained from each test. Pressure values and corresponding flow rates were read off pressure gauges and flow meters located on the manifold system of the SWiPS system set-up. In addition, pressure, water level and water temperature measurements were acquired from the Troll 700 datalogger. The logger was programmed to record data at a frequency of 20 readings/minute. However, the datalogger was damaged unexpectedly during the drilling/testing campaign and data were limited to drillholes JGW-3, JGW-1 and a portion of JGW-2.

The data were compiled and used to calculate Lugeon values and hydraulic conductivity for each test interval. The tabulated values were then used to generate pressure-flow curves, which were compared to type curves. Table 4-3 summarises the type curves. The trend graphs and calculated values were compared to drill core characteristics noted during core logging including such features as lithological characteristics, RQD, fracture frequency and general orientation of structural features such as fractures, rock cleavage and bedding (or banding).

Table 4-3: Interpretation of Pressure-Flow Curves in Lugeon Tests.

Common Graph Type	Interpretation / description
1	Ideal result where flow is laminar, probably on clean fractures, discharge proportional to pressure head.
2	Tight fractures, impermeable material
3	Highly permeable, large open fractures. Water acceptance exceeds capacity of the test system and pressure recorded is due to friction in supply system.
4	Fairly high permeability with a decrease in flow with time due partially to a change from laminar to turbulent flow, as well as partial clogging of fractures with time.
5	Low permeability, but washing out of gouge material from the fractures, increasing the permeability.
6	Laminar flow, moderate permeability but with an increase in flow with pressure. Increasing packer pressure brings the flow back to a linear relationship with pressure, indicating increased flow was previous leakage past the packer
7	Increase in permeability with increased pressure and the recovery curve follows the same path. This indicates that fractures have been opened up due to excess pressure (hydrofracturing).
8	Progressive decrease in permeability with pressure (and time) indicating incomplete blocking of the fractures by transported material.
9	Moderate permeability and flow rate is not linear.

The graphs shown in Figure 4.1 illustrate nine common type curves. These curves were used to compare and group results generated from packer testing of drillholes JGW-1 to JGW-4.

A second set of trend graphs were used displaying Lugeon Values vs. Pressure Steps. The trends observed from these graphs were compared to Pressure vs Flow Type Curves and to core characteristics from JGW-1 to JGW-4 in an attempt to delineate hydrostratigraphic units.

The Lugeon value is defined as the hydraulic conductivity required to achieve a flow rate of 1L/min/m of test interval under a reference water pressure equal to 1 MPa.

$$Lugeon\ Value = \alpha \times (q/L) \times (P_0/P)$$

Where:

q = Flow rate (L/min)

L = Length of test interval (m)

P = Step pressure (MPa)

P_0 = Reference pressure (= 1 MPa)

α = dimensionless SI unit (1)

Under ideal conditions (i.e., homogeneous and isotropic) one Lugeon is equivalent to 1.3×10^{-5} cm/s (Fell et al., 2005). Table 4-4 describes the conditions typically associated with different ranges of Lugeon values, as well as the precision used to report these values.

Table 4-4: Condition of Rock Mass Discontinuities Associated with Different Lugeon Values.

Lugeon Range	Classification	Hydraulic Conductivity Range (cm/s)	Condition of Rock Mass Discontinuities	Reporting Precision (Lugeons)
<1	Very Low	$< 1 \times 10^{-5}$	Very tight	<1
1-5	Low	1×10^{-5} – 6×10^{-5}	Tight	± 0
5-15	Moderate	6×10^{-5} - 2×10^{-4}	Few partly open	± 1
15-50	Medium	2×10^{-4} – 6×10^{-4}	Some open	± 5
50-100	High	6×10^{-4} - 1×10^{-3}	Many open	± 10
>100	Very High	$> 1 \times 10^{-3}$	Open closely spaced or voids	>100

In addition to providing an appreciation for the permeability range of the rock mass under investigation, comparative graphical interpretations can be derived from the Lugeon graphs. The graphs can be classified into five groups as presented in Figure 4.2 and Table 4-5.

Table 4-5: Interpretation of Lugeon Graphs.

Common Graph Type	Interpretation / Description
1	Laminar Flow: The hydraulic conductivity of the rock mass is independent of the water pressure employed. This behavior is characteristic of rock masses observing low hydraulic conductivities, where seepage velocities are relatively small (i.e., less than four Lugeons).
2	Turbulent Flow: The hydraulic conductivity of the rock mass decreases as the water pressure increases. This behavior is characteristic of rock masses exhibiting partly open to moderately wide cracks.
3	Dilation: Similar hydraulic conductivities are observed at low and medium pressures; however, a much greater value is recorded at the maximum pressure. This behavior – which is sometimes also observed at medium pressures – occurs when the water pressure applied is greater than the minimum principal stress of the rock mass, thus causing a temporary dilatancy (hydro-fracturing) of the fissures within the rock mass. Dilatancy causes an increase in the cross sectional area available for water to flow, and thereby increases the hydraulic conductivity.
4	Wash-Out: Hydraulic conductivities increase as the test proceeds, regardless of the changes observed in water pressure. This behavior indicates that seepage induces permanent and irrecoverable damage on the rock mass, usually due to infillings wash out and/or permanent rock movements.
5	Void Filling: Hydraulic conductivities decrease as the test proceeds, regardless of the changes observed in water pressure. This behavior indicates that either: (1) water progressively fills isolated/non-persistent discontinuities, (2) swelling occurs in the discontinuities, or (3) fines flow slowly into the discontinuities building up a cake layer that clogs them.

Finally, the hydraulic conductivity can be calculated using the packer test results. Initially, the effective transmissivity (T) can be determined by means of the Thiem equation:

$$T = \frac{Q \ln(R/r_o)}{2\pi P_i}$$

Where:

T = transmissivity (m²/day);

Q = injection rate (m³/day);

R = radius of influence (m);

r_b = radius of borehole (m);

P_i = net injection pressure (m).

Because it is inside the logarithm, the value for the radius of influence (*R*) will have a fairly insignificant effect on the value of *T* calculated, using the equations for analysing the packer data. As a result, *R* was set to 5 m in the calculation of *T*.

The net injection pressure (P_i) is defined as the total pressure head (m) that is exerted on the test interval. It is calculated as follows:

$$P_i = P_g + h_g + h_s - h_f$$

Where:

P_i = net injection pressure (m);

P_g = gauge pressure (m);

h_g = height of gauge above ground level (m);

h_s = depth to pre-test water level (m); and

h_f = friction losses (m).

The sum of h_g and h_s is usually referred to as the column height. Both components of the column height were measured before the tests were carried out. The value for h_g should be the same for each test if the testing apparatus is not changed, but h_s will vary depending on the hydrogeologic zone penetrated by the drillhole.

The hydraulic conductivity (*K*) can be calculated using transmissivity by:

$$K = T/L,$$

Where:

L = length of test

The sequence of calculations and iterations used to obtain the hydraulic conductivity (*K*) for each test interval were tabulated using a template. Appendix B presents the data and results from packer test analyses.

4.5 Pumping/Injection Test Analysis

WESA analysed the recovery in all wells using the Agarwal Skin model as implemented in the aquifer test analysis software AquiferTest™ to estimate hydraulic parameters. The Agarwal Skin model was selected based on observations made during field testing and comparison of time vs. recovery data to various type curves during analysis. Drilling mud was used during drilling to maintain hole integrity. While the drilling mud was flushed from the packer test intervals, it could not be removed from the entire hole length. The drilling mud on the borehole walls interferes with water flow between the borehole walls and the undisturbed subsurface materials. Drilling mud was observed in the discharge from the pumped wells indicating that the wells were partially developed by the pumping. A skin effect of drilling mud along the borehole walls was also indicated in the recovery data as water levels were lower than theoretical during the early-time recovery data. The Agarwal Skin model was applied to late-time recovery data as they are believed to be more reliable as they reflect the theoretical recovery data.

Data collected during the pumping test on well JGW-4 and injection test on well JGW-3 were not suitable for analysis.

Appendix B includes data and results from the short-term pumping and injection tests.

4.6 Groundwater Modelling

A three-dimensional groundwater flow model (Groundwater Model) was constructed and calibrated as part of this study. The purpose of the Groundwater Model was to serve as a design tool for the pit dewatering system, and to facilitate an evaluation of potential environmental impacts related to mining operations. MODFLOW-Surfact was used as the simulation code for the groundwater modeling study. The model domain was oriented parallel to the structure of the bedrock geologic units. A constant-head boundary was used to represent Lake Attikamagen, and the interior lakes and streams were represented as boundary conditions based on surface-water levels and base conductance estimates. Wetlands were simulated as drains in the groundwater flow model. The results of packer, pumping and injection tests were used to specify initial hydraulic conductivity estimates for various geologic sub-units. Average annual infiltration was specified to be uniform in the model domain.

The Groundwater Model was calibrated to the October 2012 groundwater synoptic monitoring event. Parameters adjusted during the calibration process included hydraulic conductivity of various sub-units, and lake bed conductance. A sensitivity analysis was conducted to evaluate the sensitivity of the model calibration statistics to various model input parameters. The Groundwater Model was then used to evaluate various design alternatives for the pit dewatering system (Dewatering Model).

The most likely scenario for pit operation involves complete dewatering of Joyce Lake. A desktop study was conducted to assess the potential influence to the draining stream and downstream wetland. The results of this desktop study were used to adjust how this stream and downstream wetland were represented in the Dewatering Model. Joyce Lake was not represented in this version of the Dewatering Model. A sensitivity analysis was conducted to estimate the range of pumping rates and the number of wells required for the dewatering system, and to determine the key model input parameters that influence these design factors. An alternative dewatering scenario was also simulated, whereby a dam was installed in Joyce Lake, and only the northern portion of this lake was dewatered. The model simulation results, including a water balance for each scenario, were used to summarise the range of potential environmental impacts including recharge/discharge rates for lakes, streams and wetlands in the vicinity of the proposed pit and Joyce Lake.

5. GROUNDWATER STUDY RESULTS

5.1 Stratigraphy

The stratigraphy was primarily established from core log reports obtained from LCIO's exploratory campaigns and from the current hydrogeological and geotechnical drilling campaign. Additional information including rock quality designation (RQD), a qualitative evaluation of fracture density and characteristics, condition, petrology, structural features, colour patterns, texture and fabric from core samples derived from the current drilling campaign were also used characterise the various rock units identified in the Joyce Lake property. Appendix A includes the detailed core log reports from the JGW and BH borehole series.

The rock classification system established by LCIO from their exploratory campaigns was also used for the current study. Table A-1 in Appendix A presents the main criteria used to identify the various rock units encountered during drilling.

The rate of advancement and drilling efficiency varied during drilling operations over the span of the four boreholes. Two general trends were observed. First, drilling rates were relatively slow in banded iron formation rock units, predominantly in the chert-rich horizons and particularly when the Red Chert units and Lower Massive Hematite (LMH) to Lower Red Chert (LRC) interfaces were intercepted. The core retrieved from these horizons was also highly fractured to granulated to altered. Second, drilling progressed rapidly through altered and soft horizons. The core extracted from these horizons consists of argillaceous and disaggregated material. Water intake was relatively high in fractured zones and in all instances drilling muds were required to maintain the integrity of the borehole and drilling efficiency. In one occurrence, the drill rod advanced almost instantly through approximately 1 m of material at approximately 72 m in depth in borehole JGW-2. Although the recovery rate was very good (generally between 85 to 98%), this interval is interpreted to intercept a fault or shear zone containing clay and granulated core over its length. This observation is consistent with structural cross section interpretations where "thickening" and/or displacement of several stratigraphic units are observed in this zone.

The fault however may be a local feature, but additional data would be required to confirm its attitude and extent.

The subsurface materials at boreholes JGW-1 and JGW-3 display similar lithological, structural and geotechnical characteristics.

In summary, JGW-3 intercepted the following rock units:

- From 0 to 20.02 m Upper Massive Hematite Formation
- From 20.92 to 75 m Red Chert Formation
- From 75 to 96 m Lower Massive Hematite Formation
- From 96 to 170 m Lower Red Chert Formation

RQD values in JGW-3 can be separated into three average ranges based on depth. RQD values ranged from 0 to 50%, averaging 30%, from 0 to 64 m in depth. The RQD values ranged from < 5 to 41%, averaging < 20 % from 64 to 96 m in depth. At depths greater than 96 m, the RQD's ranged from 6 to 79 % and averaged close to 40%.

In terms of rock fracture characteristics, the core obtained from JGW-3 was generally highly fractured to granulated and in many instances disintegrated and altered with very few widely fractured or intact core intervals. Even though the core was highly fractured, the recovery rate was over 85% in most cases.

In summary, JGW-1 intercepted the following rock units:

- From 0 to 27 m Upper Massive Hematite Formation
- From 27 to 63 m Red Chert Formation
- From 63 to 105 m Lower Massive Hematite Formation
- From 105 to 171 m Lower Red Chert Formation

RQD values in JGW-1 can be separated into two groups. RQD values ranged from 0 to 50%, averaging 20%, from 0 to 96 m in depth. The RQD values ranged from 0 to 60%, averaging at 23%, from 96 to 171 meters in depth.

In terms of rock fracture characteristics, the core was generally moderately to highly fractured with frequent granulated, disintegrated and altered intervals.

Both JGW-1 and JGW-3 exclusively intercepted geological units within the banded iron formations. Small-scale structures evident in core samples included inter-banding (perceived as bedding) between chert and hematite bands. Bands were generally inclined relative to the core axis between 30 and 45°. Several intervals showed wavy to contorted and sub-vertically oriented bands. These intervals were often accompanied by a brecciated fabric with quartz and carbonate filled veins. Core samples displaying a brecciated fabric were often highly fractured to granulated to altered occasionally accompanied by limonitic overprint in the bands. Bands in these zones were also observed to be contorted to wavy. Fractures were principally oriented parallel to banding. The fractures were straight and continuous occasionally to frequently bordered by secondary iron oxides, limonite and/or quartz and carbonate. A secondary fracture set was also observed at approximately a perpendicular angle to the banding. These fractures were irregular and discontinuous, which appeared to be derived from micro-fractures perpendicular to banding within individual microcrystalline chert bands.

Boreholes JGW-2 and JGW-4 equally display similar lithological, structural and geotechnical characteristics.

In summary, JGW-2 intercepted the following rock units:

- From 0 to 60.6 m — Lower Massive Hematite Formation
- From 60.6 to 72.9 m — Lower Red Chert Formation
- From 72.9 to 90.8 m — Lower Red Chert Formation with intercalated shale beds
- From 90.8 to 111.72 m — Ruth Shale Formation
- From 111.72 to 115.42 m — Ruth Shale Formation with sandstone interbeds
- From 115.42 to 142.57 m — Wishart Sandstone Formation (with thin intercalated black chert or shale seams / beds / laminations)
- From 142.57 to 147.60 m — Wishart Sandstone Formation (uniform crystalline equigranular mosaic variety)
- From 147.60 to 171.30 m — Wishart Sandstone Formation (with thin intercalated black chert or shale seams/beds/laminations and with wider passages of uniform crystalline variety)

In summary, JGW-4 intercepted the following rock units:

- From 0 to 41.27 m — Lower Massive Hematite Formation
- From 41.27 to 63.97 m — Lower Red Chert Formation
- From 63.97 to 97.80 m — Ruth Shale Formation
- From 97.80 to 127.09 m — Wishart Sandstone Formation (with thin intercalated black chert or shale seams/beds/laminations)

- From 127.09 to 135.30 m Wishart Sandstone Formation (uniform crystalline equigranular mosaic variety)
- From 135.30 to 171.30 m Wishart Sandstone Formation (with thin intercalated black chert or shale seams beds/laminations and with wider passages of uniform crystalline variety)

The RQD values measured in JGW-2 and JGW-4 were similar. Two general ranges were observed. A lower range of values associated to the Iron Banded Formations and Ruth Shale and higher RQD values associated with the sandstone formation.

RQD values ranged from 0 to 63%, averaging approximately 24%, in the iron banded formations (LMH, LRC and RC). However, higher measurements (up to 82%) were observed in JGW-2 within the LRC formation with intercalated shale beds. Finally, RQD values generally ranged between 70 and 100% in the Wishart Sandstone, but some values were as low as 30% and lower. Frequent fluctuations within the Wishart sandstone with lower RQD values (from 0 to 30%) were observed associated with uniform sandstone beds within this rock unit.

In terms of rock fracture characteristics, the core obtained from both JGW-2 and JGW-4 was generally highly fractured to granulated and in many instances disintegrated and altered with very few widely fractured or intact core intervals within the Iron Band Formation Units. Core extracted from the Ruth Shale and the Wishart Sandstone was generally lightly fractured to intact core with few narrow intervals that were in a granulated state. The recovery rate in the Wishart was close to 100%. JGW-2 and JGW-4 displayed similar structural features to JGW-1 and JGW-3 in core extracted from the Iron Banded Units. The Ruth Shale displayed thinly laminated bands from straight to irregular and fractures were parallel to the banding plane. Bands were oriented horizontal (90° to the core axis) to slightly inclined. The Wishart Sandstone displayed relic bedding features such as thin shale / chert lamellae, cross-bedding and graded bedding. Bedding was horizontal to inclined to sub-vertical (i.e., 90°, 30 to 45°, and up to 70° with respect the core axis). There were intervals of sandstone absent of bedding. In most instances, the core observed over these intervals was friable due to an inherent planar rock cleavage produced by the presence of interstitial chlorite. These intervals also displayed a greenish hue. The fractures occurred in a sub-vertical orientation along the fabric of the rock.

5.1.1 Petrologic Features

The petrologic characteristics of each rock unit based on core derived from boreholes JGW-1 and JGW-4 can be summarised as follows:

Menihek Formation: Dull green-grey argillaceous slate and greywacke, blocky in nature. Where present, core samples observed possibly comprise an erratic or boulder within the overburden sequence, due to the rounded nature of pieces within the core.

Upper Massive Hematite: Medium to dark grey, to steel black to black with red interbands of chert, hematite, carbonate and lenses of siltstone and shale. Weak to strong disruptions in the bands by annealed shear planes, veins, veinlets and tension gashes injected with white quartz and/or carbonate and/or iron oxides (including red hematite, mustard yellow limonite and dark brown goethite).

The core is generally weathered with some intervals of fresh rock within this unit. In its altered state, the core is highly fractured to granulated to disintegrated into a clay-rich mass. Fresh rock is observed as intact core with unaltered fractured surfaces along bands or, as irregular fractures crosscutting the bands.

Locally, trace amounts of pyrite and chalcopyrite clusters or disseminations are present along fracture surfaces.

The interbands can be disrupted by brecciated intervals that appear annealed in most instances, however produce local sheared structures displacing or microfolding interbands of chert and hematite. White and grey chert bands are thin (less than 1 cm in general) and appear as poorly defined bands composed of interlocking fine-grained rounded quartz grains forming an equigranular crystalline matrix. Red chert bands are composed of spherically shaped microcrystalline quartz overprinted or replaced by red hematite and /or iron oxides. Hematite appears also as finely disseminated particles in chert bands. An equigranular texture is observed in both instances. Occasional intraclasts of chert replaced by hematite and/or limonite are also apparent. Black colored hematite bands constitute as pitch black to metallic grey black subhedral fine-grained hematite aggregates forming an equigranular texture. Occasional lenses and pockets of fine-grained specularite are present within the hematite bands.

Interbands are generally parallel with black hematite bands being the predominant rock type and intercalated with red chert/hematite bands and some white/grey chert bands. Boundaries between bands are smooth to wavy to locally disrupted by veins and microshears. Occasional mottled fabric is produced by irregular masses of red chert perturbations across interbands between hematite and chert. The bands are generally inclined (between 20 to 45°), but can occur as subhorizontal to vertical and occasionally with microfold structures, the latter occurring over a decimetric scale.

Red Chert: Meso-banded medium to dark grey, to steel black to black with red interbands of chert, hematite and carbonate. The fabric of the rock is slightly disrupted by annealed shear planes, veins, veinlets and tension gashes injected with white quartz and/or carbonate and/or iron oxides (including red hematite, mustard yellow coloured limonite).

The core varies irregularly from altered to fresh rock intervals. Altered intervals are overprinted by disseminated limonitic masses overprinting the banded rock. The core, in its altered state, is highly fractured along the band planes to granulated to disintegrated, the latter forming a limonitic or oxide-rich argillaceous mass.

Fresh rock is observed as intact core or core that is fractured along bands with few irregular fractures crosscutting the bands. Locally, clusters and/or disseminated pyrite and chalcopyrite are present in trace amounts along fracture surfaces.

The interbands can be disrupted by brecciated intervals that appear annealed in most instances (brecciated chert), however produce local sheared structures displacing or microfolding interbands of chert and hematite. These intervals appear as granulated core.

White and grey chert bands are thin (less than 1 cm in general), continuous but faint. They are composed of interlocking fine-grained spherically shaped quartz equigranular crystalline matrix occasionally disrupted by intraband microshears oriented perpendicular to the individual bands. The microshears terminate along extremities of individual bands. Red chert bands display an oolitic to pisolitic texture. Individual ooliths/pisoliths defined by concentric layers of hematite and ringed jasper, interlocked in a microcrystalline siliceous matrix. Nodules and intraclasts, some reaching a up to 2 mm. in length, are also present within the oolithic chert. Black colored hematite bands are observed as pitch black to metallic grey black equigranular microcrystalline texture and as an oolitic texture of fine-grained hematite aggregates. Occasional lenses, pockets and disseminated fine-grained specularite are present within the hematite bands.

Interbands are poorly defined, but generally parallel with black hematite bands. Red chert bands are the predominant rock type and intercalated with black oolitic and microcrystalline hematite bands.

Boundaries between bands are smooth to wavy to locally disrupted by veins and microshears. The bands are generally inclined (between 20 to 45°) but can occur as subhorizontal to vertical and occasionally with microfold structure. Red chert bands can occur up to 10's of centimetres in thickness.

Lower Massive Hematite: Interbands of black and deep metallic blue coloured hematite bands intercalated with white, pale grey to grey chert bands and white carbonate bands. Presence of dull black thin laminar shale bands displaying a fissile nature. The latter is interrupted by alteration in the form of iron oxides. Occasional thin lenticular passages of sandstone are also observed. The grains within these passages are well sorted, equigranular and constitute rounded quartz grains with trace amounts of feldspar and lithic fragments.

Interbands can be observed disrupted by brecciated intervals that appear annealed in most instances, however produce local sheared structures displacing or microfolding interbands of chert and hematite.

The core varies irregularly between altered to fresh rock intervals. Altered intervals are overprinted by disseminated limonite overprinting the banded rock. The core, in its altered state, is highly fractured along the band planes to granulated to disintegrated into an argillaceous material, the latter composed of iron oxides and limonite.

Fresh rock is observed as intact core or core that is fractured along bands with few irregular fractures crosscutting the bands.

Local clusters of pyrite and chalcopyrite are present along fracture surfaces. The rock mass within this unit displays a faint magnetism along short intervals, predominantly within black hematite bands.

Numerous intervals transected veins, veinlets and tension gashed in-filled with quartz and hematite. White and grey chert bands are thin (less than 1 cm in general), continuous but faint. Some bands appear in the form of irregular lenticular to elliptical shaped pockets. They are composed of interlocking fine-grained spherically shaped quartz grains forming an equigranular crystalline matrix occasionally disrupted by intraband microshears oriented perpendicular to the individual bands. The microshears terminate along individual band extremities. Black coloured hematite bands are observed as pitch black to metallic blue grey coloured microcrystalline to fine-grained hematite aggregates forming an equigranular texture. Occasional lenses, pockets and disseminated fine-grained specularite are present within the hematite bands.

Interbands are well defined, and generally parallel with black hematite bands. Hematite bands are predominant with respect to red chert bands and show thicknesses varying from 1 to 15 cm. Boundaries between bands are smooth to wavy to frequently disrupted by veins and microshears. Microshear bands can transect across several interbands to produce irregular fractures oriented parallel to the length of the core (or roughly perpendicular to the orientation of the bands). The bands are generally inclined (between 20 to 45°), but can occur as subhorizontal to vertical and occasionally with microfold structures.

Lower Red Chert: Frequent interbands of black hematite bands intercalated with white, pale grey to grey chert bands, red chert bands and white carbonate bands. Occasional intervals of dull black thin laminar shale bands displaying a fissile nature. Interbanding between chert bands and hematite bands are frequent. Bands are generally thinner (< 1 cm) and repetitive. The core varies irregularly between altered to fresh rock intervals. Altered intervals are overprinted by disseminated limonite and iron oxides. The core, in its altered state, is highly fractured along the band planes to granulated to disintegrated into a clay-rich mass, the latter composed of iron oxides and limonite. Fresh rock is observed as intact core or core that is fractured along bands with minor irregular fractures crosscutting the bands.

Locally, trace amounts of pyrite and chalcopyrite clusters or disseminations are present along fracture surfaces. There is also presence of magnetite due to a slight magnetism present in black hematite and red chert bands. The interbands can be disrupted by brecciated intervals that appear annealed in most instances, however produce local sheared structures displacing or microfolding interbands of chert and hematite. Presence of some intervals transected by quartz and hematite filled veins and tension gashes.

White and grey chert bands are thin (up to 5 cm in thickness) and continuous. They are composed of interlocking fine-grained spherically shaped quartz equigranular crystalline matrix occasionally disrupted by intraband microshears oriented perpendicular to the individual bands. The microshears terminate along individual band extremities.

Black colored hematite bands are observed as pitch black equigranular microcrystalline to fine-grained hematite aggregates. Occasional lenses, pockets and disseminated fine-grained specularite are present within the hematite bands. Interbands are well defined, and generally parallel with black hematite and grey and white bands.

Boundaries between bands are smooth to wavy and occasionally disrupted by veins and microshears. Microshear bands can transect across several interbands to produce irregular fractures oriented parallel to the length of the core (or approximately perpendicular to the orientation of the bands). The bands are generally inclined (between 20 to 45°), but can occur as subhorizontal to vertical and occasionally with microfold structures.

Ruth Shale: Dull black to maroon coloured laminated to massive shale with lenticular passages of black to dark and pale grey chert. Occasional strewn-out fine-grained subrounded quartz grains present throughout this interval forming thin discontinuous lamellae. Quartz grains also appear sparsely disseminated (wackestone texture) within the shale. Occasional dark to light grey siltstone bands.

The shale is massive, however the matrix contains sparsely disseminated pale coloured mica, feldspar grains and lithic intraclasts of shale and chert. Iron oxides are prevalent appearing as small clusters and disseminated pyrite and chalcopyrite within the shale matrix.

Core varies from fresh to altered intervals. Rock fresh surface is black with thin pale grey to white lamellae of carbonate, quartz and siltstone. Weathered surface is usually lined with dull grey argillaceous mass and reddish brown / ochre colored iron oxides.

Lamellae are continuous and strewn out, orientation of lamellae are horizontal to slightly inclined.

Wishart Sandstone: Uniform crystalline mosaic of quartzite composed of well-rounded fragments of quartz and rounded fragments of pink, brown and grey feldspar with interstitial quartz matrix and minor amounts of hematite and other iron oxides. The latter appearing as very fine-grained black specs 'peppered throughout the rock.

Also presence of thin black bands and traces (possibly hematite, chert, siltstone or shale) overprinted by recrystallised quartz mosaic.

Fresh surfaces of the rock are medium grey to pink or with some red. The thickness of the beds varies from 3 cm to about 20 cm. Cross-bedding and gradational bedding is present in some intervals. Individual bands can appear wavy, straight continuous and discontinuous. Overall bedding varies from horizontal to slightly inclined.

A second variety of quartzite appears as a pale grey homogenous mosaic with a greenish hue. Upon close observation, the interstitial matrix appears to constitute very fine-grained chloritic mass, forming a faint lineation in the fabric of the rock. The lineation is oriented perpendicular to the bedding, along which irregular shaped fractures are observed.

5.2 PIT AREA BEDROCK HYDRAULIC PROPERTIES

Packer testing was performed on four hydrogeological wells from JGW-1 to JGW-4. Tests were performed within each successive geological unit for every exploratory drill hole of the drilling campaign. The length of test intervals varied from 4.7 to 24.2 meters. The lengths and locations of test intervals were dependent on the lithological and structural nature of the rock mass intercepted during drilling and after examining the core. In addition, the majority of targeted packer test intervals did not overlap into multiple geological units.

Data obtained from the packer tests include flow rate (read in L/30 second) and water pressure steps (read in psi units). Recorded data were initially treated to produce and interpret trend graphs comparing flow rate (m^3/day) vs. pressure steps (psi) and histograms of Lugeon values vs. pressure steps. Behavioural trends observed over a pressure loop, which is defined over the five stages with a particular water pressure magnitude associated with each stage, were classified accordingly.

Subsequently, the water pressure and flow rate values recorded from each packer test were then used to compute the Lugeon value and hydraulic conductivity for each step. Once the Lugeon values and the hydraulic conductivity values have been calculated for each of the five test steps, a representative value was selected based on the trend observed throughout the test, in most instances, the value associated with the highest water pressure step was selected based on consistency in pressure observed over the third step of the test.

Table 5-1 summarises results of hydraulic tests including the packer tests. Table B-1 in Appendix B provides a more detailed summary of packer test data, computed values and trend graphs. Appendix B also presents individual detail sheets for the calculation of hydraulic conductivity and for trend analyses for each packer test interval. Section 4.2 includes the theory with respect to the calculation of hydraulic conductivity and the Lugeon value.

Table 5-1: Summary of Hydraulic Test Results

Well	Unit	Interval (mbgs)	Packer Test Interval	Hydraulic Conductivity (m/s)			
				Packer Test	Geomean of Packer Tests	Pumping Test	Injection Test
JGW-1	Overburden	0.0 – 0.6			7.6E-07	9E-06†	3E-07
	Menihek	0.6 – 3.9					
	UMH	3.9 – 27					
	RC	27 – 63	37.3 – 48.0	1.0E-06			
	LMH/URC	63 – 105	60 – 72	2.2E-06			
			88.3 – 96	3.7E-06			
	LIF/LRC	105 – 171	111 – 120	9.1E-08			
			131.6 – 140	2.0E-07			
			160.3 – 170.5	1.3E-06			
JGW-2	Overburden	0.0 – 2.9			9.6E-07	n/a	1E-07 8E-08
	LMH/URC	2.9 – 60.6	28.9 – 36.6	2.0E-06			
			49.9 – 60.6	1.4E-06			
	LIF/LRC	60.6 – 72.9					
	LRC/RS	72.9 – 90.8	79.9 – 90.6	1.6E-06			
	RS	90.8 – 111.7	100.9 – 111.6	2.3E-06			
	RS/QTZ	111.7 – 115.42					
	QTZ	115.42 – 171.3	121.9 – 141.6	8.7E-08			
			154.9 – 164.1	1.1E-06			
			159.9 – 170.6	7.9E-07			
JGW-3	Overburden	0.0 – 0.3			4.5E-07	3E-07	n/a
	UMH	0.3 – 20.9					
	RC	20.9 – 75	64.3 – 75	8.4E-07			
	LMH/URC	75 – 96	74.8 – 99	5.0E-07			
	LIF/LRC	96 – 168	112.05 – 120	5.0E-07			
			130.3 – 141	8.3E-07			
			142.3 – 148.5	4.2E-07			
			157.8 – 171.5	1.1E-07			
JGW-4	Overburden	0.0 – 3.3			6.6E-07	n/a	2E-07
	LMH/URC	3.3 – 41.3	37.6 – 42.3	2.1E-06			
	LIF/LRC	41.3 – 64.0	52.6 – 63.3	1.6E-06			
	RS	64.0 – 97.8	88.6 – 96.3	2.3E-06			
	QTZ	97.8 – 171.3	112.6 – 123.3	1.1E-08			
			133.6 – 144.3	8.0E-07			
			145.6 – 156.3	6.9E-07			
			163.6 – 171.3	1.2E-06			
BH-P-03						7E-07	2E-06
BH-P-04						3E-07	5E-07

Notes:

† Result is uncertain.

n/a – data could not be analysed.

An initial assessment of trends and hydraulic conductivity (*K*) derived from packer tests of drill holes JGW-1 to JGW-4 shows ranges from very tight rock (low permeability) with values ranging from 1.7 to 9.7 x 10^{-8} m/s to moderately and highly permeable rock showing values as high as 3.4 x 10^{-6} m/s.

The flow rates associated with very tight rock formations were extremely low. Taking into consideration the maximum pressure step (step 3) of each packer test, flow rates were observed to vary from 1.73 to 21.89 m^3/d. A decrease in flow rates with increasing pressures was also observed in test intervals associated with low permeability. Conversely, test intervals over permeable rock showed moderate to high flow rates, which varied from 30 to 205 m^3/d.

Trend graphs generated from packer testing of JGW-1 to JGW-4 show three general patterns when compared to common graph types as shown in Figure 4.1. The patterns observed include a combination of types 4 and 9, the second pattern associated with type 7 and the third pattern associated with types 2 and 5. However, there is no distinguishable pattern associated to any particular rock formation observed in the pit area. The trends observed are more a reflection of the condition of the rock mass affected by hydraulic pressure and flow within a packer test interval. Based on these trends, the different conditions of the rock can be summarised as follows:

1) For trend graphs associated with types 4 and 9, the rock mass is relatively permeable with a decrease in flow due to a change from laminar to turbulent flow caused by partial clogging of fractures over time. In most instances, the flow rate associated with the water pressure in the down steps is greater possibly due to clearing of debris situated in the fractures. It appears that banded iron formations (intercalated chert and hematite bands) were frequently observed with this trend. Fracture observed in core samples were oriented parallel to the banding plane and normally inclined (with respect to the core axis) at approximately 35 to 45°. In addition, tests conducted in the banded iron formation, including the formations UMH, RC, LMH and LRC, often contained iron oxides and altered debris including limonitic bands present along the fracture planes. This material often produced fragmented core that could act as gouged debris either clogging or clearing the fractures during packer testing. The downward curvature of trend lines between consecutive up- and down-steps indicates incomplete blockage of the fractures by transported debris.

2) Type 7 curves display trends of increased permeability with increase in water pressure indicative that rock fractures are expanding due to excess pressure. This trend was observed in the banded iron formations, the Ruth Shale and in the Wishart Formation.

3) Type 2 and 5 are quite apparent in that they are associated with rock with low permeability and tight fractures. The flow rates associated with this trend are very low. Core samples derived from test intervals with these trends display low fracture frequency (i.e., a high RQD). The trend line is relatively flat, but in some instances a gentle slope is

present indicating washing out of gouged material from fractures thus increasing permeability. As in the previous two type curves, no lithological associations are evident however, in drill holes JGW-2 and JGW-4, where the Wishart Formation is intercepted, low permeability characteristics are apparent within the Wishart unit just below the contact with the Ruth Shale Formation. In JGW-1 and JGW-3, which intercept the banded iron formations, similar locations of low permeability zones are observed in the banded iron formation within the LRC Formation just below the contact with the LMH unit. Each of these sets appears on opposite flanks of the structural syncline and at similar depths in the pit area under investigation, however both sets of drill holes intercept formational units at extreme intervals. The structural syncline plunges southward, and as a result, lower formational units are situated at shallower depths along the northern fringe of the projected pit area and intercepting drill holes JGW-2 and JGW-4. These units would appear at depths beyond 200 me near the northern periphery of Joyce Lake, or near drill holes JGW-1 and JGW-3, thus intercepting the low permeability zone beyond the base of the projected pit.

Lugeon values and histograms projecting computed Lugeon values over pressure stages, display three distinctive groups. The groupings are based on common trends described in Section 4 of the report.

1) In the first grouping, Lugeon values in the range below 1.7 are associated with low permeability rock where possibly the rock mass is very tight. Histogram trends over different pressure steps are relatively flat indicating laminar flow and where seepage velocities are small.

2) The second grouping shows Lugeon values greater than 1.7 up to 10, which appear to be associated with rock units with moderate permeability. Histograms associated with this group are two-fold; either Lugeon values decrease as the water pressure increases or the Lugeon values increase as the test proceeds indicative of turbulent to wash-out conditions and as in types 4 and 9, it is indicative of gouged material in fractures progressively washed out by pressurised water or clogging the fractures. The core samples associated with this group belong to the altered banded iron formations, less frequently in Ruth Shale and the Wishart Formations.

3) The third grouping shows Lugeon values, greater than 10, are associated with permeable rock units. This type is indicative of turbulent flow, which is characteristic of rock masses exhibiting moderately wide to open fractures. Trend histograms associated with this group display decrease in Lugeon values with increasing water pressure (i.e., the minimum Lugeon value is observed at the stage with the maximum water pressure). Based on core sample observations, majority of the rock formations displaying strong banding and alteration are associated with this trend.

Correlations between hydraulic properties and individual formational units is inconclusive, since the study in the pit area rely on test results and core sample characteristics (both structural and compositional) observed over four drill holes, two of which do not intercept the lower units including the Ruth Shale and the Wishart. Nevertheless, based on packer test results alone, a low permeability zone, intermediate in depth, separates a highly permeable zone from surface and a moderate to highly permeably zone at depth. This pattern is observed in all four drill holes at similar depths.

A partial correlation can be established from the drill-holes situated along upper and lower portions of the structural syncline within the projected pit area.

With respect to drill holes JGW-2 and JGW-4, both intercept the lower geological units of the plunging syncline structure, in particular, the Ruth Shale and the Wishart Sandstone. Both holes are located along the northern extremity of the projected pit area, and a change in permeability over a few orders of magnitude from 10^{-6} m/s to 10^{-8} m/s is observed between the Ruth Shale and the upper Wishart Sandstone. The low permeability zone is situated in the Wishart Sandstone. This zone is approximately 20 to 40 m in width below the Ruth Shale contact. An increase in permeability to an order of 10^{-7} to 10^{-6} m/s occurs afterwards. This change is associated with core samples showing a change in textural characteristics of the Wishart Formation from ‘bedded’ sandstone to ‘uniform’ sandstone. In the latter case, upon close observations of core samples in this unit, the uniform sandstone displays a planar cleavage fabric derived from a chloritic matrix. The planar fabric enhances fracture planes perpendicular to faint trace of relic bedding. The rock mass itself is friable in nature displaying a higher permeability than the overlying bedded Wishart.

A bedded Wishart reappears below the uniform Wishart however; it shows a moderate to high permeability, contrary to the bedded Wishart located in contact with the Ruth Shale. This is possibly due to the presence of repetitive small intervals of uniform sandstone interbeds within lower portion of the bedded Wishart sandstone thus changing the overall rock mass characteristics and change in permeability.

The drill holes situated adjacent to Joyce Lake (including JGW-1 and JGW-3) intercept the upper geological units of the Sokoman formation including UMH, RC, LMH and LRC formations. However, permeability changes can only be observed over two zones. A permeable zone associated with the UMH, RC and LMH with permeability values measured in the order of 10^{-7} to 10^{-6} m/s and; a lower permeability zone that appears in the LRC near the LMH contact. This lower permeability zone is present but poorly defined with respect to its extents, both along the upper and lower limits. Permeability values are in the order of 10^{-8} to 10^{-7} m/s.

This pattern is not observable over the LRC and LMH contacts intercepted at drill holes JGW-2 and JGW-4. It is possible that other structural traits such as faults or shear zones may impinge on the rock mass condition. It was also observed that the LRC unit is significantly 'thinner' over JGW-2 and JGW-4 in comparison to JGW-1 and JGW-3, which may indicate a local and complex change in the structural or bedding orientation of sequence of formations (i.e., local parasitic folds may impact the rock cleavage and ultimately the permeability of the rock mass). Based on core sample observations of JGW-1 and JGW-3, the RQD values show a greater variation between low and high values at roughly greater than 100 m in depth.

Although several structural faults were identified in the pit area through the analyses of various cross sections and drill hole data derived from LCIO exploratory drilling campaigns and the current study, permeability zones cannot be directly correlated within the structural model. Irrelevant to the nature of the rock mass and the rock type, this information may be crucial in refining the hydrogeological model since sudden variations in permeability could be associated with rock mass units within fault zones.

In a broader view, the results of the short-term pumping and injection tests, which tested the entire geological profile intercepted in each of the six wells, are incorporated with the packer test results. As shown on Table 5-1, the hydraulic conductivity was generally in the range of 10^{-7} to 10^{-6} m/s. These results suggest that the subsurface materials in the vicinity of the proposed pit are moderately permeable.

5.3 Groundwater Occurrence, Aquifers, Aquitards

The main aquifers appear to be found in fractured bedrock. Under the current study, distinctive local groundwater flow systems of fractured rock systems are identifiable. The drilling campaign from the current study produced boreholes along the eastern and western limbs of the syncline. These boreholes intercepted several fracture zones over the length of the borehole. An attempt to correlate packer test results and interpretations with stratigraphy revealed both closed fracture zones interpreted as areas with limited groundwater flow and other zones where the fracture density in the rock mass is observed to be high and which is associated with regions in bedrock where groundwater flow could be high. Stratigraphic interpretations were drawn from correlations using current and LCIO's core log reports.

The flanks of the syncline display plunging strata from the northwest towards the southeast and the units show variable thicknesses over the southeast portions of the study area. Fracture zones identified within the LMH and RC units, are likely to occur along the length of the limbs of the structural syncline. Hydraulic conductivity values obtained from packer testing were observed in the order of 10^{-6} m/s. These values are observed over both the northeast and southwest flanks of the syncline. Although packer test results were not obtained in the UMH unit, core log reports reflect a unit that is highly fractured showing low RQD values and a highly granulated nature of core samples extracted. As a result, the UMH unit is considered as part of the upper permeable fractured zone along with LMH and RC units.

The LRC unit on the other hand showed variable results depending on its location. Where the LRC unit was intercepted at depth, as in boreholes JGW-1 and JGW-3, a distinctive low permeability zone was identified with hydraulic conductivity values of the order of 10^{-8} m/s. These intervals are located along the flanks of the syncline. However, the LRC unit intercepted at JGW-2 and JGW-4, located upgradient along the flanks of the syncline, does not display permeability values similar to its downgradient equivalents; they are in the order of 10^{-6} to 10^{-7} m/s. The high permeability zone appears to continue into the RS, intercepted only upgradient along the flanks of the syncline. The LRC is characterised as a highly fractured zone along both flanks of the syncline with the possibility of displaying local discrete and closed fracture sets such as it is interpreted over boreholes intercepting LRC at JGW-1 and JGW-3.

Finally, the Wishart Sandstone appears to have a region in the vicinity of the RS contact, where the permeability values are low in the range of 10^{-8} m/s. This appears to be a sublinear structural feature associated with the orientation of this unit that transcends along the flanks of the syncline. The lower portion of the Wishart displays moderate to high permeability in the range of 10^{-6} to 10^{-7} m/s.

The lone discrepancy appears to be associated with the LRC unit. However, it was also noted that the low permeability zone occurs at depths between 110 and 145 m transecting three formational units from LRC, RS and Wishart. This array could be indicative of widespread shear zones and fracture systems located within this depth interval and which could generate considerable fracture porosity. Additional boreholes and testing would be necessary within the hinge area of the syncline to confirm these trends.

Based on these observations, fractured bedrock characterised by UMH, RC, LMH and LRC form a continuous water-bearing unit. In addition, a lower water-bearing unit appears within the Wishart Sandstone. This unit is separated by a low permeability zone within the Wishart Sandstone, adjacent to the lower contact with the RS unit.

Since the permeability characteristics can be correlated to similar stratigraphic units on both flanks of the syncline, it is most likely that the aquifers trend down-plunge similar to the orientation of the beds of the Ferriman Group within the syncline. However, it is possible that a structurally controlled level barrier displaying lower permeability exists at approximately 120 to 140 m in depth. Hydraulic conductivity calculated in this zone appears two orders lower than its overlying and underlying counterparts. Table B-1 in Appendix B summarises the correlations described in this section.

5.3.1 Groundwater Chemistry

Table C-1 in Appendix C summarises the chemical results for the collected groundwater. The results were compared to Schedule 4 of the Metals Mining Effluent Regulations (MMER), the Canadian Water Quality Guidelines for Aquatic Protection, and Schedule A of Newfoundland and Labrador Regulation 65/03 (NL 65/03). All of the results were well below Schedule 4 MMER and Schedule A of NL 65/03. Copper concentrations were above the WQI criterion for samples taken from monitoring wells JGW-1, JGW-3, and BH4 at 7.5, 9.9, and 4.7 μg/L respectively, while the zinc concentration was above the CWQG criterion for the sample collected from monitoring well JGW-1 (69.2 ug/L versus 30 ug/L).

Hardness concentrations ranged from 7.9 to 61.8 mg/L, alkalinity ranged between 14.9 and 53.1 mg/L (as $CACO_3$) total dissolved solids (TDS) ranged from 40 to 130 mg/L, and acidity results were between 11.6 and 15 mg/L.

Iron results were variable, from a low of < 20 to 929 μg/L, which are still more than one order of magnitude less than the NL 65-03 criterion of 10000 μg/L. Manganese concentrations were quite elevated, from a low of 414 to a high of 5140 μg/L, these concentrations are of low concern because there are no standards for manganese.

Pit dewatering will be accomplished using large diameter dewatering wells that will be constructed with stainless steel well screens surrounded by sand filter packs which will be thoroughly developed. It is expected that the dewatering wells will show improved water quality over the groundwater quality from samples already taken from the monitoring wells because of the filter pack and well development. This improvement of water quality has been our experience with another project in the Schefferville area. The water quality of the groundwater extracted from the dewatering wells is expected to be suitable for direct discharge to receiving water bodies given the groundwater results reported above. Water samples should be analysed from each dewatering well after development to ensure the water is suitable for discharge.

5.4 GROUNDWATER FLOW

Figure 5.1 shows groundwater elevation contours in the vicinity of the proposed pit. These contours are based on groundwater elevations measured October 13, 2014 at five of the six install monitoring wells. The sixth monitoring well, BH-P-04, had not yet been constructed on that date and the groundwater elevation was measured on October 18, 2014. These 2014 elevations were combined with groundwater elevations measured in October 2012 (Stassinu Stantec, 2013a) to determine groundwater flow directions in the vicinity of the proposed pit. Groundwater elevations range from approximately 505 masl near Joyce Lake, which correspondingly has an elevation of approximately 505 masl, to approximately 511 masl northwest of Joyce Lake on the southwest flank of the syncline. Groundwater flows toward Joyce Lake. The groundwater flow velocity in the area of the pit can be calculated using the following equation:

$$v = \frac{Ki}{n_e}$$

Where:

K = hydraulic conductivity (m/s)

i = hydraulic gradient (dimensionless)

n_e = effective porosity (dimensionless)

Horizontal hydraulic gradients in the pit area range from approximately 0.014 to 0.039. As summarised in Section 5.2 the bulk hydraulic conductivity in the pit area ranges from 10^{-7} to 10^{-6} m/s. Effective porosity in the study area has not been measured, and is not easily determined. The effective porosity is estimated to be 0.005. Based on these values, groundwater flow velocities in the pit area are estimated to range from 9 to 200 m/yr.

Due to the need to use HQ-coring equipment for drilling and the limited time available, it was not possible to install nested monitoring wells to assess vertical gradients.

Beyond the immediate area of the pit, groundwater is inferred to flow toward Joyce Lake from a catchment area of approximately 1.82 km^2 (Stassinu Stantec, 2013a). Groundwater elsewhere on the peninsula reports directly to Attikamagen Lake or other smaller surface-water features.

5.5 Groundwater/Surface-Water Interaction

An understanding of groundwater and surface-water interactions is needed to identify streams and surface-water bodies that are susceptible to groundwater diversions and changes to the hydrological regime that can impact the environment, ecosystems and water resources.

A broad reconnaissance was performed of topography, drainage and surface features on the Joyce Lake Property (including bodies of water and soil conditions) in the course of fly-in / fly-out work-shift changes, drilling and pumping test phases of the field work program.

The Joyce Lake Property is situated on an elongated land mass forming a peninsula within the Attikamagen Lake system. The property is located on rough topography with ridges lining the eastern and western periphery of the landmass. Both ridges are hinged across the north. The ridges, trending northwest - southeast along with the hinged section on the northern periphery, reflect the underlying synclinal structure in the bedrock. The overall structure forms a bowl-like valley inclined towards Joyce Lake, the high ridges, resulting from resistant quartzite and sandstone rock units.

Within the valley itself, the physiography is made up of smaller rolling hills and slumps. The area located between boreholes JGW-3 and JGW-4 shows a small wetland possibly fed by groundwater springs. The wetland is located over a flat area and runoff downgradient is very restrained, resulting with flows visually evaluated in the 10's of L/min, although a continuous flow in the form of a stream was not apparent. The intermittent flow could also be the result of surface-water seepage through porous overburden and fractured and weathered bedrock thus locally contributing to the groundwater recharge downgradient. Another small slumping area downgradient of JGW-2 displays boggy soil conditions in low brush. No run off was observed in this area, but this zone could also be the result of groundwater springs arising from very steep slopes directly up gradient to the northeast.

No formal measurements were taken of the height of the water levels; however minor fluctuations were noted over a four-week period in September and October 2014. A slight increase in the area over which the wetland presided was noted during and after intense rainfall and after a rapid snow melt. The runoff after these episodes was more prevalent showing a consistent flow in very small creeks, which dissipated possibly due to seepage.

The Joyce Lake Study Area has a thin cover of overburden. Based on field observations and from material extracted from the JGW boreholes, the overburden is observed to be composed of a rocky till constituting a sand/silt and clay medium with some blocky material possibly colluvium in origin. The thickness of the till is approximately 3 m upgradient (in the vicinity of boreholes JGW-4 and JGW-2), and considerably thinner (less than 0.5 m) downgradient over the other two boreholes. The till appears to be relatively porous given the blocky nature.

Rocky outcrop was apparent over the study area showing up mostly over high points on hilly terrain. The bedrock underlying the till or outcropping was generally composed of various units of the banded iron formation of the Sokoman Group. Given the highly fractured nature of the rock mass, and the inclined orientation of these fracture sets, it could be perceived that prevalent surface/groundwater seepage is discharging into Joyce Lake.

Aside from Joyce Lake, there does not appear to be other creeks or springs in the area north of Joyce Lake.

The watershed appears to form an elongated bowl-shaped feature, where drainage is dominated by Joyce Lake and that wetlands located to the north along with groundwater migrating through fractured bedrock from the upper units of banded iron formation of the Sokoman Group drain into the lake southward. Groundwater recharge derived from within the bowl shaped valley of the Joyce Lake landmass and the orientation of the fractures that are controlled by the plunging structural syncline may define the watershed around Joyce Lake.

6. POTENTIAL IMPACTS TO GROUNDWATER FROM PROPOSED PIT DEVELOPMENT

6.1 Pit Dewatering

Operation of the open pit mine will require dewatering to ensure that the water table is maintained below the bottom of the pit and more than 25 m from the pit walls. Appendix D describes the design, calibration and simulations of a numerical, three-dimensional groundwater flow model used to evaluate various dewatering configurations. The objectives of the model include the following:

- Estimate the number of wells and total pumping rates required during various phases of mine operation.
- Evaluate the influence of mine dewatering operations on recharge/discharge rates for nearby surface-water bodies including Joyce Lake, ponds, streams and wetlands.

Four phases of dewatering were considered: Phase I involves dewatering below a pit bottom elevation of 480 masl; Phases II, III and IV involved pit bottom elevations of 460, 420 and 380 masl, respectively. The final bottom elevation of the pit will be approximately 380 masl.

As shown on Figure 5.1, the proposed open pit extends into the north portion of Joyce Lake. Two cases were considered for future dewatering. The base case involved complete dewatering of Joyce Lake. The optional case involved partial dewatering of Joyce Lake with construction of a berm situated approximately 100 to 200 m from the limits of the open pit. As discussed in Appendix D, the permeability of sediments at the bottom of Joyce Lake has not been assessed in the field. Thus, the optional case included the following two sets of simulations:

- Scenario 1 - silty sediments in Joyce Lake with a hydraulic conductivity of 0.01 m/d (1.2×10^{-7} m/s); and

- Scenario 2 - sandy sediments in Joyce Lake with a hydraulic conductivity of 10 m/d (1.2 x 10^{-4} m/s).

Given that Pond A is located approximately 100 m from the east rim of the proposed open pit, it was assumed that this pond would be dewatered for all three options/scenarios.

Section 6.1.1 discusses the estimated number of dewatering wells and associated pumping rates for each of the dewatering configuration simulations. Section 6.1.2 presents the results of a water balance that estimates the change to recharge/discharge rates for nearby surface-water bodies associated with these dewatering configurations.

6.1.1 Simulated Number of Wells and Pumping Rates

The model results show that dewatering of the subsurface around the open pit to the design criteria is achievable. Table 6-1 presents the simulated numbers of wells and total pumping rates for each of the four mine dewatering phases associated with the base case and two optional scenarios.

Table 6-1: Summary of Simulated Pumping Rates for Mine Dewatering

Case	Scenario	Description	Phase	Pit Bottom Elevation (masl)	Simulated No. of Dewatering Wells	Total Pumping Rate (m^3/d)
Base	n/a	Joyce Lake completely dewatered	I	480	7	2,642
			II	460	7	3,330
			III	420	7	4,866
			IV	380	7	5,714
Optional	1	Joyce Lake partially dewatered (silty sediments at bottom of lake)	I	480	7	2,868
			II	460	7	3,721
			III	420	7	5,552
			IV	380	9	6,764
Optional	2	Joyce Lake partially dewatered (sandy sediments at bottom of lake)	I	480	8	3,524
			II	460	8	4,623
			III	420	10	7,131
			IV	380	11	7,821

As shown in this table, the groundwater model suggests that at least seven to eleven dewatering wells are necessary. The model assumed that the dewatering wells are completed to an elevation of 250 masl or depths of approximately 240 to 290 m, depending on the location. Table 6-2 presents the depth and numbers of wells for the base and optional cases. The optimal depth and number of wells required to meet the design criteria and safe mining requirements may differ from those presented in Table 6-2 for the following reasons:

- The hydrogeologic conditions at the dewatering well locations may differ from those observed in the tested drillholes and assumed in the model. In particular, the lowest elevation tested during the current program was 346 masl, but the wells are modeled to be completed to 250 masl. Also, the dewatering wells north of the proposed pit are modeled to be completed within the Dolly Formation, but this formation has not been intersected and tested during drilling at this site.
- The groundwater model simulated constant heads over 50 m x 50 m grid cells – the actual water table elevation outside the annulus of an individual well (with a diameter of only 0.15 to 0.3 m) will be lower than was simulated over the entire grid cell. Until field testing of actual dewatering wells is completed, it is not possible to assess the actual response of the aquifer to pumping and the required depth of wells.
- The groundwater model does not consider well skin or well loss effects, which will further limit the available drawdown of individual wells.
- As back-up, in the event that pump failure or regular maintenance requires the shutdown of one or more dewatering wells for a period of time.
- Following an economic assessment, it may be more cost effective to have a higher number of shallower wells.

Table 6-2: Dewatering Well Pumping Rates (m³/d)

	Joyce Lake completely dewatered					Joyce Lake partially dewatered, silty lakebed sediments					Joyce Lake partially dewatered, sandy lakebed sediments				
Well ID	Depth	Phase I	Phase II	Phase III	Phase IV	Depth	Phase I	Phase II	Phase III	Phase IV	Depth	Phase I	Phase II	Phase III	Phase IV
DEW-1	280	327	451	705	886	280	338	474	755	942	280	327	453	778	896
DEW-2	290	221	297	496	619	290	228	311	531	649	290	218	297	560	627
DEW-3	285	258	372	697	880	285	269	399	777	948	285	263	387	807	906
DEW-4	270	257	344	608	822	270	277	375	648	585	270	274	389	728	853
DEW-5	240	922	1,075	1,055	771	240	1,073	1,327	1,441	701	245	946	1,203	574	534
DEW-6	275	362	416	703	1,003	275	378	439	746	1,015	240	862	1,101	818	639
DEW-7	280	294	375	604	733	280	305	397	655	794	275	341	414	894	1,084
DEW-8	n/a	n/a	n/a	n/a	n/a	245	n/a	n/a	n/a	594	280	293	378	701	756
DEW-9	n/a	n/a	n/a	n/a	n/a	245	n/a	n/a	n/a	536	245	n/a	n/a	668	686
DEW-10	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	245	n/a	n/a	605	433
DEW-11	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	240	n/a	n/a	n/a	407
Total:		2,642	3,330	4,866	5,714		2,868	3,721	5,552	6,764		3,524	4,623	7,131	7,821
Minimum:		221	297	496	619		228	311	531	535		218	297	560	407
Maximum:		922	1,075	1,055	1,003		1,073	1,327	1,441	1,015		946	1,203	894	1,084
Average:		377	476	695	816		410	532	793	752		441	578	713	711
Number of wells:		7	7	7	7		7	7	7	10		8	8	10	11

Table 6-1 shows that the pumping rates for the base and optional cases progressively increase with each phase of mining, corresponding to a deepening of the open pit with each phase. The maximum total pumping rates are associated with Phase IV (bottom elevation of 380 masl) and were simulated to be:

- Base Case (complete dewatering of Joyce Lake): 5,714 m^3/d;
- Optional Case, Scenario 1 (partial dewatering of Joyce Lake, silty sediments): 6,764 m^3/d ;
- Optional Case, Scenario 2 (partial dewatering of Joyce Lake, sandy sediments): 7,821 m^3/d.

As shown in Table 6-1, the Phase IV total pumping rates were simulated to be 2.2 to 2.3 times higher than the Phase I dewatering rates. The highest pumping rates were simulated to occur for the scenario where Joyce Lake is only partially dewatered and lakebed sediments are sandy with a relatively high hydraulic conductivity. The higher pumping rates occur for this scenario because of enhanced recharge from Joyce Lake to the underlying water table during dewatering.

Table 6-2 presents simulated individual dewatering well pumping rates for all four phases of the base and optional cases. The individual modeled dewatering well pumping rates under the base case for Phase I (to 480 masl) range from 221 to 922 m^3/d (41 to 169 USgpm). During Phase IV (to 380 masl), the pumping rates range from 619 to 1,003 m^3/d (114 to 184 USgpm). For the optional cases, pumping rates were modeled to range as high as 1,441 m^3/d (264 USgpm).

Figures 6.1 through 6.4 show the modeled locations of the seven dewatering wells for the base case. The figures also present the simulated groundwater elevation contours for Phases I through IV, respectively. Figure 6.5 presents the simulated drawdown relative to pre-mine groundwater elevations for Phase IV of the base case. The highest drawdown occurs directly below the pit limit, and the drawdown due to mine dewatering decreases substantially with distance from the pit. Drawdowns are modeled to range from less than 0.1 m up to about 5 m at Timmins Bay northeast of the proposed mine and at Attikamagen Lake to the northwest. The drawdown at Iron Arm to the southwest is modeled to be less than 1 m.

Appendix D shows additional details regarding the dewatering conditions. In particular, it shows that the Phase IV water table clearly meets the 25-m design criterion to the west, north and east of the proposed pit. However, modeled hydrogeologic conditions to the south of the pit, toward Joyce Lake, are close to the design criterion near the base of the pit. As discussed above, additional dewatering wells may be required depending on actual hydrogeologic conditions.

Figures 6.6 and 6.7 present the simulated groundwater elevation and drawdown contours for Phase IV in Scenario 1 of the optional case (partial dewatering of Joyce Lake, silty lakebed sediments). Seven wells were required for the first three phases of this scenario. An additional two wells, for a total of nine wells, would have to be installed between the pit and Joyce Lake prior to the start of Phase IV mining. These wells are required to intercept the enhanced recharge from the silty-bottomed, partially-dewatered Joyce Lake in this scenario.

Figures 6.8 and 6.9 present the simulated groundwater elevation and drawdown contours for Phase IV in Scenario 2 of the optional case (partial dewatering of Joyce Lake, sandy lakebed sediments). As shown on Table 6-1, eight dewatering wells are required for Phases I and II. Two wells would have to be added for Phase III, for a total of ten, and one additional well for Phase IV for a total of eleven. These additional wells would be constructed between the pit and Joyce Lake to intercept the higher enhanced recharge from the sandy-bottomed partially-dewatered Joyce Lake in this scenario.

Figures 6.5, 6.7 and 6.9, which show the drawdown of groundwater (the difference in groundwater elevation between current conditions and final pit development), illustrate that the maximum drawdown is similar for all three options/scenarios (contours 160 to 170 m), which suggests that the influence of each of these scenarios outside of Joyce Lake are relatively similar.

6.1.2 Simulated Impact on Surface-Water Bodies

Table 6-3 presents the simulated net discharge rates for various surface-water bodies near the proposed open pit area, including Joyce Lake, ponds, streams and wetlands. The pre-mine discharge rates are shown based on the calibrated model or "current conditions" (Case 1 with silty lakebed sediments in Joyce Lake). Positive values of discharge rates indicate that groundwater discharges into the surface-water body, and negative values of discharge rates indicate that the surface-water body is providing a net recharge to groundwater. The simulated net discharge rates for Phases I through IV of the base case (i.e., Joyce Lake is completely dewatered) are also shown in Table 6-3, as well as the change in these discharge rates relative to the pre-mine rates.

Table 6-3: Base Case - Influence of Mine Dewatering on Recharge/Discharge at Various Surface-Water Features

			Flow Difference Relative to Pre-Mine				Net Groundwater Discharge (m^3/d)				
Description	HSU ID	B.C.	Phase I	Phase II	Phase III	Phase IV	Pre-Dewatering	Phase I	Phase II	Phase III	Phase IV
Attikamagen Lake†	1, 8, 12	CH	-8%	-11%	-17%	-21%	15,484	14,198	13,774	12,786	12,218
Joyce Lake	2	RIV	n/a	n/a	n/a	n/a	1,533	0	0	0	0
Lake E	7	RIV	4%	1%	-6%	-9%	870	905	876	820	795
Pond A	3	RIV	n/a	n/a	n/a	n/a	-499	0	0	0	0
Pond B	4	RIV	8%	14%	26%	31%	-301	-325	-344	-379	-394
Pond C	5	RIV	4%	8%	15%	18%	-237	-248	-257	-274	-280
Pond D	6	RIV	-6%	-16%	-35%	-42%	283	265	237	185	164
Pond E1 & Stream 4	15	RIV	8%	4%	-4%	-7%	104	113	108	100	96
Pond F	9	RIV	2%	2%	2%	2%	273	278	278	278	278
Ponds G,H,I,J & Stream 2	8	RIV	4%	4%	3%	3%	2,037	2,120	2,115	2,107	2,104
Stream 1	12	RIV	-17%	-23%	-39%	-49%	1,270	1,058	972	769	648
Stream 3	16	RIV	29%	38%	55%	62%	-189	-244	-261	-292	-306
Wetland W-1	13	DRN	-7%	-11%	-19%	-24%	234	217	209	190	178
Wetland W-2	14	DRN	-15%	-20%	-33%	-40%	48	41	39	33	29
Wetland W-3	12	DRN	-11%	-17%	-29%	-36%	445	396	371	316	286
Wetland W-4	11	DRN	-8%	-10%	-14%	-16%	423	392	382	363	354
Wetland W-5	7	DRN	-18%	-22%	-30%	-34%	17	14	13	12	11
Wetland W-6	8	DRN	-9%	-13%	-20%	-22%	511	463	444	410	396

Note: negative discharge implies that surface-water body is a net recharge source to groundwater.
† Attikamagen Lake includes discharge to Timmins Bay, main body of Attikamagen Lake and Iron Arm.

Ponds A, B and C, and Stream 3 are modeled as losing surface-water features (recharging groundwater), while all other surface-water features are modeled as gaining (receiving water from groundwater) in the pre-mining simulation.

As discussed above, Pond A is assumed to be dewatered completely when dewatering starts because it is approximately 100 m from the proposed pit. Losses to groundwater in Ponds B and C, and Stream 3 increase by between 18 and 62%. Although water levels may decrease, these water features are not expected to be completely dewatered.

Groundwater discharge to the remaining water bodies decrease by between 7 and 49%. Although water levels may decrease, no surface-water features are expected to be dewatered.

Table 6-4 and Table 6-5 present similar relative discharge rate changes for the optional case (partial dewatering of Joyce Lake) for both Scenarios 1 and 2 (silty and sandy lakebed sediments), respectively. These two tables indicate that Scenario 1 (silty lakebed sediments) was simulated to result in enhanced recharge to the pit from the remaining portion of Joyce Lake, ranging from 366 to 1,550 m^3/d for Phases I through IV, respectively, and Scenario 2 (sandy sediments) results in enhanced recharge up to 2,897 m^3/d for Phase IV. The influence on other nearby surface-water features were simulated to be relatively similar to, but in general slightly less than, the simulated influence for the base case.

Table 6-4: Optional Case, Scenario 1 - Influence of Mine Dewatering on Recharge/Discharge at Various Surface-Water Features

			Flow Difference Relative to Pre-Mine				Net Groundwater Discharge (m^3/d)				
Description	HSU ID	B.C.	Phase I	Phase II	Phase III	Phase IV	Pre-Dewatering	Phase I	Phase II	Phase III	Phase IV
Attikamagen Lake†	1, 8, 12	CH	-8%	-10%	-17%	-20%	15,375	14,147	13,761	12,811	12,222
Joyce Lake	2	RIV	n/a	n/a	n/a	n/a	1,374	-366	-679	-1,188	-1,550
Lake E	7	RIV	-3%	-4%	-7%	-8%	861	836	826	804	845
Pond A	3	RIV	n/a	n/a	n/a	n/a	-509	0	0	0	0
Pond B	4	RIV	5%	6%	10%	12%	-224	-234	-238	-247	-261
Pond C	5	RIV	2%	3%	5%	6%	-209	-214	-216	-220	-227
Pond D	6	RIV	-5%	-7%	-12%	-15%	301	285	279	264	256
Pond E1 & Stream 4	15	RIV	-5%	-7%	-12%	-14%	87	82	81	77	86
Pond F	9	RIV	0%	0%	0%	0%	287	287	287	287	293
Ponds G,H,I,J & Stream 2	8	RIV	0%	0%	0%	0%	2,099	2,095	2,094	2,090	2,177
Stream 1	12	RIV	-17%	-23%	-39%	-49%	1,287	1,067	985	782	652
Stream 3	16	RIV	7%	9%	16%	19%	-184	-196	-201	-212	-259
Wetland W-1	13	DRN	-10%	-14%	-22%	-27%	235	211	203	183	175
Wetland W-2	14	DRN	-17%	-23%	-38%	-47%	43	35	33	26	23
Wetland W-3	12	DRN	-12%	-16%	-27%	-34%	442	390	370	322	296
Wetland W-4	11	DRN	-3%	-5%	-7%	-9%	427	414	408	396	376
Wetland W-5	7	DRN	-4%	-5%	-9%	-11%	17	16	16	15	13
Wetland W-6	8	DRN	-2%	-3%	-5%	-6%	575	562	557	544	505

Note: negative discharge implies that surface-water body is a net recharge source to groundwater.
† Attikamagen Lake includes discharge to Timmins Bay, main body of Attikamagen Lake and Iron Arm.

Table 6-5: Optional Case, Scenario 2 - Influence of Mine Dewatering on Recharge/Discharge at Various Surface Water Features

			Flow Difference Relative to Pre-Mine				Net Groundwater Discharge (m^3/d)				
Description	HSU ID	B.C.	Phase I	Phase II	Phase III	Phase IV	Pre-Dewatering	Phase I	Phase II	Phase III	Phase IV
Attikamagen Lake†	1, 8, 12	CH	-8%	-10%	-17%	-19%	15,484	14,261	13,910	12,849	12,538
Joyce Lake	2	RIV	n/a	n/a	n/a	n/a	1,533	-973	-1,582	-2,640	-2,897
Lake E	7	RIV	5%	4%	1%	0%	870	913	903	880	873
Pond A	3	RIV	n/a	n/a	n/a	n/a	-499	0	0	0	0
Pond B	4	RIV	6%	7%	10%	11%	-301	-319	-322	-331	-334
Pond C	5	RIV	4%	4%	5%	6%	-237	-246	-247	-251	-252
Pond D	6	RIV	-4%	-6%	-9%	-10%	283	271	267	258	255
Pond E1 & Stream 4	15	RIV	9%	8%	4%	3%	104	114	112	109	107
Pond F	9	RIV	2%	2%	2%	2%	273	278	278	278	278
Ponds G,H,I,J & Stream 2	8	RIV	4%	4%	4%	4%	2,037	2,121	2,120	2,117	2,116
Stream 1	12	RIV	-16%	-22%	-40%	-46%	1,270	1,063	986	758	687
Stream 3	16	RIV	27%	29%	33%	34%	-189	-240	-243	-252	-254
Wetland W-1	13	DRN	-7%	-11%	-21%	-24%	234	217	209	186	179
Wetland W-2	14	DRN	-15%	-20%	-36%	-40%	48	41	39	31	29
Wetland W-3	12	DRN	-10%	-14%	-25%	-29%	445	400	382	332	317
Wetland W-4	11	DRN	-7%	-8%	-11%	-12%	423	394	389	377	373
Wetland W-5	7	DRN	-17%	-18%	-20%	-21%	17	14	14	13	13
Wetland W-6	8	DRN	-9%	-9%	-11%	-11%	511	467	464	456	454

Note: negative discharge implies that surface-water body is a net recharge source to groundwater.
† Attikamagen Lake includes discharge to Timmins Bay, main body of Attikamagen Lake and Iron Arm.

6.1.3 Pit Dewatering Summary

The simulated total pumping rates and individual well pumping rates are less than has been observed at other iron ore mines in the Schefferville, Quebec area. For example, Stubbins and Munro (1965) reported that in excess of 16,000 USgpm were pumped from dewatering wells at the Iron Ore Company of Canada Knob Lake Operations. Elsewhere, WESA has observed individual well pumping rates exceeding 1,000 USgpm. These operations were in the same geologic formations targeted by the Joyce Lake Project.

There is uncertainty in the groundwater model results for the following reasons:

- Estimates of hydraulic conductivity are based on short-term single-well hydraulic tests conducted in small-diameter wells.
- Hydraulic conductivity estimates are affected by the use of mud during drilling of the test holes.
- The groundwater elevations used for calibration were collected from an area of approximately 0.6 km^2, but the model domain covers 45 km^2.
- No hydraulic data were available for the Dolly Formation, which the model sensitivity analysis indicates is the most sensitive parameter in the model.
- In a more general sense, a complex geological and hydrogeological condition is being represented by 50 m x 50 m x 20 m grid cells.

Despite these uncertainties, the resulting model is reasonable. Joyce Lake, and other smaller surface-water bodies, are present on the peninsula approximately 35 m above the much larger Attikamagen Lake. Similarly, groundwater elevations in monitoring wells and exploration boreholes in the pit area range between 505 and 512 masl. The open interval for the holes in which these elevations were measured extend as deep as 346 masl. The hydraulic conductivity of the subsurface materials in the vicinity of Joyce Lake must be sufficiently low to prevent infiltrating precipitation within the 1.82-km^2 catchment area of the lake from draining deeper and flowing to Attikamagen Lake. The hydraulic properties that limit drainage similarly will prevent induced capture of significant quantities of water from Attikamagen Lake when the open pit advances below the level of the larger lake.

6.2 Mitigative Measures for Potential Impacts from Pit Dewatering

The groundwater modelling simulations indicate that pit dewatering will affect surface-water bodies in the vicinity of Joyce Lake pit to varying degrees. Significant dewatering impacts on surface-water features that are fish habitat could result in serious harm to fish (Section 35 of

Fisheries Act), therefore mitigative measures may be required in such cases. One mitigative option is to create fish habitat in another location not impacted by dewatering to make up the loss. Another mitigative measure is to use the water pumped from the dewatering wells as a source of water to feed back to the affected surface-water body. It is expected that the water quality from the dewatering wells will be suitable for direct discharge to the environment. Recommendation 4 in Section 7.2 provides specific guidance for next steps with respect to mitigative measures.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

Operation of the open pit mine will require dewatering to ensure that the water table is maintained below the bottom of the pit and more than 25 m from the pit walls. The most effective pit dewatering approach is considered to be a pit perimeter dewatering well system. The predicted maximum rate of dewatering is 5,714 m^3/day for the base case scenario where Joyce Lake is dewatered before pit development begins. This would be accomplished using at least seven dewatering wells. The estimated maximum dewatering rate if Joyce Lake is not dewatered prior to pit development is 7,821 m^3/day. The groundwater model estimates that as many as eleven dewatering wells may be required under this scenario.

Surface-water features in the vicinity of the pit will be affected by the pit dewatering system. These impacts will range from complete dewatering at Pond A to minimal impacts at Attikamagen Lake. Mitigative measures will be required for surface-water bodies that contain fish or are fish habitat. Mitigative measures could include diverting water from the pit dewatering system to the surface-water bodies that are affected by the dewatering system.

7.2 RECOMMENDATIONS

1. The estimate of pit dewatering requirements (number of wells, estimated dewatering rates) presented in this report is partially based on the results of testing conducted on small-diameter (50-mm) monitoring wells. The diameter of the wells limited the size of pump that could be used to conduct the pumping tests. Long-term (minimum 72-hour or until steady state is reached) pumping tests should be conducted at higher pumping rates to optimise the dewatering plan. These pumping tests should be conducted in wells that will have a minimum diameter of 200 mm. These types of wells are normally drilled using an air rotary drill rig. The wells should be constructed using stainless steel well screen with properly designed and installed filter pack because of the leached nature of some of the bedrock. Access to the site for such a rig could be accomplished using the

barge at Iron Arm camp and access roads will need to be constructed at the site. It is recommended that a minimum of three wells should be drilled and tested. These "test wells" should be located at dewatering well locations simulated during the groundwater modelling so that they can be used as future dewatering wells, and specifically we recommend that they could be drilled as dewatering wells DEW-2, DEW-4 and DEW-6 (Figure 6.1) to ensure lateral coverage and so that the monitoring wells installed during this study can be used as observation wells for the pumping tests. Each well should be drilled to a bottom elevation of approximately 250 masl. The wells should be thoroughly developed to ensure removal of fines and drilling additives, and connection with the aquifer. Each pumping test should consist of a step test to determine the optimum long-term sustainable pumping rate, and then a constant-discharge test should be conducted at that rate. Each pumping test should be followed by a recovery test. Water samples should be collected every 24 hours during the test to track any water quality changes that may occur as pumping progresses. These samples should be analysed for metals content and general chemistry.

2. Two clusters of nested monitoring wells, each with three wells, should be drilled adjacent to each dewatering well. Groundwater elevations would be monitored during the pumping tests to allow assessment of the response of the individual screened units to pumping. The nested monitoring wells will also be used to assess vertical hydraulic gradients as required by the Environmental Impact Statement Guidelines.
3. The pumping and recovery testing data should be analysed to determine aquifer properties such as hydraulic conductivity, transmissivity and storativity. Well efficiencies should also be calculated for each well.
4. The Dolly Formation should be assessed as part of the hydraulic characterisation. It is anticipated that dewatering well DEW-2 and associated deep monitoring wells will encounter this formation.
5. The hydraulic properties determined from the pumping and recovery tests should be used to update the groundwater model that was developed during this study. Dewatering simulations should be run with the updated model to optimise the pit dewatering plan with respect to number of wells required, optimum well locations, and refined estimates of dewatering rates.
6. An impact assessment should be performed of each of the surface-water features that are predicted to be affected by the pit dewatering system. This assessment should determine if the surface-water feature is fish habitat, and if it is, it should evaluate the effect that a lowering of water level in the feature will have on fish habitat. If it is determined that the effect could harm fish, then specific mitigative measures should be developed to prevent harm from occurring. This could involve determining the magnitude of the impact and designing a water supply system that would provide make-up water to the surface-water feature from the pit dewatering system.

7. Runoff and minor pit seeps should be managed in in-pit sumps together with water that will collect in the pit from direct precipitation. This pit water is expected to be red and will require water treatment before discharge to the environment. It is recommended that pit water treatment options should be assessed and a plan should be developed to manage the pit water.
8. Prior to mine commissioning, monitoring wells will have to be installed between each pair of dewatering wells to ensure that the water table meets the 25-m design criterion.

8. LIMITING CONDITIONS

The information presented in this report is based on groundwater measurements made and samples collected from specific locations at the site and at specific moments in time. Groundwater conditions may be different at locations other than those specifically evaluated during this study. The aquifer testing results are based on tests conducted on small diameter boreholes that were drilled using drilling mud because of the very poor quality of the rock. Efforts were made to minimise the effects of the mud by flushing the zones before packer testing was conducted and by developing the wells to the extent possible for the pumping and injection testing, but some residual effects from the mud along the walls of the boreholes may have affected the well testing. Limitations of the groundwater modelling are stated in the groundwater modelling report in Appendix D.

This report has been prepared for the exclusive use of Labec Century Iron Ore Inc. No other party may use or rely on this report without the expressed written consent of BluMetric Environmental Inc.

After the submission of the draft report WESA was informed that a revised pit design involves a proposed bottom pit elevation of 314 masl rather than 380 masl. The drilling program and subsequent well testing and groundwater modelling work were based on a maximum pit bottom elevation of 380 masl. Deepening the pit to 314 masl will likely require approximately three (3) additional dewatering wells. In addition, all dewatering wells will have to be drilled deeper, likely to an elevation of 180 masl rather than 250 masl. The impact of pit deepening on nearby surface-water features is predicted to be minimal.

Respectfully submitted,

WESA, a Division of BluMetric Environmental Inc.

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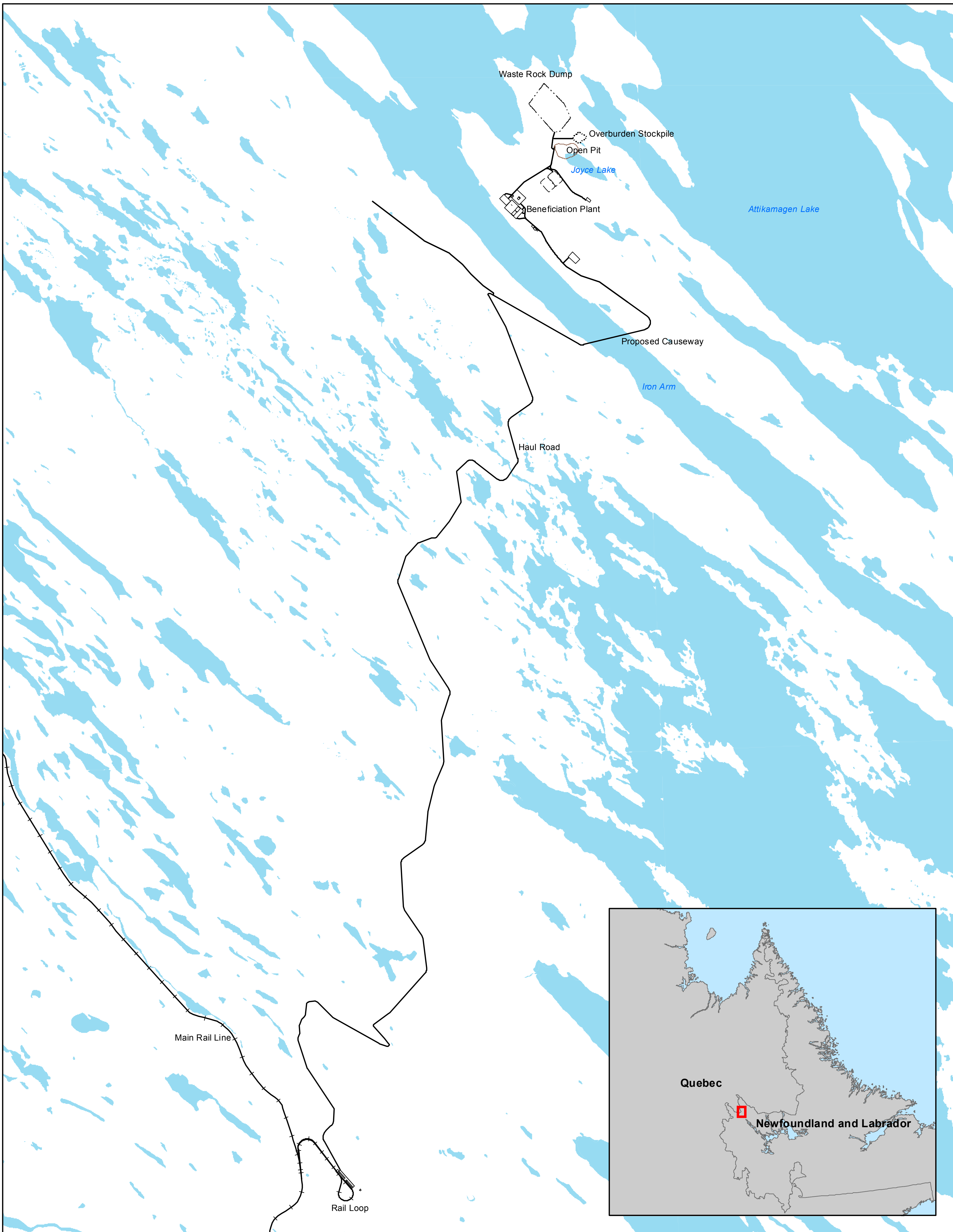
LIST OF FIGURES



LEGEND

- Road
- Rail Line
- Beneficiation Building
- Pit Limit
- Low Grade Stockpile
- Overburden Stockpile
- Waste Dump
- Waterbodies

N W E S

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CLIENT
Labec Century Iron Ore Inc.

PROJECT
Joyce Lake and Area DSO Project
Hydrogeological Study

TITLE
Site Location Plan
and Project Features

PROJECT #	DATE		
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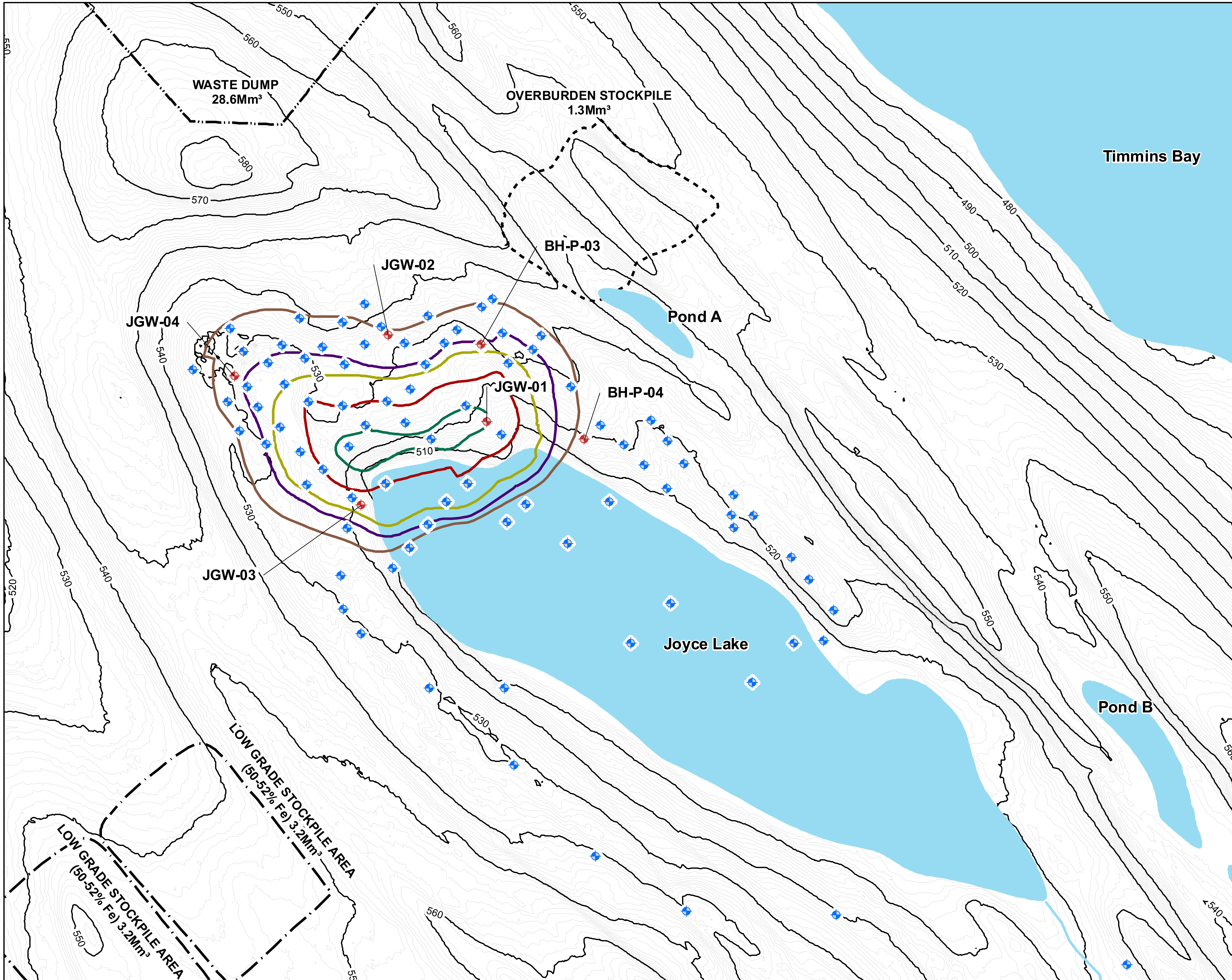
IB	**BOC**	**1.1**	**0**



LEGEND

- Test Wells
- Exploration Holes
- Topographic Contours (1m)
- Perimeter of Pit Bottom - Phase I (480masl)
- Perimeter of Pit Bottom - Phase II (460masl)
- Perimeter of Pit Bottom - Phase III (420masl)
- Perimeter of Pit Bottom - Phase IV (380masl)
- Perimeter of Pit at Surface
- Waterbodies

Stockpiles

- Waste Dump
- Overburden Stockpile
- Low Grade Stockpile Area

REFERENCES

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PROJECT

Joyce Lake and Area DSO Project
Hydrogeological Study

TITLE

Well Location Plan

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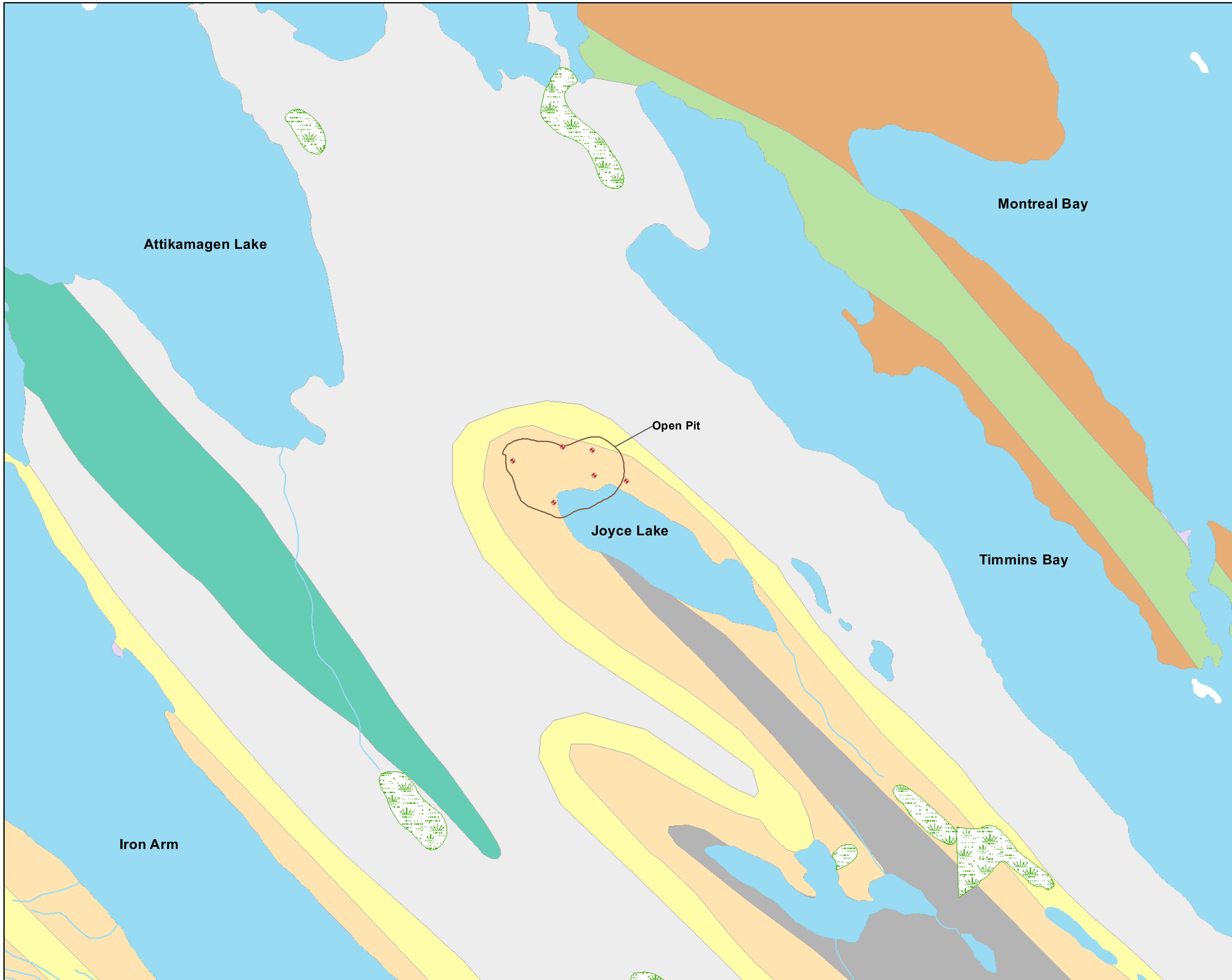

LEGEND

- Test Wells
- Perimeter of Pit at Surface
- Wetlands
- Streams
- Lakes

Kaniapiskau Supergroup

- Gabbro, diabase

Knob Lake Group

Upper Knob Lake Group

Ferriman Subgroup

Menihek Shale

- Grey, Black and red shale

Sokoman Formation

- Cherty iron formation includes basal black shale unit previously known as Ruth Formation

Wishart Formation

- Orthoquartzite, quartzite and siltstone, minor chert

Lower Knob Lake Group

Attikamagen Subgroup

Dolly Shale

- Gray shale and siltstone, black shale

Denault Formation

- Massive cream dolomite; brown laminated and crossbedded dolomite; minor conglomerate

Le Fer Formation

- Pillow Basalt, and tuff

REFERENCES

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PROJECT

Joyce Lake and Area DSO Project
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TITLE

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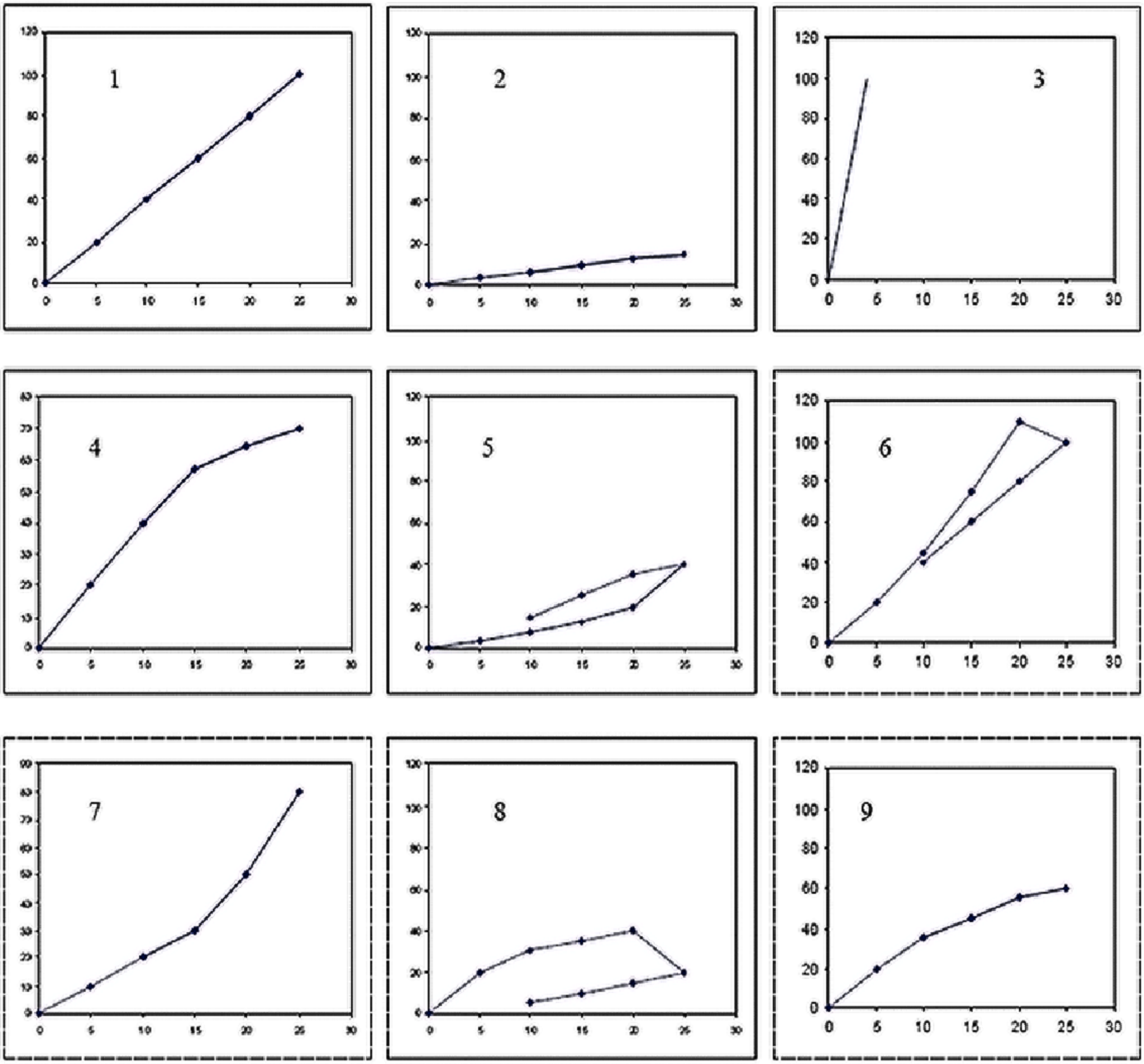

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TITLE

Lugeon Type Curves

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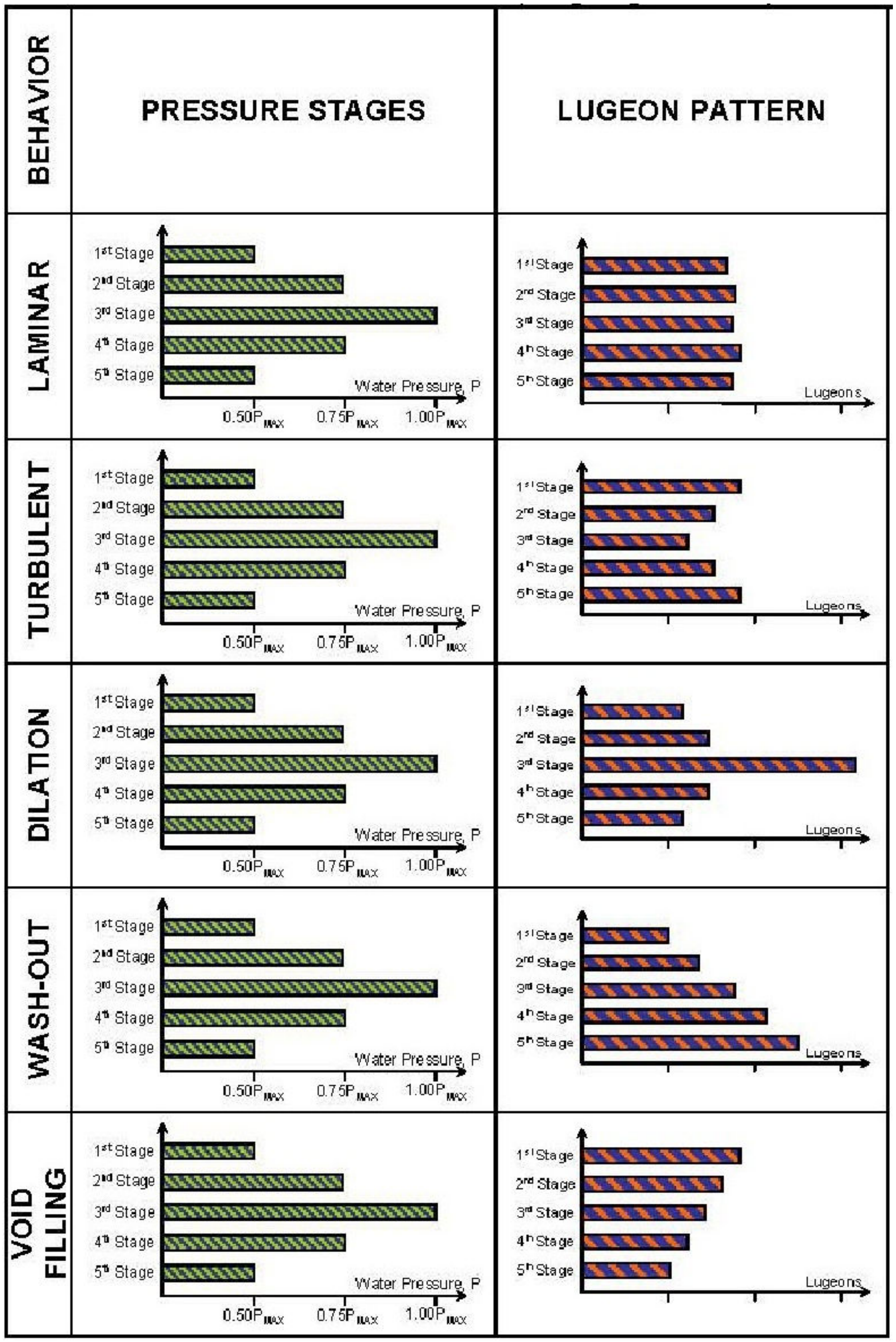

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		PROJECT **Joyce Lake and Area DSO Project Hydrogeological Study**
	BluMetric Environmental Inc. *3108 Carp Rd PO Box 430* *Ottawa, Ontario K0A 1L0* *TEL: (613) 839-3053* *FAX: (613) 839-5376* *Email: info@blumetric.ca* *Web: http://www.blumetric.ca*	TITLE **Lugeon Histogram Patterns**

PROJECT #	DATE
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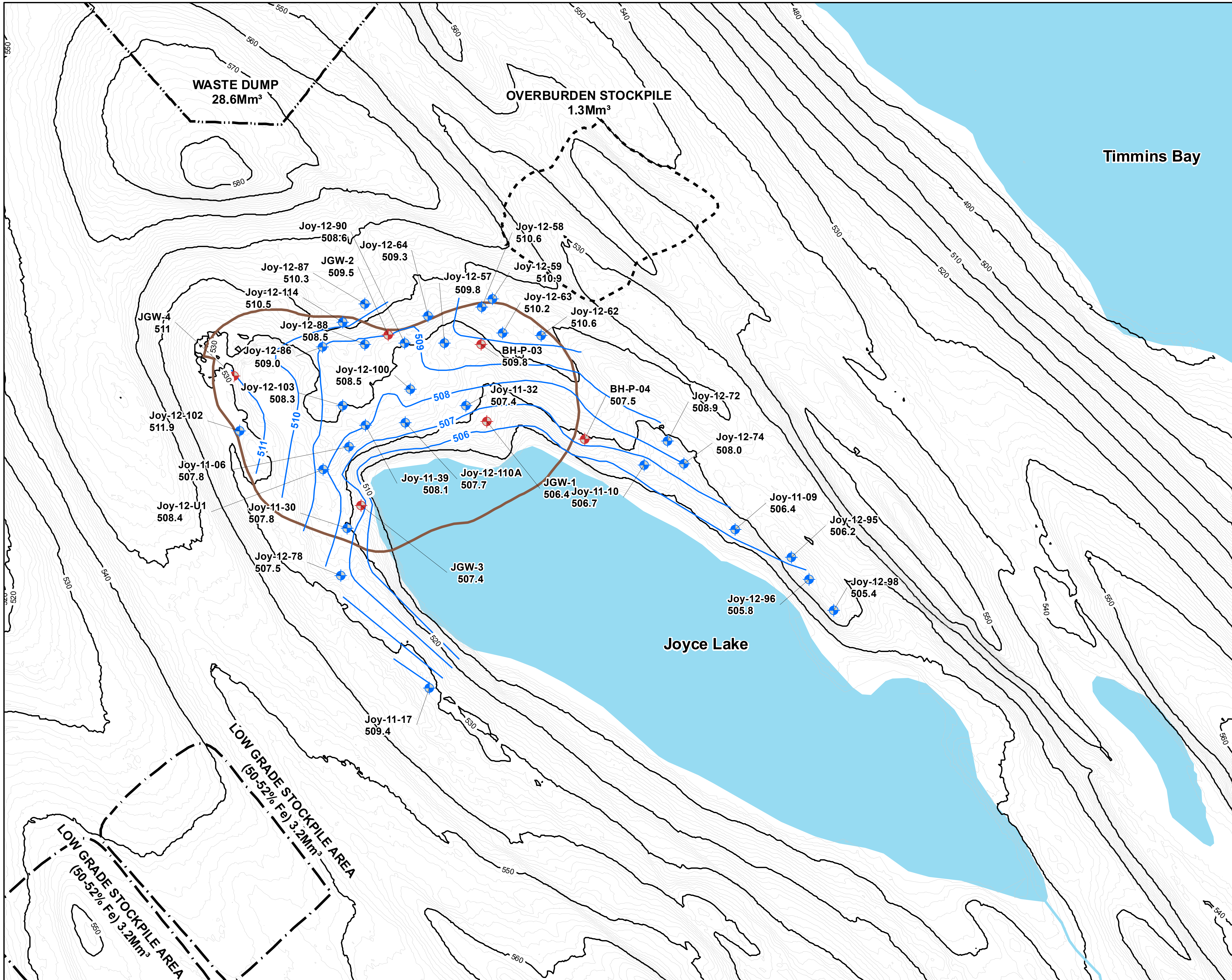


LEGEND

- Test Wells
- Exploration Holes
- Topographic Contours (1m)
- Groundwater Elevation Contours (1m)
- Waste Dump
- Overburden Stockpile
- Low Grade Stockpile Area
- Perimeter of Pit at Surface

Note:
Groundwater elevations for Exploration Holes measured October 2012 by Stassinu Stantec.
Groundwater elevations for Test Wells measured October 13 to 18, 2014 by WESA.

REFERENCES

0 125 250 500
Meters

CLIENT

Labec Century Iron Ore Inc.

PROJECT

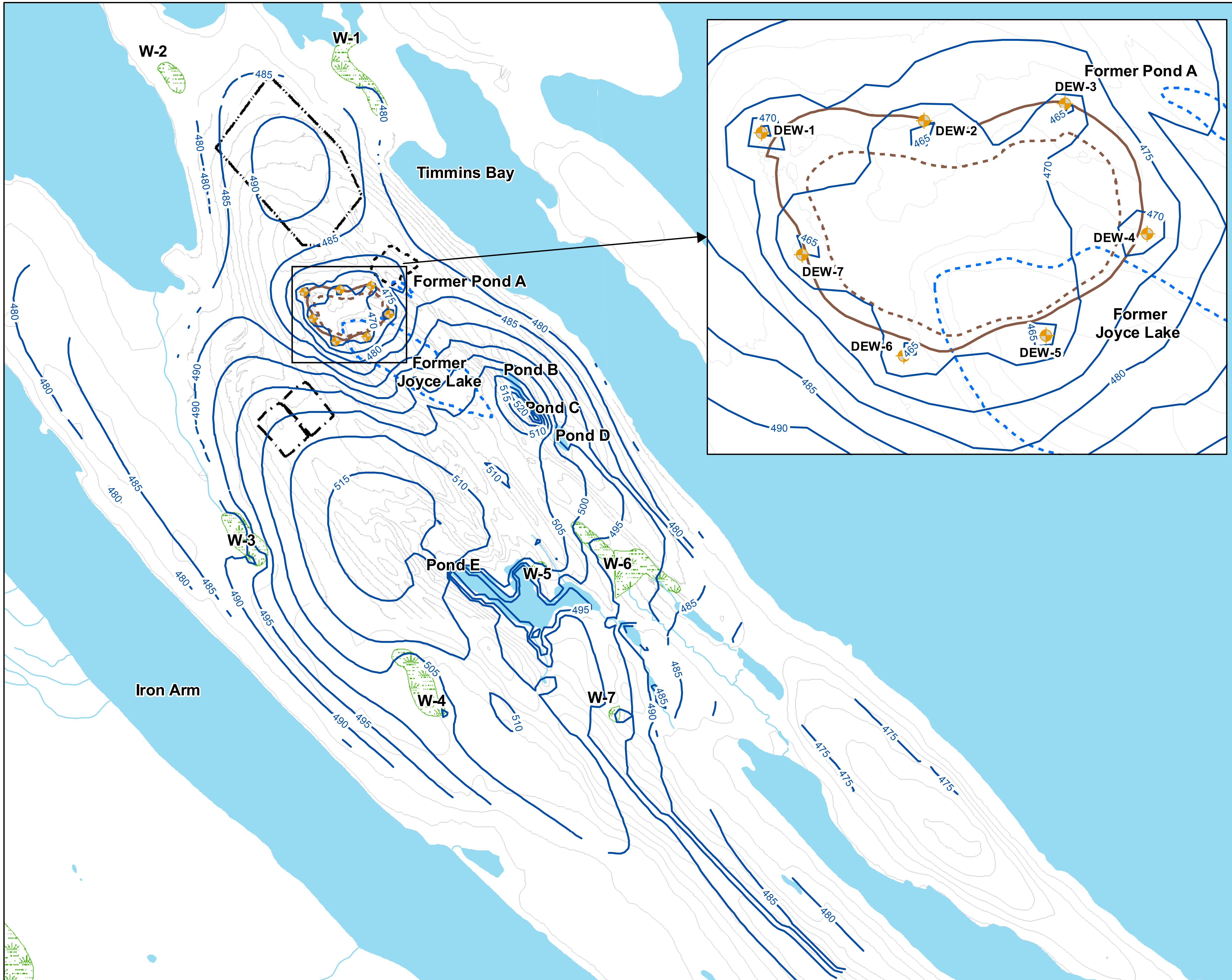
Joyce Lake and Area DSO Project
Hydrogeological Study

TITLE

Groundwater Elevations and Flow

BluMetric Environmental Inc.
3108 Carp Rd PO Box 430
Ottawa, Ontario K0A 1L0
TEL: (613) 839-3053
FAX: (613) 839-5376
Email: info@blumetric.ca
Web: http://www.blumetric.ca

PROJECT #	DATE		
S-B12738-05	January 8, 2015		
DRAWN	VERIFIED	FIG NO.	REV
IB	BOC	5.1	0



LEGEND

- Dewatering Wells
- Topographic Contours (10m)
- Simulated Groundwater Elevation Contour
- Perimeter of Pit Bottom (480masl)
- Perimeter of Pit at Surface
- Streams
- Dewatered Waterbodies
- Waterbodies
- Wetlands (W-5)

Stockpiles

- Waste Dump
- Overburden Stockpile
- Low Grade Stockpile Area

Note: Former Pond A will be dewatered during mine operations

REFERENCES

0 250 500 1,000
Meters

CLIENT

Labec Century Iron Ore Inc.

PROJECT

Joyce Lake and Area DSO Project Hydrogeological Study

TITLE **Perdicted Groundwater Elevations Joyce Lake Dewatered and Pit Development - Ground Surface to 480 masl**

BluMetric Environmental Inc.

3108 Carp Rd PO Box 430
Ottawa, Ontario K0A 1L0
TEL: (613) 839-3053
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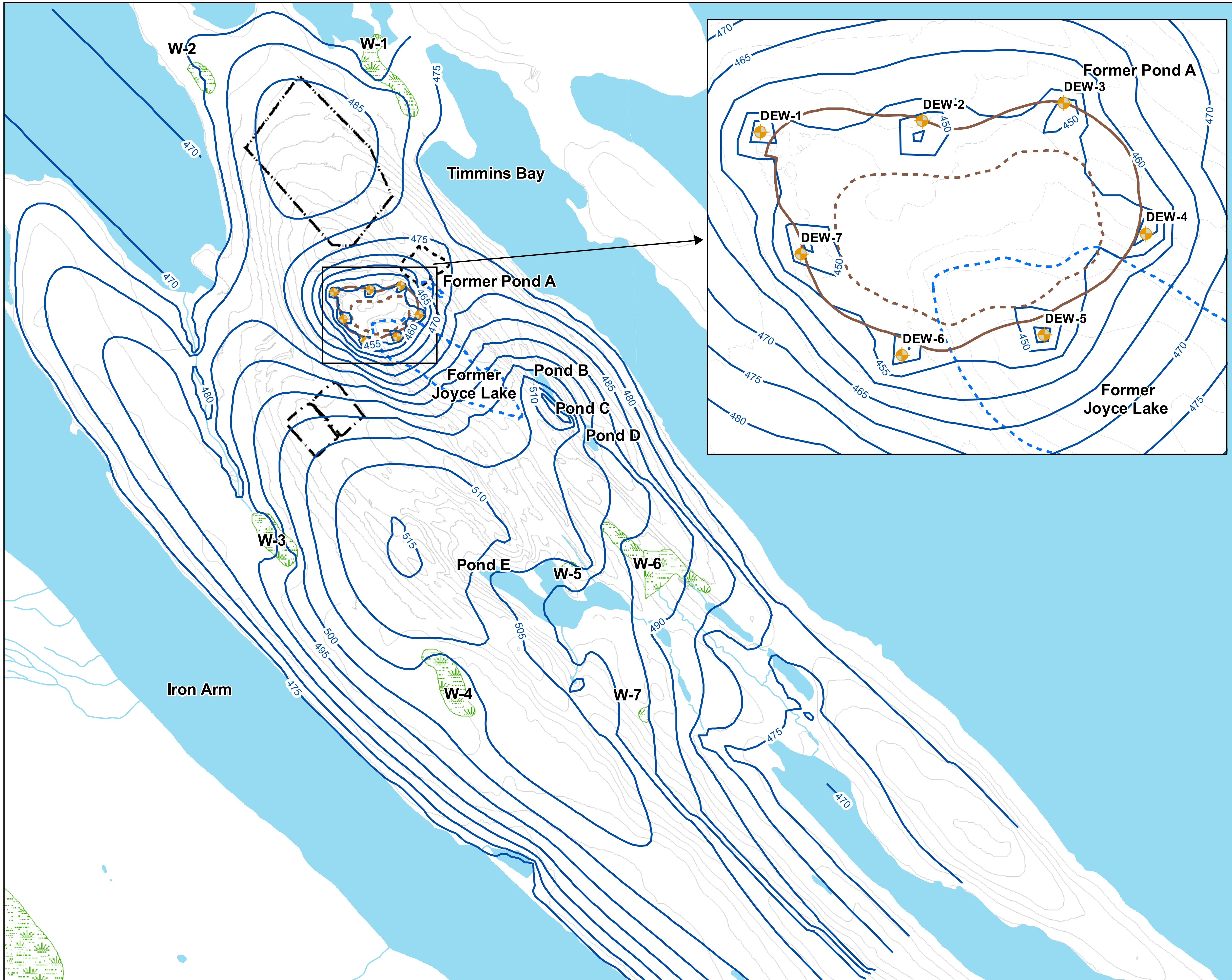
Web: http://www.blumetric.ca

PROJECT #		DATE	
S-B12738-05		November 28, 2014	
DRAWN	VERIFIED	FIG NO.	REV
IB	BOC	6.1	0



LEGEND

- Dewatering Wells
- Topographic Contours (10m)
- Simulated Groundwater Elevation Contour
- Perimeter of Pit Bottom (460masl)
- Perimeter of Pit at Surface
- Streams
- Dewatered Waterbodies
- Waterbodies
- Wetlands (W-5)

Stockpiles

- Waste Dump
- Overburden Stockpile
- Low Grade Stockpile Area

Note: Former Pond A will be dewatered during mine operations

REFERENCES

PROPRIETARY INFORMATION MAY NOT BE REPRODUCED OR DIVULGED WITHOUT PRIOR WRITTEN CONSENT OF BLUMETRIC ENVIRONMENTAL INC.
DO NOT SCALE DRAWING.
THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED ARE BASED ON 11"x17" FORMAT DRAWINGS.

N W E S

0 250 500 1,000
Meters

CLIENT

Labec Century Iron Ore Inc.

PROJECT

Joyce Lake and Area DSO Project
Hydrogeological Study

TITLE **Predicted Groundwater Elevations Joyce Lake Dewatered and Pit Development – 480 masl - 460 masl**

BluMetric Environmental Inc.

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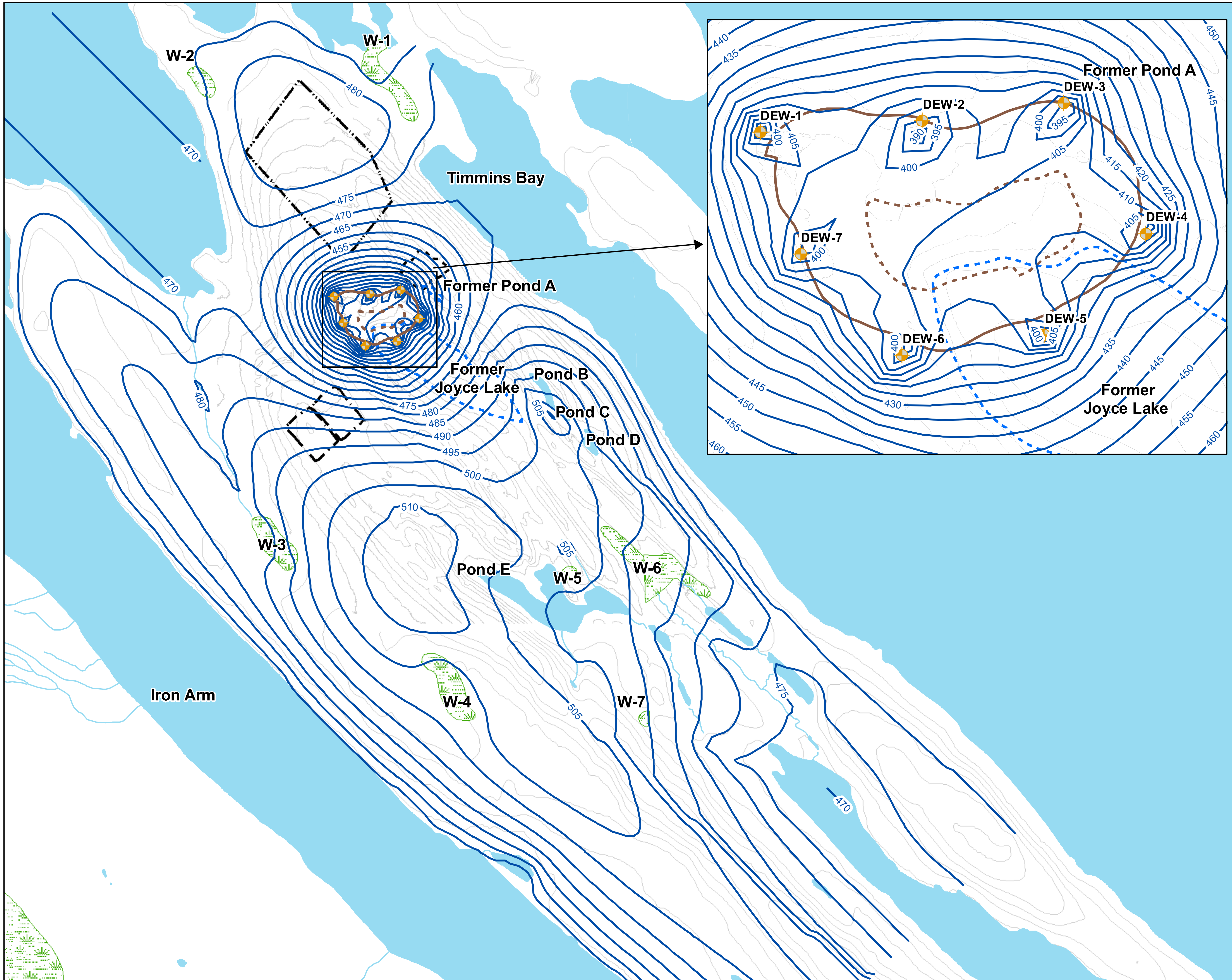
Web: http://www.blumetric.ca

PROJECT #	DATE		
S-B12738-05	November 28, 2014		
DRAWN	VERIFIED	FIG NO.	REV
IB	BOC	6.2	0



LEGEND

- Dewatering Wells
- Topographic Contours (10m)
- Simulated Groundwater Elevation Contour
- Perimeter of Pit Bottom (420masl)
- Perimeter of Pit at Surface
- Streams
- Dewatered Waterbodies
- Waterbodies
- Wetlands (W-5)

Stockpiles

- Waste Dump
- Overburden Stockpile
- Low Grade Stockpile Area

Note: Former Pond A will be dewatered during mine operations

REFERENCES

N E S W

0 250 500 1,000
Meters

CLIENT

Labec Century Iron Ore Inc.

PROJECT

Joyce Lake and Area DSO Project
Hydrogeological Study

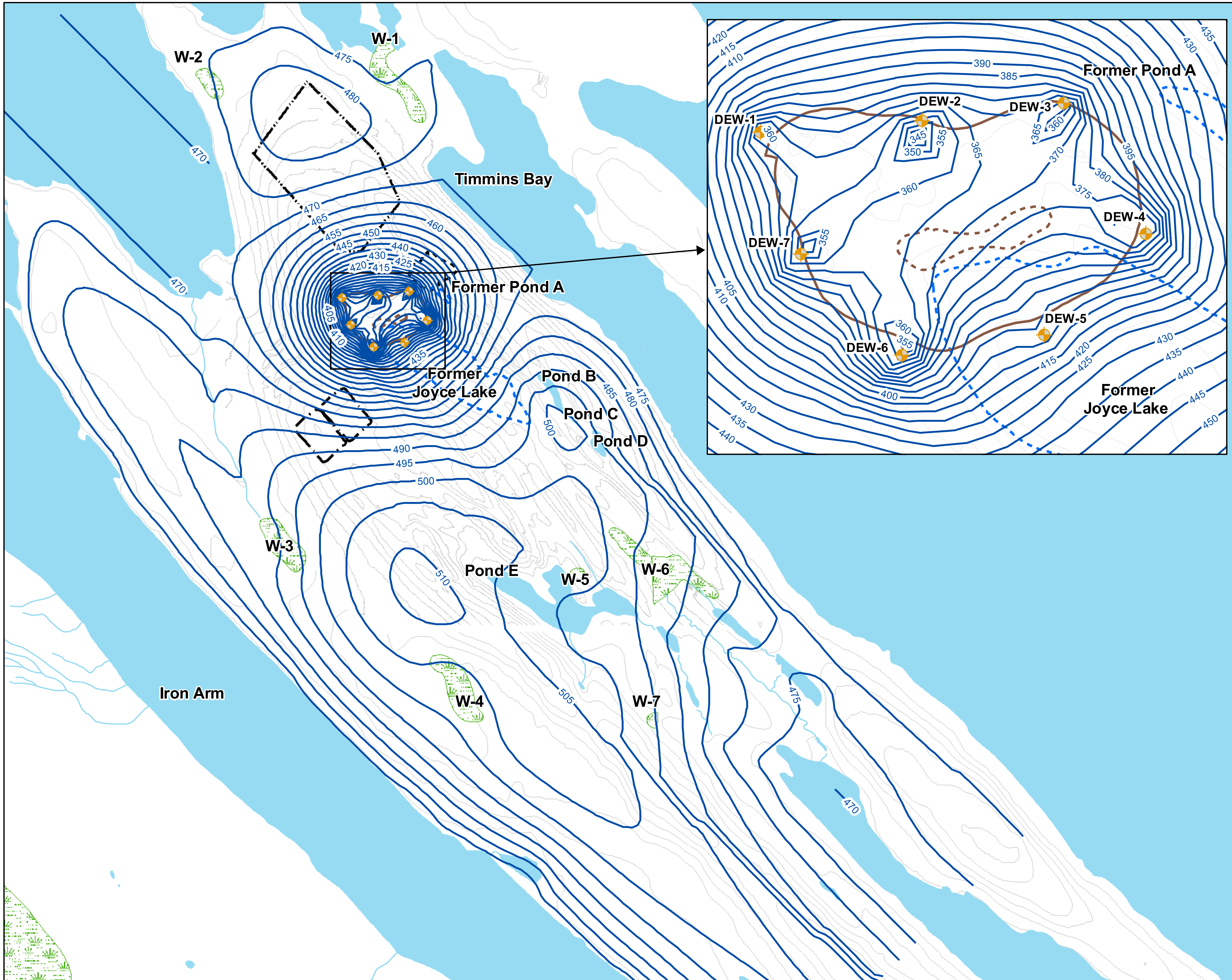
TITLE **Predicted Groundwater Elevations Joyce Lake Dewatered and Pit Development – 460 masl - 420 masl**

BluMetric Environmental Inc.

BluMetric™

3108 Carp Rd PO Box 430
Ottawa, Ontario K0A 1L0
TEL: (613) 839-3053
FAX: (613) 839-5376
Email: info@blumetric.ca
Web: http://www.blumetric.ca

PROJECT #	DATE		
S-B12738-05	November 28, 2014		
DRAWN	VERIFIED	FIG NO.	REV
IB	BOC	6.3	0



LEGEND

- Dewatering Wells
- Topographic Contours (10m)
- Simulated Groundwater Elevation Contour
- Perimeter of Pit Bottom (380 masl)
- Perimeter of Pit at Surface
- Streams
- Dewatered Waterbodies
- Waterbodies
- Wetlands (W-5)

Stockpiles

- Waste Dump
- Overburden Stockpile
- Low Grade Stockpile Area

Note: Former Pond A will be dewatered during mine operations

REFERENCES

N S E W

0 250 500 1,000
Meters

CLIENT

Labec Century Iron Ore Inc.

PROJECT

Joyce Lake and Area DSO Project
Hydrogeological Study

TITLE **Predicted Groundwater Elevations Joyce Lake Dewatered and Pit Development – 420 masl - 380 masl**

BluMetric Environmental Inc.

3108 Carp Rd PO Box 430
Ottawa, Ontario K0A 1L0
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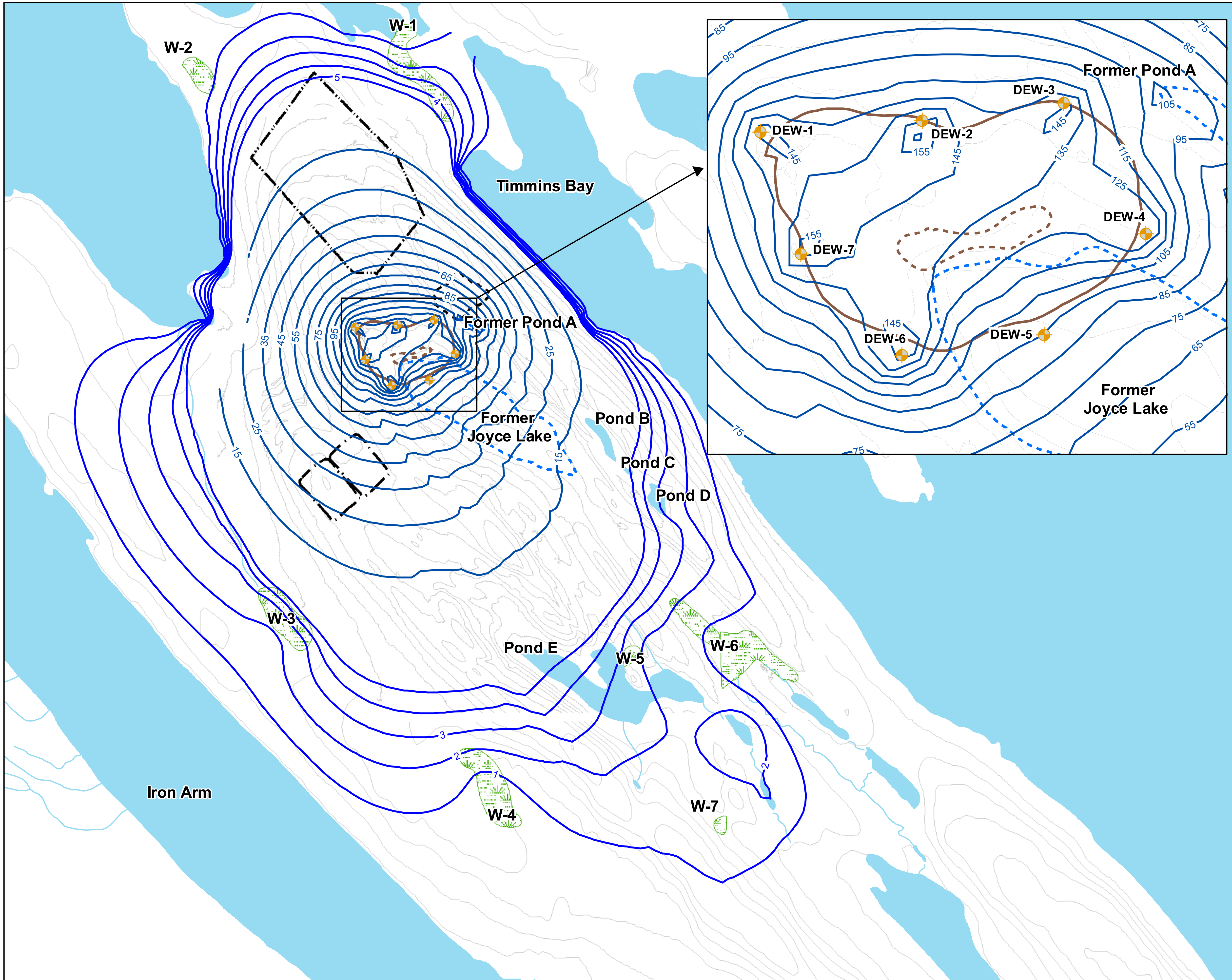
Web: http://www.blumetric.ca

PROJECT #		DATE	
S-B12738-05		November 28, 2014	
DRAWN	VERIFIED	FIG NO.	REV
IB	BOC	6.4	0



LEGEND

- Dewatering Wells
- Topographic Contours (10m)
- Simulated Drawdown Contour (1 m)
- Simulated Drawdown Contour (10 m)
- Perimeter of Pit Bottom (380masl)
- Perimeter of Pit at Surface
- Streams
- Dewatered Waterbodies
- Waterbodies
- Wetlands (W-5)

Stockpiles

- Waste Dump
- Overburden Stockpile
- Low Grade Stockpile Area

Note: Former Pond A will be dewatered during mine operations

REFERENCES

N, E, S, W

0 250 500 1,000
Meters

CLIENT

Labec Century Iron Ore Inc.

PROJECT

Joyce Lake and Area DSO Project Hydrogeological Study

TITLE

Predicted Groundwater Elevations Joyce Lake Dewatered and Pit Development – Groundwater Drawdown 380 masl

BluMetric Environmental Inc.

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Ottawa, Ontario K0A 1L0
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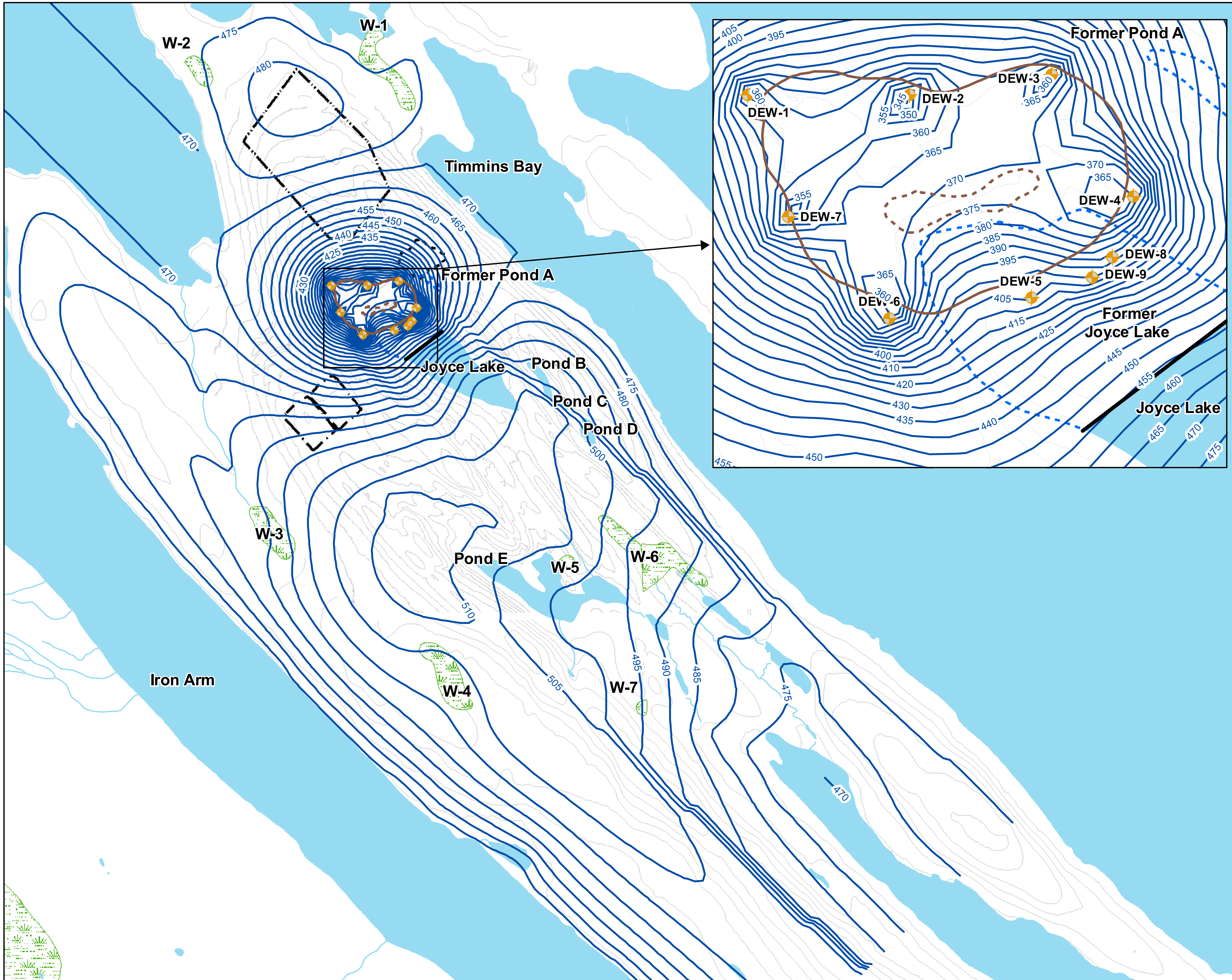
PROJECT #	DATE		
S-B12738-05	November 28, 2014		
DRAWN	VERIFIED	FIG NO.	REV
IB	BOC	6.5	0



LEGEND

- Dewatering Wells
- Topographic Contours (10m)
- Proposed Berm
- Perimeter of Pit Bottom (380masl)
- Perimeter of Pit at Surface
- Simulated Groundwater Elevation Contours
- Streams
- Dewatered Waterbodies
- Waterbodies
- Wetlands (W-5)

Stockpiles

- Waste Dump
- Overburden Stockpile
- Low Grade Stockpile Area

Note: Former Pond A will be dewatered during mine operations

REFERENCES

0 250 500 1,000
Meters

CLIENT

Labec Century Iron Ore Inc.

PROJECT

Joyce Lake and Area DSO Project Hydrogeological Study

TITLE **Predicted Groundwater Elevations Joyce Lake Partially Dewatered and Pit Development – Groundwater Surface 420 - 380 masl (Senario 1)**

BluMetric Environmental Inc.

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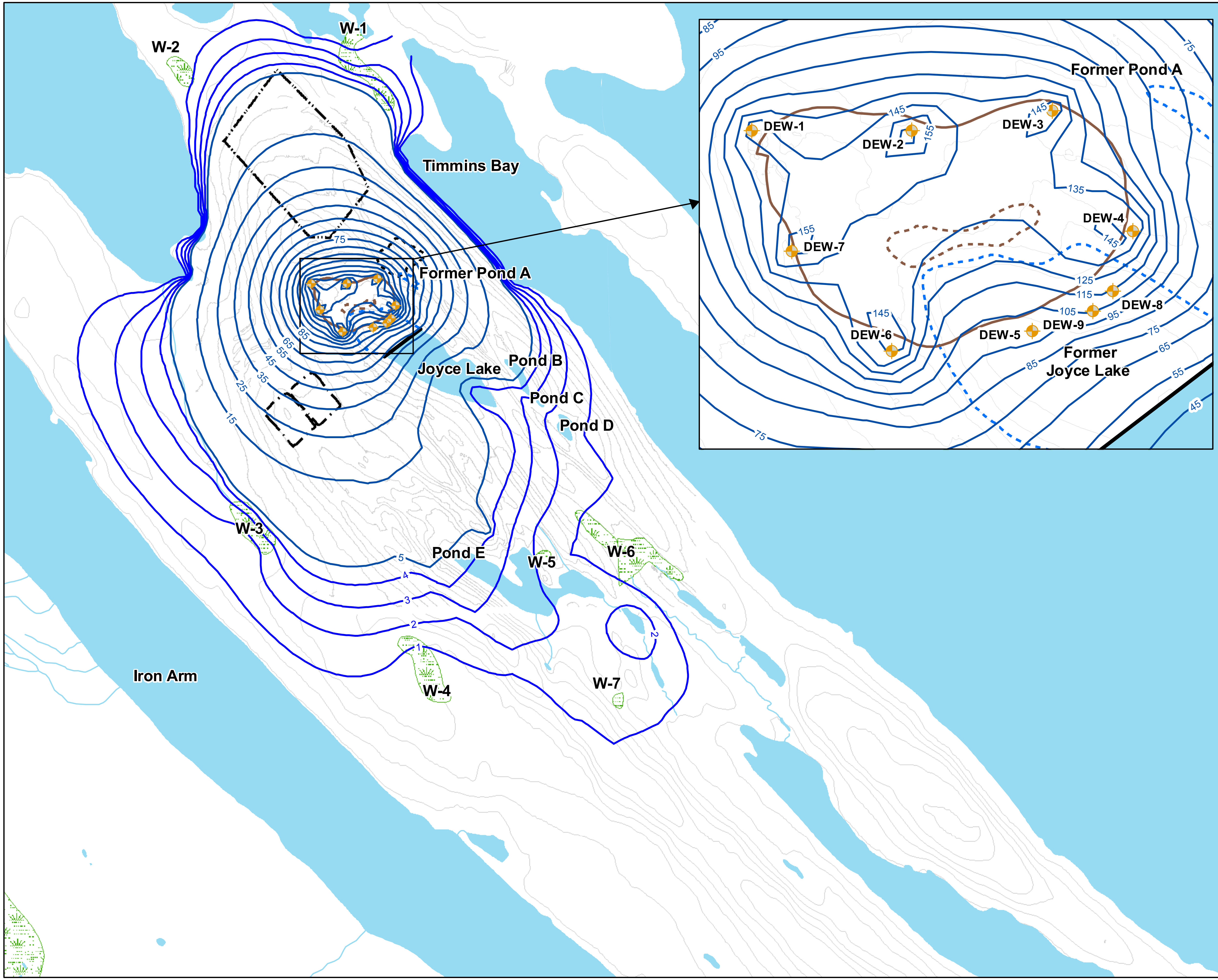
PROJECT #	DATE		
S-B12738-05	December 22, 2014		
DRAWN	VERIFIED	FIG NO.	REV
IB	BOC	6.6	0



LEGEND

- Dewatering Wells
- Topographic Contours (10m)
- Simulated Drawdown Contour (1m)
- Simulated Drawdown Contour (10m)
- Proposed Berm
- Perimeter of Pit Bottom (380masl)
- Perimeter of Pit at Surface
- Streams
- Dewatered Waterbodies
- Waterbodies
- Wetlands (W-5)

Stockpiles

- Waste Dump
- Overburden Stockpile
- Low Grade Stockpile Area

Note: Former Pond A will be dewatered during mine operations

REFERENCES

0 250 500 1,000
Meters

CLIENT

Labec Century Iron Ore Inc.

PROJECT

Joyce Lake and Area DSO Project Hydrogeological Study

TITLE **Predicted Groundwater Elevations Joyce Lake Partially Dewatered and Pit Development – Groundwater Drawdown 380 masl (Scenario 1)**

BluMetric Environmental Inc.

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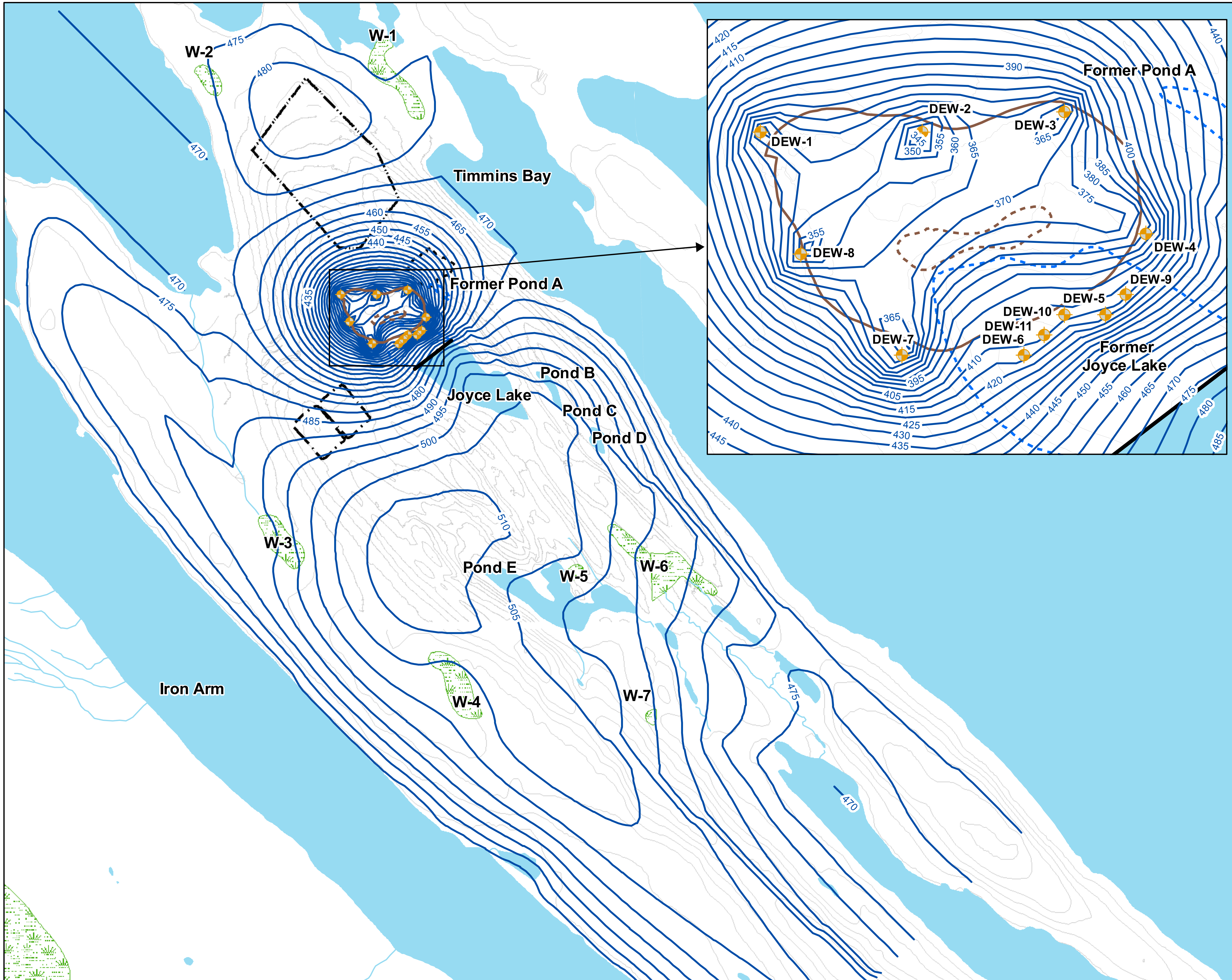
Web: http://www.blumetric.ca

PROJECT #	DATE		
S-B12738-05	December 10, 2014		
DRAWN	VERIFIED	FIG NO.	REV
IB	BOC	6.7	0



LEGEND

- Dewatering Wells
- Topographic Contours (10m)
- Proposed Berm
- Simulated Groundwater Elevation Contour
- Perimeter of Pit Bottom (380masl)
- Perimeter of Pit at Surface
- Streams
- Dewatered Waterbodies
- Waterbodies
- Wetlands (W-5)

Stockpiles

- Waste Dump
- Overburden Stockpile
- Low Grade Stockpile Area

Note: Former Pond A will be dewatered during mine operations

REFERENCES

0 250 500 1,000
Meters

CLIENT

Labec Century Iron Ore Inc.

PROJECT

Joyce Lake and Area DSO Project
Hydrogeological Study

TITLE

Predicted Groundwater Elevations Joyce Lake Partially Dewatered and Pit Development – Ground Surface 420 masl - 380 masl (Scenario 2)

BluMetric Environmental Inc.

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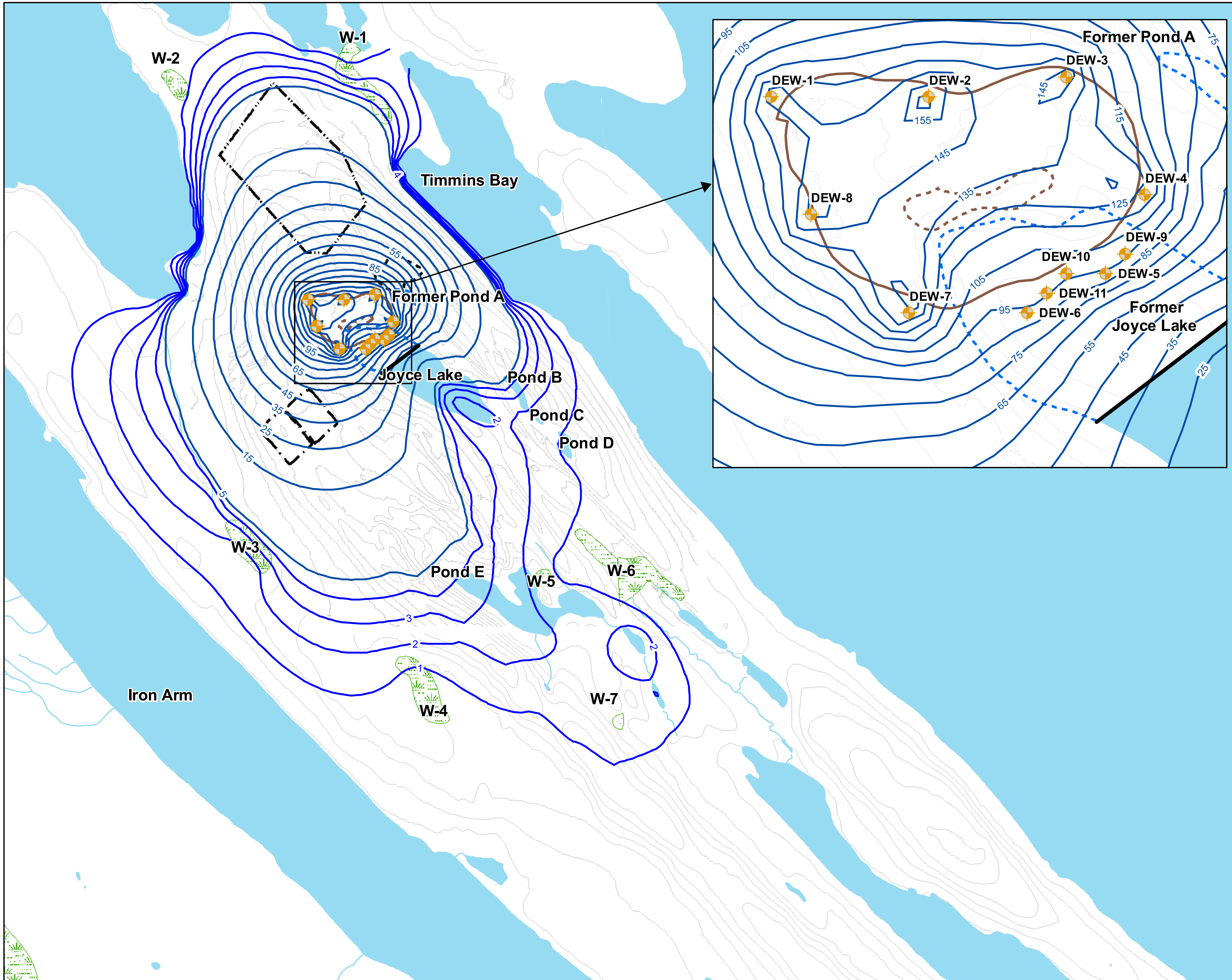
Web: http://www.blumetric.ca

PROJECT #	DATE		
S-B12738-05	December 22, 2014		
DRAWN	VERIFIED	FIG NO.	REV
IB	BOC	6.8	0



LEGEND

- Dewatering Wells
- Proposed Berm
- Topographic Contours (10m)
- Simulated Drawdown Contour (1m)
- Simulated Drawdown Contour (10m)
- Perimeter of Pit Bottom (380masl)
- Perimeter of Pit at Surface
- Streams
- Dewatered Waterbodies
- Waterbodies
- Wetlands (W-5)

Stockpiles

- Waste Dump
- Overburden Stockpile
- Low Grade Stockpile Area

Note: Former Pond A will be dewatered during mine operations

REFERENCES

0 250 500 1,000
Meters

CLIENT

Labec Century Iron Ore Inc.

PROJECT

Joyce Lake and Area DSO Project Hydrogeological Study

TITLE

Predicted Groundwater Elevations Joyce Lake Partially Dewatered and Pit Development – Groundwater Drawdown 380 masl (Scenario 2)

BluMetric Environmental Inc.
3108 Carp Rd PO Box 430
Ottawa, Ontario K0A 1L0
TEL: (613) 839-3053
FAX: (613) 839-5376
Email: info@blumetric.ca
Web: http://www.blumetric.ca

PROJECT #		DATE	
S-B12738-05		December 10, 2014	
DRAWN	VERIFIED	FIG NO.	REV
IB	BOC	6.9	0

APPENDIX A

Borehole Logs

Table A-1: Rock Classification Scheme

Rock Formation		Rock Type	Diagnostic Rock Characteristics	Distinctive Rock Characteristics
Ferriman Group	**Menihek**	Shale / siltstone / greywacke		Colluvium associated with overburden sequence
	Sokoman (Banded Iron Formation)	Upper Massive Hematite (UMH)	Hematite, jasper, magnetite, white, grey and red cherts, massive; major mineral being hematite, minor magnetite, occasional specularite and abundant geothite; bedding/banding	frequent banding between hematite and red/white chert bands, highly fractured
		Red Chert (RC)	Meso-banded hematite and red chert, weak planar fabric, 15 to 20% jasper, oolitic texture of hematite and ringed jasper and chert, no discernable bedding; no green chert; bedding/banding	Oolitic texture, red chert bands prevalent
		Lower Massive Hematite (LMH)	Contains a high proportion of hematote and magnetite with respect to UMH); constitutes hematite, magnetite, white chert, carbonate. Presence of tension gashes of specularite, magnetite and quartz/carbonate. Distinctive metallic blue massive hematite bands; could contain green and thick pink chert bands, lower member is high in magnetite concentration. Bedding / banding	Metallic blue hematite bands
	Ruth Shale (RS)	Shale / Siltstone	Black shale with pyrite, magnetite, hematite, quartz; very thinnly continuous bands / laminations. Ferruginous slate, maroon coloured, fissile, lenses of black chert, iron oxides, quartz, feldspar fine grained masses, chloritic white micas and quartz/feldspar sparsely disemninated.	Thin laminations / bands, fissile nature
	Wishart	Quartzite / Sandstone / Arkose	Massive quartzite, 10-50% quartz, feldspar with some minor hematite, iron-oxides. Beds are a few centimeters to approximately a meter in thickness, no apparent bedding although observations show sedimentary sytructures (cross-bedding, convoluted bedding, graded bedding)	Arenaceous rock with relic clay/chert beds, clay/replaced chloritic matrix and recrystallized quarzite with granoblastic texture of annealed quartz mosaic

BOREHOLE ID: JGW-1

Project No.: S-B 12738
Client: Labec Century Iron Ore Inc
Report: Joyce Lake and Area DSO Project Hydrogeological Study
Site Address: Joyce Lake, Labrador

Elevation Ground: *517.31 m.a.s.l.*
TOP: *517.45 m.a.s.l.*
UTM (Zone): 6086430 N
658427 E

SUBSURFACE PROFILE

Depth (m) / Elev. (m.a.s.l.)	Description
0.00	Ground Surface
0.00 / 517.31 – 0.60 / 516.71	**OVERBURDEN** Pebbly to COBBLY
0.60 / 516.71 – 2.60 / 514.71	**MENIHEK** MENIHEK Formation, Shale, siltstone, greywacke, rockmass, possibly colluvium
3.00 / 514.31 – 3.88 / 513.43	**MENIHEK** MENIHEK Formation, Colour of rockmass mustard yellow
	MENIHEK/UMH MENIHEK/ UPPER MASSIVE HEMATITE, Presence of greywacke interbedded with black medium sized bands of fine grained hematite with disseminated and pockets of fine grained specularite
	UMH UPPER MASSIVE HEMATITE, Black colored fine grained medium sized bands of hematite and red chert. Presence of faint banding and red chert bands interrupted by irregularly shaped grey and white chert bands. Bands (bedding) are generally inclined between 25 - 35°.
27.00 / 490.31	**RC** RED CHERT, Meso banded black metallic lustre hematite with grey and white oolitic hematized chert bands interrupted by red oolitic hematized jasper ringed chert bands and irregular passages of fine grained specularite.

SAMPLE (BEDROCK)

RQD (%)	Recovery (%)
10	85
11	85
30	75
0	35
6	35
36	95
0	35
31	85
9	85
16	91
14	93
15	80
15	77
0	87
0	72
0	30

WELL COMPLETION

Notes: 50 mm solid PVC pipe

PACKER TESTING

Interval (m.a.s.l.)	K m/s
480.01 – 469.31	$1.00x10^{-6}$

Drill Date: 17 October 2014
Drilled By: LF 70 - Downing
Drilling Method: Diamond Drilling
Hole Diameter: HQ 0.096 m (OD)
Logged By: VM
Checked By: RTS

Notes: CORE SAMPLE

BOREHOLE ID: JGW-1

Project No.: S-B 12738
Client: Labec Century Iron Ore Inc
Report: Joyce Lake and Area DSO Project Hydrogeological Study
Site Address: Joyce Lake, Labrador

Elevation Ground: *517.31 m.a.s.l.*
TOP: *517.45 m.a.s.l.*
UTM (Zone): 6086430 N
658427 E

SUBSURFACE PROFILE

Depth (m)	Description	Depth (m) / Elev. (m.a.s.l.)
49–63		
63–98	**LMH/URC** LOWER MASSIVE HEMATITE/UPPER RED CHERT, Interbanded black bluish hematite bands with white, pale and dark grey chert bands.	63.00 454.31

SAMPLE (BEDROCK)

Sample ID	Type	RQD (%)	Recovery (%)
	Core	19	57
	Core	19	80
	Core	17	90
	Core	18	95
	Core	31	92
	Core	31	95
	Core	16	62
	Core	4	82
	Core	0	36
	Core	5	45
	Core	20	55
	Core	0	24
	Core	0	80
	Core	3	72
	Core	13	95
	Core	4	100
	Core	35	100

WELL COMPLETION

Notes: 50 mm 010 slot PVC pipe

PACKER TESTING

Interval (m.a.s.l.)	K m/s
457.31 – 445.31	2.20×10^{-6}
429.01 – 421.31	3.70×10^{-6}

Drill Date: 17 October 2014
Drilled By: LF 70 - Downing
Drilling Method: Diamond Drilling
Hole Diameter: HQ 0.096 m (OD)
Logged By: VM
Checked By: RTS

Notes: CORE SAMPLE

BOREHOLE ID: JGW-1

Project No.: S-B 12738
Client: Labec Century Iron Ore Inc
Report: Joyce Lake and Area DSO Project Hydrogeological Study
Site Address: Joyce Lake, Labrador

Elevation Ground: *517.31 m.a.s.l.* TOP: *517.45 m.a.s.l.*
UTM (Zone): 6086430 N 658427 E

Depth (m)	Description	Depth (m) / Elev. (m.a.s.l.)	Sample Type (BEDROCK)	RQD (%)	Recovery (%)	Packer Interval (m.a.s.l.)	K m/s
100–105			Core	60	84		
			Core	39	92		
105	**LIF/LRC** LOWER IRON FORMATION/LOWER RED CHERT, Grey and white chert bands interbanded with medium and thin black hematite bands. Some hematite bands display reddish hue.	105.00 412.31	Core	15	100		
			Core	21	100		
111			Core	31	95	406.31	
			Core	28	95		9.10x10^-8
			Core	28	90		
120			Core	6	95	397.31	
			Core	4	95		
			Core	0	92		
			Core	5	94		
131.6			Core	23	80	385.71	
			Core	0	92		2.00x10^-7
140			Core	7	95	377.31	
			Core	36	95		
			Core	24	100		
			Core	0	0		

Drill Date: 17 October 2014
Drilled By: LF 70 - Downing
Drilling Method: Diamond Drilling
Hole Diameter: HQ 0.096 m (OD)
Logged By: VM
Checked By: RTS

Notes: CORE SAMPLE

BOREHOLE ID: JGW-1

WESA
a BluMetric company

Project No.: S-B 12738
Client: Labec Century Iron Ore Inc
Report: Joyce Lake and Area DSO Project Hydrogeological Study
Site Address: Joyce Lake, Labrador

Elevation Ground: *517.31 m.a.s.l.*
TOP: *517.45 m.a.s.l.*
UTM (Zone): 6086430 N
658427 E

Depth (m)	Description	Depth (m) / Elev. (m.a.s.l.)	Sample ID	Type (Bedrock)	RQD (%)	Recovery (%)	Notes	Packer Interval (m.a.s.l.)	K m/s
150–151				Core					
151–153				Core	44	95	32 mm 010 slot PVC pipe		
153–156				Core	50	98			
156–159				Core	30	98			
159–162				Core	32	98		357.01	
162–165				Core	4	98			
165–168				Core	46	98			1.30×10^{-6}
168–171		171.00 / 346.31		Core	13	98		346.81	
171	End of borehole at 171.00 m Groundwater Information: Elevation = 505.90 m.a.s.l. ()								

Drill Date: 17 October 2014
Drilled By: LF 70 - Downing
Drilling Method: Diamond Drilling
Hole Diameter: HQ 0.096 m (OD)
Logged By: VM
Checked By: RTS

Notes: CORE SAMPLE

BOREHOLE ID: JGW-2

WESA a BluMetric™ company

Project No.: S-B 12738
Client: Labec Century Iron Ore Inc
Report: Joyce Lake and Area DSO Project Hydrogeological Study
Site Address: Joyce Lake, Labrador

Elevation Ground: *532.78 m.a.s.l.* TOP: *532.96 m.a.s.l.*
UTM (Zone): 6086579.63 N 658260.976 E

SUBSURFACE PROFILE

Depth (m) / Elev. (m.a.s.l.)	Description
0.00	Ground Surface
0.00 / 532.78	**OVERBURDEN**
2.90 / 529.88	**LMH/URC** LOWER MASSIVE HEMATITE/UPPER RED CHERT, Blue and black colored hematite with a metallic lustre occuring in large bands. Hematite is fine to medium grained and hosts lenticular shaped passages of specularite. These bands are intercalated with red, white and grey chert bands. Bands are inclined between 25-40°

SAMPLE (BEDROCK)

Type	RQD (%)	Recovery (%)
Auger	0	0
Core	0	95
Core	6	60
Core	11	95
Core	30	88
Core	10	89
Core	15	98
Core	44	98
Core	32	98
Core	43	88
Core	6	85
Core	0	94
Core	43	82
Core	6	75
Core	8	82
Core	38	98
Core	43	98
Core	16	91
Core	0	94
Core	13	98
Core	59	0
Core	15	92
Core	24	95
Core	34	97
Core	46	95
Core	44	91
Core	23	95
Core	40	92
Core	30	95

WELL COMPLETION

Notes:
50 mm solid PVC pipe
bentonite seal

PACKER TESTING

Interval (m.a.s.l.)	K m/s
503.88 – 496.78	2.00×10^{-6}

Drill Date: 16 October 2014
Drilled By: LF 70 - Downing
Drilling Method: Diamond Drilling
Hole Diameter: HQ 0.096 m (OD)
Logged By: VM
Checked By: RTS

Notes: AUGER SAMPLE; CORE SAMPLE

BOREHOLE ID: JGW-2

Project No.: S-B 12738
Client: Labec Century Iron Ore Inc
Report: Joyce Lake and Area DSO Project Hydrogeological Study
Site Address: Joyce Lake, Labrador

Elevation Ground: *532.78 m.a.s.l.*
TOP: *532.96 m.a.s.l.*
UTM (Zone): 6086579.63 N
658260.976 E

SUBSURFACE PROFILE

Depth (m)	Depth (m) / Elev. (m.a.s.l.)	Description
50–60.60		
60.60–90.80	60.60 / 472.18	**LIF/LRC** LOWER IRON FORMATION/LOWER RED CHERT, Micro to medium banded grey, white and red colored chert bands intercalated with small black hematite bands. Chert bands are frequent and concentration of hematite rich bands are lower within this unit. Some tension gashes appear in grey and white chert
90.80–98+	90.80 / 441.98	**RS** RUTH SHALE

SAMPLE (BEDROCK)

Type	RQD (%)	Recovery (%)
Core	64	90
Core	55	95
Core	14	88
Core	16	88
Core	32	89
Core	13	87
Core	30	91
Core	27	92
Core	56	68
Core	0	68
Core	0	95
Core	17	80
Core	12	75
Core	8	83
Core	42	85
Core	23	85
Core	0	90
Core	75	80
Core	64	98
Core	73	98
Core	40	98
Core	56	98
Core	82	98
Core	82	90
Core	48	85
Core	35	95
Core	84	90
Core	45	63
Core	63	86
Core	86	43
Core	43	97
Core	89	70
Core	70	68

WELL COMPLETION

Notes: 50 mm 010 slot PVC pipe

PACKER TESTING

Interval (m.a.s.l.)	K m/s
482.88 – 472.18	1.40×10^{-6}
452.88 – 442.18	1.60×10^{-6}

Drill Date: 16 October 2014
Drilled By: LF 70 - Downing
Drilling Method: Diamond Drilling
Hole Diameter: HQ 0.096 m (OD)
Logged By: VM
Checked By: RTS

Notes: AUGER SAMPLE CORE SAMPLE

WESA™
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BOREHOLE ID: JGW-2

Project No.: S-B 12738
Client: Labec Century Iron Ore Inc
Report: Joyce Lake and Area DSO Project Hydrogeological Study
Site Address: Joyce Lake, Labrador

Elevation Ground: *532.78 m.a.s.l.*
TOP: *532.96 m.a.s.l.*
UTM (Zone): 6086579.63 N
658260.976 E

SUBSURFACE PROFILE | SAMPLE | WELL COMPLETION | PACKER TESTING

Depth (m): 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148

Depth (m) / Elev. (m.a.s.l.)	Description
115.42 / 417.36	**QTZITE/SANDSTONE** Quartzite bands that range in thickness from 1cm to 3cm and interbanded with black shale.

BEDROCK

RQD (%)	Recovery (%)
68	86
86	52
52	35
35	27
27	71
71	90
43	90
23	98
58	95
60	98
53	95
13	95
41	80
38	98
38	98
86	85
60	98
78	98
90	98
65	98
90	98
82	99
77	98
85	98
34	98
67	93
73	96
54	99
95	98

PACKER TESTING

Interval (m.a.s.l.)	K m/s
431.88 – 421.18	2.30×10^{-6}
410.88 – 391.18	8.70×10^{-8}

Drill Date: 16 October 2014
Drilled By: LF 70 - Downing
Drilling Method: Diamond Drilling
Hole Diameter: HQ 0.096 m (OD)
Logged By: VM
Checked By: RTS

Notes: AUGER SAMPLE CORE SAMPLE

BOREHOLE ID: JGW-2

Project No.: S-B 12738
Client: Labec Century Iron Ore Inc
Report: Joyce Lake and Area DSO Project Hydrogeological Study
Site Address: Joyce Lake, Labrador

Elevation Ground: *532.78 m.a.s.l.* TOP: *532.96 m.a.s.l.*
UTM (Zone): 6086579.63 N 658260.976 E

Sample (Bedrock) RQD (%)	Recovery (%)
70	94
73	85
74	99
94	95
62	98
88	98
88	98
89	98
90	98
91	99
86	80
38	99
76	98
73	96
72	96

Depth (m) / Elev. (m.a.s.l.): 171.30 / 361.48

End of borehole at 171.30 m

Groundwater Information:
Elevation = 509.34 m.a.s.l. ()

PACKER TESTING

Interval (m.a.s.l.)	K m/s
377.88 – 372.88	$1.10x10^{-6}$
368.68 – 362.18	$7.90x10^{-7}$

Drill Date: 16 October 2014
Drilled By: LF 70 - Downing
Drilling Method: Diamond Drilling
Hole Diameter: HQ 0.096 m (OD)
Logged By: VM
Checked By: RTS

Notes: AUGER SAMPLE CORE SAMPLE

WESA
a BluMetric™ company

BOREHOLE ID: JGW-3

Project No.: S-B 12738
Client: Labec Century Iron Ore Inc
Report: Joyce Lake and Area DSO Project Hydrogeological Study
Site Address: Joyce Lake, Labrador

Elevation Ground: *517.01 m.a.s.l.*
TOP: *518.31 m.a.s.l.*
UTM (Zone): 6086282.807 N
658213.384 E

SUBSURFACE PROFILE

Depth (m) / Elev. (m.a.s.l.)	Description
0.00	Ground Surface
0.30 / 517.01 / 516.71	**OVERBURDEN**
	UMH UPPER MASSIVE HEMATITE, Medium to dark grey and some white fine grained and aphanitic bands of chert intercalated with red chert / jasper bands and black massive aphanitic to fine grained hematite bands. Hematite bands are overprinted by a mottling of red chert and disseminated specularite. Bands range from 1 to 8 mm in thickness. Bands are generally inclined (45°)
20.92 / 496.09	**RC** RED CHERT, White and grey colored bands of chert intercalated with grey to black hematite bands. Hematite bands are interrupted with red chert bands some producing a mottled texture. Bands are generally inclined and constitute an oolitic texture. Hematized ooliths in a siliceous matrix. Chert bands also display intraclasts of chert.

Depth (m): -1, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48

SAMPLE

Sample ID	Type	BEDROCK RQD (%)	BEDROCK Recovery (%)
	Core	39	100
	Core	38	82
	Core	4	88
	Core	27	77
	Core	48	65
	Core	13	84
	Core	46	63
	Core	46	86
	Core	0	93
	Core	28	88
	Core	47	98
	Core	14	98
	Core	39	98
	Core	34	96
	Core	27	92
	Core	49	94

WELL COMPLETION

Construction	Notes
	50 mm solid PVC pipe
	bentonite seal

PACKER TESTING

Interval (m.a.s.l.)	K m/s

Drill Date: 18 October 2014
Drilled By: LF 70 - Downing
Drilling Method: Diamond Drilling
Hole Diameter: HQ 0.096 m (OD)
Logged By: VM
Checked By: RTS

Notes: CORE SAMPLE

BOREHOLE ID: JGW-3

WESA a BluMetric company

Project No.: S-B 12738
Client: Labec Century Iron Ore Inc
Report: Joyce Lake and Area DSO Project Hydrogeological Study
Site Address: Joyce Lake, Labrador

Elevation Ground: *517.01 m.a.s.l.*
TOP: *518.31 m.a.s.l.*
UTM (Zone): 6086282.807 N
658213.384 E

SUBSURFACE PROFILE: Depth (m)	Description	Depth (m) / Elev. (m.a.s.l.)	SAMPLE: Sample ID	BEDROCK: Type	RQD (%)	Recovery (%)	WELL COMPLETION: Construction	Notes	PACKER TESTING: Interval (m.a.s.l.)	K m/s
49–50					49	95				
51–53					26	100				
54–56					46	98				
57–59					21	92				
60–62					47	98				
63–65					43	98			452.71	
66–68					20	83				
69–71					7	90				8.40x10^{-7}
72–74					10	88			442.21	
75–77	**LMH/URC** LOWER MASSIC HEMATITE/ UPPER RED CHERT, Presence of thin black shaley interbands crosscut by iron oxides. Limonitic alteration. Frequent white and grey chert bands intermixed with aphanitic black hematite bands which display passages of disseminated fine grained specularite.	75.00 / 442.01			11	86			442.01	
78–80					12	83				
81–83					28	80				
84–86					16	88				
87–89					16	91		50 mm 010 slot PVC pipe		5.00x10^{-7}
90–92					0	78				
93–95					41	95				
96–98	**LIF/LRC** LOWER IRON FORMATION/ LOWER RED CHERT, Appearance of higher concentration of chert bands	96.00 / 421.01			36	92				

Drill Date: 18 October 2014
Drilled By: LF 70 - Downing
Drilling Method: Diamond Drilling
Hole Diameter: HQ 0.096 m (OD)
Logged By: VM
Checked By: RTS

Notes: CORE SAMPLE

BOREHOLE ID: JGW-3

WESA a BluMetric company

Project No.: S-B 12738
Client: Labec Century Iron Ore Inc
Report: Joyce Lake and Area DSO Project Hydrogeological Study
Site Address: Joyce Lake, Labrador

Elevation Ground: *517.01 m.a.s.l.*
TOP: *518.31 m.a.s.l.*
UTM (Zone): 6086282.807 N
658213.384 E

SUBSURFACE PROFILE				SAMPLE	BEDROCK			WELL COMPLETION		PACKER TESTING	
Depth (m)	Symbol	Description	Depth (m) / Elev. (m.a.s.l.)	Sample ID	Type	RQD (%)	Recovery (%)	Construction	Notes	Interval (m.a.s.l.)	K m/s
99–102		with respect to hematite-rich bands. Bands are micro - medium in thickness, black, grey white and some red banding. Presence of specularite pods, thin and wispy band boundaries are observed, occasionally wavy.				26	88			418.01	
						20	94				
						9	80				
						60	97				
						16	50			404.91	
						6	60				$5.00x10^{-7}$
						15	85				
						35	98			396.91	
						79	95				
						30	90				
						48	48			386.71	
						78	100				
						50	100				$8.30x10^{-7}$
						38	98				
						54	98			376.01 / 374.71	
						20	89				$4.20x10^{-7}$
						24	90				

Drill Date: 18 October 2014
Drilled By: LF 70 - Downing
Drilling Method: Diamond Drilling
Hole Diameter: HQ 0.096 m (OD)
Logged By: VM
Checked By: RTS

Notes: CORE SAMPLE

BOREHOLE ID: JGW-3

Project No.: S-B 12738
Client: Labec Century Iron Ore Inc
Report: Joyce Lake and Area DSO Project Hydrogeological Study
Site Address: Joyce Lake, Labrador

Elevation Ground: *517.01 m.a.s.l.*
TOP: *518.31 m.a.s.l.*
UTM (Zone): 6086282.807 N
658213.384 E

SUBSURFACE PROFILE | SAMPLE | WELL COMPLETION | PACKER TESTING

Depth (m)	Sample type (BEDROCK)	RQD (%)	Recovery (%)
150–153	Core	67	100
153–156	Core	66	100
156–159	Core	50	96
159–162	Core	54	80
162–165	Core	50	88
165–168	Core	26	98
168–171	Core	12	100

Depth (m) / Elev. (m.a.s.l.): 171.00 / 346.01

End of borehole at 171.00 m

Groundwater Information:
Elevation = 506.10 m.a.s.l. ()

Packer Testing Interval (m.a.s.l.)	K m/s
368.51	
359.21 – 346.01	1.10×10^{-7}

Drill Date: 18 October 2014
Drilled By: LF 70 - Downing
Drilling Method: Diamond Drilling
Hole Diameter: HQ 0.096 m (OD)
Logged By: VM
Checked By: RTS

Notes: CORE SAMPLE

BOREHOLE ID: JGW-4

WESA™ a BluMetric™ company

Project No.: S-B 12738
Client: Labec Century Iron Ore Inc
Report: Joyce Lake and Area DSO Project Hydrogeological Study
Site Address: Joyce Lake, Labrador

Elevation Ground: *529.49 m.a.s.l.*
TOP: *529.55 m.a.s.l.*

UTM (Zone): 6086507.424 N
657993.235 E

SUBSURFACE PROFILE

Depth (m) / Elev. (m.a.s.l.)	Description
0.00 / 529.49	Ground Surface
0.00–3.30	**OVERBURDEN**
3.30 / 526.19	**LMH/URC** LOWER MASSIVE HEMATITE/UPPER RED CHERT, Blue and black metallic luster meso-banded and fine grained hematite with lenticular passages of specularite and minor magnetite. Mottled texture with red chert lesions protruding the hematite rich bands. Very few chert bands, banding is not discernible.
11.27 / 518.22	**LIF/LRC** LOWER IRON FORMATION/LOWER RED CHERT, Frequent interbanding between grey red, and white colored chert bands with black hematite bands. Presence of lenticular passages of specularite. Bands are well defined. Presence of iron oxides over several intervals.

SAMPLE (BEDROCK)

Interval (m)	Type	RQD (%)	Recovery (%)
0–3	Core		
3–6	Core	81	24
6–9	Core	0	8
9–12	Core	0	10
12–15	Core	0	50
15–18	Core	58	93
18–21	Core	41	95
21–24	Core	0	68
24–27	Core	31	93
27–30	Core	0	73.5
30–33	Core	40	83
33–36	Core	13	95
36–39	Core	17	90
39–42	Core	20	83
42–45	Core	0	80
45–48	Core	0	92

WELL COMPLETION

Notes:
- 50 mm solid PVC pipe
- bentonite seal

PACKER TESTING

Interval (m.a.s.l.)	K m/s
491.89 – 487.19	$2.10x10^{-6}$

Drill Date: 15 October 2014
Drilled By: LF 70 - Downing
Drilling Method: Diamond Drilling
Hole Diameter: HQ 0.096 m (OD)
Logged By: VM
Checked By: RTS

Notes: CORE SAMPLE

BOREHOLE ID: JGW-4

Project No.: S-B 12738
Client: Labec Century Iron Ore Inc
Report: Joyce Lake and Area DSO Project Hydrogeological Study
Site Address: Joyce Lake, Labrador

Elevation Ground: *529.49 m.a.s.l.*
TOP: *529.55 m.a.s.l.*
UTM (Zone): 6086507.424 N
657993.235 E

SUBSURFACE PROFILE				SAMPLE (BEDROCK)				WELL COMPLETION		PACKER TESTING	
Depth (m)	Symbol	Description	Depth (m) / Elev. (m.a.s.l.)	Sample ID	Type	RQD (%)	Recovery (%)	Construction	Notes	Interval (m.a.s.l.)	K m/s
50						0	82				
52						24	93			476.89	
55						8	84				
58						13	89				1.60x10⁻⁶
61						0	30				
64		**RC** RED CHERT-, Dull black color with thinly laminated red maroon colored ferrigeneous slate. Fissile nature, presence of lenses and passages of dull grey and black colored massive chert. Also presence of 'floating' quartz grains sparsely disseminated at various intervals. Orientation of bands are horizontal to slightly inclined.	63.95 465.54			52	96			466.19	
67						0	70				
70						46	70.8				
73						48	75				
76						8	90				
79						13	85				
82						45	85				
85						63	90				
88						15	85			440.89	
91						17	95		50 mm 010 slot PVC pipe		2.30x10⁻⁶
94						26	90				
97						68	95			433.19	
98		**WISHART QUARTZITE**	97.80 431.69								

Drill Date: 15 October 2014
Drilled By: LF 70 - Downing
Drilling Method: Diamond Drilling
Hole Diameter: HQ 0.096 m (OD)
Logged By: VM
Checked By: RTS

Notes: CORE SAMPLE

BOREHOLE ID: JGW-4

WESA™ a BluMetric™ company

Project No.:	S-B 12738	**Elevation** Ground:	*529.49 m.a.s.l.*
Client:	Labec Century Iron Ore Inc	TOP:	*529.55 m.a.s.l.*
Report:	Joyce Lake and Area DSO Project Hydrogeological Study		
Site Address:	Joyce Lake, Labrador	**UTM (Zone):**	6086507.424 N 657993.235 E

SUBSURFACE PROFILE | **SAMPLE** | **WELL COMPLETION** | **PACKER TESTING**

Columns: Depth (m) | Symbol | Description | Depth (m) / Elev. (m.a.s.l.) | Sample ID | BEDROCK: Type, RQD (%), Recovery (%) | Construction | Notes | Interval (m.a.s.l.) | K m/s

Depth scale: 100 to 148 m

Description: Uniform mosaic of fine grained quartz grains with minor amounts of feldspar within a silica matrix. The fabric can also display intervals with thinly interbedded sequences of fine grained quartz, trace amounts of pyrite and lithic fragments. Presence of cross-bedding

Type	RQD (%)	Recovery (%)
Core sample	61	99
Core sample	63	98
Core sample	76	98
Core sample	63	95
Core sample	82	95
Core sample	100	100
Core sample	60	99
Core sample	45	96
Core sample	56	100
Core sample	34	96
Core sample	0	93
Core sample	61	97
Core sample	41	100
Core sample	60	96
Core sample	64	95
Core sample	73	98
Core sample	66	87

Packer Testing

Interval (m.a.s.l.)	K m/s
416.89 – 406.19	1.10×10^{-8}
395.89 – 385.19	8.00×10^{-7}
383.89 –	

Drill Date:	15 October 2014		
Drilled By:	LF 70 - Downing		
Drilling Method:	Diamond Drilling	**Logged By:**	VM
Hole Diameter:	HQ 0.096 m (OD)	**Checked By:**	RTS

Notes: ◧ CORE SAMPLE

BOREHOLE ID: JGW-4

Project No.: S-B 12738
Client: Labec Century Iron Ore Inc
Report: Joyce Lake and Area DSO Project Hydrogeological Study
Site Address: Joyce Lake, Labrador

Elevation Ground: *529.49 m.a.s.l.* TOP: *529.55 m.a.s.l.*
UTM (Zone): 6086507.424 N 657993.235 E

Depth (m)	Description	Depth (m) / Elev. (m.a.s.l.)	Sample ID	Type	RQD (%)	Recovery (%)	Notes	Packer Interval (m.a.s.l.)	K m/s
150–171				Core	60	99			6.90x10^-7
				Core	95	98		373.19	
				Core	90	98			
				Core	98	99			
				Core	98	99		365.89	
				Core	74	95			1.20x10^-6
				Core	78	98			
171.30	End of borehole at 171.30 m Groundwater Information: Elevation = 510.96 m.a.s.l. ()	171.30 / 358.19						358.19	

Depth scale: 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198

Drill Date: 15 October 2014
Drilled By: LF 70 - Downing
Drilling Method: Diamond Drilling
Hole Diameter: HQ 0.096 m (OD)
Logged By: VM
Checked By: RTS

Notes: CORE SAMPLE

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-01

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	
Northing:	6086486.969	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658114.121	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	527.85	Azimut:	303.70°	Drillers:	Drillers
Inclination:	70°	Bit type: / Flush: / Feed:	Feed	Drill Rig:	LF-70

Casing&Core Diameter/Depth (m)	Water Notes	DEPTH/Elev.(m)	DESCRIPTION (ROCK TYPE)	Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index	Depth (m)	Type & Number (#)	Orientation: DIP	Orientation: DIP DIRECTION	Shape	Roughness	Infill	Jr	Ja	Jn	Fault Breccia/ Gouge	Broken Core	NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
		527.85 / 0.00	**Casing**																			
		520.81 / 7.50	**Iron oxyde** interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.	0.5	100	0		R4	W3													
				1.0	25	0																
				1.5	27	0																
				1.0	85	0		R4														
				0.5	100	20		R4														
				1.2	65			R4														
		515.45 / 13.20	20 to 40% of white chert.	0.9	100	20	22	R5	W2													Bedding at 50° Joints at 20,45 and 60°
				0.9	100	33	22															

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

LVM

HOLE #:

BH-P-01

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-01

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	
Northing:	6086486.969	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658114.121	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	527.85	Azimut:	303.70°	Drillers:	Drillers
Inclination:	70°	Bit type:	Flush: Feed: Feed	Drill Rig:	LF-70

DEPTH/Elev.(m)	ROCK TYPE – DESCRIPTION	Interval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Strength Index
15.00	**Iron oxyde** interbedded with millimetric bands of red chert and millimetric to centimetric bands of white chert.	3.0	13	0	
510.28 / 18.70	**Highly weathered zone**	3.0	27	0	
508.12 / 21.00	**Iron oxyde** interbedded with millimetric bands of red chert and millimetric to centimetric bands of white chert.	3.0	3	0	
		3.0	8	0	
502.48 / 27.00	**Highly weathered zone**				
502.20 / 27.30	**Iron oxyde** interbedded with millimetric bands of red chert and millimetric to centimetric bands of white chert.	2.2	36		R3
		0.8	4		

Casing&Core Diameter/Depth (m); Water Notes; Depth (m); Fractures per_1_m; Weathering Index; DISCONTINUITY DATA: Depth (m), Type & Number (#), Orientation (DIP, DIP DIRECTION), Surface Description (Shape, Roughness, Infill), Jr, Ja, Jn; Fault Breccia/Gouge; Broken Core; NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS

Depth scale (m): 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

LVM

HOLE #: **BH-P-01**

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-01

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	
Northing:	6086486.969	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658114.121	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	527.85	Azimut:	303.70°	Drillers:	Drillers
Inclination:	70°	Bit type: Flush:	Feed: Feed	Drill Rig:	LF-70

B-0010504-2

ROCK TYPE

Casing&Core Diameter/Depth (m)	Water Notes	DEPTH/Elev.(m)	DESCRIPTION
		498.25 / 31.50	**Highly weathered zone**
		498.06 / 31.70	**Iron oxyde** interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.
		495.39 / 34.55	**Highly weathered zone** 20 to 30% of white chert.
		495.25 / 34.70	
		494.59 / 35.40	**Iron oxyde** interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert. [Weathered massive Iron oxyde]"/b"
		494.02 / 36.00	
		489.89 / 40.40	**Iron oxyde** interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.
		486.04	

Depth (m): 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44

INTERVAL REC. DATA / STRENGTH DATA

Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index
1.5	10				
1.5	16				
1.7	80	28	30	R4	W4
1.3	100	23			
1.0	50			R4	W4
0.5	100			R4	W4
1.3	50			R4	W4
1.6	19				
1.6	25	19		R4	W4
1.5	0	0			
1.5	66	13.5		R4	W4

DISCONTINUITY DATA

Depth (m)	Type & Number (#)	Orientation: DIP	Orientation: DIP DIRECTION	Surface Description: Shape	Surface Description: Roughness	Surface Description: Infill	Jr	Ja	Jn	Fault Breccia/ Gouge	Broken Core	NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
												Joints at 10 to 30°
												Bedding at 25° Joints at 5 to 35°
												Bedding N/A Joints at 40 to 75°

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

LVM

HOLE #:

BH-P-01

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-01

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	
Northing:	6086486.969	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658114.121	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	527.85	Azimut:	303.70°	Drillers:	Drillers
Inclination:	70°	Bit type: / Flush: / Feed:	Feed	Drill Rig:	LF-70

ROCK TYPE

DEPTH/Elev.(m)	DESCRIPTION
485.47 / 45.10	**Highly weathered zone**
485.10 / 45.50	**Iron oxyde** interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.
	Highly weathered zone
481.24 / 49.60	[Weathered massive Iron oxyde]"/b"
476.92 / 54.20	**Highly weathered zone**
476.64 / 54.50	**Iron oxyde** interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.
471.85	

Depth (m) scale: 45 – 59

INTERVAL REC. DATA / STRENGTH DATA

Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index
0.5	80	100	18	R3	W4
2.5	40	0		R2	W5
1.5	0	0		R2	W5
1.5	13	0			
1.5	33	10			
1.5	13				
1.5	13				
0.7	42			R4	W3
0.8	19				
1.5	0	0			
1.3	15				

DISCONTINUITY DATA

Depth (m)	Type & Number (#)	Orientation: DIP	Orientation: DIP DIRECTION	Surface Description: Shape	Surface Description: Roughness	Infill	Jr	Ja	Jn	Fault Breccia/ Gouge	Broken Core	NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
												Bedding at 65° Joints at 65 to 80°

Casing&Core Diameter/Depth (m) — Water Notes

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

HOLE #: **BH-P-01**

B.T.

Vertical Scale = 1 : 100

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-01

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	
Northing:	6086486.969	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658114.121	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	527.85	Azimut:	303.70°	Drillers:	Drillers
Inclination:	70°	Bit type:	Flush: Feed: Feed	Drill Rig:	LF-70

ROCK TYPE

DEPTH/Elev.(m)	DESCRIPTION
59.60 / 471.47	**Highly weathered zone**
60.00 / 470.91	**Iron oxyde** interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.
60.60 / 470.81	**Highly weathered zone**
60.70 / 466.02	**Iron oxyde** interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.
65.80 / 465.83	**Highly weathered zone**
66.00 / 464.42	**Iron oxyde** interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.
67.50 / 464.00	>50% of white chert.
67.95 / 463.30	**Iron oxyde** interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.
68.70 / 463.11	**Highly weathered zone**
68.90 / 462.83	**Iron oxyde** interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.
69.20 / 462.36	4 centimetric bands of earthy material.
69.70 / 462.07	**Iron oxyde** interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.
70.00 / 461.60	**Highly weathered zone**
70.50 / 461.32	**Iron oxyde** interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.
70.80 / 461.23	
70.90	

INTERVAL REC. DATA / STRENGTH DATA

Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index
1.2	75	8.3		R4	W4
0.5	60			R4	W3
0.5	20	0		R4	W3
1.0	60	12		R4	W3
1.0	70	50	16	R4	W3
1.5	66	47	24	R4	W3
0.3	100			R4	W3
0.2	100			R0	W5
1.5	20				
1.5	83	44	19	R4	W5
1.8	89	31	20	R5	W3
1.2	100	63	9	R5	W5
1.0	85	65		R5	W3
0.2	100				
1.6	94	60	13	R5	W3

Depth (m): 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74

DISCONTINUITY DATA

Depth (m)	Type & Number (#)	Orientation: DIP	Orientation: DIP DIRECTION	Surface Description: Shape	Surface Description: Roughness	Infill	Jr	Ja	Jn	Fault Breccia/ Gouge	Broken Core

NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS

- Bedding at 70° Joints at 45,70 and 85°
- Bedding at 65° Joints at 65 to 75°
- Bedding at 70° Joints at 70 to 90°
- Bedding at 70° Joints at 70 to 90°
- Bedding at 70° Joints at 70 to 90°
- Bedding at 60° Joints at 70 to 85°
- Bedding at 60 to 70° Joints at 60 to 70°

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja:			
Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

HOLE #: BH-P-01

B.T.

Vertical Scale = 1 : 100

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-01

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	
Northing:	6086486.969	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658114.121	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	527.85	Azimut:	303.70°	Drillers:	Drillers
Inclination:	70°	Bit type:	Flush: Feed: Feed	Drill Rig:	LF-70

ROCK TYPE

DEPTH/Elev.(m)	DESCRIPTION
74.60 / 457.56	**Highly weathered zone**
74.80 / 456.62	**Iron oxyde** interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.
75.80	50% of white chert.
455.50 / 77.00	**Iron oxyde** interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.
	30 to 40% of white chert.
454.32 / 78.25	**Iron oxyde** interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.
453.99 / 78.60	
453.15 / 79.50	30% of white chert.
452.68 / 80.00	**Iron oxyde** interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.
	Highly weathered zone
	Iron oxyde interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.
450.80 / 82.00	
450.23 / 82.60	40 to 50% of white chert.
	Iron oxyde interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.
446.95 / 86.10	**Highly weathered zone**
446.85 / 86.20	**Iron oxyde** interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.
444.60 / 88.60	**Iron enriched** dark grey zone.

INTERVAL REC. DATA / STRENGTH DATA / DISCONTINUITY DATA

Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index	NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
1.0	100	10		R4	W3	
1.7	67	88	48	R5		Bedding at 60 to 70° Joints at 60°
0.8	100	13		R5		Bedding N/A Joints at 80°
1.8	86	5		R5	W5	Bedding at 5 to 40° Joints at 10 and 60 to 70°
1.0	80	30	10	R5	W3	Bedding at 20° Joints at 20 to 45° and 80°
1.6	50	28	16	R5	W3	Bedding at 80° Joints at 45 to 80°
1.4	100	24	19	R5	W3	
1.5	100	27	30	R5	W3	Bedding at 80° Joints at 80°
1.5	100	20	18	R1	W4	Bedding N/A Joints at 60 to 70°
1.5	100	61		R3	W4	Bedding N/A Joints at 45,60 and 85°
1.6	94	25	35	R5	W3	Bedding at 70° Joints at 70°
1.1	73	9		R5	W2	

Other columns: Casing&Core Diameter/Depth (m), Water Notes, Depth (m), Type & Number (#), Orientation (DIP, DIP DIRECTION), Surface Description (Shape, Roughness, Infill), Jr, Ja, Jn, Fault Breccia/Gouge, Broken Core.

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

HOLE #: **BH-P-01**

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-01

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	
Northing:	6086486.969	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658114.121	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	527.85	Azimut:	303.70°	Drillers:	Drillers
Inclination:	70°	Bit type: Flush:	Feed: Feed	Drill Rig:	LF-70

B.T.

Vertical Scale = 1 : 100

ROCK TYPE

DEPTH/Elev.(m)	DESCRIPTION
443.37 / 89.90	**Iron oxyde** interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.
443.19 / 90.10	80% of white chert.
442.95 / 90.35	**Iron oxyde** interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.
442.81 / 90.50	**Highly weathered zone**
442.72 / 90.60	**Iron oxyde** interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.
442.34 / 91.00	N/A
441.68 / 91.70	**Iron oxyde** interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.
439.52 / 94.00	**Highly weathered zone**
439.33 / 94.20	**Iron oxyde** interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.

Depth (m): 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104

INTERVAL REC. DATA / STRENGTH DATA / DISCONTINUITY DATA

Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index	NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
1.0	100	100	23	R5	W3	Bedding at 80° Joints at 70 to 80°
1.0	0	0				
1.3	31	0				
1.5	80	66	15	R5	W3	Bedding N/A Joints at 20,45, 60 and 85°
1.2	60	20	18			Bedding N/A Joints at 10,30, 55 and 70°
1.3	76	15		R5	W3	
0.3	50					
1.7	24					
0.8	100			R5	W3	
1.2	100	46				
1.0	60	23				
1.5	51			R5	W3	
1.5	20					

Other columns: Casing&Core Diameter/Depth (m); Water Notes; Depth (m); Type & Number (#); Orientation: DIP, DIP DIRECTION; Surface Description: Shape, Roughness, Infill; Jr; Ja; Jn; Fault Breccia/ Gouge; Broken Core

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

LVM

HOLE #: **BH-P-01**

B.T.

Vertical Scale = 1 : 100

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-01

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	
Northing:	6086486.969	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658114.121	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	527.85	Azimut:	303.70°	Drillers:	Drillers
Inclination:	70°	Bit type:	Flush: Feed: Feed	Drill Rig:	LF-70

ROCK TYPE

DEPTH/Elev.(m)	DESCRIPTION
424.96 / 109.50 – 424.67 / 109.80	Altered black mineralized material
109.80 – 424.02 / 110.50	**Weathered Iron oxyde** interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.
110.50 – 423.78 / 110.75	(continued)
110.75 – 422.23 / 112.40	**Iron oxyde** interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.
112.40 – 420.73 / 114.00	Altered black mineralized material
114.00 – 419.51 / 115.30	**Weathered Iron oxyde** interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.
115.30 – 419.04 / 115.80	Altered black mineralized material
115.80 –	Altered black mineralized material & **Iron oxyde** interbeded with millimetric bands of red chert and millimetric to centimetric bands of white chert.
– 416.12 / 118.90	**Iron oxyde** blackish interbeded with millimetric bands of red chert and millimetric to centimetric

INTERVAL REC. DATA / STRENGTH DATA

Depth (m)	Interval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index
105–106	1.3	100	0		R5	W3
107	1.7	20				
108–109	1.5	33	17		R4	W3
110	1.0	100	60		R0	W5
111	0.5	100	50		R2	W4
112	1.7	60	19		R0	W5
113	1.3	100	100		R2	W5
115	1.5	80	40			
116–117	1.7	88	88	15	R4	W5
117	0.5	80				
118	1.0	80	80	12	R4	W5
119	0.5	100	80	5		

DISCONTINUITY DATA

Columns: Depth (m) | Type & Number (#) | Orientation: DIP, DIP DIRECTION | Surface Description: Shape, Roughness, Infill | Jr | Ja | Jn | Fault Breccia/Gouge | Broken Core | NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS

NOTES/COMMENTS: Bedding N/A
Joints at 10,45 and 70°

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

LVM

HOLE #: **BH-P-01**

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-01

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	
Northing:	6086486.969	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658114.121	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	527.85	Azimut:	303.70°	Drillers:	Drillers
Inclination:	70°	Bit type: Flush:	Feed: Feed	Drill Rig:	LF-70

B.T.

Vertical Scale = 1 : 100

ROCK TYPE / INTERVAL REC. DATA / STRENGTH DATA

DEPTH/Elev.(m)	DESCRIPTION	Depth (m)	Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index	NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
	bands of white chert.		0.8	100	80	21			Bedding N/A Joints at 10,45 and 70°
	Black Shale	120	1.5	100	90	15	R4	W2	Bedding N/A Joints at 10,45 and 70°
		121							Bedding N/A Joints at 10,45 and 70°
		122	1.5	100	67	13			Bedding N/A Joints at 10,45 and 70°
		123	1.5	100	59	19	R4	W2	Bedding N/A Joints at 10,45 and 70°
		124							
		125	1.5	100	93	6	R4	W2	Bedding N/A Joints at 10,45 and 70°
		126	1.5	100	87	8	R4	W2	Bedding N/A Joints at 15,45 and 70°
408.09 127.45	Bed of Siltstone	127							
408.04 127.50	Black Shale	128	1.5	100	100	4	R4	W2	Bedding at 75° Joints at 15,45 and 70°
406.63 129.00	Interbedded Grey Siltstone / Blackshale	129							Bedding at 80° Joints N/A
		130	1.5	100	93	14	R4	W2	Bedding at 75° Joints at 10,45, 60 and 85°
		131	1.5	100	90	15	R4	W2	
		132	1.5	93	51	10	R4	W2	Bedding at 75° Joints at 10,45, 65 and 85°
401.84		133 / 134							

DISCONTINUITY DATA

Depth (m)	Type & Number (#)	DIP	DIP DIRECTION	Shape	Roughness	Infill	Jr	Ja	Jn	Fault Breccia/ Gouge	Broken Core

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

HOLE #: **BH-P-01**

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-01

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	
Northing:	6086486.969	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658114.121	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	527.85	Azimut:	303.70°	Drillers:	Drillers
Inclination:	70°	Bit type: Flush: Feed:	Feed	Drill Rig:	LF-70

B.T.

Vertical Scale = 1 : 100

Casing&Core Diameter/Depth (m)	Water Notes	DEPTH/Elev.(m)	DESCRIPTION	Depth (m)	Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index	NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
		134.10	Grey Sandstone, fine to medium grain		1.5	97	80	6	R4	W2	Bedding N/A Joints at 5 to 15,45, 60 and 85°
				135	1.5	100	90	5	R4	W2	
				136							
				137	1.5	100	53	10	R4	W2	Bedding N/A Joints at 5 to 15,45, 60 and 85°
				138	1.5	80	10	12	R4	W2	
				139							Bedding N/A Joints at 5 to 15,45, 60 and 85°
				140	1.5	100	95	5			
				141	1.5	100	40	17	R4	W2	
				142							Fine Bedding at 90° Joints at 5 to 10,20, 60 to 70°
				143	1.5	100	73	7			
				144	1.5	100	13	93	R4	W2	
		391.13 145.50	Grey Sandstone, fine to medium grain centimetric interdedded with black shale.	145							
				146	1.5	100	93	8			Well marked Beddings at 60 to 90° Joints at 20,40, 60 and 80°
				147	1.5	100	73	11	R4	W2	Orientation test
				148							

DISCONTINUITY DATA

Depth (m)	Type & Number (#)	DIP	DIP DIRECTION	Shape	Roughness	Infill	Jr	Ja	Jn	Fault Breccia/ Gouge	Broken Core
147.60	JN	56	315	PL	SM	QZ					
147.69	JN	78	280	UN	SM	QZ					
147.80	JN	70	290	PL	SM	FR					
147.82	JN	73	310	PL	SM	FR					
147.94	JN	73	310	PL	SM	FR					
147.98	JN	64	310	PL	SM	FR					
148.06	JN	73	310	PL	SM	FR					

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja:			
Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

LVM

HOLE #: **BH-P-01**

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-01

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	
Northing:	6086486.969	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658114.121	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	527.85	Azimut:	303.70°	Drillers:	Drillers
Inclination:	70°	Bit type: Flush: Feed:	Feed	Drill Rig:	LF-70

B.T.

Vertical Scale = 1 : 100

ROCK TYPE

DEPTH/Elev.(m)	DESCRIPTION
384.74 152.30	Grey Sandstone
377.50 160.00	End of borehole at a depth of 160.00m.

Depth (m) scale: 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163

INTERVAL REC. DATA / STRENGTH DATA

Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index
1.5	100	100	5		
1.5	100	100	8		
1.5	100	93	5	R4	W2
0.2	100	100	0		
0.5	80	80	2	R4	W2
0.6	100	100	4	R4	W2
0.9	100	100	3	R4	W2
0.8	100	100	4	R4	W2
1.0	100	80	7	R4	W2
0.5	100	100	2	R4	W2
1.5	100	100	8	R4	W2
1.0	100	100	6	R4	W2

DISCONTINUITY DATA

Depth (m)	Type & Number (#)	DIP	DIP DIRECTION	Shape	Roughness	Infill	Jr	Ja	Jn
148.06	JN	73	310	PL	SM	FR			
148.28	JN	64	340	PL	SM	FR			
148.50	BD	60	305-360	PL	C	QZ			
148.50	JN	75	30	PL	SM	FR			
149.05	JN	70	330	PL	SN	QZ			
149.25	BD	70-76	10	PL	PO	QZ			
149.54	JN	63	285	PL	PO	CH			
150.00	JN	42	325	IR	RO	FR			
150.08	JN	87	290	PL	SM	FE			
150.27	BD	83	90	UN	C	C			
150.27	JN	78	165	IR	SM	QZ			
150.46	JN	67	70	CU	SM	FE			
150.58	JN	65	67	CU	SM	QZ			
150.83	JN	56	80	PL	PO	FR			
150.86	JN	50	85	PL	PO	FR			
151.01	JN	36	85	UN	C	C			
151.07	BD	37-63	60	UN	C	C			
151.07	JN	61	100	CU	PO	FR			
151.08	JN	40	100	PL	PO	FR			
151.14	JN	71	95	PL	RO	FE			
151.40	JN	77	315	IR	SM	EP			
151.50	JN	73	295	PL	PO	FR			
154.10	JN	76	50	CU	SM	FR			
154.28	JN	10	215	PL	SM	FR			
154.65	JN	81	70	PL	RO	QZ			
154.83	JN	70	195	PL	RO	QZ			
155.20	JN	78	65	PL	RO	FE			

Fault Breccia/ Gouge | Broken Core

NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS

- Orientation test
- Variation of Bedding 70 to 90° Joints at 60 to 75°
- Orientation test
- Bedding at 75° Joints at 75°
- Bedding N/A Joints at 5 to 10,40 to 50 and 75°

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

HOLE #: **BH-P-01**

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B-0010504-2

B.T.

Vertical Scale = 1 : 100

EQ-09-Ge-66A R.1 04.03.2009

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-02

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	2014-09-25
Northing:	6086299.006	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658177.634	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	522.18	Azimut:	197.40°	Drillers:	Drillers
Inclination:	60°	Bit type: / Flush: / Feed:	Feed	Drill Rig:	LF-70

DEPTH/Elev.(m)	DESCRIPTION	Interval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index	NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
522.18 / 0.00	**Casing**	3.0						
519.58 / 3.00	**Iron oxyde** with white and red chert, fine to medium grained, dark grey, with centimetric bands of white to reddish medium grained chert and millimetric bands of fine grained red chert. Presence of nodules of white chert and pockets of iron oxyde. Fractured rock with limonite in most fracture. Mostly non magnetic with few weakly magnetic zone.	1.5	70	0		R5	W2	
		0.9	60	10		R5	W2	Bedding at 15° Joint at 20°
		0.6	66	17		R5	W2	Bedding at 30° Joint at 30°
		0.5	70	20		R5	W2	Bedding at 0° Joint at 20°
		0.5	80	20		R5	W2	
		0.5	100	40	10	R5	W2	Bedding at 40 to 50° Joint at 5 to 50°
		0.5	60	0		R5	W2	
		1.5	17	0		R5	W2	No recuperation from 8.0 to 9.0m
		1.2	29	0		R5	W2	
		0.3	57	0		R5	W2	
		1.0	0	0				
		0.7	21	0		R5	W2	
		2.0	35	10		R5	W3	Bedding at 35° Joint at 25 and 50°

Other column headings: Casing&Core Diameter/Depth (m); Water Notes; Depth (m); DISCONTINUITY DATA: Depth (m), Type & Number (#), Orientation (DIP, DIP DIRECTION), Surface Description (Shape, Roughness, Infill), Jr, Ja, Jn; Fault Breccia/Gouge; Broken Core.

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

HOLE #: **BH-P-02**

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-02

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	2014-09-25
Northing:	6086299.006	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658177.634	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	522.18	Azimut:	197.40°	Drillers:	Drillers
Inclination:	60°	Bit type:	Flush: Feed: Feed	Drill Rig:	LF-70

ROCK TYPE

DEPTH/Elev.(m)	DESCRIPTION
	Banded (3) white chert at 59.44° and 34°
	White chert and hematite nodules. White 60° chert bands from 20 to 20.1m and 60° red chert from 20.1 to 20.2m.
504.86 / 20.00	**Gradual contact**
502.69 / 22.50	**Iron oxyde** with much more red chert, few white chert, fine to medium grained, dark grey to reddish, centimetric (1 to 5cm) bands of granulated white chert. Presence of nodules and small veins of white chert. Highly weathered zone from 25.4 to 25.5m. 2 white chert bands at ±30°.
498.10 / 27.80	Highly weathered zone from 27.5 to 27.8m.
497.32 / 28.70	Well defined bands (millimetric to centimetric) of hematite white chert and red chert at ±30°.

INTERVAL REC. DATA / STRENGTH DATA

Depth (m) scale: 16 to 29

Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index
0.3	83	47		R5	W2
0.2	100	0		R5	W2
0.1	100	0	16	R5	W2
0.8	81	71		R5	W2
0.5	60	0		R5	W2
1.4	57	31		R5	W2
1.7	0	0			
0.4	100	65	5	R5	W2
0.3	83	73		R5	W2
0.2	100	0		R5	W2
0.5	89	33		R5	W2
0.9	100	0		R5	W2
0.3	100	0		R5	W2
0.9	94	30		R5	W2
0.3	100	0		R5	W2
0.6	45	0		R0	W45
0.7	36	0		R5	W2
0.2	100	0		R5	W2
0.5	40	0		R5	W2
0.6	55	0		R1	W4
0.4	100	29		R5	W2
0.2	75	0			
1.3	65	27		R5	W3
0.9	100	46	15	R5	W2
0.7	86	33		R2	W3

DISCONTINUITY DATA

Columns: Depth (m) | Type & Number (#) | Orientation: DIP, DIP DIRECTION | Surface Description: Shape, Roughness, Infill | Jr | Ja | Jn | Fault Breccia/Gouge | Broken Core | NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS

NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
Joints at 0°
Joints at 5 to 20°
Bedding at 3 to 60° Joints at 30 to 40°
Bedding at 65° Joints at 40 to 90°
Joints at 30°
Bedding at 30° Joints at 30 and 45°
Smalls zones R1 and W4 at 24.6 and 25.2m
Joints at 10 to 35°
Joints at 30° few at 65°

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

LVM

HOLE #: **BH-P-02**

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-02

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	2014-09-25
Northing:	6086299.006	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658177.634	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	522.18	Azimut:	197.40°	Drillers:	Drillers
Inclination:	60°	Bit type: Flush:	Feed: Feed	Drill Rig:	LF-70

B.T.

Vertical Scale = 1 : 100

ROCK TYPE

Columns: Casing&Core Diameter/Depth (m) | Water Notes | DEPTH/Elev.(m) | DESCRIPTION | Depth (m)

DESCRIPTION (depth 30 to 44 m):

29.6 to 29.9m: weathered band.
30.0 to 30.2m: weathered band.
30.35 to 31.3m: mostly white chert with hermatite as a secondary component..

Weakly magnetic around 36.5 and 37.8m.

39.0 to 39.3m: weathered band.

40.0 to 41.0m: weathered band.

Weakly magnetic around 41.0 and 41.2m.

INTERVAL REC. DATA / STRENGTH DATA

Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index
1.9	95	42	26	R0	W2
2.1	100	32		R1	W3
1.0	100	13		R1	W3
0.2	100	0		R2	W3
0.2	100	0		R5	W2
1.2	100	70		R5	W2
0.4	86	0			
1.2	82	41	20		
0.2	100	50	20		
0.3	100	90	22		
1.2	91	41	17		
1.2	52	10			
0.4	62	0			
1.5	100	27			
0.3	100	0			
1.2	54	13			
1.6	12	0			

DISCONTINUITY DATA

Depth (m)	Type & Number (#)	Orientation: DIP	Orientation: DIP DIRECTION	Surface Description: Shape	Surface Description: Roughness	Infill	Jr	Ja	Jn
30.70	JN	30	265	PL	SM	FE			
30.90	JN	23	80	PL	SM	QZ			
30.90	JN	0	15	PL	RO	QZ-FE			
31.08	JN	28	45	ST	SM	QZ-FE			
32.10	BD	30	85	PL	C	C			
32.80	JN	30	85	PL	SM	FR			

Fault Breccia/ Gouge | Broken Core

NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS

- Bedding of Iron Oxyde and red Chert
- Joints at 20 to 40°
- Bedding at 30° Joints at 30 to 45° some at 5 to 10°
- Bedding at 25° Joints at 25 and 45°
- Beddings at 20° Joint at 20°
- Fine Bedding at 5° Joints at 5°
- Fine Bedding at 5° Joints at 5° and 50 to 90°
- Bedding at 5° Joint at 5°
- Bedding at 10° Joints at 10 and 30°
- Bedding at 5° Joint at 5°
- Bedding at 45° Joint at 30,45 and 90°

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

LVM

HOLE #:

BH-P-02

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-02

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	2014-09-25
Northing:	6086299.006	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658177.634	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	522.18	Azimut:	197.40°	Drillers:	Drillers
Inclination:	60°	Bit type: Flush:	Feed: Feed	Drill Rig:	LF-70

ROCK TYPE / INTERVAL REC. DATA / STRENGTH DATA / DISCONTINUITY DATA

Columns: Casing&Core Diameter/Depth (m); Water Notes; DEPTH/Elev.(m); DESCRIPTION; Depth (m); Inertval No. & Depth (from-to)(m); TCR (%); RQD (%); Fractures per_1_m; Strength Index; Weathering Index; Depth (m); Type & Number (#); Orientation: DIP, DIP DIRECTION; Surface Description: Shape, Roughness, Infill; Jr; Ja; Jn; Fault Breccia/ Gouge; Broken Core; NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS

DESCRIPTION:

49.0 to 49.8m: weathered band.

51.05 to 51.10m: weathered band.

52.0 to 52.2m: weathered band.

56.0 to 56.1m, 56.2 to 56.6m and 56.9 to 57.0m: weathered band.

58.3 to 59.0m: weathered band.

Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index	NOTES/COMMENTS
						Bedding at 45° Joint at 30,45 and 90°
1.7	15	0		R5	W3	
0.3	100	0		R5	W3	
0.7	100	58	7	R5	W2	Joints at 60 and 5°
1.0	100	62	80	R5	W2	Joints at 40,60 and 20°
0.8	31	0		R1	W4	
1.2	43	0		R2	W3	
1.2	67	43	5	R2	W4	Joints at 30 and 60°
0.2	75	0		R4	W2	
0.4	63	0		R4	W2	
1.2	8	0				
1.0	100	22		R3	W3	Joints at 10,20 and 45°
0.5	50	0		R4	W3	
0.6	50	0		R1	W3	
0.9	100	0		R1	W4	
0.4	100	38	12	R4	W2	
1.6	58	30		R3	W2	Joints at 0 and 45°
0.7	70	0		R5	W3	

Depth scale (m): 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

HOLE #: **BH-P-02**

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B-0010504-2

B.T.

Vertical Scale = 1 : 100

EQ-09-Ge-66A R.1 04.03.2009

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-02

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	2014-09-25
Northing:	6086299.006	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658177.634	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	522.18	Azimut:	197.40°	Drillers:	Drillers
Inclination:	60°	Bit type: Flush:	Feed: Feed	Drill Rig:	LF-70

ROCK TYPE

Casing&Core Diameter/Depth (m) B-0010504-2 | Water Notes | DEPTH/Elev.(m)

DESCRIPTION

Thinly bedded (Iron oxyde and mostly red and some white chert) from 60.40 to 65.57m.

64.3 to 64.4m: weathered band.
64.8 to 64.9m: band of white chert.

68.0 to 74.0m: centimetric (2 to 5cm) bands of white chert. About 5 per meter.

70.5 to 75.5m: fine bedding of chert and iron oxyde.

Depth (m): 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74

INTERVAL REC. DATA / STRENGTH DATA

Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index
0.7	11	0		R3	W3
0.6	100	83	13	R3	W3
0.6	100	48	33	R3	W3
1.6	100	6		R3	W3
1.0	100	47	20	R5	W3
0.9	100	30		R3	W3
0.5	100	0		R3	W3
1.5	40	0		R5	W2
0.1	100	0		R5	W2
2.1	100	67	16	R5	W2
0.8	53	37		R5	W2
0.8	100	64	20	R5	W2
0.8	100	41		R5	W2
0.2	50	0		R5	W2
1.0	100	31	41	R5	W2
0.8	44	0		R5	W3
1.0	100	56	11	R5	W2

DISCONTINUITY DATA

Depth (m)	Type & Number (#)	DIP	DIP DIRECTION	Shape	Roughness	Infill	Jr	Ja	Jn
68.63	BD	30	345	PL	C	C			
68.64	JN	45	90	PL	SM	FR			
68.78	JN	43	95	PL	SM	FR			
68.78	JN	40	295	PL	SM	FR			
68.88	JN	40	55	IR	ST	FR			
68.95	JN	90	42	IR	SM	FR			
69.04	JN	46	38	IR	RO	FR			
69.11	JN	33	40	IR	RO	FR			
69.19	JN	52	20	PL	RO	FR			
69.21	JN	42		PL	RO	FR			

Fault Breccia/Gouge | Broken Core

NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS

No core between 59.70 and 60.10m

Bedding at 50°
Joints at 45 to 60°

Bedding at 5 to 10°
Joints at 5 to 10° and 30, 70°

Bedding at 30°

Bedding at 30°
Joints at 30,45 and 55°

Bedding at 40°
Joint at 40°

Bedding at 30°
Joints at 10 and 45°

From 69.64 to 70.24m: fine bedding

Bedding at 45°
Vein at 0°

Bedding at 40°
Joints at 30° and 50 to 6°

Bedding at 35 to 45°
Joints at 45 and 5°

Bedding at 25 to 35°
Joints at 40 to 60°

Bedding at 35°
Joints at 60°

B.T.

Vertical Scale = 1 : 100

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja:			
Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

HOLE #:

BH-P-02

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-02

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	2014-09-25
Northing:	6086299.006	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658177.634	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	522.18	Azimut:	197.40°	Drillers:	Drillers
Inclination:	60°	Bit type: Flush:	Feed: Feed	Drill Rig:	LF-70

ROCK TYPE

DESCRIPTION

Presence of centimetrics beds of iron, black and fissile. Mineralisation from 75.0 to 75.5m. Presence of beds of yellow limonite.

From 87.3 to 97.1, the white chert represente 30° to 50° of rock. It is oriented randomly.

Depth (m): 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89

INTERVAL REC. DATA / STRENGTH DATA

Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index
1.0	100	36	20	R5	W3
1.3	100	100	20	R2	W2
1.1	60	18	18	R1	W4
1.8	83	32	10	R1	W4
1.2	100	28	18	R1	W4
1.4	100	34		R2	W4
1.6	96	25	30	R1	W4
1.3	100	10		R1	W4
1.7	88	34	8	R1	W2
0.4	100	30		R1	W4
0.2	100	70		R4	W4

DISCONTINUITY DATA

Depth (m)	Type & Number (#)	Orientation: DIP	Orientation: DIP DIRECTION	Surface Description: Shape	Surface Description: Roughness	Surface Description: Infill	Jr	Ja	Jn	Fault Breccia/ Gouge	Broken Core

NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS

- Bedding at 25 to 30°
- Bedding at 30° Joints at 30,45 and 60°
- Bedding at 30° Joint at 30°
- Bedding at 30 to 35° Joints at 25 to 45°
- Bedding at 30 to 35° Joints at 30 to 35°
- Bedding at 30° Joint at 30°
- Bedding at 30 to 40° Joints at 5,30 and 45°
- Bedding and Joints at 30 to 60°
- Bedding at 4° Joint at 25,50 and 70°
- Joints at 40 to 70°

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

HOLE #:

BH-P-02

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-02

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	2014-09-25
Northing:	6086299.006	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658177.634	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	522.18	Azimut:	197.40°	Drillers:	Drillers
Inclination:	60°	Bit type: Flush:	Feed: Feed	Drill Rig:	LF-70

B.T.

Vertical Scale = 1 : 100

ROCK TYPE — **DESCRIPTION**

Concentration of yellowish limonite from 90.6 to 91.1.

From 98.7 the white chert represents 50% of the mass.

Depth (m): 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104

Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index	NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
0.9	100	63	15	R4	W2	
1.2	100	45	17	R4	W2	Joints at 25 to 35°
1.1	100	0	14	R4	W2	Joints at 5,20, 40 and 65 to 90°
0.7	100	38		R2	W3	Bedding at 20 to 35° Joints at 20 to 35°
1.0	85	14		R4	W3	
1.2	100	36	15	R3	W3	Bedding at 30° Joints at 15 to 20, 30 and 45°
1.7	88	0		R3	W2	Joints at 15 to 45 Vein at 5°
0.2	100	0		R2	W2	
1.4	100	68	19	R2	W3	Bedding at 30° Vein at 20° Joints at 20,30 and 45°
1.7	100	41	12	R2	W3	Bedding at 30 and 45° Joints at 30 and 45°
0.8	100	50	14	R2	W3	Bedding at 20° Joints at 25 to 35 and 70°
0.7	100	50	14	R3	W3	Bedding at 20° Joint at 20°
1.6	100	36	25	R4	W3	Bedding at 30° Joints at 30 and 85°
1.2	100	21	32	R4	W5	

Column headings: Casing&Core Diameter/Depth (m); Water Notes; DEPTH/Elev.(m); DESCRIPTION; Depth (m); INTERVAL REC. DATA; STRENGTH DATA; DISCONTINUITY DATA: Depth (m), Type & Number (#), Orientation (DIP, DIP DIRECTION), Surface Description (Shape, Roughness, Infill), Jr, Ja, Jn; Fault Breccia/ Gouge; Broken Core; NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

HOLE #: **BH-P-02**

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B-0010504-2

B.T.

Vertical Scale = 1 : 100

EQ-09-Ge-66A R.1 04.03.2009

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-02

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	2014-09-25
Northing:	6086299.006	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658177.634	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	522.18	Azimut:	197.40°	Drillers:	Drillers
Inclination:	60°	Bit type: / Flush: / Feed:	Feed	Drill Rig:	LF-70

ROCK TYPE

DESCRIPTION

From 106.0m, the white chert is pratically absent and the rock is altered.

Depth (m): 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119

INTERVAL REC. DATA / STRENGTH DATA

Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index
0.5	100	60		R3	W5
1.6	90	25	27	R3	W3
1.4	27	8		R3	W3
1.7	39	0		R1	W5
1.3	69	0	12	R2	W5
0.8	67	0		R2	W4
1.0	50	30		R2	W4
0.1	100	90		R2	W4
1.1	100	90	12	R4	W4
1.3	100	73		R2	W2
0.1	100	100		R4	W2
0.2	100	100		R4	W2
1.4	64	43		R4	W2
0.9	100	89	18	R4	W2
0.7	86	0		R3	W3

DISCONTINUITY DATA

Depth (m)	Type & Number (#)	Orientation DIP	Orientation DIP DIRECTION	Surface Description Shape	Surface Description Roughness	Infill	Jr	Ja	Jn
114.40	JN	19	75	IR	VR	QZ			
114.43	BD	25	53	UN	C	QZ			
114.51	BD	25	35	UN	C	QZ			
114.57	BD+JN	21	35	PL	RO	QZ			
114.63	JN	32	35	PL	C	QZ			
114.66	BD	36	55	PL	C	QZ			
114.68	BD	36	50	PL	C	QZ			
114.76	BD	36	65	PL	C	QZ			
114.81	BD	25	50	PL	C	QZ			
114.89	BD	19	70	PL	C	QZ			
114.91	JN	58	35	IR	C	FE			
114.99	BD	27	80	PL	C	QZ			
115.13	BD	40	118	PL	C	QZ			
115.14	JN	48	70	IR	RO	FE			
115.16	BD	40	118	PL	C	QZ			
115.19	BD	60	118	PL	C	QZ			
115.30	JN	32	285	IR	RO	QZ-FE			

Fault Breccia/ Gouge | Broken Core

NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS

Bedding at 25°
Joints at 20 and 45°

Joints at 20 and 50°

Bedding at 25°
Joints at 25°

Orientation test.

Bedding at 30°
Joint at 30 and 70°

Bedding at 45°
Joints at 45 and 60°

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja:			
Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

HOLE #:

BH-P-02

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-02

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	2014-09-25
Northing:	6086299.006	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658177.634	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	522.18	Azimut:	197.40°	Drillers:	Drillers
Inclination:	60°	Bit type:	Flush: Feed: Feed	Drill Rig:	LF-70

B.T.

Vertical Scale = 1 : 100

ROCK TYPE / INTERVAL REC. DATA / STRENGTH DATA

Depth (m)	Description	Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index
119.2–120.8		1.6	100	38		R3	W3
120.8–122.1		1.3	23	0		R5	W2
122.1–123.7		1.6	88	75	17	R5	W2
123.7–124.2		0.5	100	72	17	R5	W2
124.2–125.4		1.2	100	17		R4	W2
125.4–126.7		1.3	100	100	10	R4	W3
126.7–128.3		1.6	100	69	10	R4	W3
128.3–128.6		0.3	100	33		R1	W5
128.6–129.7		1.1	100	50	18	R1	W5
129.7–131.1		1.4	100	17	18	R1	W5
131.1–132.6		1.5	100	20		R2	W4
132.6–134.2	50% white chert	1.6	100	69	11	R3	W3

Depth scale: 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134

DISCONTINUITY DATA

Depth (m)	Type & Number (#)	DIP	DIP DIRECTION	Shape	Roughness	Infill
119.60	JN	38	45	PL	RO	FE-QZ
119.67	BD	33	45	PL	C	QZ
119.75	JN	33	60	PL	SM	FE
119.75	BD	33	40-45	PL	C	FE+QZ
119.80	JN	73	55	PL	RO	FQ
119.91	JN	39	57	PL	C	C
119.91	BD	40	57	PL	C	QZ
120.11	JN	24	55-60	PL	C	C
120.20	BD			PL	C	FE-QZ
132.35	JN	74	345	PL	RO	LI
132.37	JN	47	125	IR	RO	FE
132.42	BD	33	165	IR	C	QZ
132.43	JN	33	180	IR	C	C
132.53	BD	30-51	140	IR	C	QZ+FE
132.56	BD	33	140	PL	C	QZ
132.62	JN	43	60	PL	C	C
132.63	BD	33	140	IR	C	QZ
132.71	JN	40	85	IR	RO	FE+QZ

Columns also present (no values): Casing&Core Diameter/Depth (m), Water Notes, DEPTH/Elev.(m), Jr, Ja, Jn, Fault Breccia/Gouge, Broken Core.

NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS

- Orientation test.
- Bedding at 35 to 45°
  Joints mostly between
  25 to 40°
  some at 60°
- Bedding at 25 and 35°
  Joints at 30,45, 60 and 70°
- Few visible Bedding
  at 35°
  Joints at 35 to 50 and 75 to 85°
- Orientation test.

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja:			
Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

HOLE #:

BH-P-02

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-02

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	2014-09-25
Northing:	6086299.006	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658177.634	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	522.18	Azimut:	197.40°	Drillers:	Drillers
Inclination:	60°	Bit type: Flush:	Feed: Feed	Drill Rig:	LF-70

ROCK TYPE

Columns: Casing&Core Diameter/Depth (m) | Water Notes | DEPTH/Elev.(m) | DESCRIPTION | Depth (m)

DESCRIPTION:

Bands of limonite.

138.0m to 139.0m, black, very altered.

139.0m to 146.2m, 20 to 30% of white chert.

146.2m to 149.3m mostly limonite.

Depth scale (m): 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148

INTERVAL REC. DATA / STRENGTH DATA

Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index
1.4	100	71	11	R3	W4
1.6	94	83	11	R3	W4
1.4	100	57		R3	W4
1.6	94	34	1	R5	
1.4	100	50	12	R4	W3
1.5	100	57	12	R5	W2
1.5	93	40	12	R5	W2
1.5	67	33		R3	W3
1.5	100	37		R3	W3
1.5	100	63	14	R3	W2

DISCONTINUITY DATA

Depth (m)	Type & Number (#)	Orientation DIP	Orientation DIP DIRECTION	Surface Description Shape	Surface Description Roughness	Infill	Jr	Ja	Jn
132.78	BD	40	145	PL	C	QZ			
132.94	JN	36	120	PL	RO	FE+QZ			
132.94	BD	36	120	PL	C	QZ+FE			
134.08	JN	33	210	PL	RO	FE			
134.12	JN	31	10	UN	RO	QZ			
134.17	BD	31	15	IR	C	QZ			
134.22	BD	36	15	PL	C	QZ			
134.25	BD	36	15	PL	C	QZ			
134.26	JN	33	20	PL	SM	FE			
134.33	BD	33	0	PL	C	QZ			
134.37	BD	32	0	PL	C	QZ			
134.41	BD	30	0	PL	C	QZ			
134.47	JN	55	220	IR	RO	FE+QZ			
134.54	JN	26	245	IR	SM	FE+QZ			
134.74	BD	41-43	15	PL	C	FE+QZ			
134.80	BD	34	0	PL	C	QZ			
134.88	JN	38	5	IR	RO	LI			
134.92	BD	42	5	PL	C	FE			
134.96	BD	38	5	PL	C	FE			
135.00	JN	45	5	IR	RO	LI+QZ			
140.45	JN	39	0	C	C	C			
140.59	BD	36-41	0	C	C	C			
140.68	JN	40	0	C	C	C			
140.72	BD	40-43	0	C	C	C			
141.22	BD	38-40	0	C	C	C			
141.22	JN	39	0	C	C	C			
141.31	BD	39	0	C	C	C			
141.33	JN	38	0	C	C	C			
141.40	BD	39	0	C	C	C			
141.64	BD	36-39	0	C	C	C			
141.70	BD	43	0	C	C	C			
141.88	BD	43	0	C	C	C			
142.03	BD	40	0	C	C	C			
142.20	JN	35	0	C	C	C			
142.45	JN	31	0	C	C	C			
142.45	BD	49	0	C	C	C			
146.79	JN	48	250	PL	SM	LI			
146.85	JN	51	50	PL	SM	LI			
146.93	JN	34	135	PL	SM	LI			
147.00	JN	36	40	PL	SM	LI			
147.00	JN	38	250	PL	SM	LI			
147.66	JN	41	175	IR	RO	QZ			
147.74	BD	44	165	PL	C	FE+QZ			
147.78	JN	42	340	IR	RO	FE			
147.82	JN	47	175	IR	RO	FE			
147.83	BD	50	0	PL	C	QZ			
147.86	JN	56	180	PL	SM	FE			

Fault Breccia/ Gouge | Broken Core

NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS

Orientation test.

Orientation test.

Bedding at 35 to 40°
Joints at 35 to 40°

Bedding at 40°
Joint at 40°

Orientation test.

Orientation test.

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja:			
Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

HOLE #:

BH-P-02

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	2014-09-25
Northing:	6086299.006	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658177.634	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	522.18	Azimut:	197.40°	Drillers:	Drillers
Inclination:	60°	Bit type: Flush:	Feed: Feed	Drill Rig:	LF-70

B.T.

Vertical Scale = 1 : 100

ROCK TYPE

Depth (m)	DESCRIPTION
~150	Presence of limonite.
~151.5–152	Iron oxyde with few bands of white chert up to 155,0m.
~155.5–156	Iron oxyde with 5 to 10% of white chert and 50% of limonite.

INTERVAL REC. DATA / STRENGTH DATA

Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index
1.5	100	93		R3	W2
1.5	60	11		R3	W2
1.0	50	0		R4	W2
0.5	100	100		R4	W2
1.5	93	0	12	R4	W2
0.5	80	40		R4	W4
1.0	50	12		R4	W4
1.0	100	16		R3	W4
0.5	90	80		R3	W3
1.5	90	56	12	R3	W3
0.5	100	50	12	R3	W3
1.0	100	70	9	R3	W3
1.5	80	77	9	R3	W3
0.3	100	50	8	R4	W3
2.7	100	92	8	R4	W3

DISCONTINUITY DATA

Depth (m)	Type & Number (#)	DIP	DIP DIRECTION	Shape	Roughness	Infill
148.08	JN	37	180	IR	RO	LI
148.33	JN	58	200	PL	RO	LI
148.43	JN	65	210	PL	SM	LI
148.50	BD	38	20-25	PL	C	LI
148.51	JN	63	210	PL	SM	LI
152.45	JN	39	15	IR	RO	QZ
152.54	JN	49	20	IR	RO	FE
152.64	JN	44	145	IR	RO	FR
152.65	JN	36	5	PL	SM	FE
152.75	JN	41	20	PL	SM	FE
152.79	BD	43	20	PL	C	QZ
152.86	JN+BD	42	25	PL	RO	QZ
152.94	JN	32	210	PL	RO	FR
153.24	JN	50	200	IR	VR	FE
157.06	BD	40	60	PL	C	LI
157.12	JN	56	310	PL	SM	LI
157.39	JN	56	320	PL	SM	LI
157.50	JN	54	280	PL	SM	LI
157.61	BD	36	125	PL	C	FE+LI
157.64	JN	61	310	IR	RO	LI
157.79	JN	33	150	IR	RO	LI
157.81	JN	13	10	PL	SM	FE+LI
157.85	JN	46	180	IR	RO	FR
157.88	JN	16	10	PL	SM	FE+QZ
157.90	BD	36-41	125	PL	C	FE+LI
160.93	JN	43	180	PL	C	C
160.95	JN	42	180	PL	C	C
161.01	JN	45	305	IR	RO	FR
161.33	JN	36	180	PL	SM	FE+LI
161.36	BD	41	180	PL	C	FE
161.39	BD	41	180	PL	C	QZ
161.48	JN	45	180	PL	C	FE
161.64	JN	54	305	IR	BR	FE+LI
161.82	BD	39	180	PL	C	FE+LI
161.95	JN	57	25	PL	SM	FE+LI
162.00	JN	57	25	PL	SM	FE+LI

Columns Jr, Ja, Jn, Fault Breccia/Gouge, Broken Core: no values printed.

NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS

- Joints at 30 and 60°
- Orientation test.
- Bedding at 35°
  Joints at 35 and 60°
- Orientation test.
- Bedding at 35 to 45°
  Joints at 5,30, 40 and 60°
- Bedding at 40°
  Joint at 30 to 40°
- Orientation test.
- Bedding at 35 to 45°
  Joint at 35 to 45, 60 and 90°

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja:			
Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

LVM

HOLE #: **BH-P-02**

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-02

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	2014-09-25
Northing:	6086299.006	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658177.634	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	522.18	Azimut:	197.40°	Drillers:	Drillers
Inclination:	60°	Bit type:	Flush: Feed: Feed	Drill Rig:	LF-70

DEPTH/Elev.(m)	DESCRIPTION	Depth (m)	Interval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index	Broken Core	NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
	Iron oxyde with less then 5% of white chert and few bands of limonite. Concentration of limonite from 165,9 to 166,6m.	165								Bedding at 35 to 45° Joint at 35 to 45, 60 and 90°
		166	1.5	100	70		R3	W3		
		167	1.0	85	70	10	R3	W3		
	Iron oxyde with 30 to 50% of white chert.	168	0.5	80	80	10	R4	W3		Bedding at 40 to 45° Joints at 30,45 and 60°
		169	1.5	93	67	10	R4	W3		
	Highly weathered zone from 170,70 to 171,0m.	170	0.6	50	33		R3	W3		
			0.3	67	0		R3	W3		
		171	1.6	81	53	9	R3	W3		
		172	1.0	100	40		R3	W3		
372.36 173.00	End of borehole at a depth of 173.00m.	173								
		174								
		175								
		176								
		177								
		178								

Other columns (Casing&Core Diameter/Depth (m), Water Notes, Discontinuity Data: Depth (m), Type & Number (#), Orientation: DIP, DIP DIRECTION, Surface Description: Shape, Roughness, Infill, Jr, Ja, Jn, Fault Breccia/Gouge) contain no entries.

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

HOLE #: **BH-P-02**

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B.T.

Vertical Scale = 1 : 100

EQ-09-Ge-66A R.1 04.03.2009

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-03

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	
Northing:	6086562.697	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658422.620	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	526.33	Azimut:	45.00°	Drillers:	Drillers
Inclination:	60°	Bit type: Flush: Feed:	Feed	Drill Rig:	LF-70

B-0010504-2

Casing&Core Diameter/Depth (m)	Water Notes	DEPTH/Elev.(m)	DESCRIPTION	Depth (m)	Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index	Depth (m)	Type & Number (#)	DIP	DIP DIRECTION	Shape	Roughness	Infill	Jr	Ja	Jn	Fault Breccia/ Gouge	Broken Core	NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
		526.33 0.00	**Casing**	0–9																			
		518.54 9.00	Completely weathered grey to reddish **Iron Oxyde** with milimetric and centimetrics bands of red and white chert.	10	2.0	2	20																
				11	1.0	20	40																
				12–13	1.5	40	0		R0	W5												Broken Core	
				14	1.5	40	0		R0	W5												Broken Core	

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja:			
Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

LVM

HOLE #: **BH-P-03**

B.T.

Vertical Scale = 1 : 100

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-03

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	
Northing:	6086562.697	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658422.620	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	526.33	Azimut:	45.00°	Drillers:	Drillers
Inclination:	60°	Bit type:	Flush: Feed: Feed	Drill Rig:	LF-70

Casing&Core Diameter/Depth (m) B-0010504-2

DEPTH/Elev.(m)	DESCRIPTION	Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index	NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
		1.5	47	0		R0	W5	
		0.2	100	0		R0	W5	
		1.3	92	70		R0	W5	Bedding at 50° Joints at 60 to 80°
		1.3	100	50		R0	W5	
		0.2	50	0		R0	W5	
		1.5	6	0				
		1.5	13	0				
		1.5	33	0		R0	W5	
		1.2	100	80	17	R0	W5	Bedding at 60° Joints at 55 to 65°
		0.3				R0	W5	
		1.5	47	0		R0	W5	
		1.5	13	0				
501.82 28.30	Grey to blackish massive **Iron Oxyde** , weathered. Medium grain.	1.5	33	0		R3	W4	

Depth scale (m): 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29

DISCONTINUITY DATA: Depth (m) | Type & Number (#) | Orientation: DIP, DIP DIRECTION | Surface Description: Shape, Roughness, Infill | Jr | Ja | Jn | Fault Breccia/ Gouge | Broken Core

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja:			
Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

LVM

HOLE #: **BH-P-03**

B.T.

Vertical Scale = 1 : 100

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-03

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	
Northing:	6086562.697	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658422.620	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	526.33	Azimut:	45.00°	Drillers:	Drillers
Inclination:	60°	Bit type:	Flush: / Feed: Feed	Drill Rig:	LF-70

ROCK TYPE

DEPTH/Elev.(m)	DESCRIPTION
499.48 / 31.00	**Highly weathered zone**
499.31 / 31.20	Grey to blackish massive **Iron Oxyde**, weathered. Medium grain.
499.14 / 31.40	**Highly weathered zone**
499.05 / 31.50	Grey to blackish massive **Iron Oxyde**, weathered. Medium grain.
496.02 / 35.00	**Iron Oxyde** interbeded with milimetrics band of red chert and milimetrics to centimetrics band of white chert.
489.35 / 42.70	Completely weathered [Iron Oxyde]"/b" interbeded with milimetrics band of red chert and milimetrics to centimetrics band of white chert.
488.83 / 43.30	
488.05 / 44.20	
487.97	

INTERVAL REC. DATA / STRENGTH DATA

Depth (m)	Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index
30–31	1.5	33	0		R3	W4
31–33	1.5	20	0			
33–34	0.8	100	37		R3	W4
34	0.7	71	0		R3	W4
35	0.8	75	0		R3	W4
35–36	0.7	43	0		R3	W4
36–37	1.0	15	0			
37	0.5	40	0		R3	W4
38	1.5	53	0		R3	W4
39–40	1.5	33	0		R3	W4
41	1.5	13	0			
42–43	1.5	100	0		R3	W4
44	1.5	100	0		R5	W5

DISCONTINUITY DATA

Depth (m) | Type & Number (#) | Orientation: DIP, DIP DIRECTION | Surface Description: Shape, Roughness, Infill | Jr | Ja | Jn | Fault Breccia/Gouge | Broken Core | NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS

Bedding at 75°
Joints at 75°

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

HOLE #:

BH-P-03

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-03

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	
Northing:	6086562.697	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658422.620	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	526.33	Azimut:	45.00°	Drillers:	Drillers
Inclination:	60°	Bit type: Flush:	Feed: Feed	Drill Rig:	LF-70

B.T.

Vertical Scale = 1 : 100

ROCK TYPE

DEPTH/Elev.(m)	DESCRIPTION
487.71 / 44.60 487.19 / 45.20	Altered **Iron Oxyde** interbeded with milimetrics band of red Chert and milimetrics to centimetrics band of white Chert. **Quartz vein** **Highly weathered zone** **Quartz vein** **Iron Oxyde** interbeded with milimetrics band of red Chert and milimetrics to centimetrics band of white Chert. Interbeded with 5 to 10 cm earth zones bands.
479.05 / 54.60 478.70 / 55.00	**Iron Oxyde** with 70% of white Chert.
	Iron Oxyde interbeded with milimetrics band of red Chert and milimetrics to centimetrics band of white Chert. Interbeded with 5 to 10 cm earth zones bands.
477.83 / 56.00 477.66 / 56.20	**Iron Oxyde** with 70% of white Chert.
	Altered **Iron Oxyde** interbeded with milimetrics band of red Chert and milimetrics to centimetrics band of white Chert.

Depth (m) scale: 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59

INTERVAL REC. DATA / STRENGTH DATA

Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index
1.5	17	0			
1.5	23	0		R4	W4
1.5	100	12	18	R4	W4
1.5	80	0		R4	W4
1.5	20	0	17	R4	W4
1.5	50	16		R4	W4
1.0	90	30	10	R4	W4
1.7	100	30		R4	W4
1.1	55	0		R4	W4
0.7	100	21	17	R4	W4
0.8	100	25		R4	W4
0.7	100	0		R4	W4

DISCONTINUITY DATA

Depth (m)	Type & Number (#)	Orientation DIP	DIP DIRECTION	Surface Description Shape	Roughness	Infill	Jr	Ja	Jn	Fault Breccia/ Gouge	Broken Core	NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
												Bedding at 70° Joints at 5,30 and 70°
												Bedding at 70° Joints at 70°
												Bedding at 70 to 75° Joints at 10,50 and 70°
												Bedding at 70° Joints at 10,30 and 70°

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

LVM

HOLE #: **BH-P-03**

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B.T.

Vertical Scale = 1 : 100

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-03

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	
Northing:	6086562.697	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658422.620	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	526.33	Azimut:	45.00°	Drillers:	Drillers
Inclination:	60°	Bit type: Flush:	Feed: Feed	Drill Rig:	LF-70

Casing&Core Diameter/Depth (m) B-0010504-2

ROCK TYPE

DEPTH/Elev.(m)	DESCRIPTION
468.09 / 67.25 – 467.87 / 67.50	**Hematite** red and white Chert, Limonite.
67.50 – 467.18 / 68.30	Grey massive **Iron Oxyde** with few fine beddings of white Chert.
466.75 / 68.80; 466.40 / 69.20; 466.14 / 69.50	**Iron Oxyde** interbedded with milimetrics band of red Chert and milimetrics to centimetrics band of white Chert. More then 50% of white Chert.
464.24 / 71.70	**Iron Oxyde** interbedded with milimetrics band of red Chert and milimetrics to centimetrics band of white Chert, Limonite.
463.98 / 72.00 – 462.76 / 73.40	**Iron Oxyde** interbedded with milimetrics band of red Chert and milimetrics to centimetrics band of white Chert. More then 50% of white Chert.
461.90	

INTERVAL REC. DATA / STRENGTH DATA

Depth (m)	Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index
60	0.7	100	0		R4	W4
	0.2	100	0		R4	W4
61	1.3	30	0		R4	W4
62	1.5	100	30	26	R4	W4
63	0.6	83	0		R4	W4
64	1.5	100	0		R4	W4
65	0.3	100	67		R4	W4
	0.6			20	R4	W4
66	1.5	53	23		R4	W4
67	0.8	100	88		R5	W2
68	0.7	100	50	22	R5	W2
69	1.5	53	40		R3	W4
70	1.2	58	0		R3	W4
71	0.3				R0	W5
72	1.5	47	0		R3	W4
73–74	0.9	78	56	12	R2	W4

DISCONTINUITY DATA

Depth (m)	Type & Number (#)	Orientation DIP	DIP DIRECTION	Surface Description Shape	Roughness	Infill	Jr	Ja	Jn	Fault Breccia/ Gouge	Broken Core

NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS

- Bedding at 20 to 30° Joints at 20, 30 and 45°
- Bedding at 60 to 70° Joints at 10, 60 and 75°
- Bedding at 65 to 70° Joints at 5,10 and 65, 70°
- Bedding at 65° Joints at 40 and 65°

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

HOLE #: **BH-P-03**

EQ-09-Ge-66A R.1 04.03.2009

B.T.

Vertical Scale = 1 : 100

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-03

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	
Northing:	6086562.697	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658422.620	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	526.33	Azimut:	45.00°	Drillers:	Drillers
Inclination:	60°	Bit type: Flush:	Feed: Feed	Drill Rig:	LF-70

ROCK TYPE

DEPTH/Elev.(m)	DESCRIPTION
461.38 / 75.00	Weathered **Iron Oxyde** interbedded with milimetrics band of red Chert and milimetrics to centimetrics band of white Chert.
	Highly weathered zone
	Weathered **Iron Oxyde** interbedded with milimetrics band of red Chert and milimetrics to centimetrics band of white Chert. With few 5cm Earthy zones.
458.78 / 78.00	Completely weathered, iron Oxyde, interbedded with milimetrics band of red Chert and milimetrics to centimetrics band of white Chert. weathered zone at depth of 74.0m.
457.13 / 79.90	**Hematite** red and white Chert, ±Limonite.
456.61 / 80.50	Weathered black **Shale** with bands of **Iron Oxyde** interbedded with milimetrics band of red Chert and milimetrics to centimetrics band of white Chert.
454.71 / 82.70	Black **Shale** with milimetrics beds of white Chert.
	Black **Shale** with more then 50% of white Chert.
	Black **Shale** with milimetrics beds of white Chert.
	Black **Shale** with more then 50% of white Chert.
452.20 / 85.60	Black **Shale** with milimetrics beds of white Chert.

Depth (m): 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89

INTERVAL REC. DATA / STRENGTH DATA / DISCONTINUITY DATA

Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index	Broken Core	NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
0.6	100	33		R3	W5		Bedding at 65° Joints at 40 and 65°
1.5	80	10		R3	W5	shaded	
0.3	67	0		R3	W5	shaded	
0.7				R3	W5	shaded	
0.5				R3	W5	shaded	
1.5	100	93	7	R6	W3		Bedding at 70° Joints at 5, 20, 45 and 70°
1.5	100	77	11	R6	W2		Bedding at 65 to 70° Joints at 20 and 70°
1.5	100	75	9	R6	W2		Bedding at 70° Joints at 5, 45 and 70°
1.5	100	75	10	R6	W2		Bedding at 70° Joints at 30 and 70°
1.5	100	73	12	R6	W2		Bedding at 70 to 75° Joints at 5, 30 and 70, 75°
1.5	100	56	10	R6	W2		Bedding at 65 to 70° Joints at 5, 20 and 65, 70°
1.5	100	67	13	R6	W2		Bedding at 70° Joints at 5, 30 and 70°
1.5	87	80	3	R6	W2		Bedding at 70 to 75° Joints at 20 and 70°

Other columns (no entries on this page): Casing&Core Diameter/Depth (m); Water Notes; Depth (m); Type & Number (#); Orientation: DIP, DIP DIRECTION; Surface Description: Shape, Roughness, Infill; Jr; Ja; Jn; Fault Breccia/ Gouge.

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

HOLE #:

BH-P-03

B.T.

Vertical Scale = 1 : 100

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-03

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	
Northing:	6086562.697	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658422.620	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	526.33	Azimut:	45.00°	Drillers:	Drillers
Inclination:	60°	Bit type:	Flush: Feed: Feed	Drill Rig:	LF-70

ROCK TYPE

DEPTH/Elev.(m)	DESCRIPTION
445.36 / 93.50 – 445.10 / 93.80	Black **Shale** with motre then 50% of white chert. Crushed rock
445.10 / 93.80 – 443.23 / 95.96	Black **Shale** with milimetrics beds of white Chert.
443.23 / 95.96 – 443.19 / 96.00	Quartz/felspath vein.
443.19 / 96.00 – 443.02 / 96.20	Black **Shale** with milimetrics beds of white Chert.
443.02 / 96.20 – 442.89 / 96.35	Quartz/felspath vein.
442.89 / 96.35 – 441.89 / 97.50	Massive black shale
441.89 / 97.50 – 436.13	Black **Shale** with milimetrics beds of white Chert.

INTERVAL REC. DATA / STRENGTH DATA / NOTES

Depth (m)	Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index	NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
90							Bedding at 70 to 75°; Joints at 20 and 70°
91	1.5	100	67	12	R6	W2	Bedding at 70 to 75°; Joints at 15, 30 and 70°
92	1.5	100	40	11	R6	W2	
93	0.5	100	31	16	R6	W2	Bedding at 70°; Joints at 30 and 70°
94	1.0	100	31	17	R6	W2	Bedding at 70°; Joints at 30 and 70°
95	1.5	97	54	10	R6	W2	Bedding at 70°; Joints at 20, 30 and 70°
96–97	1.5	100	40	10	R6	W2	Joints at 30 and 70°
98	1.5	100	50	10	R6	W2	Bedding at 75°; Joints at 40 and 70°
99–100	1.5	100	63	6	R6	W2	Bedding at 70°; Joints at 70°
101	1.5	100	59	18	R6	W2	Bedding at 70°; Joints at 5, 30 and 70°
102–103	1.6	100	69	12	R6	W2	Bedding at 70°; Joints at 5, 10 and 30, 70°
104	1.4	100	27		R9	W2	

DISCONTINUITY DATA

Depth (m)	Type & Number (#)	Orientation: DIP	Orientation: DIP DIRECTION	Surface Description: Shape	Surface Description: Roughness	Surface Description: Infill	Jr	Ja	Jn	Fault Breccia/ Gouge	Broken Core

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

LVM

HOLE #: **BH-P-03**

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-03

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	
Northing:	6086562.697	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658422.620	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	526.33	Azimut:	45.00°	Drillers:	Drillers
Inclination:	60°	Bit type: / Flush: / Feed:	Feed	Drill Rig:	LF-70

DEPTH/Elev.(m)	DESCRIPTION (ROCK TYPE)	Depth (m)	Interval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index	NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
	Black **Shale** interbedded with grey sandstone.		1.4	100	27		R9	W2	
435.22 / 105.20	Black **Shale** with milimetrics beds of white Chert.	105–106	1.5	100	93	11	R6	W2	Bedding at 70° Joints at 5, 45, 60 and 70°
		107	1.5	83	83	5	R6	W2	Bedding at 70° Joints at 30 and 70°
432.37 / 108.50	Gray **Sandstone**, fine to medium grain.	108–109	1.5	100	70	13	R6	W2	Bedding at 70° Joints at 5, 10 and 30, 70°
		110	1.5	100	100	4	R6	W2	Joints at 10, 15 and 30°
		111–112	1.5	100	80	5	R6	W2	Joints at 5 and 30°
		113	1.5	87	35	10	R6	W2	Joints at 5,10 and 60, 80°
428.04 / 113.50	Grey to yellow to brown, altered coarse grained sandstone.	114	0.7	100	29	20	R6	W2	Joints at 5,10 and 60, 70, 80°
427.43 / 114.20	Grey **Sandstone**, fine to medium grain.	115	0.8	100	30	11	R6	W2	Joints at 30,60 and 70°
		116	1.5	93	73	10	R6	W2	Joints at 10, 20 and 70°
		117	0.3	100	100	10	R6	W2	
		118	1.2	100	100	10	R6	W2	Bedding at 75° Joints at 20 and 70°
423.97 / 118.20; 423.71 / 118.50	Grey **Sandstone**, fine to medium grain interbedded with black shale.	119	1.5	93	87	9	R6	W2	

DISCONTINUITY DATA: Depth (m) | Type & Number (#) | Orientation: DIP, DIP DIRECTION | Surface Description: Shape, Roughness, Infill | Jr | Ja | Jn | Fault Breccia/Gouge | Broken Core

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

LVM

HOLE #: **BH-P-03**

B.T.

Vertical Scale = 1 : 100

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-03

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	
Northing:	6086562.697	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658422.620	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	526.33	Azimut:	45.00°	Drillers:	Drillers
Inclination:	60°	Bit type: Flush:	Feed: Feed	Drill Rig:	LF-70

ROCK TYPE

DEPTH/Elev.(m)	DESCRIPTION
	Grey **Sandstone**, fine to medium grain.
422.84 / 119.50	Interbedded with black shale.
422.23 / 120.20	Grey **Sandstone**, fine to medium grain.
421.54 / 121.00	Interbedded with black shale.
421.11 / 121.50	Grey **Sandstone**, fine to medium grain.
420.33 / 122.40	Interbedded with black shale.
420.07 / 122.70	Grey **Sandstone**, fine to medium grain.
415.91 / 127.50	Grey **Sandstone**, coarse grain altered.
414.09 / 129.60	**Siltstone**

Depth (m) scale: 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134

INTERVAL REC. DATA / STRENGTH DATA / DISCONTINUITY DATA

Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index	Depth (m)	Type & Number (#)	DIP	DIP DIRECTION	Shape	Roughness	Infill	Jr	Ja	Jn	Fault Breccia/ Gouge	Broken Core	NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
1.5	93	87	9	R6	W2													Bedding at 50 to 75° Joints at 5, 30 and 50,70°
1.5	100	80	10	R6	W2													Bedding at 60 to 75° Joints at 15, 30 and 50,70°
1.1	100	100	17	R6	W2													
0.4	100	62		R6	W2													
1.5	100	100	8	R6	W2													Bedding at 60 to 75° Joints at 5, 30 and 60°
1.0	100	100	7	R6	W2													Bedding at 70° Joints at 30, 45 and 70°
0.5	100	100	7	R6	W2													
1.5	100	77	11	R6	W2													Bedding at 75° Joints at 20, 25 and 70°
1.5	93	100	12	R6	W2													Joints at 20, 60 and 70°
1.5	100	89	8	R4	W3													Joints at 50 and 70°
1.5	93	75	4	R4	W3													Joints at 30 and 90°
1.5	100	50	17	R6	W2													Joints at 10,40 and 60, 65°

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

HOLE #: **BH-P-03**

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-03

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	
Northing:	6086562.697	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658422.620	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	526.33	Azimut:	45.00°	Drillers:	Drillers
Inclination:	60°	Bit type: Flush:	Feed: Feed	Drill Rig:	LF-70

DEPTH/Elev.(m)	DESCRIPTION	Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index	NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
		1.5	100	91	7	R6	W2	Bedding at 75° Joints at 20, 45 and 70°
		1.5	100	80	15	R6	W2	Bedding at 70° Joints at 15, 50 and 70°
		1.5	100	59	11	R6	W2	
		1.5	100	55	7	R6	W2	Joints at 10 an 65°
405.09 / 140.00	Siltstone interbedded with black shale.	1.5	100	80	9	R6	W2	Joints at 40,50 and 70°
		1.5	100	87	7	R6	W2	Bedding at 60 to 70° Joints at 30 and 60, 70°
403.35 / 142.00	Siltstone.	1.5	100	40	3	R6	W2	Bedding at 65 to 70° Joints at 5 and 60, 70°
		1.5	100	93	10	R6	W2	Joints at 40 60 and 70°
		1.5	100	56	5	R6	W2	Bedding at 75° Joints at 20, 30 and 70°
		1.5	100	0	9	R6	W2	Bedding at 75° Joints at 15, 25 and 65, 70°
		1.2	100	88	3	R6	W2	Joints at 65°

Depth scale (m): 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint: JN		Bedding:	BD
Fault: FLT		Foliation:	FO
Shear: SHR		Contact:	CO
Vein: VN		Orthogonal:	OR
Conjugate: CJ		Cleavage:	CL

Roughness:		
Polished: PO	Smooth: SM	Very Rough: VR
Slickinsided: K	Rough: Ro	Closed: C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:		
Planar: PL	Undulating: UN	Irregular: IR
Curved: CU	Stepped: ST	Closed: C

Infilling:			
Broken Rock: Br		Gouge: Go	Sand: Sa
Biotite: Bt	Calcite: Ca	Gravel: Gr	Sericite: Se
Clay: Cl	Epiclote: Ep	Hematite: He	Silt: Si
Chlorite: Ch	Iron: Fe	Quartz: Qz	Sulphide: Su
Fresh: Fr	Closed: C		

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

HOLE #: BH-P-03

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B.T.

Vertical Scale = 1 : 100

EQ-09-Ge-66A R.1 04.03.2009

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-03

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	
Northing:	6086562.697	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658422.620	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	526.33	Azimut:	45.00°	Drillers:	Drillers
Inclination:	60°	Bit type: Flush:	Feed: Feed	Drill Rig:	LF-70

Casing&Core Diameter/Depth (m)	Water Notes	DEPTH/Elev.(m)	ROCK TYPE – DESCRIPTION	Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index	Depth (m)	Type & Number (#)	DIP	DIP DIRECTION	Shape	Roughness	Infill	Jr	Ja	Jn	Fault Breccia/ Gouge	Broken Core	NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
		397.03 / 149.30	Siltstone interbedded with black shale.	1.2	100	88	3	R6	W2													Joints at 65°
				1.7	100	82	7	R6	W2													Bedding at 70° Joints at 15, 45 and 65, 75°
				1.6	100	100	7	R6	W2													Joints at 45 and 65, 75°
		393.83 / 153.00	Siltstone.	1.5	100	93	5	R6	W2													Joints at 15, 45 and 60, 65°
		392.53 / 154.50	Siltstone interbedded with black shale.	1.5	88	88	5	R6	W2													Bedding at 60 to 65° Joints at 60 and 70°
		390.80 / 156.50	Siltstone.	1.5	100	70	14	R6	W2													Bedding at 70° Joints at 5 and 60, 70°; Joints at 50, 60 and 70°
				1.5	97	88	6	R6	W2													Joints at 30, 50 and 70, 75°
				1.7	88	65	8	R6	W2													Joints at 30, 40 and 65, 75°
		387.16 / 160.70	End of borehole at a depth of 160,7m.																			

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

HOLE #:

BH-P-03

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-04

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	2014-10-10
Northing:	6086397.562	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658603.194	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	519.26	Azimut:	135.00°	Drillers:	Drillers
Inclination:	70°	Bit type:	Flush: Feed: Feed	Drill Rig:	LF-70

ROCK TYPE

DEPTH/Elev.(m)	DESCRIPTION
519.26 / 0.00	**Casing**
517.85 / 1.50	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert.
512.02 / 7.70	**Highly weathered zone**
511.65 / 8.10	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert.
508.83 / 11.10	**Highly weathered zone**
508.55 / 11.40	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert.
507.28 / 12.75	**Highly weathered zone**
506.95 / 13.10	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert.

INTERVAL REC. DATA / STRENGTH DATA

Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index
1.5					
1.5	26	13		R5	W2
1.1	73	0		R5	W2
0.4	100	10		R5	W2
1.2	17	0		R5	W2
0.8	27	10			W2
0.7	71	50		R4	W2
0.7	100	31		R4	W2
0.4	100	0		R0	W6
0.7	14	0		R4	W3
1.3	100	38		R5	W3
0.2	100	0		R5	W3
1.5	100	8		R5	W3
1.2	100	21		R5	W3
0.8	100	50		R5	W3
0.4	100	0		R5	W3
0.6	100	10		R5	W3

DISCONTINUITY DATA

Depth (m) | Type & Number (#) | Orientation: DIP, DIP DIRECTION | Surface Description: Shape, Roughness, Infill | Jr | Ja | Jn | Fault Breccia/Gouge | Broken Core | NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS

Casing&Core Diameter/Depth (m) | Water Notes

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

HOLE #: **BH-P-04**

B.T.

Vertical Scale = 1 : 100

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-04

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	2014-10-10
Northing:	6086397.562	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658603.194	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	519.26	Azimut:	135.00°	Drillers:	Drillers
Inclination:	70°	Bit type: Flush:	Feed: Feed	Drill Rig:	LF-70

ROCK TYPE

DEPTH/Elev.(m)	DESCRIPTION
504.13 / 16.10	**Highly weathered zone**
503.76 / 16.50	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert.
500.56 / 19.90	**Highly weathered zone**
500.47 / 20.00	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert.
497.37 / 23.30	**White Chert**
496.71 / 24.00	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert.
496.05 / 24.70	**Highly weathered zone**
495.77 / 25.00	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert.
494.55 / 26.30	**Highly weathered zone**
494.26 / 26.60	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert.
491.45	

INTERVAL REC. DATA / STRENGTH DATA

Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index
1.3	75	10		R5	W3
0.2	100	0		R0	W6
1.3	100	77	21	R5	W3
0.5	51	0		R5	W3
0.3	100	0		R5	W3
1.2	100	17		R5	W3
1.2	90	0		R5	W3
1.5	68	0		R5	W2
0.2	100	60	18	R5	W2
1.3	100	54	22	R5	W2
0.5	100	0		R5	W3
0.5	100	0		R0	W6
1.5	30	0		R0	W6
0.5	100	0			W3
1.0	70	60	11		W3
1.0	100	50			W3
0.5	100	80			W3
0.5	100	0		R0	W6

Depth (m): 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29

DISCONTINUITY DATA

Depth (m)	Type & Number (#)	Orientation: DIP	DIP DIRECTION	Surface Description: Shape	Roughness	Infill	Jr	Ja	Jn	Fault Breccia/ Gouge	Broken Core

NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS

Bedding at 55°
Joints at 15 to 30°

Bedding N/A
Joints at 15 to 30°

Bedding N/A
Joints at 5 to 20° and 45 to 60°

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

LVM

HOLE #:

BH-P-04

B.T.

Vertical Scale = 1 : 100

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-04

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	2014-10-10
Northing:	6086397.562	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658603.194	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	519.26	Azimut:	135.00°	Drillers:	Drillers
Inclination:	70°	Bit type:	Flush: Feed: Feed	Drill Rig:	LF-70

ROCK TYPE

DEPTH/Elev.(m)	DESCRIPTION
491.07 / 30.00	Highly weathered zone
490.88 / 30.20	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert. **Highly weathered zone**
489.28 / 31.90	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert.
488.34 / 32.90	**Highly weathered zone**
488.25 / 33.00	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert.
486.46 / 34.90	**Highly weathered zone**
486.28 / 35.10	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert.
481.25 / 40.45	**Highly weathered zone**
480.92 / 40.80	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert.

INTERVAL REC. DATA / STRENGTH DATA

Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index
0.5	100	0		R0	W6
1.5	40	0		R0	W6
1.5	67	0		R4	W3
1.4	86	0		R4	W3
0.2	100	0		R4	W2
0.9	89	0		R3	W6
0.5	100	0		R5	W2
1.5	27	0		R5	W2
1.0		0		R5	W2
0.5	30	0		R5	W2
1.5	27	0		R5	W2
1.5	75	0		R0	W6
1.5	60	0		R5	W2
0.5	60	0		R5	W2
1.0	50	0		R5	W2

Depth (m): 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44

DISCONTINUITY DATA

Depth (m)	Type & Number (#)	Orientation DIP	DIP DIRECTION	Surface Description Shape	Roughness	Infill	Jr	Ja	Jn	Fault Breccia/ Gouge	Broken Core	NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
												N/A

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

LVM

HOLE #: **BH-P-04**

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-04

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	2014-10-10
Northing:	6086397.562	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658603.194	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	519.26	Azimut:	135.00°	Drillers:	Drillers
Inclination:	70°	Bit type: Flush:	Feed: Feed	Drill Rig:	LF-70

B.T.

ROCK TYPE

DEPTH/Elev.(m)	DESCRIPTION
475.09 / 47.00	Grey Massive Iron Oxyde, fine grain.
474.81 / 47.30	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert.
474.53 / 47.60	Grey Massive Iron Oxyde, fine grain.
474.06 / 48.10	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert.
473.87 / 48.30	**Highly weathered zone**
473.68 / 48.50	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert.
471.34 / 51.00	Grey Massive Iron Oxyde, fine grain.
471.15 / 51.20	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert.
470.30 / 52.10	**Highly weathered zone**
469.74 / 52.70	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert.
467.48 / 55.10	**White Chert Band**
467.29 / 55.30	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert.
466.92 / 55.70	**White Chert Band**
466.64 / 56.00	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert.
466.36 / 56.30	**White Chert** >50%
465.79 / 56.90	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert.

Depth (m): 45 – 59

INTERVAL REC. DATA / STRENGTH DATA

Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index
1.5	26	0			
0.4	100	0		R5	
1.1	100	81	16	R5	W4
1.5	58	17		R3	W6
1.5	38	0		R3	W4
1.5	72	20		R3	W4
0.4	100	0		R0	W6
1.1	60	20		R3	W4
0.2	100	100		R3	W4
1.5	87	23	10	R5	W3
1.5	87	37	21	R5	W3
1.0	100	75	9	R5	W3
0.4	100	0		R5	W3
1.3	100	0		R5	W3

DISCONTINUITY DATA

Depth (m)	Type & Number (#)	Orientation: DIP	Orientation: DIP DIRECTION	Surface Description: Shape	Surface Description: Roughness	Infill	Jr	Ja	Jn	Fault Breccia/ Gouge	Broken Core

NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS

- Bedding N/A
  Joints at 30°
- Bedding at 30°
  Joints at 30°
- Bedding at 40°
  Joints at 45 to 50° and 80°
- Bedding at 5 to 10°
  Joints at 25,40 and 60°

Vertical Scale = 1 : 100

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

HOLE #:

BH-P-04

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B.T.

Vertical Scale = 1 : 100

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-04

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	2014-10-10
Northing:	6086397.562	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658603.194	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	519.26	Azimut:	135.00°	Drillers:	Drillers
Inclination:	70°	Bit type: Flush:	Feed: Feed	Drill Rig:	LF-70

ROCK TYPE

DEPTH/Elev.(m)	DESCRIPTION
462.78 / 60.10	**White Chert Band**
462.64 / 60.25	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert.
462.31 / 60.60	**2 White Chert Bands**
461.66 / 61.30	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert.
457.05 / 66.20	**White Chert** >50%
453.01 / 70.50	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert.
450.19 / 73.50	**White Chert Band**
449.72 / 74.00	**Dark grey Iron Oxyde** with

Depth (m): 60 – 74

INTERVAL REC. DATA / STRENGTH DATA

Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index
1.6	100	88	12	R5	W3
0.5	100	0		R5	W3
1.0	100	50	17	R5	W3
1.0	100	80	11	R5	W3
0.5	100	70	4	R5	W3
1.4	100	35			W3
0.3	100	0		R5	W3
1.5	100	57	7	R5	W3
0.2	100	6	16	R5	W3
0.5	100	70	6	R5	W3
0.6	67	40		R5	W3
1.5	100	60	11	R5	W3
1.2	100	15	10	R5	W3
1.8	85	56	6	R5	W3
1.1	100	82	10	R5	W3

DISCONTINUITY DATA

Depth (m)	Type & Number (#)	Orientation: DIP	DIP DIRECTION	Surface Description: Shape	Roughness	Infill	Jr	Ja	Jn	Fault Breccia/ Gouge	Broken Core	NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
												Beddings at 5 and 10° Joints at 45,60 and 75°
												Bedding at 1° Joints at 0 and 45°
												Bedding at 20° Joints at 5,20 and 60°
												Bedding at 30° Joints at 30°
												Bedding at 25° Joints at 25 and 30°
												Bedding at 20° Joints at 5,20 and 50 to 75°
												Bedding at 15 to 20° Joints at 15 to 20°
												Bedding at 20° Joints at 20,30 and 45°
												Bedding N/A Joints at 20,30 and 45°
												Bedding at 20° Joints at 20 and 50°
												Bedding at 20° Joints at 30 and 50°

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

LVM

HOLE #:

BH-P-04

EQ-09-Ge-66A R.1 04.03.2009

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-04

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	2014-10-10
Northing:	6086397.562	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658603.194	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	519.26	Azimut:	135.00°	Drillers:	Drillers
Inclination:	70°	Bit type: Flush:	Feed: Feed	Drill Rig:	LF-70

B.T.

ROCK TYPE

DEPTH/Elev.(m)	DESCRIPTION
74.60	millimetric to centimetric beds of red an white chert.
448.97 / 74.80	Quartz Feldspath vein
448.78 / 75.00	Dark grey Iron Oxyde with millimetric to centimetric beds of red an white chert.
448.03 / 75.80	White Chert
447.84 / 76.00	Hematite and White Chert >50%
	Dark grey Iron Oxyde with millimetric to centimetric beds of red an white chert.
445.96 / 78.00	White Chert
445.59 / 78.40	Grey Iron Oxyde with Quartz and white Chert.
441.17 / 83.10	White Chert 30 to 50%
440.80 / 83.50	Dark grey Iron Oxyde with millimetric to centimetric beds of red an white chert.
438.92 / 85.50	White Chert 30 to 50%
436.47 / 88.10	Dark grey Iron Oxyde with millimetric to centimetric beds of red an white chert.

INTERVAL REC. DATA / STRENGTH DATA

Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index
1.5	100	30	14	R5	W3
0.3	67	0		R3	W4
1.6	85	45	13	R3	W4
1.5	100	18	11	R5	W2
1.5	16	0		R5	W2
1.6	68	38	6	R5	W2
0.5	80	0		R5	W2
0.4	100	0		R5	W3
0.4	100	50		R5	W3
1.6	100	80	22	R5	W3
1.6	100	50	17	R5	W3
0.5	100	0		R5	W3
1.1	91	32		R5	W3
1.4	86	79	7	R5	W3

DISCONTINUITY DATA

Depth (m)	Type & Number (#)	DIP	DIP DIRECTION	Shape	Roughness	Infill	Jr	Ja	Jn
88.40	JN	17	280	PL	SM	FE			
88.50	JN	45	215	PL	RO	FE			
88.60	JN	29	345	PL	C	C			

NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS

- Bedding N/A Joints at 20,30 and 60°
- Bedding at 10° Joints at 20,30 and 60°
- Bedding at 25° Joints at 30 and 40°
- Bedding at 30° Joints at 10 and 30°
- Bedding N/A Joints at 15°
- Bedding at 80° Joints at 45 and 50 to 60°
- Beddings at 5 to 20° Joints at 20 to 35°
- Bedding at 5° Joints at 5 to 20° and 35 to 50°

Vertical Scale = 1 : 100

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

HOLE #: **BH-P-04**

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B.T.

Vertical Scale = 1 : 100

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-04

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	2014-10-10
Northing:	6086397.562	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658603.194	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	519.26	Azimut:	135.00°	Drillers:	Drillers
Inclination:	70°	Bit type: Flush:	Feed: Feed	Drill Rig:	LF-70

ROCK TYPE

DEPTH/Elev.(m)	DESCRIPTION
433.18 / 91.60	**White Chert** 30 to 50%
423.98 / 101.40	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert.

INTERVAL REC. DATA / STRENGTH DATA

Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index
1.5	100	13	12	R5	W3
0.5	100	25	8	R5	W3
0.5	100	0		R5	W3
0.4	100	100		R5	W3
1.3	92	92		R5	W3
0.2	100	0		R5	W3
1.5	100	80	11	R5	W3
0.5	100	100		R5	W3
1.5	100	67		R5	W3
0.6	100	100	10		W3
0.4			20	R5	W3
1.5	100	60	8	R5	W3
1.5	100	53		R5	W3
1.5	100	0		R5	W3
1.2	100	0		R5	W3

DISCONTINUITY DATA

Depth (m)	Type & Number (#)	DIP	DIP DIRECTION	Shape	Roughness	Infill	Jr	Ja	Jn
97.80	BD	41	70	PL	C	QZ			
97.85	JN	41	70	PL	RO	QZ			
98.00	BD	9	265	UN	C	QZ			

NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS

- ° and 35 to 50°
- Bedding at 0 to 20° Joints at 20 and 50°
- Bedding at 0 to 20° Joints at 10 to 45°
- Bedding at 20 to 35° Joints at 20,35 and 45°
- Bedding at 30 to 40° Joints at 20,40 and 50°
- Bedding at 30° Joints at 30°
- Bedding at 15 to 40° Joints at 30 and 45°

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

LVM

HOLE #: **BH-P-04**

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-04

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	2014-10-10
Northing:	6086397.562	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658603.194	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	519.26	Azimut:	135.00°	Drillers:	Drillers
Inclination:	70°	Bit type: Flush:	Feed: Feed	Drill Rig:	LF-70

B.T.

Vertical Scale = 1 : 100

ROCK TYPE

DEPTH/Elev.(m)	DESCRIPTION
417.77 / 108.00	**White Chert** > 50%
416.08 / 109.80	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert.
415.10 / 110.85	**Limonite band**
414.95 / 111.00	**White Chert** > 50%
410.07 / 116.20	Completely weathered reddish Iron Oxyde

INTERVAL REC. DATA / STRENGTH DATA

Depth (m)	Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index
105–106	1.2	96	3	11	R5	W3
106–108	2.1	71	0		R5	W3
108–109.5	1.5	100	13	8	R4	W3
109.5–111	1.5	100	0	15	R4	W4
111–112.5	1.5	50	0		R4	W3
112.5–114	1.5	0	0			
114–115.5	1.5	13	0			
115.5–117	1.5	100	30	12	R3	W5
117–118.5	1.5	100	0		R0	W5
118.5–119	1.5	100	23	11	R0	W5

DISCONTINUITY DATA

Depth (m)	Type & Number (#)	DIP	DIP DIRECTION	Shape	Roughness	Infill	Jr	Ja	Jn	Fault Breccia/ Gouge	Broken Core	NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
												Bedding at 30 to 35° Joints at 30 and 35°
												Bedding at 0 to 20° Joints at 0 to 20°
												Bedding at 20° Joints at 20 and 40°
												Bedding N/A Joints at 30 and 60°

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

LVM

HOLE #: **BH-P-04**

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-04

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	2014-10-10
Northing:	6086397.562	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658603.194	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	519.26	Azimut:	135.00°	Drillers:	Drillers
Inclination:	70°	Bit type: Flush:	Feed: Feed	Drill Rig:	LF-70

B.T.

Vertical Scale = 1 : 100

ROCK TYPE

DEPTH/Elev.(m)	DESCRIPTION
406.68 / 119.80	[White Quartz Feldspath vein]"/b" well crystalized.
406.12 / 120.40	Completely weathered reddish Iron Oxyde
405.09 / 121.50	Dark grey Massive Iron Oxyde with red Chert veinlets.
394.28 / 133.00	Dark grey Massive Iron Oxyde Steel with more red Chert veinlets concentration

INTERVAL REC. DATA / STRENGTH DATA

Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index
1.5	100	33	6	R5	W5
1.5	100	32	2	R6	W4
1.1	100	100		R6	W2
0.4	100	50		R6	W2
1.3	83	83		R6	W2
1.3	100	58	3	R6	W2
0.3	100	100		R6	W2
1.3	100	0		R6	W2
1.1	82	45	5	R6	W2
0.3	100	0		R6	W2
0.4	100	80	12	R6	W2
0.1	100	0		R6	W2
1.4	100	100	2	R6	W2
0.3	100	100		R6	W2
0.8	0	0			
0.4	100	50		R2	W2
1.6	100	59	12	R6	W4

DISCONTINUITY DATA

Depth (m)	Type & Number (#)	Orientation DIP	Orientation DIP DIRECTION	Surface Description Shape	Surface Description Roughness	Infill	Jr	Ja	Jn	Fault Breccia/ Gouge	Broken Core

NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS

- Bedding at 50° Joints at 40 to 50° and 80°
- Joints at 15 to 60°
- Bedding N/A Joints at 50 to 60°
- Bedding N/A Joints at 40 to 55°
- Bedding N/A Joints at 5,20 and 60°
- Bedding at 20° Joints at 30 to 60°
- Bedding N/A Joints at 30 to 60°
- Loss of water
- Joints at 30,60 and 130°

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

LVM

HOLE #: **BH-P-04**

B.T.

Vertical Scale = 1 : 100

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-04

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	2014-10-10
Northing:	6086397.562	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658603.194	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	519.26	Azimut:	135.00°	Drillers:	Drillers
Inclination:	70°	Bit type: Flush:	Feed: Feed	Drill Rig:	LF-70

ROCK TYPE

DEPTH/Elev.(m)	DESCRIPTION
	and more alteration.
388.64 / 139.00	Highly weathered zones, 5 to 10cm each.
388.08 / 139.60	Alternance of slightly altered massive Iron Oxyde with extremely weathered Iron Oxyde.
384.23 / 143.70	**Massive Iron Oxyde** with white Chert.
382.30 / 145.75	**Highly weathered zone**
382.16 / 145.90	**Massive Iron Oxyde** with white Chert.

Depth (m) scale: 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148

INTERVAL REC. DATA / STRENGTH DATA

Inertval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index
1.5	100	0		R6	W4
1.5	100	31		R6	W4
0.6	100	100	5	R5	W3
1.0	100	35	9	R4	W4
1.0	50	10		R5	W4
0.4	100	0		R4	W4
1.2	100	54	4	R5	W4
1.2	100	50		R4	W4
0.3	100	100		R5	W3
1.3	100	92	3	R5	W3
0.5	100	60		R5	W3
1.5	100	65	6	R5	W6
1.5	16	0		R5	W3

DISCONTINUITY DATA

Columns: Depth (m) | Type & Number (#) | Orientation: DIP, DIP DIRECTION | Surface Description: Shape, Roughness, Infill | Jr | Ja | Jn | Fault Breccia/Gouge | Broken Core | NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS

NOTES/COMMENTS:

- Joints at 15,30,45 and 60°
- Joints at 30°
- Bedding at 35° Joints at 30°
- Beddings at 25, 1 to 5° and 25 to 30°
- Bedding at 20 to 30° Joints at 20 to 35°
- Bedding at 20 to 30° Joints at 30°

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

LVM

HOLE #: **BH-P-04**

RECORD OF ROCK CORE DRILLING AND TESTING - BOREHOLE N°: BH-P-04

File n°:	B-0010504-2	Project Name:	Joyce Lake - Open Pit	Date drilled & Logged:	2014-10-10
Northing:	6086397.562	Reference Point:	Precision GPS	Logged by:	Alain Lemonde
Easting:	658603.194	Datum:	NAD83 UTM ZONE 19	Drilling Contractor:	Downing
Elevation:	519.26	Azimut:	135.00°	Drillers:	Drillers
Inclination:	70°	Bit type: Flush:	Feed: Feed	Drill Rig:	LF-70

DEPTH/Elev.(m)	DESCRIPTION	Interval No. & Depth (from-to)(m)	TCR (%)	RQD (%)	Fractures per_1_m	Strength Index	Weathering Index	NOTES/COMMENTS /IMPRINT DEPTH/ INFILL TYPE & THICKNESS
		1.5	100	80	7	R5	W3	Bedding at 25° Joints at 25 and 70°
378.02 / 150.30	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert.	1.5	100	70	20	R5	W3	Bedding at 20° Joints at 20°
376.90 / 151.50	**N/A**	1.5	0	0				
		1.5						
374.08 / 154.50	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert. Presence of a few centimetric Massive Iron Oxyde bands.	1.5	87	55	14	R5	W4	Bedding at 20° Joints at 30 and 60°
372.67 / 156.00	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert.	1.5	100	20	7	R5	W6	Bedding N/A Joints at 40°
371.73 / 157.00	**Highly weathered zone**							
371.45 / 157.30	**Dark grey Iron Oxyde** with millimetric to centimetric beds of red an white chert.							
371.16 / 157.60	Grey Massive Iron Oxyde, no alteration.	1.5	100	33	5	R6	W2	Bedding N/A Joints at 35 and 45°
369.75 / 159.10	**Highly weathered zone**	1.0	100	0		R0	W6	
368.91 / 160.00	End of borehole at a depth of 160.00m.							

Depth scale (m): 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163

Other columns: Casing&Core Diameter/Depth (m), Water Notes, DISCONTINUITY DATA (Depth (m), Type & Number (#), Orientation: DIP, DIP DIRECTION; Surface Description: Shape, Roughness, Infill; Jr, Ja, Jn), Fault Breccia/Gouge, Broken Core.

B.T.

Vertical Scale = 1 : 100

Joint Roughness, Jr:	
Wavy and Rough	3.0
Wavy and Smooth	2.0
Planar and Rough	1.5
Planar/Smooth/Fill	1.0
Planar/Slickensided	0.5

Type:			
Joint:	JN	Bedding:	BD
Fault:	FLT	Foliation:	FO
Shear:	SHR	Contact:	CO
Vein:	VN	Orthogonal:	OR
Conjugate:	CJ	Cleavage:	CL

Roughness:					
Polished:	PO	Smooth:	SM	Very Rough:	VR
Slickinsided:	K	Rough:	Ro	Closed:	C

Joint Alteration, Ja: Unfilled:		Filled:	
Healed Fractures	0.75	Sand/Crushed Rock	4
Staining only	1	Stiff Clay < 5mm	6
Slightly altered wall	2	Soft Clay < 5mm	8
Silty/sandy coating	3	Swell. Clay < 5mm	12
Clay coating	4	Stiff Clay > 5mm	10
		Soft Clay > 5mm	15
		Swell. Clay > 5mm	20

Shape:					
Planar:	PL	Undulating:	UN	Irregular:	IR
Curved:	CU	Stepped:	ST	Closed:	C

Infilling:							
Broken Rock:	Br			Gouge:	Go	Sand:	Sa
Biotite:	Bt	Calcite:	Ca	Gravel:	Gr	Sericite:	Se
Clay:	Cl	Epiclote:	Ep	Hematite:	He	Silt:	Si
Chlorite:	Ch	Iron:	Fe	Quartz:	Qz	Sulphide:	Su
Fresh:	Fr	Closed:	C				

Joint Number, Jn:	
Massive	0.5
One set	2
One plus random	3
Two sets	4
Two sets plus random	6
Three sets	9
Three sets plus random	12
Four or more sets	15
Crushed rock	20

LVM

HOLE #: **BH-P-04**

APPENDIX B

Hydraulic Conductivity Results

Packer Injection Tests

Table B-1: Summary of Packer Test Results - Lugeon Values and Patterns

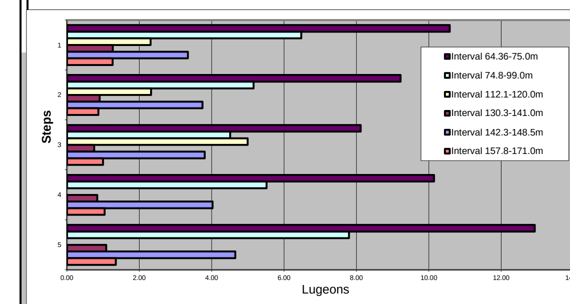
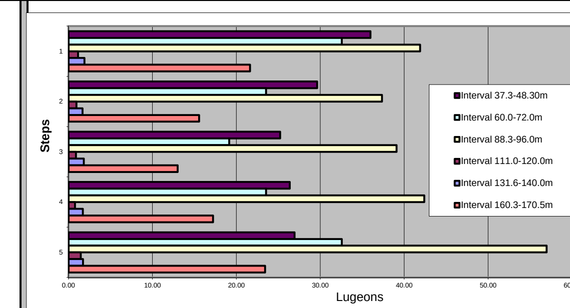
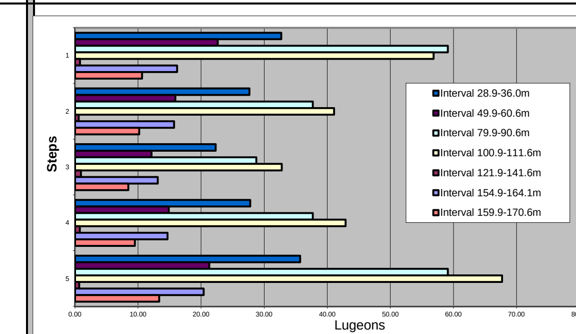
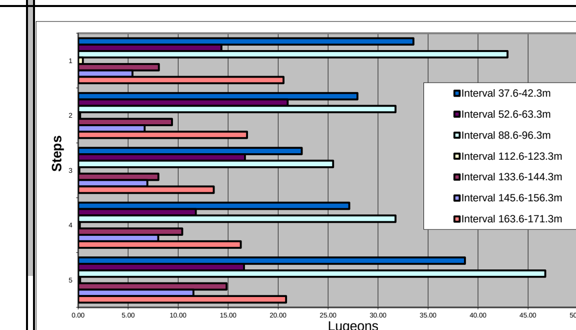
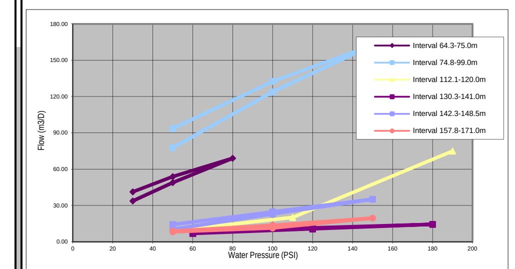
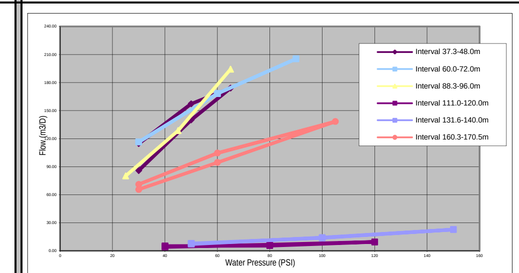
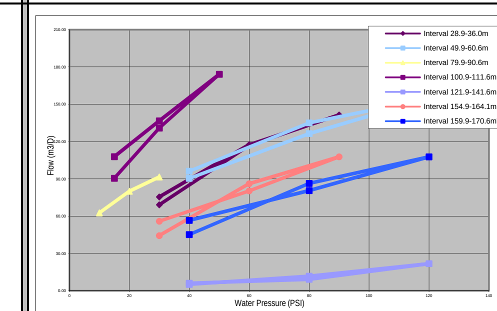
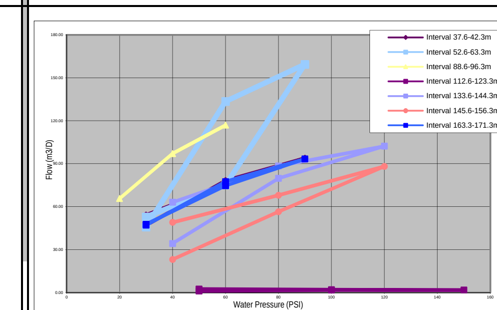
DDH	Date	Time			Packer Test Interval			Discharge Rate (Q) (m^3/day)					Packer Test Pressure					Lugeon Value						Lugeon Pattern
		From	To	Duration	From	To	Length	Step 1	Step 2	Step 3	Step 4	Step 5	Step 1	Step 2	Step 3	Step 4	Step 5	Step 1	Step 2	Step 3	Step 4	Step 5	Geometric	
	(M/D/YR)	*(h:min)*	*(h:min)*	*(h:min)*	*(m)*	*(m)*	*(m)*	*(m^3/d)*	*(m^3/d)*	*(m^3/d)*	*(m^3/d)*	*(m^3/d)*	*(PSI)*	*(PSI)*	*(PSI)*	*(PSI)*	*(PSI)*						Average	
JGW-3	Sep 23 2014	16:20	17:45	1:25	64.3	75.0	10.7	33.70	48.96	68.98	53.86	41.18	30	50	80	50	30	10.57	9.22	8.12	10.14	12.92	10.07	
JGW-3	Sep 24 2014	8:00	10:00	2:00	74.8	99.0	24.2	77.76	123.84	162.43	132.48	93.60	50	100	150	100	50	6.47	5.15	4.51	5.51	7.79	5.78	
JGW-3	Sep 24 2014	16:10	18:00	1:50	112.1	120.0	8.0	10.94	20.16	74.88	#N/A	#N/A	60	110	190			2.31	2.32	4.99	#N/A	#N/A	2.99	
JGW-3	Sep 25 2014	3:30	5:10	1:40	130.3	141.0	10.7	8.06	11.52	14.40	10.66	6.91	60	120	180	120	60	1.27	0.90	0.75	0.84	1.08	0.95	
JGW-3	Sep 25 2014	11:30	12:40	1:10	142.3	148.5	6.2	10.28	23.04	35.14	24.77	14.31	50	100	150	100	50	3.34	3.74	3.81	4.02	4.65	3.89	
JGW-3	Sep 26 2014	7:10	8:15	1:05	157.8	171.0	13.2	8.27	11.35	19.58	13.65	8.84	50	100	150	100	50	1.26	0.87	1.00	1.04	1.35	1.09	
JGW-1	Sep 28 2014	15:00	17:30	2:30	37.3	48.0	10.7	114.62	157.31	174.04	140.03	85.82	30	50	65	50	30	35.97	29.61	25.20	26.36	26.93	28.58	
JGW-1	Sep 29 2014	4:00	6:00	2:00	60.0	72.0	12.0	116.35	168.19	205.34	168.19	116.35	30	60	90	60	30	32.55	23.53	19.15	23.53	32.55	25.71	
JGW-1	Sep 29 2014	15:00	17:30	2:30	88.3	96.0	7.7	80.06	128.51	194.26	145.79	108.86	25	45	65	45	25	41.89	37.35	39.09	42.38	56.96	43.04	
JGW-1	Sep 30 2014	4:00	6:00	2:00	111.0	120.0	9.0	4.03	6.62	9.50	5.47	5.18	40	80	120	80	40	1.13	0.93	0.89	0.77	1.45	1.01	
JGW-1	Sep 30 2014	9:00	10:30	1:30	131.6	140.0	8.4	7.92	13.82	22.75	14.11	7.20	50	100	150	100	50	1.90	1.66	1.82	1.69	1.73	1.76	
JGW-1	Oct 1 2014	9:00	10:30	1:30	160.3	170.5	10.2	65.66	94.46	138.24	104.54	71.14	30	60	105	60	30	21.61	15.55	13.00	17.21	23.41	17.75	
JGW-2	Oct 3 2014	15:00	18:00	3:00	28.9	36.0	7.1	69.12	116.93	141.41	117.50	75.46	30	60	90	60	30	32.68	27.65	22.29	27.78	35.68	28.84	
JGW-2	Oct 4 2014	7:15	9:15	2:00	49.9	60.6	10.7	96.19	135.07	154.66	126.43	90.43	40	80	120	80	40	22.64	15.89	12.13	14.88	21.28	16.91	
JGW-2	Oct 5 2014	4:00	6:00	2:00	79.9	90.6	10.7	62.78	80.06	91.58	80.06	62.78	10	20	30	20	10	59.10	37.68	28.74	37.68	59.10	42.73	
JGW-2	Oct 5 2014	16:00	18:00	2:00	100.9	111.6	10.7	90.58	130.90	174.10	136.66	107.86	15	30	50	30	15	56.84	41.07	32.78	42.88	67.68	46.70	
JGW-2	Oct 6 2014	8:30	10:00	1:30	121.9	141.6	19.7	6.19	9.22	21.89	11.81	5.18	40	80	120	80	40	0.79	0.59	0.93	0.75	0.66	0.74	
JGW-2	Oct 6 2014	22:30	0:30	2:00	154.9	164.1	9.2	44.35	86.11	107.71	80.35	55.87	30	60	90	60	30	16.19	15.71	13.10	14.66	20.39	15.84	
JGW-2	Oct 7 2014	22:30	0:30	2:00	159.9	170.6	10.7	45.22	86.40	107.71	80.64	56.74	40	80	120	80	40	10.64	10.17	8.45	9.49	13.35	10.30	
JGW-4	Oct 8 2014	13:00	14:30	1:30	37.6	42.3	4.7	46.94	78.19	93.89	75.89	54.14	30	60	90	60	30	33.53	27.93	22.36	27.10	38.68	29.40	
JGW-4	Oct 9 2014	13:00	14:30	1:30	52.6	63.3	10.7	45.65	133.49	159.41	75.02	52.85	30	60	90	60	30	14.32	20.94	16.67	11.77	16.58	15.77	
JGW-4	Oct 9 2014	1:00	2:15	1:15	88.6	96.3	7.7	65.66	97.06	116.93	97.06	71.42	20	40	60	40	20	42.95	31.74	25.49	31.74	46.71	34.86	
JGW-4	Oct 10 2014	10:00	11:00	1:00	112.6	123.3	10.7	2.45	2.02	1.73	1.67	1.01	50	100	150	100	50	0.46	0.19	0.11	0.16	0.19	0.20	
JGW-4	Oct 10 2014	22:00	23:30	1:30	133.6	144.3	10.7	34.3	79.8	102.2	88.4	63.1	40	80	120	80	40	8.07	9.39	8.02	10.40	14.84	9.87	
JGW-4	Oct 11 2014	2:30	4:00	1:30	145.6	156.3	10.7	23.04	56.45	88.13	67.97	48.96	40	80	120	80	40	5.42	6.64	6.91	8.00	11.52	7.45	
JGW-4	Oct 11 2014	7:00	9:00	2:00	163.6	171.3	7.7	47.09	77.47	93.31	74.59	47.66	30	60	90	60	30	20.53	16.89	13.56	16.26	20.78	17.39	

Table B-1: Summary of Packer Test Results - Hydraulic Conductivity Values and Trend Graphs

DDH	Date	Time From	Time To	Duration	Packer Test Interval From	Packer Test Interval To	Length	Discharge Rate (Q) (m3/Day) Step 1	Step 2	Step 3	Step 4	Step 5	Packer Test Pressure Step 1	Step 2	Step 3	Step 4	Step 5	Hydraulic Conductivity (K) Values Step 1	Step 2	Step 3	Step 4	Step 5	Geometric Average	Water Loss vs. Pressure Pattern	Comments	
	(M/D/YR)	*(h:min)*	*(h:min)*	*(h:min)*	*(m)*	*(m)*	*(m)*	*(m^3/d)*	*(m^3/d)*	*(m^3/d)*	*(m^3/d)*	*(m^3/d)*	*(PSI)*	*(PSI)*	*(PSI)*	*(PSI)*	*(PSI)*	*(m/s)*	*(m/s)*	*(m/s)*	*(m/s)*	*(m/s)*				
JGW-3	Sep 23 2014	16:20	17:45	1:25	64.3	75.0	10.7	33.70	48.96	68.98	53.86	41.18	30	50	80	50	30	8.40E-07	8.49E-07	8.21E-07	9.34E-07	1.03E-06	8.91E-07		JGW-3 intercepts RC, LMH and LRC Units	Low hydraulic conductivity values are observed from 111 to 140 meters in depth in the LRC unit near the LMH Contact
JGW-3	Sep 24 2014	8:00	10:00	2:00	74.8	99.0	24.2	77.76	123.84	162.43	132.48	93.60	50	100	150	100	50	5.98E-07	5.42E-07	4.97E-07	5.80E-07	7.21E-07	5.83E-07			
JGW-3	Sep 24 2014	16:10	18:00	1:50	112.1	120.0	8.0	10.94	20.16	74.88	#N/A	#N/A	60	110	190			2.30E-07	2.57E-07	5.87E-07	#N/A	#N/A	3.26E-07			
JGW-3	Sep 25 2014	3:30	5:10	1:40	130.3	141.0	10.7	8.06	11.52	14.40	10.66	6.91	60	120	180	120	60	1.19E-07	9.55E-08	8.30E-08	8.83E-08	1.02E-07	9.67E-08			
JGW-3	Sep 25 2014	11:30	12:40	1:10	142.3	148.5	6.2	10.28	23.04	35.14	24.77	14.31	50	100	150	100	50	3.04E-07	3.88E-07	4.14E-07	4.17E-07	4.23E-07	3.86E-07			
JGW-3	Sep 26 2014	7:10	8:15	1:05	157.8	171.0	13.2	8.27	11.35	19.58	13.65	8.84	50	100	150	100	50	1.13E-07	8.93E-08	1.08E-07	1.07E-07	1.21E-07	1.07E-07			
JGW-1	Sep 28 2014	15:00	17:30	2:30	37.3	48.0	10.7	114.62	157.31	174.04	140.03	85.82	30	50	65	50	30	2.71E-06	2.65E-06	2.41E-06	2.35E-06	2.01E-06	2.41E-06		JGW-1 intercepts RC, LMH and LRC Units	Low hydraulic conductivity values are observed from 112.1 to 170 meters in depth in the LRC Unit near the LMH Contact
JGW-1	Sep 29 2014	4:00	6:00	2:00	60.0	72.0	12.0	116.35	168.19	205.34	168.19	116.35	30	60	90	60	30	2.45E-06	2.21E-06	1.95E-06	2.21E-06	2.45E-06	2.25E-06			
JGW-1	Sep 29 2014	15:00	17:30	2:30	88.3	96.0	7.7	80.06	128.51	194.26	145.79	108.86	25	45	65	45	25	2.84E-06	3.17E-06	3.70E-06	3.61E-06	3.89E-06	3.42E-06			
JGW-1	Sep 30 2014	4:00	6:00	2:00	111.0	120.0	9.0	4.03	6.62	9.50	5.47	5.18	40	80	120	80	40	9.09E-08	8.96E-08	9.17E-08	7.40E-08	1.17E-07	9.16E-08			
JGW-1	Sep 30 2014	9:00	10:30	1:30	131.6	140.0	8.4	7.92	13.82	22.75	14.11	7.20	50	100	150	100	50	1.64E-07	1.67E-07	1.94E-07	1.70E-07	1.49E-07	1.68E-07			
JGW-1	Oct 1 2014	9:00	10:30	1:30	160.3	170.5	10.2	65.66	94.46	138.24	104.54	71.14	30	60	105	60	30	1.58E-06	1.42E-06	1.33E-06	1.57E-06	1.71E-06	1.52E-06			
JGW-2	Oct 3 2014	15:00	18:00	3:00	28.9	36.0	7.1	69.12	116.93	141.41	117.50	75.46	30	60	90	60	30	1.81E-06	2.11E-06	1.95E-06	2.12E-06	1.98E-06	1.99E-06		JGW-2 intercepts LMH, LRC, RS and Wishart Units	Low hydraulic conductivity values are observed in Wishart near RS contact from 121.9 to 141.6 meters in depth
JGW-2	Oct 4 2014	7:15	9:15	2:00	49.9	60.6	10.7	96.19	135.07	154.66	126.43	90.43	40	80	120	80	40	1.46E-06	1.34E-06	1.14E-06	1.25E-06	1.37E-06	1.31E-06			
JGW-2	Oct 5 2014	4:00	6:00	2:00	79.9	90.6	10.7	62.78	80.06	91.58	80.06	62.78	10	20	30	20	10	1.58E-06	1.65E-06	1.60E-06	1.65E-06	1.58E-06	1.61E-06			
JGW-2	Oct 5 2014	16:00	18:00	2:00	100.9	111.6	10.7	90.58	130.90	174.10	136.66	107.86	15	30	50	30	15	2.06E-06	2.30E-06	2.36E-06	2.41E-06	2.46E-06	2.31E-06			
JGW-2	Oct 6 2014	8:30	10:00	1:30	121.9	141.6	19.7	6.19	9.22	21.89	11.81	5.18	40	80	120	80	40	5.06E-08	4.92E-08	8.69E-08	6.31E-08	4.24E-08	5.66E-08			
JGW-2	Oct 6 2014	22:30	0:30	2:00	154.9	164.1	9.2	44.35	86.11	107.71	80.35	55.87	30	60	90	60	30	8.96E-07	1.20E-06	1.14E-06	1.12E-06	1.13E-06	1.09E-06			
JGW-2	Oct 7 2014	22:30	0:30	2:00	159.9	170.6	10.7	45.22	86.40	107.71	80.64	56.74	40	80	120	80	40	6.81E-07	8.53E-07	7.90E-07	7.96E-07	8.56E-07	7.93E-07			
JGW-4	Oct 8 2014	13:00	14:30	1:30	37.6	42.3	4.7	46.94	78.19	93.89	75.89	54.14	30	60	90	60	30	2.14E-06	2.34E-06	2.09E-06	2.27E-06	2.47E-06	2.25E-06		JGW-4 intercepts LMH, LRC, RS and Wishart Units	Low hydraulic conductivity values are observed in Wishart near RS contact from 112.6 to 144.3 meters in depth
JGW-4	Oct 9 2014	13:00	14:30	1:30	52.6	63.3	10.7	45.65	133.49	159.41	75.02	52.85	30	60	90	60	30	9.13E-07	1.76E-06	1.57E-06	9.84E-07	1.06E-06	1.21E-06			
JGW-4	Oct 9 2014	1:00	2:15	1:15	88.6	96.3	7.7	65.66	97.06	116.93	97.06	71.42	20	40	60	40	20	2.22E-06	2.31E-06	2.14E-06	2.31E-06	2.42E-06	2.28E-06			
JGW-4	Oct 10 2014	10:00	11:00	1:00	112.6	123.3	10.7	2.45	2.02	1.73	1.67	1.01	50	100	150	100	50	3.62E-08	1.80E-08	1.11E-08	1.49E-08	1.49E-08	1.74E-08			
JGW-4	Oct 10 2014	22:00	23:30	1:30	133.6	144.3	10.7	34.3	79.8	102.2	88.4	63.1	40	80	120	80	40	5.82E-07	8.50E-07	7.94E-07	9.43E-07	1.07E-06	8.32E-07			
JGW-4	Oct 11 2014	2:30	4:00	1:30	145.6	156.3	10.7	23.04	56.45	88.13	67.97	48.96	40	80	120	80	40	3.91E-07	6.01E-07	6.83E-07	7.24E-07	8.33E-07	6.27E-07			
JGW-4	Oct 11 2014	7:00	9:00	2:00	163.6	171.3	7.7	47.09	77.47	93.31	74.59	47.66	30	60	90	60	30	1.31E-06	1.41E-06	1.26E-06	1.36E-06	1.32E-06	1.33E-06			

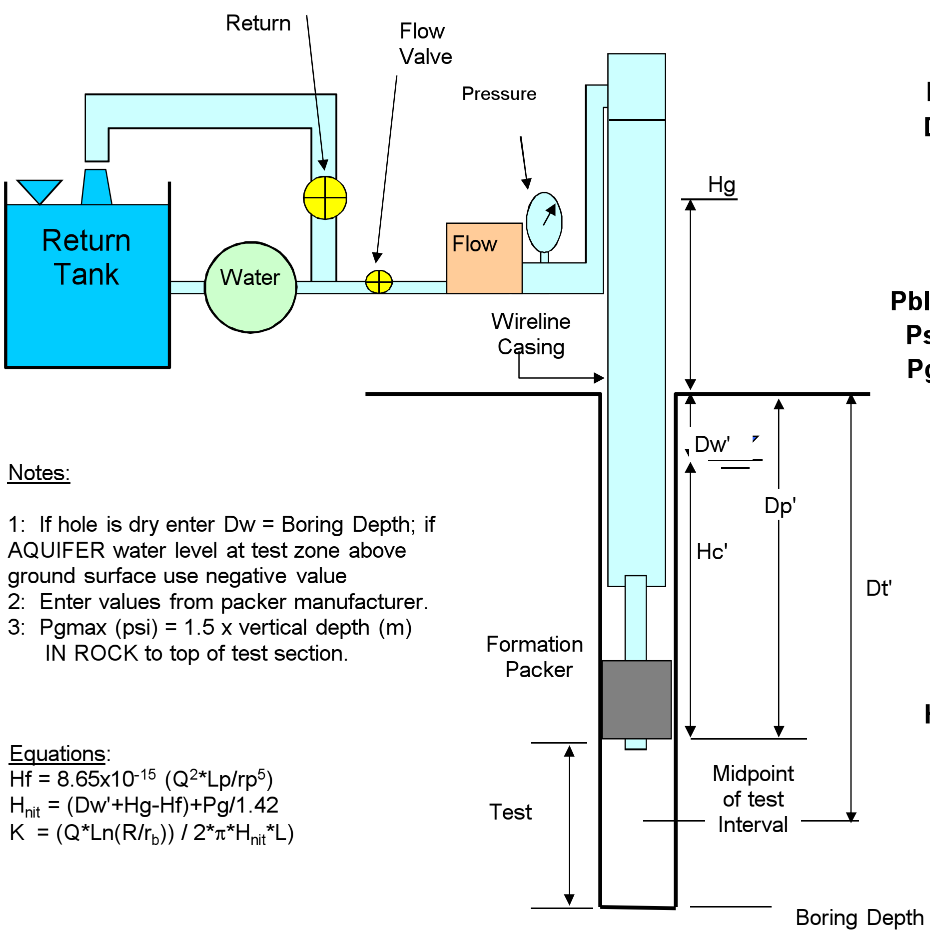
PACKER INJECTION TEST

WESA — a BluMetric company

Project:	S-B12738	**Test Interval (m):**	37.3	**to**	48.0	**Drillhole N°**	JGW-1
UTM (x,y)	658427, 6086430	**Start Date:**	Sep 29 2014	**Time:**	15:00	**Test hole N°**	N/A
Datum:		**End Date:**	Sep 29 2014	**Time:**	17:30	**Test N°**	1
GS Elevation:		**Supervisor:**	VM/DP	**Rig:**	LF-70	**DH Depth (m)**	48.0

Max Injection P (psi)

56



Dw	Measured depth of static water level (1)	11.2	
Dbr	Measured depth to bedrock	0.6	m
Dp	Measured depth to packer	**37.3**	m
Dt	Measured depth to midpoint of test	**42.7**	m
ß	Inclination from horizontal (degrees)	90	°
Dw'	Vertical depth to static water level	**11.2**	m
Dbr'	Vertical dept to bedrock	**0.6**	m
Dp'	Vertical depth to packer	**37.3**	m
Dt'	Vertical depth to midpoint of test	**42.7**	m
SP	Shear Pin Rating (psi)	500	psi
Pblowout	Water column pressure in drill rods at plug	**53**	psi
Pshear	Estimated differential shear pressure required	**500**	psi
Pgmax	Maximum injection gauge pressure (3)	**63**	psi
Hg	Gauge height	2.0	m
Dp'	Length of discharge pipe	1.50	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0127	m
R	Radius of influence (10 m is standard value)	5	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.048	m
L	Length of test section	**10.7**	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		

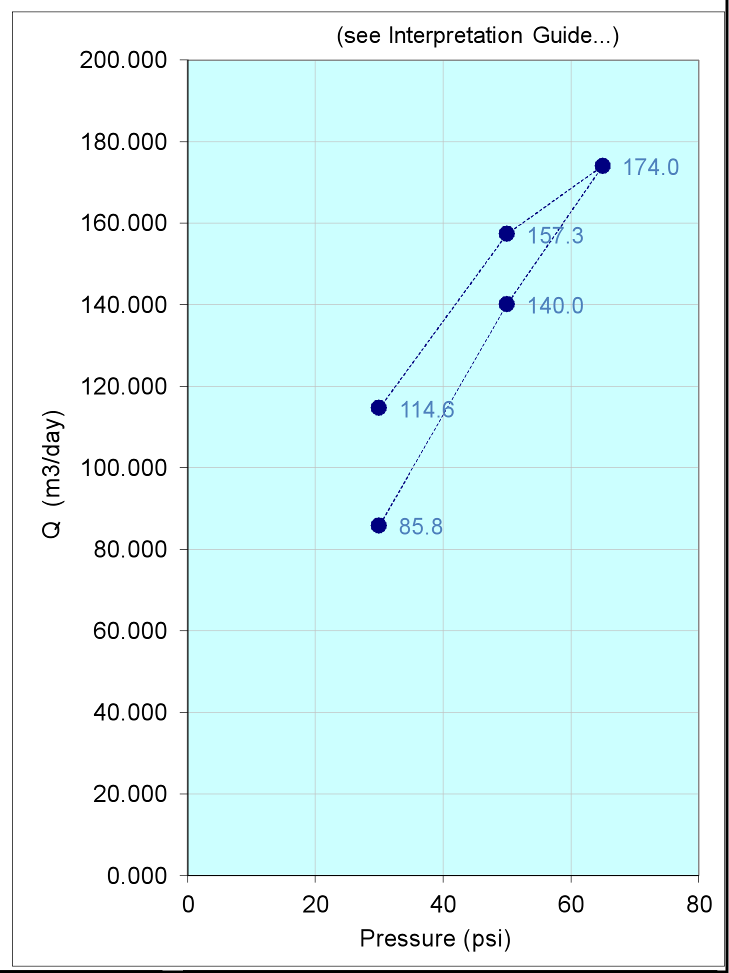
Notes:

1: If hole is dry enter Dw = Boring Depth; if AQUIFER water level at test zone above ground surface use negative value
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m) IN ROCK to top of test section.

Equations:
$Hf = 8.65x10^{-15}\ (Q^2*Lp/rp^5)$
$H_{nit} = (Dw'+Hg-Hf)+Pg/1.42$
$K = (Q*Ln(R/r_b))\ /\ 2*\pi*H_{nit}*L)$

Conversion Factors:
10 m of water = 0.9807 bar = 1kg/cm^2 = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bar, which is approx. 1.4 x 10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement (show last 3 to 5 flow meter readings)	Q (Liters / 30sec)				
	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
	30	50	65	50	30
1	41.00	55.00	62.00	50.00	30.00
2	41.00	55.00	61.00	49.00	30.00
3	39.00	56.00	59.00	49.00	29.00
4	39.00	55.00	60.00	48.00	30.00
5					
Stable Q (L/30sec)	40.00	55.00	61.00	49.00	30.00
Leak Q (L/30sec)	0.20	0.38	0.57	0.38	0.20
Q (m^3/day)	114.6	157.3	174.0	140.0	85.8
Hf (m)	0.52	0.97	1.19	0.77	0.29
Hnit (m)	33.8	47.5	57.8	47.7	34.1
K (m/day)	2.3E-01	2.3E-01	2.1E-01	2.0E-01	1.7E-01
K (m/s)	**2.7E-06**	**2.7E-06**	**2.4E-06**	**2.3E-06**	**2.0E-06**
+/- (m/s)	-3.5E-07	-1.5E-07	0.0E+00	1.5E-07	3.5E-07
+/- order of mag.	-0.06	-0.03	0.00	0.03	0.07



WESA a BluMetric company	PACKER INJECTION TEST (page 2)	Drillhole Nº	JGW-1
		Test hole Nº	N/A
		Test Nº	1

Pressure oscillation during test

Pressure step	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
Min P during step	30	50	65	50	30
Max P during step	30	50	65	50	30
average pressure +/- psi					

Flowmeter measurement reading accuracy

volume +/- Liters / 30 sec					

High estimate of K

Q_{avg} (m^3/day)	114.62	157.31	174.04	140.03	85.82
Hf (m)	0.52	0.97	1.19	0.77	0.29
Hnit (m)	33.8	47.5	57.8	47.7	34.1
K (m/sec)	2.7E-06	2.7E-06	2.4E-06	2.3E-06	2.0E-06

Low estimate of K

Q_{avg} (m^3/day)	114.62	157.31	174.04	140.03	85.82
Hf (m)	0.52	0.97	1.19	0.77	0.29
Hnit (m)	33.8	47.5	57.8	47.7	34.1
K (m/sec)	2.7E-06	2.7E-06	2.4E-06	2.3E-06	2.0E-06

K averages for P step (m/second)

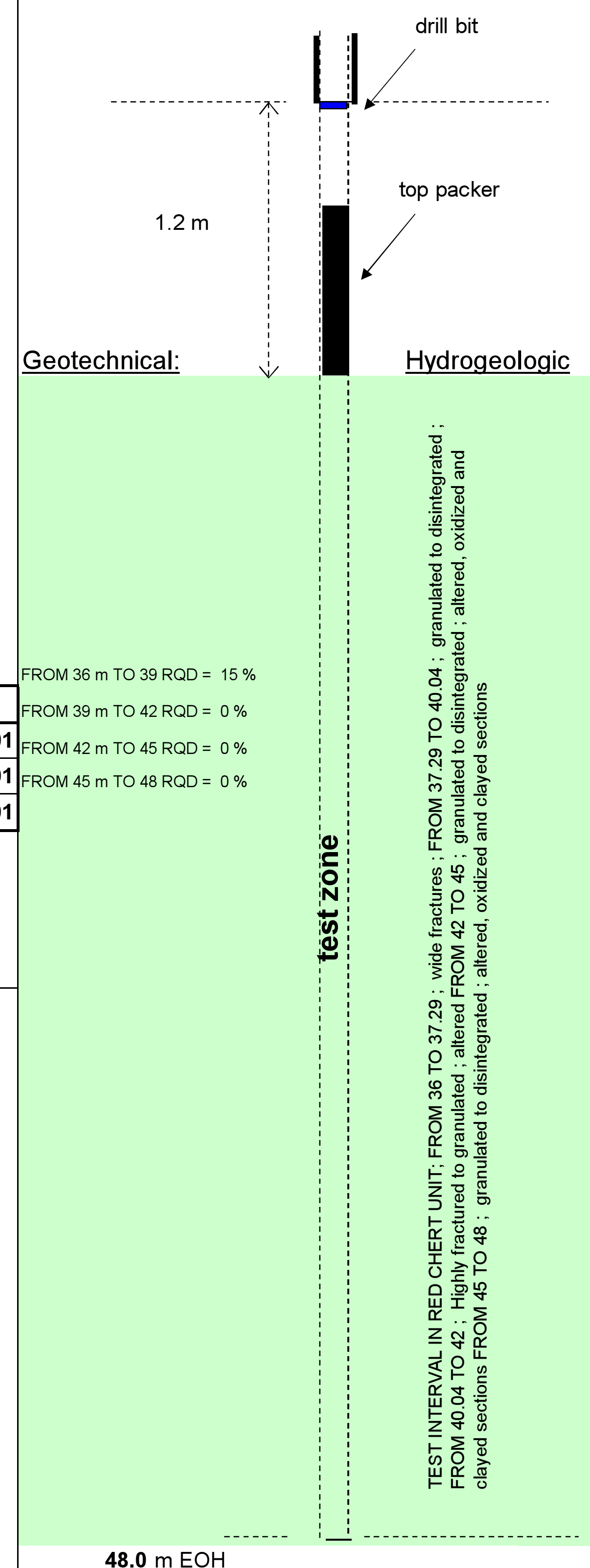
P	30	50	65
high est of K	2.E-06	2.E-06	2.E-06
average K	2.E-06	2.E-06	2.E-06
low est of K	2.E-06	2.E-06	2.E-06

K avg all P steps

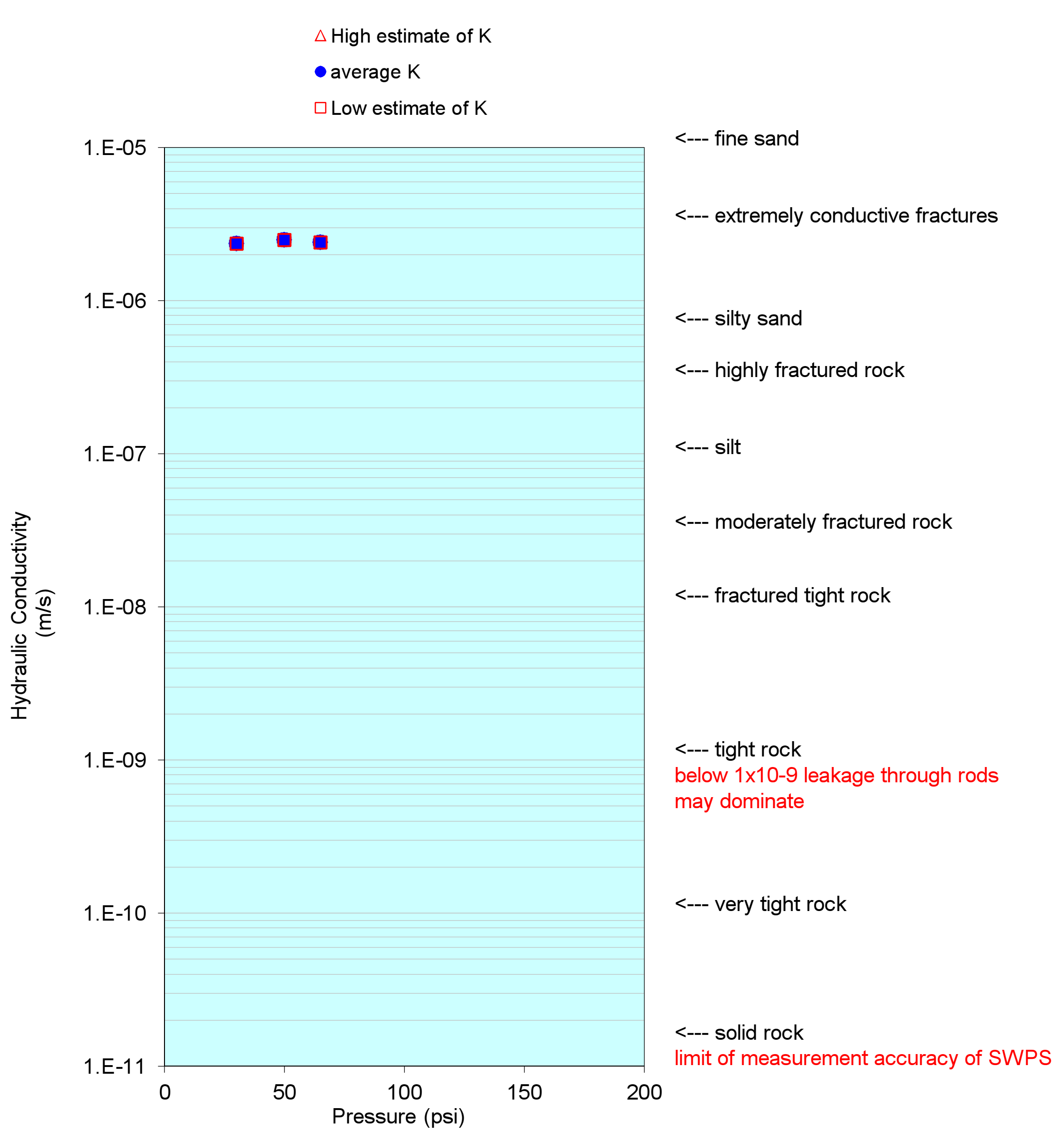
	m/sec	m/day
MAX	2.E-06	2.2E-01
geomean	2.E-06	2.1E-01
MIN	2.E-06	2.0E-01

Comments:

Drawing of zone tested, including geotech / hydrogeo. conditions:



Graph of estimated hydraulic conductivity and error bounds.



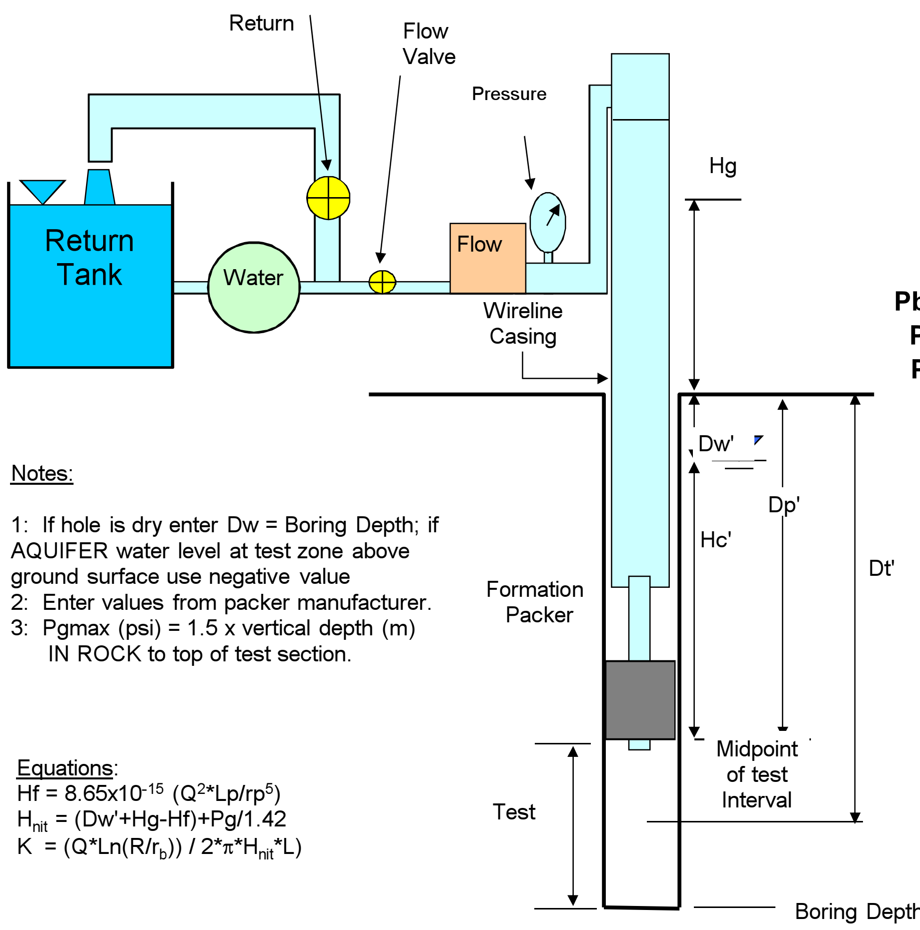
PACKER INJECTION TEST

WESA — a BluMetric company

Project:	S-B12738	**Test Interval (m):**	60.0	**to**	72.0	**Drillhole N°**	JGW-1
UTM (x,y)	658427, 6086430	**Start Date:**	Sep 29 2014	**Time:**	4:00	**Test hole N°**	N/A
Datum:		**End Date:**	Sep 29 2014	**Time:**	6:00	**Test N°**	2
GS Elevation:		**Supervisor:**	VM/DP	**Rig:**	LF-70	**DH Depth (m)**	72.0

Max Injection P (psi)

90



Dw	Measured depth of static water level (1)	11.2	
Dbr	Measured depth to bedrock	0.6	m
Dp	Measured depth to packer	**60.0**	m
Dt	Measured depth to midpoint of test	**66.0**	m
ß	Inclination from horizontal (degrees)	90	°
Dw'	Vertical depth to static water level	**11.2**	m
Dbr'	Vertical dept to bedrock	**0.6**	m
Dp'	Vertical depth to packer	**60.0**	m
Dt'	Vertical depth to midpoint of test	**66.0**	m
SP	Shear Pin Rating (psi)	500	psi
Pblowout	Water column pressure in drill rods at plug	**85**	psi
Pshear	Estimated differential shear pressure required	**500**	psi
Pgmax	Maximum injection gauge pressure (3)	**98**	psi
Hg	Gauge height	2.0	m
Dp'	Length of discharge pipe	1.50	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0127	m
R	Radius of influence (10 m is standard value)	5	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.048	m
L	Length of test section	**12.0**	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		

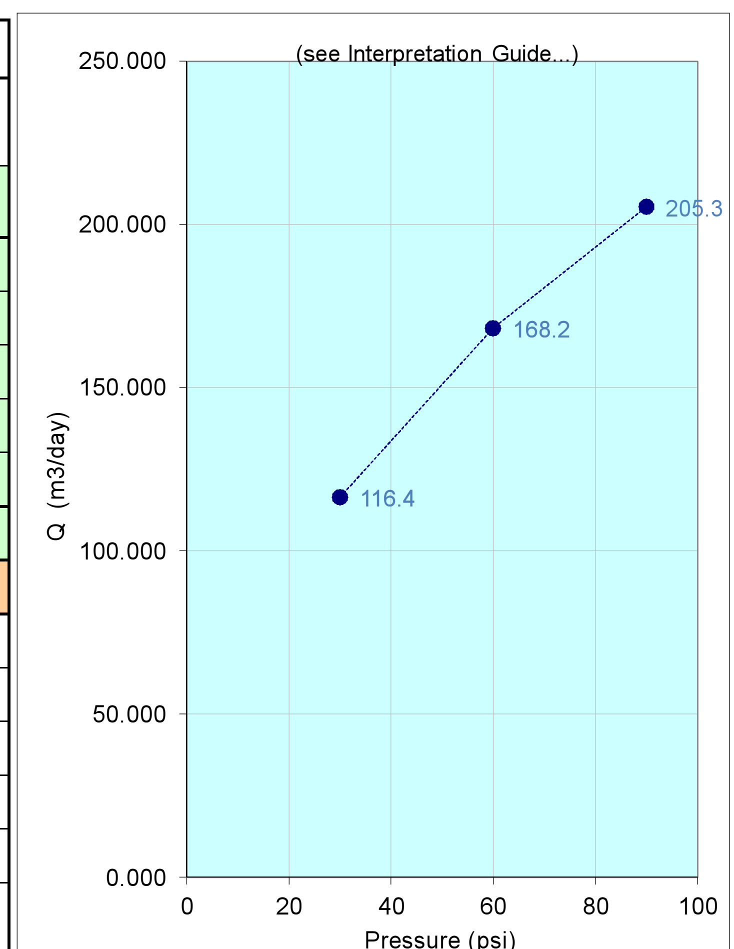
Notes:

1: If hole is dry enter Dw = Boring Depth; if AQUIFER water level at test zone above ground surface use negative value
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m) IN ROCK to top of test section.

Equations:
$Hf = 8.65\times10^{-15}\ (Q^2 * Lp/rp^5)$
$H_{nit} = (Dw'+Hg-Hf)+Pg/1.42$
$K = (Q*Ln(R/r_b))\ /\ 2*\pi*H_{nit}*L)$

Conversion Factors:
10 m of water = 0.9807 bar = 1kg/cm^2 = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bar, which is approx. 1.4×10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement (show last 3 to 5 flow meter readings)	Q (Liters / 30sec)				
	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
	30	60	90	60	30
1	42.00	59.00	72.00	60.00	42.00
2	40.00	59.00	72.00	59.00	41.00
3	41.00	59.00	72.00	58.00	41.00
4	40.00	59.00	73.00		41.00
5	41.00	60.00	71.00		40.00
Stable Q (L/30sec)	41.00	59.00	72.00	59.00	41.00
Leak Q (L/30sec)	0.60	0.60	0.70	0.60	0.60
Q (m^3/day)	116.4	168.2	205.3	168.2	116.4
Hf (m)	0.53	1.11	1.66	1.11	0.53
Hnit (m)	33.8	54.4	75.0	54.4	33.8
K (m/day)	2.1E-01	1.9E-01	1.7E-01	1.9E-01	2.1E-01
K (m/s)	**2.5E-06**	**2.2E-06**	**2.0E-06**	**2.2E-06**	**2.5E-06**
+/- (m/s)	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
+/- order of mag.	0.00	0.00	0.00	0.00	0.00



WESA a BluMetric company	PACKER INJECTION TEST (page 2)	Drillhole Nº	JGW-1
		Test hole Nº	N/A
		Test Nº	2

Pressure oscillation during test

Pressure step	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
Min P during step	30	60	90	60	30
Max P during step	30	60	90	60	30
average pressure +/- psi					

Flowmeter measurement reading accuracy

volume +/- Liters / 30 sec					

High estimate of K

Q_{avg} (m^3/day)	116.35	168.19	205.34	168.19	116.35
Hf (m)	0.53	1.11	1.66	1.11	0.53
Hnit (m)	33.8	54.4	75.0	54.4	33.8
K (m/sec)	2.5E-06	2.2E-06	2.0E-06	2.2E-06	2.5E-06

Low estimate of K

Q_{avg} (m^3/day)	116.35	168.19	205.34	168.19	116.35
Hf (m)	0.53	1.11	1.66	1.11	0.53
Hnit (m)	33.8	54.4	75.0	54.4	33.8
K (m/sec)	2.5E-06	2.2E-06	2.0E-06	2.2E-06	2.5E-06

K averages for P step — m/second

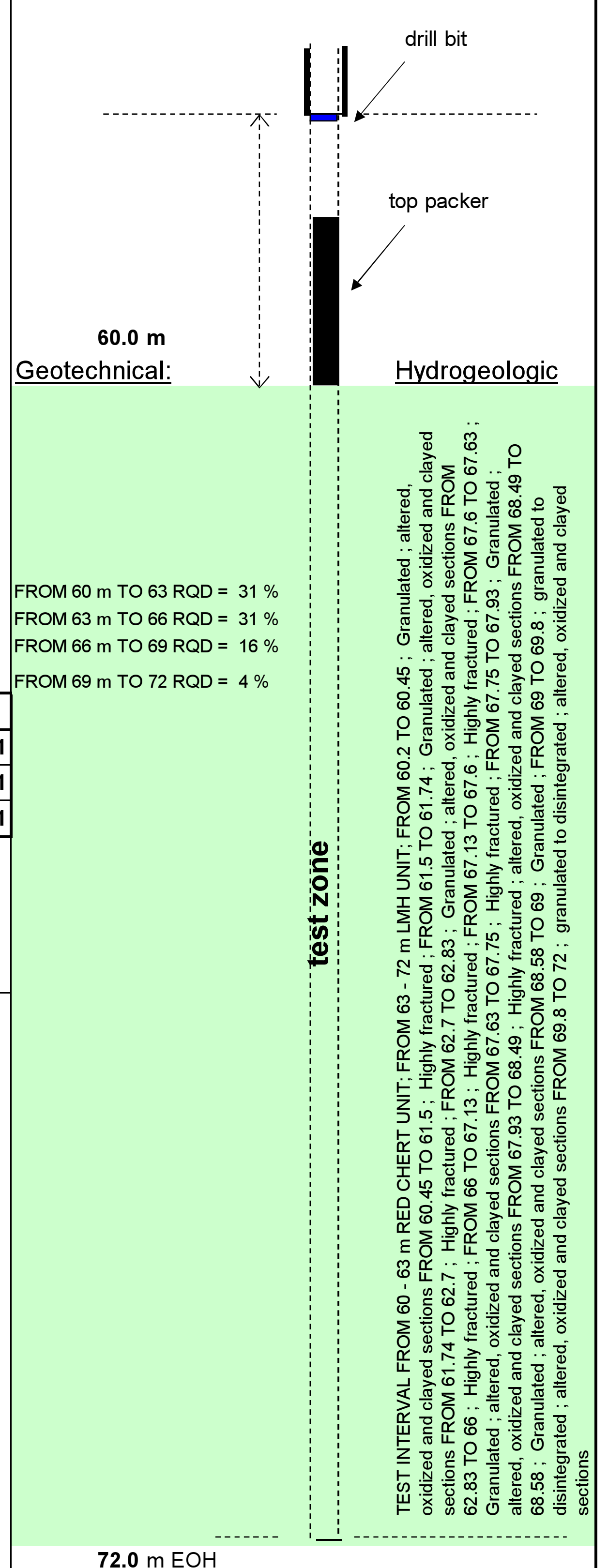
P	30	60	90
high est of K	2.E-06	2.E-06	2.E-06
average K	2.E-06	2.E-06	2.E-06
low est of K	2.E-06	2.E-06	2.E-06

K avg all P steps

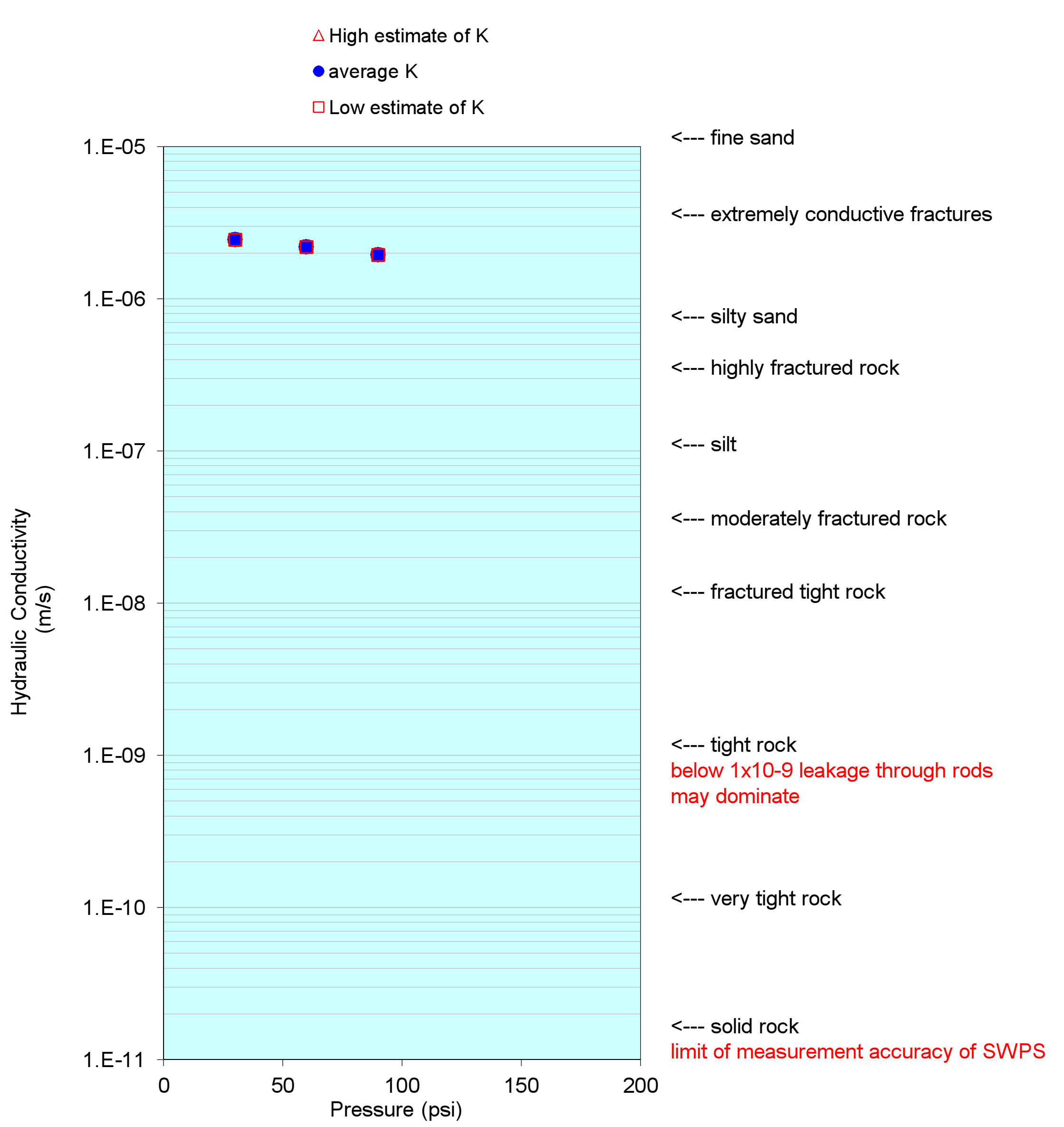
	m/sec	m/day
MAX	2.E-06	2.1E-01
geomean	2.E-06	1.9E-01
MIN	2.E-06	1.7E-01

Comments:

Drawing of zone tested, including geotech / hydrogeo. conditions:



Graph of estimated hydraulic conductivity and error bounds.



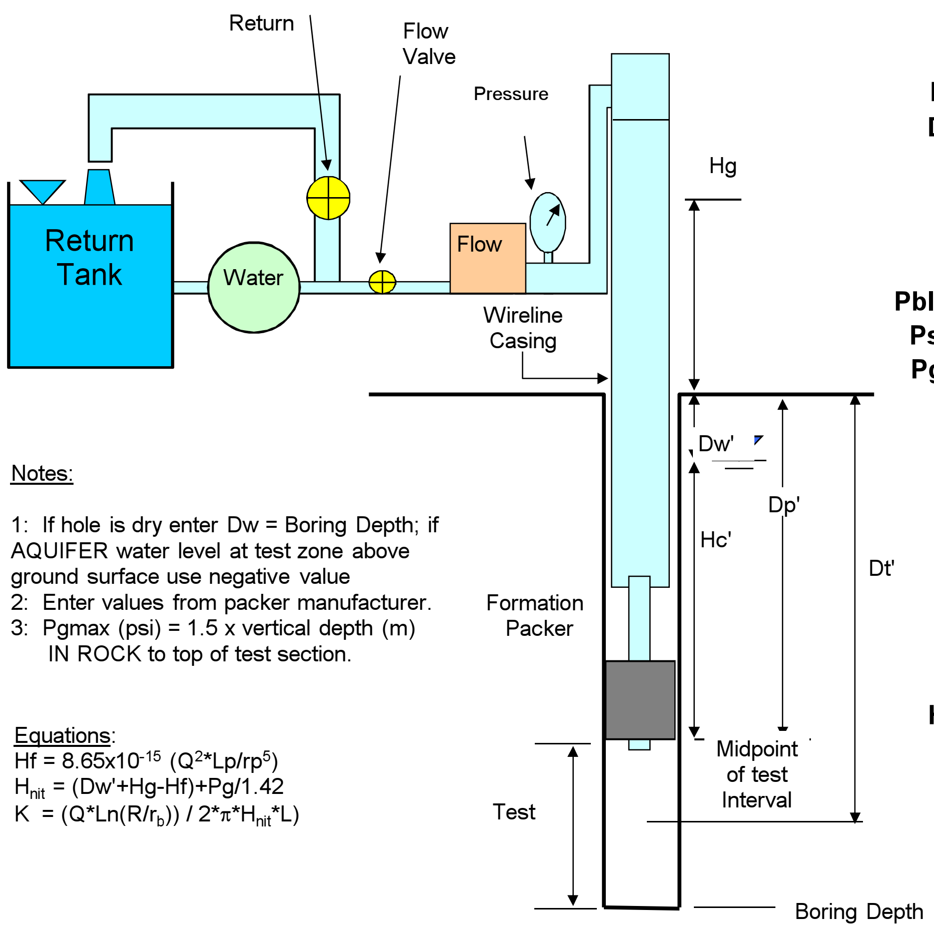
WESA
a BluMetric company

PACKER INJECTION TEST

Project:	S-B12738	**Test Interval (m):**	88.3	**to**	96.0	**Drillhole N°**	JGW-1
UTM (x,y)	658427, 6086430	**Start Date:**	Sep 29 2014	**Time:**	15:00	**Test hole N°**	N/A
Datum:		**End Date:**	Sep 29 2014	**Time:**	17:30	**Test N°**	3
GS Elevation:		**Supervisor:**	VM/DP	**Rig:**	LF-70	**DH Depth (m)**	96.0

Max Injection P (psi)

132



<u>Notes</u>:

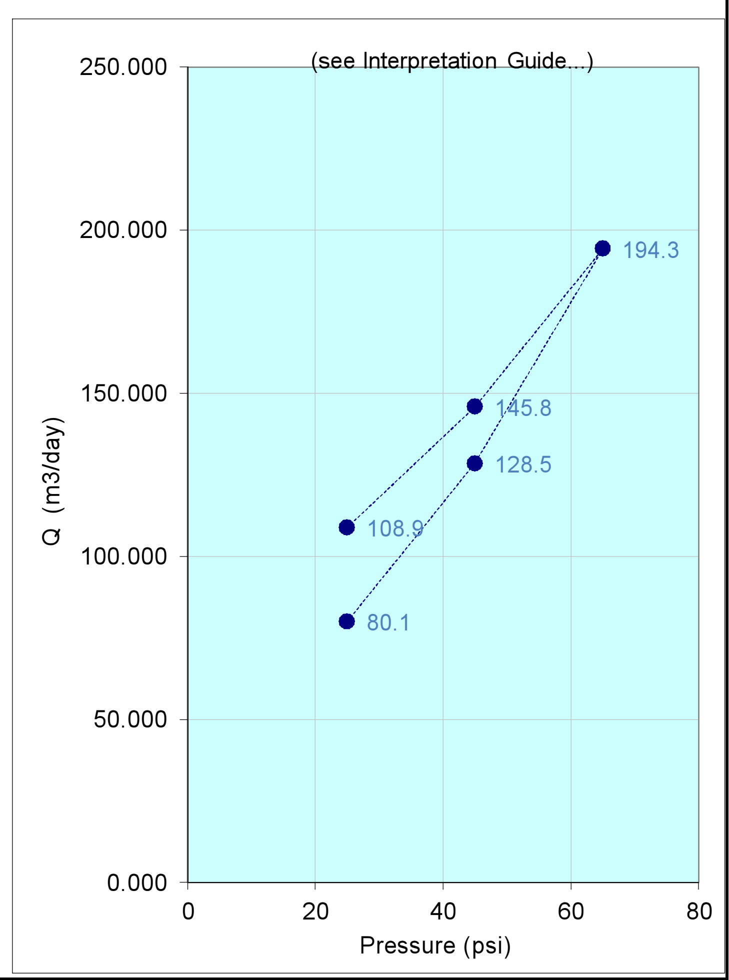
1: If hole is dry enter Dw = Boring Depth; if AQUIFER water level at test zone above ground surface use negative value
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m) IN ROCK to top of test section.

<u>Equations</u>:
$Hf = 8.65\times10^{-15}\ (Q^2 * Lp/rp^5)$
$H_{nit} = (Dw' + Hg - Hf) + Pg/1.42$
$K = (Q * Ln(R/r_b)) / 2 * \pi * H_{nit} * L)$

Dw	Measured depth of static water level (1)	12.0	
Dbr	Measured depth to bedrock	0.6	m
Dp	Measured depth to packer	88.3	m
Dt	Measured depth to midpoint of test	92.2	m
ß	Inclination from horizontal (degrees)	90	°
Dw'	Vertical depth to static water level	12.0	m
Dbr'	Vertical dept to bedrock	0.6	m
Dp'	Vertical depth to packer	88.3	m
Dt'	Vertical depth to midpoint of test	92.2	m
SP	Shear Pin Rating (psi)	500	psi
Pblowout	Water column pressure in drill rods at plug	125	psi
Pshear	Estimated differential shear pressure required	500	psi
Pgmax	Maximum injection gauge pressure (3)	137	psi
Hg	Gauge height	2.0	m
Dp'	Length of discharge pipe	1.50	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0127	m
R	Radius of influence (10 m is standard value)	5	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.048	m
L	Length of test section	7.7	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		

<u>Conversion Factors</u>:
10 m of water = 0.9807 bar = 1kg/cm^2 = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bar, which is approx. 1.4 x 10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement (show last 3 to 5 flow meter readings)	**Q (Liters / 30sec)**				
	P_g (psi) Step 1	**P_g (psi) Step 2**	**P_g (psi) Step 3**	**P_g (psi) Step 4**	**P_g (psi) Step 5**
	25	**45**	**65**	**45**	**25**
1	28.00	45.00	67.00	51.00	38.00
2	28.00	47.00	67.00	51.00	34.00
3	27.00	45.00	68.00	51.00	39.00
4	29.00	44.00	70.00		38.00
5	28.00	43.00			
Stable Q (L/30sec)	28.00	45.00	68.00	51.00	38.00
Leak Q (L/30sec)	0.20	0.38	0.55	0.38	0.20
Q (m^3/day)	80.1	128.5	194.3	145.8	108.9
Hf (m)	0.25	0.65	1.48	0.83	0.47
Hnit (m)	31.4	45.0	58.3	44.9	31.1
K (m/day)	2.5E-01	2.7E-01	3.2E-01	3.1E-01	3.4E-01
K (m/s)	**2.8E-06**	**3.2E-06**	**3.7E-06**	**3.6E-06**	**3.9E-06**
+/- (m/s)	5.2E-07	2.2E-07	0.0E+00	-2.2E-07	-5.2E-07
+/- order of mag.	0.07	0.03	0.00	-0.03	-0.06



WESA a BluMetric company	PACKER INJECTION TEST (page 2)	Drillhole Nº	JGW-1
		Test hole Nº	N/A
		Test Nº	3

Pressure oscillation during test

Pressure step	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
Min P during step	25	45	65	45	25
Max P during step	25	45	65	45	25
average pressure +/- psi					

Flowmeter measurement reading accuracy

volume +/- Liters / 30 sec					

High estimate of K

Q_{avg} (m^3/day)	80.06	128.51	194.26	145.79	108.86
Hf (m)	0.25	0.65	1.48	0.83	0.47
Hnit (m)	31.4	45.0	58.3	44.9	31.1
K (m/sec)	2.8E-06	3.2E-06	3.7E-06	3.6E-06	3.9E-06

Low estimate of K

Q_{avg} (m^3/day)	80.06	128.51	194.26	145.79	108.86
Hf (m)	0.25	0.65	1.48	0.83	0.47
Hnit (m)	31.4	45.0	58.3	44.9	31.1
K (m/sec)	2.8E-06	3.2E-06	3.7E-06	3.6E-06	3.9E-06

K averages for P step — m/second

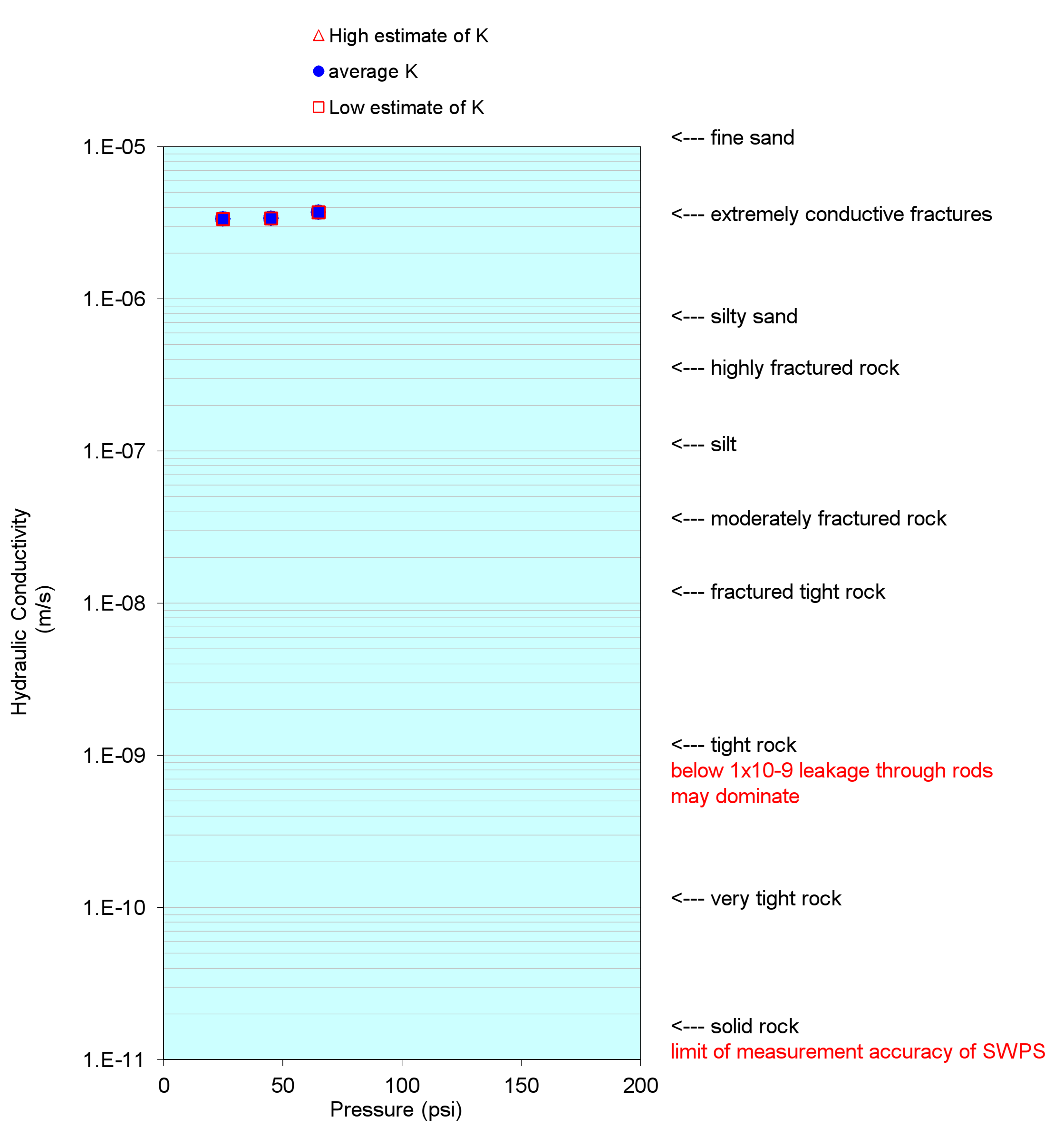
P	25	45	65
high est of K	3.E-06	3.E-06	4.E-06
average K	3.E-06	3.E-06	4.E-06
low est of K	3.E-06	3.E-06	4.E-06

K avg all P steps

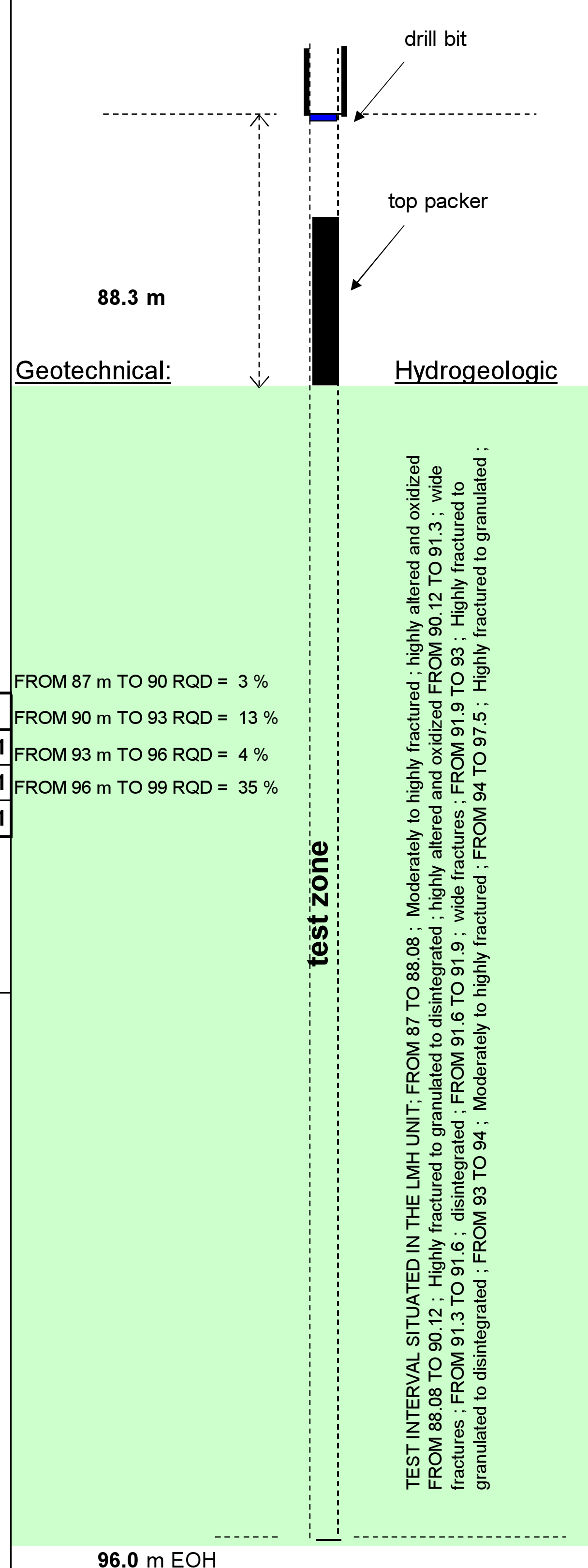
	m/sec	m/day
MAX	4.E-06	3.2E-01
geomean	3.E-06	3.0E-01
MIN	3.E-06	2.9E-01

Comments:

Graph of estimated hydraulic conductivity and error bounds.



Drawing of zone tested, including geotech / hydrogeo. conditions:



PACKER INJECTION TEST

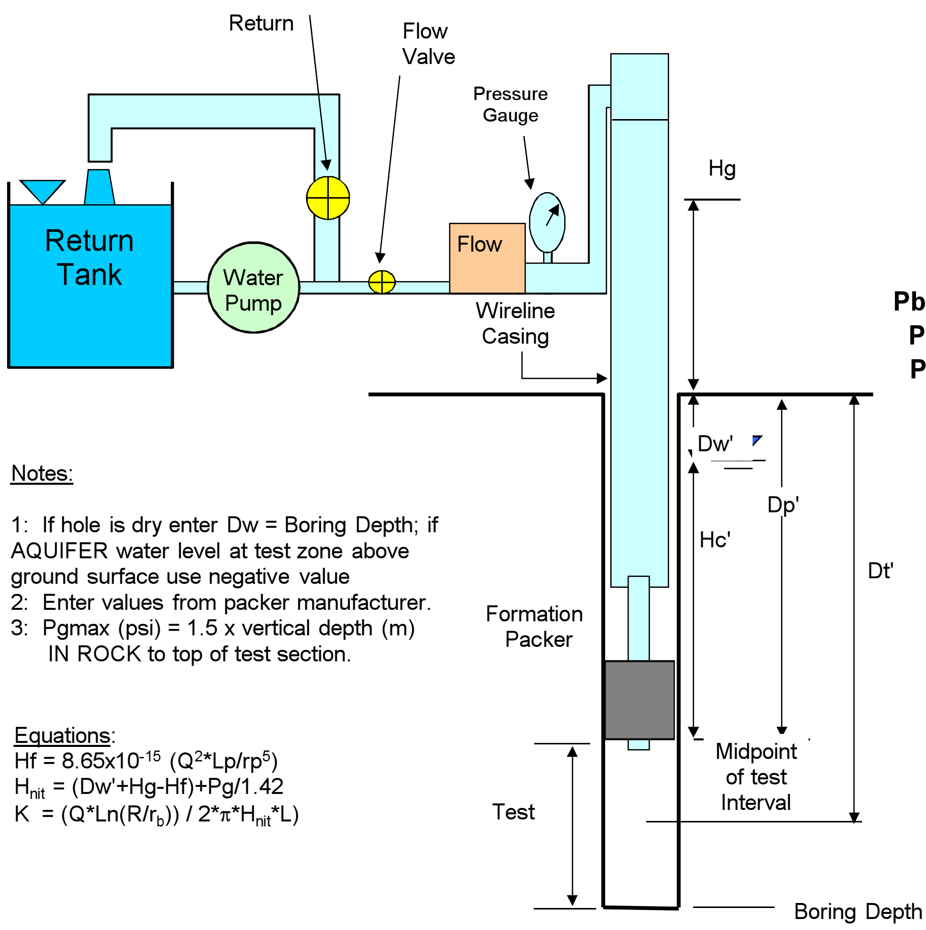
WESA a BluMetric company

Project:	S-B12738	**Test Interval (m):**	111.0	**to**	120.0	**Drillhole N°**	JGW-1
UTM (x,y)	658427, 6086430	**Start Date:**	Sep 29 2014	**Time:**	4:00	**Test hole N°**	N/A
Datum:		**End Date:**	Sep 29 2014	**Time:**	6:00	**Test N°**	4
GS Elevation:		**Supervisor:**	VM/DP	**Rig:**	LF-70	**DH Depth (m)**	120.0

Max Injection P (psi)

167

Symbol	Description	Value	Unit
Dw	Measured depth of static water level (1)	12.0	
Dbr	Measured depth to bedrock	0.6	m
Dp	Measured depth to packer	111.0	m
Dt	Measured depth to midpoint of test	115.5	m
ß	Inclination from horizontal (degrees)	90	°
Dw'	Vertical depth to static water level	12.0	m
Dbr'	Vertical dept to bedrock	0.6	m
Dp'	Vertical depth to packer	111.0	m
Dt'	Vertical depth to midpoint of test	115.5	m
SP	Shear Pin Rating (psi)	500	psi
Pblowout	Water column pressure in drill rods at plug	158	psi
Pshear	Estimated differential shear pressure required	500	psi
Pgmax	Maximum injection gauge pressure (3)	172	psi
Hg	Gauge height	2.0	m
Dp'	Length of discharge pipe	1.50	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0127	m
R	Radius of influence (10 m is standard value)	5	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.048	m
L	Length of test section	9.0	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		



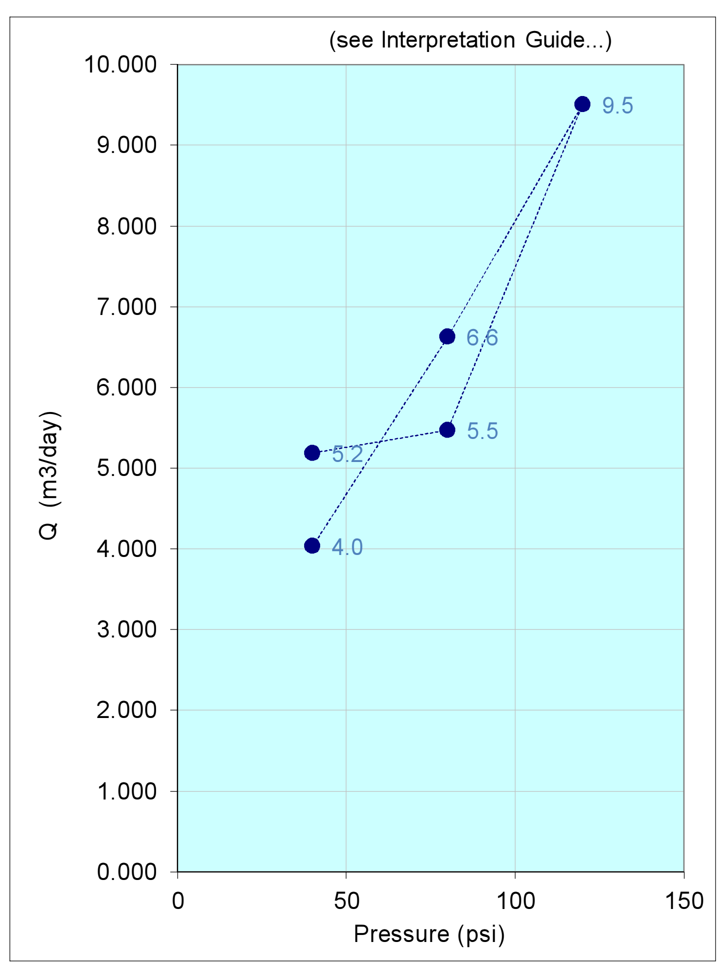
Notes:

1: If hole is dry enter Dw = Boring Depth; if AQUIFER water level at test zone above ground surface use negative value
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m) IN ROCK to top of test section.

Equations:
$Hf = 8.65 \times 10^{-15} (Q^2 * Lp/rp^5)$
$H_{nit} = (Dw' + Hg - Hf) + Pg/1.42$
$K = (Q * Ln(R/r_b)) / 2 * \pi * H_{nit} * L$

Conversion Factors:
10 m of water = 0.9807 bar = 1kg/cm^2 = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bar, which is approx. 1.4 x 10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement (show last 3 to 5 flow meter readings)	Q (Liters / 30sec)				
	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
	40	80	120	80	40
1	4.00	6.30	8.50	5.80	4.50
2	4.00	6.20	8.20	5.80	4.30
3	3.80	5.60	8.30	5.70	4.30
4	3.80	6.60	8.00	5.70	4.30
5	3.70	6.10	8.20	5.70	4.30
Stable Q (L/30sec)	3.90	6.10	8.20	5.70	4.30
Leak Q (L/30sec)	2.50	3.80	4.90	3.80	2.50
Q (m^3/day)	4.0	6.6	9.5	5.5	5.2
Hf (m)	0.00	0.00	0.00	0.00	0.00
Hnit (m)	42.2	70.3	98.5	70.3	42.2
K (m/day)	7.9E-03	7.7E-03	7.9E-03	6.4E-03	1.0E-02
K (m/s)	**9.1E-08**	**9.0E-08**	**9.2E-08**	**7.4E-08**	**1.2E-07**
+/- (m/s)	1.3E-08	-7.8E-09	0.0E+00	7.8E-09	-1.3E-08
+/- order of mag.	0.06	-0.04	0.00	0.04	-0.05



WESA a BluMetric company	PACKER INJECTION TEST (page 2)	Drillhole Nº	JGW-1
		Test hole Nº	N/A
		Test Nº	4

Pressure oscillation during test

Pressure step	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
Min P during step	40	80	120	80	40
Max P during step	40	80	120	80	40
average pressure +/- psi					

Flowmeter measurement reading accuracy

volume +/- Liters / 30 sec					

High estimate of K

Q_{avg} (m^3/day)	4.03	6.62	9.50	5.47	5.18
Hf (m)	0.00	0.00	0.00	0.00	0.00
Hnit (m)	42.2	70.3	98.5	70.3	42.2
K (m/sec)	9.1E-08	9.0E-08	9.2E-08	7.4E-08	1.2E-07

Low estimate of K

Q_{avg} (m^3/day)	4.03	6.62	9.50	5.47	5.18
Hf (m)	0.00	0.00	0.00	0.00	0.00
Hnit (m)	42.2	70.3	98.5	70.3	42.2
K (m/sec)	9.1E-08	9.0E-08	9.2E-08	7.4E-08	1.2E-07

K averages for P step (m/second)

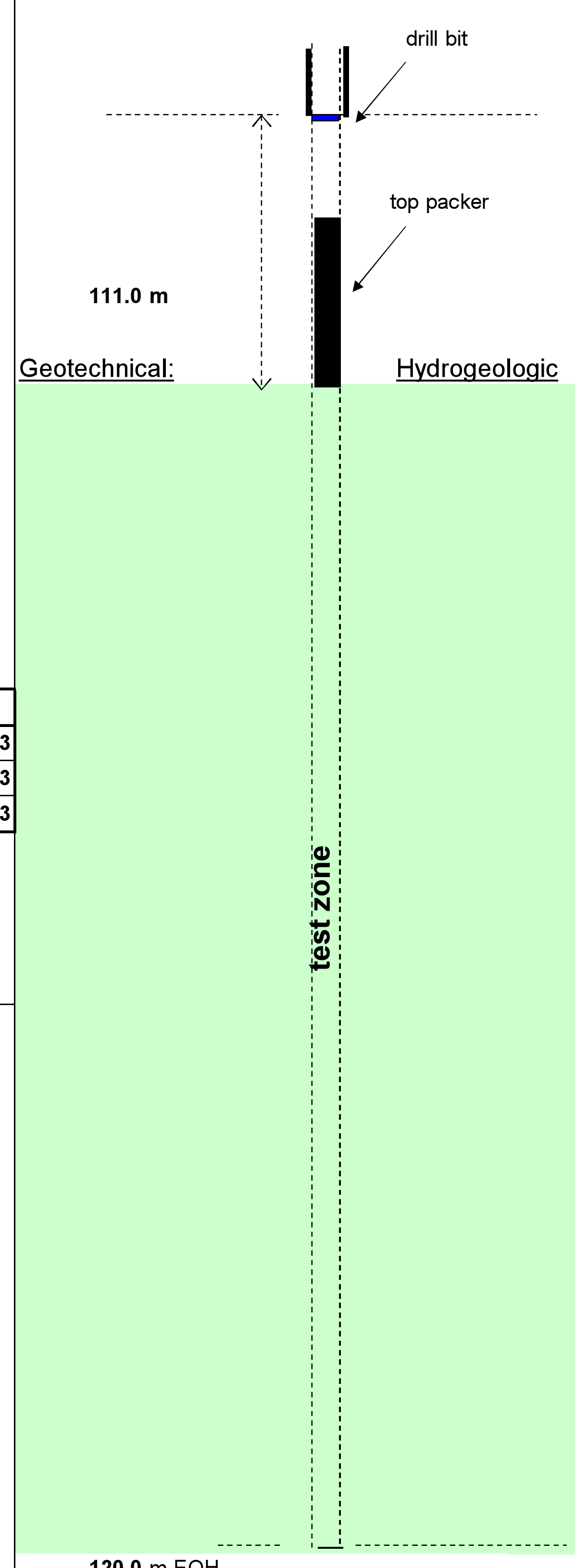
P	40	80	120
high est of K	1.E-07	8.E-08	9.E-08
average K	1.E-07	8.E-08	9.E-08
low est of K	1.E-07	8.E-08	9.E-08

K avg all P steps

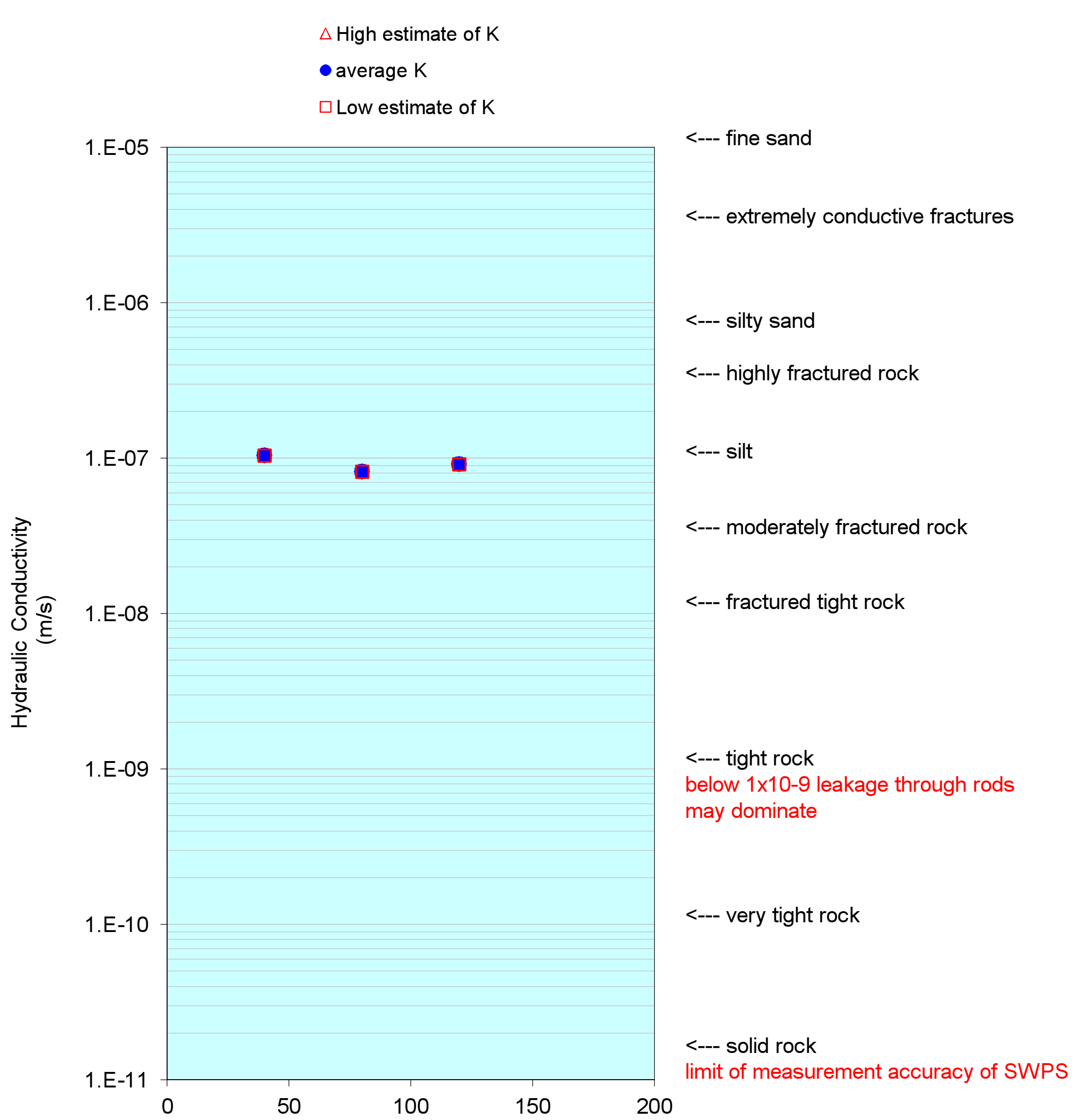
	m/sec	m/day
MAX	1.E-07	9.0E-03
geomean	9.E-08	8.0E-03
MIN	8.E-08	7.1E-03

Comments:

Drawing of zone tested, including geotech / hydrogeo. conditions:



Graph of estimated hydraulic conductivity and error bounds.



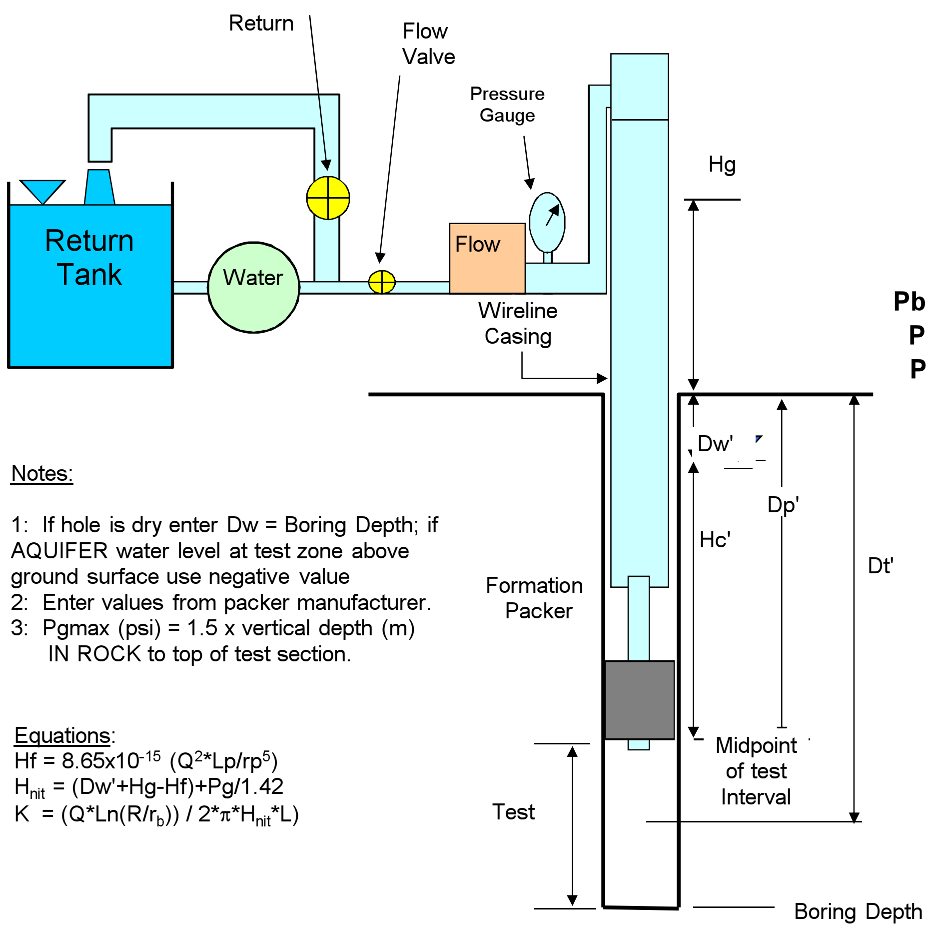
PACKER INJECTION TEST

WESA — a BluMetric company

Project:	S-B12738	**Test Interval (m):**	131.6	**to**	140.0	**Drillhole N°**	JGW-1
UTM (x,y)	658427, 6086430	**Start Date:**	Sep 30 2014	**Time:**	9:00	**Test hole N°**	N/A
Datum:		**End Date:**	Sep 30 2014	**Time:**	10:30	**Test N°**	5
GS Elevation:		**Supervisor:**	VM/DP	**Rig:**	LF-70	**DH Depth (m)**	140.0

Max Injection P (psi)

197



Dw	Measured depth of static water level (1)	12.0	
Dbr	Measured depth to bedrock	0.6	m
Dp	Measured depth to packer	131.6	m
Dt	Measured depth to midpoint of test	135.8	m
ß	Inclination from horizontal (degrees)	90	°
Dw'	Vertical depth to static water level	12.0	m
Dbr'	Vertical dept to bedrock	0.6	m
Dp'	Vertical depth to packer	131.6	m
Dt'	Vertical depth to midpoint of test	135.8	m
SP	Shear Pin Rating (psi)	500	psi
Pblowout	Water column pressure in drill rods at plug	187	psi
Pshear	Estimated differential shear pressure required	500	psi
Pgmax	Maximum injection gauge pressure (3)	203	psi
Hg	Gauge height	2.0	m
Dp'	Length of discharge pipe	1.50	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0127	m
R	Radius of influence (10 m is standard value)	5	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.048	m
L	Length of test section	8.4	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		

Notes:

1: If hole is dry enter Dw = Boring Depth; if AQUIFER water level at test zone above ground surface use negative value
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m) IN ROCK to top of test section.

Equations:

$H_f = 8.65 \times 10^{-15}\ (Q^2 * Lp/rp^5)$

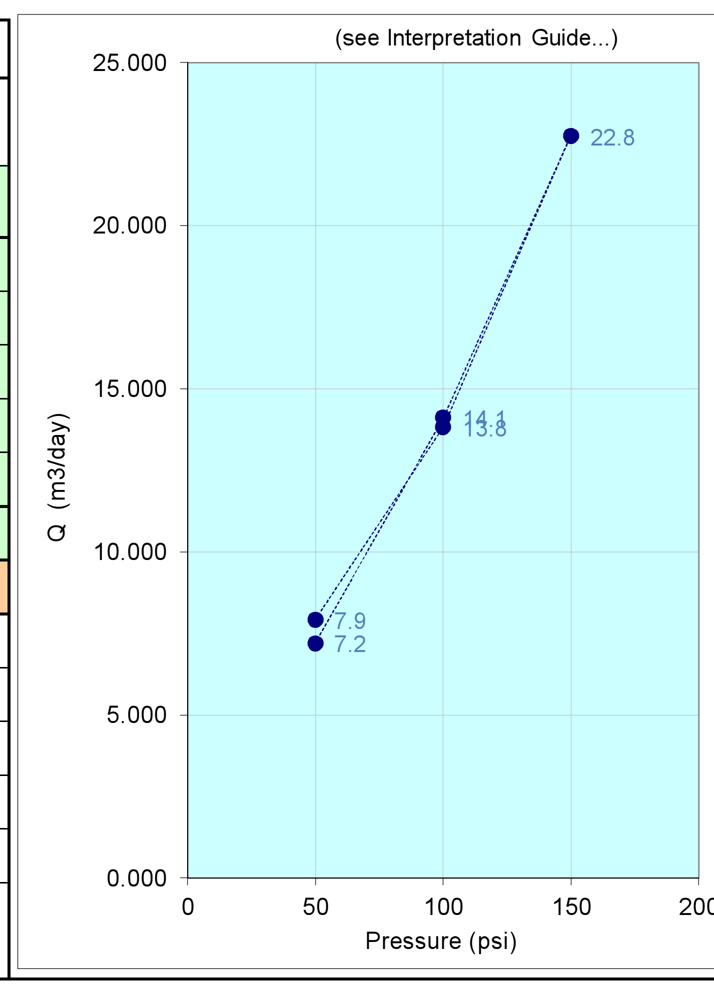
$H_{nit} = (Dw'+Hg-Hf)+Pg/1.42$

$K = (Q*Ln(R/r_b)) / 2*\pi*H_{nit}*L)$

Conversion Factors:

10 m of water = 0.9807 bar = 1kg/cm^2 = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bar, which is approx. 1.4 x 10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement (show last 3 to 5 flow meter readings)	Q (Liters / 30sec)				
	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
	50	100	150	100	50
1	4.50	7.00	10.60	7.00	4.00
2	4.30	6.90	10.40	6.90	4.00
3	3.90	6.60	10.50	6.80	4.00
4	3.70	6.70	10.20	6.90	4.00
5	4.20	6.60	10.40	6.90	4.00
Stable Q (L/30sec)	4.25	6.80	10.40	6.90	4.00
Leak Q (L/30sec)	1.50	2.00	2.50	2.00	1.50
Q (m^3/day)	7.9	13.8	22.8	14.1	7.2
Hf (m)	0.00	0.01	0.02	0.01	0.00
Hnit (m)	49.2	84.4	119.6	84.4	49.2
K (m/day)	1.4E-02	1.4E-02	1.7E-02	1.5E-02	1.3E-02
K (m/s)	**1.6E-07**	**1.7E-07**	**1.9E-07**	**1.7E-07**	**1.5E-07**
+/- (m/s)	-7.5E-09	1.7E-09	0.0E+00	-1.7E-09	7.5E-09
+/- order of mag.	-0.02	0.00	0.00	0.00	0.02



WESA a BluMetric company	PACKER INJECTION TEST (page 2)	Drillhole Nº	JGW-1
		Test hole Nº	N/A
		Test Nº	5

Pressure oscillation during test

Pressure step	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
Min P during step	50	100	150	100	50
Max P during step	50	100	150	100	50
average pressure +/- psi					

Flowmeter measurement reading accuracy

volume +/- Liters / 30 sec					

High estimate of K

Q_{avg} (m^3/day)	7.92	13.82	22.75	14.11	7.20
Hf (m)	0.00	0.01	0.02	0.01	0.00
Hnit (m)	49.2	84.4	119.6	84.4	49.2
K (m/sec)	1.6E-07	1.7E-07	1.9E-07	1.7E-07	1.5E-07

Low estimate of K

Q_{avg} (m^3/day)	7.92	13.82	22.75	14.11	7.20
Hf (m)	0.00	0.01	0.02	0.01	0.00
Hnit (m)	49.2	84.4	119.6	84.4	49.2
K (m/sec)	1.6E-07	1.7E-07	1.9E-07	1.7E-07	1.5E-07

K averages for P step m/second

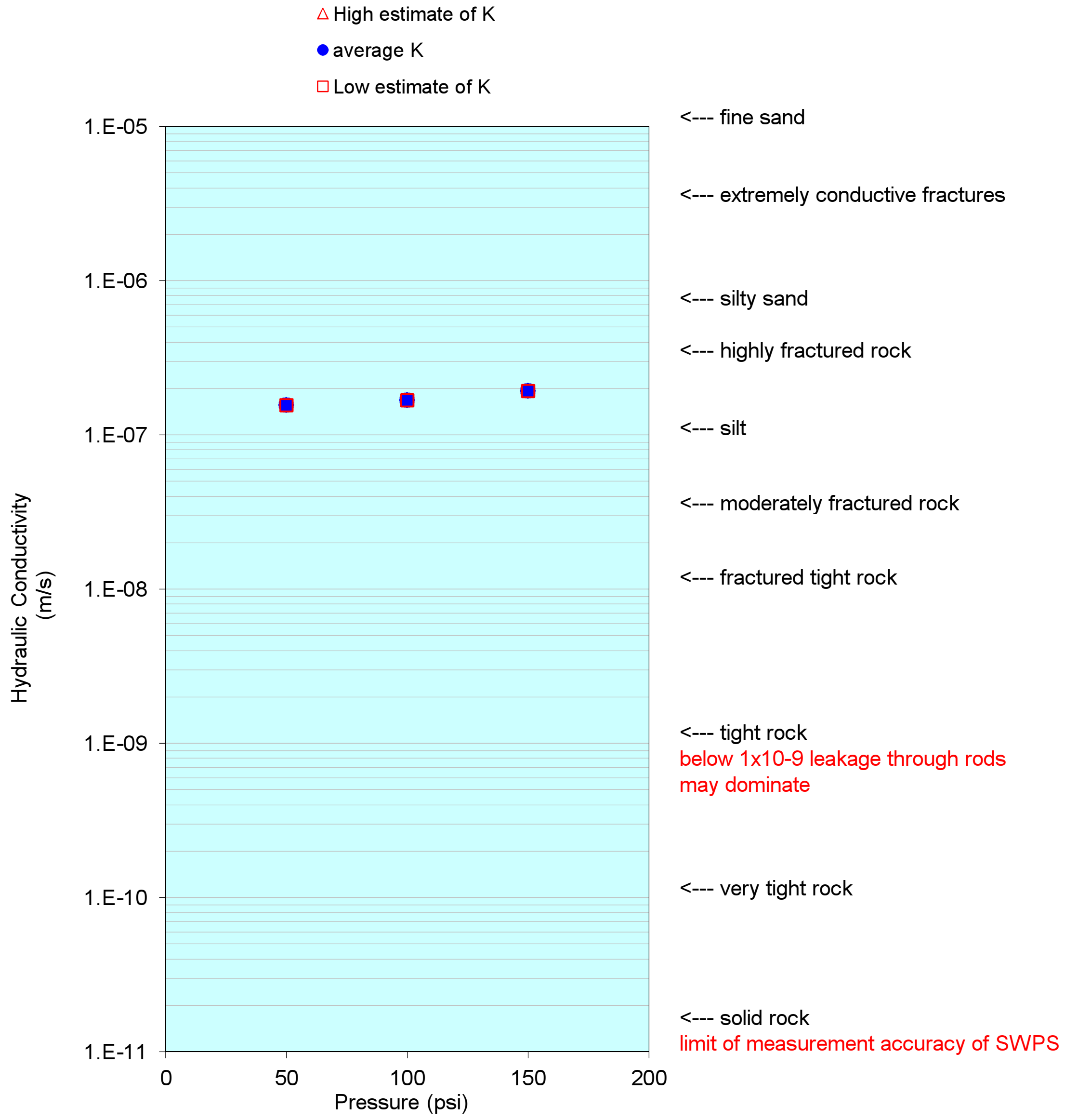
P	50	100	150
high est of K	2.E-07	2.E-07	2.E-07
average K	2.E-07	2.E-07	2.E-07
low est of K	2.E-07	2.E-07	2.E-07

K avg all P steps

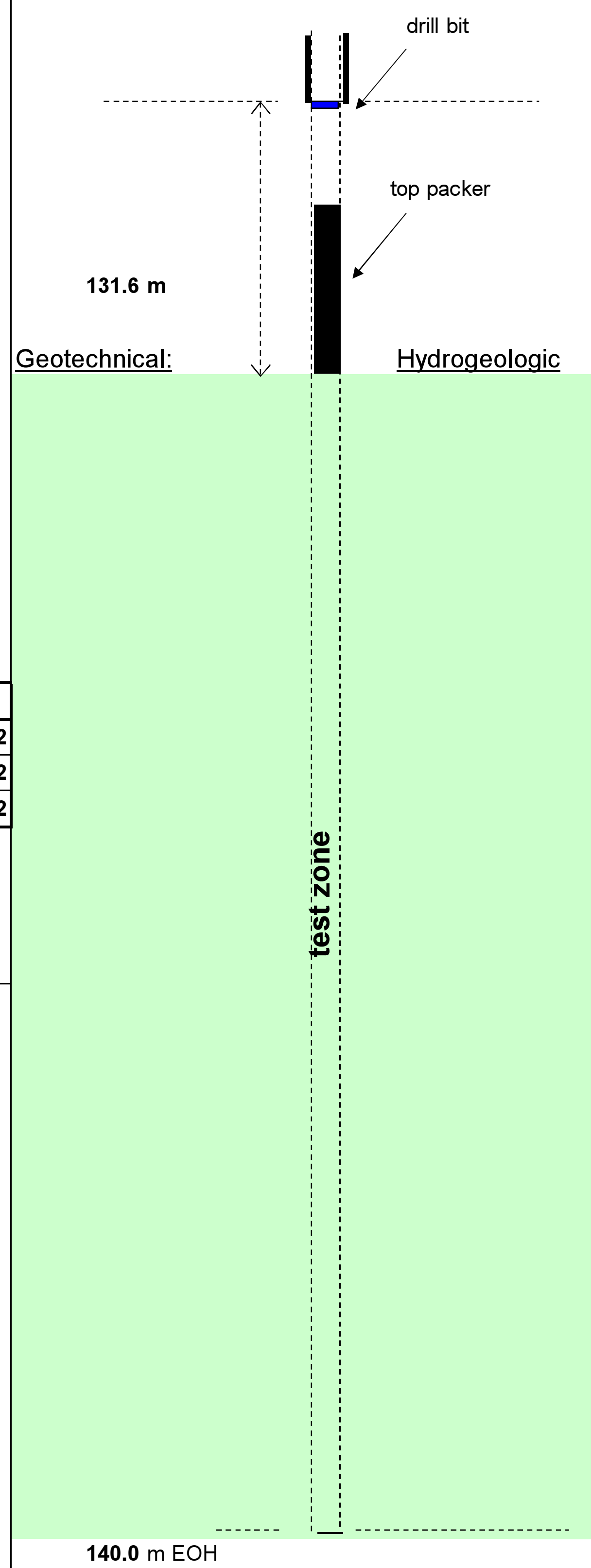
	m/sec	m/day
MAX	2.E-07	1.7E-02
geomean	2.E-07	1.5E-02
MIN	2.E-07	1.4E-02

Comments:

Graph of estimated hydraulic conductivity and error bounds.



Drawing of zone tested, including geotech / hydrogeo. conditions:



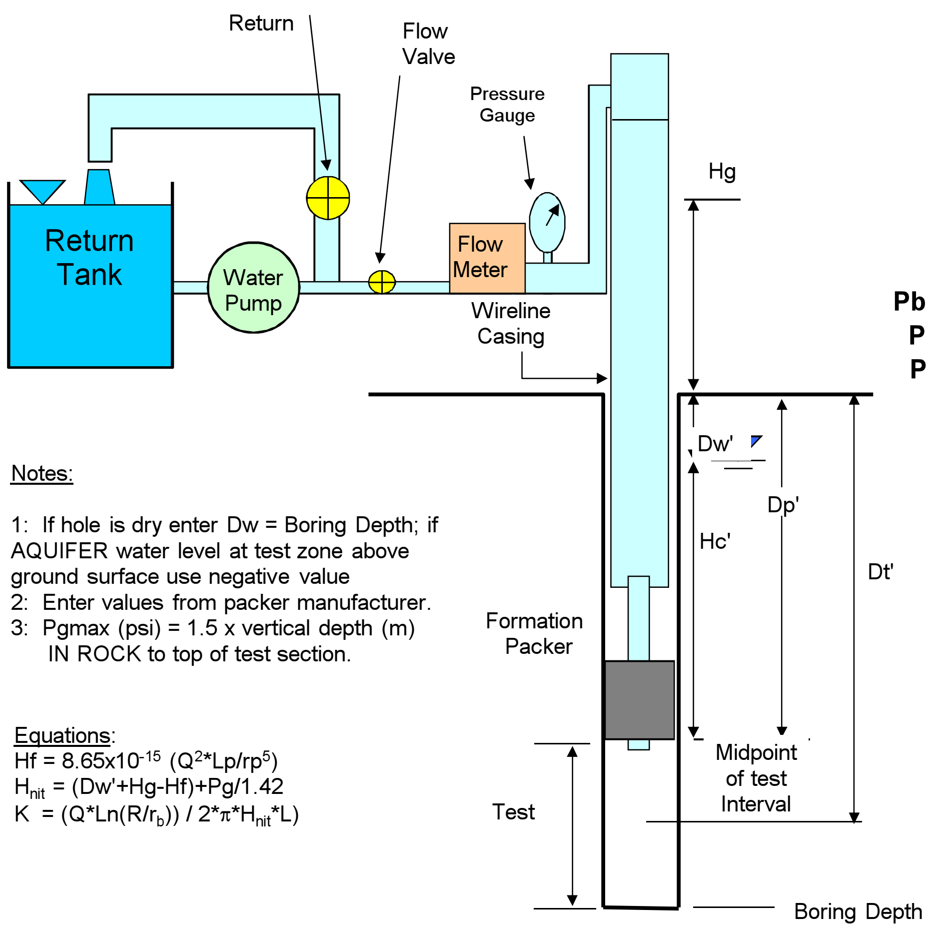
PACKER INJECTION TEST

WESA a BluMetric company

Project:	S-B12738	**Test Interval (m):**	160.3	**to**	170.5	**Drillhole N°**	JGW-1
UTM (x,y)	658211.292, 6086278.287	**Start Date:**	Oct 1 2014	**Time:**	9:00	**Test hole N°**	N/A
Datum:		**End Date:**	Oct 1 2014	**Time:**	10:30	**Test N°**	6
GS Elevation:		**Supervisor:**	VM/DP	**Rig:**	LF-70	**DH Depth (m)**	170.5

Max Injection P (psi)

240



Symbol	Description	Value	Unit
Dw	Measured depth of static water level (1)	12.0	
Dbr	Measured depth to bedrock	0.6	m
Dp	Measured depth to packer	160.3	m
Dt	Measured depth to midpoint of test	165.4	m
ß	Inclination from horizontal (degrees)	85	°
Dw'	Vertical depth to static water level	12.0	m
Dbr'	Vertical dept to bedrock	0.6	m
Dp'	Vertical depth to packer	159.7	m
Dt'	Vertical depth to midpoint of test	164.8	m
SP	Shear Pin Rating (psi)	500	psi
Pblowout	Water column pressure in drill rods at plug	227	psi
Pshear	Estimated differential shear pressure required	500	psi
Pgmax	Maximum injection gauge pressure (3)	246	psi
Hg	Gauge height	2.0	m
Dp'	Length of discharge pipe	1.50	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0127	m
R	Radius of influence (10 m is standard value)	5	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.048	m
L	Length of test section	10.2	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		

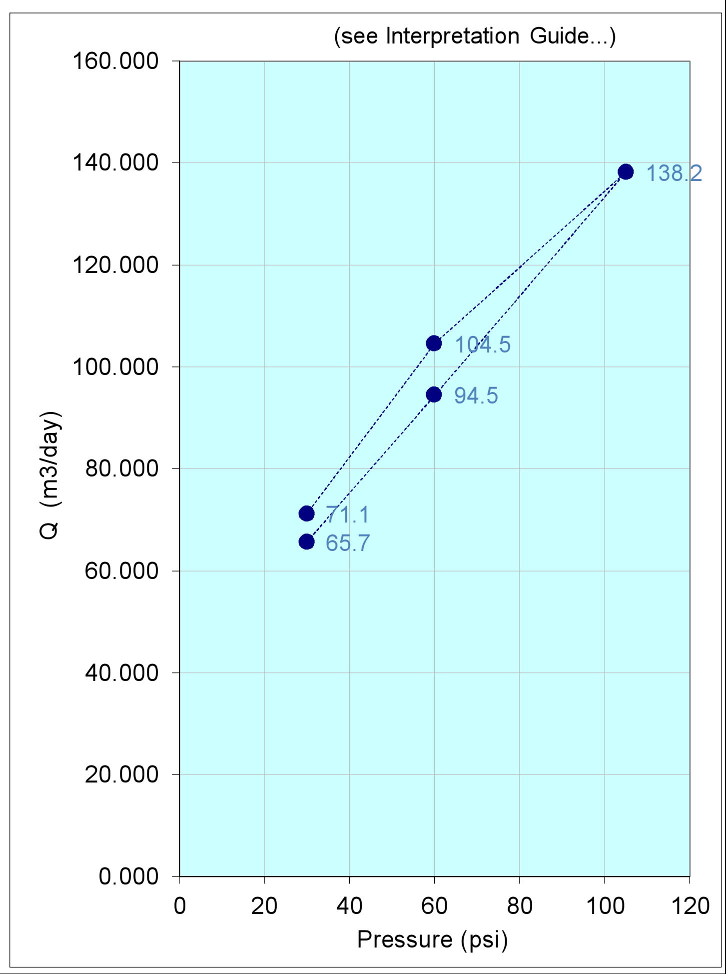
Notes:

1: If hole is dry enter Dw = Boring Depth; if AQUIFER water level at test zone above ground surface use negative value
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m) IN ROCK to top of test section.

Equations:
$H_f = 8.65 \times 10^{-15} (Q^2 * Lp/rp^5)$
$H_{nit} = (Dw'+Hg-Hf)+Pg/1.42$
$K = (Q*Ln(R/r_b)) / 2*\pi*H_{nit}*L)$

Conversion Factors:
10 m of water = 0.9807 bar = 1kg/cm^2 = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bar, which is approx. 1.4 x 10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement (show last 3 to 5 flow meter readings)	Q (Liters / 30sec)				
	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
	30	60	105	60	30
1	23.90	34.80	48.00	37.60	25.30
2	23.20	35.20	50.00	37.40	25.40
3	23.80	34.00	50.00	37.50	25.90
4	24.00	34.00	49.50	37.50	25.60
5	23.70	33.30	50.50	37.50	25.80
Stable Q (L/30sec)	23.90	34.00	49.50	37.50	25.80
Leak Q (L/30sec)	1.10	1.20	1.50	1.20	1.10
Q (m^3/day)	65.7	94.5	138.2	104.5	71.1
Hf (m)	0.17	0.35	0.75	0.43	0.20
Hnit (m)	34.9	55.9	87.1	55.8	34.9
K (m/day)	1.4E-01	1.2E-01	1.1E-01	1.4E-01	1.5E-01
K (m/s)	**1.6E-06**	**1.4E-06**	**1.3E-06**	**1.6E-06**	**1.7E-06**
+/- (m/s)	6.6E-08	7.7E-08	0.0E+00	-7.7E-08	-6.6E-08
+/- order of mag.	0.02	0.02	0.00	-0.02	-0.02



WESA a BluMetric company	PACKER INJECTION TEST (page 2)	Drillhole Nº	JGW-1
		Test hole Nº	N/A
		Test Nº	6

Pressure oscillation during test

Pressure step	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
Min P during step	30	60	105	60	30
Max P during step	30	60	105	60	30
average pressure +/- psi					

Flowmeter measurement reading accuracy

volume +/- Liters / 30 sec					

High estimate of K

Q_{avg} (m^3/day)	65.66	94.46	138.24	104.54	71.14
Hf (m)	0.17	0.35	0.75	0.43	0.20
Hnit (m)	34.9	55.9	87.1	55.8	34.9
K (m/sec)	1.6E-06	1.4E-06	1.3E-06	1.6E-06	1.7E-06

Low estimate of K

Q_{avg} (m^3/day)	65.66	94.46	138.24	104.54	71.14
Hf (m)	0.17	0.35	0.75	0.43	0.20
Hnit (m)	34.9	55.9	87.1	55.8	34.9
K (m/sec)	1.6E-06	1.4E-06	1.3E-06	1.6E-06	1.7E-06

K averages for P step (m/second)

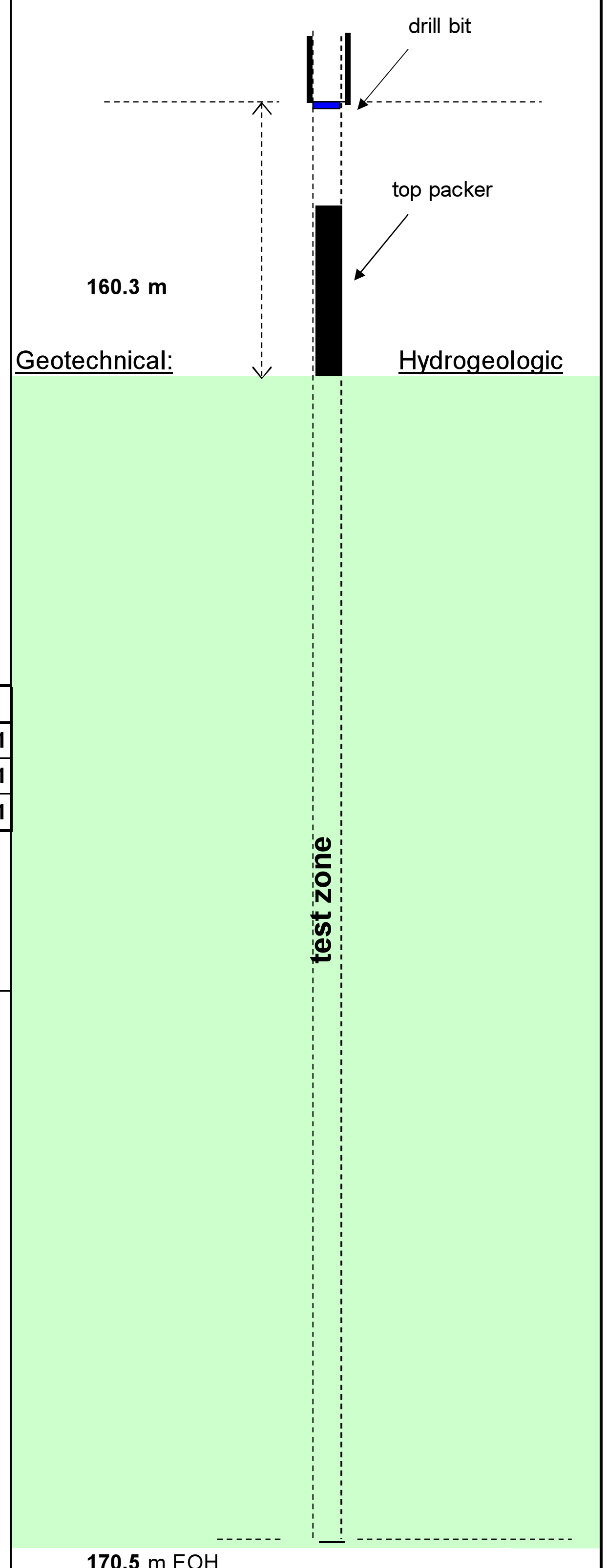
P	30	60	105
high est of K	2.E-06	1.E-06	1.E-06
average K	2.E-06	1.E-06	1.E-06
low est of K	2.E-06	1.E-06	1.E-06

K avg all P steps

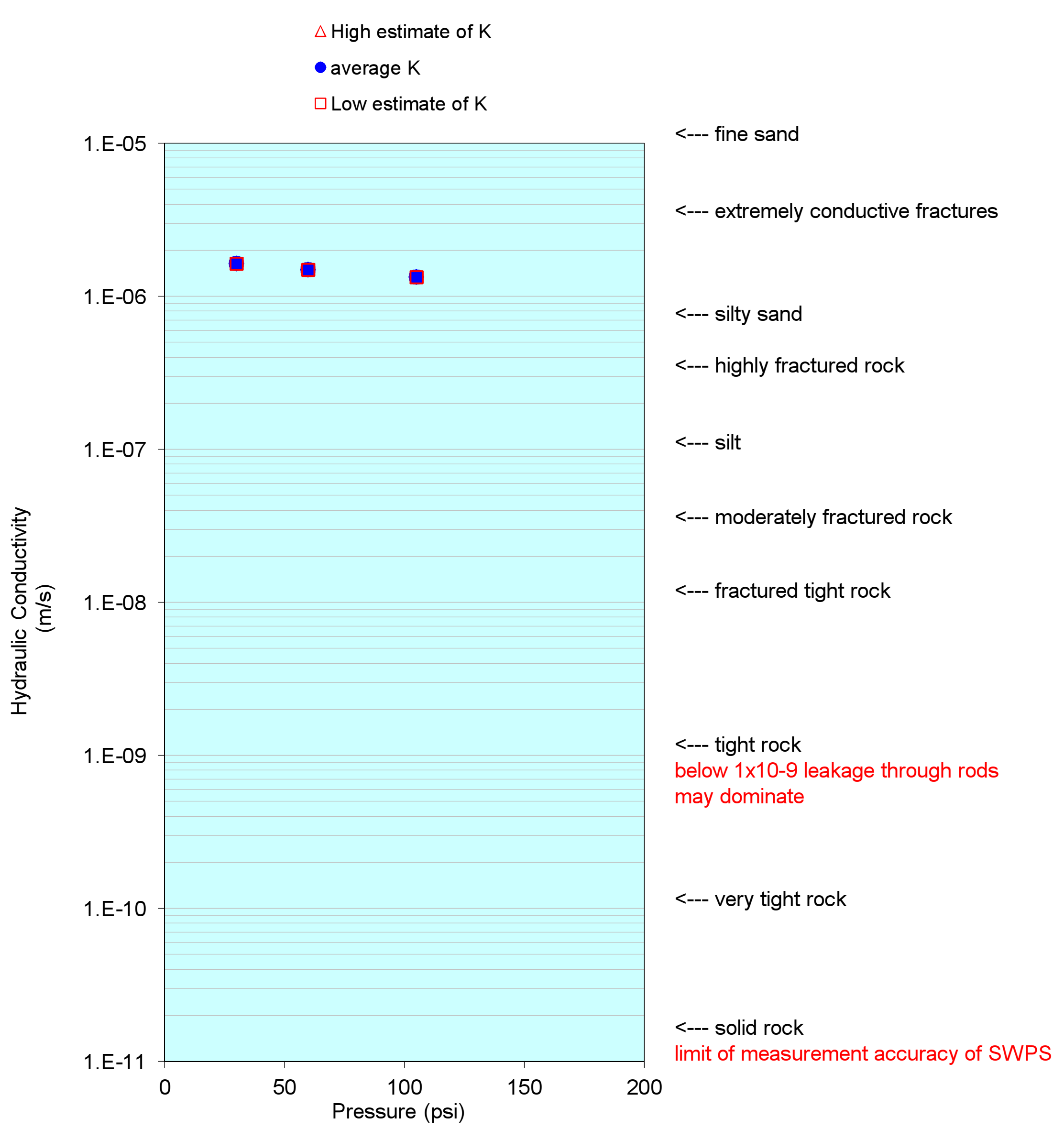
	m/sec	m/day
MAX	2.E-06	1.4E-01
geomean	1.E-06	1.3E-01
MIN	1.E-06	1.1E-01

Comments:

Drawing of zone tested, including geotech / hydrogeo. conditions:



Graph of estimated hydraulic conductivity and error bounds.



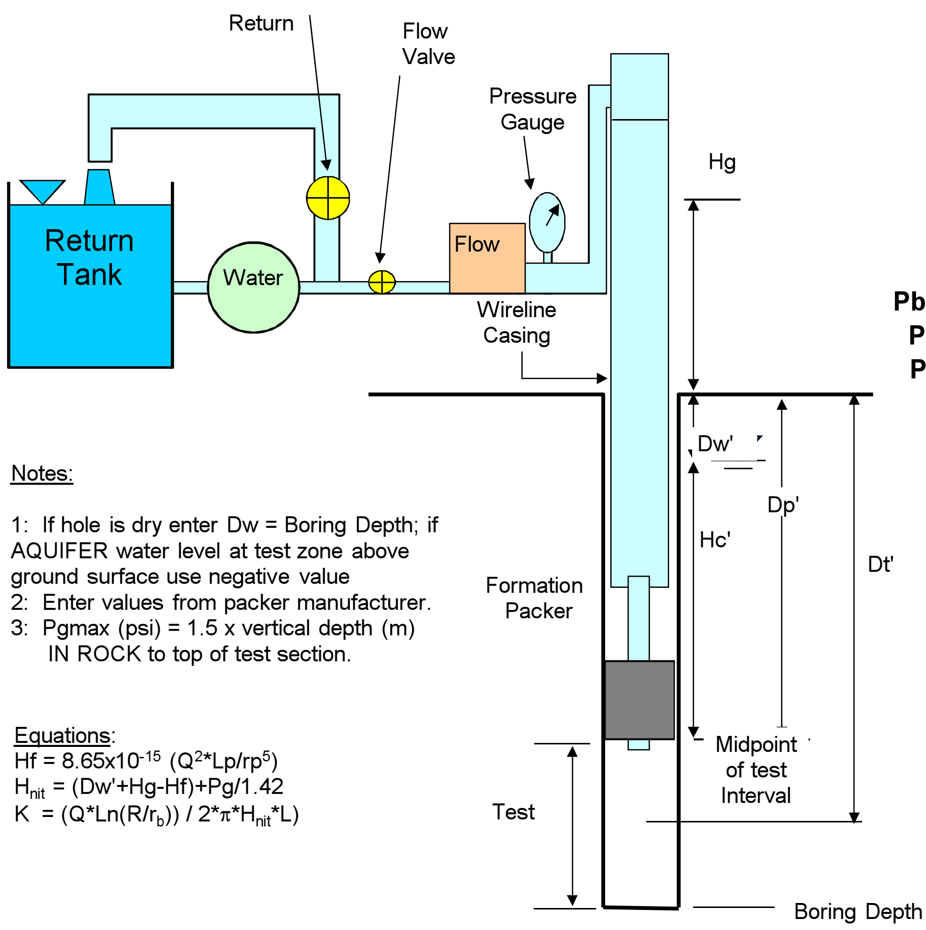
WESA a BluMetric company

PACKER INJECTION TEST (modified from HCI)

Project:	S-B12738	**Test Interval (m):**	28.9	**to**	36.0	**Drillhole N°**	JGW-2
UTM (x,y)	658260, 6086594	**Start Date:**	Oct 3 2014	**Time:**	15:00	**Test hole N°**	N/A
Datum:		**End Date:**	Oct 3 2014	**Time:**	18:00	**Test N°**	1
GS Elevation:		**Supervisor:**	VM/DP	**Rig:**	LF-70	**DH Depth (m)**	36.0

Max Injection P (psi)
43

Symbol	Description	Value	Unit
Dw	Measured depth of static water level (1)	23.0	
Dbr	Measured depth to bedrock	0.6	m
Dp	Measured depth to packer	**28.9**	m
Dt	Measured depth to midpoint of test	**32.5**	m
ß	Inclination from horizontal (degrees)	90	°
Dw'	Vertical depth to static water level	**23.0**	m
Dbr'	Vertical dept to bedrock	**0.6**	m
Dp'	Vertical depth to packer	**28.9**	m
Dt'	Vertical depth to midpoint of test	**32.5**	m
SP	Shear Pin Rating (psi)	500	psi
Pblowout	Water column pressure in drill rods at plug	**41**	psi
Pshear	Estimated differential shear pressure required	**500**	psi
Pgmax	Maximum injection gauge pressure (3)	**48**	psi
Hg	Gauge height	2.0	m
Dp'	Length of discharge pipe	1.50	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0127	m
R	Radius of influence (10 m is standard value)	5	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.048	m
L	Length of test section	**7.1**	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		



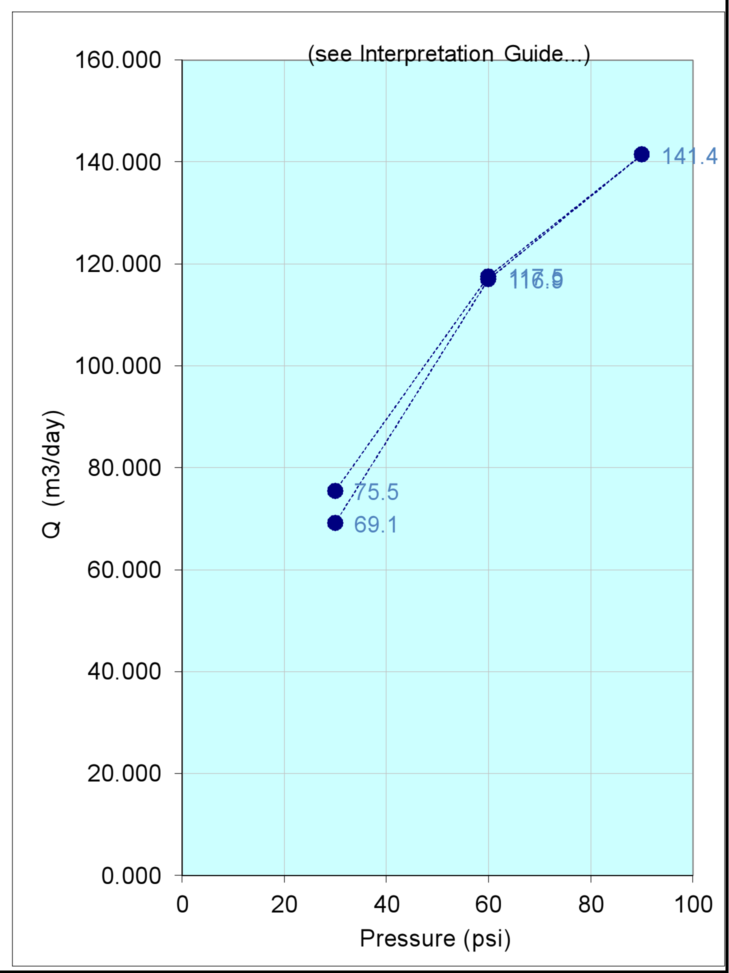
Notes:

1: If hole is dry enter Dw = Boring Depth; if AQUIFER water level at test zone above ground surface use negative value
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m) IN ROCK to top of test section.

Equations:
$Hf = 8.65x10^{-15} (Q^2*Lp/rp^5)$
$H_{nit} = (Dw'+Hg-Hf)+Pg/1.42$
$K = (Q*Ln(R/r_b)) / 2*\pi*H_{nit}*L)$

Conversion Factors:
10 m of water = 0.9807 bar = 1kg/cm^2 = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bar, which is approx. 1.4 x 10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement (show last 3 to 5 flow meter readings)	Q (Liters / 30sec)				
	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
	30	60	90	60	30
1	24.30	40.00	48.00	41.50	26.80
2	24.30	40.00	48.00	41.80	26.50
3	24.30	41.00	49.50	41.00	26.90
4	24.30	41.00	49.50	41.20	26.50
5		40.50	49.50	39.10	
Stable Q (L/30sec)	24.30	41.00	49.50	41.20	26.50
Leak Q (L/30sec)	0.30	0.40	0.40	0.40	0.30
Q (m^3/day)	69.1	116.9	141.4	117.5	75.5
Hf (m)	0.19	0.54	0.79	0.54	0.22
Hnit (m)	45.9	66.7	87.6	66.7	45.9
K (m/day)	1.6E-01	1.8E-01	1.7E-01	1.8E-01	1.7E-01
K (m/s)	**1.8E-06**	**2.1E-06**	**1.9E-06**	**2.1E-06**	**2.0E-06**
+/- (m/s)	8.4E-08	5.3E-09	0.0E+00	-5.3E-09	-8.4E-08
+/- order of mag.	0.02	0.00	0.00	0.00	-0.02



PACKER INJECTION TEST

(page 2)

Drillhole Nº	JGW-2
Test hole Nº	N/A
Test Nº	1

Pressure oscillation during test

Pressure step	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
Min P during step	30	60	90	60	30
Max P during step	30	60	90	60	30
average pressure +/- psi					

Flowmeter measurement reading accuracy

volume +/- Liters / 30 sec					

High estimate of K

Q_{avg} (m^3/day)	69.12	116.93	141.41	117.50	75.46
Hf (m)	0.19	0.54	0.79	0.54	0.22
Hnit (m)	45.9	66.7	87.6	66.7	45.9
K (m/sec)	1.8E-06	2.1E-06	1.9E-06	2.1E-06	2.0E-06

Low estimate of K

Q_{avg} (m^3/day)	69.12	116.93	141.41	117.50	75.46
Hf (m)	0.19	0.54	0.79	0.54	0.22
Hnit (m)	45.9	66.7	87.6	66.7	45.9
K (m/sec)	1.8E-06	2.1E-06	1.9E-06	2.1E-06	2.0E-06

K averages for P step — m/second

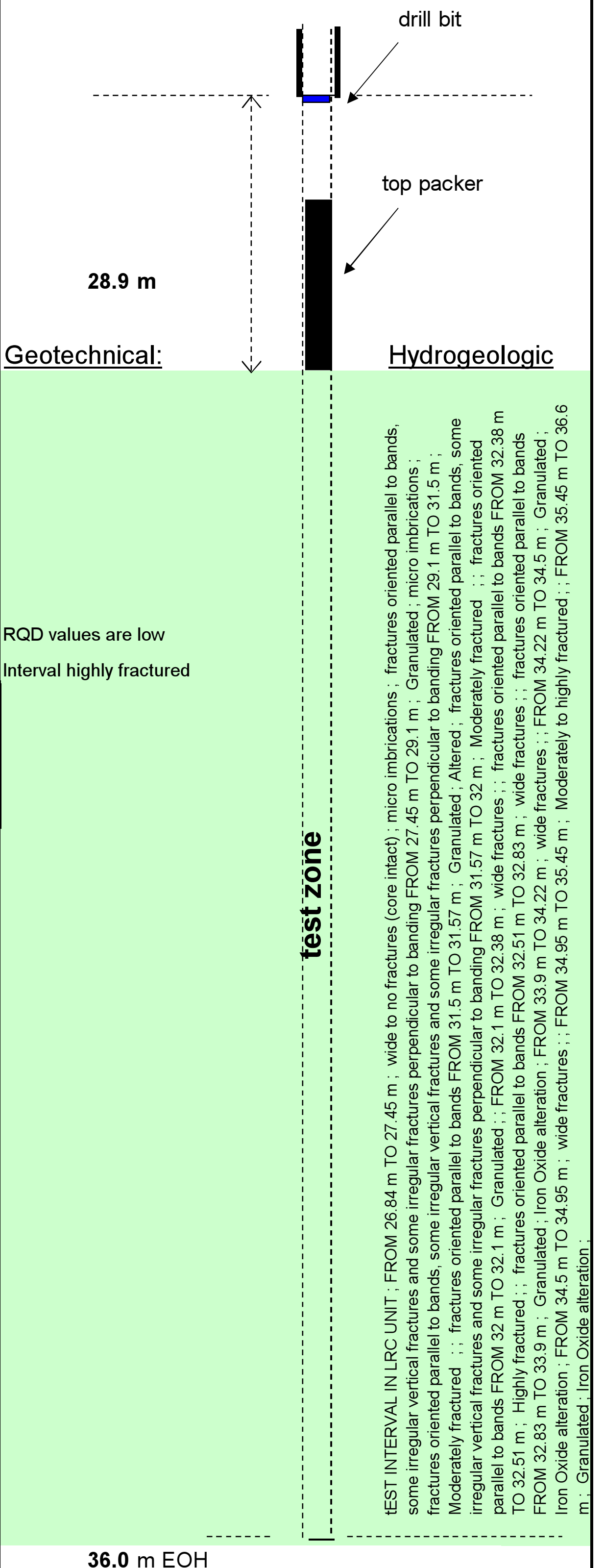
P	30	60	90
high est of K	2.E-06	2.E-06	2.E-06
average K	2.E-06	2.E-06	2.E-06
low est of K	2.E-06	2.E-06	2.E-06

K avg all P steps

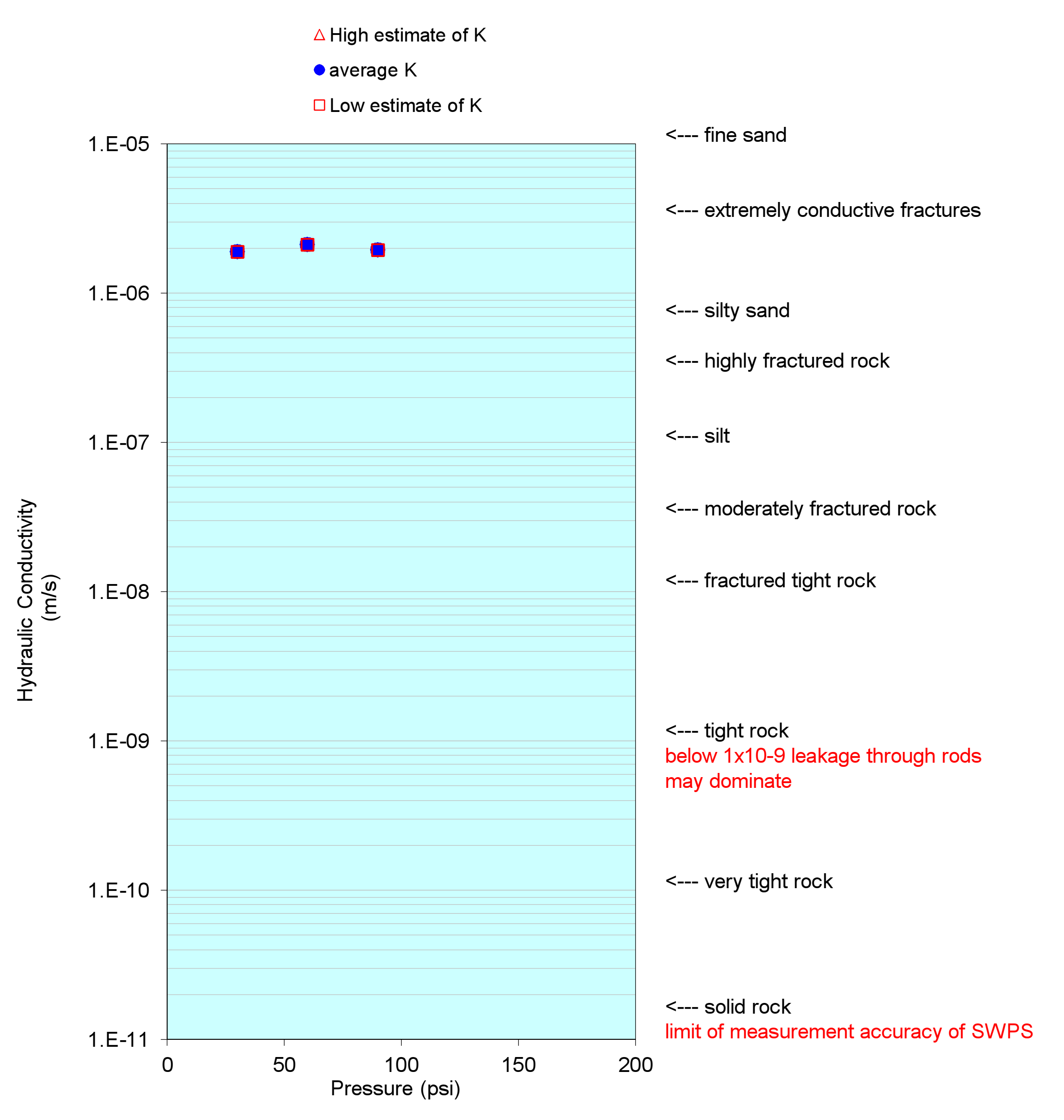
	m/sec	m/day
MAX	2.E-06	1.8E-01
geomean	2.E-06	1.7E-01
MIN	2.E-06	1.6E-01

Comments:

Drawing of zone tested, including geotech / hydrogeo. conditions:



Graph of estimated hydraulic conductivity and error bounds.



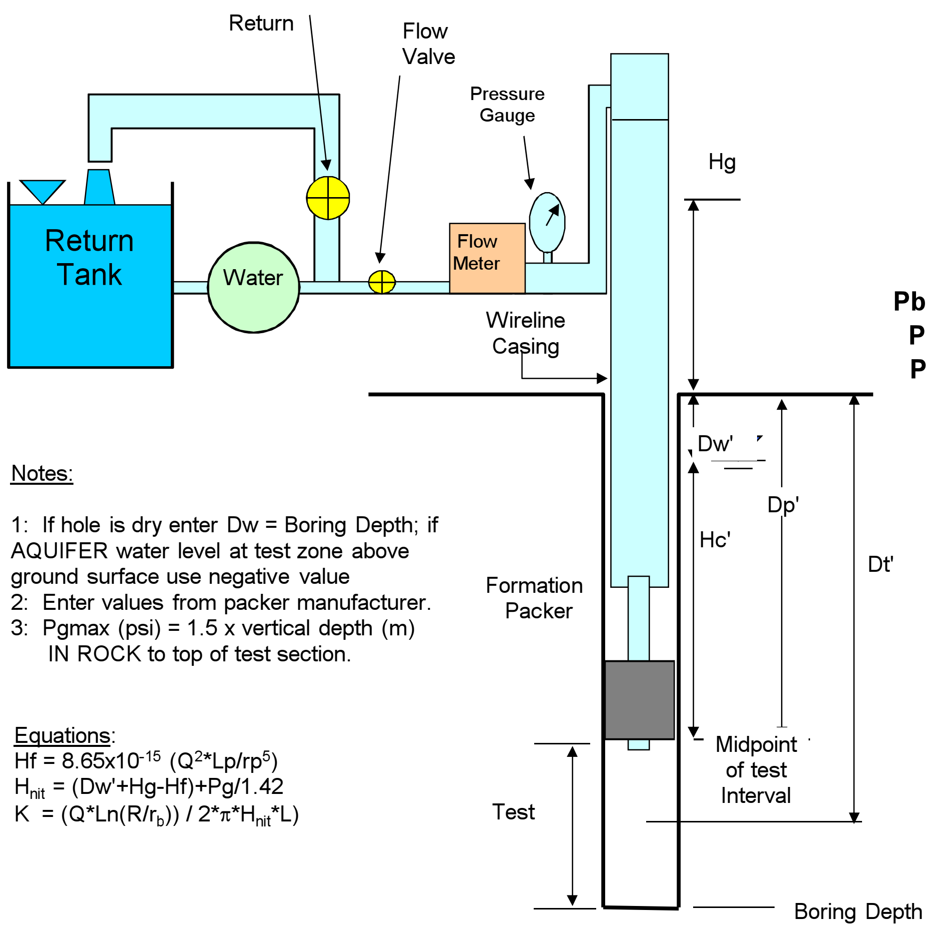
PACKER INJECTION TEST

WESA — a BluMetric company

Project:	S-B12738	**Test Interval (m):**	49.9	**to**	60.6	**Drillhole Nº**	JGW-2
UTM (x,y)	658260, 6086594	**Start Date:**	Oct 4 2014	**Time:**	7:15	**Test hole Nº**	N/A
Datum:		**End Date:**	Oct 4 2014	**Time:**	9:15	**Test Nº**	2
GS Elevation:		**Supervisor:**	VM/DP	**Rig:**	LF-70	**DH Depth (m)**	60.6

Max Injection P (psi)

75



Dw	Measured depth of static water level (1)	23.0	
Dbr	Measured depth to bedrock	0.6	m
Dp	Measured depth to packer	**49.9**	m
Dt	Measured depth to midpoint of test	**55.3**	m
ß	Inclination from horizontal (degrees)	90	º
Dw'	Vertical depth to static water level	**23.0**	m
Dbr'	Vertical dept to bedrock	**0.6**	m
Dp'	Vertical depth to packer	**49.9**	m
Dt'	Vertical depth to midpoint of test	**55.3**	m
SP	Shear Pin Rating (psi)	500	psi
Pblowout	Water column pressure in drill rods at plug	**71**	psi
Pshear	Estimated differential shear pressure required	**500**	psi
Pgmax	Maximum injection gauge pressure (3)	**82**	psi
Hg	Gauge height	2.0	m
Dp'	Length of discharge pipe	1.50	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0127	m
R	Radius of influence (10 m is standard value)	5	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.048	m
L	Length of test section	**10.7**	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		

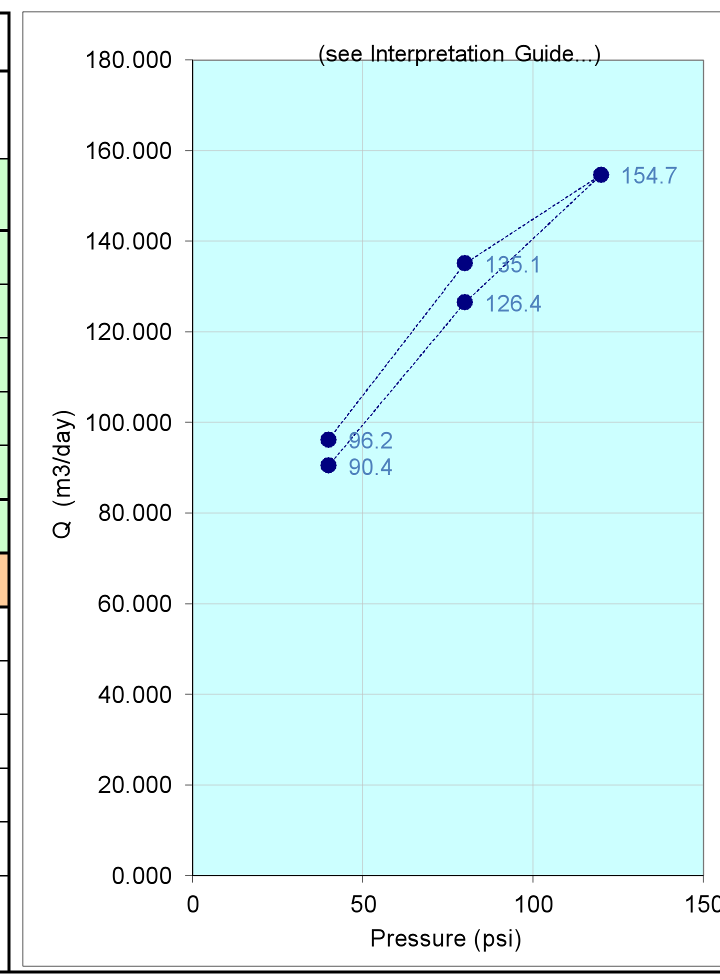
Notes:

1: If hole is dry enter Dw = Boring Depth; if AQUIFER water level at test zone above ground surface use negative value
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m) IN ROCK to top of test section.

Equations:
$Hf = 8.65\times10^{-15} (Q^2*Lp/rp^5)$
$H_{nit} = (Dw'+Hg-Hf)+Pg/1.42$
$K = (Q*Ln(R/r_b)) / 2*\pi*H_{nit}*L)$

Conversion Factors:
10 m of water = 0.9807 bar = 1kg/cm^2 = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bar, which is approx. 1.4 x 10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement (show last 3 to 5 flow meter readings)	Q (Liters / 30sec)				
	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
	40	80	120	80	40
1	33.00	48.00	56.00	46.00	33.00
2	36.00	48.00	55.00	46.00	32.00
3	34.00	48.00	55.00	45.00	33.00
4	35.00	47.00	54.00	45.00	33.00
5	34.00		54.00	45.00	32.00
Stable Q (L/30sec)	34.00	48.00	55.00	45.00	32.00
Leak Q (L/30sec)	0.60	1.10	1.30	1.10	0.60
Q (m^3/day)	96.2	135.1	154.7	126.4	90.4
Hf (m)	0.36	0.72	0.94	0.63	0.32
Hnit (m)	52.8	80.6	108.5	80.7	52.8
K (m/day)	1.3E-01	1.2E-01	9.8E-02	1.1E-01	1.2E-01
K (m/s)	**1.5E-06**	**1.3E-06**	**1.1E-06**	**1.3E-06**	**1.4E-06**
+/- (m/s)	-4.4E-08	-4.4E-08	0.0E+00	4.4E-08	4.4E-08
+/- order of mag.	-0.01	-0.01	0.00	0.01	0.01



WESA a BluMetric company	PACKER INJECTION TEST (page 2)	Drillhole Nº	JGW-2
		Test hole Nº	N/A
		Test Nº	2

Pressure oscillation during test

Pressure step	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
Min P during step	40	80	120	80	40
Max P during step	40	80	120	80	40
average pressure +/- psi					

Flowmeter measurement reading accuracy

volume +/- Liters / 30 sec					

High estimate of K

Q_{avg} (m^3/day)	96.19	135.07	154.66	126.43	90.43
Hf (m)	0.36	0.72	0.94	0.63	0.32
Hnit (m)	52.8	80.6	108.5	80.7	52.8
K (m/sec)	1.5E-06	1.3E-06	1.1E-06	1.3E-06	1.4E-06

Low estimate of K

Q_{avg} (m^3/day)	96.19	135.07	154.66	126.43	90.43
Hf (m)	0.36	0.72	0.94	0.63	0.32
Hnit (m)	52.8	80.6	108.5	80.7	52.8
K (m/sec)	1.5E-06	1.3E-06	1.1E-06	1.3E-06	1.4E-06

K averages for P step — m/second

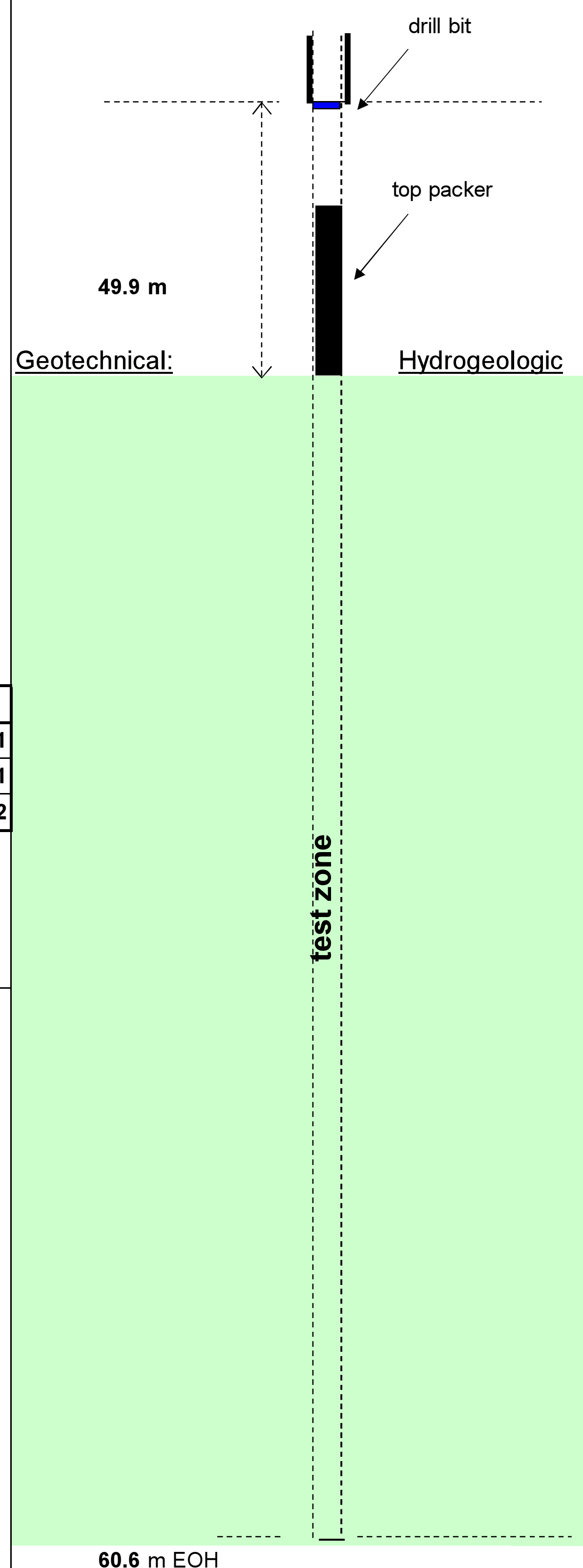
P	40	80	120
high est of K	1.E-06	1.E-06	1.E-06
average K	1.E-06	1.E-06	1.E-06
low est of K	1.E-06	1.E-06	1.E-06

K avg all P steps

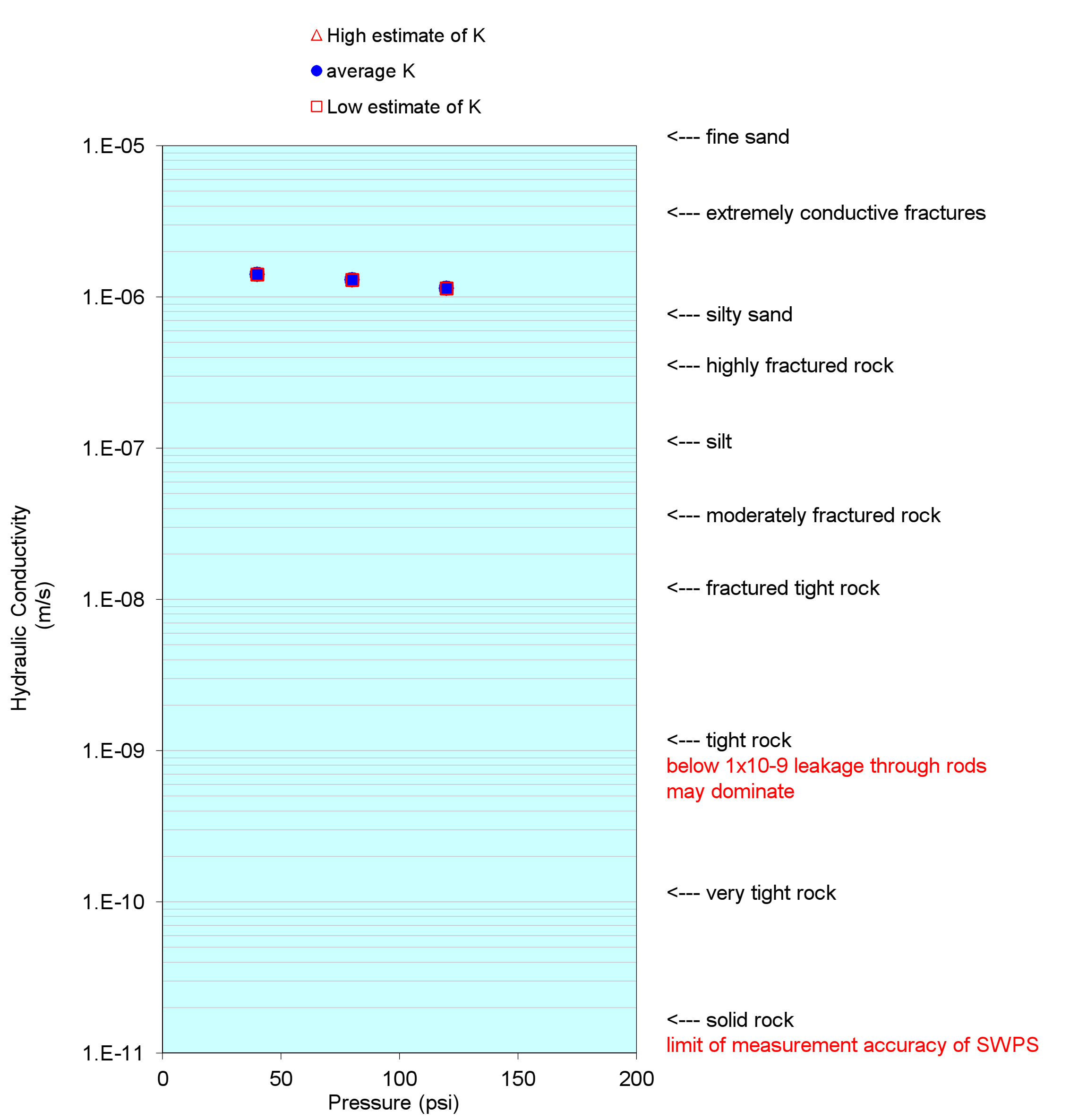
	m/sec	m/day
MAX	1.E-06	1.2E-01
geomean	1.E-06	1.1E-01
MIN	1.E-06	9.8E-02

Comments:

Drawing of zone tested, including geotech / hydrogeo. conditions:



Graph of estimated hydraulic conductivity and error bounds.



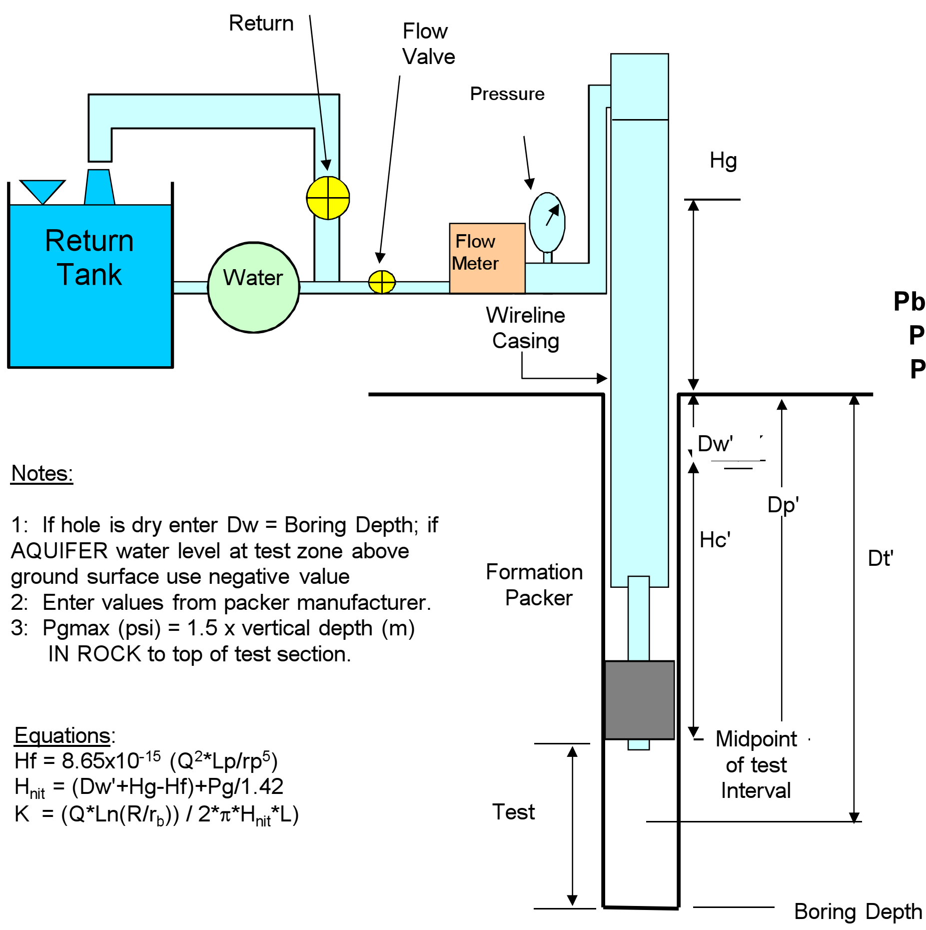
PACKER INJECTION TEST

WESA

Project:	S-B12738	**Test Interval (m):**	79.9	to	90.6	**Drillhole N°**	JGW-2
UTM (x,y)	658260, 6086594	**Start Date:**	Oct 4 2014	**Time:**	4:00	**Test hole N°**	N/A
Datum:		**End Date:**	Oct 4 2014	**Time:**	6:00	**Test N°**	3
GS Elevation:		**Supervisor:**	VM/DP	**Rig:**	LF-70	**DH Depth (m)**	90.6

Max Injection P (psi)

120



Notes:

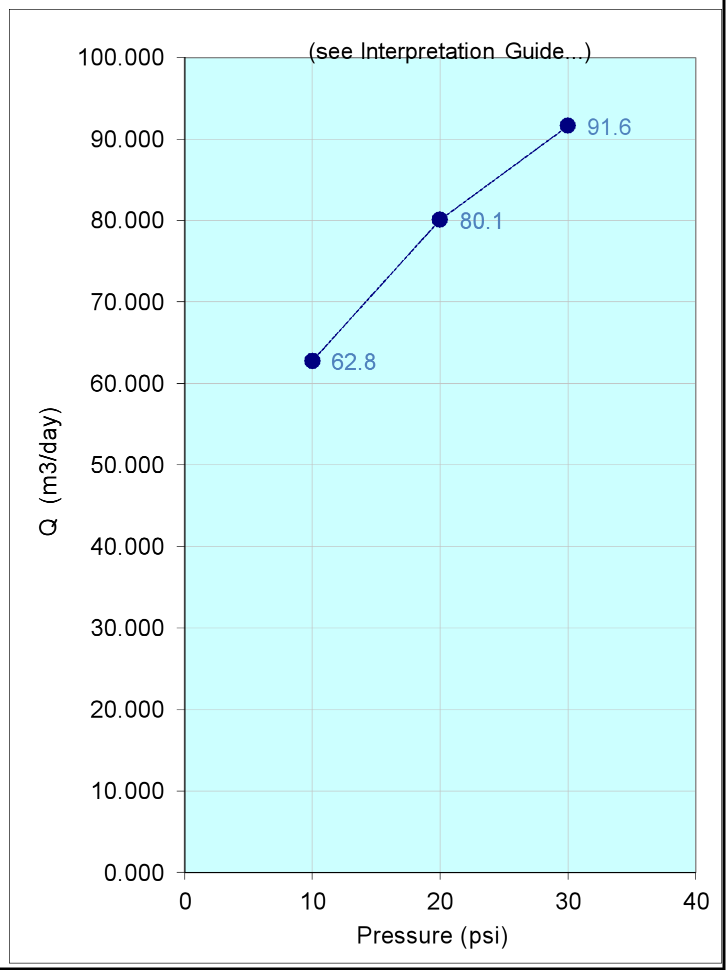
1: If hole is dry enter Dw = Boring Depth; if AQUIFER water level at test zone above ground surface use negative value
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m) IN ROCK to top of test section.

Equations:
$Hf = 8.65 \times 10^{-15} (Q^2*Lp/rp^5)$
$H_{nit} = (Dw'+Hg-Hf)+Pg/1.42$
$K = (Q*Ln(R/r_b)) / 2*\pi*H_{nit}*L)$

Dw	Measured depth of static water level (1)	23.0	
Dbr	Measured depth to bedrock	0.6	m
Dp	Measured depth to packer	79.9	m
Dt	Measured depth to midpoint of test	85.3	m
ß	Inclination from horizontal (degrees)	90	°
Dw'	Vertical depth to static water level	23.0	m
Dbr'	Vertical dept to bedrock	0.6	m
Dp'	Vertical depth to packer	79.9	m
Dt'	Vertical depth to midpoint of test	85.3	m
SP	Shear Pin Rating (psi)	500	psi
Pblowout	Water column pressure in drill rods at plug	113	psi
Pshear	Estimated differential shear pressure required	500	psi
Pgmax	Maximum injection gauge pressure (3)	127	psi
Hg	Gauge height	2.0	m
Dp'	Length of discharge pipe	1.50	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0127	m
R	Radius of influence (10 m is standard value)	5	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.048	m
L	Length of test section	10.7	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		

Conversion Factors:
10 m of water = 0.9807 bar = 1kg/cm^2 = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bar, which is approx. 1.4 x 10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement (show last 3 to 5 flow meter readings)	Q (Liters / 30sec)				
	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
	10	20	30	20	10
1	22.00	28.00	32.00	29.00	23.00
2	21.00	29.00	32.00	28.00	22.00
3	22.00	28.00	32.00	29.00	22.00
4	22.00	28.00	32.00	28.00	22.00
5					
Stable Q (L/30sec)	22.00	28.00	32.00	28.00	22.00
Leak Q (L/30sec)	0.20	0.20	0.20	0.20	0.20
Q (m^3/day)	62.8	80.1	91.6	80.1	62.8
Hf (m)	0.15	0.25	0.33	0.25	0.15
Hnit (m)	31.9	38.8	45.8	38.8	31.9
K (m/day)	1.4E-01	1.4E-01	1.4E-01	1.4E-01	1.4E-01
K (m/s)	**1.6E-06**	**1.6E-06**	**1.6E-06**	**1.6E-06**	**1.6E-06**
+/- (m/s)	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
+/- order of mag.	0.00	0.00	0.00	0.00	0.00



WESA a BluMetric company	PACKER INJECTION TEST (page 2)	Drillhole Nº	JGW-2
		Test hole Nº	N/A
		Test Nº	3

Pressure oscillation during test

Pressure step	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
Min P during step	10	20	30	20	10
Max P during step	10	20	30	20	10
average pressure +/- psi					

Flowmeter measurement reading accuracy

volume +/- Liters / 30 sec					

High estimate of K

Q_{avg} (m^3/day)	62.78	80.06	91.58	80.06	62.78
Hf (m)	0.15	0.25	0.33	0.25	0.15
Hnit (m)	31.9	38.8	45.8	38.8	31.9
K (m/sec)	1.6E-06	1.6E-06	1.6E-06	1.6E-06	1.6E-06

Low estimate of K

Q_{avg} (m^3/day)	62.78	80.06	91.58	80.06	62.78
Hf (m)	0.15	0.25	0.33	0.25	0.15
Hnit (m)	31.9	38.8	45.8	38.8	31.9
K (m/sec)	1.6E-06	1.6E-06	1.6E-06	1.6E-06	1.6E-06

K averages for P step (m/second)

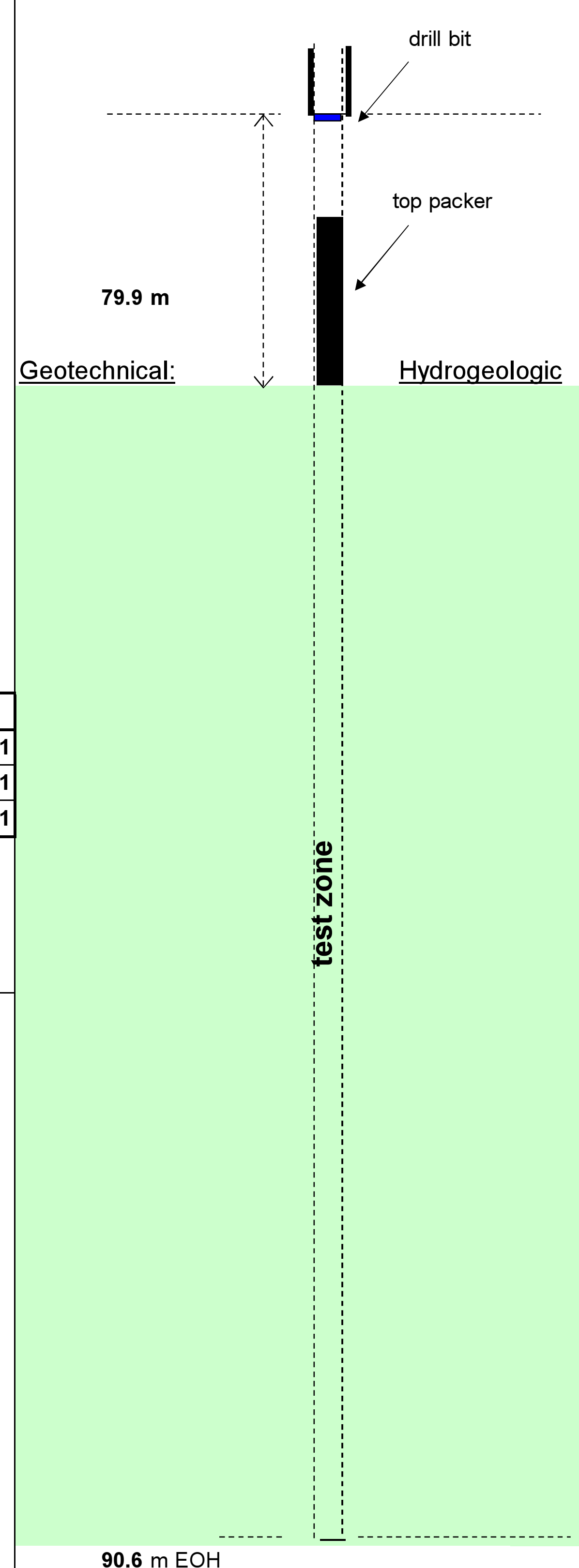
P	10	20	30
high est of K	2.E-06	2.E-06	2.E-06
average K	2.E-06	2.E-06	2.E-06
low est of K	2.E-06	2.E-06	2.E-06

K avg all P steps

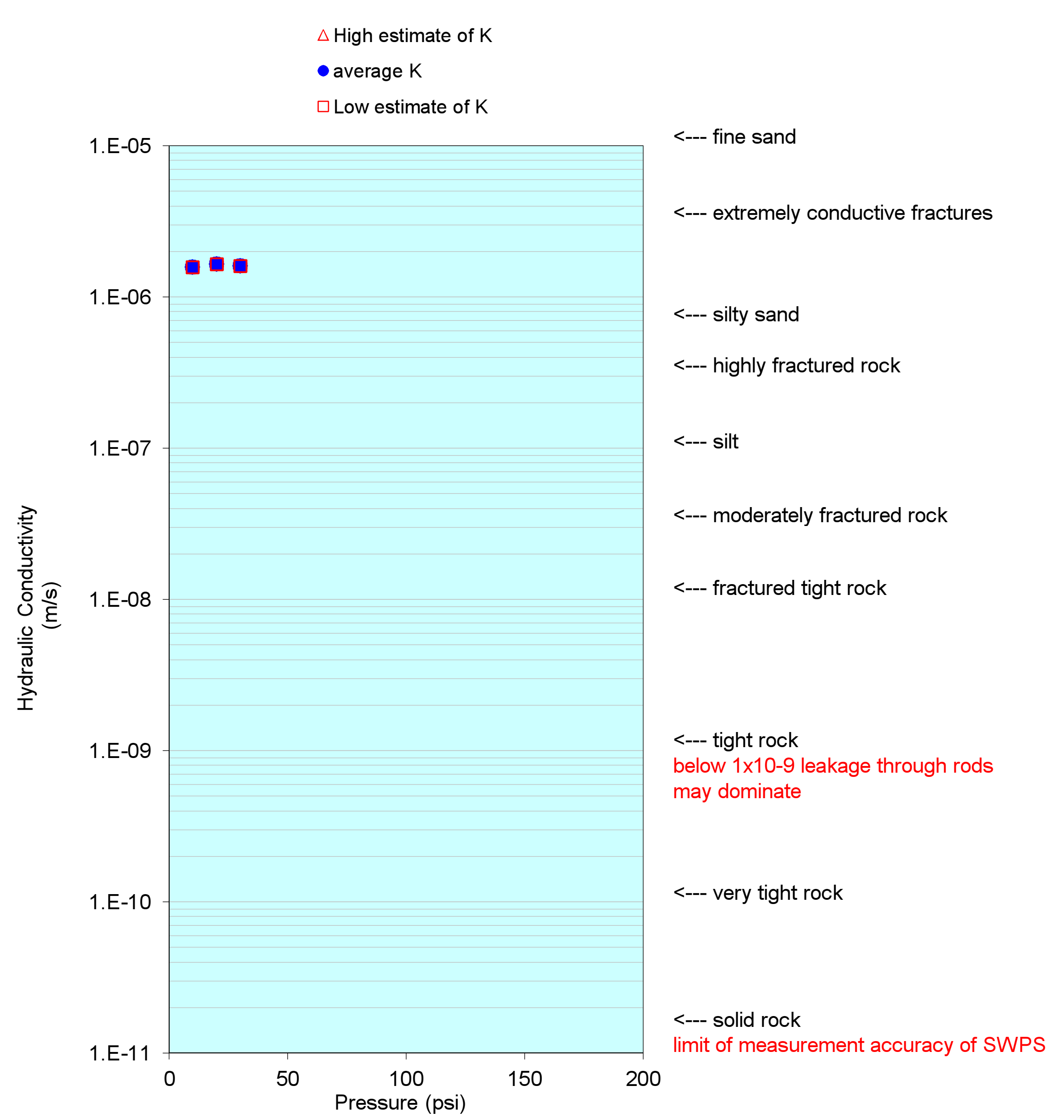
	m/sec	m/day
MAX	2.E-06	1.4E-01
geomean	2.E-06	1.4E-01
MIN	2.E-06	1.4E-01

Comments:

Drawing of zone tested, including geotech / hydrogeo. conditions:



Graph of estimated hydraulic conductivity and error bounds.



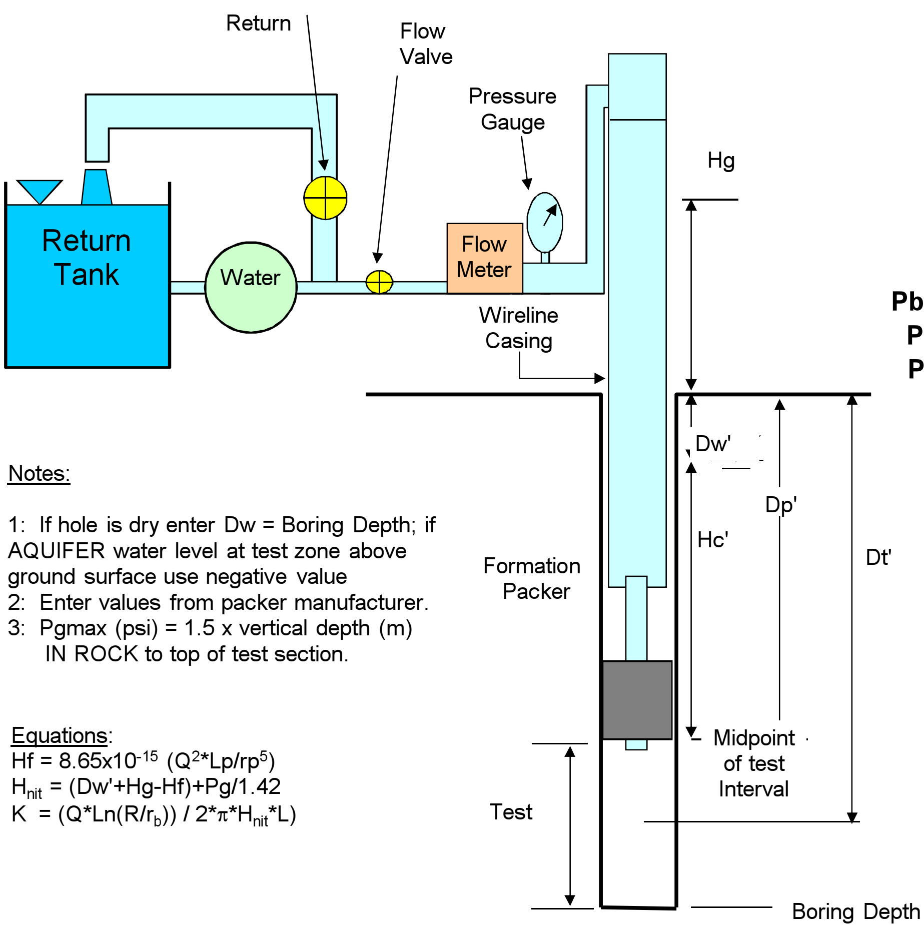
PACKER INJECTION TEST

WESA a BluMetric company

Project:	S-B12738	**Test Interval (m):**	100.9	**to**	111.6	**Drillhole N°**	JGW-2
UTM (x,y)	658260, 6086594	**Start Date:**	Oct 5 2014	**Time:**	16:00	**Test hole N°**	N/A
Datum:		**End Date:**	Oct 5 2014	**Time:**	18:00	**Test N°**	4
GS Elevation:		**Supervisor:**	VM/DP	**Rig:**	LF-70	**DH Depth (m)**	111.6

Max Injection P (psi)

151



Dw	Measured depth of static water level (1)	23.0	
Dbr	Measured depth to bedrock	0.6	m
Dp	Measured depth to packer	100.9	m
Dt	Measured depth to midpoint of test	106.3	m
ß	Inclination from horizontal (degrees)	90	°
Dw'	Vertical depth to static water level	23.0	m
Dbr'	Vertical dept to bedrock	0.6	m
Dp'	Vertical depth to packer	100.9	m
Dt'	Vertical depth to midpoint of test	106.3	m
SP	Shear Pin Rating (psi)	500	psi
Pblowout	Water column pressure in drill rods at plug	143	psi
Pshear	Estimated differential shear pressure required	500	psi
Pgmax	Maximum injection gauge pressure (3)	158	psi
Hg	Gauge height	2.0	m
Dp'	Length of discharge pipe	1.50	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0127	m
R	Radius of influence (10 m is standard value)	5	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.048	m
L	Length of test section	10.7	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		

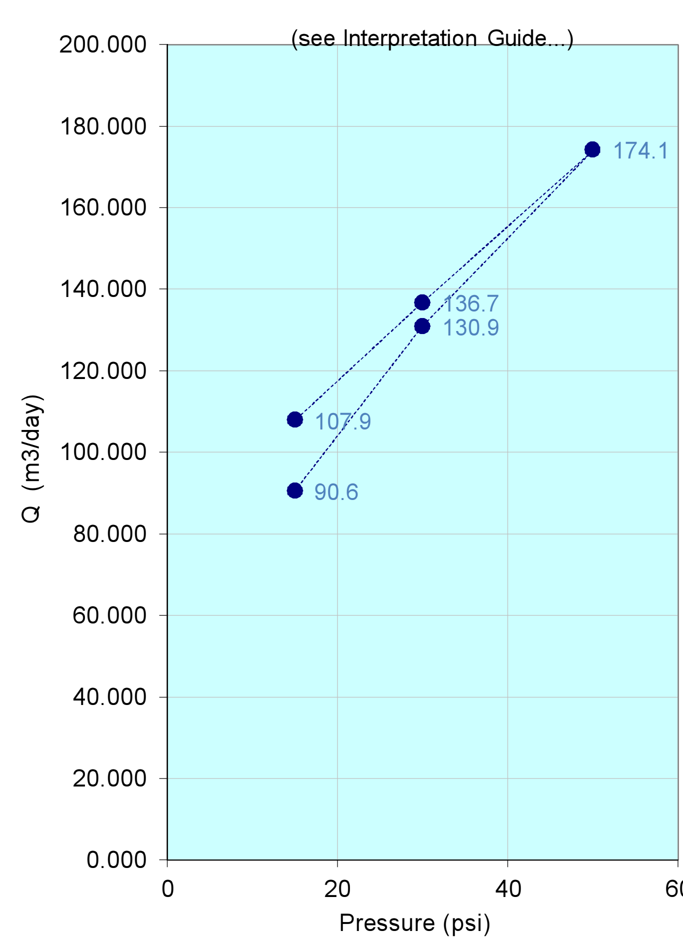
Notes:

1: If hole is dry enter Dw = Boring Depth; if AQUIFER water level at test zone above ground surface use negative value
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m) IN ROCK to top of test section.

Equations:
$Hf = 8.65\times10^{-15}\ (Q^2*Lp/rp^5)$
$H_{nit} = (Dw'+Hg-Hf)+Pg/1.42$
$K = (Q*Ln(R/r_b))\ /\ 2*\pi*H_{nit}*L)$

Conversion Factors:
10 m of water = 0.9807 bar = 1kg/cm^2 = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bar, which is approx. 1.4 x 10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement (show last 3 to 5 flow meter readings)	Q (Liters / 30sec)				
	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
	15	30	50	30	15
1	32.50	47.50	61.00	49.00	38.00
2	32.00	45.00	60.00	48.00	38.00
3	32.00	46.00	61.00	48.00	37.50
4		46.00			
5					
Stable Q (L/30sec)	32.00	46.00	61.00	48.00	38.00
Leak Q (L/30sec)	0.55	0.55	0.55	0.55	0.55
Q (m^3/day)	90.6	130.9	174.1	136.7	107.9
Hf (m)	0.32	0.67	1.19	0.73	0.46
Hnit (m)	35.2	45.4	59.0	45.4	35.1
K (m/day)	1.8E-01	2.0E-01	2.0E-01	2.1E-01	2.1E-01
K (m/s)	**2.1E-06**	**2.3E-06**	**2.4E-06**	**2.4E-06**	**2.5E-06**
+/- (m/s)	2.0E-07	5.2E-08	0.0E+00	-5.2E-08	-2.0E-07
+/- order of mag.	0.04	0.01	0.00	-0.01	-0.04



WESA

PACKER INJECTION TEST

(page 2)

Drillhole Nº	JGW-2
Test hole Nº	N/A
Test Nº	4

Pressure oscillation during test

Pressure step	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
Min P during step	15	30	50	30	15
Max P during step	15	30	50	30	15
average pressure +/- psi					

Flowmeter measurement reading accuracy

volume +/- Liters / 30 sec					

High estimate of K

Q_{avg} (m^3/day)	90.58	130.90	174.10	136.66	107.86
Hf (m)	0.32	0.67	1.19	0.73	0.46
Hnit (m)	35.2	45.4	59.0	45.4	35.1
K (m/sec)	2.1E-06	2.3E-06	2.4E-06	2.4E-06	2.5E-06

Low estimate of K

Q_{avg} (m^3/day)	90.58	130.90	174.10	136.66	107.86
Hf (m)	0.32	0.67	1.19	0.73	0.46
Hnit (m)	35.2	45.4	59.0	45.4	35.1
K (m/sec)	2.1E-06	2.3E-06	2.4E-06	2.4E-06	2.5E-06

K averages for P step — m/second

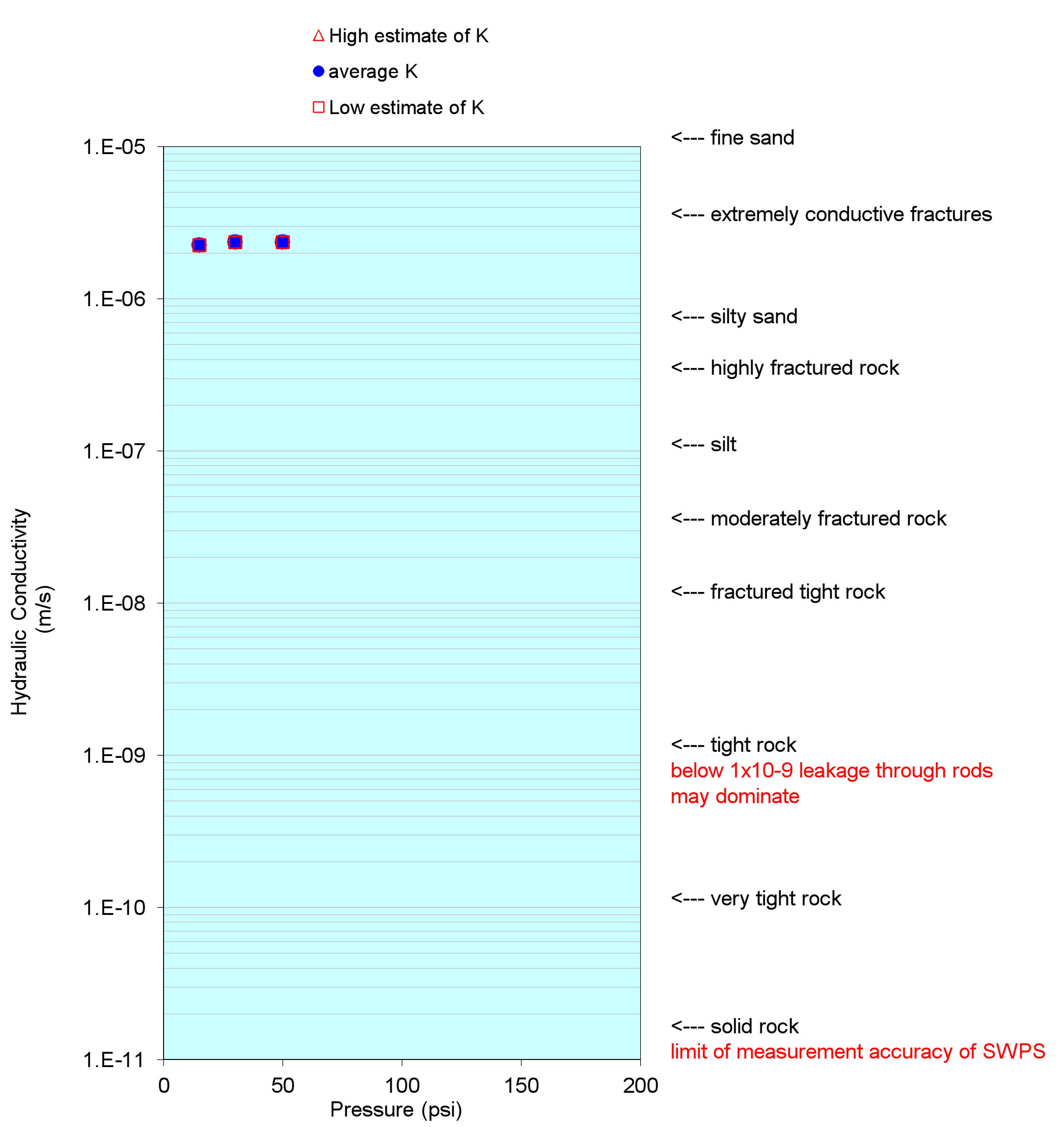
P	15	30	50
high est of K	2.E-06	2.E-06	2.E-06
average K	2.E-06	2.E-06	2.E-06
low est of K	2.E-06	2.E-06	2.E-06

K avg all P steps

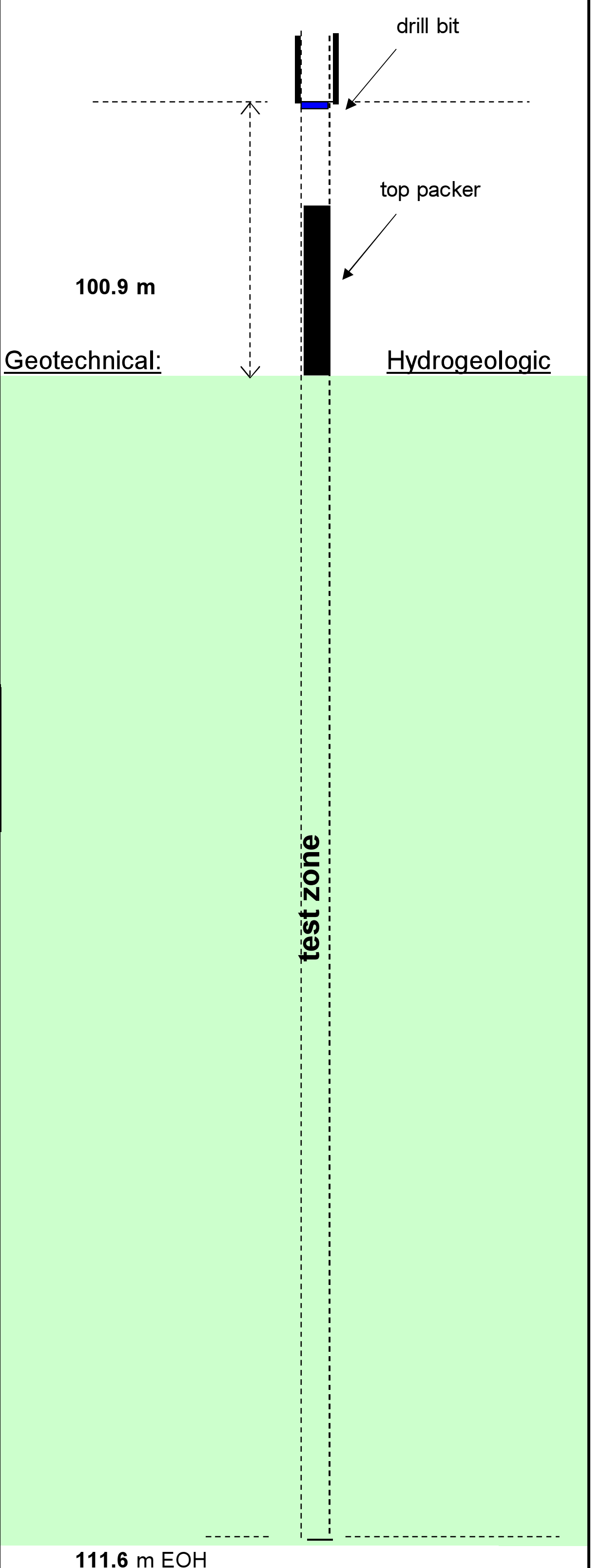
	m/sec	m/day
MAX	2.E-06	2.0E-01
geomean	2.E-06	2.0E-01
MIN	2.E-06	2.0E-01

Comments:

Graph of estimated hydraulic conductivity and error bounds.



Drawing of zone tested, including geotech / hydrogeo. conditions:



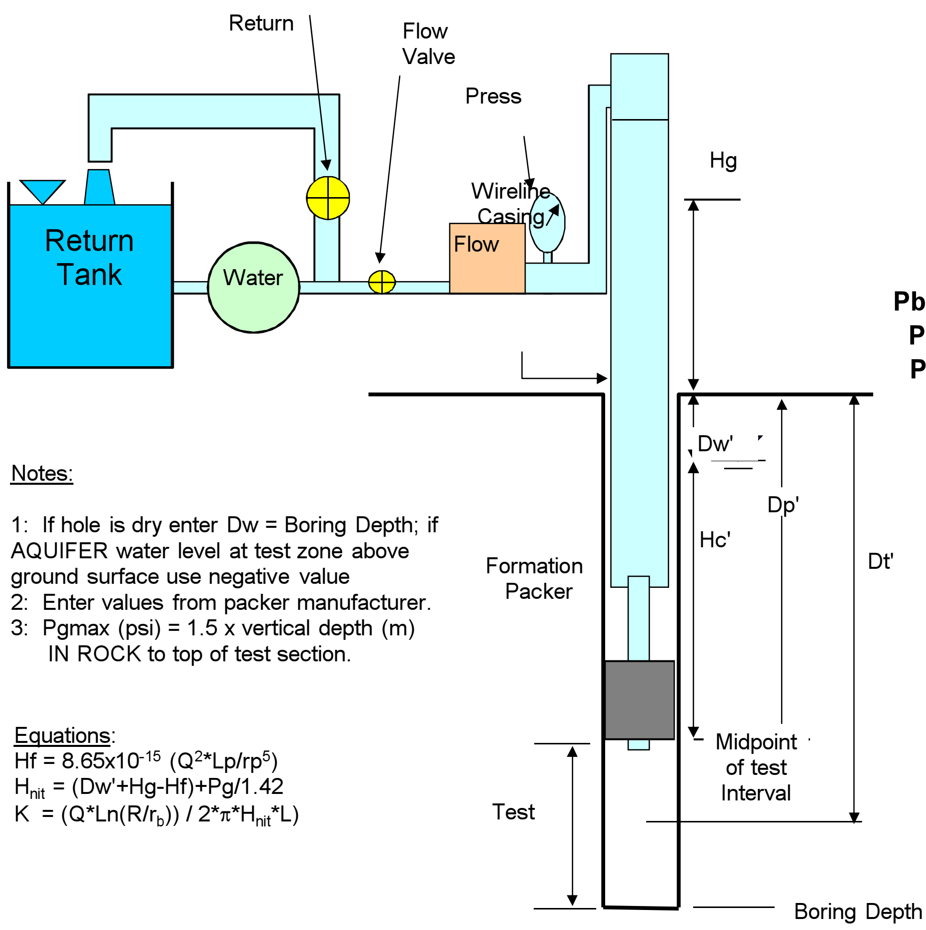
PACKER INJECTION TEST

WESA a BluMetric company

Project:	S-B12738	Test Interval (m):	121.9	to	141.6	Drillhole Nº	JGW-2
UTM (x,y)	658260, 6086594	Start Date:	Oct 6 2014	Time:	8:30	Test hole Nº	N/A
Datum:		End Date:	Oct 6 2014	Time:	10:00	Test Nº	5
GS Elevation:		Supervisor:	VM/DP	Rig:	LF-70	DH Depth (m)	141.6

Max Injection P (psi)

183



Dw	Measured depth of static water level (1)	23.0	
Dbr	Measured depth to bedrock	0.6	m
Dp	Measured depth to packer	121.9	m
Dt	Measured depth to midpoint of test	131.8	m
ß	Inclination from horizontal (degrees)	90	º
Dw'	Vertical depth to static water level	23.0	m
Dbr'	Vertical dept to bedrock	0.6	m
Dp'	Vertical depth to packer	121.9	m
Dt'	Vertical depth to midpoint of test	131.8	m
SP	Shear Pin Rating (psi)	500	psi
Pblowout	Water column pressure in drill rods at plug	173	psi
Pshear	Estimated differential shear pressure required	500	psi
Pgmax	Maximum injection gauge pressure (3)	197	psi
Hg	Gauge height	2.0	m
Dp'	Length of discharge pipe	1.50	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0127	m
R	Radius of influence (10 m is standard value)	5	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.048	m
L	Length of test section	19.7	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		

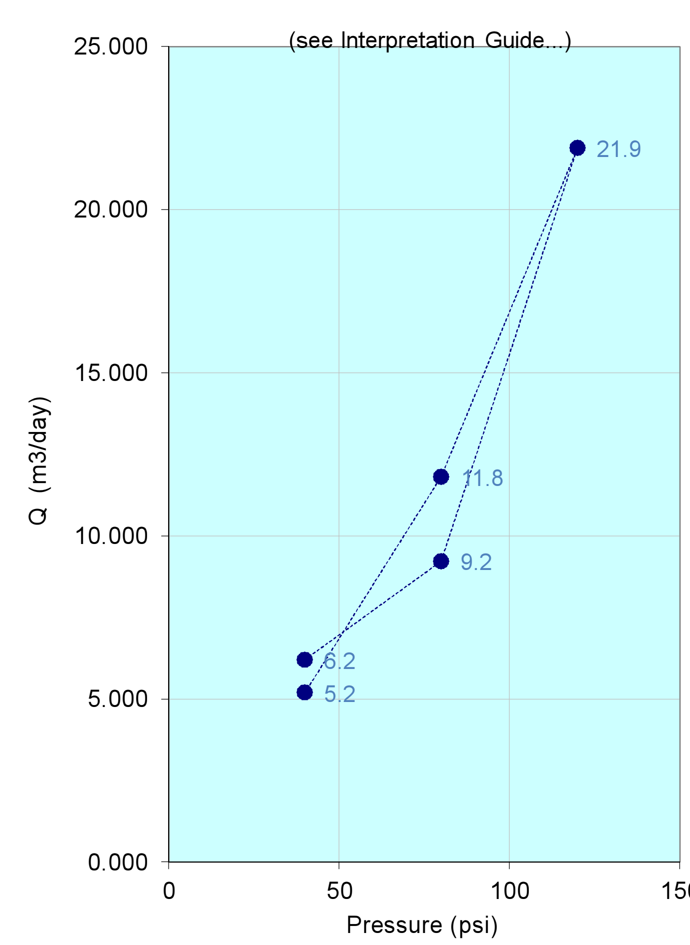
Notes:

1: If hole is dry enter Dw = Boring Depth; if AQUIFER water level at test zone above ground surface use negative value
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m) IN ROCK to top of test section.

Equations:
$H_f = 8.65\times10^{-15}\ (Q^2 \cdot L_p/r_p^5)$
$H_{nit} = (Dw'+Hg-Hf)+Pg/1.42$
$K = (Q \cdot \ln(R/r_b)) / 2 \cdot \pi \cdot H_{nit} \cdot L)$

Conversion Factors:
10 m of water = 0.9807 bar = 1kg/cm^2 = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bar, which is approx. 1.4 x 10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement (show last 3 to 5 flow meter readings)	Q (Liters / 30sec)				
	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
	40	80	120	80	40
1	4.05	4.60	9.70	4.60	2.65
2	3.85	5.30	8.80	5.30	2.65
3	3.60	4.30	9.00	5.20	2.65
4	3.00	4.40	9.00	5.20	
5	3.00	4.40	8.70	5.70	
Stable Q (L/30sec)	3.00	4.40	9.00	5.30	2.65
Leak Q (L/30sec)	0.85	1.20	1.40	1.20	0.85
Q (m^3/day)	6.2	9.2	21.9	11.8	5.2
Hf (m)	0.00	0.00	0.02	0.01	0.00
Hnit (m)	53.1	81.3	109.5	81.3	53.1
K (m/day)	4.4E-03	4.3E-03	7.5E-03	5.5E-03	3.7E-03
K (m/s)	**5.1E-08**	**4.9E-08**	**8.7E-08**	**6.3E-08**	**4.2E-08**
+/- (m/s)	-4.1E-09	6.9E-09	0.0E+00	-6.9E-09	4.1E-09
+/- order of mag.	-0.04	0.06	0.00	-0.05	0.04



WESA a BluMetric company	PACKER INJECTION TEST (page 2)	Drillhole Nº	JGW-2
		Test hole Nº	N/A
		Test Nº	5

Pressure oscillation during test

Pressure step	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
Min P during step	40	80	120	80	40
Max P during step	40	80	120	80	40
average pressure +/- psi					

Flowmeter measurement reading accuracy

volume +/- Liters / 30 sec					

High estimate of K

Q_{avg} (m^3/day)	6.19	9.22	21.89	11.81	5.18
Hf (m)	0.00	0.00	0.02	0.01	0.00
Hnit (m)	53.1	81.3	109.5	81.3	53.1
K (m/sec)	5.1E-08	4.9E-08	8.7E-08	6.3E-08	4.2E-08

Low estimate of K

Q_{avg} (m^3/day)	6.19	9.22	21.89	11.81	5.18
Hf (m)	0.00	0.00	0.02	0.01	0.00
Hnit (m)	53.1	81.3	109.5	81.3	53.1
K (m/sec)	5.1E-08	4.9E-08	8.7E-08	6.3E-08	4.2E-08

K averages for P step (m/second)

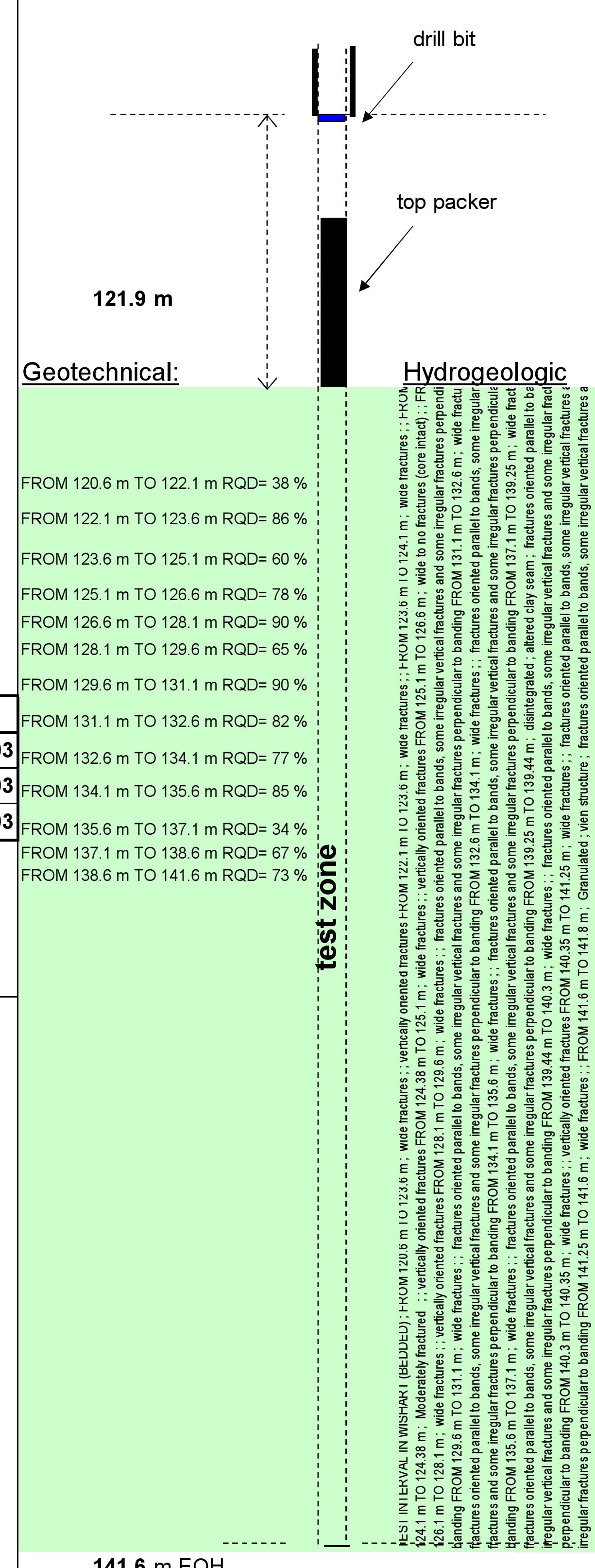
P	40	80	120
high est of K	5.E-08	6.E-08	9.E-08
average K	5.E-08	6.E-08	9.E-08
low est of K	5.E-08	6.E-08	9.E-08

K avg all P steps

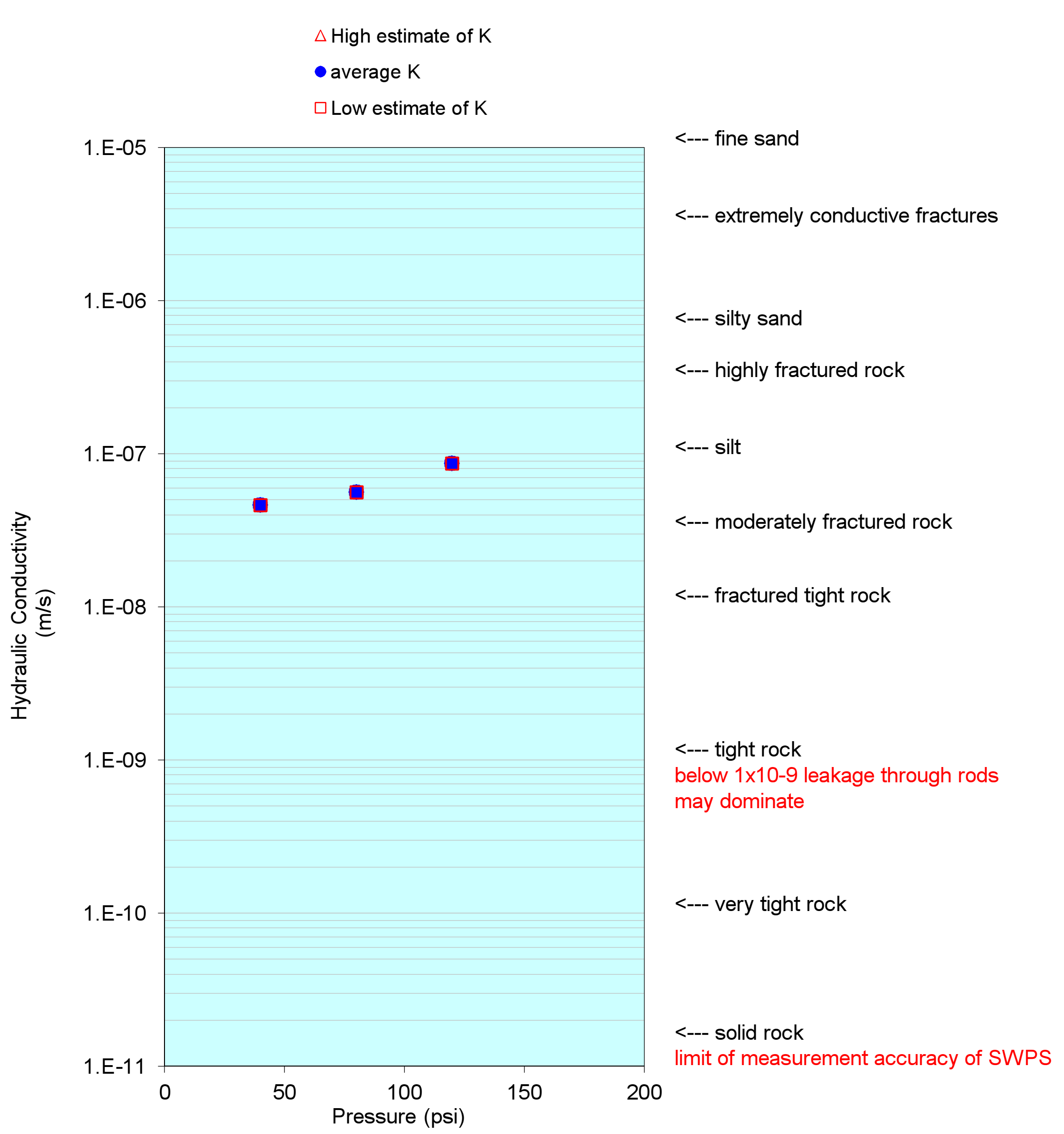
	m/sec	m/day
MAX	9.E-08	7.5E-03
geomean	6.E-08	5.3E-03
MIN	5.E-08	4.0E-03

Comments:

Drawing of zone tested, including geotech / hydrogeo. conditions:



Graph of estimated hydraulic conductivity and error bounds.



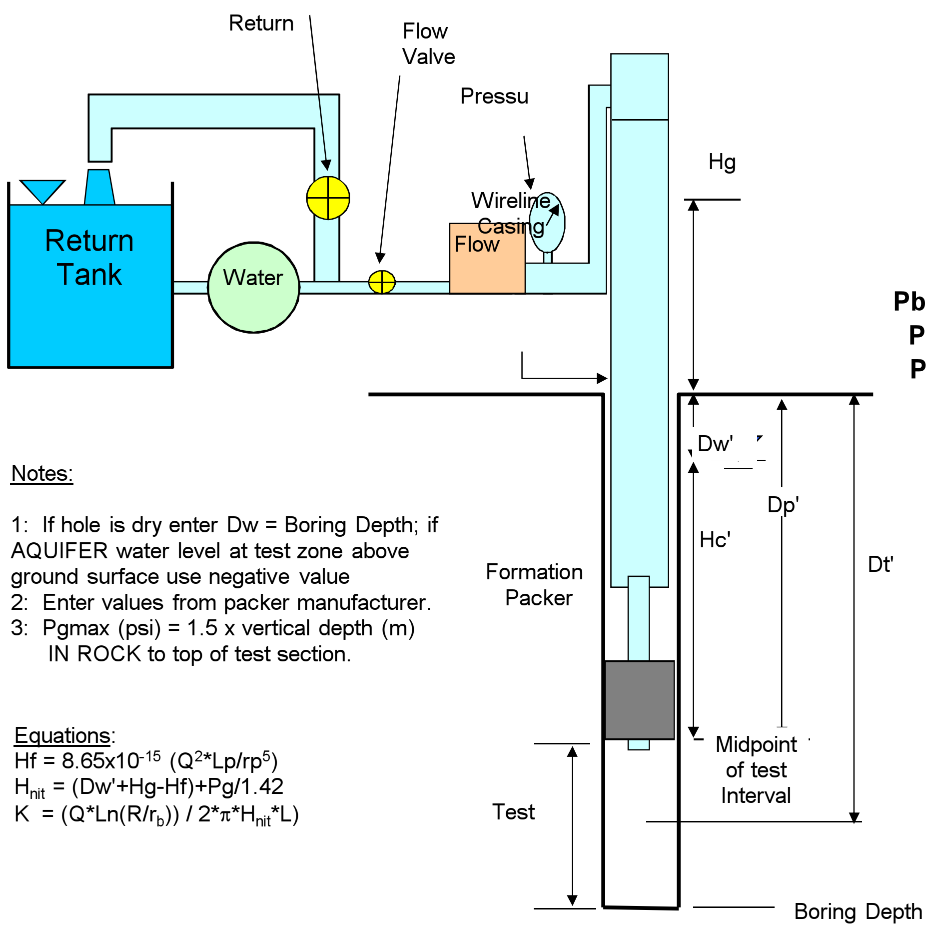
PACKER INJECTION TEST

WESA – a BluMetric company

Project:	S-B12738	**Test Interval (m):**	154.9	**to**	164.1	**Drillhole N°**	JGW-2
UTM (x,y)	658260, 6086594	**Start Date:**	Oct 6 2014	**Time:**	22:30	**Test hole N°**	N/A
Datum:		**End Date:**	Oct 6 2014	**Time:**	0:30	**Test N°**	6
GS Elevation:		**Supervisor:**	VM/DP	**Rig:**	LF-70	**DH Depth (m)**	164.1

Max Injection P (psi)

232



Dw	Measured depth of static water level (1)	23.0	
Dbr	Measured depth to bedrock	0.6	m
Dp	Measured depth to packer	154.9	m
Dt	Measured depth to midpoint of test	159.5	m
ß	Inclination from horizontal (degrees)	90	°
Dw'	Vertical depth to static water level	23.0	m
Dbr'	Vertical dept to bedrock	0.6	m
Dp'	Vertical depth to packer	154.9	m
Dt'	Vertical depth to midpoint of test	159.5	m
SP	Shear Pin Rating (psi)	500	psi
Pblowout	Water column pressure in drill rods at plug	220	psi
Pshear	Estimated differential shear pressure required	500	psi
Pgmax	Maximum injection gauge pressure (3)	238	psi
Hg	Gauge height	2.0	m
Dp'	Length of discharge pipe	1.50	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0127	m
R	Radius of influence (10 m is standard value)	5	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.048	m
L	Length of test section	9.2	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		

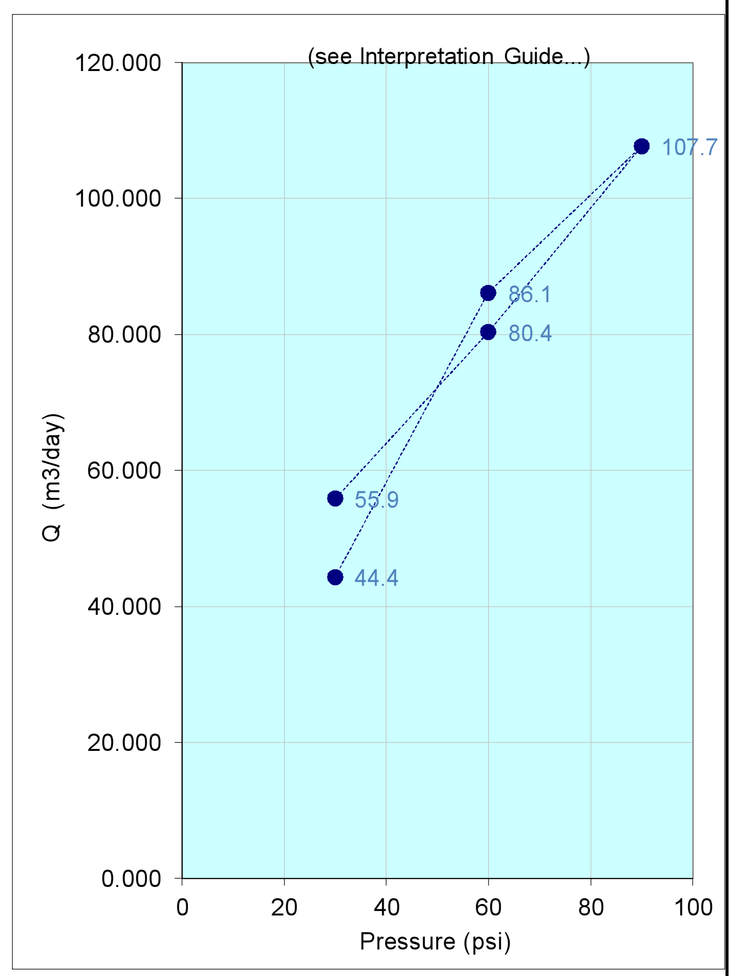
Notes:

1: If hole is dry enter Dw = Boring Depth; if AQUIFER water level at test zone above ground surface use negative value
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m) IN ROCK to top of test section.

Equations:
$Hf = 8.65x10^{-15} (Q^2*Lp/rp^5)$
$H_{nit} = (Dw'+Hg-Hf)+Pg/1.42$
$K = (Q*Ln(R/r_b)) / 2*\pi*H_{nit}*L)$

Conversion Factors:
10 m of water = 0.9807 bar = 1kg/cm^2 = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bar, which is approx. 1.4 x 10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement (show last 3 to 5 flow meter readings)	Q (Liters / 30sec)				
	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
	30	60	90	60	30
1	18.00	33.00	40.00	31.00	23.00
2	18.00	32.00	40.00	31.00	22.00
3	19.00	32.00	41.00	33.00	22.00
4	18.00	33.00		31.00	22.00
5					
Stable Q (L/30sec)	18.00	33.00	41.00	31.00	22.00
Leak Q (L/30sec)	2.60	3.10	3.60	3.10	2.60
Q (m^3/day)	44.4	86.1	107.7	80.4	55.9
Hf (m)	0.08	0.29	0.46	0.25	0.12
Hnit (m)	46.0	66.9	87.9	67.0	46.0
K (m/day)	7.7E-02	1.0E-01	9.8E-02	9.6E-02	9.8E-02
K (m/s)	**9.0E-07**	**1.2E-06**	**1.1E-06**	**1.1E-06**	**1.1E-06**
+/- (m/s)	1.2E-07	-4.0E-08	0.0E+00	4.0E-08	-1.2E-07
+/- order of mag.	0.05	-0.01	0.00	0.02	-0.05



WESA a BluMetric company	PACKER INJECTION TEST (page 2)	Drillhole Nº	JGW-2
		Test hole Nº	N/A
		Test Nº	6

Pressure oscillation during test

Pressure step	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
Min P during step	30	60	90	60	30
Max P during step	30	60	90	60	30
average pressure +/- psi					

Flowmeter measurement reading accuracy

volume +/- Liters / 30 sec					

High estimate of K

Q_{avg} (m^3/day)	44.35	86.11	107.71	80.35	55.87
Hf (m)	0.08	0.29	0.46	0.25	0.12
Hnit (m)	46.0	66.9	87.9	67.0	46.0
K (m/sec)	9.0E-07	1.2E-06	1.1E-06	1.1E-06	1.1E-06

Low estimate of K

Q_{avg} (m^3/day)	44.35	86.11	107.71	80.35	55.87
Hf (m)	0.08	0.29	0.46	0.25	0.12
Hnit (m)	46.0	66.9	87.9	67.0	46.0
K (m/sec)	9.0E-07	1.2E-06	1.1E-06	1.1E-06	1.1E-06

K averages for P step m/second

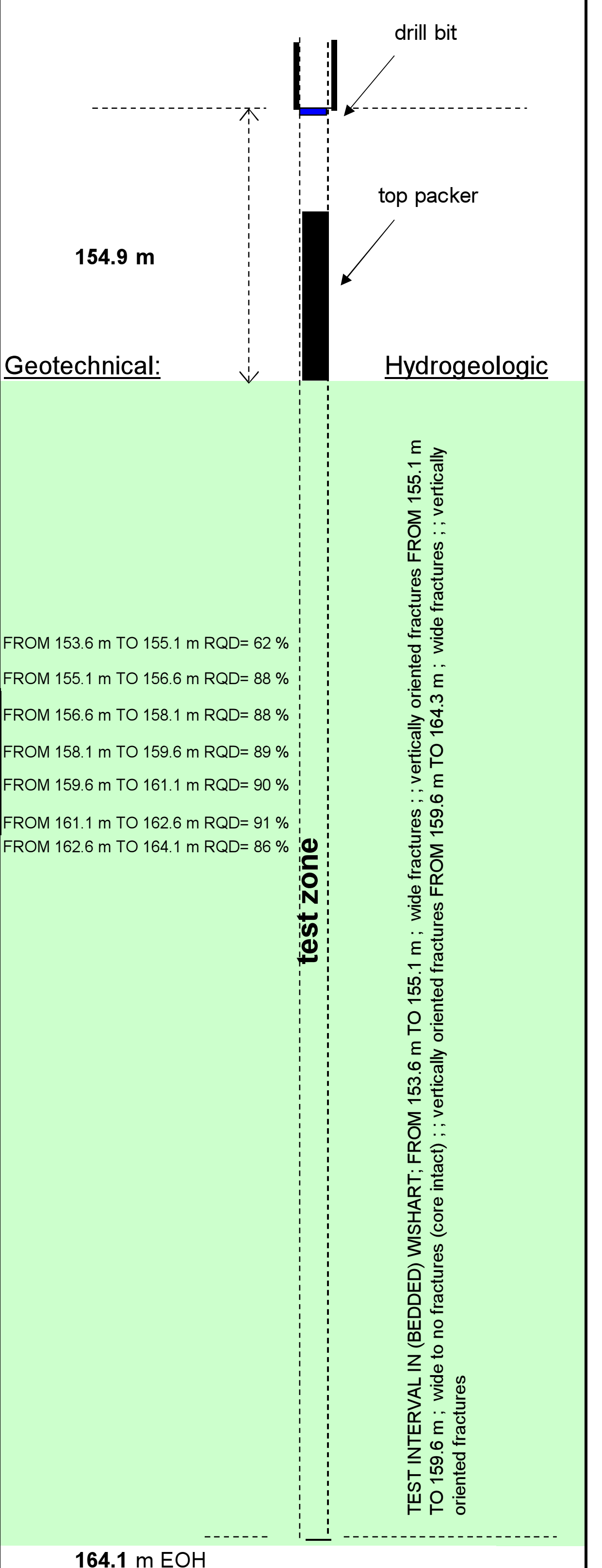
P	30	60	90
high est of K	1.E-06	1.E-06	1.E-06
average K	1.E-06	1.E-06	1.E-06
low est of K	1.E-06	1.E-06	1.E-06

K avg all P steps

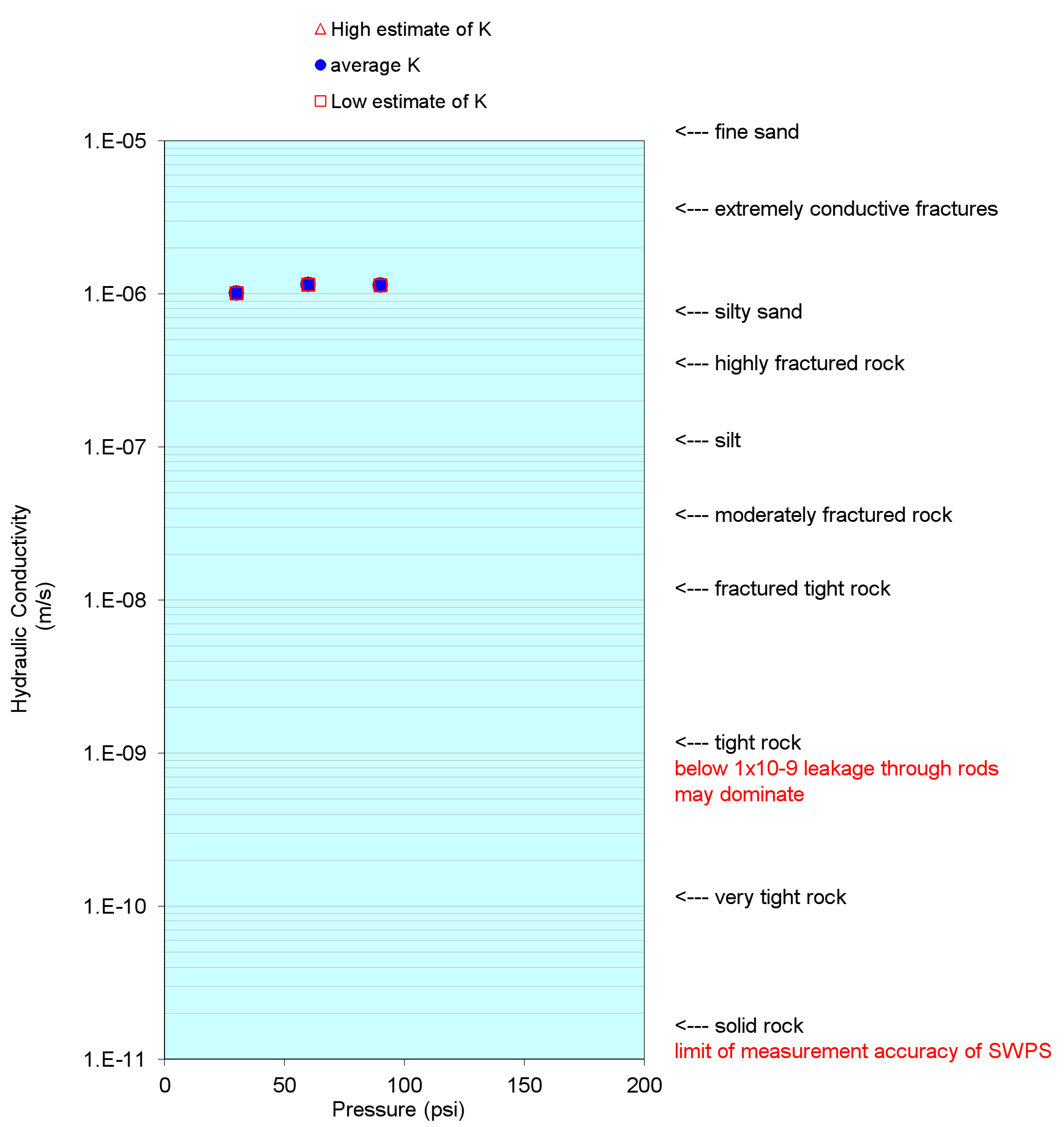
	m/sec	m/day
MAX	1.E-06	1.0E-01
geomean	1.E-06	9.5E-02
MIN	1.E-06	8.8E-02

Comments:

Drawing of zone tested, including geotech / hydrogeo. conditions:



Graph of estimated hydraulic conductivity and error bounds.



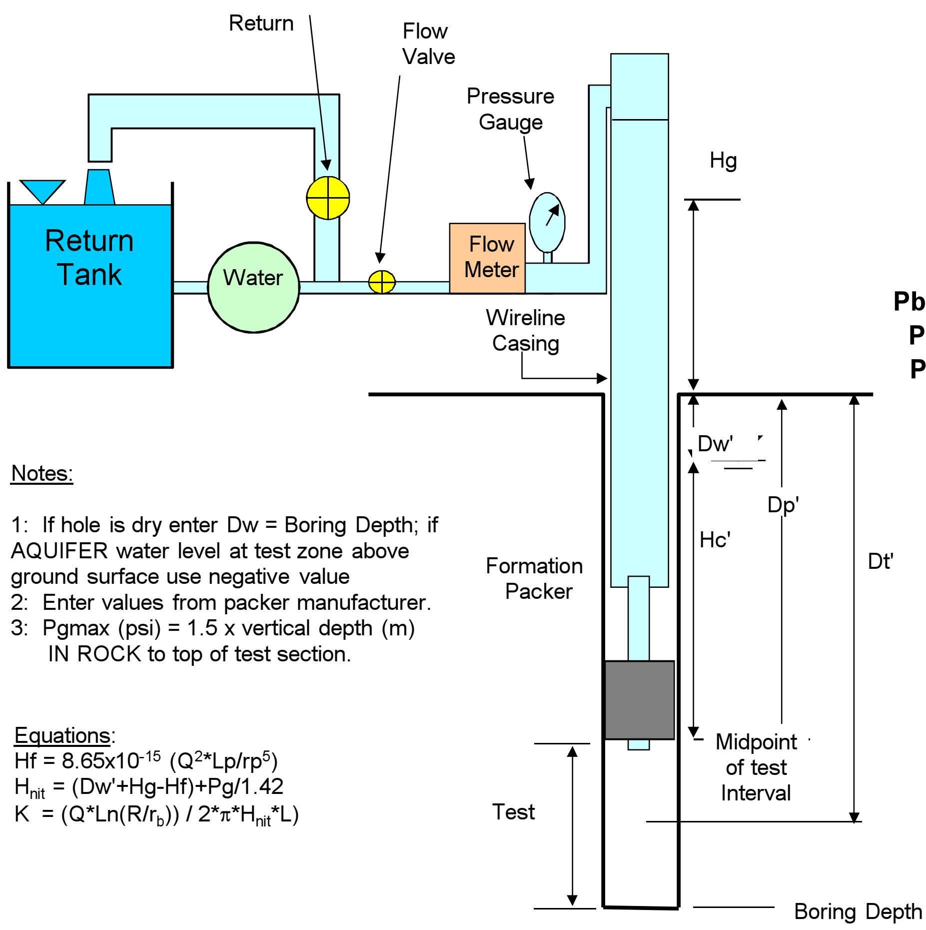
PACKER INJECTION TEST

WESA a BluMetric company

Project:	S-B12738	**Test Interval (m):**	159.9	**to**	170.6	**Drillhole N°**	JGW-2
UTM (x,y)	658260, 6086594	**Start Date:**	Oct 6 2014	**Time:**	22:30	**Test hole N°**	N/A
Datum:		**End Date:**	Oct 6 2014	**Time:**	0:30	**Test N°**	7
GS Elevation:		**Supervisor:**	VM/DP	**Rig:**	LF-70	**DH Depth (m)**	170.6

Max Injection P (psi)

240



Notes:

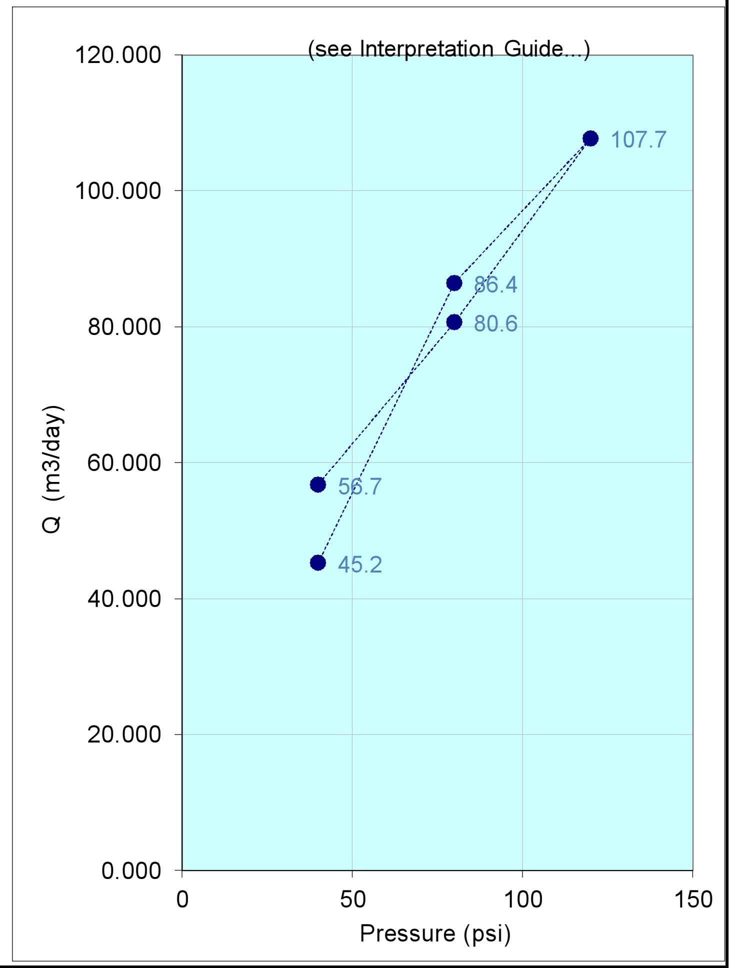
1: If hole is dry enter Dw = Boring Depth; if AQUIFER water level at test zone above ground surface use negative value
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m) IN ROCK to top of test section.

Equations:
$Hf = 8.65 \times 10^{-15} (Q^2 * Lp/rp^5)$
$H_{nit} = (Dw' + Hg - Hf) + Pg/1.42$
$K = (Q * Ln(R/r_b)) / 2 * \pi * H_{nit} * L)$

Dw	Measured depth of static water level (1)	23.0	
Dbr	Measured depth to bedrock	0.6	m
Dp	Measured depth to packer	159.9	m
Dt	Measured depth to midpoint of test	165.3	m
ß	Inclination from horizontal (degrees)	90	°
Dw'	Vertical depth to static water level	23.0	m
Dbr'	Vertical dept to bedrock	0.6	m
Dp'	Vertical depth to packer	159.9	m
Dt'	Vertical depth to midpoint of test	165.3	m
SP	Shear Pin Rating (psi)	500	psi
Pblowout	Water column pressure in drill rods at plug	227	psi
Pshear	Estimated differential shear pressure required	500	psi
Pgmax	Maximum injection gauge pressure (3)	247	psi
Hg	Gauge height	2.0	m
Dp'	Length of discharge pipe	1.50	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0127	m
R	Radius of influence (10 m is standard value)	5	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.048	m
L	Length of test section	10.7	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		

Conversion Factors:
10 m of water = 0.9807 bar = 1kg/cm^2 = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bar, which is approx. 1.4 x 10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement (show last 3 to 5 flow meter readings)	**Q (Liters / 30sec)**				
	P_g (psi) Step 1	**P_g (psi) Step 2**	**P_g (psi) Step 3**	**P_g (psi) Step 4**	**P_g (psi) Step 5**
	40	**80**	**120**	**80**	**40**
1	18.00	33.00	40.00	31.00	23.00
2	18.00	32.00	40.00	31.00	22.00
3	19.00	32.00	41.00	33.00	22.00
4	18.00	33.00		31.00	22.00
5					
Stable Q (L/30sec)	18.00	33.00	41.00	31.00	22.00
Leak Q (L/30sec)	2.30	3.00	3.60	3.00	2.30
Q (m^3/day)	45.2	86.4	107.7	80.6	56.7
Hf (m)	0.08	0.29	0.46	0.26	0.13
Hnit (m)	53.1	81.0	109.0	81.1	53.0
K (m/day)	5.9E-02	7.4E-02	6.8E-02	6.9E-02	7.4E-02
K (m/s)	**6.8E-07**	**8.5E-07**	**7.9E-07**	**8.0E-07**	**8.6E-07**
+/- (m/s)	8.7E-08	-2.9E-08	0.0E+00	2.9E-08	-8.7E-08
+/- order of mag.	0.05	-0.01	0.00	0.02	-0.05



WESA
a BluMetric company

PACKER INJECTION TEST
(page 2)

Drillhole Nº	JGW-2
Test hole Nº	N/A
Test Nº	7

Pressure oscillation during test

Pressure step	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
Min P during step	40	80	120	80	40
Max P during step	40	80	120	80	40
average pressure +/- psi					

Flowmeter measurement reading accuracy

volume +/- Liters / 30 sec					

High estimate of K

Q_{avg} (m^3/day)	45.22	86.40	107.71	80.64	56.74
Hf (m)	0.08	0.29	0.46	0.26	0.13
Hnit (m)	53.1	81.0	109.0	81.1	53.0
K (m/sec)	6.8E-07	8.5E-07	7.9E-07	8.0E-07	8.6E-07

Low estimate of K

Q_{avg} (m^3/day)	45.22	86.40	107.71	80.64	56.74
Hf (m)	0.08	0.29	0.46	0.26	0.13
Hnit (m)	53.1	81.0	109.0	81.1	53.0
K (m/sec)	6.8E-07	8.5E-07	7.9E-07	8.0E-07	8.6E-07

K averages for P step — m/second

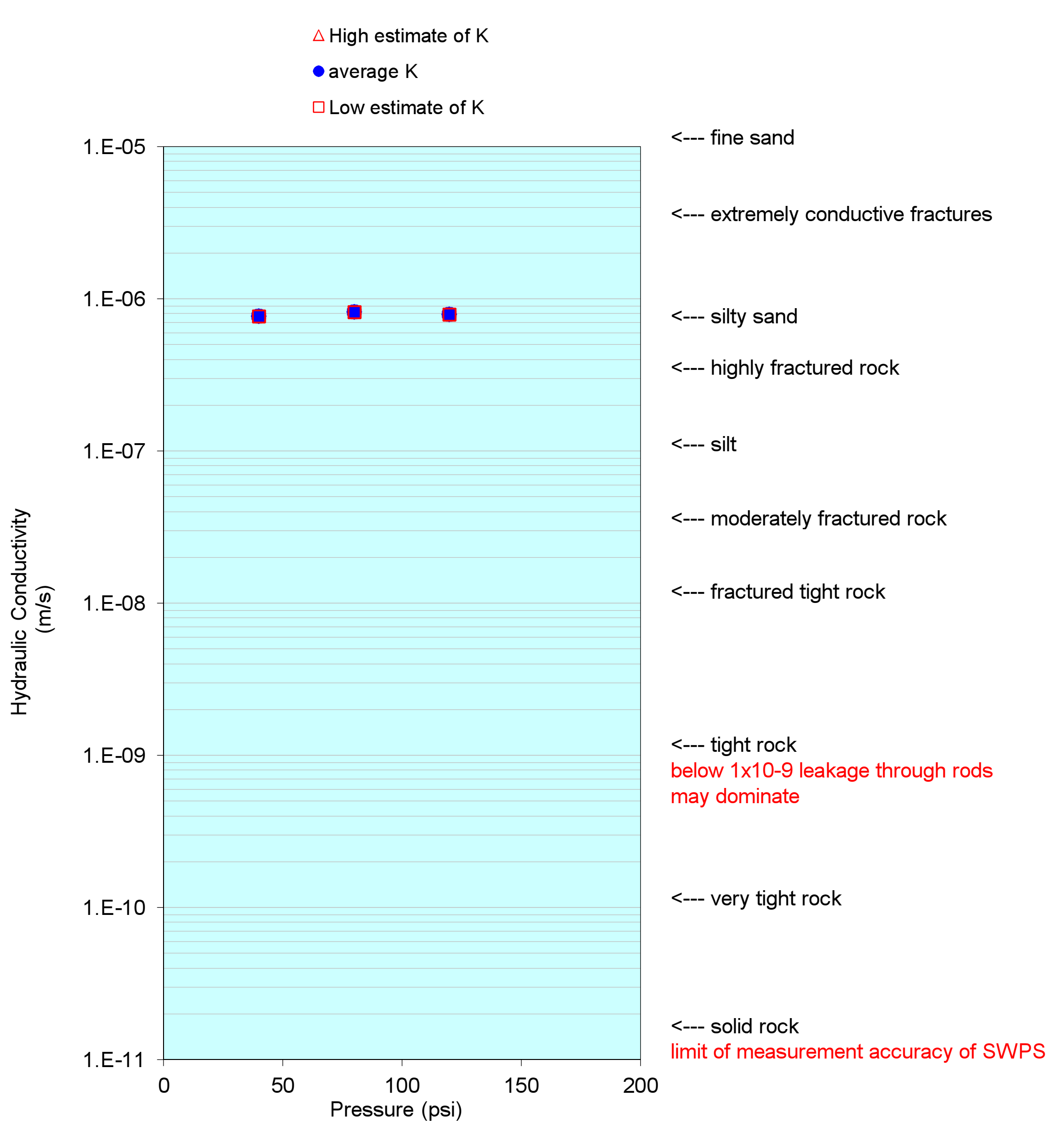
P	40	80	120
high est of K	8.E-07	8.E-07	8.E-07
average K	8.E-07	8.E-07	8.E-07
low est of K	8.E-07	8.E-07	8.E-07

K avg all P steps

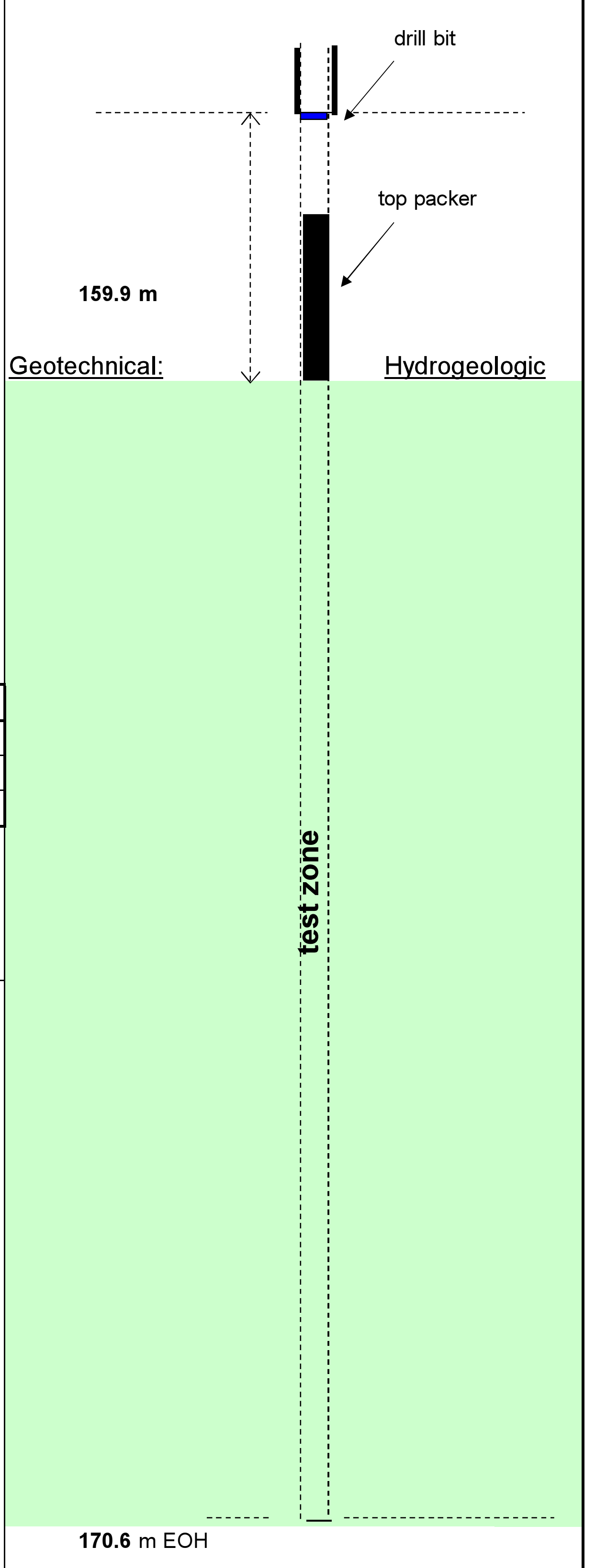
	m/sec	m/day
MAX	8.E-07	7.1E-02
geomean	8.E-07	6.9E-02
MIN	8.E-07	6.6E-02

Comments:

Graph of estimated hydraulic conductivity and error bounds.



Drawing of zone tested, including geotech / hydrogeo. conditions:



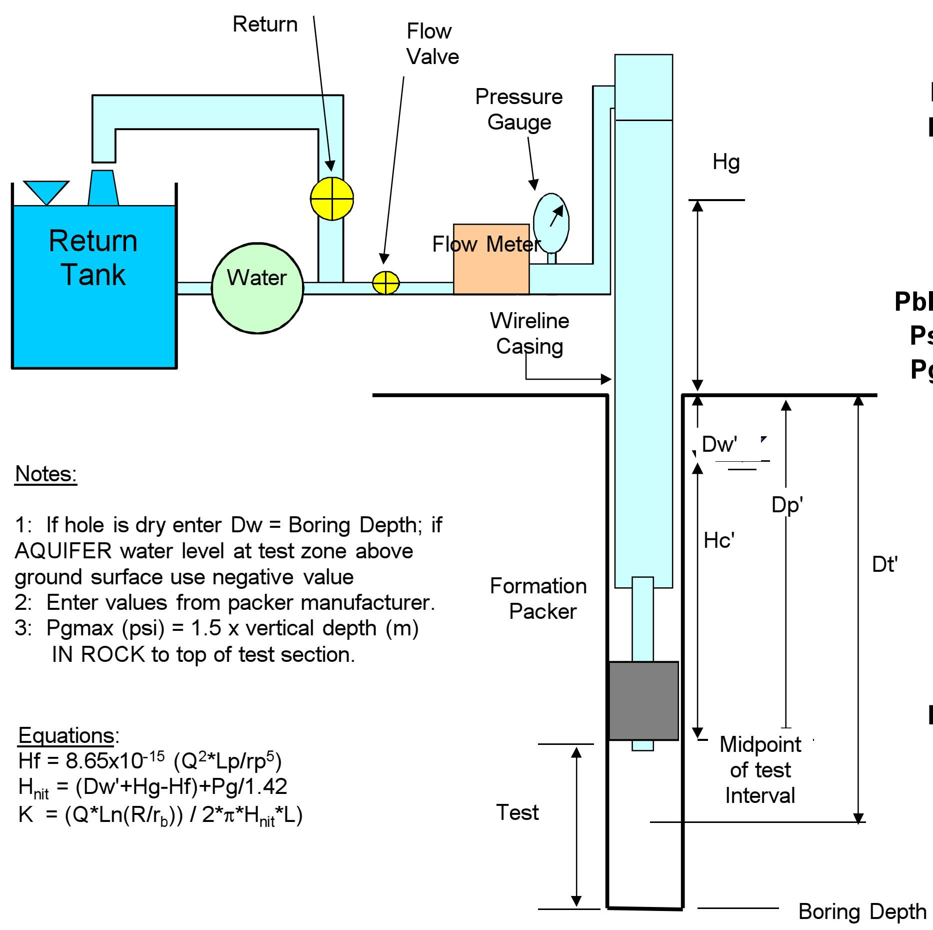
WESA

PACKER INJECTION TEST

Project:	S-B12738	**Test Interval (m):**	64.3	**to**	75.0	**Drillhole N°**	JGW-3
UTM (x,y)	658211.292, 6086278.287	**Start Date:**	Sep 23 2014	**Time:**	16:20	**Test hole N°**	N/A
Datum:		**End Date:**	Sep 23 2014	**Time:**	17:45	**Test N°**	1
GS Elevation:		**Supervisor:**	VM/DP	**Rig:**	LF-70	**DH Depth (m)**	75.0

Max Injection P (psi)

96



Dw	Measured depth of static water level (1)	10.1	
Dbr	Measured depth to bedrock	0.3	m
Dp	Measured depth to packer	**64.3**	m
Dt	Measured depth to midpoint of test	**69.7**	m
ß	Inclination from horizontal (degrees)	85	°
Dw'	Vertical depth to static water level	**10.0**	m
Dbr'	Vertical dept to bedrock	**0.3**	m
Dp'	Vertical depth to packer	**64.1**	m
Dt'	Vertical depth to midpoint of test	**69.4**	m
SP	Shear Pin Rating (psi)	500	psi
Pblowout	Water column pressure in drill rods at plug	**91**	psi
Pshear	Estimated differential shear pressure required	**500**	psi
Pgmax	Maximum injection gauge pressure (3)	**104**	psi
Hg	Gauge height	1.0	m
Dp'	Length of discharge pipe	1.50	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0127	m
R	Radius of influence (10 m is standard value)	5	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.048	m
L	Length of test section	**10.7**	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		

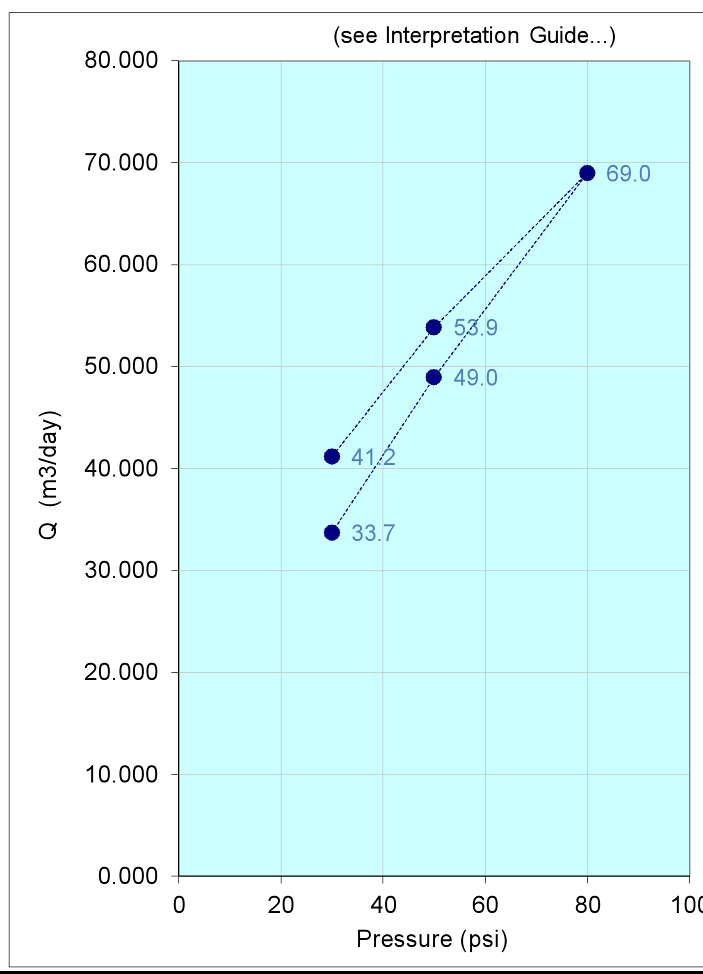
Notes:

1: If hole is dry enter Dw = Boring Depth; if AQUIFER water level at test zone above ground surface use negative value
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m) IN ROCK to top of test section.

Equations:
$H_f = 8.65\times10^{-15}$ $(Q^2 \cdot Lp/rp^5)$
$H_{nit} = (Dw' + Hg - Hf) + Pg/1.42$
$K = (Q \cdot \ln(R/r_b)) / 2 \cdot \pi \cdot H_{nit} \cdot L)$

Conversion Factors:
10 m of water = 0.9807 bar = 1kg/cm^2 = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bar, which is approx. 1.4 x 10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement (show last 3 to 5 flow meter readings)	Q (Liters / 30sec)				
	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
	30	50	80	50	30
1	11.80	16.40	24.80	19.20	14.60
2	12.20	18.60	24.80	19.30	14.10
3	12.00	17.80	24.90	19.20	14.90
4		17.50	24.40	19.10	14.00
5		16.80	25.10	19.00	14.60
Stable Q (L/30sec)	12.00	17.50	24.80	19.20	14.60
Leak Q (L/30sec)	0.30	0.50	0.85	0.50	0.30
Q (m^3/day)	33.7	49.0	69.0	53.9	41.2
Hf (m)	0.04	0.09	0.19	0.11	0.07
Hnit (m)	32.1	46.1	67.2	46.1	32.1
K (m/day)	7.3E-02	7.3E-02	7.1E-02	8.1E-02	8.9E-02
K (m/s)	**8.4E-07**	**8.5E-07**	**8.2E-07**	**9.3E-07**	**1.0E-06**
+/- (m/s)	9.4E-08	4.3E-08	0.0E+00	-4.3E-08	-9.4E-08
+/- order of mag.	0.05	0.02	0.00	-0.02	-0.04



WESA a BluMetric company	PACKER INJECTION TEST (page 2)	Drillhole Nº	JGW-3
		Test hole Nº	N/A
		Test Nº	1

Pressure oscillation during test

Pressure step	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
Min P during step	30	50	80	50	30
Max P during step	30	50	80	50	30
average pressure +/- psi					

Flowmeter measurement reading accuracy

volume +/- Liters / 30 sec					

High estimate of K

Q_{avg} (m^3/day)	33.70	48.96	68.98	53.86	41.18
Hf (m)	0.04	0.09	0.19	0.11	0.07
Hnit (m)	32.1	46.1	67.2	46.1	32.1
K (m/sec)	8.4E-07	8.5E-07	8.2E-07	9.3E-07	1.0E-06

Low estimate of K

Q_{avg} (m^3/day)	33.70	48.96	68.98	53.86	41.18
Hf (m)	0.04	0.09	0.19	0.11	0.07
Hnit (m)	32.1	46.1	67.2	46.1	32.1
K (m/sec)	8.4E-07	8.5E-07	8.2E-07	9.3E-07	1.0E-06

K averages for P step m/second

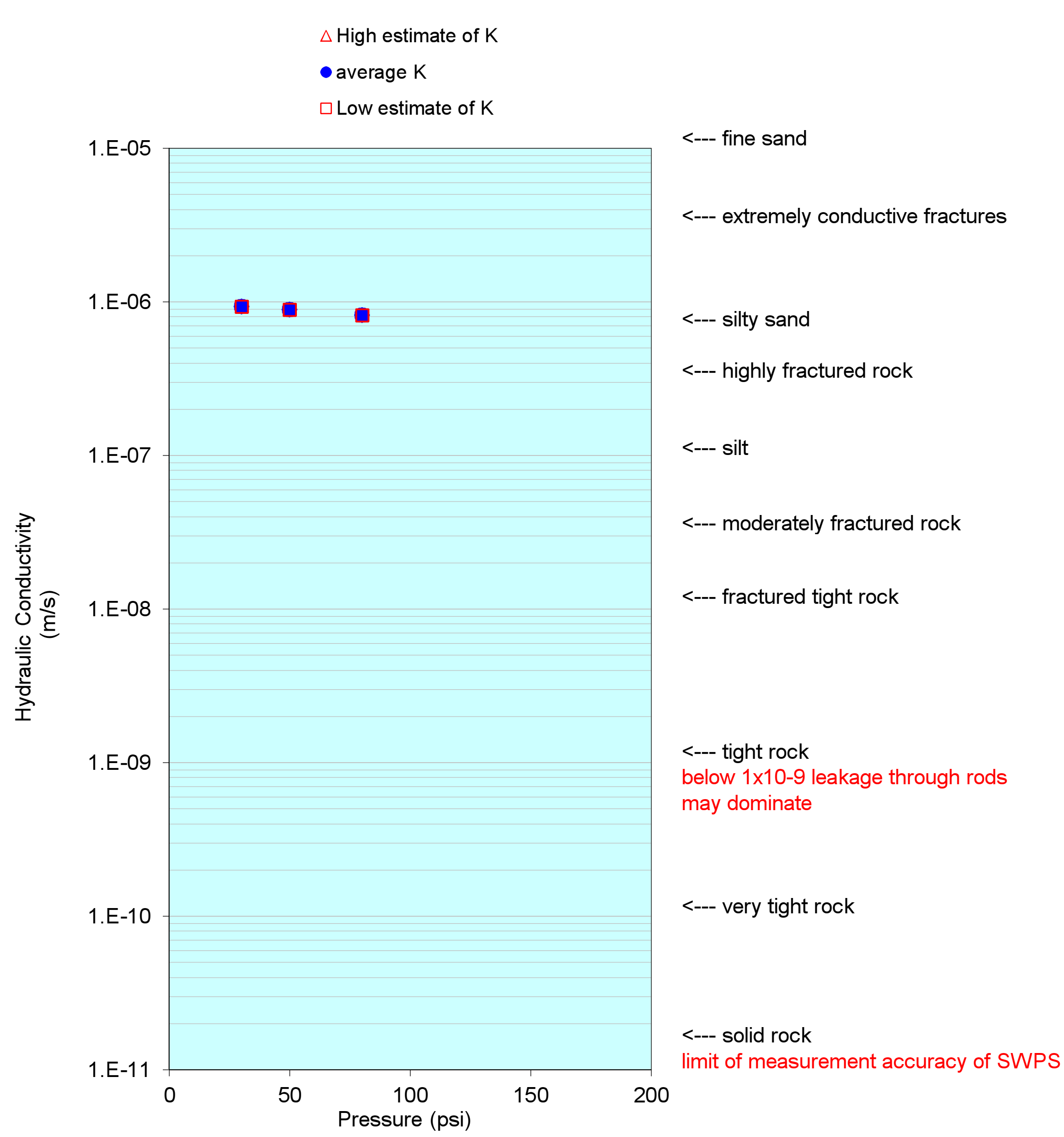
P	30	50	80
high est of K	9.E-07	9.E-07	8.E-07
average K	9.E-07	9.E-07	8.E-07
low est of K	9.E-07	9.E-07	8.E-07

K avg all P steps

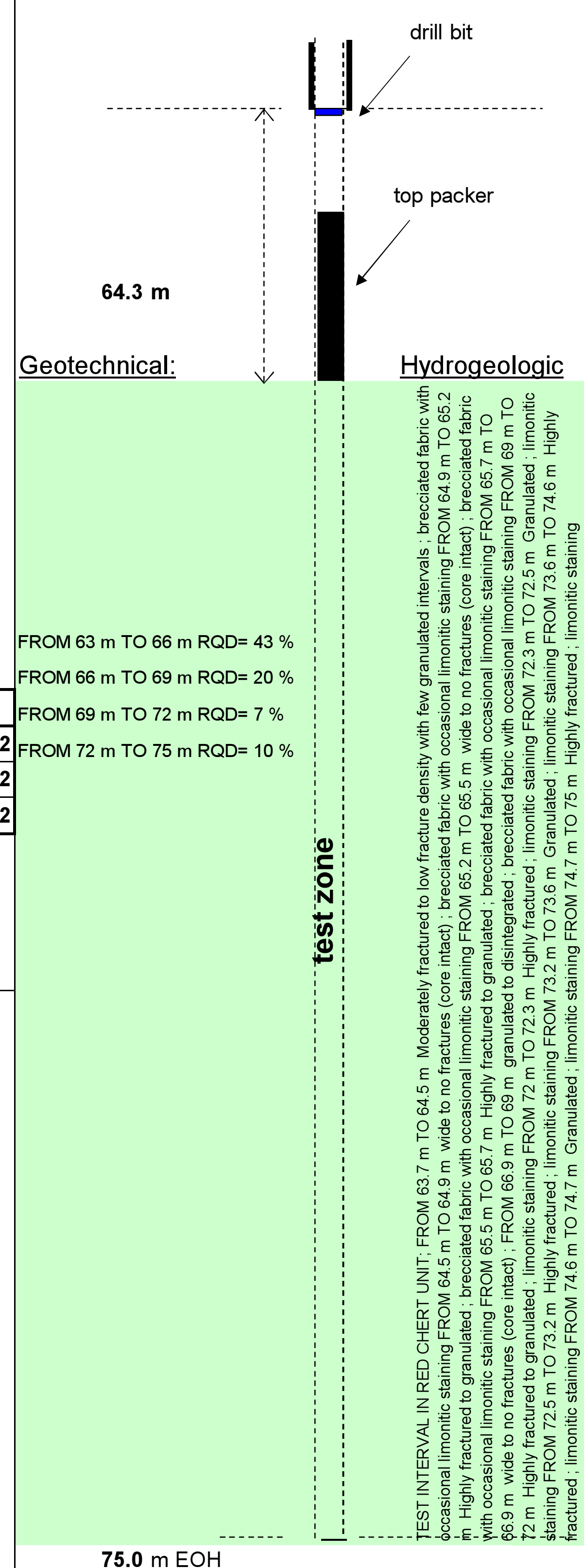
	m/sec	m/day
MAX	9.E-07	8.1E-02
geomean	9.E-07	7.6E-02
MIN	8.E-07	7.1E-02

Comments:

Graph of estimated hydraulic conductivity and error bounds.



Drawing of zone tested, including geotech / hydrogeo. conditions:



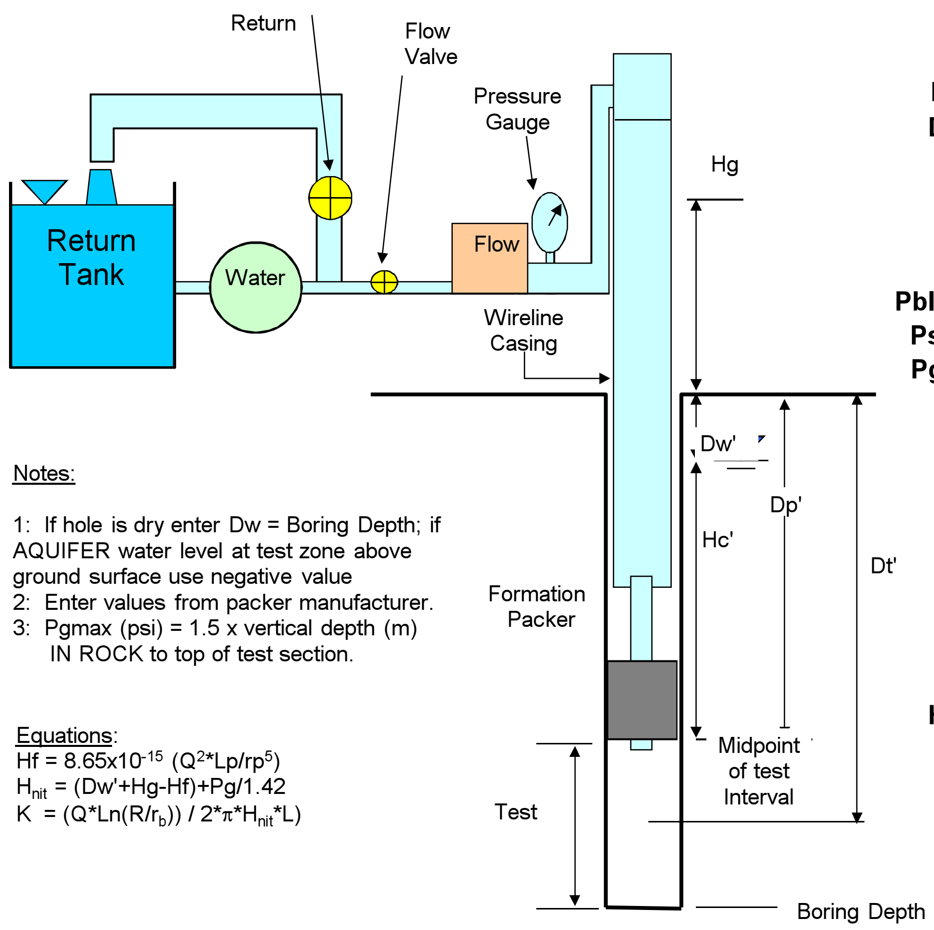
WESA a BluMetric company

PACKER INJECTION TEST

Project:	S-B12738	**Test Interval (m):**	74.8	**to**	99.0	**Drillhole N°**	JGW-3
UTM (x,y)	658211.292, 6086278.287	**Start Date:**	Sep 24 2014	**Time:**	N/A	**Test hole N°**	N/A
Datum:		**End Date:**	Sep 24 2014	**Time:**	N/A	**Test N°**	2
GS Elevation:		**Supervisor:**	VM/DP	**Rig:**	LF-70	**DH Depth (m)**	99.0

Max Injection P (psi)

112



Symbol	Description	Value	Unit
Dw	Measured depth of static water level (1)	10.1	
Dbr	Measured depth to bedrock	0.3	m
Dp	Measured depth to packer	74.8	m
Dt	Measured depth to midpoint of test	86.9	m
ß	Inclination from horizontal (degrees)	85	°
Dw'	Vertical depth to static water level	10.0	m
Dbr'	Vertical dept to bedrock	0.3	m
Dp'	Vertical depth to packer	74.5	m
Dt'	Vertical depth to midpoint of test	86.6	m
SP	Shear Pin Rating (psi)	500	psi
Pblowout	Water column pressure in drill rods at plug	106	psi
Pshear	Estimated differential shear pressure required	500	psi
Pgmax	Maximum injection gauge pressure (3)	129	psi
Hg	Gauge height	1.0	m
Dp'	Length of discharge pipe	1.50	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0127	m
R	Radius of influence (10 m is standard value)	5	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.048	m
L	Length of test section	24.2	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		

Notes:

1: If hole is dry enter Dw = Boring Depth; if AQUIFER water level at test zone above ground surface use negative value
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m) IN ROCK to top of test section.

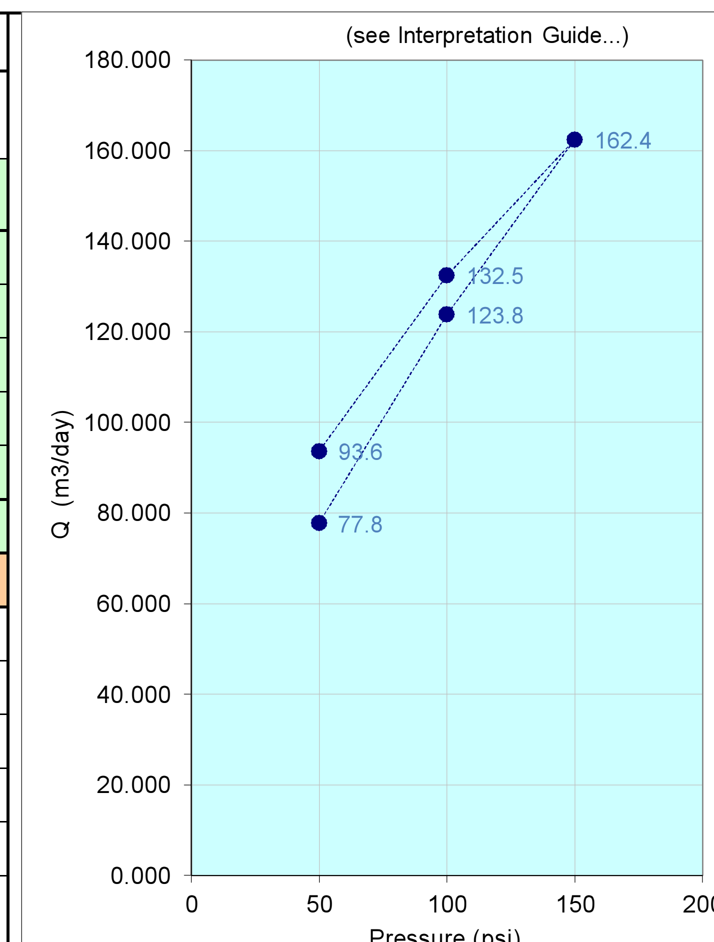
Equations:

$Hf = 8.65x10^{-15} (Q^2*Lp/rp^5)$
$H_{nit} = (Dw'+Hg-Hf)+Pg/1.42$
$K = (Q*Ln(R/r_b)) / 2*\pi*H_{nit}*L)$

Conversion Factors:

10 m of water = 0.9807 bar = $1 kg/cm^2$ = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bar, which is approx. 1.4×10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement (show last 3 to 5 flow meter readings)	Q (Liters / 30sec)				
	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
	50	100	150	100	50
1	27.20	43.00	58.00	48.00	34.00
2	27.80	45.00	58.00	47.00	33.00
3	26.50	43.00	59.00	46.00	33.00
4	27.00	44.00	58.00	47.00	33.00
5	27.00	44.00		47.00	
Stable Q (L/30sec)	27.50	44.00	58.00	47.00	33.00
Leak Q (L/30sec)	0.50	1.00	1.60	1.00	0.50
Q (m^3/day)	77.8	123.8	162.4	132.5	93.6
Hf (m)	0.24	0.60	1.04	0.69	0.34
Hnit (m)	46.0	80.8	115.6	80.7	45.9
K (m/day)	5.2E-02	4.7E-02	4.3E-02	5.0E-02	6.2E-02
K (m/s)	**6.0E-07**	**5.4E-07**	**5.0E-07**	**5.8E-07**	**7.2E-07**
+/- (m/s)	6.2E-08	1.9E-08	0.0E+00	-1.9E-08	-6.2E-08
+/- order of mag.	0.04	0.02	0.00	-0.01	-0.04



<table>
<tr><td>WESA
a BluMetric company</td><td>PACKER INJECTION TEST
(page 2)</td><td>Drillhole Nº</td><td>JGW-3</td></tr>
<tr><td></td><td></td><td>Test hole Nº</td><td>N/A</td></tr>
<tr><td></td><td></td><td>Test Nº</td><td>2</td></tr>
</table>

Pressure oscillation during test

Pressure step	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
Min P during step	50	100	150	100	50
Max P during step	50	100	150	100	50
average pressure +/- psi					

Flowmeter measurement reading accuracy

volume +/- Liters / 30 sec					

High estimate of K

Q_{avg} (m^3/day)	77.76	123.84	162.43	132.48	93.60
Hf (m)	0.24	0.60	1.04	0.69	0.34
Hnit (m)	46.0	80.8	115.6	80.7	45.9
K (m/sec)	6.0E-07	5.4E-07	5.0E-07	5.8E-07	7.2E-07

Low estimate of K

Q_{avg} (m^3/day)	77.76	123.84	162.43	132.48	93.60
Hf (m)	0.24	0.60	1.04	0.69	0.34
Hnit (m)	46.0	80.8	115.6	80.7	45.9
K (m/sec)	6.0E-07	5.4E-07	5.0E-07	5.8E-07	7.2E-07

K averages for P step

m/second

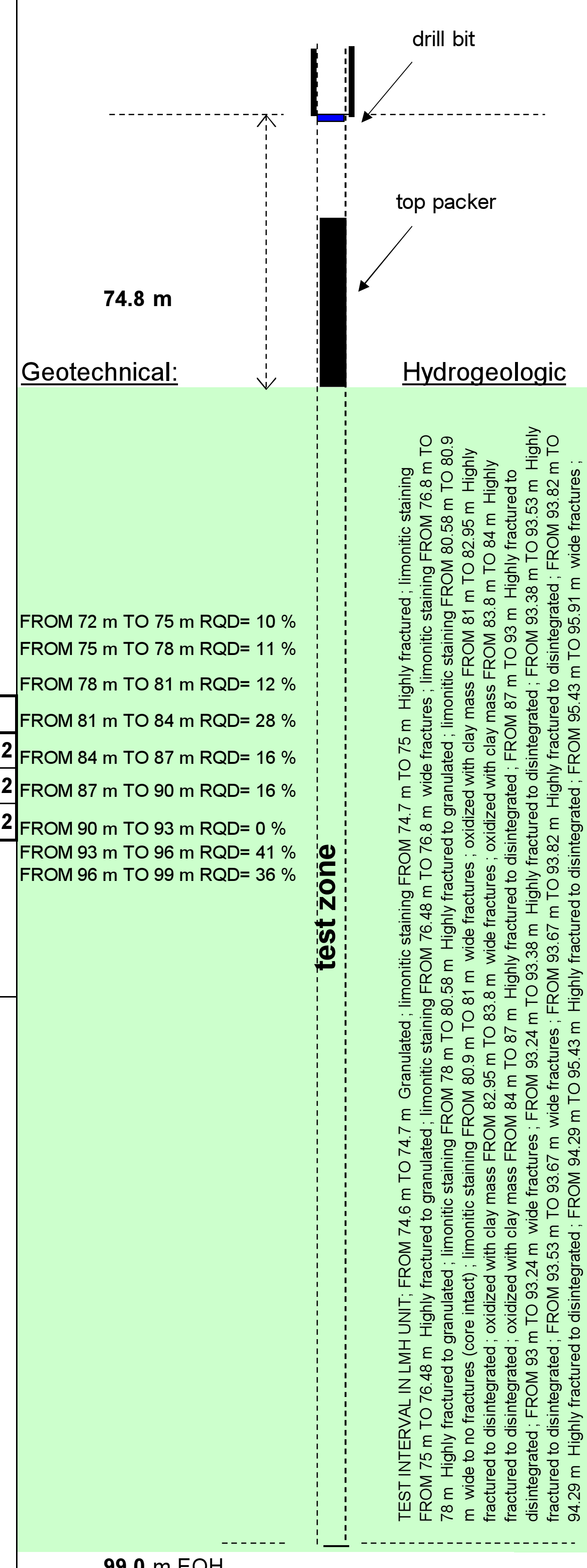
P	50	100	150
high est of K	7.E-07	6.E-07	5.E-07
average K	7.E-07	6.E-07	5.E-07
low est of K	7.E-07	6.E-07	5.E-07

K avg all P steps

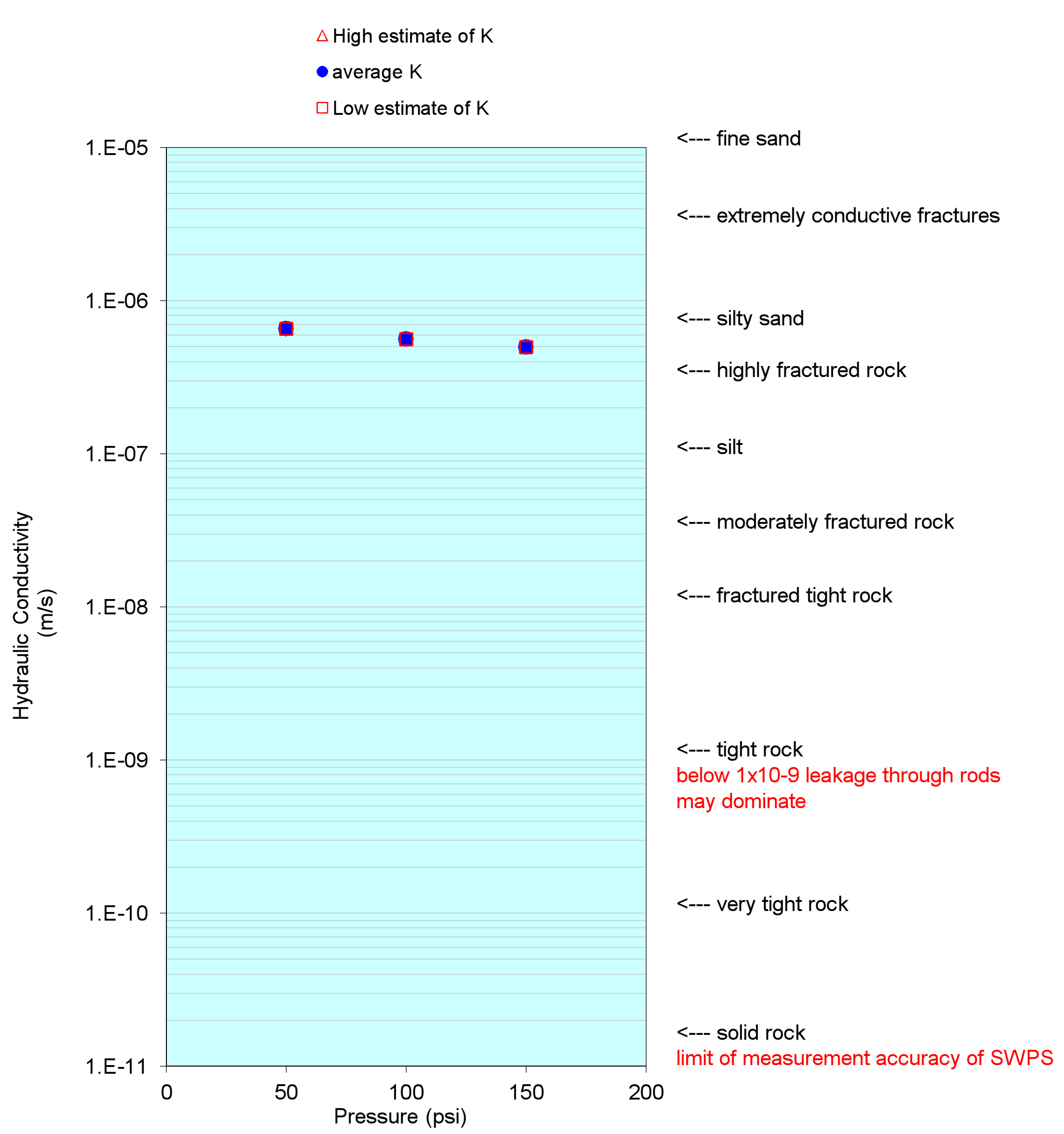
	m/sec	m/day
MAX	7.E-07	5.7E-02
geomean	6.E-07	4.9E-02
MIN	5.E-07	4.3E-02

Comments:

Drawing of zone tested, including geotech / hydrogeo. conditions:



Graph of estimated hydraulic conductivity and error bounds.



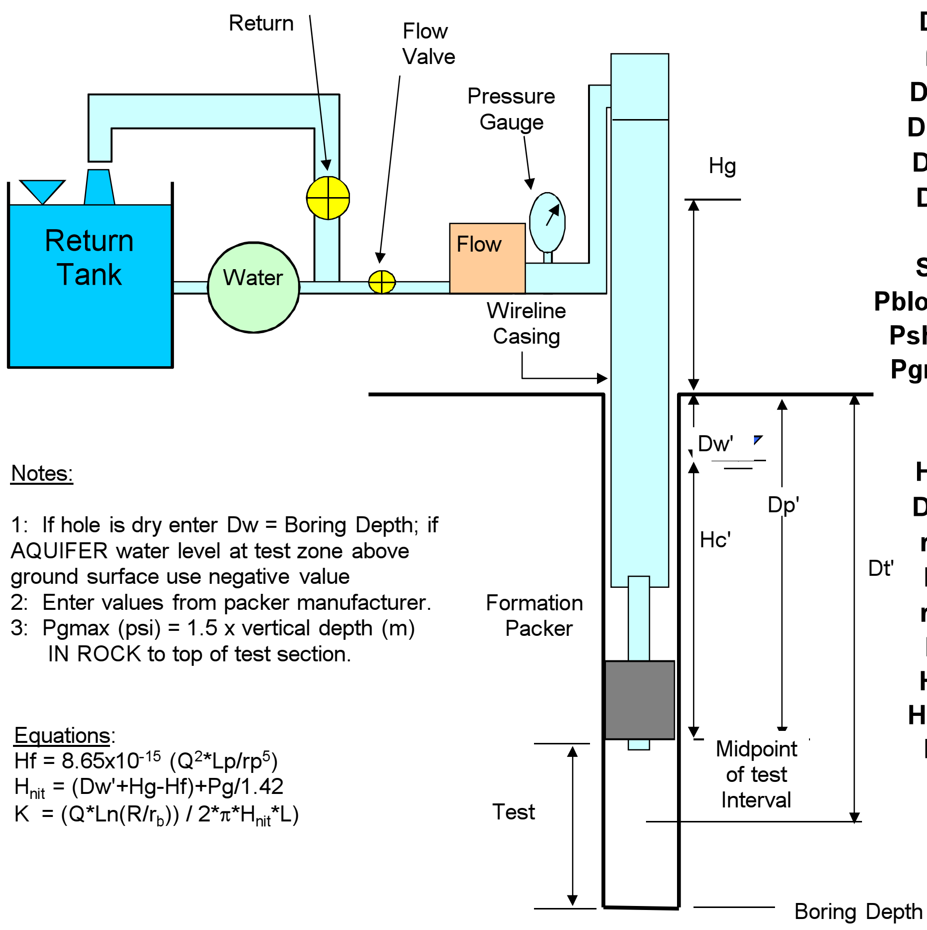
PACKER INJECTION TEST

WESA

Project:	S-B12738	**Test Interval (m):**	112.1	**to**	120.0	**Drillhole Nº**	JGW-3
UTM (x,y)	658211.292, 6086278.287	**Start Date:**	Sep 24 2014	**Time:**	16:10	**Test hole Nº**	N/A
Datum:		**End Date:**	Sep 24 2014	**Time:**	18:00	**Test Nº**	3
GS Elevation:		**Supervisor:**	VM/DP	**Rig:**	LF-70	**DH Depth (m)**	120.0

Max Injection P (psi)

167



Notes:

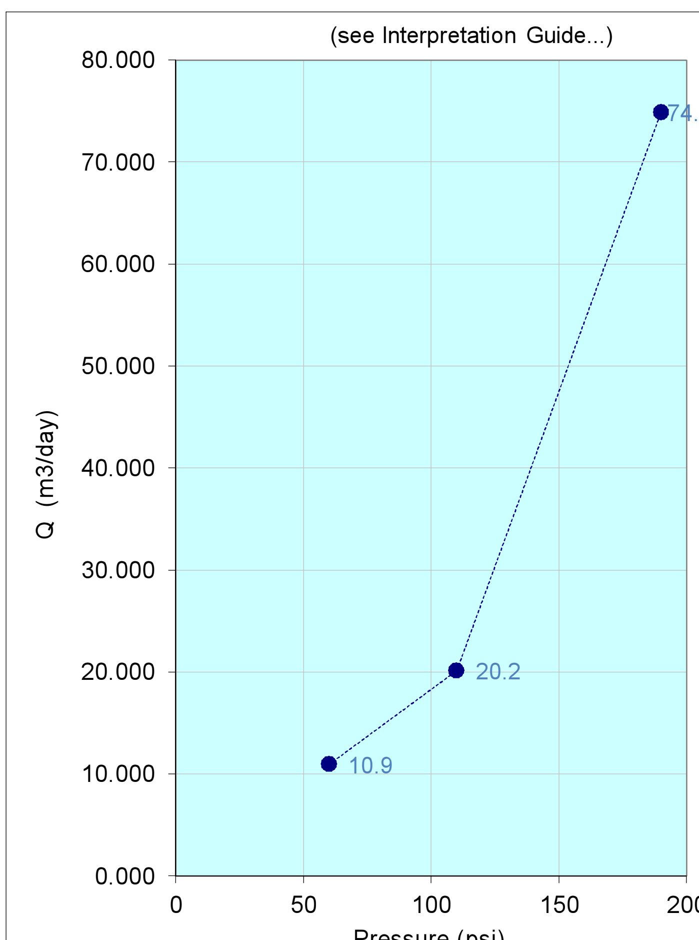
1: If hole is dry enter Dw = Boring Depth; if AQUIFER water level at test zone above ground surface use negative value
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m) IN ROCK to top of test section.

Equations:
$Hf = 8.65x10^{-15} (Q^2*Lp/rp^5)$
$H_{nit} = (Dw'+Hg-Hf)+Pg/1.42$
$K = (Q*Ln(R/r_b)) / 2*\pi*H_{nit}*L)$

Dw	Measured depth of static water level (1)	10.1	
Dbr	Measured depth to bedrock	0.3	m
Dp	Measured depth to packer	**112.1**	m
Dt	Measured depth to midpoint of test	**116.0**	m
ß	Inclination from horizontal (degrees)	85	º
Dw'	Vertical depth to static water level	**10.0**	m
Dbr'	Vertical dept to bedrock	**0.3**	m
Dp'	Vertical depth to packer	**111.6**	m
Dt'	Vertical depth to midpoint of test	**115.6**	m
SP	Shear Pin Rating (psi)	500	psi
Pblowout	Water column pressure in drill rods at plug	**159**	psi
Pshear	Estimated differential shear pressure required	**500**	psi
Pgmax	Maximum injection gauge pressure (3)	**173**	psi
Hg	Gauge height	2.0	m
Dp'	Length of discharge pipe	1.50	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0127	m
R	Radius of influence (10 m is standard value)	5	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.048	m
L	Length of test section	**8.0**	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		

Conversion Factors:
10 m of water = 0.9807 bar = 1kg/cm^2 = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bar, which is approx. 1.4 x 10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement (show last 3 to 5 flow meter readings)	**Q (Liters / 30sec)**				
	P_g (psi) Step 1	**P_g (psi) Step 2**	**P_g (psi) Step 3**	**P_g (psi) Step 4**	**P_g (psi) Step 5**
	60	**110**	**190**		
1	**4.40**	**8.00**	**20.50**		
2	**4.40**	**8.00**	**25.10**		
3	**4.20**	**8.00**	**32.00**		
4			**35.20**		
5					
Stable Q (L/30sec)	**4.40**	**8.00**	**28.00**		
Leak Q (L/30sec)	**0.60**	**1.00**	**2.00**	**1.00**	**0.60**
Q (m^3/day)	10.9	20.2	74.9	#N/A	#N/A
Hf (m)	0.00	0.02	0.22	#N/A	#N/A
Hnit (m)	54.3	89.5	145.6	#N/A	#N/A
K (m/day)	1.9E-02	2.1E-02	4.8E-02	#N/A	#N/A
K (m/s)	**2.2E-07**	**2.4E-07**	**5.5E-07**	**#N/A**	**#N/A**
+/- (m/s)	0.0E+00	0.0E+00	0.0E+00	#N/A	#N/A
+/- order of mag.	0.00	0.00	0.00	#N/A	#N/A



WESA a BluMetric company	PACKER INJECTION TEST (page 2)	Drillhole Nº	JGW-3
		Test hole Nº	N/A
		Test Nº	3

Pressure oscillation during test

Pressure step	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
Min P during step	60	110	190	0	0
Max P during step	60	110	190	0	0
average pressure +/- psi					

Flowmeter measurement reading accuracy

volume +/- Liters / 30 sec					

High estimate of K

Q_{avg} (m^3/day)	10.94	20.16	74.88	#N/A	#N/A
Hf (m)	0.00	0.02	0.22	#N/A	#N/A
Hnit (m)	54.3	89.5	145.6	#N/A	#N/A
K (m/sec)	2.2E-07	2.4E-07	5.5E-07	#N/A	#N/A

Low estimate of K

Q_{avg} (m^3/day)	10.94	20.16	74.88	#N/A	#N/A
Hf (m)	0.00	0.02	0.22	#N/A	#N/A
Hnit (m)	54.3	89.5	145.6	#N/A	#N/A
K (m/sec)	2.2E-07	2.4E-07	5.5E-07	#N/A	#N/A

K averages for P step (m/second)

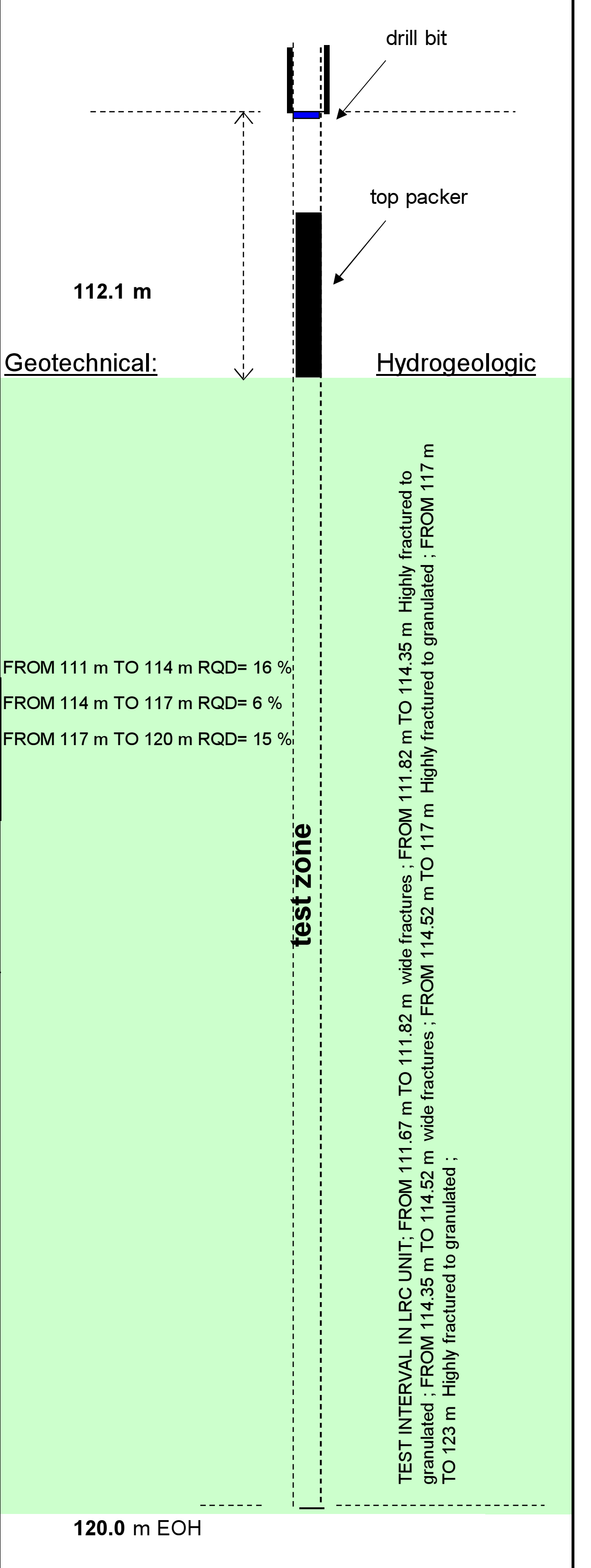
P	60	110	190
high est of K	2.E-07	2.E-07	6.E-07
average K	2.E-07	2.E-07	6.E-07
low est of K	2.E-07	2.E-07	6.E-07

K avg all P steps

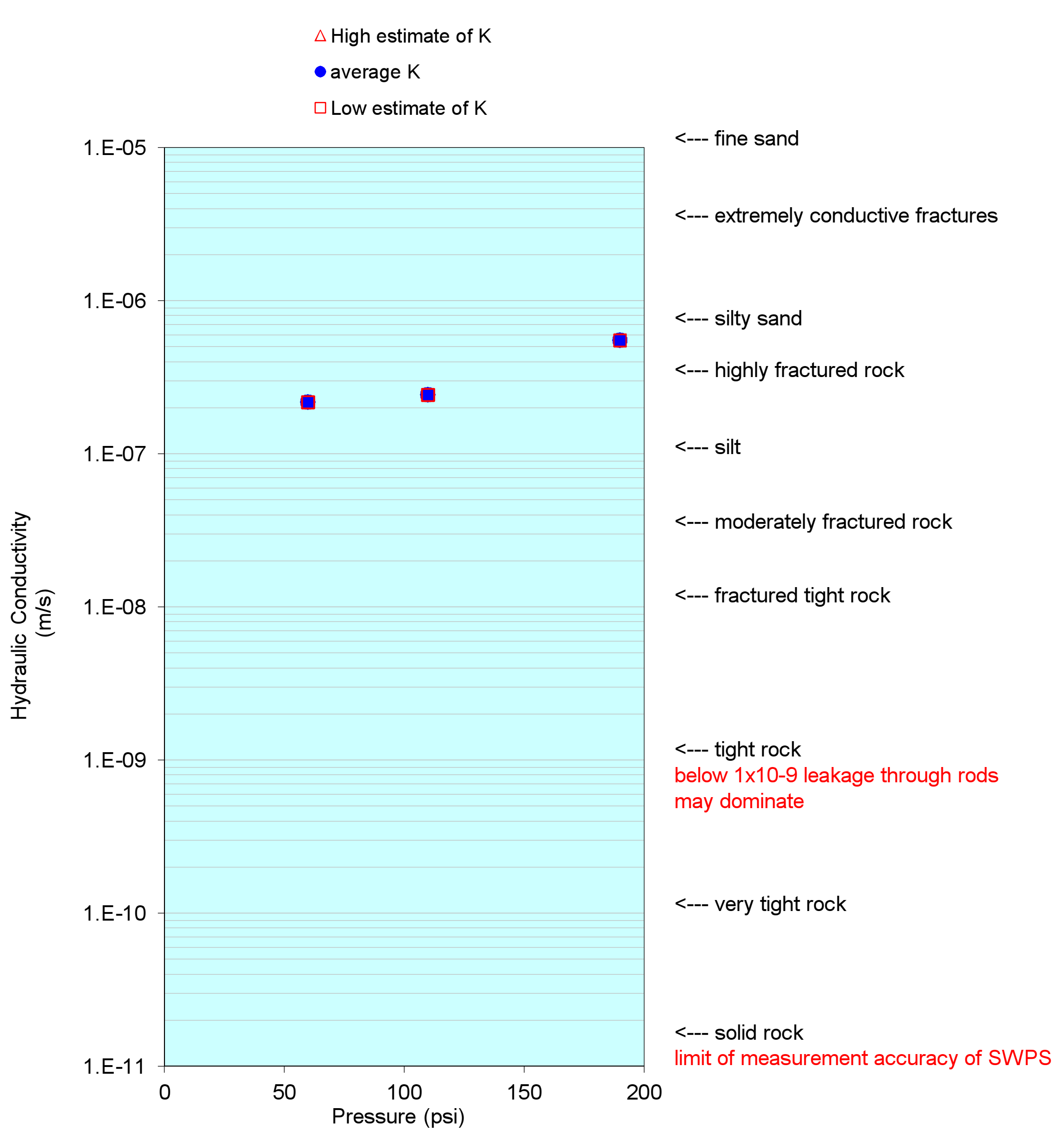
	m/sec	m/day
MAX	6.E-07	4.8E-02
geomean	3.E-07	2.7E-02
MIN	2.E-07	1.9E-02

Comments:

Drawing of zone tested, including geotech / hydrogeo. conditions:



Graph of estimated hydraulic conductivity and error bounds.



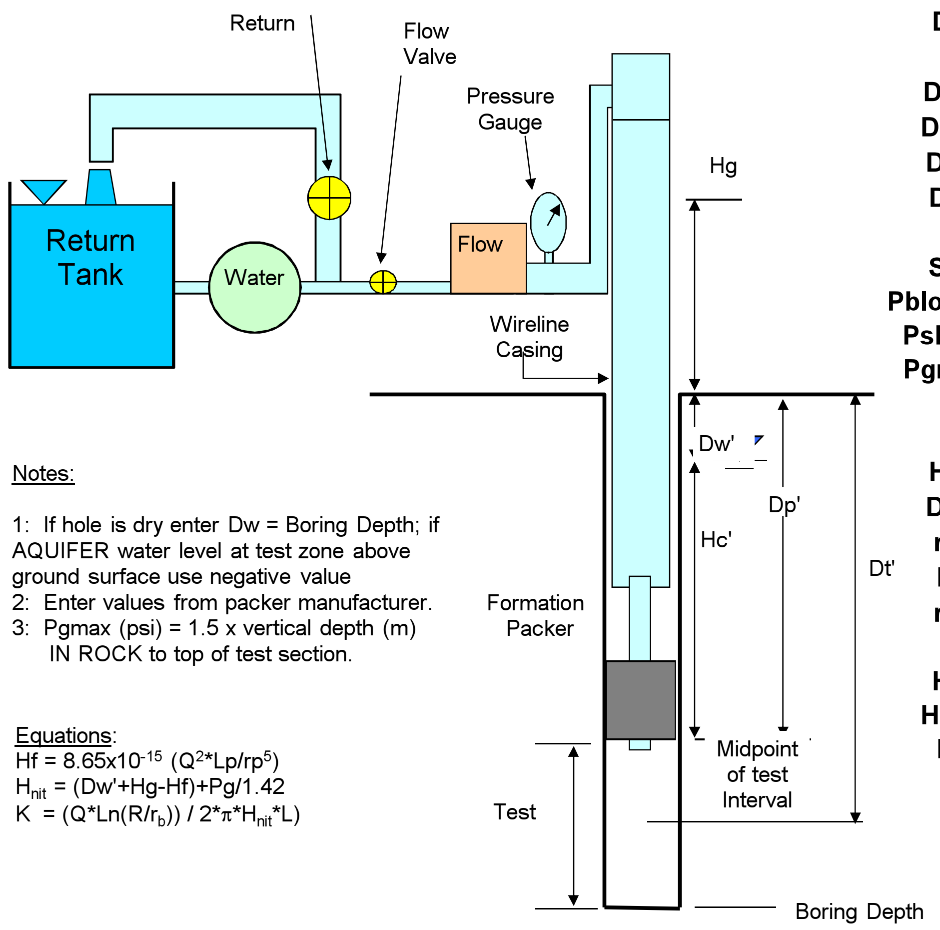
PACKER INJECTION TEST

WESA a BluMetric company

Project:	S-B12738	**Test Interval (m):**	130.3	to	141.0	**Drillhole N°**	JGW-3
UTM (x,y)	658211.292, 6086278.287	**Start Date:**	Sep 25 2014	**Time:**	3:30	**Test hole N°**	N/A
Datum:		**End Date:**	Sep 25 2014	**Time:**	5:10	**Test N°**	4
GS Elevation:		**Supervisor:**	VM/DP	**Rig:**	LF-70	**DH Depth (m)**	141.0

Max Injection P (psi)

195



Dw	Measured depth of static water level (1)	10.1	
Dbr	Measured depth to bedrock	0.3	m
Dp	Measured depth to packer	**130.3**	m
Dt	Measured depth to midpoint of test	**135.7**	m
ß	Inclination from horizontal (degrees)	85	°
Dw'	Vertical depth to static water level	**10.0**	m
Dbr'	Vertical dept to bedrock	**0.3**	m
Dp'	Vertical depth to packer	**129.8**	m
Dt'	Vertical depth to midpoint of test	**135.1**	m
SP	Shear Pin Rating (psi)	500	psi
Pblowout	Water column pressure in drill rods at plug	**184**	psi
Pshear	Estimated differential shear pressure required	**500**	psi
Pgmax	Maximum injection gauge pressure (3)	**202**	psi
Hg	Gauge height	2.0	m
Dp'	Length of discharge pipe	1.50	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0127	m
R	Radius of influence (10 m is standard value)	5	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.048	m
L	Length of test section	**10.7**	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		

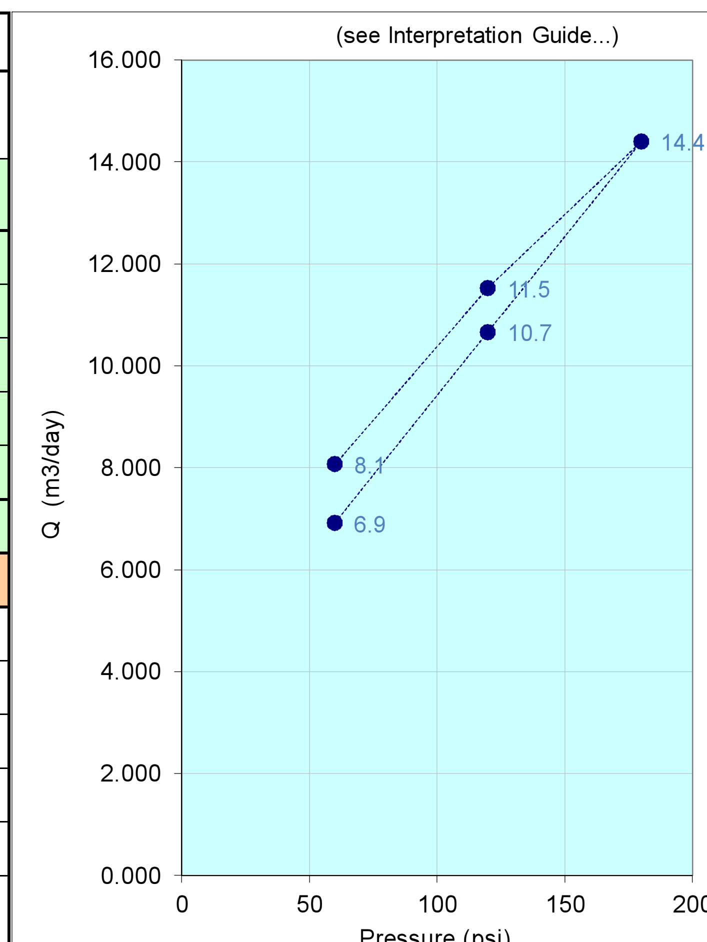
Notes:

1: If hole is dry enter Dw = Boring Depth; if AQUIFER water level at test zone above ground surface use negative value
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m) IN ROCK to top of test section.

Equations:
$Hf = 8.65x10^{-15} (Q^2 * Lp/rp^5)$
$H_{nit} = (Dw'+Hg-Hf)+Pg/1.42$
$K = (Q * Ln(R/r_b)) / 2 * \pi * H_{nit} * L$

Conversion Factors:
10 m of water = 0.9807 bar = 1kg/cm^2 = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bar, which is approx. 1.4 x 10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement (show last 3 to 5 flow meter readings)	Q (Liters / 30sec)				
	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
	60	120	180	120	60
1	3.50	5.30	7.10	5.10	3.00
2	3.40	5.10	6.90	4.90	3.00
3	3.40	5.30	7.00	4.90	3.00
4	3.30	5.30	6.80	5.00	3.00
5	3.40	5.20	6.90	5.00	2.90
Stable Q (L/30sec)	3.40	5.30	6.90	5.00	3.00
Leak Q (L/30sec)	0.60	1.30	1.90	1.30	0.60
Q (m^3/day)	8.1	11.5	14.4	10.7	6.9
Hf (m)	0.00	0.01	0.01	0.00	0.00
Hnit (m)	54.3	96.5	138.8	96.5	54.3
K (m/day)	1.0E-02	8.2E-03	7.2E-03	7.6E-03	8.8E-03
K (m/s)	**1.2E-07**	**9.5E-08**	**8.3E-08**	**8.8E-08**	**1.0E-07**
+/- (m/s)	-8.5E-09	-3.6E-09	0.0E+00	3.6E-09	8.5E-09
+/- order of mag.	-0.03	-0.02	0.00	0.02	0.03



WESA a BluMetric company	PACKER INJECTION TEST (page 2)	Drillhole Nº	JGW-3
		Test hole Nº	N/A
		Test Nº	4

Pressure oscillation during test

Pressure step	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
Min P during step	60	120	180	120	60
Max P during step	60	120	180	120	60
average pressure +/- psi					

Flowmeter measurement reading accuracy

volume +/- Liters / 30 sec					

High estimate of K

Q_{avg} (m^3/day)	8.06	11.52	14.40	10.66	6.91
Hf (m)	0.00	0.01	0.01	0.00	0.00
Hnit (m)	54.3	96.5	138.8	96.5	54.3
K (m/sec)	1.2E-07	9.5E-08	8.3E-08	8.8E-08	1.0E-07

Low estimate of K

Q_{avg} (m^3/day)	8.06	11.52	14.40	10.66	6.91
Hf (m)	0.00	0.01	0.01	0.00	0.00
Hnit (m)	54.3	96.5	138.8	96.5	54.3
K (m/sec)	1.2E-07	9.5E-08	8.3E-08	8.8E-08	1.0E-07

K averages for P step m/second

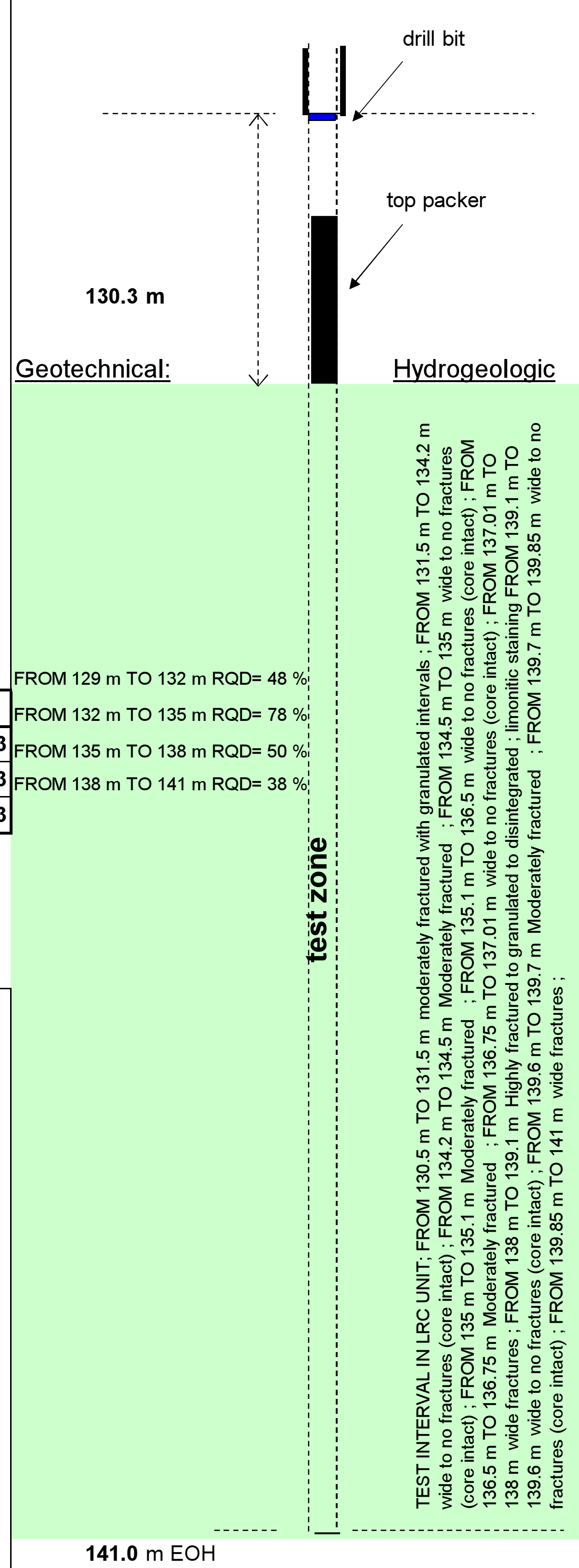
P	60	120	180
high est of K	1.E-07	9.E-08	8.E-08
average K	1.E-07	9.E-08	8.E-08
low est of K	1.E-07	9.E-08	8.E-08

K avg all P steps

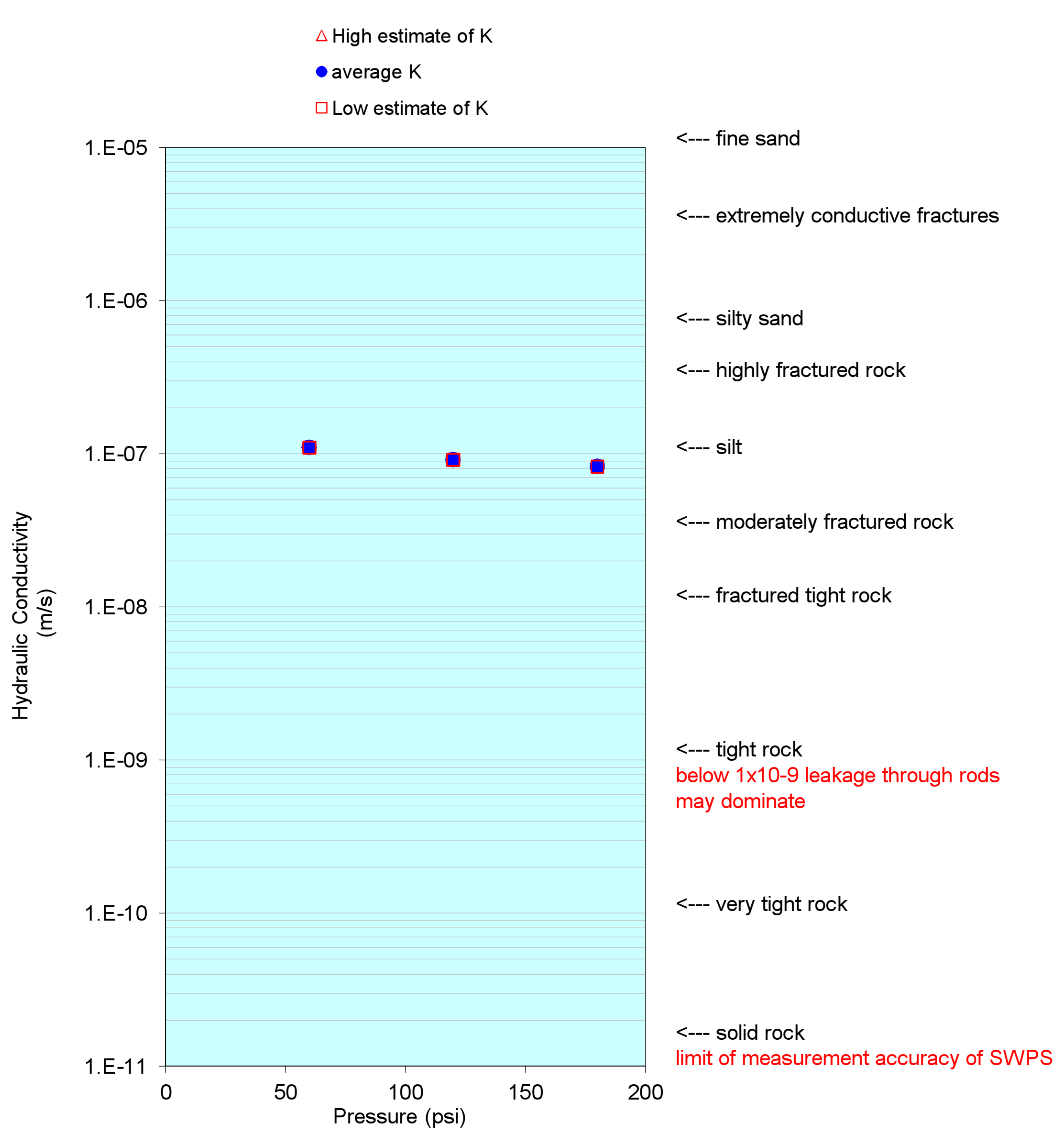
	m/sec	m/day
MAX	1.E-07	9.5E-03
geomean	9.E-08	8.2E-03
MIN	8.E-08	7.2E-03

Comments:

Drawing of zone tested, including geotech / hydrogeo. conditions:



Graph of estimated hydraulic conductivity and error bounds.



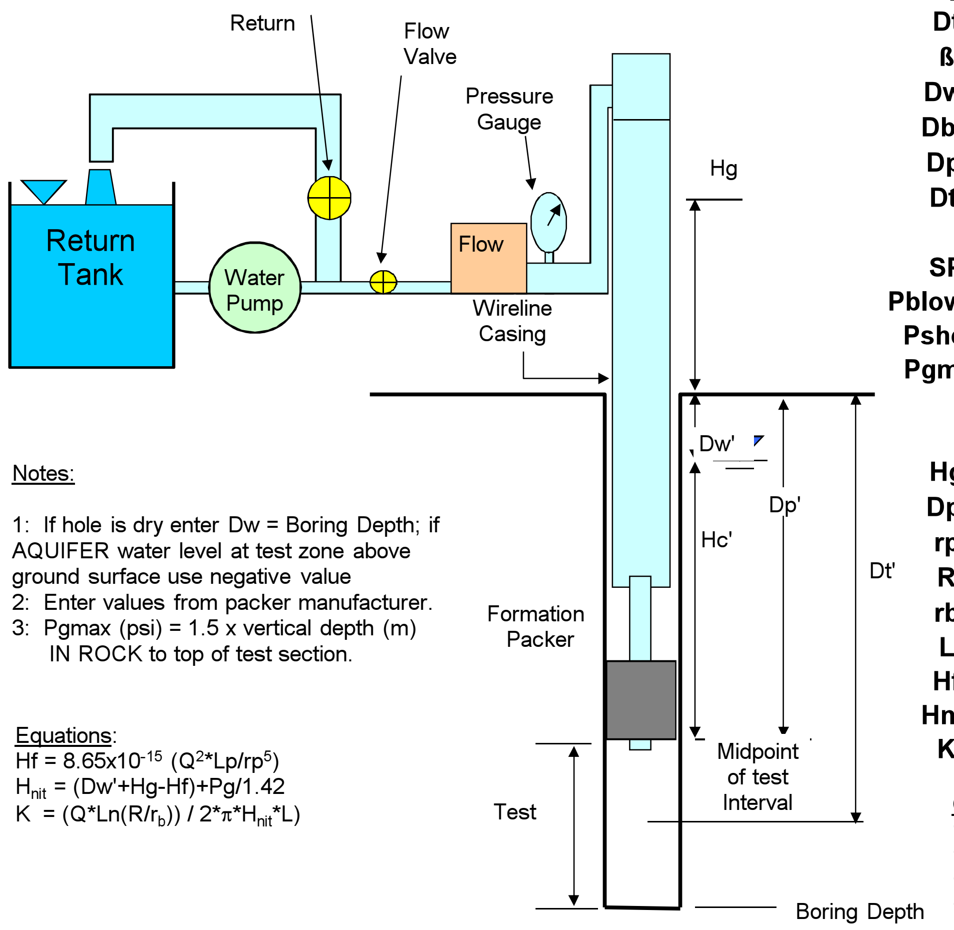
PACKER INJECTION TEST

WESA a BluMetric company

Project:	S-B12738	**Test Interval (m):**	142.3	to	148.5	**Drillhole N°**	JGW-3
UTM (x,y)	658211.292, 6086278.287	**Start Date:**	Sep 25 2014	**Time:**	11:30	**Test hole N°**	N/A
Datum:		**End Date:**	Sep 25 2014	**Time:**	12:40	**Test N°**	5
GS Elevation:		**Supervisor:**	VM/DP	**Rig:**	LF-70	**DH Depth (m)**	148.5

Max Injection P (psi)

213



Dw	Measured depth of static water level (1)	9.6	
Dbr	Measured depth to bedrock	0.3	m
Dp	Measured depth to packer	**142.3**	m
Dt	Measured depth to midpoint of test	**145.4**	m
ß	Inclination from horizontal (degrees)	85	°
Dw'	Vertical depth to static water level	**9.5**	m
Dbr'	Vertical dept to bedrock	**0.3**	m
Dp'	Vertical depth to packer	**141.8**	m
Dt'	Vertical depth to midpoint of test	**144.8**	m
SP	Shear Pin Rating (psi)	500	psi
Pblowout	Water column pressure in drill rods at plug	**201**	psi
Pshear	Estimated differential shear pressure required	**500**	psi
Pgmax	Maximum injection gauge pressure (3)	**217**	psi
Hg	Gauge height	2.0	m
Dp'	Length of discharge pipe	1.50	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0127	m
R	Radius of influence (10 m is standard value)	5	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.048	m
L	Length of test section	**6.2**	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		

Notes:

1: If hole is dry enter Dw = Boring Depth; if AQUIFER water level at test zone above ground surface use negative value
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m) IN ROCK to top of test section.

Equations:

$H_f = 8.65 \times 10^{-15} (Q^2 * L_p / r_p^5)$

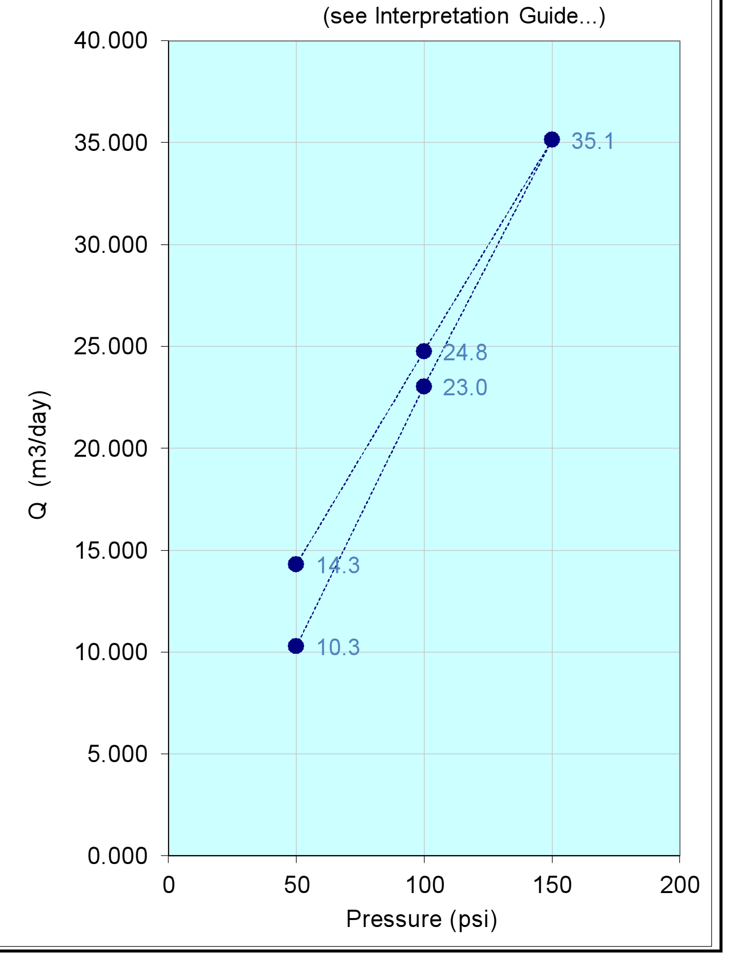
$H_{nit} = (Dw' + Hg - Hf) + Pg/1.42$

$K = (Q * \ln(R/r_b)) / 2 * \pi * H_{nit} * L)$

Conversion Factors:

10 m of water = 0.9807 bar = 1kg/cm^2 = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bar, which is approx. 1.4 x 10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement (show last 3 to 5 flow meter readings)	Q (Liters / 30sec)				
	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
	50	100	150	100	50
1	4.30	8.60	13.40	9.60	5.70
2	4.10	8.80	13.70	9.50	5.70
3	4.00	9.00	13.80	9.40	5.60
4	4.10	9.00	14.30	9.40	5.40
5	4.00	8.80		9.10	5.50
Stable Q (L/30sec)	4.10	8.80	13.80	9.40	5.50
Leak Q (L/30sec)	0.53	0.80	1.60	0.80	0.53
Q (m^3/day)	10.3	23.0	35.1	24.8	14.3
Hf (m)	0.00	0.02	0.05	0.02	0.01
Hnit (m)	46.7	81.9	117.1	81.9	46.7
K (m/day)	2.6E-02	3.4E-02	3.6E-02	3.6E-02	3.7E-02
K (m/s)	**3.0E-07**	**3.9E-07**	**4.1E-07**	**4.2E-07**	**4.2E-07**
+/- (m/s)	6.0E-08	1.5E-08	0.0E+00	-1.5E-08	-6.0E-08
+/- order of mag.	0.08	0.02	0.00	-0.02	-0.07



WESA a BluMetric company	PACKER INJECTION TEST (page 2)	Drillhole Nº	JGW-3
		Test hole Nº	N/A
		Test Nº	5

Pressure oscillation during test

Pressure step	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
Min P during step	50	100	150	100	50
Max P during step	50	100	150	100	50
average pressure +/- psi					

Flowmeter measurement reading accuracy

volume +/- Liters / 30 sec					

High estimate of K

Q_{avg} (m^3/day)	10.28	23.04	35.14	24.77	14.31
Hf (m)	0.00	0.02	0.05	0.02	0.01
Hnit (m)	46.7	81.9	117.1	81.9	46.7
K (m/sec)	3.0E-07	3.9E-07	4.1E-07	4.2E-07	4.2E-07

Low estimate of K

Q_{avg} (m^3/day)	10.28	23.04	35.14	24.77	14.31
Hf (m)	0.00	0.02	0.05	0.02	0.01
Hnit (m)	46.7	81.9	117.1	81.9	46.7
K (m/sec)	3.0E-07	3.9E-07	4.1E-07	4.2E-07	4.2E-07

K averages for P step — m/second

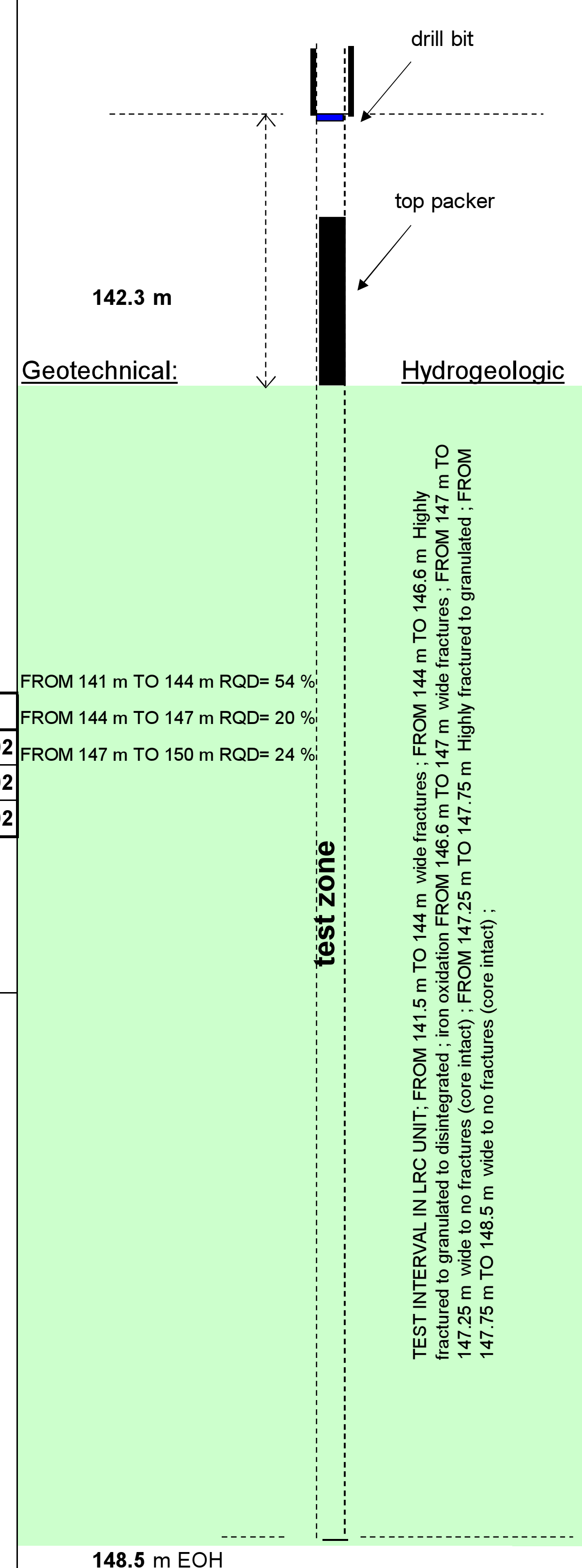
P	50	100	150
high est of K	4.E-07	4.E-07	4.E-07
average K	4.E-07	4.E-07	4.E-07
low est of K	4.E-07	4.E-07	4.E-07

K avg all P steps

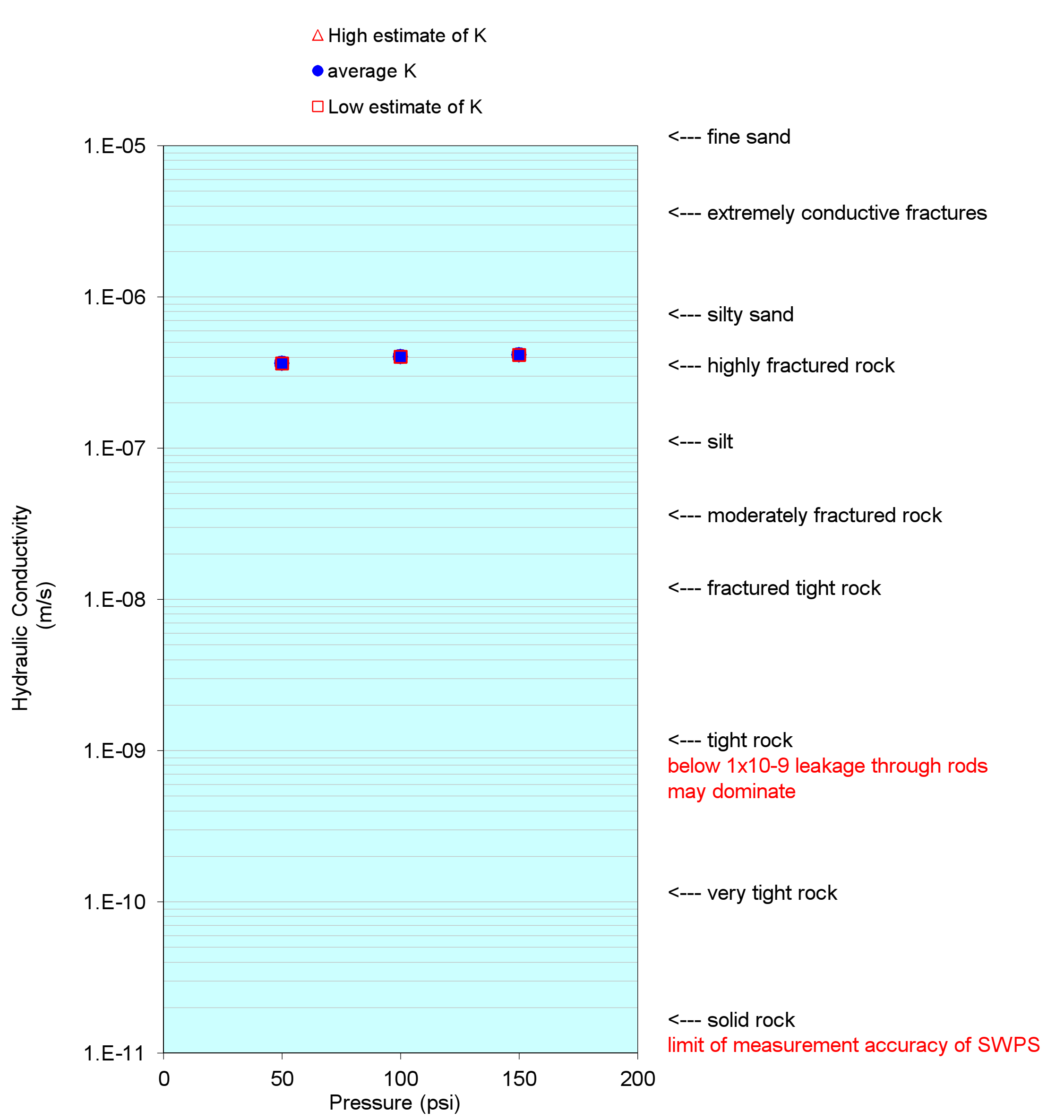
	m/sec	m/day
MAX	4.E-07	3.6E-02
geomean	4.E-07	3.4E-02
MIN	4.E-07	3.1E-02

Comments:

Drawing of zone tested, including geotech / hydrogeo. conditions:



Graph of estimated hydraulic conductivity and error bounds.



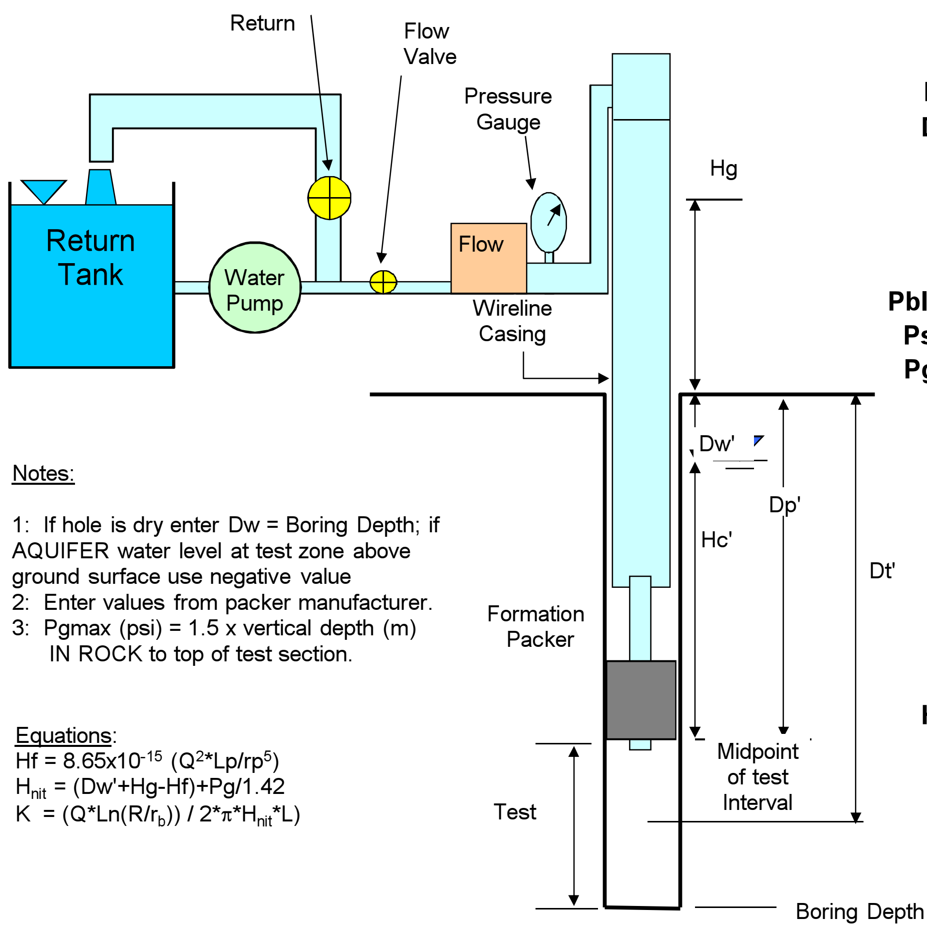
PACKER INJECTION TEST

WESA a BluMetric company

Project:	S-B12738	**Test Interval (m):**	157.8	**to**	171.0	**Drillhole Nº**	JGW-3
UTM (x,y)	658211.292, 6086278.287	**Start Date:**	Sep 26 2014	**Time:**	7:10	**Test hole Nº**	N/A
Datum:		**End Date:**	Sep 26 2014	**Time:**	8:15	**Test Nº**	6
GS Elevation:		**Supervisor:**	VM/DP	**Rig:**	LF-70	**DH Depth (m)**	171.0

Max Injection P (psi)

236



Notes:

1: If hole is dry enter Dw = Boring Depth; if AQUIFER water level at test zone above ground surface use negative value
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m) IN ROCK to top of test section.

Equations:

$Hf = 8.65x10^{-15}\ (Q^2*Lp/rp^5)$

$H_{nit} = (Dw'+Hg-Hf)+Pg/1.42$

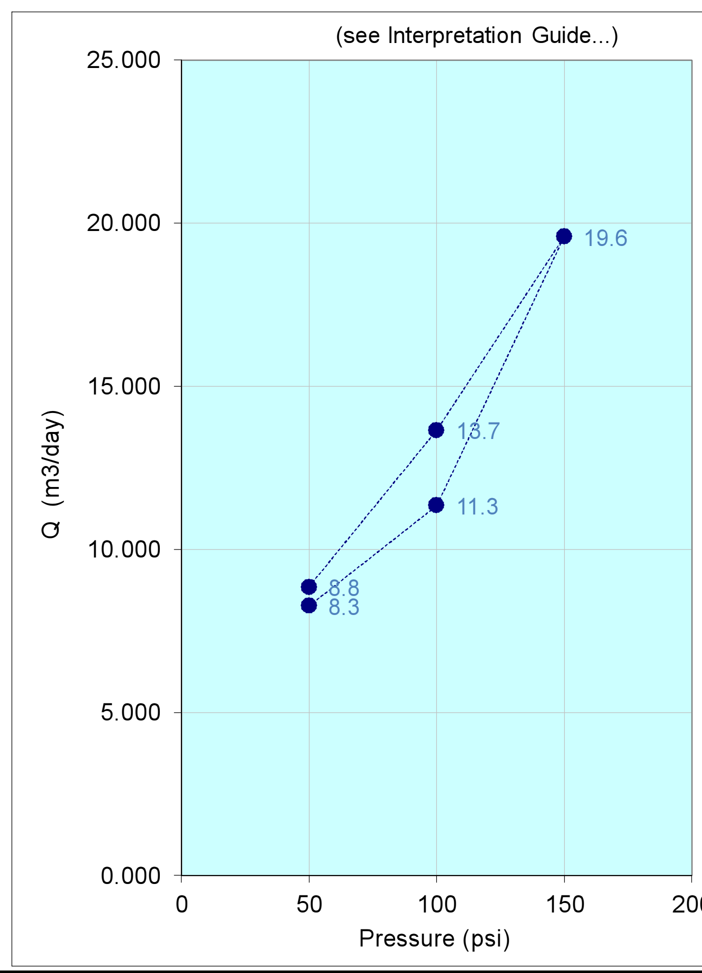
$K = (Q*Ln(R/r_b)) / 2*\pi*H_{nit}*L)$

Dw	Measured depth of static water level (1)	10.1	
Dbr	Measured depth to bedrock	0.3	m
Dp	Measured depth to packer	**157.8**	m
Dt	Measured depth to midpoint of test	**164.4**	m
ß	Inclination from horizontal (degrees)	85	º
Dw'	Vertical depth to static water level	**10.0**	m
Dbr'	Vertical dept to bedrock	**0.3**	m
Dp'	Vertical depth to packer	**157.2**	m
Dt'	Vertical depth to midpoint of test	**163.8**	m
SP	Shear Pin Rating (psi)	500	psi
Pblowout	Water column pressure in drill rods at plug	**223**	psi
Pshear	Estimated differential shear pressure required	**500**	psi
Pgmax	Maximum injection gauge pressure (3)	**245**	psi
Hg	Gauge height	2.0	m
Dp'	Length of discharge pipe	1.50	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0127	m
R	Radius of influence (10 m is standard value)	5	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.048	m
L	Length of test section	**13.2**	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		

Conversion Factors:

10 m of water = 0.9807 bar = 1kg/cm² = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bar, which is approx. 1.4×10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m³/day

Measurement (show last 3 to 5 flow meter readings)	**Q (Liters / 30sec)**				
	P_g (psi) Step 1	**P_g (psi) Step 2**	**P_g (psi) Step 3**	**P_g (psi) Step 4**	**P_g (psi) Step 5**
	50	**100**	**150**	**100**	**50**
1	**3.40**	**5.60**	**8.20**	**6.00**	**3.70**
2	**3.80**	**5.10**	**8.70**	**6.60**	**3.70**
3	**3.50**	**5.20**	**8.90**	**6.40**	**3.60**
4	**3.40**	**5.40**	**9.20**	**6.00**	**3.60**
5	**3.60**	**5.20**	**8.30**	**6.00**	**3.70**
Stable Q (L/30sec)	**3.50**	**5.20**	**8.70**	**6.00**	**3.70**
Leak Q (L/30sec)	**0.63**	**1.26**	**1.90**	**1.26**	**0.63**
Q (m³/day)	8.3	11.3	19.6	13.7	8.8
Hf (m)	0.00	0.01	0.02	0.01	0.00
Hnit (m)	47.2	82.4	117.6	82.4	47.2
K (m/day)	9.8E-03	7.7E-03	9.3E-03	9.3E-03	1.0E-02
K (m/s)	**1.1E-07**	**8.9E-08**	**1.1E-07**	**1.1E-07**	**1.2E-07**
+/- (m/s)	4.0E-09	9.1E-09	0.0E+00	-9.1E-09	-4.0E-09
+/- order of mag.	0.01	0.04	0.00	-0.04	-0.01



WESA a BluMetric company	PACKER INJECTION TEST (page 2)	Drillhole Nº	JGW-3
		Test hole Nº	N/A
		Test Nº	6

Pressure oscillation during test

Pressure step	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
Min P during step	50	100	150	100	50
Max P during step	50	100	150	100	50
average pressure +/- psi					

Flowmeter measurement reading accuracy

volume +/- Liters / 30 sec					

High estimate of K

Q_{avg} (m^3/day)	8.27	11.35	19.58	13.65	8.84
Hf (m)	0.00	0.01	0.02	0.01	0.00
Hnit (m)	47.2	82.4	117.6	82.4	47.2
K (m/sec)	1.1E-07	8.9E-08	1.1E-07	1.1E-07	1.2E-07

Low estimate of K

Q_{avg} (m^3/day)	8.27	11.35	19.58	13.65	8.84
Hf (m)	0.00	0.01	0.02	0.01	0.00
Hnit (m)	47.2	82.4	117.6	82.4	47.2
K (m/sec)	1.1E-07	8.9E-08	1.1E-07	1.1E-07	1.2E-07

K averages for P step m/second

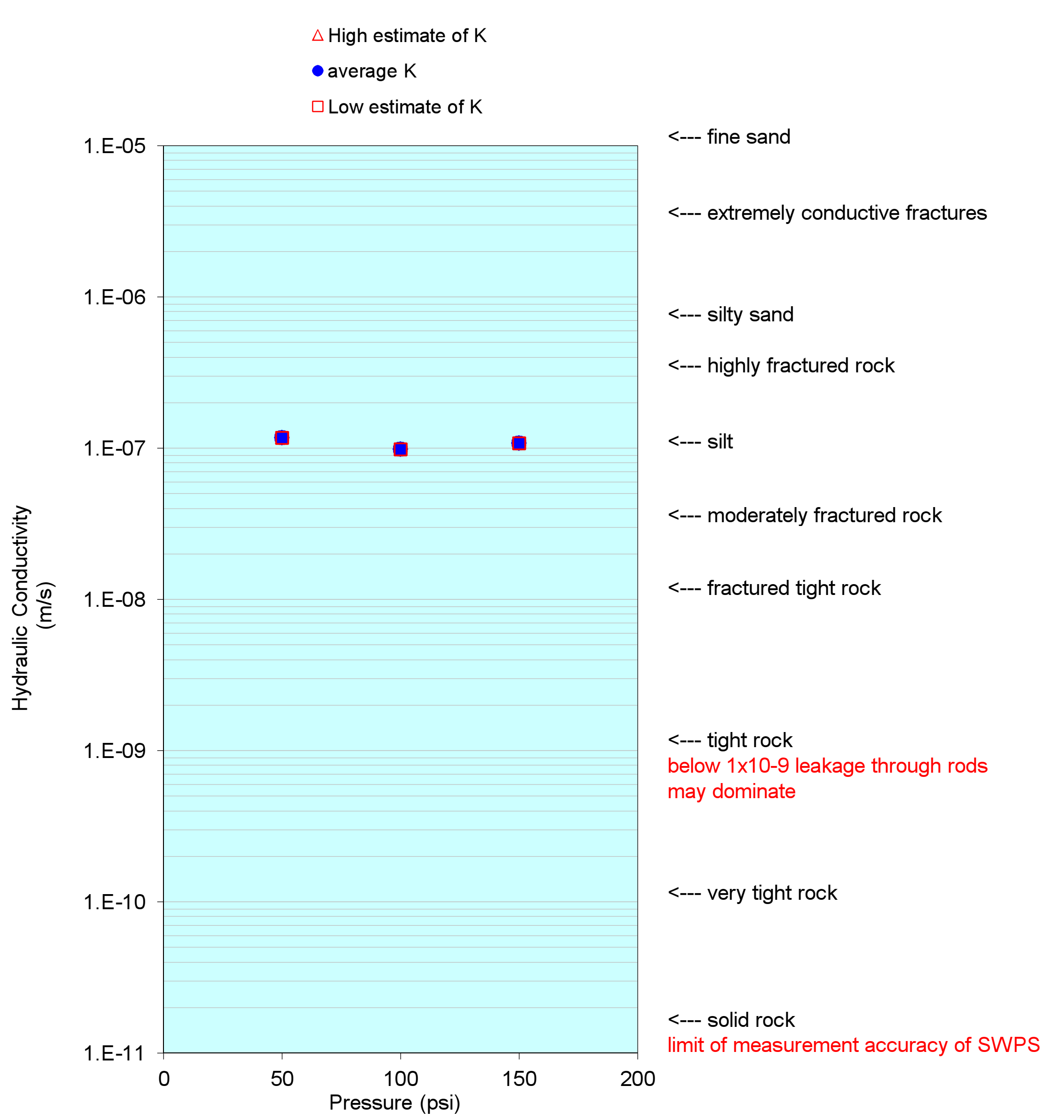
P	50	100	150
high est of K	1.E-07	1.E-07	1.E-07
average K	1.E-07	1.E-07	1.E-07
low est of K	1.E-07	1.E-07	1.E-07

K avg all P steps

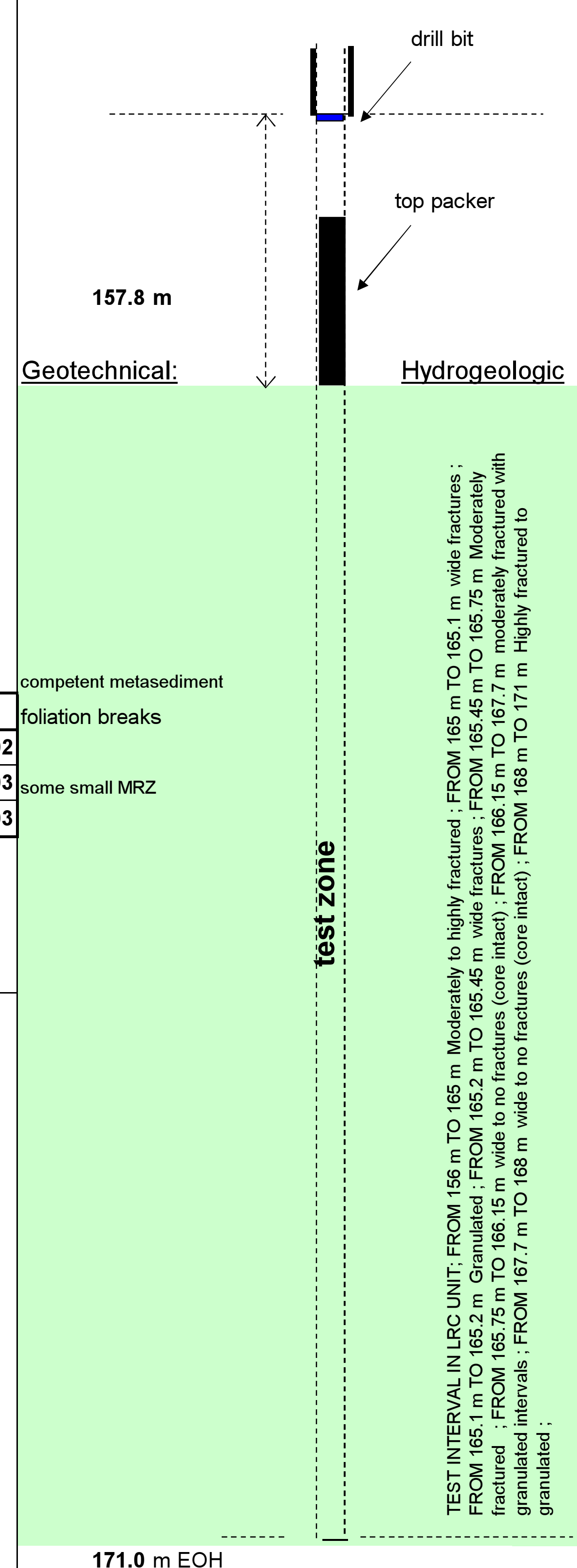
	m/sec	m/day
MAX	1.E-07	1.0E-02
geomean	1.E-07	9.3E-03
MIN	1.E-07	8.5E-03

Comments:

Graph of estimated hydraulic conductivity and error bounds.



Drawing of zone tested, including geotech / hydrogeo. conditions:



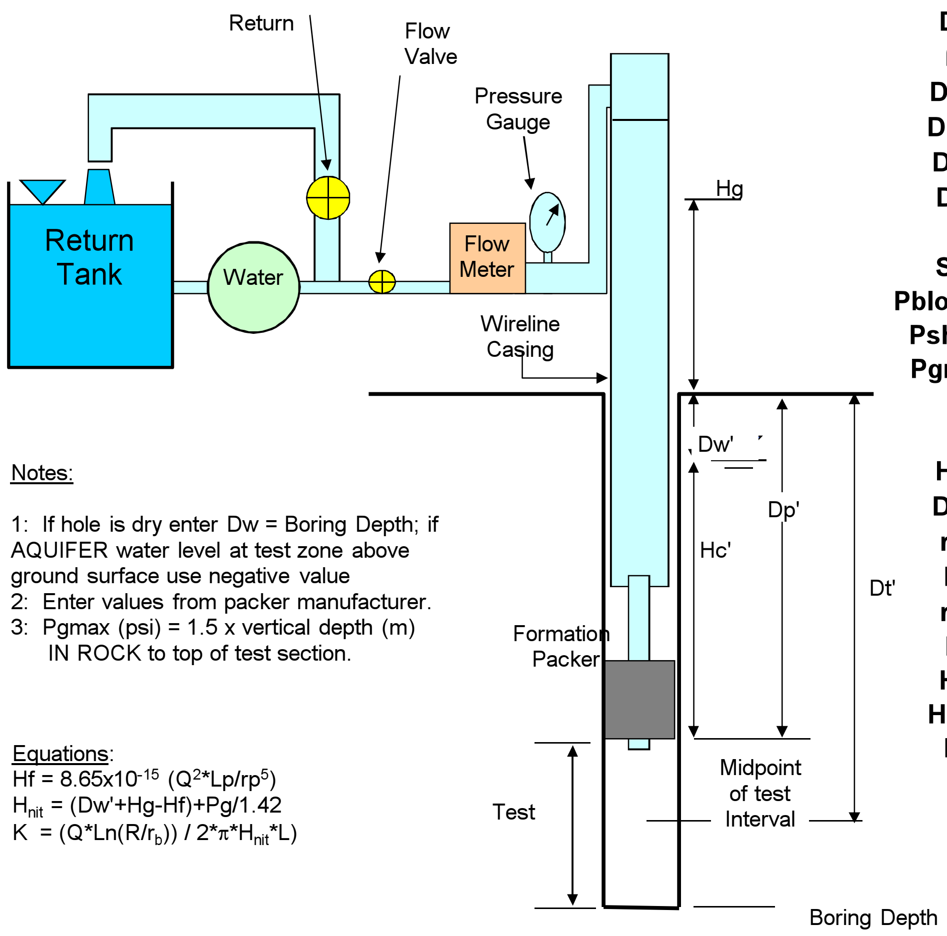
WESA
a BluMetric company

PACKER INJECTION TEST

Project:	S-B12738	**Test Interval (m):**	37.6	**to**	42.3	**Drillhole N°**	JGW-4
UTM (x,y)	657990, 6086500	**Start Date:**	Oct 8 2014	**Time:**	13:00	**Test hole N°**	N/A
Datum:		**End Date:**	Oct 8 2014	**Time:**	14:30	**Test N°**	1
GS Elevation:		**Supervisor:**	VM/DP	**Rig:**	LF-70	**DH Depth (m)**	42.3

Max Injection P (psi)

56



Notes:

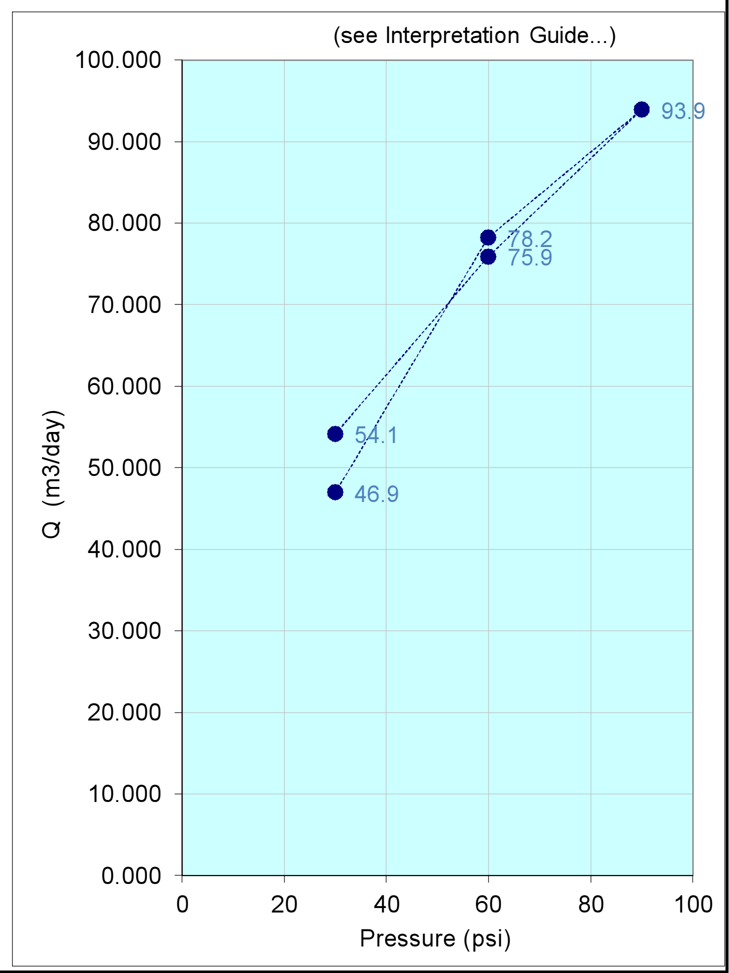
1: If hole is dry enter Dw = Boring Depth; if AQUIFER water level at test zone above ground surface use negative value
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m) IN ROCK to top of test section.

Equations:
$H_f = 8.65 \times 10^{-15} (Q^2 * L_p / r_p^5)$
$H_{nit} = (Dw' + Hg - Hf) + Pg/1.42$
$K = (Q * \ln(R/r_b)) / 2 * \pi * H_{nit} * L)$

Dw	Measured depth of static water level (1)	17.0	
Dbr	Measured depth to bedrock	0.6	m
Dp	Measured depth to packer	37.6	m
Dt	Measured depth to midpoint of test	40.0	m
ß	Inclination from horizontal (degrees)	90	°
Dw'	Vertical depth to static water level	17.0	m
Dbr'	Vertical dept to bedrock	0.6	m
Dp'	Vertical depth to packer	37.6	m
Dt'	Vertical depth to midpoint of test	40.0	m
SP	Shear Pin Rating (psi)	500	psi
Pblowout	Water column pressure in drill rods at plug	53	psi
Pshear	Estimated differential shear pressure required	500	psi
Pgmax	Maximum injection gauge pressure (3)	59	psi
Hg	Gauge height	2.0	m
Dp'	Length of discharge pipe	1.50	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0127	m
R	Radius of influence (10 m is standard value)	5	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.048	m
L	Length of test section	4.7	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		

Conversion Factors:
10 m of water = 0.9807 bar = 1kg/cm^2 = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bar, which is approx. 1.4 x 10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement (show last 3 to 5 flow meter readings)	Q (Liters / 30sec)				
	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
	30	60	90	60	30
1	16.50	28.70	34.00	26.30	18.60
2	16.60	28.30	33.00	26.70	18.90
3	16.20	27.00	33.00	27.00	18.50
4	16.30	27.50	32.50		18.80
5		27.50	32.80		
Stable Q (L/30sec)	16.30	27.50	33.00	26.70	18.80
Leak Q (L/30sec)	0.00	0.35	0.40	0.35	0.00
Q (m^3/day)	46.9	78.2	93.9	75.9	54.1
Hf (m)	0.09	0.24	0.35	0.23	0.12
Hnit (m)	40.0	61.0	82.0	61.0	40.0
K (m/day)	1.8E-01	2.0E-01	1.8E-01	2.0E-01	2.1E-01
K (m/s)	**2.1E-06**	**2.3E-06**	**2.1E-06**	**2.3E-06**	**2.5E-06**
+/- (m/s)	1.6E-07	-3.5E-08	0.0E+00	3.5E-08	-1.6E-07
+/- order of mag.	0.03	-0.01	0.00	0.01	-0.03



WESA a BluMetric company	PACKER INJECTION TEST (page 2)	Drillhole N°	JGW-4
		Test hole N°	N/A
		Test N°	1

Pressure oscillation during test

Pressure step	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
Min P during step	30	60	90	60	30
Max P during step	30	60	90	60	30
average pressure +/- psi					

Flowmeter measurement reading accuracy

volume +/- Liters / 30 sec					

High estimate of K

Q_{avg} (m^3/day)	46.94	78.19	93.89	75.89	54.14
Hf (m)	0.09	0.24	0.35	0.23	0.12
Hnit (m)	40.0	61.0	82.0	61.0	40.0
K (m/sec)	2.1E-06	2.3E-06	2.1E-06	2.3E-06	2.5E-06

Low estimate of K

Q_{avg} (m^3/day)	46.94	78.19	93.89	75.89	54.14
Hf (m)	0.09	0.24	0.35	0.23	0.12
Hnit (m)	40.0	61.0	82.0	61.0	40.0
K (m/sec)	2.1E-06	2.3E-06	2.1E-06	2.3E-06	2.5E-06

K averages for P step — m/second

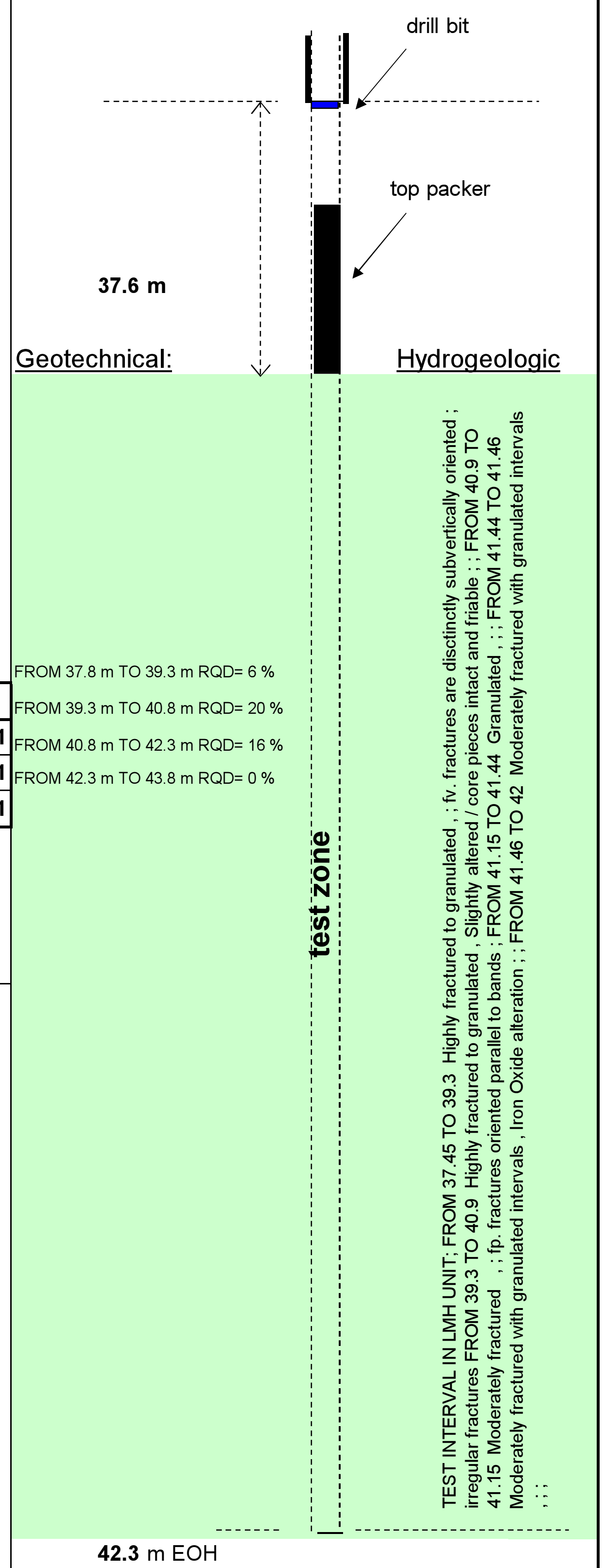
P	30	60	90
high est of K	2.E-06	2.E-06	2.E-06
average K	2.E-06	2.E-06	2.E-06
low est of K	2.E-06	2.E-06	2.E-06

K avg all P steps

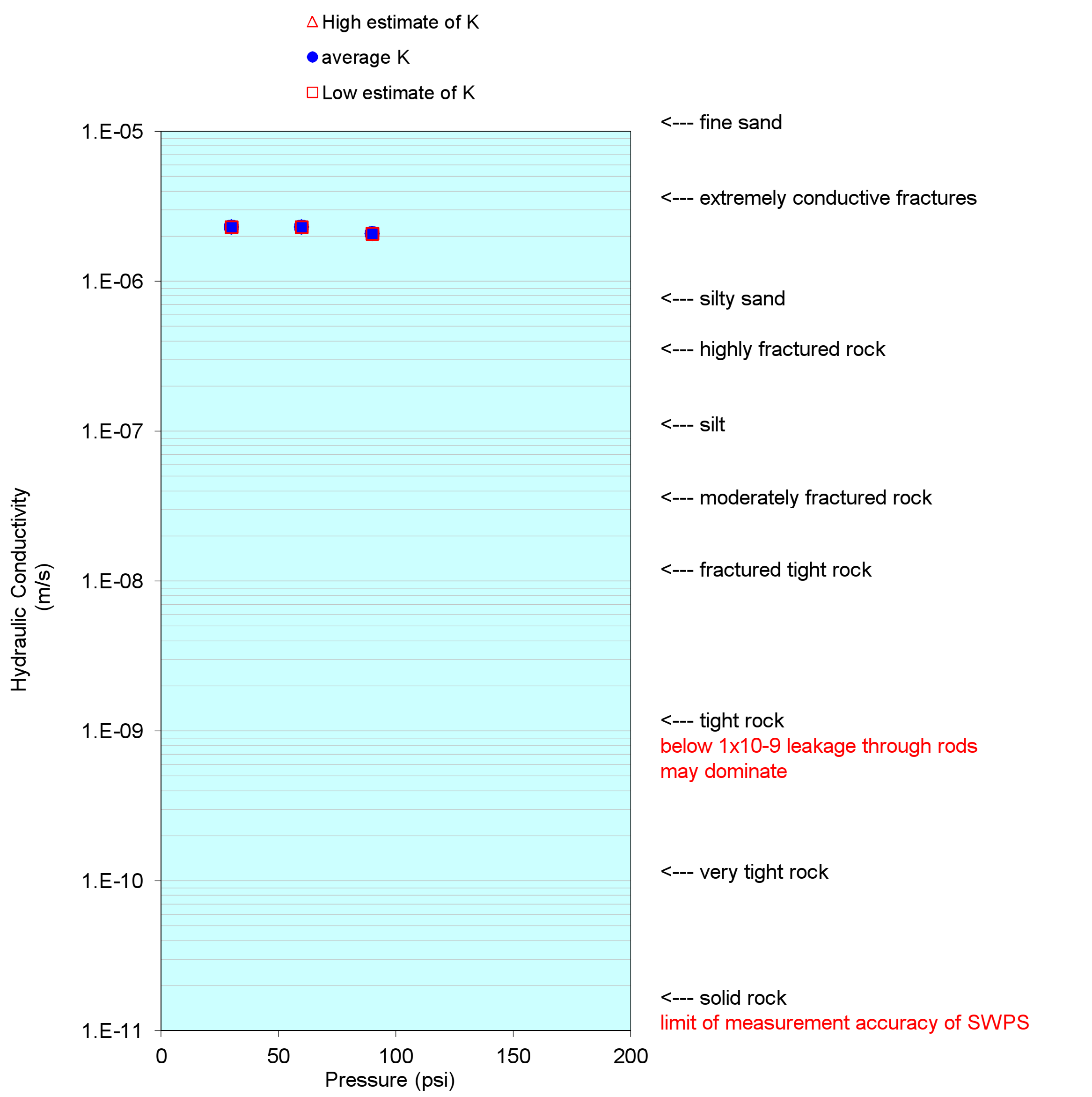
	m/sec	m/day
MAX	2.E-06	2.0E-01
geomean	2.E-06	1.9E-01
MIN	2.E-06	1.8E-01

Comments:

Drawing of zone tested, including geotech / hydrogeo. conditions:



Graph of estimated hydraulic conductivity and error bounds.



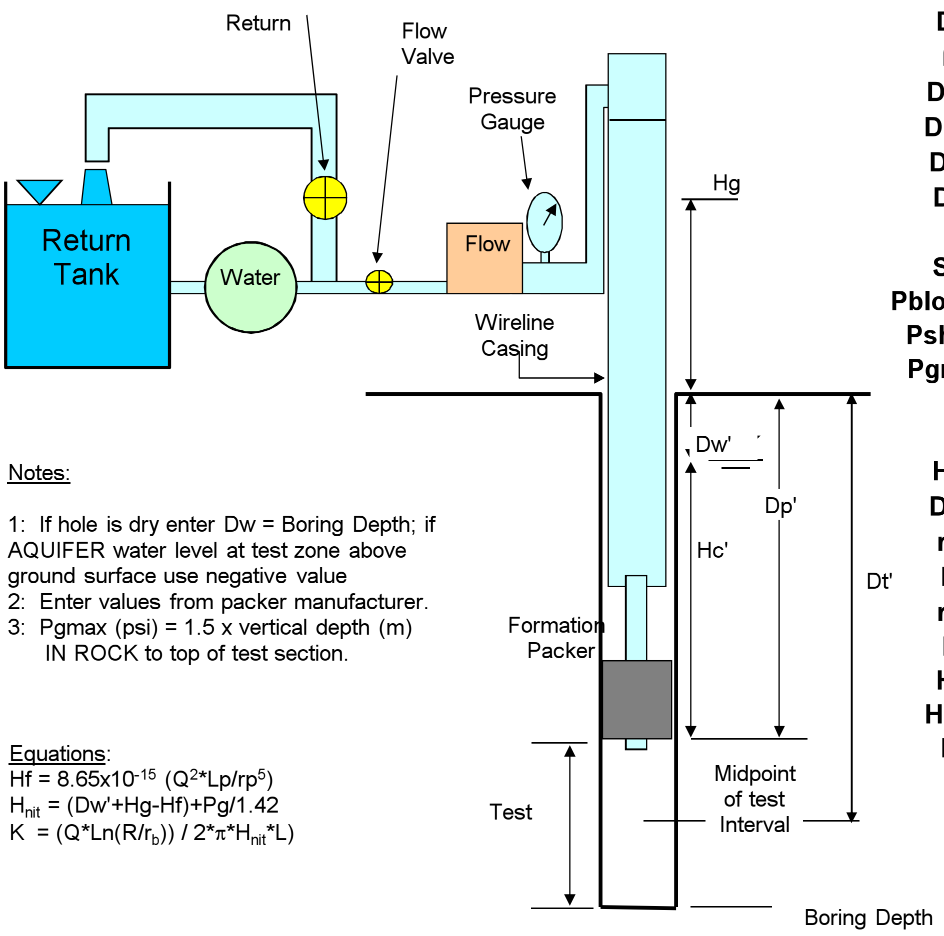
PACKER INJECTION TEST

WESA — a BluMetric company

Project:	S-B12738	**Test Interval (m):**	52.6	**to**	63.3	**Drillhole Nº**	JGW-4
UTM (x,y)	657990, 6086500	**Start Date:**	Oct 9 2014	**Time:**	13:00	**Test hole Nº**	N/A
Datum:		**End Date:**	Oct 9 2014	**Time:**	14:30	**Test Nº**	2
GS Elevation:		**Supervisor:**	VM/DP	**Rig:**	LF-70	**DH Depth (m)**	63.3

Max Injection P (psi)

79



Dw	Measured depth of static water level (1)	17.0	
Dbr	Measured depth to bedrock	0.6	m
Dp	Measured depth to packer	52.6	m
Dt	Measured depth to midpoint of test	58.0	m
ß	Inclination from horizontal (degrees)	90	º
Dw'	Vertical depth to static water level	17.0	m
Dbr'	Vertical dept to bedrock	0.6	m
Dp'	Vertical depth to packer	52.6	m
Dt'	Vertical depth to midpoint of test	58.0	m
SP	Shear Pin Rating (psi)	500	psi
Pblowout	Water column pressure in drill rods at plug	75	psi
Pshear	Estimated differential shear pressure required	500	psi
Pgmax	Maximum injection gauge pressure (3)	86	psi
Hg	Gauge height	2.0	m
Dp'	Length of discharge pipe	1.50	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0127	m
R	Radius of influence (10 m is standard value)	5	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.048	m
L	Length of test section	10.7	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		

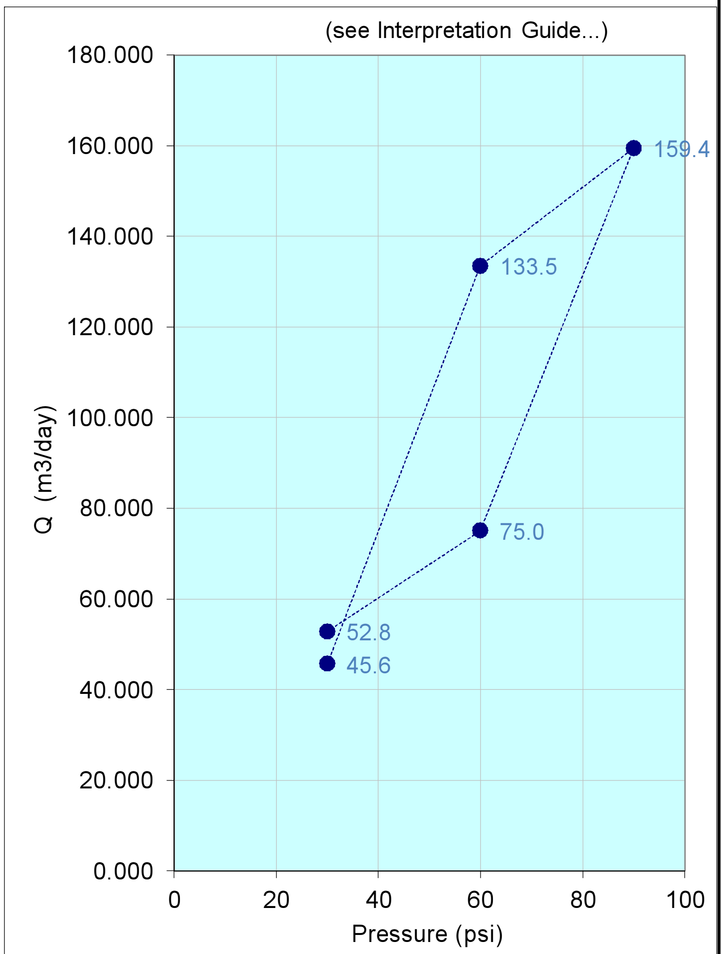
Notes:

1: If hole is dry enter Dw = Boring Depth; if AQUIFER water level at test zone above ground surface use negative value
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m) IN ROCK to top of test section.

Equations:
$Hf = 8.65x10^{-15} (Q^2*Lp/rp^5)$
$H_{nit} = (Dw'+Hg-Hf)+Pg/1.42$
$K = (Q*Ln(R/r_b)) / 2*\pi*H_{nit}*L)$

Conversion Factors:
10 m of water = 0.9807 bar = 1kg/cm^2 = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bar, which is approx. 1.4 x 10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement (show last 3 to 5 flow meter readings)	Q (Liters / 30sec)				
	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
	30	60	90	60	30
1	30.00	48.00	56.00	26.30	18.60
2	30.00	47.00	57.00	26.70	18.90
3	31.00	48.00	56.00	27.00	18.50
4	30.00	47.00	56.00		18.80
5					
Stable Q (L/30sec)	16.30	47.00	56.00	26.70	18.80
Leak Q (L/30sec)	0.45	0.65	0.65	0.65	0.45
Q (m^3/day)	45.6	133.5	159.4	75.0	52.8
Hf (m)	0.08	0.70	1.00	0.22	0.11
Hnit (m)	40.0	60.5	81.3	61.0	40.0
K (m/day)	7.9E-02	1.5E-01	1.4E-01	8.5E-02	9.1E-02
K (m/s)	**9.1E-07**	**1.8E-06**	**1.6E-06**	**9.8E-07**	**1.1E-06**
+/- (m/s)	7.2E-08	-3.9E-07	0.0E+00	3.9E-07	-7.2E-08
+/- order of mag.	0.03	-0.11	0.00	0.15	-0.03



WESA a BluMetric company	PACKER INJECTION TEST (page 2)	Drillhole N°	JGW-4
		Test hole N°	N/A
		Test N°	2

Pressure oscillation during test

Pressure step	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
Min P during step	30	60	90	60	30
Max P during step	30	60	90	60	30
average pressure +/- psi					

Flowmeter measurement reading accuracy

volume +/- Liters / 30 sec					

High estimate of K

Q_{avg} (m^3/day)	45.65	133.49	159.41	75.02	52.85
Hf (m)	0.08	0.70	1.00	0.22	0.11
Hnit (m)	40.0	60.5	81.3	61.0	40.0
K (m/sec)	9.1E-07	1.8E-06	1.6E-06	9.8E-07	1.1E-06

Low estimate of K

Q_{avg} (m^3/day)	45.65	133.49	159.41	75.02	52.85
Hf (m)	0.08	0.70	1.00	0.22	0.11
Hnit (m)	40.0	60.5	81.3	61.0	40.0
K (m/sec)	9.1E-07	1.8E-06	1.6E-06	9.8E-07	1.1E-06

K averages for P step (m/second)

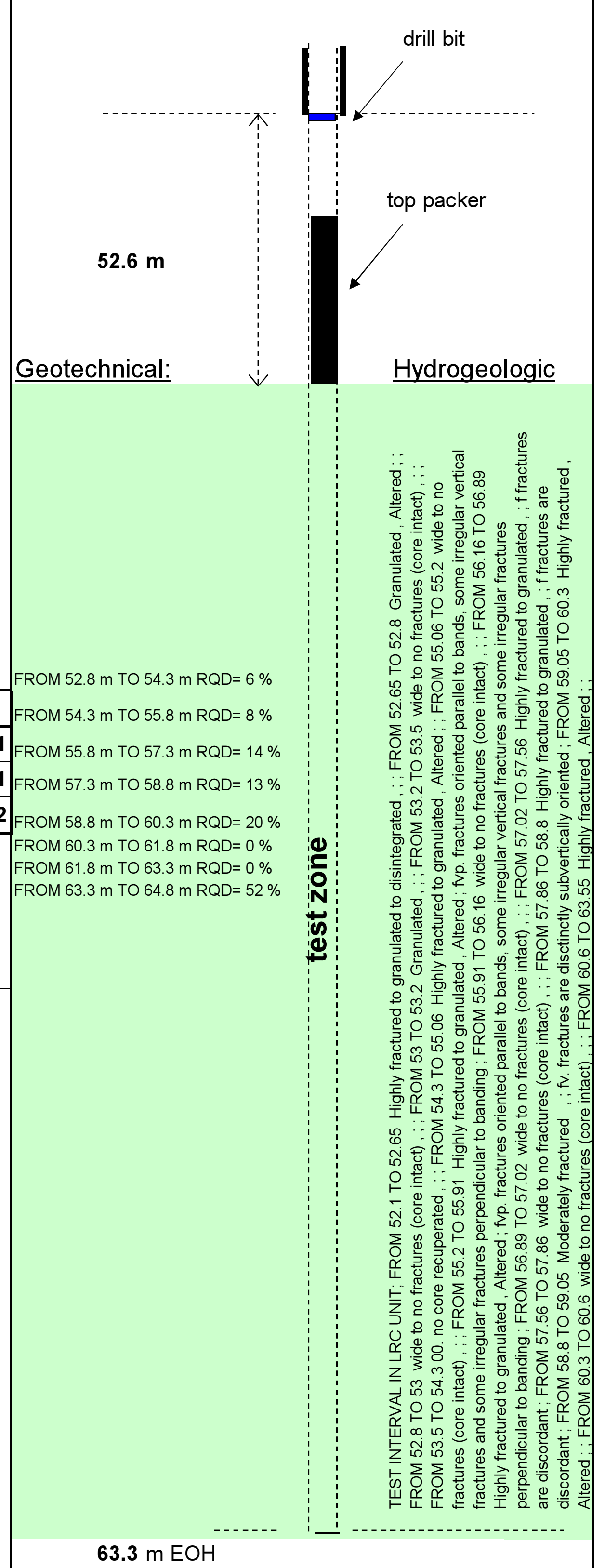
P	30	60	90
high est of K	1.E-06	1.E-06	2.E-06
average K	1.E-06	1.E-06	2.E-06
low est of K	1.E-06	1.E-06	2.E-06

K avg all P steps

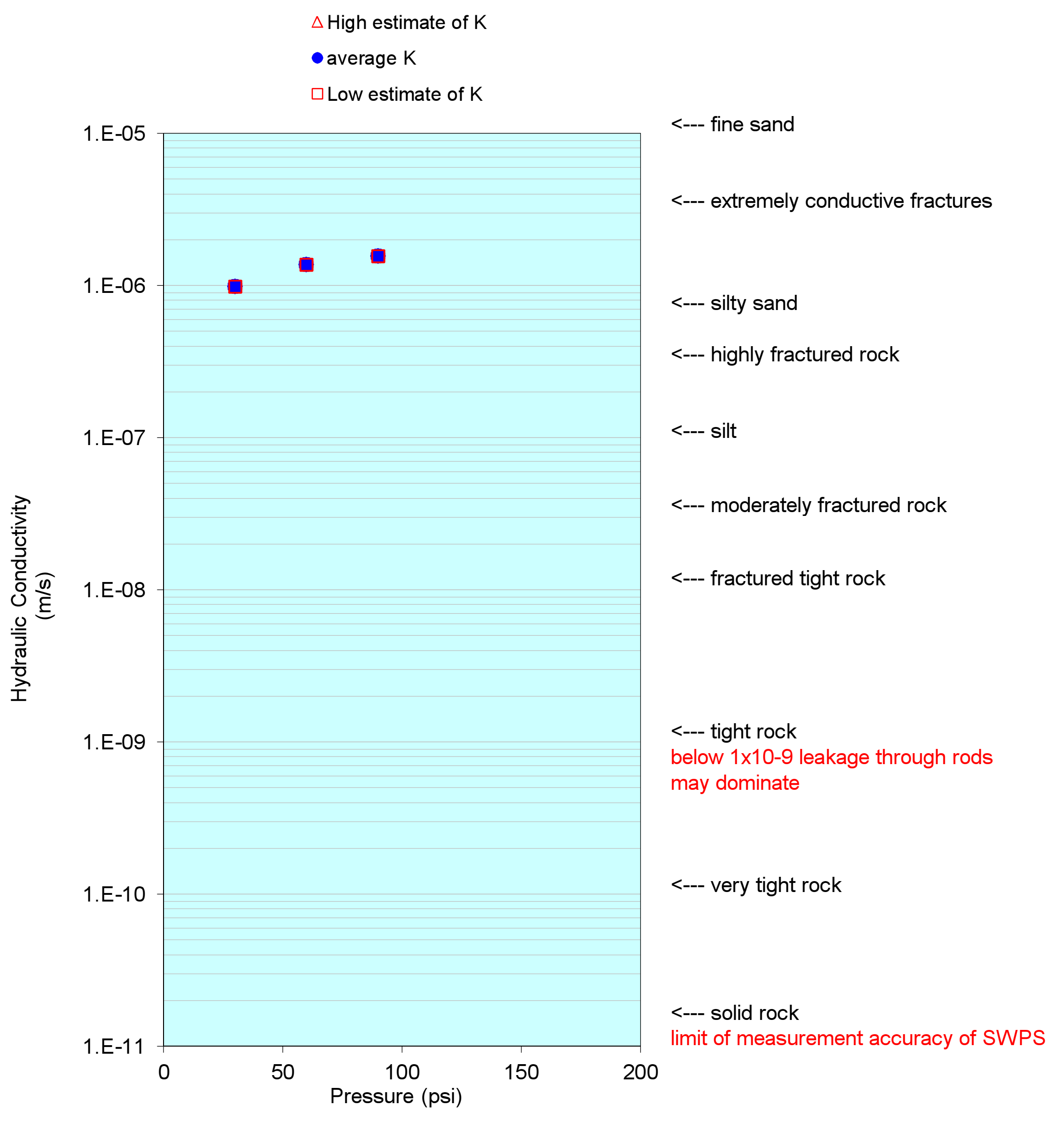
	m/sec	m/day
MAX	2.E-06	1.4E-01
geomean	1.E-06	1.1E-01
MIN	1.E-06	8.5E-02

Comments:

Drawing of zone tested, including geotech / hydrogeo. conditions:



Graph of estimated hydraulic conductivity and error bounds.



PACKER INJECTION TEST

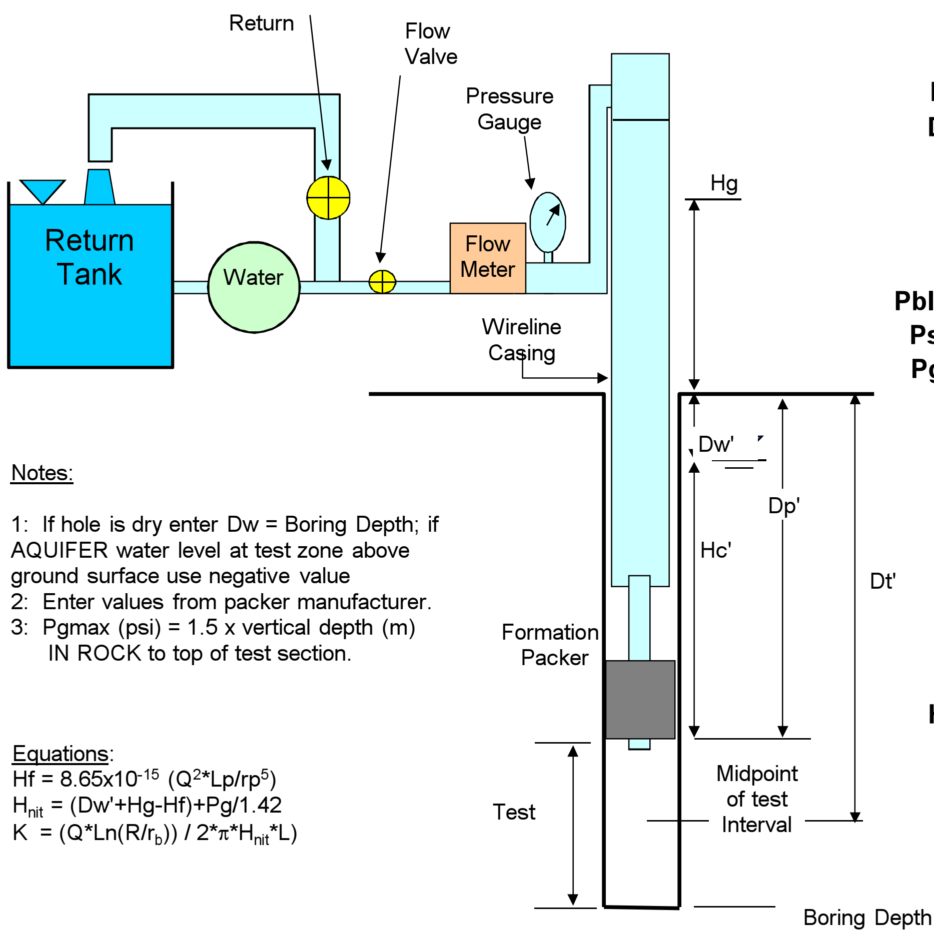
WESA
a BluMetric company

Project:	S-B12738	**Test Interval (m):**	88.6	**to**	96.3	**Drillhole N°**	JGW-4
UTM (x,y)	657990, 6086500	**Start Date:**	Oct 9 2014	**Time:**	1:00	**Test hole N°**	N/A
Datum:		**End Date:**	Oct 9 2014	**Time:**	2:15	**Test N°**	3
GS Elevation:		**Supervisor:**	VM/DP	**Rig:**	LF-70	**DH Depth (m)**	96.3

Max Injection P (psi)

133

Dw	Measured depth of static water level (1)	17.0	
Dbr	Measured depth to bedrock	0.6	m
Dp	Measured depth to packer	**88.6**	m
Dt	Measured depth to midpoint of test	**92.5**	m
ß	Inclination from horizontal (degrees)	90	°
Dw'	Vertical depth to static water level	**17.0**	m
Dbr'	Vertical dept to bedrock	**0.6**	m
Dp'	Vertical depth to packer	**88.6**	m
Dt'	Vertical depth to midpoint of test	**92.5**	m
SP	Shear Pin Rating (psi)	500	psi
Pblowout	Water column pressure in drill rods at plug	**126**	psi
Pshear	Estimated differential shear pressure required	**500**	psi
Pgmax	Maximum injection gauge pressure (3)	**138**	psi
Hg	Gauge height	2.0	m
Dp'	Length of discharge pipe	1.50	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0127	m
R	Radius of influence (10 m is standard value)	5	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.048	m
L	Length of test section	**7.7**	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		



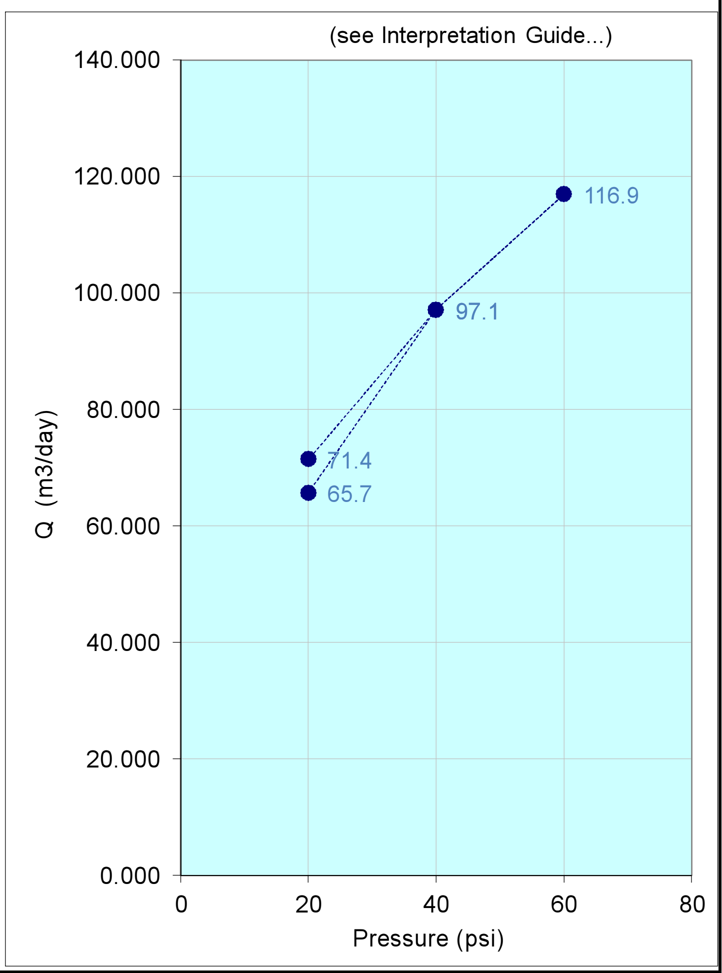
Notes:

1: If hole is dry enter Dw = Boring Depth; if AQUIFER water level at test zone above ground surface use negative value
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m) IN ROCK to top of test section.

Equations:
$H_f = 8.65\times10^{-15} (Q^2 * L_p/r_p^5)$
$H_{nit} = (Dw'+Hg-Hf)+Pg/1.42$
$K = (Q*\mathrm{Ln}(R/r_b)) / 2*\pi*H_{nit}*L)$

Conversion Factors:
10 m of water = 0.9807 bar = 1kg/cm^2 = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bar, which is approx. 1.4 x 10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement (show last 3 to 5 flow meter readings)	Q (Liters / 30sec)				
	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
	20	40	60	40	20
1	24.00	34.00	41.00	34.00	25.00
2	24.00	34.00	41.00	34.00	25.00
3	24.00	34.00	40.00	34.00	25.00
4	23.00	34.00	41.00	34.00	25.00
5	23.00				
Stable Q (L/30sec)	23.00	34.00	41.00	34.00	25.00
Leak Q (L/30sec)	0.20	0.30	0.40	0.30	0.20
Q (m^3/day)	65.7	97.1	116.9	97.1	71.4
Hf (m)	0.17	0.37	0.54	0.37	0.20
Hnit (m)	32.9	46.7	60.7	46.7	32.8
K (m/day)	1.9E-01	2.0E-01	1.9E-01	2.0E-01	2.1E-01
K (m/s)	**2.2E-06**	**2.3E-06**	**2.1E-06**	**2.3E-06**	**2.4E-06**
+/- (m/s)	9.9E-08	0.0E+00	0.0E+00	0.0E+00	-9.9E-08
+/- order of mag.	0.02	0.00	0.00	0.00	-0.02



WESA a BluMetric company	PACKER INJECTION TEST (page 2)	Drillhole N°	JGW-4
		Test hole N°	N/A
		Test N°	3

Pressure oscillation during test

Pressure step	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
Min P during step	20	40	60	40	20
Max P during step	20	40	60	40	20
average pressure +/- psi					

Flowmeter measurement reading accuracy

volume +/- Liters / 30 sec					

High estimate of K

Q_{avg} (m^3/day)	65.66	97.06	116.93	97.06	71.42
Hf (m)	0.17	0.37	0.54	0.37	0.20
Hnit (m)	32.9	46.7	60.7	46.7	32.8
K (m/sec)	2.2E-06	2.3E-06	2.1E-06	2.3E-06	2.4E-06

Low estimate of K

Q_{avg} (m^3/day)	65.66	97.06	116.93	97.06	71.42
Hf (m)	0.17	0.37	0.54	0.37	0.20
Hnit (m)	32.9	46.7	60.7	46.7	32.8
K (m/sec)	2.2E-06	2.3E-06	2.1E-06	2.3E-06	2.4E-06

K averages for P step — m/second

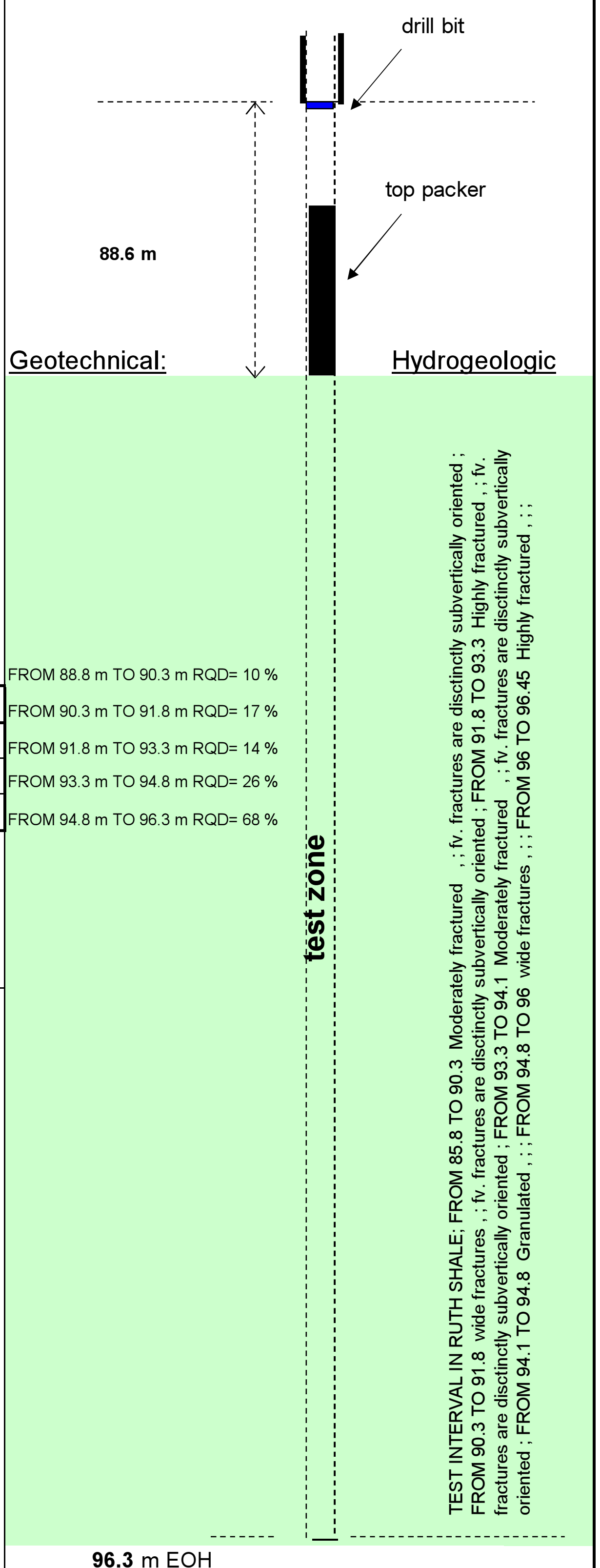
P	20	40	60
high est of K	2.E-06	2.E-06	2.E-06
average K	2.E-06	2.E-06	2.E-06
low est of K	2.E-06	2.E-06	2.E-06

K avg all P steps

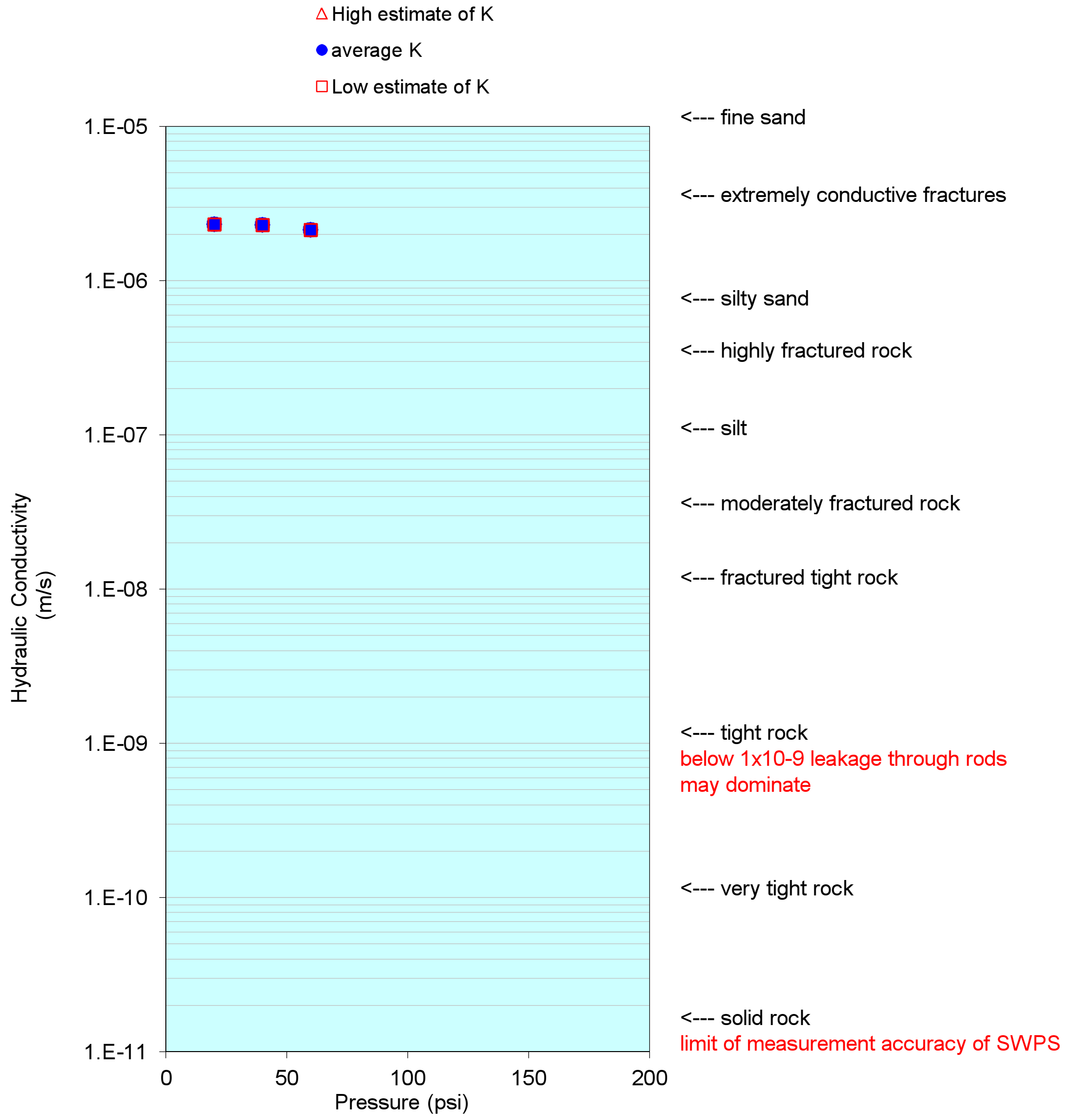
	m/sec	m/day
MAX	2.E-06	2.0E-01
geomean	2.E-06	1.9E-01
MIN	2.E-06	1.9E-01

Comments:

Drawing of zone tested, including geotech / hydrogeo. conditions:



Graph of estimated hydraulic conductivity and error bounds.



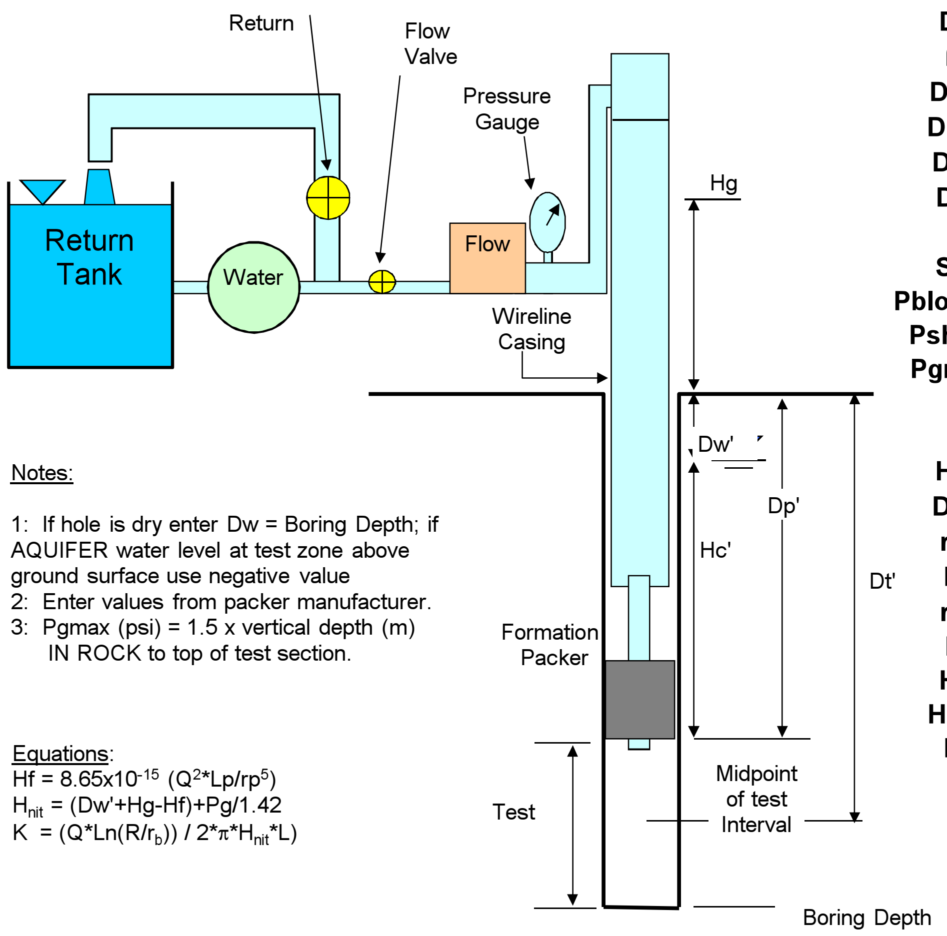
PACKER INJECTION TEST

WESA a BluMetric company

Project:	S-B12738	**Test Interval (m):**	112.6	**to**	123.3	**Drillhole N°**	JGW-4
UTM (x,y)	657990, 6086500	**Start Date:**	Oct 10 2014	**Time:**	10:00	**Test hole N°**	N/A
Datum:		**End Date:**	Oct 10 2014	**Time:**	11:00	**Test N°**	4
GS Elevation:		**Supervisor:**	VM/DP	**Rig:**	LF-70	**DH Depth (m)**	123.3

Max Injection P (psi)

169



Notes:

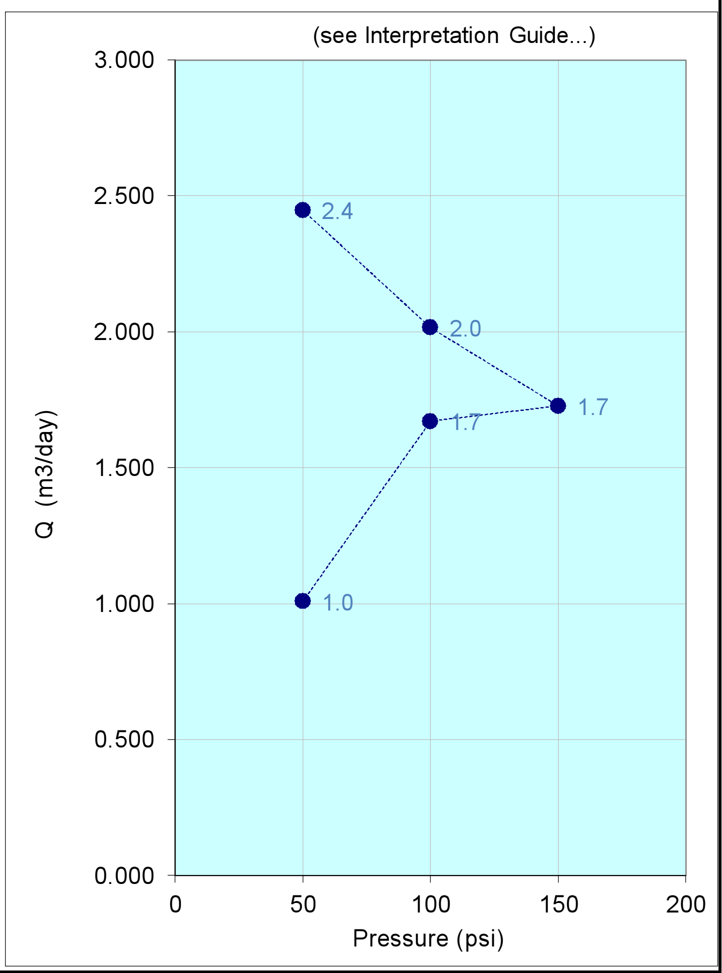
1: If hole is dry enter Dw = Boring Depth; if AQUIFER water level at test zone above ground surface use negative value
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m) IN ROCK to top of test section.

Equations:
$Hf = 8.65x10^{-15} (Q^2*Lp/rp^5)$
$H_{nit} = (Dw'+Hg-Hf)+Pg/1.42$
$K = (Q*Ln(R/r_b)) / 2*\pi*H_{nit}*L)$

Dw	Measured depth of static water level (1)	17.0	
Dbr	Measured depth to bedrock	0.6	m
Dp	Measured depth to packer	112.6	m
Dt	Measured depth to midpoint of test	118.0	m
ß	Inclination from horizontal (degrees)	90	°
Dw'	Vertical depth to static water level	17.0	m
Dbr'	Vertical dept to bedrock	0.6	m
Dp'	Vertical depth to packer	112.6	m
Dt'	Vertical depth to midpoint of test	118.0	m
SP	Shear Pin Rating (psi)	500	psi
Pblowout	Water column pressure in drill rods at plug	160	psi
Pshear	Estimated differential shear pressure required	500	psi
Pgmax	Maximum injection gauge pressure (3)	176	psi
Hg	Gauge height	2.0	m
Dp'	Length of discharge pipe	1.50	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0127	m
R	Radius of influence (10 m is standard value)	5	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.048	m
L	Length of test section	10.7	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		

Conversion Factors:
10 m of water = 0.9807 bar = 1kg/cm^2 = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bar, which is approx. 1.4 x 10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement (show last 3 to 5 flow meter readings)	Q (Liters / 30sec)				
	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
	50	100	150	100	50
1	1.05	0.75	0.75	0.60	0.35
2	0.95	0.70	0.95	0.57	0.35
3	0.85	0.75	0.30	0.58	0.35
4	0.85	0.70	0.60	0.55	0.30
5	0.85	0.70	0.60		0.35
Stable Q (L/30sec)	0.85	0.70	0.60	0.58	0.35
Leak Q (L/30sec)	0.00	0.00	0.00	0.00	0.00
Q (m^3/day)	2.4	2.0	1.7	1.7	1.0
Hf (m)	0.00	0.00	0.00	0.00	0.00
Hnit (m)	54.2	89.4	124.6	89.4	54.2
K (m/day)	3.1E-03	1.6E-03	9.6E-04	1.3E-03	1.3E-03
K (m/s)	**3.6E-08**	**1.8E-08**	**1.1E-08**	**1.5E-08**	**1.5E-08**
+/- (m/s)	-1.1E-08	-1.5E-09	0.0E+00	1.5E-09	1.1E-08
+/- order of mag.	-0.15	-0.04	0.00	0.04	0.23



WESA a BluMetric company	PACKER INJECTION TEST (page 2)	Drillhole Nº	JGW-4
		Test hole Nº	N/A
		Test Nº	4

Pressure oscillation during test

Pressure step	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
Min P during step	50	100	150	100	50
Max P during step	50	100	150	100	50
average pressure +/- psi					

Flowmeter measurement reading accuracy

volume +/- Liters / 30 sec					

High estimate of K

Q_{avg} (m^3/day)	2.45	2.02	1.73	1.67	1.01
Hf (m)	0.00	0.00	0.00	0.00	0.00
Hnit (m)	54.2	89.4	124.6	89.4	54.2
K (m/sec)	3.6E-08	1.8E-08	1.1E-08	1.5E-08	1.5E-08

Low estimate of K

Q_{avg} (m^3/day)	2.45	2.02	1.73	1.67	1.01
Hf (m)	0.00	0.00	0.00	0.00	0.00
Hnit (m)	54.2	89.4	124.6	89.4	54.2
K (m/sec)	3.6E-08	1.8E-08	1.1E-08	1.5E-08	1.5E-08

K averages for P step (m/second)

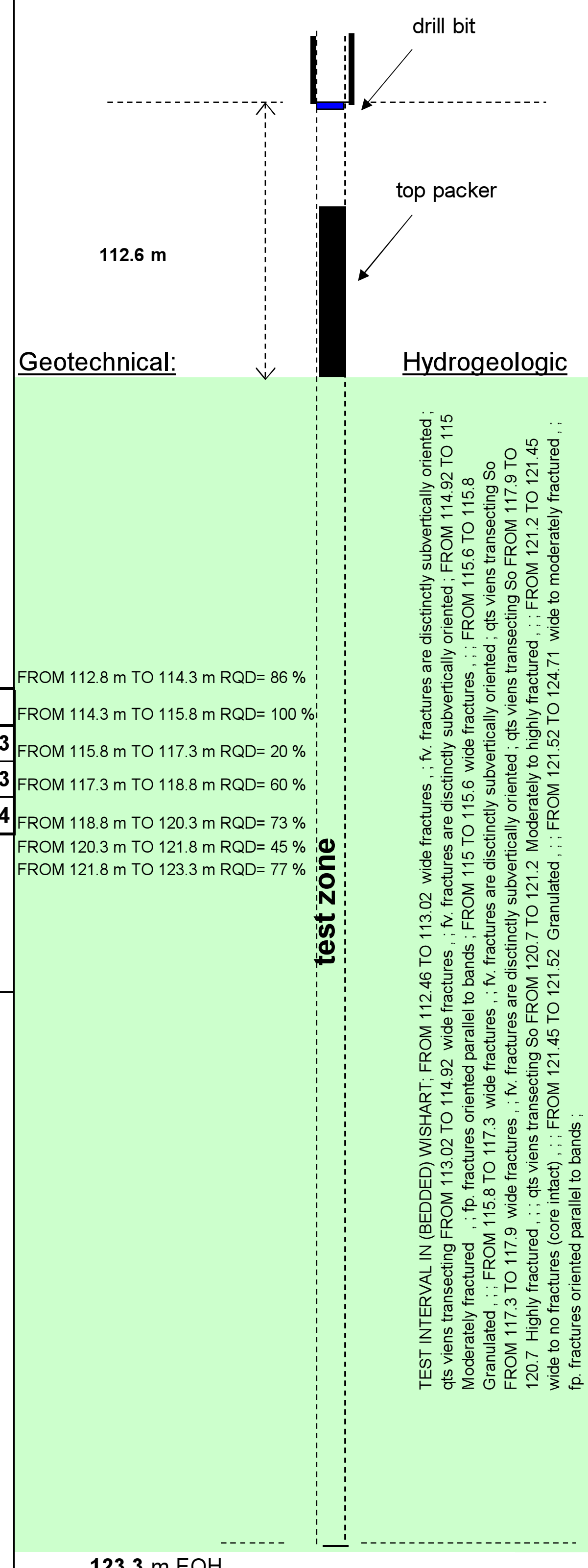
P	50	100	150
high est of K	3.E-08	2.E-08	1.E-08
average K	3.E-08	2.E-08	1.E-08
low est of K	3.E-08	2.E-08	1.E-08

K avg all P steps

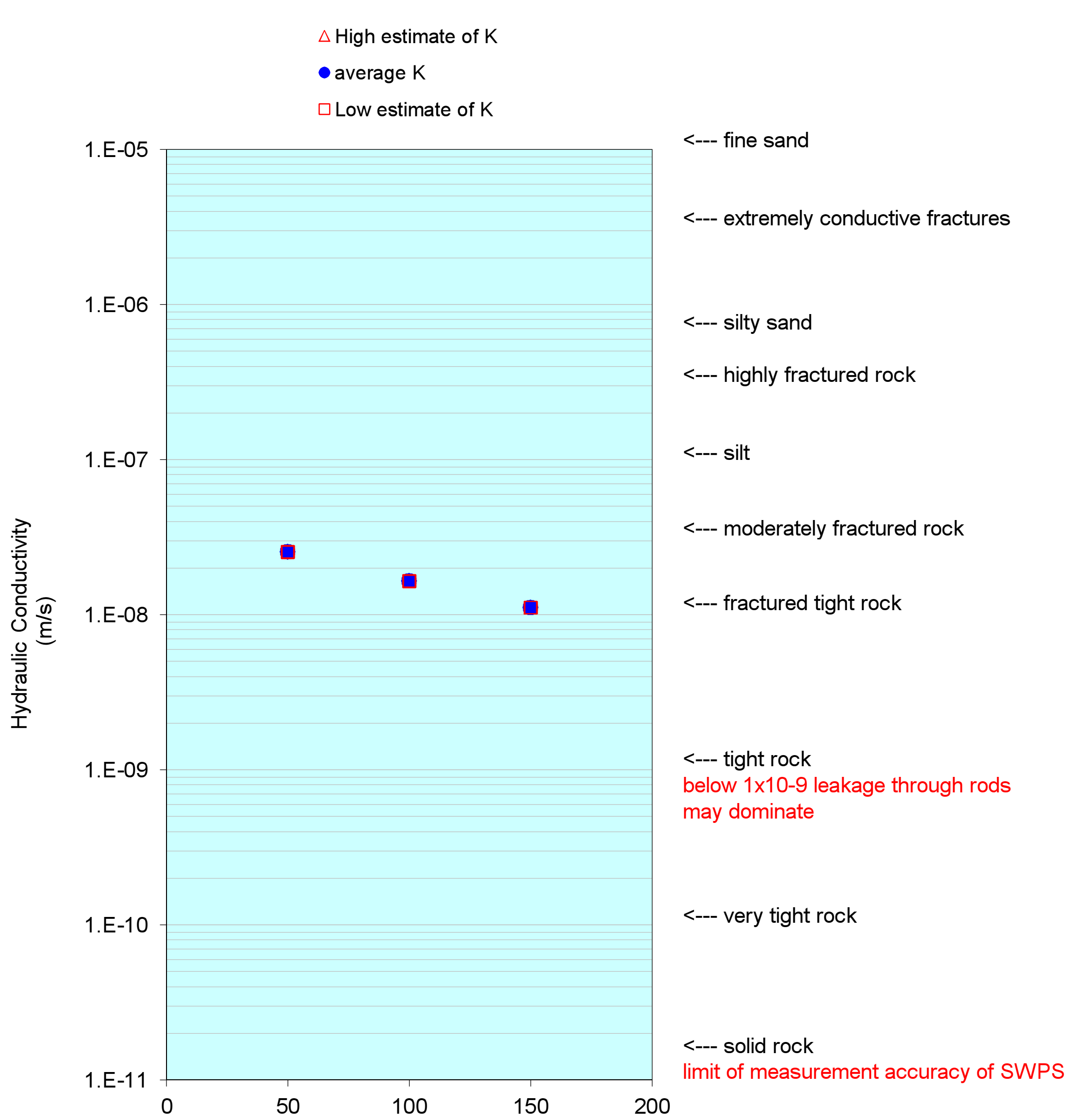
	m/sec	m/day
MAX	3.E-08	2.2E-03
geomean	2.E-08	1.4E-03
MIN	1.E-08	9.6E-04

Comments:

Drawing of zone tested, including geotech / hydrogeo. conditions:



Graph of estimated hydraulic conductivity and error bounds.



PACKER INJECTION TEST

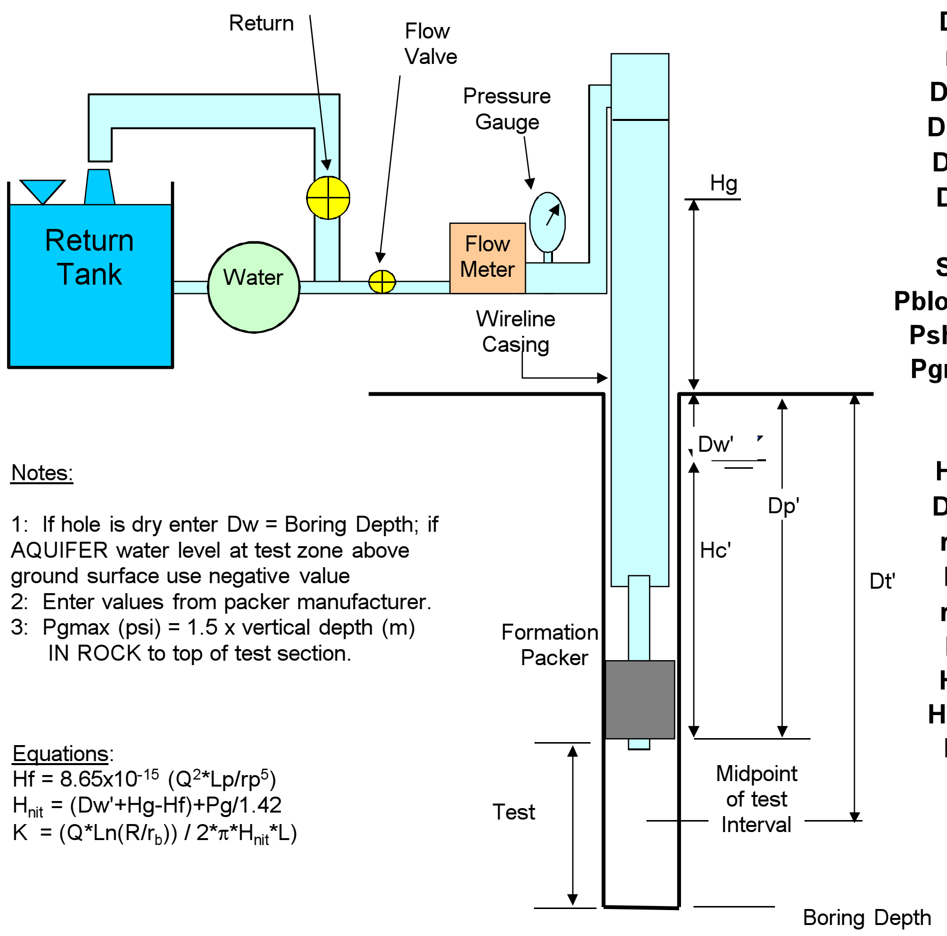
WESA a BluMetric company

Project:	S-B12738	**Test Interval (m):**	133.6	**to**	144.3	**Drillhole N°**	JGW-4
UTM (x,y)	657990, 6086500	**Start Date:**	Oct 11 2014	**Time:**	10:00	**Test hole N°**	N/A
Datum:		**End Date:**	Oct 11 2014	**Time:**	11:00	**Test N°**	5
GS Elevation:		**Supervisor:**	VM/DP	**Rig:**	LF-70	**DH Depth (m)**	144.3

Max Injection P (psi)

200

Dw	Measured depth of static water level (1)	17.0	
Dbr	Measured depth to bedrock	0.6	m
Dp	Measured depth to packer	133.6	m
Dt	Measured depth to midpoint of test	139.0	m
ß	Inclination from horizontal (degrees)	90	°
Dw'	Vertical depth to static water level	17.0	m
Dbr'	Vertical dept to bedrock	0.6	m
Dp'	Vertical depth to packer	133.6	m
Dt'	Vertical depth to midpoint of test	139.0	m
SP	Shear Pin Rating (psi)	500	psi
Pblowout	Water column pressure in drill rods at plug	190	psi
Pshear	Estimated differential shear pressure required	500	psi
Pgmax	Maximum injection gauge pressure (3)	208	psi
Hg	Gauge height	2.0	m
Dp'	Length of discharge pipe	1.50	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0127	m
R	Radius of influence (10 m is standard value)	5	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.048	m
L	Length of test section	10.7	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		



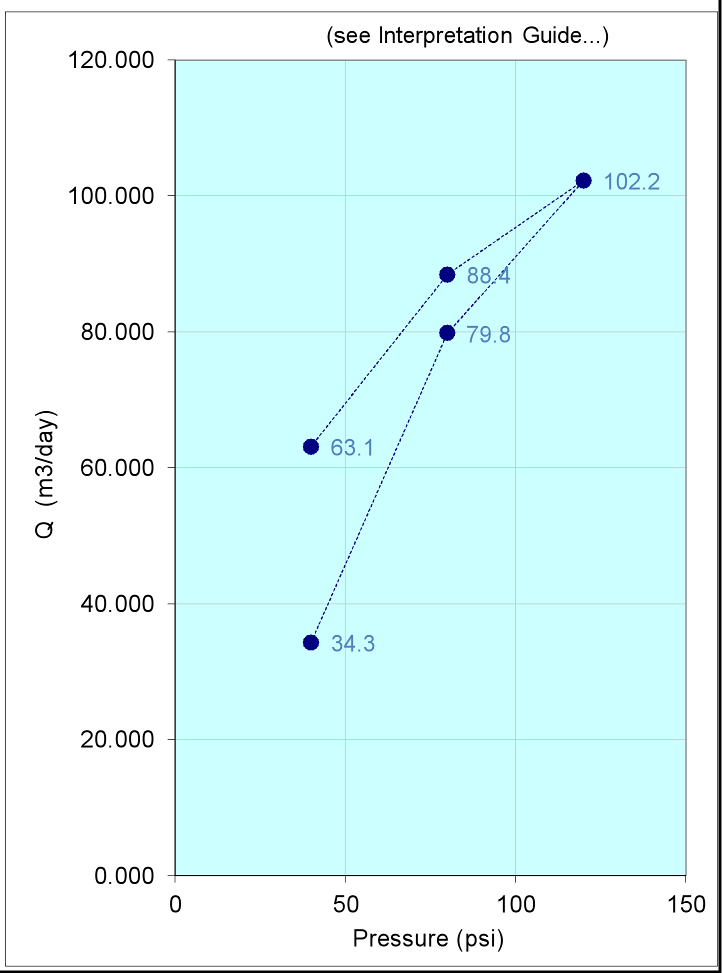
Notes:

1: If hole is dry enter Dw = Boring Depth; if AQUIFER water level at test zone above ground surface use negative value
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m) IN ROCK to top of test section.

Equations:
$Hf = 8.65x10^{-15} (Q^2*Lp/rp^5)$
$H_{nit} = (Dw'+Hg-Hf)+Pg/1.42$
$K = (Q*Ln(R/r_b)) / 2*\pi*H_{nit}*L)$

Conversion Factors:
10 m of water = 0.9807 bar = 1kg/cm^2 = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bar, which is approx. 1.4 x 10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement (show last 3 to 5 flow meter readings)	Q (Liters / 30sec)				
	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
	40	80	120	80	40
1	12.00	29.00	37.00	31.00	22.00
2	11.00	28.00	37.00	31.00	22.00
3	12.00	28.00	36.00	31.00	22.00
4	12.00	29.00	36.00	31.00	22.00
5	12.00	28.00	36.00		
Stable Q (L/30sec)	12.00	28.00	36.00	31.00	22.00
Leak Q (L/30sec)	0.10	0.30	0.50	0.30	0.10
Q (m^3/day)	34.3	79.8	102.2	88.4	63.1
Hf (m)	0.05	0.25	0.41	0.31	0.16
Hnit (m)	47.1	75.0	103.0	75.0	47.0
K (m/day)	5.0E-02	7.3E-02	6.9E-02	8.1E-02	9.3E-02
K (m/s)	**5.8E-07**	**8.5E-07**	**7.9E-07**	**9.4E-07**	**1.1E-06**
+/- (m/s)	2.5E-07	4.6E-08	0.0E+00	-4.6E-08	-2.5E-07
+/- order of mag.	0.15	0.02	0.00	-0.02	-0.11



WESA
a BluMetric company

PACKER INJECTION TEST
(page 2)

Drillhole Nº	JGW-4
Test hole Nº	N/A
Test Nº	5

Pressure oscillation during test

Pressure step	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
Min P during step	40	80	120	80	40
Max P during step	40	80	120	80	40
average pressure +/- psi					

Flowmeter measurement reading accuracy

volume +/- Liters / 30 sec					

High estimate of K

Q_{avg} (m^3/day)	34.27	79.78	102.24	88.42	63.07
Hf (m)	0.05	0.25	0.41	0.31	0.16
Hnit (m)	47.1	75.0	103.0	75.0	47.0
K (m/sec)	5.8E-07	8.5E-07	7.9E-07	9.4E-07	1.1E-06

Low estimate of K

Q_{avg} (m^3/day)	34.27	79.78	102.24	88.42	63.07
Hf (m)	0.05	0.25	0.41	0.31	0.16
Hnit (m)	47.1	75.0	103.0	75.0	47.0
K (m/sec)	5.8E-07	8.5E-07	7.9E-07	9.4E-07	1.1E-06

K averages for P step

m/second

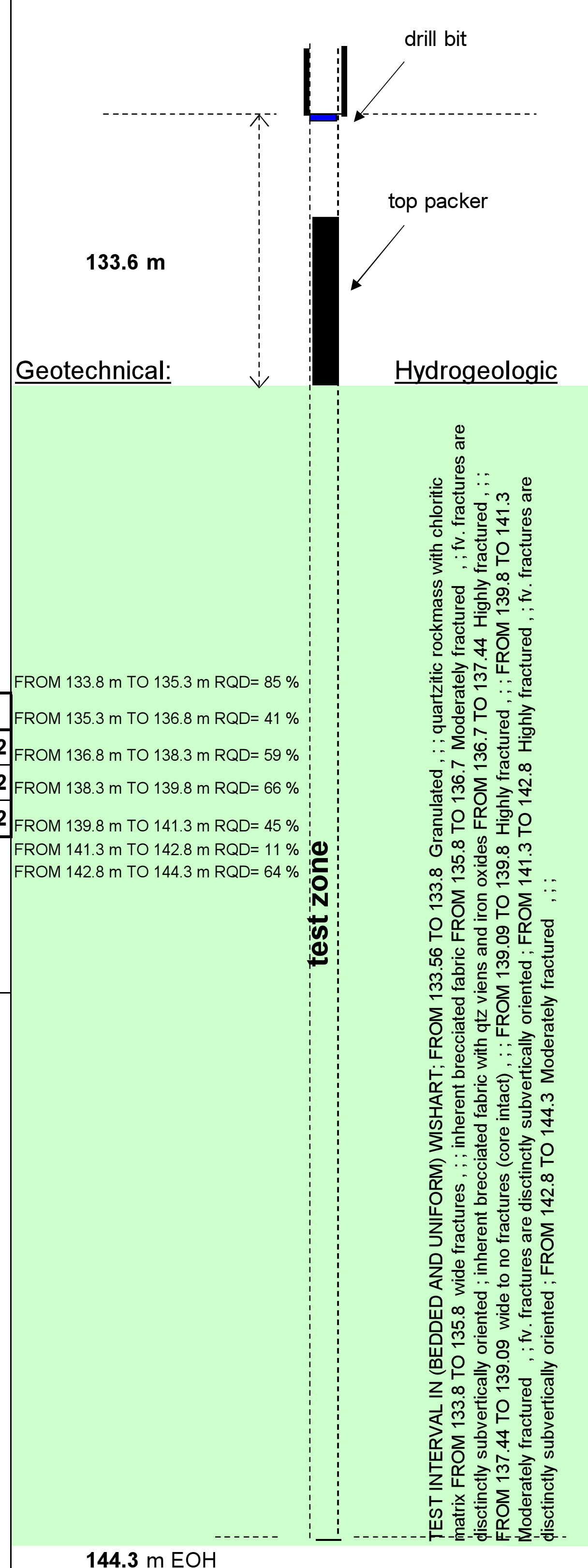
P	40	80	120
high est of K	8.E-07	9.E-07	8.E-07
average K	8.E-07	9.E-07	8.E-07
low est of K	8.E-07	9.E-07	8.E-07

K avg all P steps

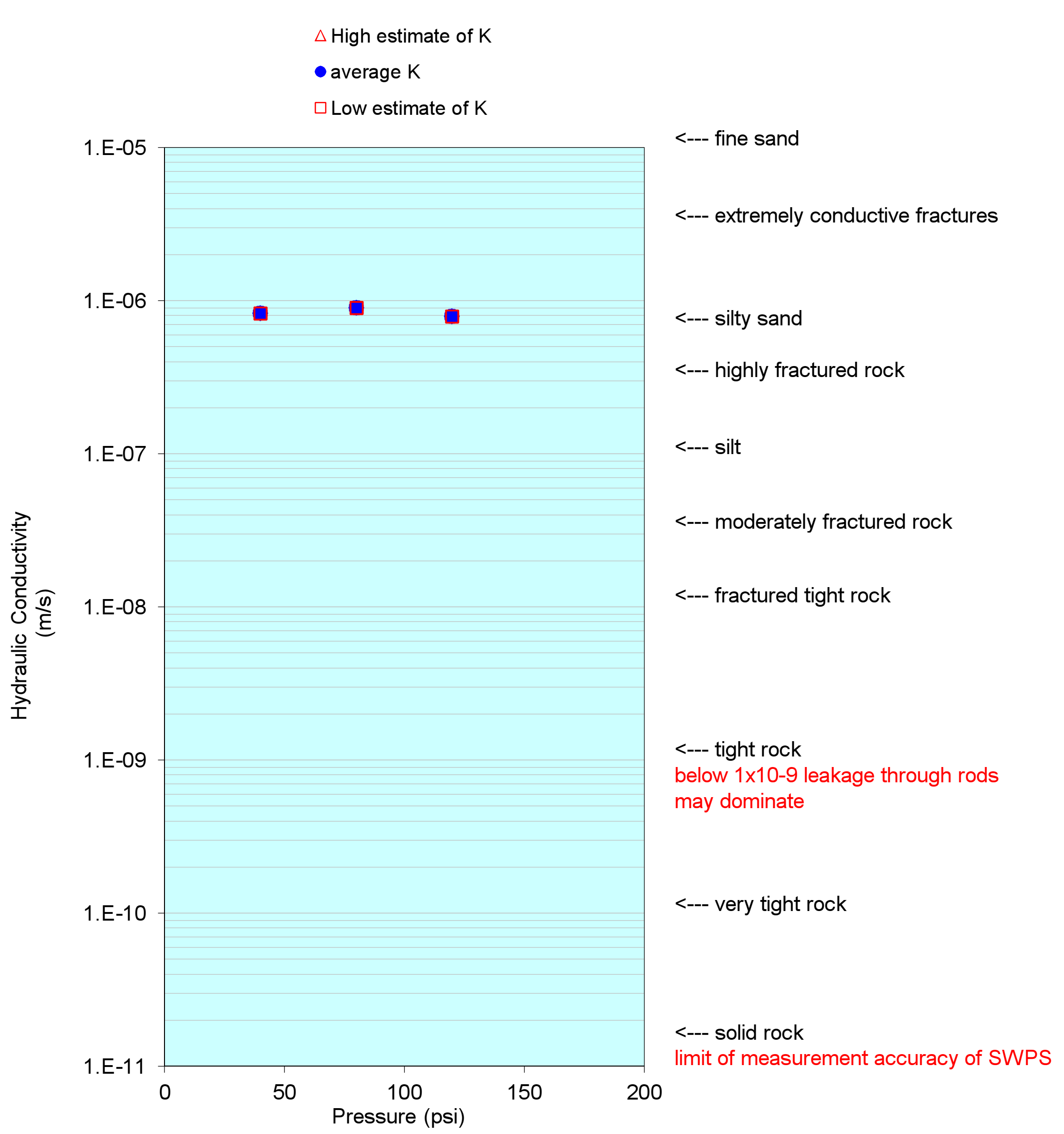
	m/sec	m/day
MAX	9.E-07	7.7E-02
geomean	8.E-07	7.2E-02
MIN	8.E-07	6.9E-02

Comments:

Drawing of zone tested, including geotech / hydrogeo. conditions:



Graph of estimated hydraulic conductivity and error bounds.

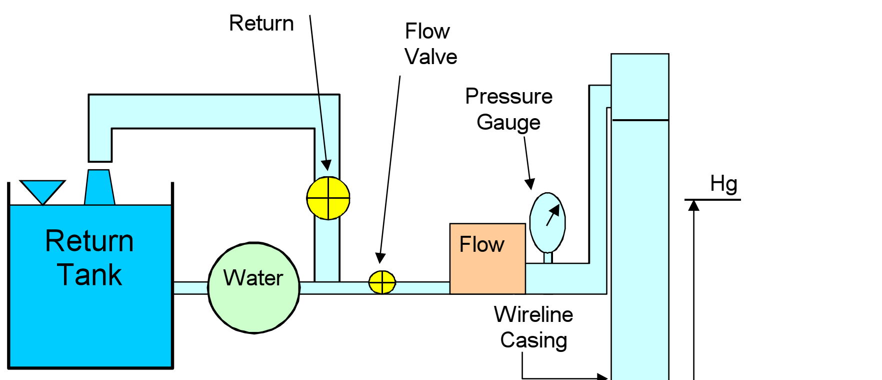


PACKER INJECTION TEST

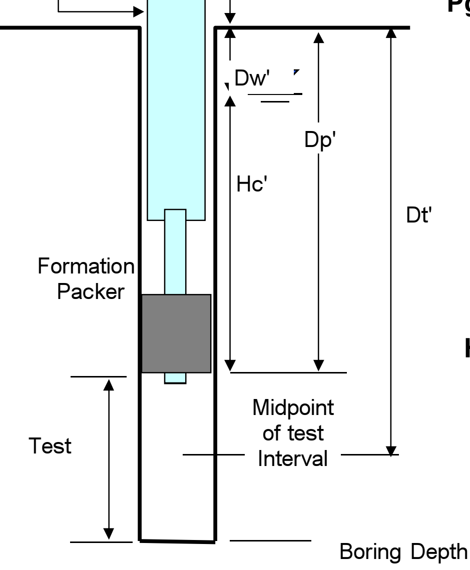
WESA
a BluMetric company

Project:	S-B12738	**Test Interval (m):**	145.6	**to**	156.3	**Drillhole Nº**	JGW-4
UTM (x,y)	657990, 6086500	**Start Date:**	Oct 11 2014	**Time:**	10:00	**Test hole Nº**	N/A
Datum:		**End Date:**	Oct 11 2014	**Time:**	11:00	**Test Nº**	6
GS Elevation:		**Supervisor:**	VM/DP	**Rig:**	LF-70	**DH Depth (m)**	156.3

Max Injection P (psi)
218



Symbol	Description	Value
Dw	Measured depth of static water level (1)	17.0
Dbr	Measured depth to bedrock	0.6 m
Dp	Measured depth to packer	145.6 m
Dt	Measured depth to midpoint of test	151.0 m
ß	Inclination from horizontal (degrees)	90 °
Dw'	Vertical depth to static water level	17.0 m
Dbr'	Vertical dept to bedrock	0.6 m
Dp'	Vertical depth to packer	145.6 m
Dt'	Vertical depth to midpoint of test	151.0 m
SP	Shear Pin Rating (psi)	500 psi
Pblowout	Water column pressure in drill rods at plug	207 psi
Pshear	Estimated differential shear pressure required	500 psi
Pgmax	Maximum injection gauge pressure (3)	226 psi
Hg	Gauge height	2.0 m
Dp'	Length of discharge pipe	1.50 m
rp	Radius of discharge pipe (1"=0.0127m)	0.0127 m
R	Radius of influence (10 m is standard value)	5 m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.048 m
L	Length of test section	10.7 m
Hf	Friction Loss	
Hnit	Net injection head at midpoint of test	
K	Hydraulic conductivity	



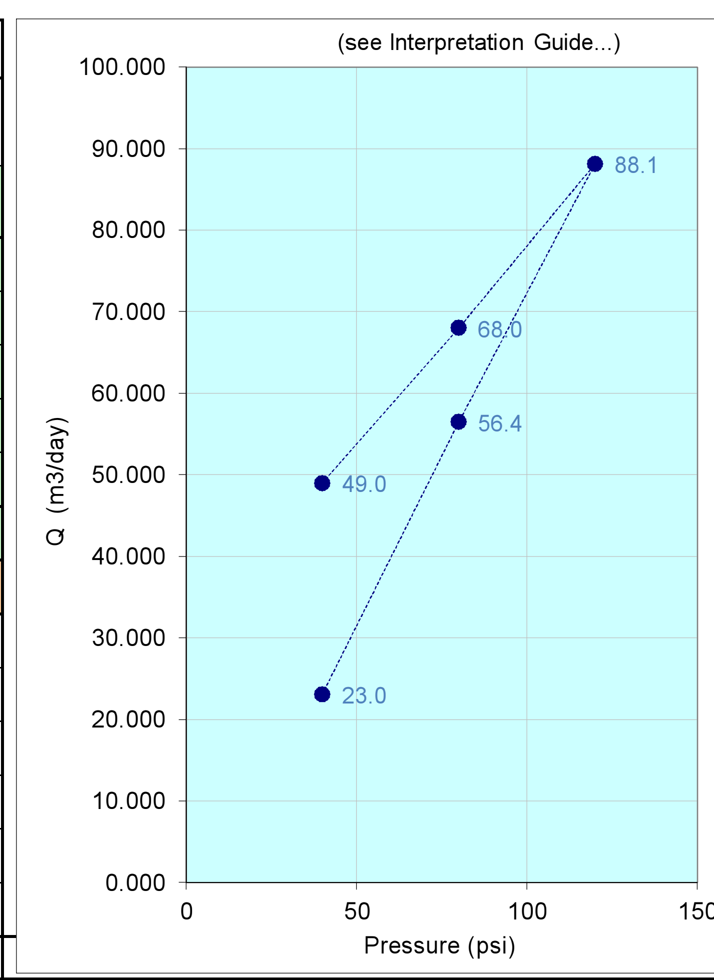
Notes:

1: If hole is dry enter Dw = Boring Depth; if AQUIFER water level at test zone above ground surface use negative value
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m) IN ROCK to top of test section.

Equations:
$H_f = 8.65\times10^{-15}\ (Q^2 * Lp/rp^5)$
$H_{nit} = (Dw' + Hg - Hf) + Pg/1.42$
$K = (Q * \ln(R/r_b)) / 2*\pi*H_{nit}*L)$

Conversion Factors:
10 m of water = 0.9807 bar = 1kg/cm^2 = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bar, which is approx. 1.4 x 10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement (show last 3 to 5 flow meter readings)	Q (Liters / 30sec)				
	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
	40	80	120	80	40
1	9.00	21.00	33.00	25.00	17.00
2	9.00	20.00	23.00	25.00	16.00
3	8.00	20.00	32.00	25.00	17.00
4	8.00	21.00	32.00	25.00	18.00
5	9.00	21.00	32.00		18.00
Stable Q (L/30sec)	9.00	21.00	32.00	25.00	18.00
Leak Q (L/30sec)	1.00	1.40	1.40	1.40	1.00
Q (m^3/day)	23.0	56.4	88.1	68.0	49.0
Hf (m)	0.02	0.13	0.31	0.18	0.09
Hnit (m)	47.1	75.2	103.2	75.1	47.0
K (m/day)	3.4E-02	5.2E-02	5.9E-02	6.3E-02	7.2E-02
K (m/s)	**3.9E-07**	**6.0E-07**	**6.8E-07**	**7.2E-07**	**8.3E-07**
+/- (m/s)	2.2E-07	6.2E-08	0.0E+00	-6.2E-08	-2.2E-07
+/- order of mag.	0.19	0.04	0.00	-0.04	-0.13



WESA a BluMetric company	PACKER INJECTION TEST (page 2)	Drillhole N°	JGW-4
		Test hole N°	N/A
		Test N°	6

Pressure oscillation during test

Pressure step	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
Min P during step	40	80	120	80	40
Max P during step	40	80	120	80	40
average pressure +/- psi					

Flowmeter measurement reading accuracy

volume +/- Liters / 30 sec					

High estimate of K

Q_{avg} (m^3/day)	23.04	56.45	88.13	67.97	48.96
Hf (m)	0.02	0.13	0.31	0.18	0.09
Hnit (m)	47.1	75.2	103.2	75.1	47.0
K (m/sec)	3.9E-07	6.0E-07	6.8E-07	7.2E-07	8.3E-07

Low estimate of K

Q_{avg} (m^3/day)	23.04	56.45	88.13	67.97	48.96
Hf (m)	0.02	0.13	0.31	0.18	0.09
Hnit (m)	47.1	75.2	103.2	75.1	47.0
K (m/sec)	3.9E-07	6.0E-07	6.8E-07	7.2E-07	8.3E-07

K averages for P step — m/second

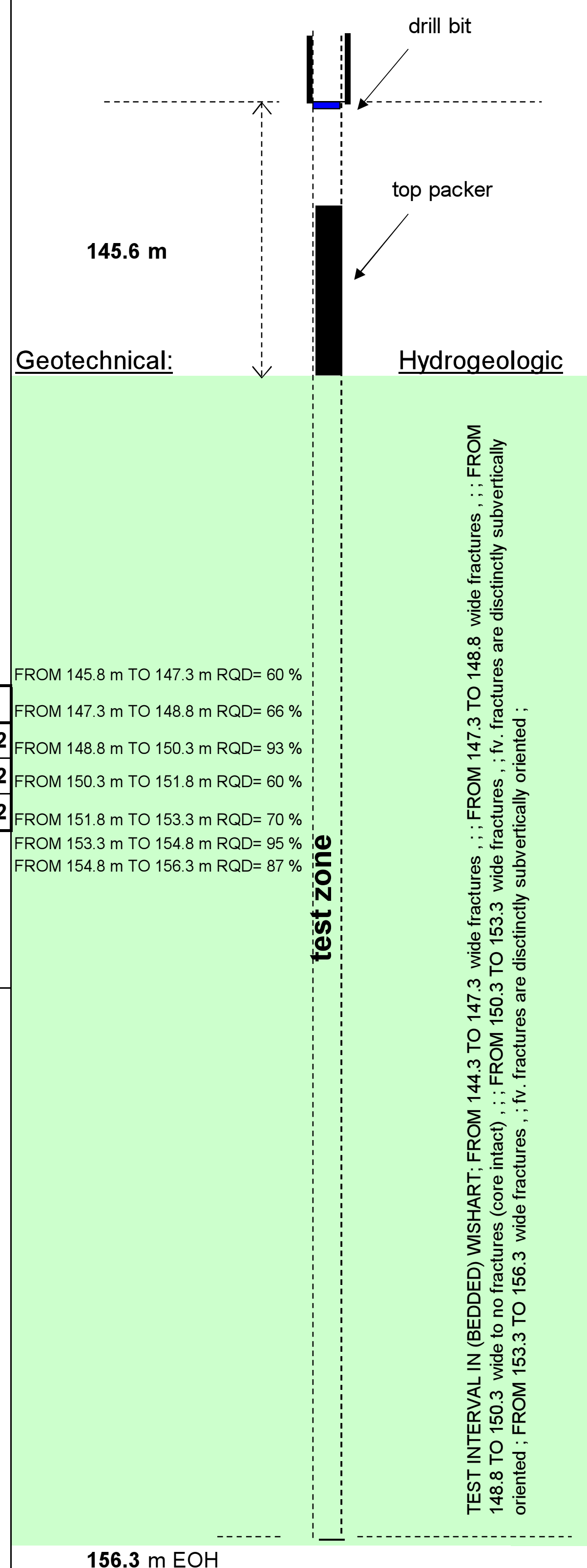
P	40	80	120
high est of K	6.E-07	7.E-07	7.E-07
average K	6.E-07	7.E-07	7.E-07
low est of K	6.E-07	7.E-07	7.E-07

K avg all P steps

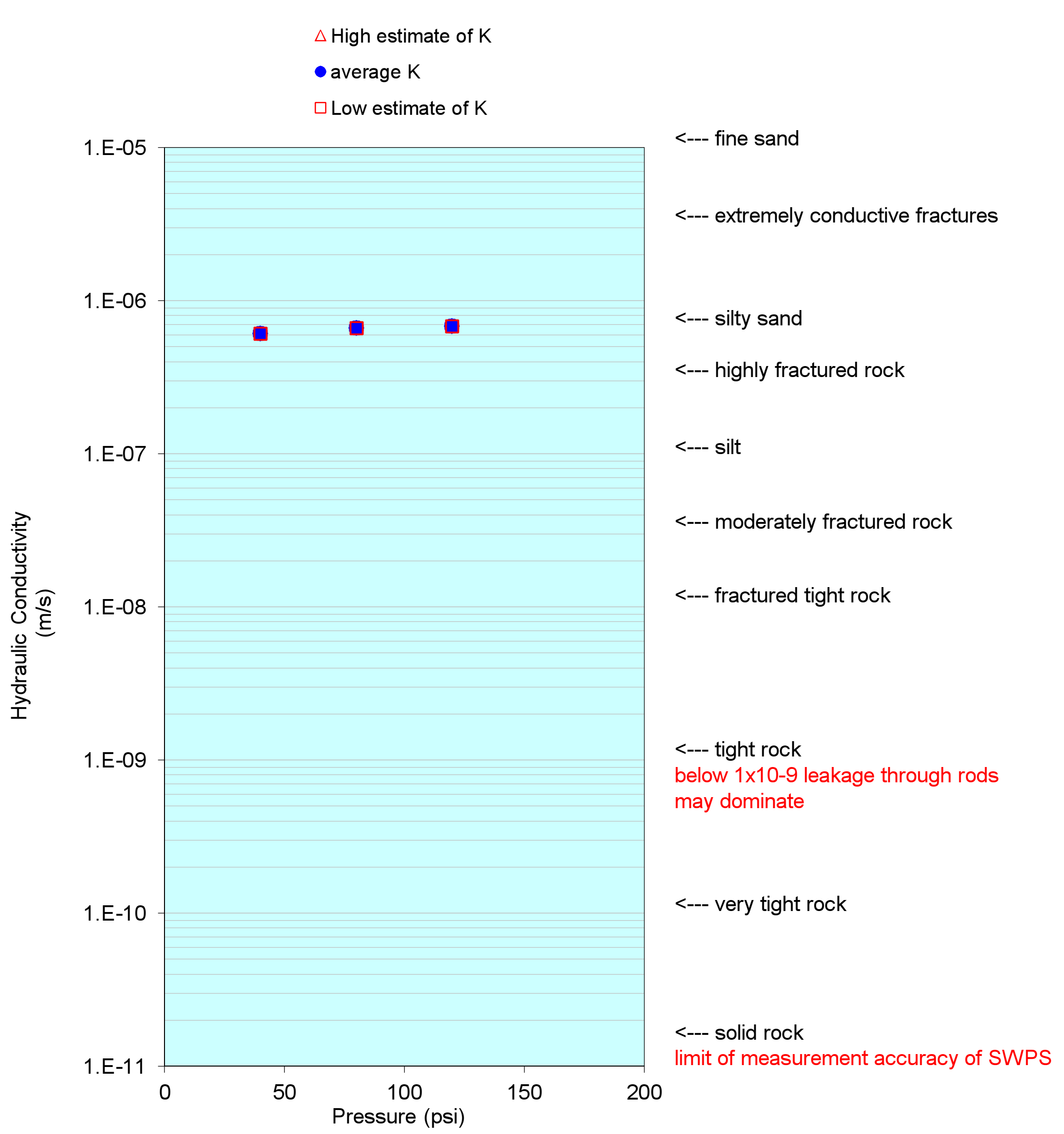
	m/sec	m/day
MAX	7.E-07	5.9E-02
geomean	7.E-07	5.6E-02
MIN	6.E-07	5.3E-02

Comments:

Drawing of zone tested, including geotech / hydrogeo. conditions:



Graph of estimated hydraulic conductivity and error bounds.



WESA a BluMetric company

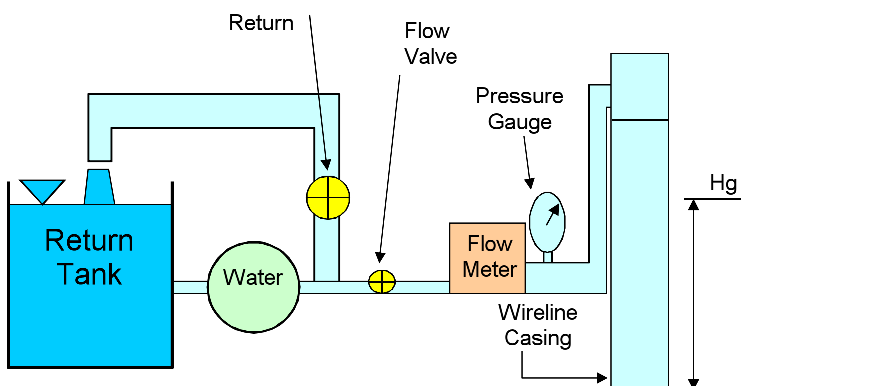
PACKER INJECTION TEST

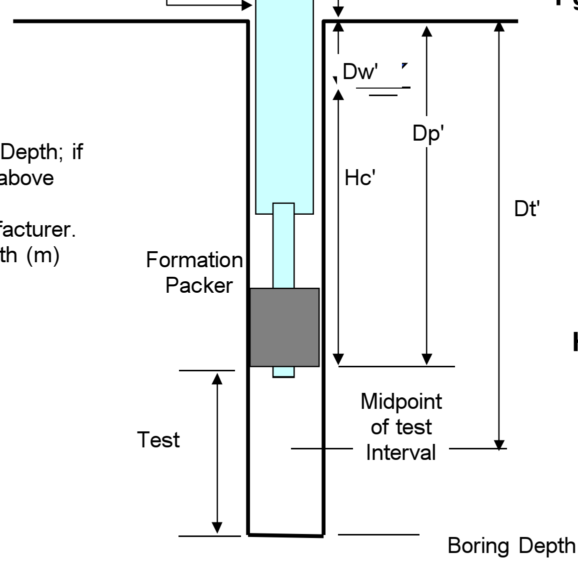
Project:	S-B12738	**Test Interval (m):**	163.6	**to**	171.3	**Drillhole N°**	JGW-4
UTM (x,y)	657990, 6086500	**Start Date:**	Oct 11 2014	**Time:**	7:00	**Test hole N°**	N/A
Datum:		**End Date:**	Oct 11 2014	**Time:**	9:00	**Test N°**	7
GS Elevation:		**Supervisor:**	VM/DP	**Rig:**	LF-70	**DH Depth (m)**	171.3

Max Injection P (psi)

245

Dw	Measured depth of static water level (1)	17.0	
Dbr	Measured depth to bedrock	0.6	m
Dp	Measured depth to packer	**163.6**	m
Dt	Measured depth to midpoint of test	**167.5**	m
ß	Inclination from horizontal (degrees)	90	°
Dw'	Vertical depth to static water level	**17.0**	m
Dbr'	Vertical dept to bedrock	**0.6**	m
Dp'	Vertical depth to packer	**163.6**	m
Dt'	Vertical depth to midpoint of test	**167.5**	m
SP	Shear Pin Rating (psi)	500	psi
Pblowout	Water column pressure in drill rods at plug	**232**	psi
Pshear	Estimated differential shear pressure required	**500**	psi
Pgmax	Maximum injection gauge pressure (3)	**250**	psi
Hg	Gauge height	2.0	m
Dp'	Length of discharge pipe	1.50	m
rp	Radius of discharge pipe (1"=0.0127m)	0.0127	m
R	Radius of influence (10 m is standard value)	5	m
rb	Borehole radius (HQ=0.048m, NQ=0.038m)	0.048	m
L	Length of test section	**7.7**	m
Hf	Friction Loss		
Hnit	Net injection head at midpoint of test		
K	Hydraulic conductivity		





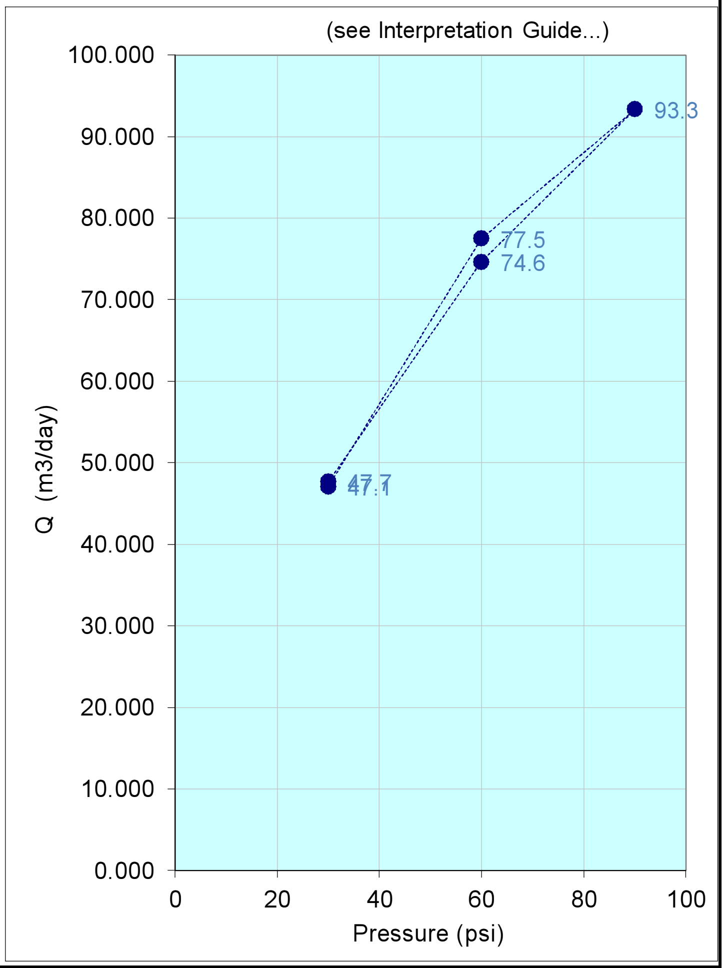
Notes:

1: If hole is dry enter Dw = Boring Depth; if AQUIFER water level at test zone above ground surface use negative value
2: Enter values from packer manufacturer.
3: Pgmax (psi) = 1.5 x vertical depth (m) IN ROCK to top of test section.

Equations:
$Hf = 8.65x10^{-15} (Q^2 * Lp/rp^5)$
$H_{nit} = (Dw'+Hg-Hf)+Pg/1.42$
$K = (Q*Ln(R/r_b)) / 2*\pi*H_{nit}*L)$

Conversion Factors:
10 m of water = 0.9807 bar = 1kg/cm^2 = 14.2 psi
1 cm/sec = 864 m/day
1 Lugeon = 1 lit/min per meter at 10 bar, which is approx. 1.4 x 10^{-5} cm/sec
1 US gpm = 3.785 lit/min = 5.45 m^3/day

Measurement (show last 3 to 5 flow meter readings)	Q (Liters / 30sec)				
	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
	30	60	90	60	30
1	18.50	30.00	35.50	28.50	19.00
2	18.30	28.80	35.00	28.00	18.60
3	18.20	29.20	35.50	28.50	18.90
4	18.70	29.50	35.00	28.50	18.50
5	18.30	29.50	35.00		18.50
Stable Q (L/30sec)	18.30	29.50	35.00	28.50	18.50
Leak Q (L/30sec)	1.95	2.60	2.60	2.60	1.95
Q (m^3/day)	47.1	77.5	93.3	74.6	47.7
Hf (m)	0.09	0.24	0.34	0.22	0.09
Hnit (m)	40.0	61.0	82.0	61.0	40.0
K (m/day)	1.1E-01	1.2E-01	1.1E-01	1.2E-01	1.1E-01
K (m/s)	**1.3E-06**	**1.4E-06**	**1.3E-06**	**1.4E-06**	**1.3E-06**
+/- (m/s)	8.0E-09	-2.6E-08	0.0E+00	2.6E-08	-8.0E-09
+/- order of mag.	0.00	-0.01	0.00	0.01	0.00



WESA a BluMetric company	PACKER INJECTION TEST (page 2)	Drillhole Nº	JGW-4
		Test hole Nº	N/A
		Test Nº	7

Pressure oscillation during test

Pressure step	P_g (psi) Step 1	P_g (psi) Step 2	P_g (psi) Step 3	P_g (psi) Step 4	P_g (psi) Step 5
Min P during step	30	60	90	60	30
Max P during step	30	60	90	60	30
average pressure +/- psi					

Flowmeter measurement reading accuracy

volume +/- Liters / 30 sec					

High estimate of K

Q_{avg} (m^3/day)	47.09	77.47	93.31	74.59	47.66
Hf (m)	0.09	0.24	0.34	0.22	0.09
Hnit (m)	40.0	61.0	82.0	61.0	40.0
K (m/sec)	1.3E-06	1.4E-06	1.3E-06	1.4E-06	1.3E-06

Low estimate of K

Q_{avg} (m^3/day)	47.09	77.47	93.31	74.59	47.66
Hf (m)	0.09	0.24	0.34	0.22	0.09
Hnit (m)	40.0	61.0	82.0	61.0	40.0
K (m/sec)	1.3E-06	1.4E-06	1.3E-06	1.4E-06	1.3E-06

K averages for P step — m/second

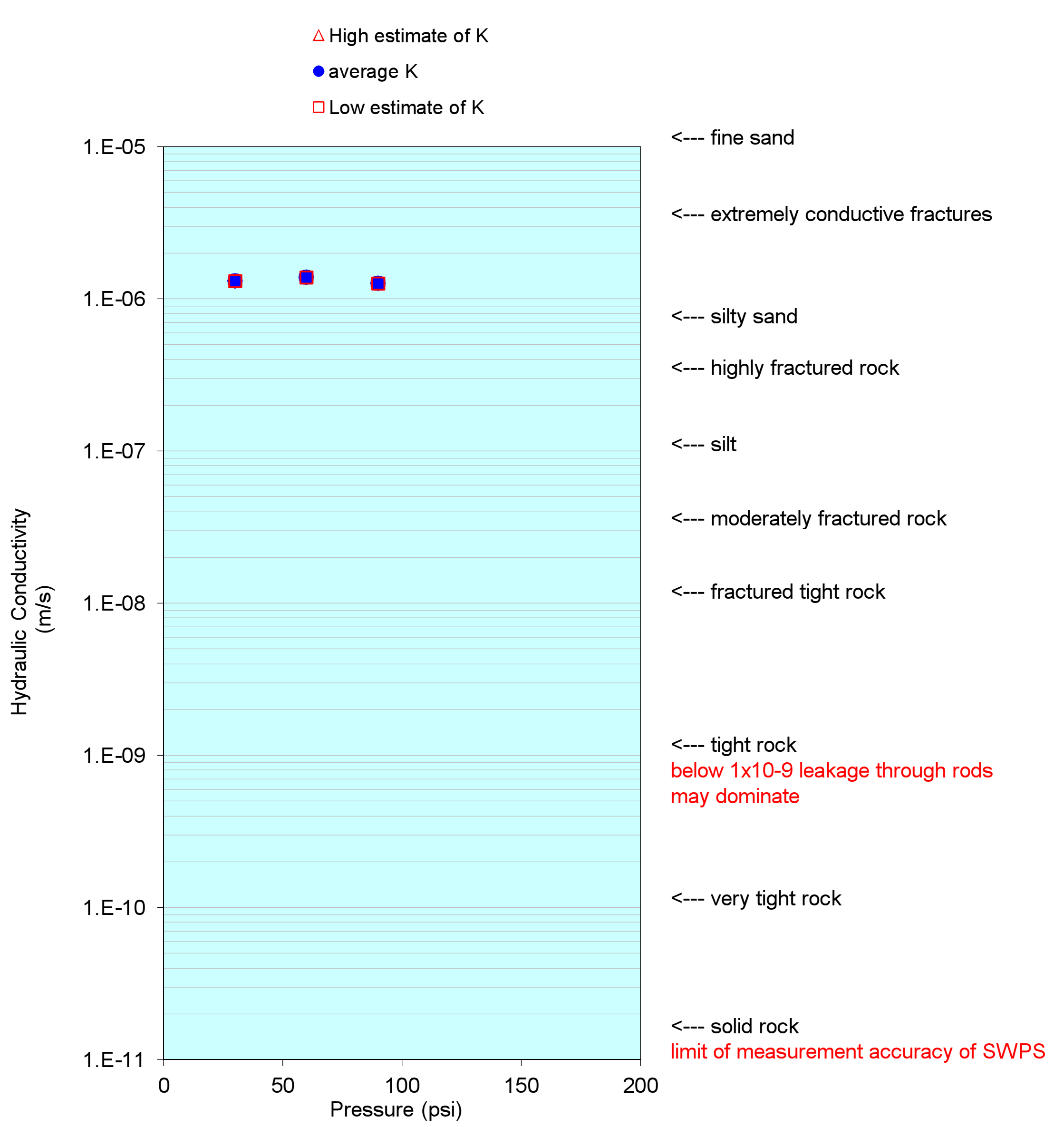
P	30	60	90
high est of K	1.E-06	1.E-06	1.E-06
average K	1.E-06	1.E-06	1.E-06
low est of K	1.E-06	1.E-06	1.E-06

K avg all P steps

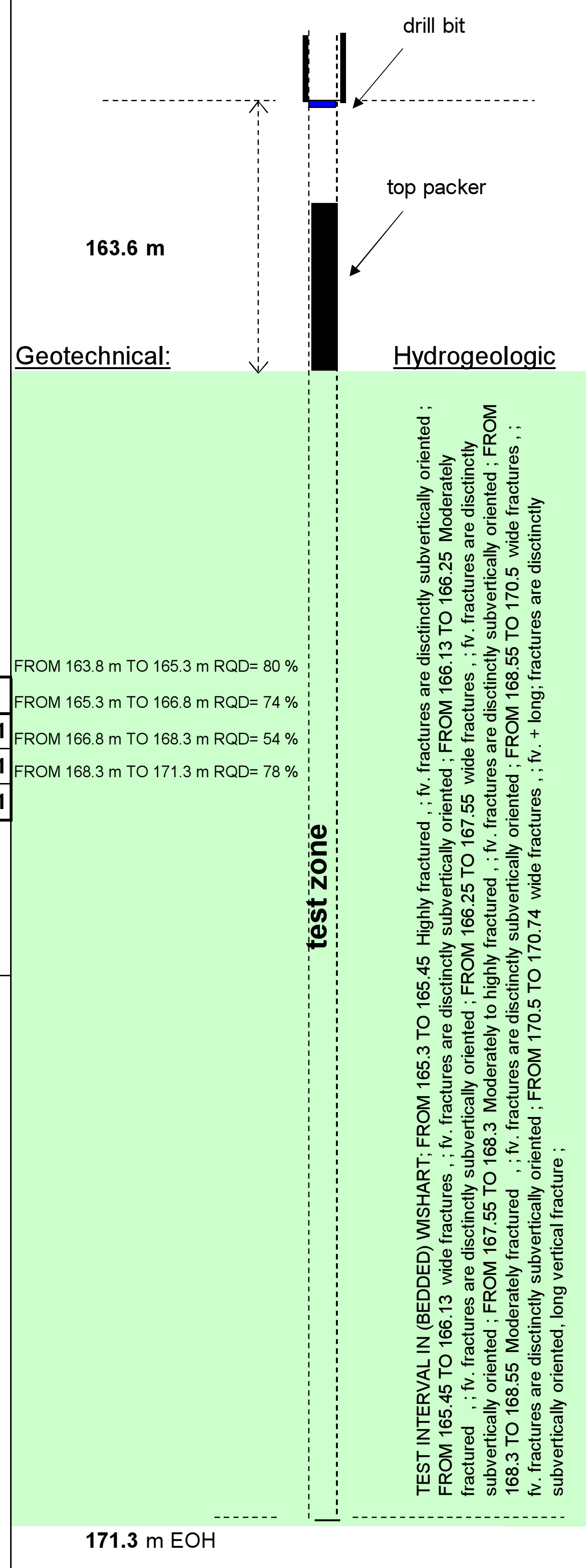
	m/sec	m/day
MAX	1.E-06	1.2E-01
geomean	1.E-06	1.1E-01
MIN	1.E-06	1.1E-01

Comments:

Graph of estimated hydraulic conductivity and error bounds.



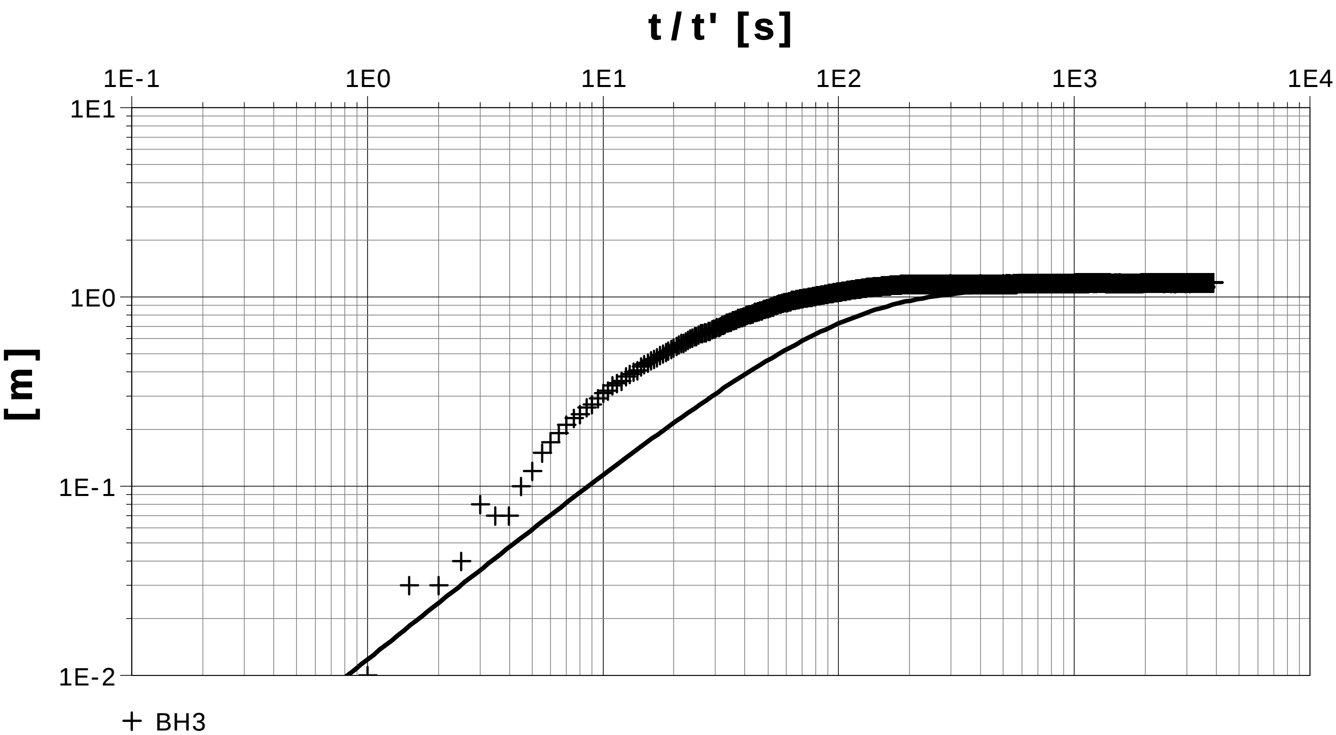
Drawing of zone tested, including geotech / hydrogeo. conditions:



Pumping Test Analysis Reports

WESA 273 Elm Street Sudbury, ON P3C 1V5	**Pumping Test Analysis Report**
	Project: Labec Century Iron
	Number: SB12738
	Client: Century Iron

Location: Schefferville - Joyce Lake	Pumping Test: BH3 Pumping - Recovery	Pumping Well: BH3
Test Conducted by: DP		Test Date: 23/10/2014
Analysis Performed by: S. Davy	Agarwal Skin	Analysis Date: 29/10/2014
Aquifer Thickness: 161.54 m	Discharge: variable, average rate 0.38 [U.S. gal/min]	



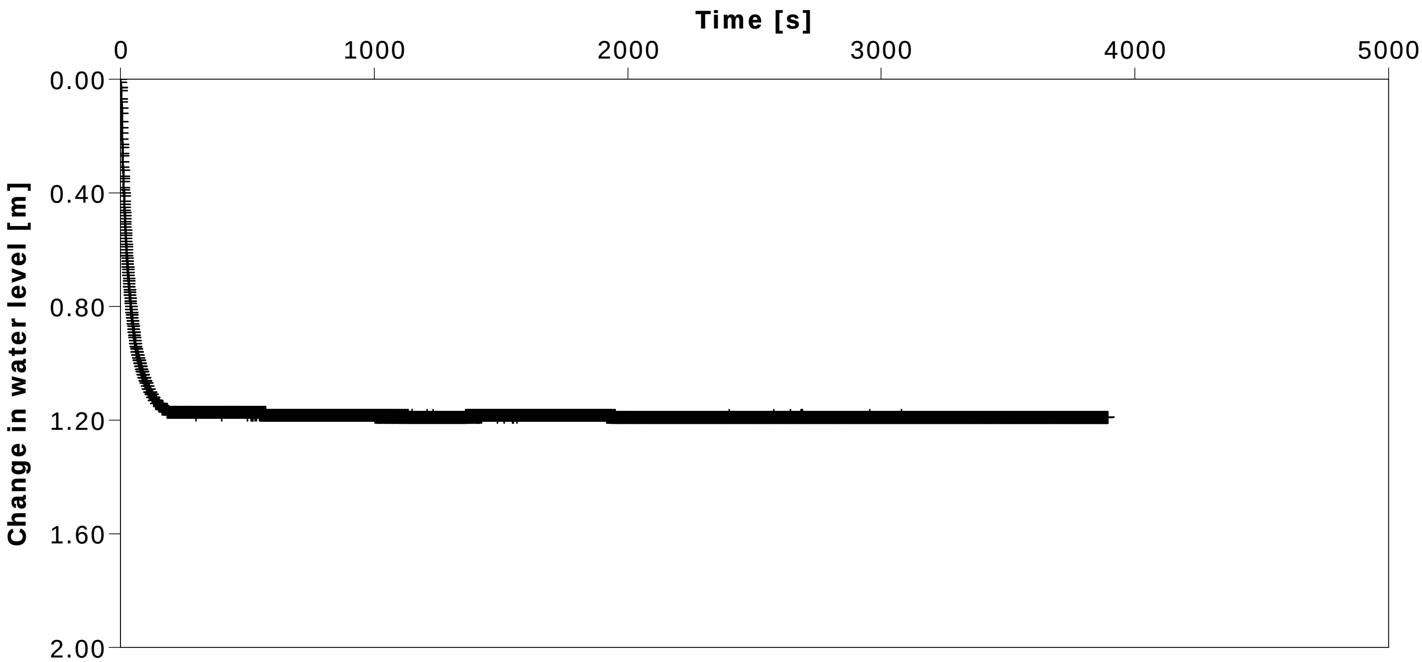
Calculation using AGARWAL + Agarwal skin

Observation Well	Transmissivity [m²/s]	Hydraulic Conductivity [m/s]	Skin factor	Radial Distance to PW [m]	
BH3	1.15×10^{-4}	7.11×10^{-7}	2.00×10^{1}	0.03	

WESA
273 Elm Street
Sudbury, ON
P3C 1V5

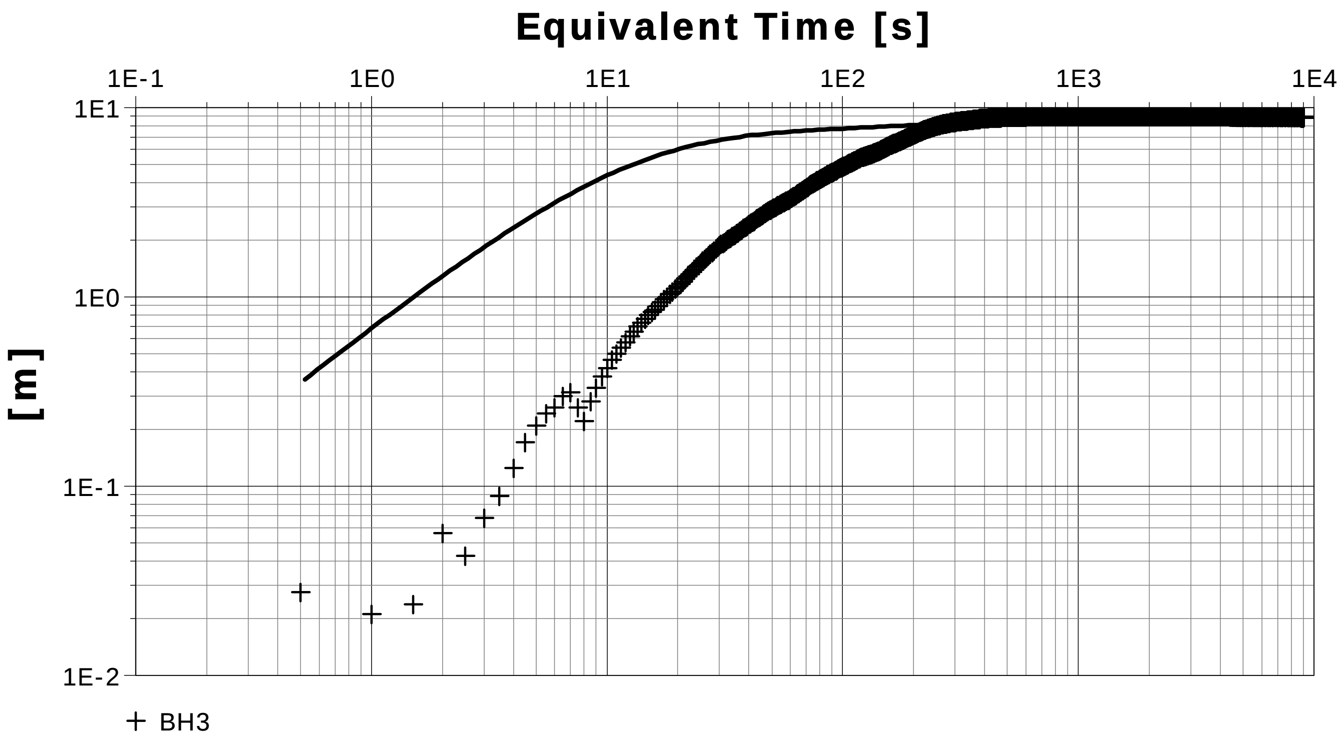
Pumping Test Analysis Report
Project: Labec Century Iron
Number: SB12738
Client: Century Iron

Location: Schefferville - Joyce Lake	Pumping Test: BH3 Pumping - Recovery	Pumping Well: BH3
Test Conducted by: DP		Test Date: 23/10/2014
Analysis Performed by: S. Davy	Time vs Change in WL	Analysis Date: 04/11/2014
Aquifer Thickness: 161.54 m	Discharge: variable, average rate 0.38 [U.S. gal/min]	



WESA 273 Elm Street Sudbury, ON P3C 1V5	Pumping Test Analysis Report
	Project: Labec Century Iron
	Number: SB12738
	Client: Century Iron

Location: Schefferville - Joyce Lake	Pumping Test: BH3 Injection - Recovery	Pumping Well: BH3
Test Conducted by: DP		Test Date: 19/10/2014
Analysis Performed by: S. Davy	Agarwal Skin	Analysis Date: 29/10/2014
Aquifer Thickness: 161.54 m	Discharge: variable, average rate 1.43 [l/s]	



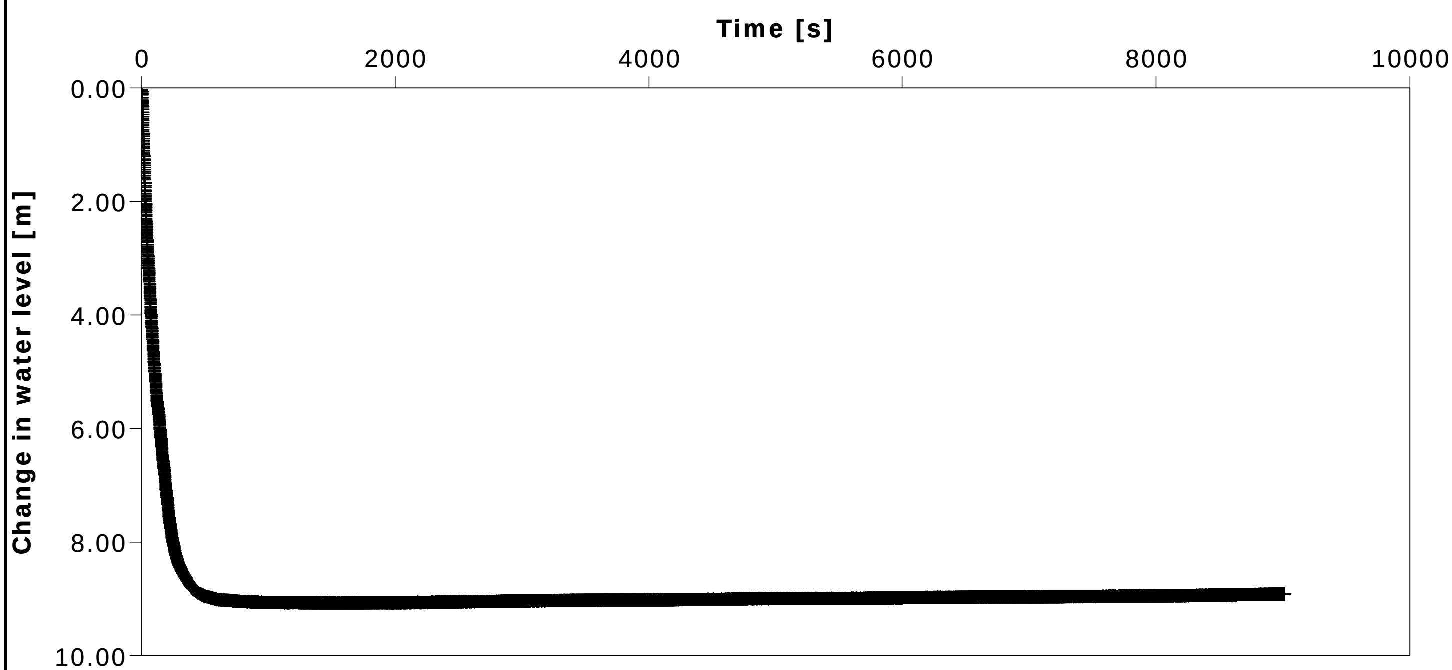
Calculation using AGARWAL + Agarwal skin

Observation Well	Transmissivity [m²/s]	Hydraulic Conductivity [m/s]	Well-bore storage coefficient	Skin factor	Radial Distance to PW [m]	
BH3	2.97×10^{-4}	1.84×10^{-6}	9.78×10^{-7}	1.00×10^{0}	0.03	

WESA
273 Elm Street
Sudbury, ON
P3C 1V5

Pumping Test Analysis Report
Project: Labec Century Iron
Number: SB12738
Client: Century Iron

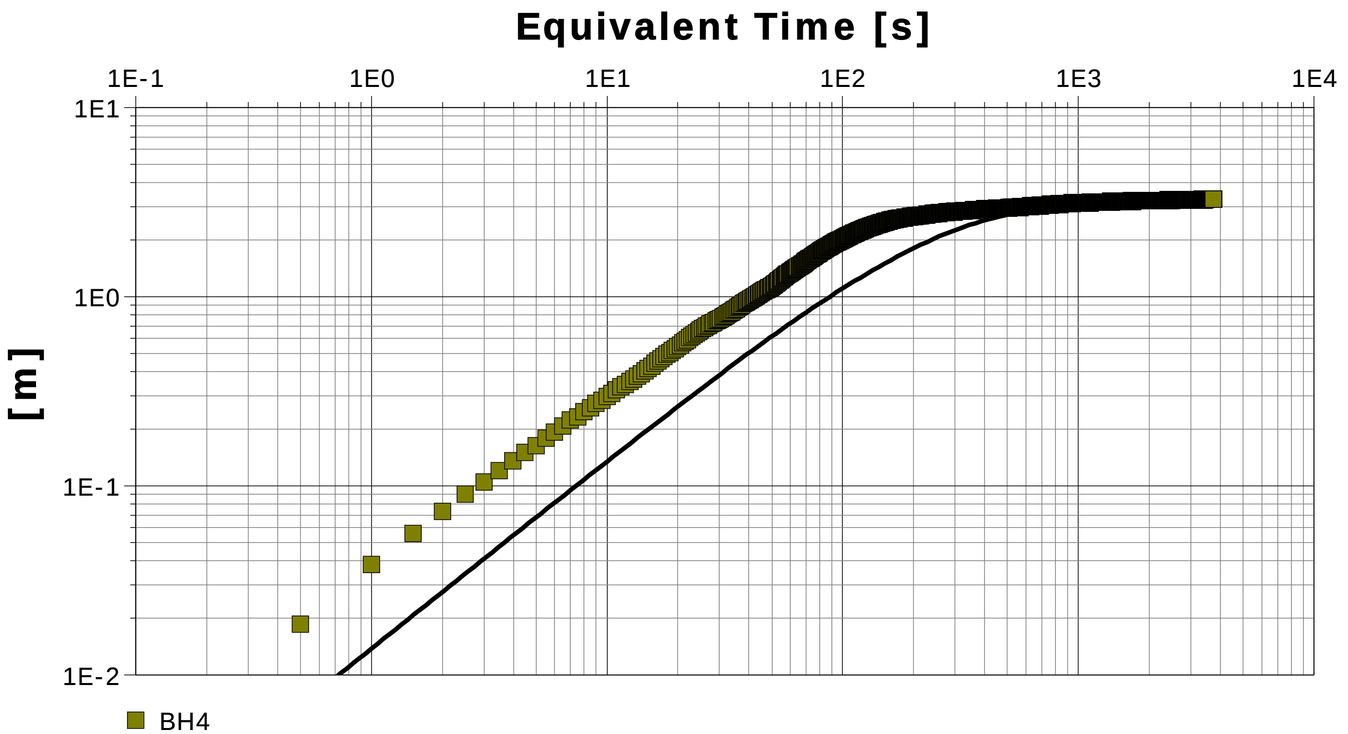
Location: Schefferville - Joyce Lake	Pumping Test: BH3 Injection - Recovery	Pumping Well: BH3
Test Conducted by: DP		Test Date: 19/10/2014
Analysis Performed by: S. Davy	Time vs Change in WL	Analysis Date: 04/11/2014
Aquifer Thickness: 161.54 m	Discharge: variable, average rate 1.43 [l/s]	



WESA
273 Elm Street
Sudbury, ON
P3C 1V5

Pumping Test Analysis Report
Project: Labec Century Iron
Number: SB12738
Client: Century Iron

Location: Schefferville - Joyce Lake	Pumping Test: BH4 Pumping - Recovery	Pumping Well: BH4
Test Conducted by: DP		Test Date: 19/10/2014
Analysis Performed by: S. Davy	Agarwal Skin	Analysis Date: 29/10/2014
Aquifer Thickness: 161.54 m	Discharge: variable, average rate 0.43 [U.S. gal/min]	



Calculation using AGARWAL + Agarwal skin

Observation Well	Transmissivity [m²/s]	Hydraulic Conductivity [m/s]	Well-bore storage coefficient	Skin factor	Radial Distance to PW [m]
BH4	4.68×10^{-5}	2.90×10^{-7}	7.26×10^{-27}	1.00×10^{0}	0.03

WESA
273 Elm Street
Sudbury, ON
P3C 1V5

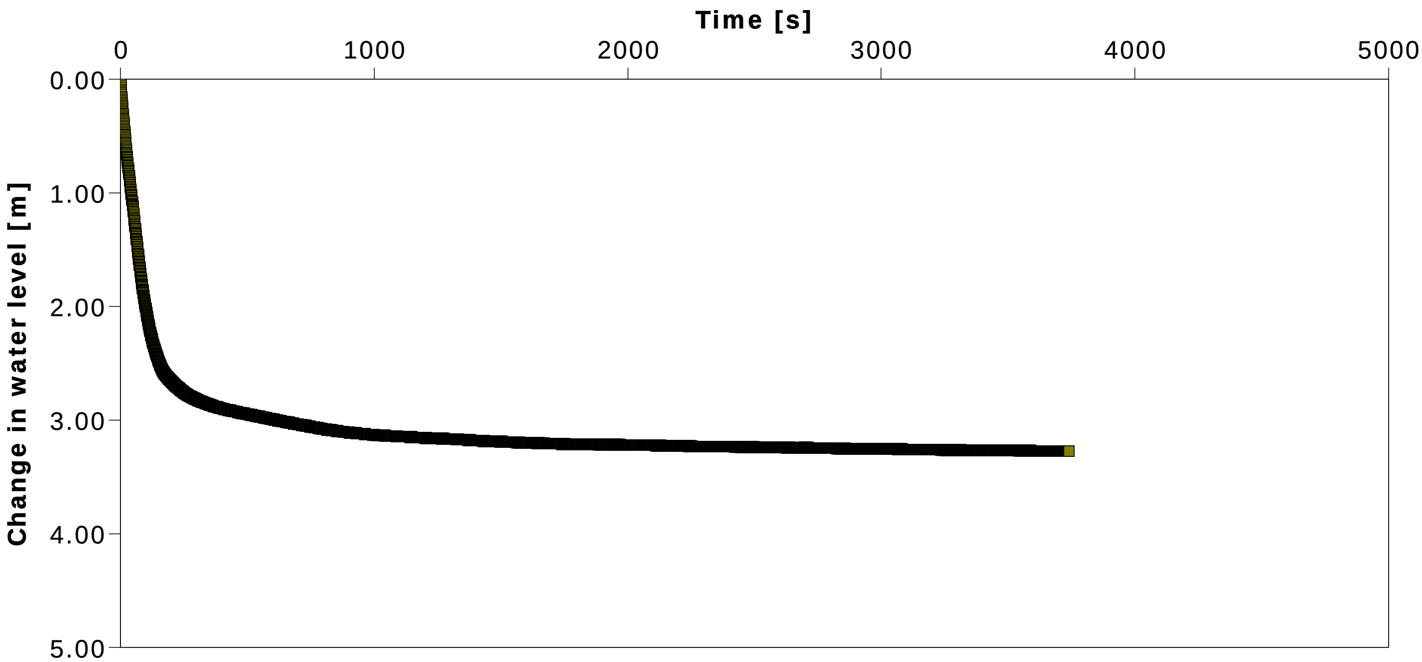
Pumping Test Analysis Report

Project: Labec Century Iron

Number: SB12738

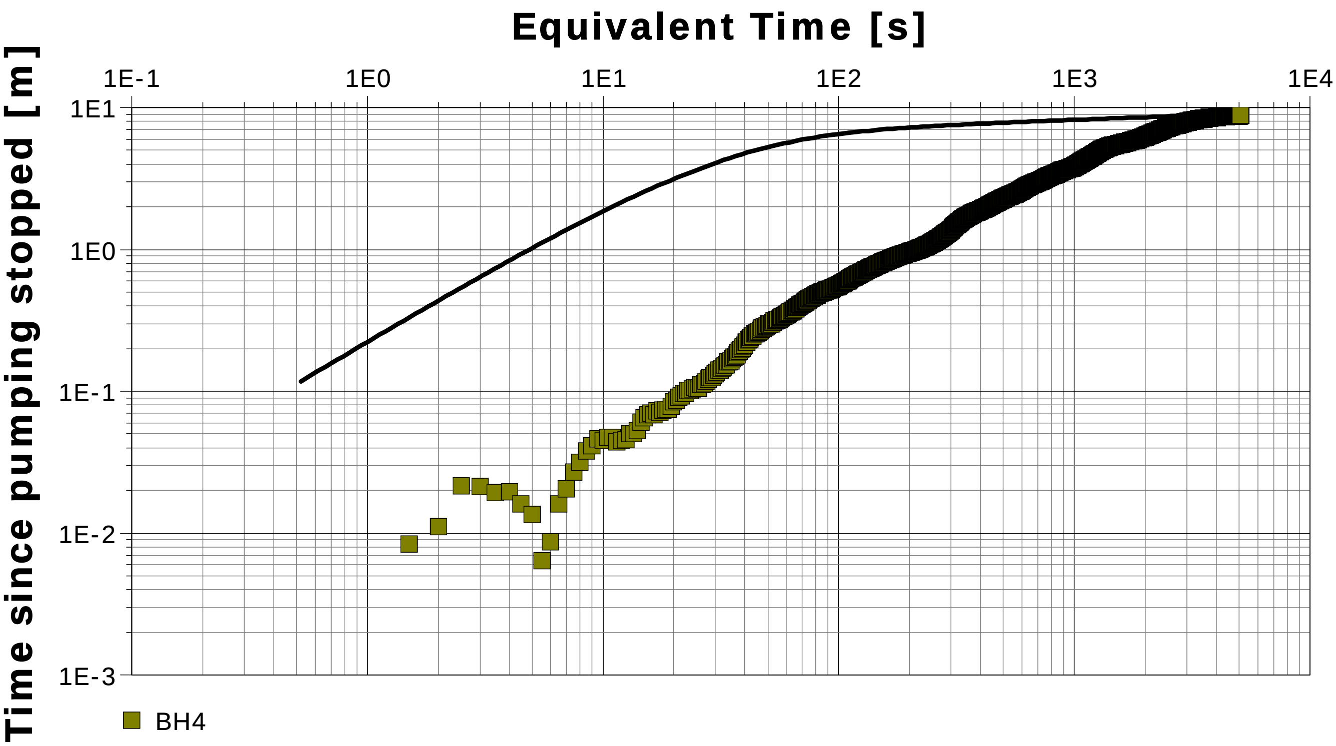
Client: Century Iron

Location: Schefferville - Joyce Lake	Pumping Test: BH4 Pumping - Recovery	Pumping Well: BH4
Test Conducted by: DP		Test Date: 19/10/2014
Analysis Performed by: S. Davy	Time vs Change in WL	Analysis Date: 04/11/2014
Aquifer Thickness: 161.54 m	Discharge: variable, average rate 0.43 [U.S. gal/min]	



WESA 273 Elm Street Sudbury, ON P3C 1V5	**Pumping Test Analysis Report** Project: Labec Century Iron Number: SB12738 Client: Century Iron

Location: Schefferville - Joyce Lake	Pumping Test: BH4 Injection - Recovery	Pumping Well: BH4
Test Conducted by: DP		Test Date: 20/10/2014
Analysis Performed by: S. Davy	Agarwal Skin	Analysis Date: 04/11/2014
Aquifer Thickness: 161.54 m	Discharge: variable, average rate 0.45 [l/s]	

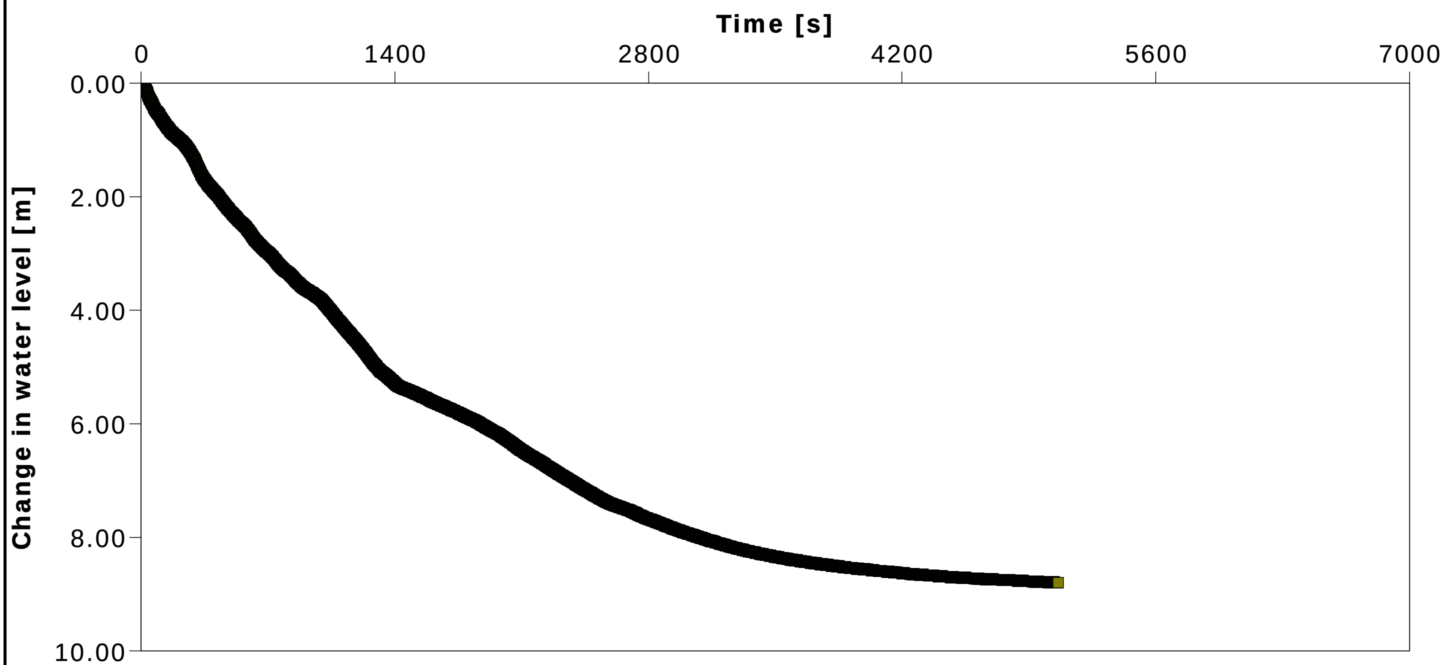


Calculation using AGARWAL + Agarwal skin

Observation Well	Transmissivity [m²/s]	Hydraulic Conductivity [m/s]	Well-bore storage coefficient	Skin factor	Radial Distance to PW [m]
BH4	7.29×10^{-5}	4.51×10^{-7}	1.00×10^{-4}	1.00×10^{0}	0.03

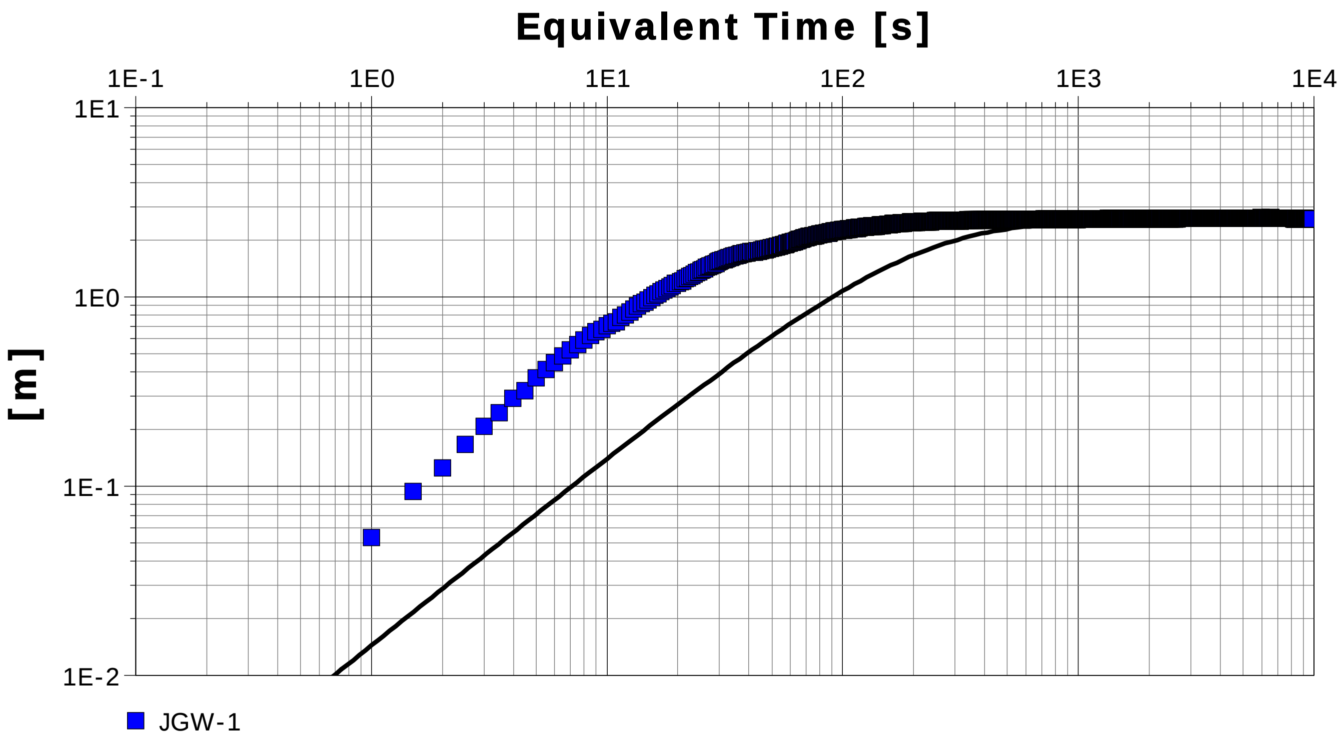
WESA
273 Elm Street
Sudbury, ON
P3C 1V5

Pumping Test Analysis Report		
Project: Labec Century Iron		
Number: SB12738		
Client: Century Iron		
Location: Schefferville - Joyce Lake	Pumping Test: BH4 Injection - Recovery	Pumping Well: BH4
Test Conducted by: DP		Test Date: 20/10/2014
Analysis Performed by: S. Davy	Time vs Change in WL	Analysis Date: 04/11/2014
Aquifer Thickness: 161.54 m	Discharge: variable, average rate 0.45 [l/s]	



WESA 273 Elm Street Sudbury, ON P3C 1V5	**Pumping Test Analysis Report** Project: Labec Century Iron Number: SB12738 Client: Century Iron

Location: Schefferville - Joyce Lake	Pumping Test: JGW-1 Injection - Recovery	Pumping Well: JGW-1
Test Conducted by: DP		Test Date: 17/10/2014
Analysis Performed by: S. Davy	Agarwal Skin	Analysis Date: 29/10/2014
Aquifer Thickness: 161.54 m	Discharge: variable, average rate 0.45 [U.S. gal/min]	



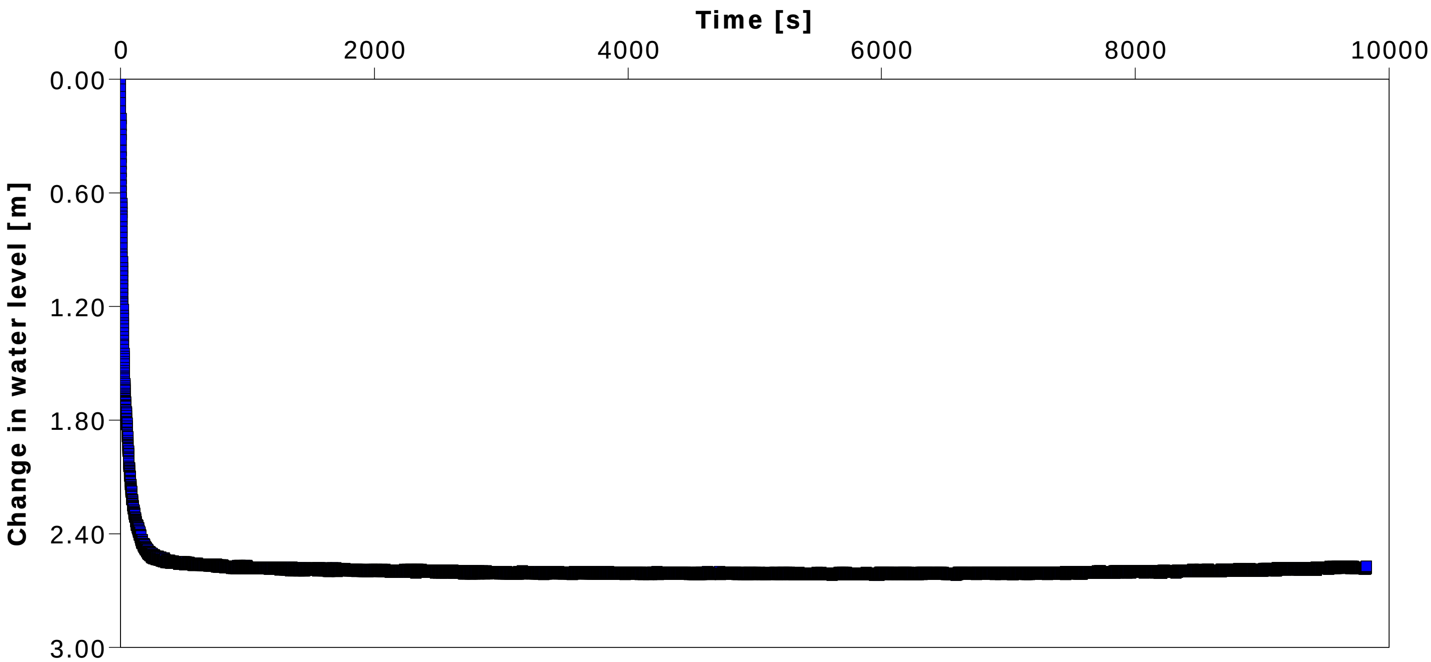
Calculation using AGARWAL + Agarwal skin

Observation Well	Transmissivity [m²/s]	Hydraulic Conductivity [m/s]	Well-bore storage coefficient	Skin factor	Radial Distance to PW [m]	
JGW-1	4.17×10^{-5}	2.58×10^{-7}	1.17×10^{-17}	1.00×10^{0}	0.03	

WESA
273 Elm Street
Sudbury, ON
P3C 1V5

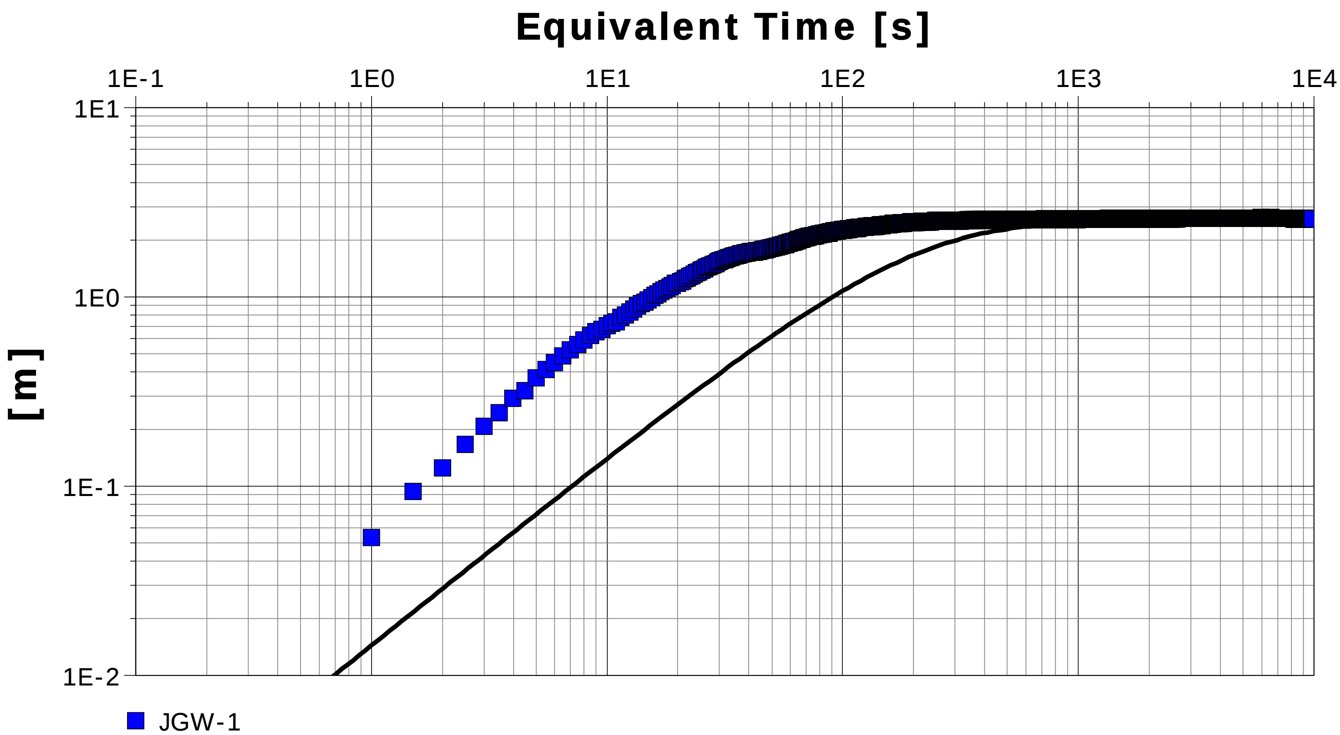
Pumping Test Analysis Report
Project: Labec Century Iron
Number: SB12738
Client: Century Iron

Location: Schefferville - Joyce Lake	Pumping Test: JGW-1 Injection - Recovery	Pumping Well: JGW-1
Test Conducted by: DP		Test Date: 17/10/2014
Analysis Performed by: S. Davy	Time vs Change in WL	Analysis Date: 04/11/2014
Aquifer Thickness: 161.54 m	Discharge: variable, average rate 0.45 [U.S. gal/min]	



WESA 273 Elm Street Sudbury, ON P3C 1V5	**Pumping Test Analysis Report** Project: Labec Century Iron Number: SB12738 Client: Century Iron

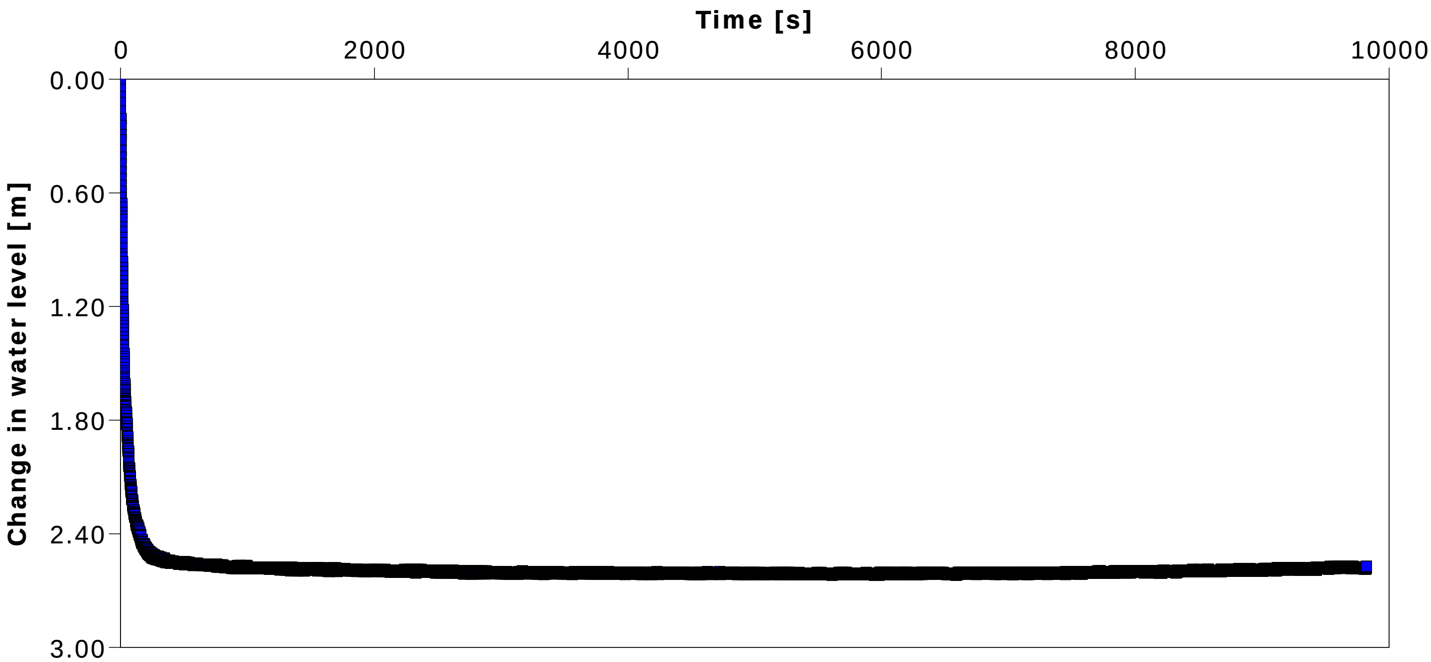
Location: Schefferville - Joyce Lake	Pumping Test: JGW-1 Injection - Recovery	Pumping Well: JGW-1
Test Conducted by: DP		Test Date: 17/10/2014
Analysis Performed by: S. Davy	Agarwal Skin	Analysis Date: 29/10/2014
Aquifer Thickness: 161.54 m	Discharge: variable, average rate 0.45 [U.S. gal/min]	



Calculation using AGARWAL + Agarwal skin

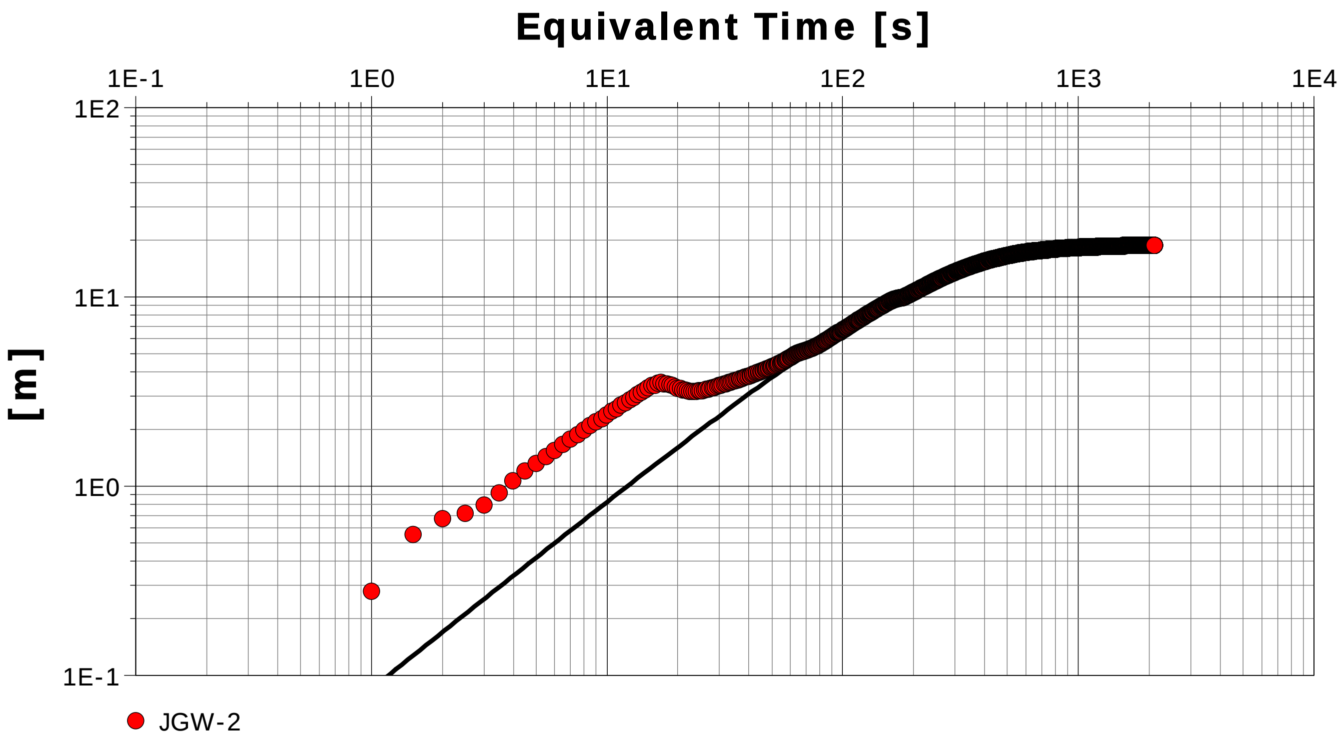
Observation Well	Transmissivity [m²/s]	Hydraulic Conductivity [m/s]	Well-bore storage coefficient	Skin factor	Radial Distance to PW [m]
JGW-1	4.17×10^{-5}	2.58×10^{-7}	1.17×10^{-17}	1.00×10^{0}	0.03

WESA 273 Elm Street Sudbury, ON P3C 1V5		**Pumping Test Analysis Report**
		Project: Labec Century Iron
		Number: SB12738
		Client: Century Iron
Location: Schefferville - Joyce Lake	Pumping Test: JGW-1 Injection - Recovery	Pumping Well: JGW-1
Test Conducted by: DP		Test Date: 17/10/2014
Analysis Performed by: S. Davy	Time vs Change in WL	Analysis Date: 04/11/2014
Aquifer Thickness: 161.54 m	Discharge: variable, average rate 0.45 [U.S. gal/min]	



WESA 273 Elm Street Sudbury, ON P3C 1V5	**Pumping Test Analysis Report**
	Project: Labec Century Iron
	Number: SB12738
	Client: Century Iron

Location: Schefferville - Joyce Lake	Pumping Test: JGW-2 Injection 1 - Recovery	Pumping Well: JGW-2
Test Conducted by: DP		Test Date: 21/10/2014
Analysis Performed by: S. Davy	Agarwal Skin	Analysis Date: 29/10/2014
Aquifer Thickness: 169.65 m	Discharge: variable, average rate 2.65 [U.S. gal/min]	



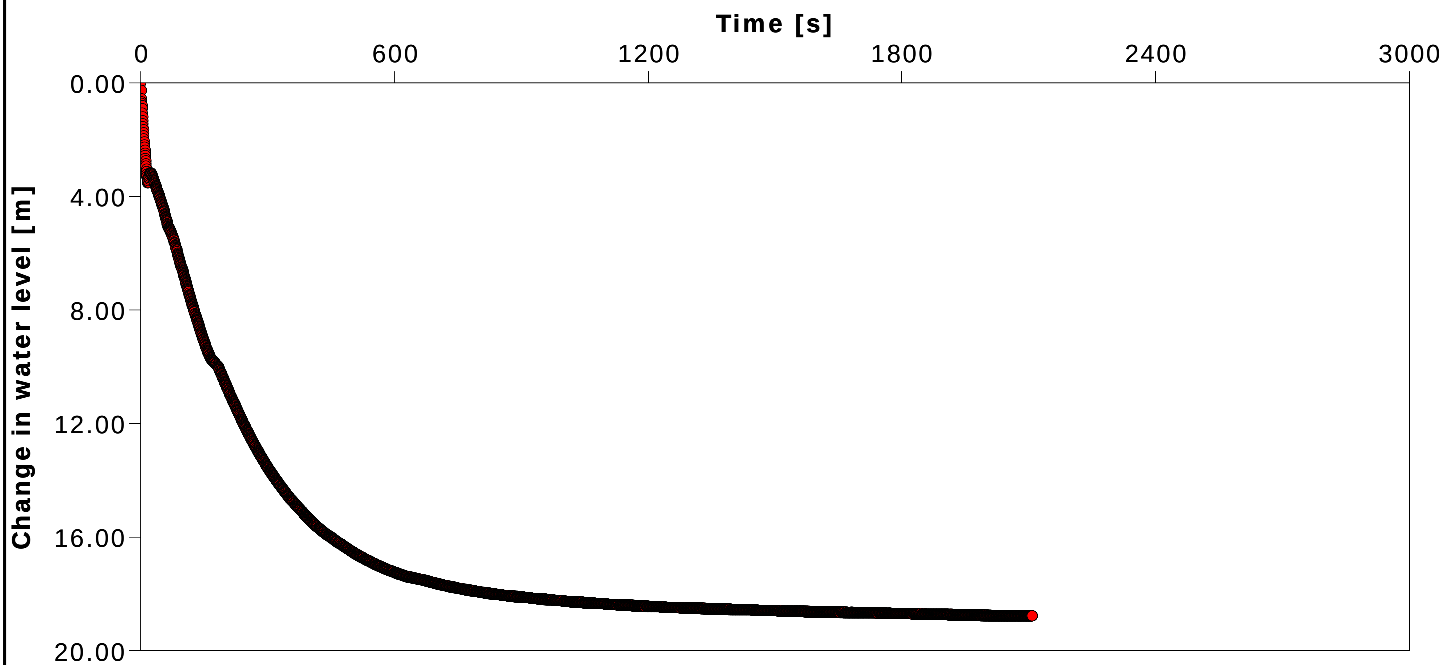
Calculation using AGARWAL + Agarwal skin

Observation Well	Transmissivity [m²/s]	Hydraulic Conductivity [m/s]	Well-bore storage coefficient	Skin factor	Radial Distance to PW [m]
JGW-2	2.12×10^{-5}	1.25×10^{-7}	5.81×10^{-11}	1.00×10^{0}	0.03

WESA
273 Elm Street
Sudbury, ON
P3C 1V5

Pumping Test Analysis Report	
Project:	Labec Century Iron
Number:	SB12738
Client:	Century Iron

Location: Schefferville - Joyce Lake	Pumping Test: JGW-2 Injection 1 - Recovery	Pumping Well: JGW-2
Test Conducted by: DP		Test Date: 21/10/2014
Analysis Performed by: S. Davy	Time vs Change in WL	Analysis Date: 04/11/2014
Aquifer Thickness: 169.65 m	Discharge: variable, average rate 2.65 [U.S. gal/min]	



WESA
273 Elm Street
Sudbury, ON
P3C 1V5

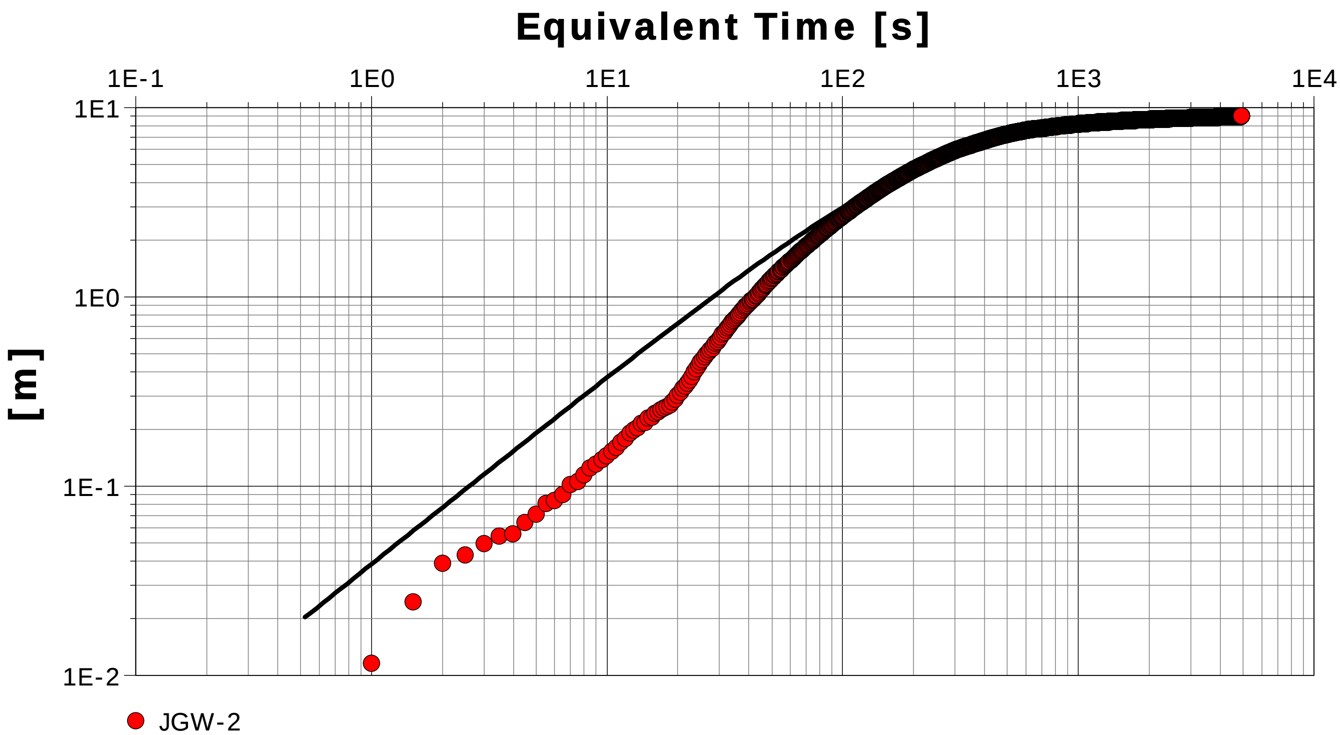
Pumping Test Analysis Report

Project: Labec Century Iron

Number: SB12738

Client: Century Iron

Location: Schefferville - Joyce Lake	Pumping Test: JGW-2 Injection 2 - Recovery	Pumping Well: JGW-2
Test Conducted by: dp		Test Date: 21/10/2014
Analysis Performed by: S. Davy	Agarwal Skin	Analysis Date: 29/10/2014
Aquifer Thickness: 169.65 m	Discharge: variable, average rate 1.21 [U.S. gal/min]	



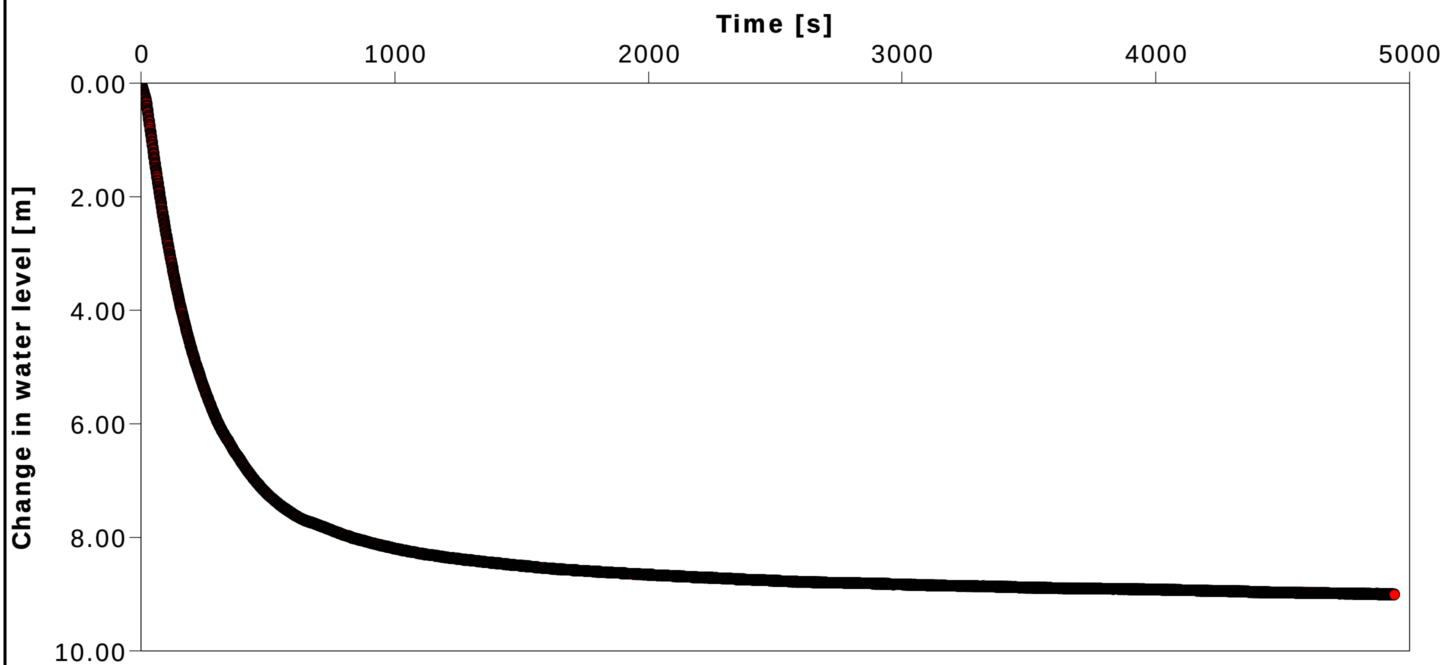
Calculation using AGARWAL + Agarwal skin

Observation Well	Transmissivity [m²/s]	Hydraulic Conductivity [m/s]	Well-bore storage coefficient	Skin factor	Radial Distance to PW [m]
JGW-2	1.29×10^{-5}	7.63×10^{-8}	4.47×10^{-6}	1.00×10^{0}	0.03

WESA
273 Elm Street
Sudbury, ON
P3C 1V5

Pumping Test Analysis Report	
Project: Labec Century Iron	
Number: SB12738	
Client: Century Iron	

Location: Schefferville - Joyce Lake	Pumping Test: JGW-2 Injection 2 - Recovery	Pumping Well: JGW-2
Test Conducted by: dp		Test Date: 21/10/2014
Analysis Performed by: S. Davy	Time vs Change in WL	Analysis Date: 04/11/2014
Aquifer Thickness: 169.65 m	Discharge: variable, average rate 1.21 [U.S. gal/min]	



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Sudbury, ON
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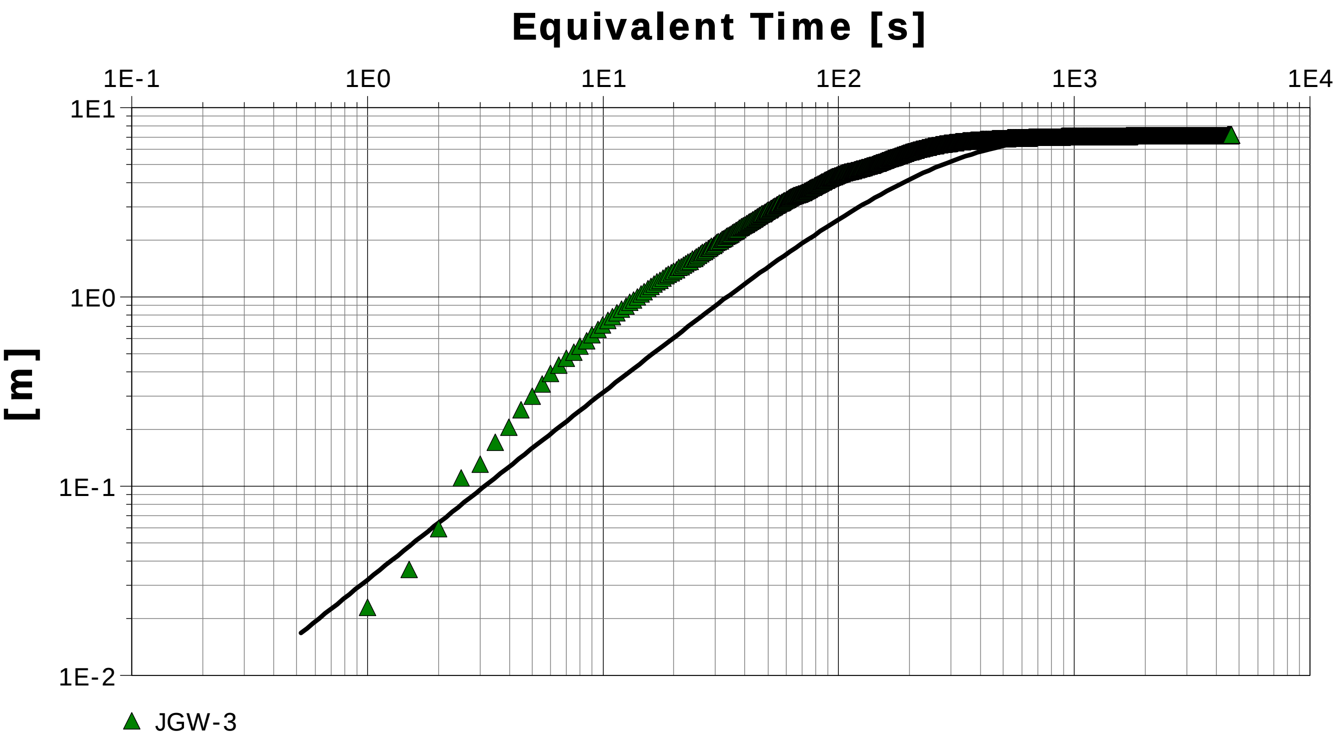
Pumping Test Analysis Report

Project: Labec Century Iron		
Number: SB12738		
Client: Century Iron		
Location: Schefferville - Joyce Lake	Pumping Test: JGW-3 Pumping - Recovery	Pumping Well: JGW-3
Test Conducted by: DP		Test Date: 29/10/2014
Analysis Performed by: S. Davy	Agarwal Skin	Analysis Date: 29/10/2014
Aquifer Thickness: 172.66 m	Discharge: variable, average rate 0.06309 [l/s]	



Calculation using AGARWAL + Agarwal skin

Observation Well	Transmissivity [m²/s]	Hydraulic Conductivity [m/s]	Well-bore storage coefficient	Skin factor	Radial Distance to PW [m]
JGW-3	5.16×10^{-5}	2.99×10^{-7}	1.54×10^{-29}	1.00×10^{0}	0.03

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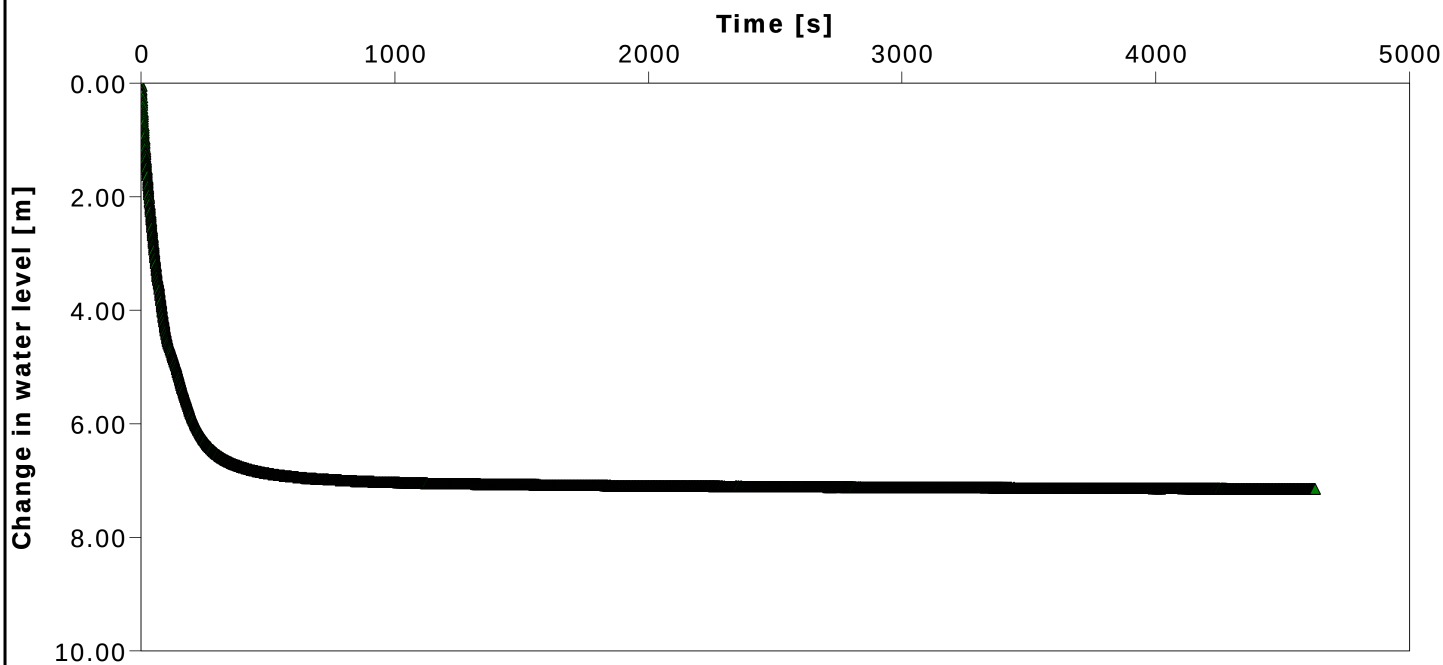
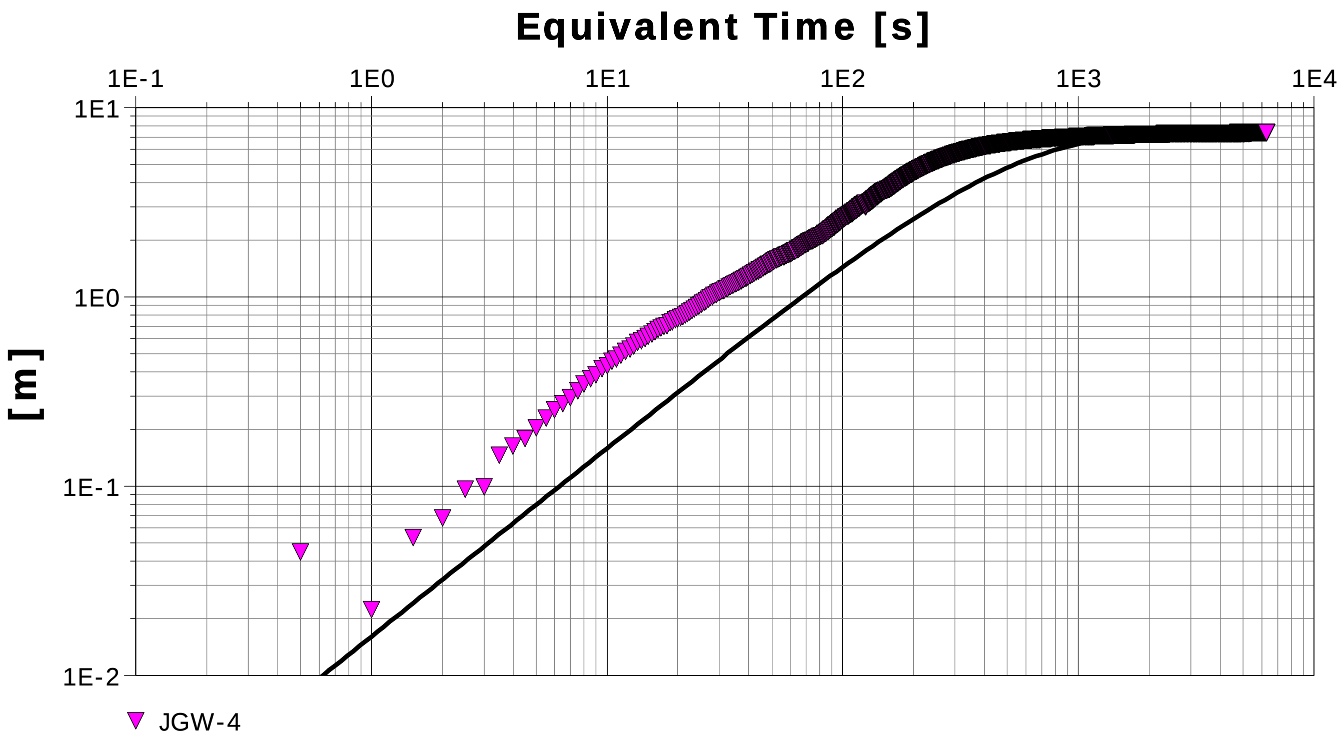
Pumping Test Analysis Report
Project: Labec Century Iron
Number: SB12738
Client: Century Iron

Location: Schefferville - Joyce Lake	Pumping Test: JGW-3 Pumping - Recovery	Pumping Well: JGW-3
Test Conducted by: DP		Test Date: 29/10/2014
Analysis Performed by: S. Davy	Time vs Change in WL	Analysis Date: 29/10/2014
Aquifer Thickness: 172.66 m	Discharge: variable, average rate 0.06309 [l/s]	



WESA 273 Elm Street Sudbury, ON P3C 1V5	Pumping Test Analysis Report
	Project: Labec Century Iron
	Number: SB12738
	Client: Century Iron

Location: Schefferville - Joyce Lake	Pumping Test: JGW-4 Injection - Recovery	Pumping Well: JGW-4
Test Conducted by: DP		Test Date: 23/10/2014
Analysis Performed by: S. Davy	Agarwal Skin	Analysis Date: 29/10/2014
Aquifer Thickness: 172.66 m	Discharge: variable, average rate 0.5 [U.S. gal/min]	



Calculation using AGARWAL + Agarwal skin

Observation Well	Transmissivity [m²/s]	Hydraulic Conductivity [m/s]	Well-bore storage coefficient	Skin factor	Radial Distance to PW [m]
JGW-4	2.60×10^{-5}	1.51×10^{-7}	1.00×10^{-30}	1.00×10^{0}	0.03

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273 Elm Street
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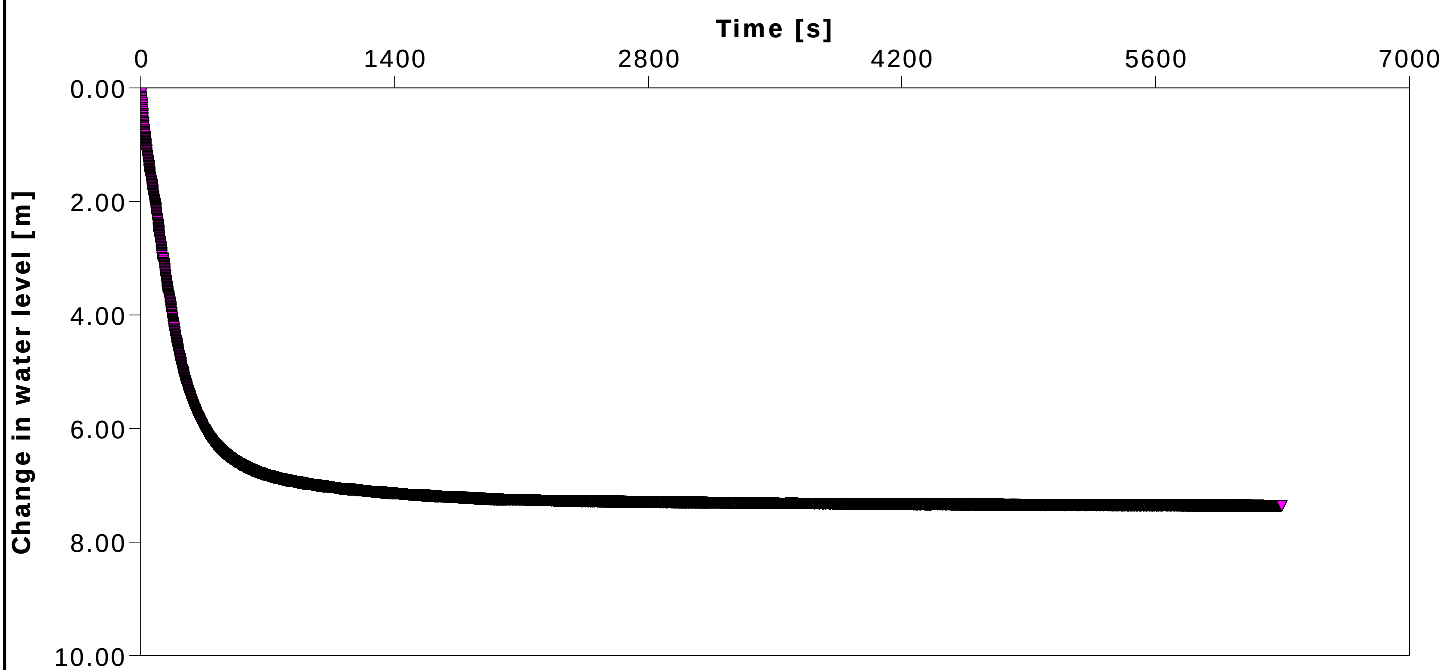
P3C 1V5

Pumping Test Analysis Report
Project: Labec Century Iron
Number: SB12738
Client: Century Iron

Location: Schefferville - Joyce Lake	Pumping Test: JGW-4 Injection - Recovery	Pumping Well: JGW-4
Test Conducted by: DP		Test Date: 23/10/2014
Analysis Performed by: S. Davy	Time vs Change in WL	Analysis Date: 04/11/2014
Aquifer Thickness: 172.66 m	Discharge: variable, average rate 0.5 [U.S. gal/min]	



APPENDIX C

Chemistry Lab Reports

Table C-1: Groundwater Chemistry - Joyce Lake DSO Project

Parameter	Units	MMER Schedule 4	CWQG	NLR 65/03 Schedule A	Well Location					
					BH3	BH4	JGW-1	JGW-2	JGW-3	JGW-4
General Chemistry					10/18/2014	10/19/2014	10/16/2014	10/21/2014	10/16/2014	10/22/2014
Acidity	mg/L				14.3	13.5	15	12.8	11.6	13
Ammonia (as N)	mg/L				0.017	0.054	0.025	<0.01	0.024	0.109
Chloride	mg/L		120		31	1.4	3.5	0.24	1.3	0.26
Conductivity	µS/cm				221	76.7	113	124	37.8	139
Hardness (as CaCO3)	mg/L				49.3	18	26.4	56.2	7.9	61.8
M-Alkalinity (pH 4.5)	mg/L as CaCO3				47.5	16	35.5	52.6	14.9	53.1
Nitrate (as N)	mg/L		13	10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrite (as N)	mg/L				<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
pH	pH		6.5-9		7.73	6.97	7.24	7.78	6.91	7.8
Sulphate	mg/L				9	13.6	15.6	11.1	2.1	13.8
Total Disolved Solids	mg/L			1000	100	40	120	100	60	130
Filtration Time	NA				17.35	17.35	17.35	17.35	17.35	17.35
Metals										
Aluminum	ug/L		100		19.6	51.3	33.6	23.1	34.5	31.9
Antimony	ug/L				<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Arsenic	ug/L	1000	5	500	<1	<1	<1	<1	<1	<1
Barium	ug/L			5000	36	<1	2	11.3	<1	9.5
Beryllium	ug/L				<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Bismuth	ug/L				<1	<1	<1	<1	<1	<1
Boron	ug/L		1500	5000	<2	<2	<2	<2	<2	<2
Cadmium	ug/L			50	0.14	<0.1	0.15	<0.1	<0.1	<0.1
Calcium	ug/L				6810	2100	3700	8880	1140	9590
Cerium	ug/L				<1	<1	<1	<1	<1	<1
Cesium	ug/L				<1	<1	<1	<1	<1	<1
Chromium	ug/L		8.9†	1000	<1	<1	1.6	<1	<1	<1
Cobalt	ug/L				0.67	1.16	1.63	0.41	0.22	0.64
Copper	ug/L	600	2	300	<1	4.7	7.5	<1	9.9	<1
Europium	ug/L				<1	<1	<1	<1	<1	<1
Gallium	ug/L				<1	<1	<1	<1	<1	<1
Iron	ug/L		300	10000	929	<20	521	618	20	647
Lanthanum	ug/L				<1	<1	<1	<1	<1	<1
Lead	ug/L	400	1	200	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Lithium	ug/L				<5	5.5	5.4	<5	<5	<5
Magnesium	ug/L				7840	3090	4160	8260	1220	9200
Manganese	ug/L				1930	4420	5140	1140	414	1040
Mercury	ug/L		0.026	5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Molybdenum	ug/L		73		1	<1	2.8	2	7.7	1.9
Nickel	ug/L	1000	25	500	1.6	7.1	14.7	1	5.7	1.1
Niobium	ug/L				<1	<1	<1	<1	<1	<1
Potassium	ug/L				1140	460	2010	800	280	970
Rubidium	ug/L				1.8	<1	1.9	1.1	<1	1.5
Scandium	ug/L				<1	<1	<1	<1	<1	<1
Selenium	ug/L		1	10	<1	<1	<1	<1	<1	<1
Silicon	ug/L				<600	<600	<600	<600	<600	<600
Silver	ug/L		0.1	50	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Sodium	ug/L				19900	2960	8920	2450	3560	2450
Strontium	ug/L				27.4	6.2	10.8	37.4	4.5	64
Sulfur	ug/L				3560	5520	5640	4340	<800	6020
Tellurium	ug/L				<1	<1	<1	<1	<1	<1
Thallium	ug/L		0.8		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Thorium	ug/L				<1	<1	<1	<1	<1	<1
Tin	ug/L				<1	<1	<1	<1	<1	<1
Titanium	ug/L				<1	<1	<1	<1	<1	<1
Tungsten	ug/L				2.4	7	25	22.4	80.8	22.4
Uranium	ug/L		15		<1	<1	<1	<1	<1	<1
Vanadium	ug/L				<1	<1	<1	<1	<1	<1
Yttrium	ug/L				<1	<1	1.8	<1	3.2	<1
Zinc	ug/L	1000	30	500	18.8	6.1	69.2	3.6	5	2.4
Zirconium	ug/L				<1	<1	<1	<1	<1	<1

MMER Schedule 4- Metal Mining Effluent Regulations
CWQG - Canadian Water Quality Guidelines
NLR 65/03 Schedule A - Newfoundland and Labrador Regulation 65/03
Metals results are dissolved metals
† *Value for trivalent chromium.*

TESTMARK Laboratories Ltd.

Committed to Quality and Service

Analytical Report

Client:	Tom Killingbeck	**Work Order Number:**	**226681**
Company:	WESA - BluMetric	**Date Order Received:**	10/27/2014
Address:	273 Elm Street	**Regulation:**	Information not provided
	Sudbury, ON, P3C 1V5	**PO #:**	
Phone:	(705) 525-6075	**Project #:**	SB12738
Fax:	(705) 525-6077		
Email:	tkillingbeck@wesa.ca		
Notes:	Lab Filter for Alkalinity/Metals Field Filtered		

Analyses were performed on the following samples submitted with your order.
The results relate only to the items tested.

Sample Name	Lab #	Matrix	Type	Comments	Date Collected	Time Collected
JGW-1	599047	Ground Water	Grab		10/16/2014	5:00
JGW-3	599048	Ground Water	Grab		10/16/2014	11:15
BH3	599049	Ground Water	Grab		10/18/2014	11:30
BH4	599050	Ground Water	Grab		10/19/2014	14:00
JGW-2	599051	Ground Water	Grab		10/21/2014	9:00
JGW-4	599052	Ground Water	Grab		10/22/2014	13:00

The following instrumentation and reference methods were used for your sample(s)

Method Name	Description	Reference
Acidity	Determination of Acidity **Instrument group:** Metrohm Analyzer	Based on APHA-2310B
Alka	Determination of Alkalinity **Instrument group:** Metrohm Analyzer	Based on APHA-2320B
Ammonia Water	Determination of Ammonia/Ammonium in Water **Instrument group:** Discrete Chemistry Analyzer	Based on APHA-4500NH3 H
Anions Water	Determination of Anions by Ion Chromatography **Instrument group:** Dionex IC	Based on SW846-9056A
Cond Water	Determination of Conductivity in Water **Instrument group:** Metrohm Analyzer	Based on APHA-2510B
Dissolved Hardness/ICP	Determination of Dissolved Hardness in Water by ICP **Instrument group:** Calculation	Based on SW846-6020
Filtration Time	**Instrument group:** Various Instruments As Required	In House
ICPMS Dis. Water	Determination of Dissolved (Lab Filtered) Metals in Water by ICP/MS **Instrument group:** Perkin Elmer ICPMS	Based on SW846-6020A
ICPMS Dis. Water FF	Determination of Dissolved (Field Filtered) Metals in Water by ICP/MS **Instrument group:** Perkin Elmer ICPMS	Based on SW846-6020A
pHWater	Determination of Water pH by Ion Selective Electrode **Instrument group:** Metrohm Analyzer	Based on APHA-4500H+ B
TDS	Determination of Total Dissolved Solids in water by gravimetry **Instrument group:** Mettler Toledo Balance	Based on APHA-2540

This report has been approved by:

Mark Charbonneau, Ph.D.
Metals Section Head

Sample Data:

Sample Name: JGW-1 **Date: 10/16/2014** **Matrix: Ground Water** **Lab #: 599047**

Acidity

Parameter	MDL	Result	Units	QAQCID
Acidity	1	15	mg/L	20141030.R24A

Alka

Parameter	MDL	Result	Units	QAQCID
M-Alkalinity (pH 4.5)	1	35.5	mg/L as CaCO3	20141030.R1B

Ammonia Water

Parameter	MDL	Result	Units	QAQCID
Ammonia (as N)	0.01	0.025	mg/L	20141029.R42.1B

Anions Water

Parameter	MDL	Result	Units	QAQCID
Chloride	0.2	3.5	mg/L	20141103.R5A
Nitrate (as N)	0.1	<0.1	mg/L	20141103.R5A
Nitrite (as N)	0.03	<0.03	mg/L	20141103.R5A
Sulphate	1	15.6	mg/L	20141103.R5A

Cond Water

Parameter	MDL	Result	Units	QAQCID
Conductivity	0.2	113	µS/cm	20141030.R12C

Dissolved Hardness/ICP

Parameter	MDL	Result	Units	QAQCID
Dissolved Hardness (as CaCO3)	1	26.4	mg/L	20141104.R13.3A

Filtration Time

Parameter	MDL	Result	Units	QAQCID
Filtration Time	N/A	17.35	NA	20141029.R99.2A

ICPMS Dis. Water

Parameter	MDL	Result	Units	QAQCID
Dissolved Aluminum	1	33.6	ug/L	20141030.R13-2o2
Dissolved Antimony	0.5	<0.5	ug/L	20141030.R13-2o2
Dissolved Arsenic	1	<1	ug/L	20141030.R13-2o2
Dissolved Barium	1	2	ug/L	20141030.R13-2o2
Dissolved Beryllium	0.5	<0.5	ug/L	20141030.R13-2o2
Dissolved Bismuth	1	<1	ug/L	20141030.R13-2o2
Dissolved Boron	2	<2	ug/L	20141030.R13-2o2
Dissolved Cadmium	0.1	0.15	ug/L	20141030.R13-2o2
Dissolved Calcium	50	3700	ug/L	20141030.R13-2o2
Dissolved Cerium	1	<1	ug/L	20141030.R13-2o2
Dissolved Cesium	1	<1	ug/L	20141030.R13-2o2
Dissolved Chromium	0.8	1.6	ug/L	20141030.R13-2o2
Dissolved Cobalt	0.1	1.63	ug/L	20141030.R13-2o2
Dissolved Copper	1	7.5	ug/L	20141030.R13-2o2
Dissolved Europium	1	<1	ug/L	20141030.R13-2o2
Dissolved Gallium	1	<1	ug/L	20141030.R13-2o2
Dissolved Iron	20	521	ug/L	20141030.R13-2o2

Sample Name: JGW-1 **Date: 10/16/2014** **Matrix: Ground Water** **Lab #: 599047**

ICPMS Dis. Water				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Dissolved Lanthanum	1	<1	ug/L	20141030.R13-2o2
Dissolved Lead	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Lithium	5	5.4	ug/L	20141030.R13-2o2
Dissolved Magnesium	4	4160	ug/L	20141030.R13-2o2
Dissolved Manganese	10	5140	ug/L	20141030.R13-2o2
Dissolved Mercury	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Molybdenum	1	2.8	ug/L	20141030.R13-2o2
Dissolved Nickel	1	14.7	ug/L	20141030.R13-2o2
Dissolved Niobium	1	<1	ug/L	20141030.R13-2o2
Dissolved Potassium	100	2010	ug/L	20141030.R13-2o2
Dissolved Rubidium	1	1.9	ug/L	20141030.R13-2o2
Dissolved Scandium	1	<1	ug/L	20141030.R13-2o2
Dissolved Selenium	1	<1	ug/L	20141030.R13-2o2
Dissolved Silicon	600	<600	ug/L	20141030.R13-2o2
Dissolved Silver	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Sodium	100	8920	ug/L	20141030.R13-2o2
Dissolved Strontium	1	10.8	ug/L	20141030.R13-2o2
Dissolved Sulfur	800	5640	ug/L	20141030.R13-2o2
Dissolved Tellurium	1	<1	ug/L	20141030.R13-2o2
Dissolved Thallium	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Thorium	1	<1	ug/L	20141030.R13-2o2
Dissolved Tin	1	<1	ug/L	20141030.R13-2o2
Dissolved Titanium	1	<1	ug/L	20141030.R13-2o2
Dissolved Tungsten	1	25	ug/L	20141030.R13-2o2
Dissolved Uranium	1	<1	ug/L	20141030.R13-2o2
Dissolved Vanadium	1	<1	ug/L	20141030.R13-2o2
Dissolved Yttrium	1	1.8	ug/L	20141030.R13-2o2
Dissolved Zinc	1	69.2	ug/L	20141030.R13-2o2
Dissolved Zirconium	1	<1	ug/L	20141030.R13-2o2

ICPMS Dis. Water FF				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Dissolved Aluminum	1	33.6	ug/L	20141030.R13-2o2
Dissolved Antimony	0.5	<0.5	ug/L	20141030.R13-2o2
Dissolved Arsenic	1	<1	ug/L	20141030.R13-2o2
Dissolved Barium	1	2	ug/L	20141030.R13-2o2
Dissolved Beryllium	0.5	<0.5	ug/L	20141030.R13-2o2
Dissolved Bismuth	1	<1	ug/L	20141030.R13-2o2
Dissolved Boron	2	<2	ug/L	20141030.R13-2o2
Dissolved Cadmium	0.1	0.15	ug/L	20141030.R13-2o2
Dissolved Calcium	50	3700	ug/L	20141030.R13-2o2
Dissolved Cerium	1	<1	ug/L	20141030.R13-2o2
Dissolved Cesium	1	<1	ug/L	20141030.R13-2o2
Dissolved Chromium	1	1.6	ug/L	20141030.R13-2o2
Dissolved Cobalt	0.1	1.63	ug/L	20141030.R13-2o2
Dissolved Copper	1	7.5	ug/L	20141030.R13-2o2

WESA - BluMetric Work Order: 226681

Sample Name: JGW-1 **Date: 10/16/2014** **Matrix: Ground Water** **Lab #: 599047**

ICPMS Dis. Water FF				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Dissolved Europium	1	<1	ug/L	20141030.R13-2o2
Dissolved Gallium	1	<1	ug/L	20141030.R13-2o2
Dissolved Iron	20	521	ug/L	20141030.R13-2o2
Dissolved Lanthanum	1	<1	ug/L	20141030.R13-2o2
Dissolved Lead	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Lithium	5	5.4	ug/L	20141030.R13-2o2
Dissolved Magnesium	4	4160	ug/L	20141030.R13-2o2
Dissolved Manganese	10	5140	ug/L	20141030.R13-2o2
Dissolved Mercury	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Molybdenum	1	2.8	ug/L	20141030.R13-2o2
Dissolved Nickel	1	14.7	ug/L	20141030.R13-2o2
Dissolved Niobium	1	<1	ug/L	20141030.R13-2o2
Dissolved Potassium	100	2010	ug/L	20141030.R13-2o2
Dissolved Rubidium	1	1.9	ug/L	20141030.R13-2o2
Dissolved Scandium	1	<1	ug/L	20141030.R13-2o2
Dissolved Selenium	1	<1	ug/L	20141030.R13-2o2
Dissolved Silicon	600	<600	ug/L	20141030.R13-2o2
Dissolved Silver	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Sodium	100	8920	ug/L	20141030.R13-2o2
Dissolved Strontium	1	10.8	ug/L	20141030.R13-2o2
Dissolved Sulfur	800	5640	ug/L	20141030.R13-2o2
Dissolved Tellurium	1	<1	ug/L	20141030.R13-2o2
Dissolved Thallium	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Thorium	1	<1	ug/L	20141030.R13-2o2
Dissolved Tin	1	<1	ug/L	20141030.R13-2o2
Dissolved Titanium	1	<1	ug/L	20141030.R13-2o2
Dissolved Tungsten	1	25	ug/L	20141030.R13-2o2
Dissolved Uranium	1	<1	ug/L	20141030.R13-2o2
Dissolved Vanadium	1	<1	ug/L	20141030.R13-2o2
Dissolved Yttrium	1	1.8	ug/L	20141030.R13-2o2
Dissolved Zinc	1	69.2	ug/L	20141030.R13-2o2
Dissolved Zirconium	1	<1	ug/L	20141030.R13-2o2

pHWater				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
pH	N/A	7.24	pH	20141030.R2D

TDS				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Total Dissolved Solids	30	120	mg/L	20141030.R27A

Sample Name: JGW-3 **Date: 10/16/2014** **Matrix: Ground Water** **Lab #: 599048**

Acidity				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Acidity	1	11.6	mg/L	20141030.R24A

Sample Name: JGW-3 **Date: 10/16/2014** **Matrix: Ground Water** **Lab #: 599048**

Alka

Parameter	MDL	Result	Units	QAQCID
M-Alkalinity (pH 4.5)	1	14.9	mg/L as CaCO3	20141030.R1B

Ammonia Water

Parameter	MDL	Result	Units	QAQCID
Ammonia (as N)	0.01	0.024	mg/L	20141029.R42.1B

Anions Water

Parameter	MDL	Result	Units	QAQCID
Chloride	0.2	1.3	mg/L	20141103.R5A
Nitrate (as N)	0.1	<0.1	mg/L	20141103.R5A
Nitrite (as N)	0.03	<0.03	mg/L	20141103.R5A
Sulphate	1	2.1	mg/L	20141103.R5A

Cond Water

Parameter	MDL	Result	Units	QAQCID
Conductivity	0.2	37.8	µS/cm	20141030.R12C

Dissolved Hardness/ICP

Parameter	MDL	Result	Units	QAQCID
Dissolved Hardness (as CaCO3)	1	7.9	mg/L	20141104.R13.3A

Filtration Time

Parameter	MDL	Result	Units	QAQCID
Filtration Time	N/A	17.35	NA	20141029.R99.2A

ICPMS Dis. Water

Parameter	MDL	Result	Units	QAQCID
Dissolved Aluminum	1	34.5	ug/L	20141030.R13-2o2
Dissolved Antimony	0.5	<0.5	ug/L	20141030.R13-2o2
Dissolved Arsenic	1	<1	ug/L	20141030.R13-2o2
Dissolved Barium	1	<1	ug/L	20141030.R13-2o2
Dissolved Beryllium	0.5	<0.5	ug/L	20141030.R13-2o2
Dissolved Bismuth	1	<1	ug/L	20141030.R13-2o2
Dissolved Boron	2	<2	ug/L	20141030.R13-2o2
Dissolved Cadmium	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Calcium	50	1140	ug/L	20141030.R13-2o2
Dissolved Cerium	1	<1	ug/L	20141030.R13-2o2
Dissolved Cesium	1	<1	ug/L	20141030.R13-2o2
Dissolved Chromium	0.8	<0.8	ug/L	20141030.R13-2o2
Dissolved Cobalt	0.1	0.22	ug/L	20141030.R13-2o2
Dissolved Copper	1	9.9	ug/L	20141030.R13-2o2
Dissolved Europium	1	<1	ug/L	20141030.R13-2o2
Dissolved Gallium	1	<1	ug/L	20141030.R13-2o2
Dissolved Iron	20	20	ug/L	20141030.R13-2o2
Dissolved Lanthanum	1	<1	ug/L	20141030.R13-2o2
Dissolved Lead	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Lithium	5	<5	ug/L	20141030.R13-2o2
Dissolved Magnesium	4	1220	ug/L	20141030.R13-2o2
Dissolved Manganese	1	414	ug/L	20141030.R13-2o2

WESA - BluMetric Work Order: 226681

Sample Name: JGW-3 **Date: 10/16/2014** **Matrix: Ground Water** **Lab #: 599048**

ICPMS Dis. Water				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Dissolved Mercury	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Molybdenum	1	7.7	ug/L	20141030.R13-2o2
Dissolved Nickel	1	5.7	ug/L	20141030.R13-2o2
Dissolved Niobium	1	<1	ug/L	20141030.R13-2o2
Dissolved Potassium	100	280	ug/L	20141030.R13-2o2
Dissolved Rubidium	1	<1	ug/L	20141030.R13-2o2
Dissolved Scandium	1	<1	ug/L	20141030.R13-2o2
Dissolved Selenium	1	<1	ug/L	20141030.R13-2o2
Dissolved Silicon	600	<600	ug/L	20141030.R13-2o2
Dissolved Silver	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Sodium	100	3560	ug/L	20141030.R13-2o2
Dissolved Strontium	1	4.5	ug/L	20141030.R13-2o2
Dissolved Sulfur	800	<800	ug/L	20141030.R13-2o2
Dissolved Tellurium	1	<1	ug/L	20141030.R13-2o2
Dissolved Thallium	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Thorium	1	<1	ug/L	20141030.R13-2o2
Dissolved Tin	1	<1	ug/L	20141030.R13-2o2
Dissolved Titanium	1	<1	ug/L	20141030.R13-2o2
Dissolved Tungsten	1	80.8	ug/L	20141030.R13-2o2
Dissolved Uranium	1	<1	ug/L	20141030.R13-2o2
Dissolved Vanadium	1	<1	ug/L	20141030.R13-2o2
Dissolved Yttrium	1	3.2	ug/L	20141030.R13-2o2
Dissolved Zinc	1	5	ug/L	20141030.R13-2o2
Dissolved Zirconium	1	<1	ug/L	20141030.R13-2o2

ICPMS Dis. Water FF				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Dissolved Aluminum	1	34.5	ug/L	20141030.R13-2o2
Dissolved Antimony	0.5	<0.5	ug/L	20141030.R13-2o2
Dissolved Arsenic	1	<1	ug/L	20141030.R13-2o2
Dissolved Barium	1	<1	ug/L	20141030.R13-2o2
Dissolved Beryllium	0.5	<0.5	ug/L	20141030.R13-2o2
Dissolved Bismuth	1	<1	ug/L	20141030.R13-2o2
Dissolved Boron	2	<2	ug/L	20141030.R13-2o2
Dissolved Cadmium	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Calcium	50	1140	ug/L	20141030.R13-2o2
Dissolved Cerium	1	<1	ug/L	20141030.R13-2o2
Dissolved Cesium	1	<1	ug/L	20141030.R13-2o2
Dissolved Chromium	1	<1	ug/L	20141030.R13-2o2
Dissolved Cobalt	0.1	0.22	ug/L	20141030.R13-2o2
Dissolved Copper	1	9.9	ug/L	20141030.R13-2o2
Dissolved Europium	1	<1	ug/L	20141030.R13-2o2
Dissolved Gallium	1	<1	ug/L	20141030.R13-2o2
Dissolved Iron	20	20	ug/L	20141030.R13-2o2
Dissolved Lanthanum	1	<1	ug/L	20141030.R13-2o2
Dissolved Lead	0.1	<0.1	ug/L	20141030.R13-2o2

Sample Name: JGW-3 **Date: 10/16/2014** **Matrix: Ground Water** **Lab #: 599048**

ICPMS Dis. Water FF				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Dissolved Lithium	5	<5	ug/L	20141030.R13-2o2
Dissolved Magnesium	4	1220	ug/L	20141030.R13-2o2
Dissolved Manganese	1	414	ug/L	20141030.R13-2o2
Dissolved Mercury	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Molybdenum	1	7.7	ug/L	20141030.R13-2o2
Dissolved Nickel	1	5.7	ug/L	20141030.R13-2o2
Dissolved Niobium	1	<1	ug/L	20141030.R13-2o2
Dissolved Potassium	100	280	ug/L	20141030.R13-2o2
Dissolved Rubidium	1	<1	ug/L	20141030.R13-2o2
Dissolved Scandium	1	<1	ug/L	20141030.R13-2o2
Dissolved Selenium	1	<1	ug/L	20141030.R13-2o2
Dissolved Silicon	600	<600	ug/L	20141030.R13-2o2
Dissolved Silver	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Sodium	100	3560	ug/L	20141030.R13-2o2
Dissolved Strontium	1	4.5	ug/L	20141030.R13-2o2
Dissolved Sulfur	800	<800	ug/L	20141030.R13-2o2
Dissolved Tellurium	1	<1	ug/L	20141030.R13-2o2
Dissolved Thallium	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Thorium	1	<1	ug/L	20141030.R13-2o2
Dissolved Tin	1	<1	ug/L	20141030.R13-2o2
Dissolved Titanium	1	<1	ug/L	20141030.R13-2o2
Dissolved Tungsten	1	80.8	ug/L	20141030.R13-2o2
Dissolved Uranium	1	<1	ug/L	20141030.R13-2o2
Dissolved Vanadium	1	<1	ug/L	20141030.R13-2o2
Dissolved Yttrium	1	3.2	ug/L	20141030.R13-2o2
Dissolved Zinc	1	5	ug/L	20141030.R13-2o2
Dissolved Zirconium	1	<1	ug/L	20141030.R13-2o2

pHWater				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
pH	N/A	6.91	pH	20141030.R2D

TDS				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Total Dissolved Solids	30	60	mg/L	20141030.R27A

Sample Name: BH3 **Date: 10/18/2014** **Matrix: Ground Water** **Lab #: 599049**

Acidity				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Acidity	1	14.3	mg/L	20141030.R24A
Acidity (Dup)	1	13.9	mg/L	20141030.R24A

Alka				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
M-Alkalinity (pH 4.5)	1	47.5	mg/L as CaCO3	20141030.R1B
M-Alkalinity (pH 4.5) (Dup)	1	44.5	mg/L as CaCO3	20141030.R1B

Sample Name: BH3 **Date: 10/18/2014** **Matrix: Ground Water** **Lab #: 599049**

Ammonia Water				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Ammonia (as N)	0.01	0.017	mg/L	20141029.R42.1B

Anions Water				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Chloride	0.2	31	mg/L	20141103.R5A
Nitrate (as N)	0.1	<0.1	mg/L	20141103.R5A
Nitrite (as N)	0.03	<0.03	mg/L	20141103.R5A
Sulphate	1	9	mg/L	20141103.R5A

Cond Water				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Conductivity	0.2	221	µS/cm	20141030.R12C
Conductivity (Dup)	0.2	224	µS/cm	20141030.R12C

Dissolved Hardness/ICP				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Dissolved Hardness (as CaCO3)	1	49.3	mg/L	20141104.R13.3A

Filtration Time				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Filtration Time	N/A	17.35	NA	20141029.R99.2A

ICPMS Dis. Water				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Dissolved Aluminum	1	19.6	ug/L	20141030.R13-2o2
Dissolved Antimony	0.5	<0.5	ug/L	20141030.R13-2o2
Dissolved Arsenic	1	<1	ug/L	20141030.R13-2o2
Dissolved Barium	1	36	ug/L	20141030.R13-2o2
Dissolved Beryllium	0.5	<0.5	ug/L	20141030.R13-2o2
Dissolved Bismuth	1	<1	ug/L	20141030.R13-2o2
Dissolved Boron	2	<2	ug/L	20141030.R13-2o2
Dissolved Cadmium	0.1	0.14	ug/L	20141030.R13-2o2
Dissolved Calcium	50	6810	ug/L	20141030.R13-2o2
Dissolved Cerium	1	<1	ug/L	20141030.R13-2o2
Dissolved Cesium	1	<1	ug/L	20141030.R13-2o2
Dissolved Chromium	0.8	<0.8	ug/L	20141030.R13-2o2
Dissolved Cobalt	0.1	0.67	ug/L	20141030.R13-2o2
Dissolved Copper	1	<1	ug/L	20141030.R13-2o2
Dissolved Europium	1	<1	ug/L	20141030.R13-2o2
Dissolved Gallium	1	<1	ug/L	20141030.R13-2o2
Dissolved Iron	20	929	ug/L	20141030.R13-2o2
Dissolved Lanthanum	1	<1	ug/L	20141030.R13-2o2
Dissolved Lead	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Lithium	5	<5	ug/L	20141030.R13-2o2
Dissolved Magnesium	4	7840	ug/L	20141030.R13-2o2
Dissolved Manganese	10	1930	ug/L	20141030.R13-2o2
Dissolved Mercury	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Molybdenum	1	1	ug/L	20141030.R13-2o2

Sample Name: BH3 **Date: 10/18/2014** **Matrix: Ground Water** **Lab #: 599049**

ICPMS Dis. Water				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Dissolved Nickel	1	1.6	ug/L	20141030.R13-2o2
Dissolved Niobium	1	<1	ug/L	20141030.R13-2o2
Dissolved Potassium	100	1140	ug/L	20141030.R13-2o2
Dissolved Rubidium	1	1.8	ug/L	20141030.R13-2o2
Dissolved Scandium	1	<1	ug/L	20141030.R13-2o2
Dissolved Selenium	1	<1	ug/L	20141030.R13-2o2
Dissolved Silicon	600	<600	ug/L	20141030.R13-2o2
Dissolved Silver	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Sodium	100	19900	ug/L	20141030.R13-2o2
Dissolved Strontium	1	27.4	ug/L	20141030.R13-2o2
Dissolved Sulfur	800	3560	ug/L	20141030.R13-2o2
Dissolved Tellurium	1	<1	ug/L	20141030.R13-2o2
Dissolved Thallium	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Thorium	1	<1	ug/L	20141030.R13-2o2
Dissolved Tin	1	<1	ug/L	20141030.R13-2o2
Dissolved Titanium	1	<1	ug/L	20141030.R13-2o2
Dissolved Tungsten	1	2.4	ug/L	20141030.R13-2o2
Dissolved Uranium	1	<1	ug/L	20141030.R13-2o2
Dissolved Vanadium	1	<1	ug/L	20141030.R13-2o2
Dissolved Yttrium	1	<1	ug/L	20141030.R13-2o2
Dissolved Zinc	1	18.8	ug/L	20141030.R13-2o2
Dissolved Zirconium	1	<1	ug/L	20141030.R13-2o2

ICPMS Dis. Water FF				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Dissolved Aluminum	1	19.6	ug/L	20141030.R13-2o2
Dissolved Antimony	0.5	<0.5	ug/L	20141030.R13-2o2
Dissolved Arsenic	1	<1	ug/L	20141030.R13-2o2
Dissolved Barium	1	36	ug/L	20141030.R13-2o2
Dissolved Beryllium	0.5	<0.5	ug/L	20141030.R13-2o2
Dissolved Bismuth	1	<1	ug/L	20141030.R13-2o2
Dissolved Boron	2	<2	ug/L	20141030.R13-2o2
Dissolved Cadmium	0.1	0.14	ug/L	20141030.R13-2o2
Dissolved Calcium	50	6810	ug/L	20141030.R13-2o2
Dissolved Cerium	1	<1	ug/L	20141030.R13-2o2
Dissolved Cesium	1	<1	ug/L	20141030.R13-2o2
Dissolved Chromium	1	<1	ug/L	20141030.R13-2o2
Dissolved Cobalt	0.1	0.67	ug/L	20141030.R13-2o2
Dissolved Copper	1	<1	ug/L	20141030.R13-2o2
Dissolved Europium	1	<1	ug/L	20141030.R13-2o2
Dissolved Gallium	1	<1	ug/L	20141030.R13-2o2
Dissolved Iron	20	929	ug/L	20141030.R13-2o2
Dissolved Lanthanum	1	<1	ug/L	20141030.R13-2o2
Dissolved Lead	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Lithium	5	<5	ug/L	20141030.R13-2o2
Dissolved Magnesium	4	7840	ug/L	20141030.R13-2o2

Sample Name: BH3 **Date: 10/18/2014** **Matrix: Ground Water** **Lab #: 599049**

ICPMS Dis. Water FF				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Dissolved Manganese	10	1930	ug/L	20141030.R13-2o2
Dissolved Mercury	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Molybdenum	1	1	ug/L	20141030.R13-2o2
Dissolved Nickel	1	1.6	ug/L	20141030.R13-2o2
Dissolved Niobium	1	<1	ug/L	20141030.R13-2o2
Dissolved Potassium	100	1140	ug/L	20141030.R13-2o2
Dissolved Rubidium	1	1.8	ug/L	20141030.R13-2o2
Dissolved Scandium	1	<1	ug/L	20141030.R13-2o2
Dissolved Selenium	1	<1	ug/L	20141030.R13-2o2
Dissolved Silicon	600	<600	ug/L	20141030.R13-2o2
Dissolved Silver	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Sodium	100	19900	ug/L	20141030.R13-2o2
Dissolved Strontium	1	27.4	ug/L	20141030.R13-2o2
Dissolved Sulfur	800	3560	ug/L	20141030.R13-2o2
Dissolved Tellurium	1	<1	ug/L	20141030.R13-2o2
Dissolved Thallium	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Thorium	1	<1	ug/L	20141030.R13-2o2
Dissolved Tin	1	<1	ug/L	20141030.R13-2o2
Dissolved Titanium	1	<1	ug/L	20141030.R13-2o2
Dissolved Tungsten	1	2.4	ug/L	20141030.R13-2o2
Dissolved Uranium	1	<1	ug/L	20141030.R13-2o2
Dissolved Vanadium	1	<1	ug/L	20141030.R13-2o2
Dissolved Yttrium	1	<1	ug/L	20141030.R13-2o2
Dissolved Zinc	1	18.8	ug/L	20141030.R13-2o2
Dissolved Zirconium	1	<1	ug/L	20141030.R13-2o2

pHWater				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
pH	N/A	7.73	pH	20141030.R2D
pH (Dup)	N/A	7.82	pH	20141030.R2D

TDS				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Total Dissolved Solids	30	100	mg/L	20141030.R27A

Sample Name: BH4 **Date: 10/19/2014** **Matrix: Ground Water** **Lab #: 599050**

Acidity				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Acidity	1	13.5	mg/L	20141030.R24A

Alka				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
M-Alkalinity (pH 4.5)	1	16	mg/L as CaCO3	20141030.R1B

Ammonia Water				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Ammonia (as N)	0.01	0.054	mg/L	20141029.R42.1B

Sample Name: BH4 **Date: 10/19/2014** **Matrix: Ground Water** **Lab #: 599050**

Anions Water				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Chloride	0.2	1.4	mg/L	20141103.R5A
Nitrate (as N)	0.1	<0.1	mg/L	20141103.R5A
Nitrite (as N)	0.03	<0.03	mg/L	20141103.R5A
Sulphate	1	13.6	mg/L	20141103.R5A

Cond Water				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Conductivity	0.2	76.7	µS/cm	20141030.R12C

Dissolved Hardness/ICP				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Dissolved Hardness (as CaCO3)	1	18	mg/L	20141104.R13.3A

Filtration Time				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Filtration Time	N/A	17.35	NA	20141029.R99.2A

ICPMS Dis. Water				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Dissolved Aluminum	1	51.3	ug/L	20141030.R13-2o2
Dissolved Antimony	0.5	<0.5	ug/L	20141030.R13-2o2
Dissolved Arsenic	1	<1	ug/L	20141030.R13-2o2
Dissolved Barium	1	<1	ug/L	20141030.R13-2o2
Dissolved Beryllium	0.5	<0.5	ug/L	20141030.R13-2o2
Dissolved Bismuth	1	<1	ug/L	20141030.R13-2o2
Dissolved Boron	2	<2	ug/L	20141030.R13-2o2
Dissolved Cadmium	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Calcium	50	2100	ug/L	20141030.R13-2o2
Dissolved Cerium	1	<1	ug/L	20141030.R13-2o2
Dissolved Cesium	1	<1	ug/L	20141030.R13-2o2
Dissolved Chromium	0.8	<0.8	ug/L	20141030.R13-2o2
Dissolved Cobalt	0.1	1.16	ug/L	20141030.R13-2o2
Dissolved Copper	1	4.7	ug/L	20141030.R13-2o2
Dissolved Europium	1	<1	ug/L	20141030.R13-2o2
Dissolved Gallium	1	<1	ug/L	20141030.R13-2o2
Dissolved Iron	20	<20	ug/L	20141030.R13-2o2
Dissolved Lanthanum	1	<1	ug/L	20141030.R13-2o2
Dissolved Lead	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Lithium	5	5.5	ug/L	20141030.R13-2o2
Dissolved Magnesium	4	3090	ug/L	20141030.R13-2o2
Dissolved Manganese	10	4420	ug/L	20141030.R13-2o2
Dissolved Mercury	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Molybdenum	1	<1	ug/L	20141030.R13-2o2
Dissolved Nickel	1	7.1	ug/L	20141030.R13-2o2
Dissolved Niobium	1	<1	ug/L	20141030.R13-2o2
Dissolved Potassium	100	460	ug/L	20141030.R13-2o2
Dissolved Rubidium	1	<1	ug/L	20141030.R13-2o2
Dissolved Scandium	1	<1	ug/L	20141030.R13-2o2

Sample Name: BH4 **Date: 10/19/2014** **Matrix: Ground Water** **Lab #: 599050**

ICPMS Dis. Water				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Dissolved Selenium	1	<1	ug/L	20141030.R13-2o2
Dissolved Silicon	600	<600	ug/L	20141030.R13-2o2
Dissolved Silver	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Sodium	100	2960	ug/L	20141030.R13-2o2
Dissolved Strontium	1	6.2	ug/L	20141030.R13-2o2
Dissolved Sulfur	800	5520	ug/L	20141030.R13-2o2
Dissolved Tellurium	1	<1	ug/L	20141030.R13-2o2
Dissolved Thallium	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Thorium	1	<1	ug/L	20141030.R13-2o2
Dissolved Tin	1	<1	ug/L	20141030.R13-2o2
Dissolved Titanium	1	<1	ug/L	20141030.R13-2o2
Dissolved Tungsten	1	7	ug/L	20141030.R13-2o2
Dissolved Uranium	1	<1	ug/L	20141030.R13-2o2
Dissolved Vanadium	1	<1	ug/L	20141030.R13-2o2
Dissolved Yttrium	1	<1	ug/L	20141030.R13-2o2
Dissolved Zinc	1	6.1	ug/L	20141030.R13-2o2
Dissolved Zirconium	1	<1	ug/L	20141030.R13-2o2

ICPMS Dis. Water FF				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Dissolved Aluminum	1	51.3	ug/L	20141030.R13-2o2
Dissolved Antimony	0.5	<0.5	ug/L	20141030.R13-2o2
Dissolved Arsenic	1	<1	ug/L	20141030.R13-2o2
Dissolved Barium	1	<1	ug/L	20141030.R13-2o2
Dissolved Beryllium	0.5	<0.5	ug/L	20141030.R13-2o2
Dissolved Bismuth	1	<1	ug/L	20141030.R13-2o2
Dissolved Boron	2	<2	ug/L	20141030.R13-2o2
Dissolved Cadmium	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Calcium	50	2100	ug/L	20141030.R13-2o2
Dissolved Cerium	1	<1	ug/L	20141030.R13-2o2
Dissolved Cesium	1	<1	ug/L	20141030.R13-2o2
Dissolved Chromium	1	<1	ug/L	20141030.R13-2o2
Dissolved Cobalt	0.1	1.16	ug/L	20141030.R13-2o2
Dissolved Copper	1	4.7	ug/L	20141030.R13-2o2
Dissolved Europium	1	<1	ug/L	20141030.R13-2o2
Dissolved Gallium	1	<1	ug/L	20141030.R13-2o2
Dissolved Iron	20	<20	ug/L	20141030.R13-2o2
Dissolved Lanthanum	1	<1	ug/L	20141030.R13-2o2
Dissolved Lead	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Lithium	5	5.5	ug/L	20141030.R13-2o2
Dissolved Magnesium	4	3090	ug/L	20141030.R13-2o2
Dissolved Manganese	10	4420	ug/L	20141030.R13-2o2
Dissolved Mercury	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Molybdenum	1	<1	ug/L	20141030.R13-2o2
Dissolved Nickel	1	7.1	ug/L	20141030.R13-2o2
Dissolved Niobium	1	<1	ug/L	20141030.R13-2o2

Sample Name: BH4 **Date: 10/19/2014** **Matrix: Ground Water** **Lab #: 599050**

ICPMS Dis. Water FF				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Dissolved Potassium	100	460	ug/L	20141030.R13-2o2
Dissolved Rubidium	1	<1	ug/L	20141030.R13-2o2
Dissolved Scandium	1	<1	ug/L	20141030.R13-2o2
Dissolved Selenium	1	<1	ug/L	20141030.R13-2o2
Dissolved Silicon	600	<600	ug/L	20141030.R13-2o2
Dissolved Silver	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Sodium	100	2960	ug/L	20141030.R13-2o2
Dissolved Strontium	1	6.2	ug/L	20141030.R13-2o2
Dissolved Sulfur	800	5520	ug/L	20141030.R13-2o2
Dissolved Tellurium	1	<1	ug/L	20141030.R13-2o2
Dissolved Thallium	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Thorium	1	<1	ug/L	20141030.R13-2o2
Dissolved Tin	1	<1	ug/L	20141030.R13-2o2
Dissolved Titanium	1	<1	ug/L	20141030.R13-2o2
Dissolved Tungsten	1	7	ug/L	20141030.R13-2o2
Dissolved Uranium	1	<1	ug/L	20141030.R13-2o2
Dissolved Vanadium	1	<1	ug/L	20141030.R13-2o2
Dissolved Yttrium	1	<1	ug/L	20141030.R13-2o2
Dissolved Zinc	1	6.1	ug/L	20141030.R13-2o2
Dissolved Zirconium	1	<1	ug/L	20141030.R13-2o2

pHWater				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
pH	N/A	6.97	pH	20141030.R2D

TDS				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Total Dissolved Solids	30	40	mg/L	20141030.R27A

Sample Name: JGW-2 **Date: 10/21/2014** **Matrix: Ground Water** **Lab #: 599051**

Acidity				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Acidity	1	12.8	mg/L	20141030.R24A

Alka				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
M-Alkalinity (pH 4.5)	1	52.6	mg/L as CaCO3	20141030.R1B

Ammonia Water				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Ammonia (as N)	0.01	<0.01	mg/L	20141029.R42.1B

Anions Water				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Chloride	0.2	0.24	mg/L	20141103.R5B
Nitrate (as N)	0.1	<0.1	mg/L	20141103.R5B
Nitrite (as N)	0.03	<0.03	mg/L	20141103.R5B
Sulphate	1	11.1	mg/L	20141103.R5B

Sample Name: JGW-2 **Date: 10/21/2014** **Matrix: Ground Water** **Lab #: 599051**

Anions Water				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**

Cond Water				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Conductivity	0.2	124	µS/cm	20141030.R12C

Dissolved Hardness/ICP				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Dissolved Hardness (as CaCO3)	1	56.2	mg/L	20141104.R13.3A

Filtration Time				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Filtration Time	N/A	17.35	NA	20141029.R99.2A

ICPMS Dis. Water				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Dissolved Aluminum	1	23.1	ug/L	20141030.R13-2o2
Dissolved Antimony	0.5	<0.5	ug/L	20141030.R13-2o2
Dissolved Arsenic	1	<1	ug/L	20141030.R13-2o2
Dissolved Barium	1	11.3	ug/L	20141030.R13-2o2
Dissolved Beryllium	0.5	<0.5	ug/L	20141030.R13-2o2
Dissolved Bismuth	1	<1	ug/L	20141030.R13-2o2
Dissolved Boron	2	<2	ug/L	20141030.R13-2o2
Dissolved Cadmium	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Calcium	50	8880	ug/L	20141030.R13-2o2
Dissolved Cerium	1	<1	ug/L	20141030.R13-2o2
Dissolved Cesium	1	<1	ug/L	20141030.R13-2o2
Dissolved Chromium	0.8	<0.8	ug/L	20141030.R13-2o2
Dissolved Cobalt	0.1	0.41	ug/L	20141030.R13-2o2
Dissolved Copper	1	<1	ug/L	20141030.R13-2o2
Dissolved Europium	1	<1	ug/L	20141030.R13-2o2
Dissolved Gallium	1	<1	ug/L	20141030.R13-2o2
Dissolved Iron	20	618	ug/L	20141030.R13-2o2
Dissolved Lanthanum	1	<1	ug/L	20141030.R13-2o2
Dissolved Lead	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Lithium	5	<5	ug/L	20141030.R13-2o2
Dissolved Magnesium	4	8260	ug/L	20141030.R13-2o2
Dissolved Manganese	10	1140	ug/L	20141030.R13-2o2
Dissolved Mercury	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Molybdenum	1	2	ug/L	20141030.R13-2o2
Dissolved Nickel	1	1	ug/L	20141030.R13-2o2
Dissolved Niobium	1	<1	ug/L	20141030.R13-2o2
Dissolved Potassium	100	800	ug/L	20141030.R13-2o2
Dissolved Rubidium	1	1.1	ug/L	20141030.R13-2o2
Dissolved Scandium	1	<1	ug/L	20141030.R13-2o2
Dissolved Selenium	1	<1	ug/L	20141030.R13-2o2
Dissolved Silicon	600	<600	ug/L	20141030.R13-2o2
Dissolved Silver	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Sodium	100	2450	ug/L	20141030.R13-2o2

Sample Name: JGW-2 **Date: 10/21/2014** **Matrix: Ground Water** **Lab #: 599051**

ICPMS Dis. Water				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Dissolved Strontium	1	37.4	ug/L	20141030.R13-2o2
Dissolved Sulfur	800	4340	ug/L	20141030.R13-2o2
Dissolved Tellurium	1	<1	ug/L	20141030.R13-2o2
Dissolved Thallium	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Thorium	1	<1	ug/L	20141030.R13-2o2
Dissolved Tin	1	<1	ug/L	20141030.R13-2o2
Dissolved Titanium	1	<1	ug/L	20141030.R13-2o2
Dissolved Tungsten	1	22.4	ug/L	20141030.R13-2o2
Dissolved Uranium	1	<1	ug/L	20141030.R13-2o2
Dissolved Vanadium	1	<1	ug/L	20141030.R13-2o2
Dissolved Yttrium	1	<1	ug/L	20141030.R13-2o2
Dissolved Zinc	1	3.6	ug/L	20141030.R13-2o2
Dissolved Zirconium	1	<1	ug/L	20141030.R13-2o2

ICPMS Dis. Water FF				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Dissolved Aluminum	1	23.1	ug/L	20141030.R13-2o2
Dissolved Antimony	0.5	<0.5	ug/L	20141030.R13-2o2
Dissolved Arsenic	1	<1	ug/L	20141030.R13-2o2
Dissolved Barium	1	11.3	ug/L	20141030.R13-2o2
Dissolved Beryllium	0.5	<0.5	ug/L	20141030.R13-2o2
Dissolved Bismuth	1	<1	ug/L	20141030.R13-2o2
Dissolved Boron	2	<2	ug/L	20141030.R13-2o2
Dissolved Cadmium	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Calcium	50	8880	ug/L	20141030.R13-2o2
Dissolved Cerium	1	<1	ug/L	20141030.R13-2o2
Dissolved Cesium	1	<1	ug/L	20141030.R13-2o2
Dissolved Chromium	1	<1	ug/L	20141030.R13-2o2
Dissolved Cobalt	0.1	0.41	ug/L	20141030.R13-2o2
Dissolved Copper	1	<1	ug/L	20141030.R13-2o2
Dissolved Europium	1	<1	ug/L	20141030.R13-2o2
Dissolved Gallium	1	<1	ug/L	20141030.R13-2o2
Dissolved Iron	20	618	ug/L	20141030.R13-2o2
Dissolved Lanthanum	1	<1	ug/L	20141030.R13-2o2
Dissolved Lead	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Lithium	5	<5	ug/L	20141030.R13-2o2
Dissolved Magnesium	4	8260	ug/L	20141030.R13-2o2
Dissolved Manganese	10	1140	ug/L	20141030.R13-2o2
Dissolved Mercury	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Molybdenum	1	2	ug/L	20141030.R13-2o2
Dissolved Nickel	1	1	ug/L	20141030.R13-2o2
Dissolved Niobium	1	<1	ug/L	20141030.R13-2o2
Dissolved Potassium	100	800	ug/L	20141030.R13-2o2
Dissolved Rubidium	1	1.1	ug/L	20141030.R13-2o2
Dissolved Scandium	1	<1	ug/L	20141030.R13-2o2
Dissolved Selenium	1	<1	ug/L	20141030.R13-2o2

Sample Name: JGW-2 **Date: 10/21/2014** **Matrix: Ground Water** **Lab #: 599051**

ICPMS Dis. Water FF				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Dissolved Silicon	600	<600	ug/L	20141030.R13-2o2
Dissolved Silver	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Sodium	100	2450	ug/L	20141030.R13-2o2
Dissolved Strontium	1	37.4	ug/L	20141030.R13-2o2
Dissolved Sulfur	800	4340	ug/L	20141030.R13-2o2
Dissolved Tellurium	1	<1	ug/L	20141030.R13-2o2
Dissolved Thallium	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Thorium	1	<1	ug/L	20141030.R13-2o2
Dissolved Tin	1	<1	ug/L	20141030.R13-2o2
Dissolved Titanium	1	<1	ug/L	20141030.R13-2o2
Dissolved Tungsten	1	22.4	ug/L	20141030.R13-2o2
Dissolved Uranium	1	<1	ug/L	20141030.R13-2o2
Dissolved Vanadium	1	<1	ug/L	20141030.R13-2o2
Dissolved Yttrium	1	<1	ug/L	20141030.R13-2o2
Dissolved Zinc	1	3.6	ug/L	20141030.R13-2o2
Dissolved Zirconium	1	<1	ug/L	20141030.R13-2o2

pHWater				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
pH	N/A	7.78	pH	20141030.R2D

TDS				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Total Dissolved Solids	30	100	mg/L	20141030.R27A

Sample Name: JGW-4 **Date: 10/22/2014** **Matrix: Ground Water** **Lab #: 599052**

Acidity				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Acidity	1	13	mg/L	20141030.R24A

Alka				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
M-Alkalinity (pH 4.5)	1	53.1	mg/L as CaCO3	20141030.R1B

Ammonia Water				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Ammonia (as N)	0.01	0.109	mg/L	20141029.R42.1B

Anions Water				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Chloride	0.2	0.26	mg/L	20141103.R5B
Nitrate (as N)	0.1	<0.1	mg/L	20141103.R5B
Nitrite (as N)	0.03	<0.03	mg/L	20141103.R5B
Sulphate	1	13.8	mg/L	20141103.R5B

Cond Water				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Conductivity	0.2	139	µS/cm	20141030.R12C

Sample Name: JGW-4 **Date: 10/22/2014** **Matrix: Ground Water** **Lab #: 599052**

Dissolved Hardness/ICP

Parameter	MDL	Result	Units	QAQCID
Dissolved Hardness (as CaCO3)	1	61.8	mg/L	20141104.R13.3A

Filtration Time

Parameter	MDL	Result	Units	QAQCID
Filtration Time	N/A	17.35	NA	20141029.R99.2A

ICPMS Dis. Water

Parameter	MDL	Result	Units	QAQCID
Dissolved Aluminum	1	31.9	ug/L	20141030.R13-2o2
Dissolved Aluminum (Dup)	1	30.9	ug/L	20141030.R13-2o2
Dissolved Antimony	0.5	<0.5	ug/L	20141030.R13-2o2
Dissolved Antimony (Dup)	0.5	<0.5	ug/L	20141030.R13-2o2
Dissolved Arsenic	1	<1	ug/L	20141030.R13-2o2
Dissolved Arsenic (Dup)	1	<1	ug/L	20141030.R13-2o2
Dissolved Barium	1	9.5	ug/L	20141030.R13-2o2
Dissolved Barium (Dup)	1	10	ug/L	20141030.R13-2o2
Dissolved Beryllium	0.5	<0.5	ug/L	20141030.R13-2o2
Dissolved Beryllium (Dup)	0.5	<0.5	ug/L	20141030.R13-2o2
Dissolved Bismuth	1	<1	ug/L	20141030.R13-2o2
Dissolved Bismuth (Dup)	1	<1	ug/L	20141030.R13-2o2
Dissolved Boron	2	<2	ug/L	20141030.R13-2o2
Dissolved Boron (Dup)	2	<2	ug/L	20141030.R13-2o2
Dissolved Cadmium	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Cadmium (Dup)	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Calcium	50	9590	ug/L	20141030.R13-2o2
Dissolved Calcium (Dup)	50	9330	ug/L	20141030.R13-2o2
Dissolved Cerium	1	<1	ug/L	20141030.R13-2o2
Dissolved Cerium (Dup)	1	<1	ug/L	20141030.R13-2o2
Dissolved Cesium	1	<1	ug/L	20141030.R13-2o2
Dissolved Cesium (Dup)	1	<1	ug/L	20141030.R13-2o2
Dissolved Chromium	0.8	<0.8	ug/L	20141030.R13-2o2
Dissolved Chromium (Dup)	0.8	<0.8	ug/L	20141030.R13-2o2
Dissolved Cobalt	0.1	0.64	ug/L	20141030.R13-2o2
Dissolved Cobalt (Dup)	0.1	0.6	ug/L	20141030.R13-2o2
Dissolved Copper	1	<1	ug/L	20141030.R13-2o2
Dissolved Copper (Dup)	1	<1	ug/L	20141030.R13-2o2
Dissolved Europium	1	<1	ug/L	20141030.R13-2o2
Dissolved Europium (Dup)	1	<1	ug/L	20141030.R13-2o2
Dissolved Gallium	1	<1	ug/L	20141030.R13-2o2
Dissolved Gallium (Dup)	1	<1	ug/L	20141030.R13-2o2
Dissolved Iron	20	647	ug/L	20141030.R13-2o2
Dissolved Iron (Dup)	20	621	ug/L	20141030.R13-2o2
Dissolved Lanthanum	1	<1	ug/L	20141030.R13-2o2
Dissolved Lanthanum (Dup)	1	<1	ug/L	20141030.R13-2o2
Dissolved Lead	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Lead (Dup)	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Lithium	5	<5	ug/L	20141030.R13-2o2

Sample Name: JGW-4 **Date: 10/22/2014** **Matrix: Ground Water** **Lab #: 599052**

ICPMS Dis. Water				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Dissolved Lithium (Dup)	5	<5	ug/L	20141030.R13-2o2
Dissolved Magnesium	4	9200	ug/L	20141030.R13-2o2
Dissolved Magnesium (Dup)	4	8790	ug/L	20141030.R13-2o2
Dissolved Manganese	10	1040	ug/L	20141030.R13-2o2
Dissolved Manganese (Dup)	10	1030	ug/L	20141030.R13-2o2
Dissolved Mercury	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Mercury (Dup)	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Molybdenum	1	1.9	ug/L	20141030.R13-2o2
Dissolved Molybdenum (Dup)	1	1.6	ug/L	20141030.R13-2o2
Dissolved Nickel	1	1.1	ug/L	20141030.R13-2o2
Dissolved Nickel (Dup)	1	1	ug/L	20141030.R13-2o2
Dissolved Niobium	1	<1	ug/L	20141030.R13-2o2
Dissolved Niobium (Dup)	1	<1	ug/L	20141030.R13-2o2
Dissolved Potassium	100	970	ug/L	20141030.R13-2o2
Dissolved Potassium (Dup)	100	950	ug/L	20141030.R13-2o2
Dissolved Rubidium	1	1.5	ug/L	20141030.R13-2o2
Dissolved Rubidium (Dup)	1	1.4	ug/L	20141030.R13-2o2
Dissolved Scandium	1	<1	ug/L	20141030.R13-2o2
Dissolved Scandium (Dup)	1	<1	ug/L	20141030.R13-2o2
Dissolved Selenium	1	<1	ug/L	20141030.R13-2o2
Dissolved Selenium (Dup)	1	<1	ug/L	20141030.R13-2o2
Dissolved Silicon	600	<600	ug/L	20141030.R13-2o2
Dissolved Silicon (Dup)	600	<600	ug/L	20141030.R13-2o2
Dissolved Silver	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Silver (Dup)	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Sodium	100	2450	ug/L	20141030.R13-2o2
Dissolved Sodium (Dup)	100	2440	ug/L	20141030.R13-2o2
Dissolved Strontium	1	64	ug/L	20141030.R13-2o2
Dissolved Strontium (Dup)	1	60.9	ug/L	20141030.R13-2o2
Dissolved Sulfur	800	6020	ug/L	20141030.R13-2o2
Dissolved Sulfur (Dup)	800	5440	ug/L	20141030.R13-2o2
Dissolved Tellurium	1	<1	ug/L	20141030.R13-2o2
Dissolved Tellurium (Dup)	1	<1	ug/L	20141030.R13-2o2
Dissolved Thallium	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Thallium (Dup)	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Thorium	1	<1	ug/L	20141030.R13-2o2
Dissolved Thorium (Dup)	1	<1	ug/L	20141030.R13-2o2
Dissolved Tin	1	<1	ug/L	20141030.R13-2o2
Dissolved Tin (Dup)	1	<1	ug/L	20141030.R13-2o2
Dissolved Titanium	1	<1	ug/L	20141030.R13-2o2
Dissolved Titanium (Dup)	1	<1	ug/L	20141030.R13-2o2
Dissolved Tungsten	1	22.4	ug/L	20141030.R13-2o2
Dissolved Tungsten (Dup)	1	20.7	ug/L	20141030.R13-2o2
Dissolved Uranium	1	<1	ug/L	20141030.R13-2o2
Dissolved Uranium (Dup)	1	<1	ug/L	20141030.R13-2o2
Dissolved Vanadium	1	<1	ug/L	20141030.R13-2o2

Sample Name: JGW-4 **Date: 10/22/2014** **Matrix: Ground Water** **Lab #: 599052**

ICPMS Dis. Water				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Dissolved Vanadium (Dup)	1	<1	ug/L	20141030.R13-2o2
Dissolved Yttrium	1	<1	ug/L	20141030.R13-2o2
Dissolved Yttrium (Dup)	1	<1	ug/L	20141030.R13-2o2
Dissolved Zinc	1	2.4	ug/L	20141030.R13-2o2
Dissolved Zinc (Dup)	1	2.2	ug/L	20141030.R13-2o2
Dissolved Zirconium	1	<1	ug/L	20141030.R13-2o2
Dissolved Zirconium (Dup)	1	<1	ug/L	20141030.R13-2o2

ICPMS Dis. Water FF				
Parameter	**MDL**	**Result**	**Units**	**QAQCID**
Dissolved Aluminum	1	31.9	ug/L	20141030.R13-2o2
Dissolved Antimony	0.5	<0.5	ug/L	20141030.R13-2o2
Dissolved Arsenic	1	<1	ug/L	20141030.R13-2o2
Dissolved Barium	1	9.5	ug/L	20141030.R13-2o2
Dissolved Beryllium	0.5	<0.5	ug/L	20141030.R13-2o2
Dissolved Bismuth	1	<1	ug/L	20141030.R13-2o2
Dissolved Boron	2	<2	ug/L	20141030.R13-2o2
Dissolved Cadmium	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Calcium	50	9590	ug/L	20141030.R13-2o2
Dissolved Cerium	1	<1	ug/L	20141030.R13-2o2
Dissolved Cesium	1	<1	ug/L	20141030.R13-2o2
Dissolved Chromium	1	<1	ug/L	20141030.R13-2o2
Dissolved Cobalt	0.1	0.64	ug/L	20141030.R13-2o2
Dissolved Copper	1	<1	ug/L	20141030.R13-2o2
Dissolved Europium	1	<1	ug/L	20141030.R13-2o2
Dissolved Gallium	1	<1	ug/L	20141030.R13-2o2
Dissolved Iron	20	647	ug/L	20141030.R13-2o2
Dissolved Lanthanum	1	<1	ug/L	20141030.R13-2o2
Dissolved Lead	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Lithium	5	<5	ug/L	20141030.R13-2o2
Dissolved Magnesium	4	9200	ug/L	20141030.R13-2o2
Dissolved Manganese	10	1040	ug/L	20141030.R13-2o2
Dissolved Mercury	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Molybdenum	1	1.9	ug/L	20141030.R13-2o2
Dissolved Nickel	1	1.1	ug/L	20141030.R13-2o2
Dissolved Niobium	1	<1	ug/L	20141030.R13-2o2
Dissolved Potassium	100	970	ug/L	20141030.R13-2o2
Dissolved Rubidium	1	1.5	ug/L	20141030.R13-2o2
Dissolved Scandium	1	<1	ug/L	20141030.R13-2o2
Dissolved Selenium	1	<1	ug/L	20141030.R13-2o2
Dissolved Silicon	600	<600	ug/L	20141030.R13-2o2
Dissolved Silver	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Sodium	100	2450	ug/L	20141030.R13-2o2
Dissolved Strontium	1	64	ug/L	20141030.R13-2o2
Dissolved Sulfur	800	6020	ug/L	20141030.R13-2o2
Dissolved Tellurium	1	<1	ug/L	20141030.R13-2o2

WESA - BluMetric Work Order: 226681

Sample Name: JGW-4 **Date: 10/22/2014** **Matrix: Ground Water** **Lab #: 599052**

ICPMS Dis. Water FF

Parameter	MDL	Result	Units	QAQCID
Dissolved Thallium	0.1	<0.1	ug/L	20141030.R13-2o2
Dissolved Thorium	1	<1	ug/L	20141030.R13-2o2
Dissolved Tin	1	<1	ug/L	20141030.R13-2o2
Dissolved Titanium	1	<1	ug/L	20141030.R13-2o2
Dissolved Tungsten	1	22.4	ug/L	20141030.R13-2o2
Dissolved Uranium	1	<1	ug/L	20141030.R13-2o2
Dissolved Vanadium	1	<1	ug/L	20141030.R13-2o2
Dissolved Yttrium	1	<1	ug/L	20141030.R13-2o2
Dissolved Zinc	1	2.4	ug/L	20141030.R13-2o2
Dissolved Zirconium	1	<1	ug/L	20141030.R13-2o2

pHWater

Parameter	MDL	Result	Units	QAQCID
pH	N/A	7.8	pH	20141030.R2D

TDS

Parameter	MDL	Result	Units	QAQCID
Total Dissolved Solids	30	130	mg/L	20141030.R27A

MDL Method detection limit or minimum reporting limit.
% Rec Surrogate compounds are added to the sample in some cases and the recovery is reported as a percent recovered.
QAQCID This is a unique reference to the quality control data set used to generate the reported value.
Data reported for organic analysis in soil samples are corrected for moisture content
Matrix If the matrix is a leachate, the sample was extracted according to regulation 558.
INT Interferences
TNTC Too numerous to count
ND Not detected
NDOGN No Data, Overgrown with Non-Target
NDOGT No Data, Overgrown with Target
NDOGHPC No Data, Overgrown HPC

Quality Control Data:

Acidity

% RPD						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Acidity	N/A	%	0	2.8	20	20141030.R24A

Lab Control Sample 105						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Acidity	1	mg/L	95	108	120	20141030.R24A

Method Blank						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Acidity	1	mg/L	<1	<1	5	20141030.R24A

Alka

% RPD						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
M-Alkalinity (pH 4.5)	N/A	%	0	6.5	20	20141030.R1B

Lab Control Sample 155						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
M-Alkalinity (pH 4.5)	N/A	%	85	93	115	20141030.R1B

Method Blank						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
M-Alkalinity (pH 4.5)	1	mg/L	<1	<1	5	20141030.R1B

Ammonia Water

%RPD						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Ammonia (as N)	N/A	%	0	N/A	20	20141029.R42.1B

Lab Control Sample 250						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Ammonia (as N)	0.01	mg/L	0.2	0.247	0.3	20141029.R42.1B

Lab Control Sample 500						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Ammonia (as N)	0.01	mg/L	0.4	0.472	0.6	20141029.R42.1B

Matrix Spike						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Ammonia (as N)	N/A	% Rec	75	88.7	125	20141029.R42.1B

Method Blank						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Ammonia (as N)	0.01	mg/L	<0.01	0.014	0.03	20141029.R42.1B

Anions Water

% RPD						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Chloride	N/A	%	0	N/A	20	20141103.R5A
Nitrate (as N)	N/A	%	0	N/A	20	20141103.R5A
Nitrite (as N)	N/A	%	0	N/A	20	20141103.R5A
Sulphate	N/A	%	0	1.3	20	20141103.R5A
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Chloride	N/A	%	0	0.1	20	20141103.R5B
Nitrate (as N)	N/A	%	0	6.5	20	20141103.R5B
Nitrite (as N)	N/A	%	0	N/A	20	20141103.R5B
Sulphate	N/A	%	0	0	20	20141103.R5B

Lab Control Sample 1						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Chloride	N/A	% Rec	80	84	115	20141103.R5A
Nitrate (as N)	N/A	% Rec	75	101	115	20141103.R5A
Nitrite (as N)	N/A	% Rec	80	92	115	20141103.R5A
Sulphate	N/A	% Rec	80	85	115	20141103.R5A
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Chloride	N/A	% Rec	80	85	115	20141103.R5B
Nitrate (as N)	N/A	% Rec	75	102	115	20141103.R5B
Nitrite (as N)	N/A	% Rec	80	92	115	20141103.R5B
Sulphate	N/A	% Rec	80	80	115	20141103.R5B

Lab Control Sample 2						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Chloride	N/A	% Rec	85	92	115	20141103.R5A
Nitrate (as N)	N/A	% Rec	85	100	115	20141103.R5A
Nitrite (as N)	N/A	% Rec	85	93	115	20141103.R5A
Sulphate	N/A	% Rec	78	95	115	20141103.R5A
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Chloride	N/A	% Rec	85	94	115	20141103.R5B
Nitrate (as N)	N/A	% Rec	85	101	115	20141103.R5B
Nitrite (as N)	N/A	% Rec	85	92	115	20141103.R5B
Sulphate	N/A	% Rec	78	96	115	20141103.R5B

MatrixSpike						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Chloride	N/A	% Rec	70	86.1	130	20141103.R5A
Nitrate (as N)	N/A	% Rec	70	101	130	20141103.R5A
Nitrite (as N)	N/A	% Rec	70	91.5	130	20141103.R5A
Sulphate	N/A	% Rec	70	100	130	20141103.R5A
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Chloride	N/A	% Rec	70	95.4	130	20141103.R5B
Nitrate (as N)	N/A	% Rec	70	103	130	20141103.R5B
Nitrite (as N)	N/A	% Rec	70	97.5	130	20141103.R5B
Sulphate	N/A	% Rec	70	92.3	130	20141103.R5B

Anions Water

Method Blank						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Chloride	0.2	mg/L	<0.2	<0.2	0.3	20141103.R5A
Nitrate (as N)	0.1	mg/L	<0.1	<0.1	0.2	20141103.R5A
Nitrite (as N)	0.03	mg/L	<0.03	<0.03	0.04	20141103.R5A
Sulphate	1	mg/L	<1	<1	1.1	20141103.R5A
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Chloride	0.2	mg/L	<0.2	<0.2	0.3	20141103.R5B
Nitrate (as N)	0.1	mg/L	<0.1	<0.1	0.2	20141103.R5B
Nitrite (as N)	0.03	mg/L	<0.03	<0.03	0.04	20141103.R5B
Sulphate	1	mg/L	<1	<1	1.1	20141103.R5B

Cond Water

%RPD						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Conductivity	N/A	%	0	1.3	10	20141030.R12C

Lab Control Sample 500						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Conductivity	1	µS/cm	450	491	550	20141030.R12C

Method Blank						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Conductivity	1	µS/cm	<1	<1	5	20141030.R12C

ICPMS Dis. Water

%RPD						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Dissolved Aluminum	N/A	%	0	3.2	20	20141030.R13-2o2
Dissolved Antimony	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Arsenic	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Barium	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Beryllium	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Bismuth	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Boron	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Cadmium	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Calcium	N/A	%	0	2.7	20	20141030.R13-2o2
Dissolved Cerium	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Cesium	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Chromium	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Cobalt	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Copper	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Europium	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Gallium	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Iron	N/A	%	0	4.1	20	20141030.R13-2o2
Dissolved Lanthanum	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Lead	N/A	%	0	N/A	20	20141030.R13-2o2

ICPMS Dis. Water

%RPD						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Dissolved Lithium	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Magnesium	N/A	%	0	4.6	20	20141030.R13-2o2
Dissolved Manganese	N/A	%	0	1	20	20141030.R13-2o2
Dissolved Mercury	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Molybdenum	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Nickel	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Niobium	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Potassium	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Rubidium	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Scandium	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Selenium	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Silicon	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Silver	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Sodium	N/A	%	0	0.4	20	20141030.R13-2o2
Dissolved Strontium	N/A	%	0	5	20	20141030.R13-2o2
Dissolved Sulfur	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Tellurium	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Thallium	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Thorium	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Tin	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Titanium	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Tungsten	N/A	%	0	7.9	20	20141030.R13-2o2
Dissolved Uranium	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Vanadium	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Yttrium	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Zinc	N/A	%	0	N/A	20	20141030.R13-2o2
Dissolved Zirconium	N/A	%	0	N/A	20	20141030.R13-2o2

EU-L-3						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Dissolved Aluminum	1	ug/L	47.8	73.1	77.8	20141030.R13-2o2
Dissolved Antimony	0.5	ug/L	12.8	20.4	24	20141030.R13-2o2
Dissolved Arsenic	1	ug/L	73.2	91.1	93.8	20141030.R13-2o2
Dissolved Barium	1	ug/L	103	136	145	20141030.R13-2o2
Dissolved Beryllium	0.5	ug/L	10.8	12.3	13.7	20141030.R13-2o2
Dissolved Cadmium	0.1	ug/L	18.6	23.8	27	20141030.R13-2o2
Dissolved Calcium	50	ug/L	1720	1740	2450	20141030.R13-2o2
Dissolved Chromium	1	ug/L	48.7	64.2	76.6	20141030.R13-2o2
Dissolved Cobalt	0.1	ug/L	76.2	85.5	88.8	20141030.R13-2o2
Dissolved Copper	1	ug/L	87.1	108	125	20141030.R13-2o2
Dissolved Iron	20	ug/L	50.4	64	70	20141030.R13-2o2
Dissolved Lead	1	ug/L	36.1	43	47.5	20141030.R13-2o2
Dissolved Magnesium	4	ug/L	753	1130	1150	20141030.R13-2o2
Dissolved Manganese	1	ug/L	107	127	138	20141030.R13-2o2
Dissolved Molybdenum	1	ug/L	32.7	38.8	46.7	20141030.R13-2o2
Dissolved Nickel	1	ug/L	73.1	84.6	93.8	20141030.R13-2o2

ICPMS Dis. Water

EU-L-3						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Dissolved Selenium	1	ug/L	13.7	26.2	42.2	20141030.R13-2o2
Dissolved Strontium	1	ug/L	102	163	177	20141030.R13-2o2
Dissolved Thallium	0.1	ug/L	72.3	97.2	98	20141030.R13-2o2
Dissolved Uranium	1	ug/L	89.7	109	119	20141030.R13-2o2
Dissolved Vanadium	1	ug/L	43.4	51.8	55.7	20141030.R13-2o2
Dissolved Zinc	1	ug/L	12.5	28.5	48.4	20141030.R13-2o2

Lab Control Sample						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Dissolved Aluminum	N/A	%	80	107	120	20141030.R13-2o2
Dissolved Arsenic	N/A	%	80	107	120	20141030.R13-2o2
Dissolved Barium	N/A	%	80	102	120	20141030.R13-2o2
Dissolved Beryllium	N/A	%	80	111	120	20141030.R13-2o2
Dissolved Cadmium	N/A	%	80	101	120	20141030.R13-2o2
Dissolved Calcium	N/A	%	80	89	120	20141030.R13-2o2
Dissolved Chromium	N/A	%	90	106	120	20141030.R13-2o2
Dissolved Cobalt	N/A	%	80	104	120	20141030.R13-2o2
Dissolved Copper	N/A	%	80	100	120	20141030.R13-2o2
Dissolved Iron	N/A	%	80	105	120	20141030.R13-2o2
Dissolved Lead	N/A	%	80	100	120	20141030.R13-2o2
Dissolved Magnesium	N/A	%	80	102	120	20141030.R13-2o2
Dissolved Manganese	N/A	%	80	103	120	20141030.R13-2o2
Dissolved Molybdenum	N/A	%	80	101	120	20141030.R13-2o2
Dissolved Nickel	N/A	%	80	102	120	20141030.R13-2o2
Dissolved Selenium	N/A	%	80	111	120	20141030.R13-2o2
Dissolved Sodium	N/A	%	80	98	120	20141030.R13-2o2
Dissolved Thallium	N/A	%	80	111	120	20141030.R13-2o2
Dissolved Vanadium	N/A	%	80	108	120	20141030.R13-2o2
Dissolved Zinc	N/A	%	80	98	120	20141030.R13-2o2

Matrix Spike						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Dissolved Aluminum	N/A	% Rec	70	108	130	20141030.R13-2o2
Dissolved Antimony	N/A	% Rec	70	103	130	20141030.R13-2o2
Dissolved Arsenic	N/A	% Rec	70	114	130	20141030.R13-2o2
Dissolved Barium	N/A	% Rec	70	120	130	20141030.R13-2o2
Dissolved Beryllium	N/A	% Rec	70	104	130	20141030.R13-2o2
Dissolved Cadmium	N/A	% Rec	70	103	130	20141030.R13-2o2
Dissolved Chromium	N/A	% Rec	70	106	130	20141030.R13-2o2
Dissolved Cobalt	N/A	% Rec	70	107	130	20141030.R13-2o2
Dissolved Copper	N/A	% Rec	70	106	130	20141030.R13-2o2
Dissolved Iron	N/A	% Rec	70	105	130	20141030.R13-2o2
Dissolved Lead	N/A	% Rec	70	104	130	20141030.R13-2o2
Dissolved Molybdenum	N/A	% Rec	70	100	130	20141030.R13-2o2
Dissolved Nickel	N/A	% Rec	70	105	130	20141030.R13-2o2
Dissolved Selenium	N/A	% Rec	70	106	130	20141030.R13-2o2
Dissolved Thallium	N/A	% Rec	70	105	130	20141030.R13-2o2

ICPMS Dis. Water

Matrix Spike						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Dissolved Vanadium	N/A	% Rec	70	105	130	20141030.R13-2o2
Dissolved Zinc	N/A	% Rec	70	109	130	20141030.R13-2o2

Method Blank						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Dissolved Aluminum	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Antimony	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Arsenic	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Barium	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Beryllium	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Bismuth	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Boron	2	ug/L	<2	<2	2	20141030.R13-2o2
Dissolved Cadmium	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Calcium	50	ug/L	<50	<50	50	20141030.R13-2o2
Dissolved Cerium	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Cesium	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Chromium	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Cobalt	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Copper	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Europium	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Gallium	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Iron	20	ug/L	<20	<20	20	20141030.R13-2o2
Dissolved Lanthanum	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Lead	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Lithium	5	ug/L	<5	<5	5	20141030.R13-2o2
Dissolved Magnesium	4	ug/L	<4	<4	4	20141030.R13-2o2
Dissolved Manganese	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Mercury	0.1	ug/L	<0.1	<0.1	0.1	20141030.R13-2o2
Dissolved Molybdenum	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Nickel	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Niobium	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Rubidium	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Scandium	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Selenium	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Silver	5	ug/L	<5	<5	5	20141030.R13-2o2
Dissolved Strontium	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Thallium	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Thorium	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Tin	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Titanium	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Tungsten	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Uranium	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Vanadium	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Yttrium	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Zinc	1	ug/L	<1	<1	1	20141030.R13-2o2
Dissolved Zirconium	1	ug/L	<1	<1	1	20141030.R13-2o2

pHWater

%RPD						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
pH	N/A	pH	0	0.09	0.3	20141030.R2D

Lab Control Sample 8						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
pH	N/A	pH	7.8	8.07	8.2	20141030.R2D

TDS

% RPD						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Total Dissolved Solids	N/A	%	0	0	20	20141030.R27A

Lab Control Sample						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Total Dissolved Solids	30	mg/L	180	180	220	20141030.R27A

Method Blank						
Parameter	**MDL**	**Units**	**LCL**	**Result**	**UCL**	**QAQCID**
Total Dissolved Solids	30	mg/L	<30	<30	50	20141030.R27A

UCL Upper Control Limit
LCL Lower Control Limit

APPENDIX D

Groundwater Modelling Report

APPENDIX D

JOYCE LAKE AND AREA DSO PROJECT HYDROGEOLOGICAL MODELLING

Submitted to:

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January 2015

S-B12738-00-00

Ref: SB12738 - Labec Century Iron - Hydrogeological and Geotechnical Study\Report\FINAL\Appendices\Appendix D - Groundwater Modelling Report

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D.1 INTRODUCTION

Labec Century Iron Ore Inc. (LCIO) retained WESA, a division of Blumetric Environmental Inc. to conduct hydrogeological studies of the Joyce Lake and Area Direct Shipping Ore (Joyce Lake DSO) Project. The Joyce Lake orebody is located in western Labrador on a peninsula that juts out into Attikamagen Lake. The deposit is bounded by Attikamagen Lake to the north, Iron Arm to the west, Timmins Bay to the east and Joyce Lake to the southeast (Figure D.1). The proposed open pit would be developed to a maximum depth of 150 m below ground surface and would be approximately 650 m long by 400 m wide, partly extending into Joyce Lake. Dewatering of the underlying aquifer is required to operate the pit, and Joyce Lake would have to be either completely drained, or bermed and partially drained, to access the ore body. A numerical groundwater model was constructed for this site. Results from the numerical modelling are used to estimate dewatering fluxes required to lower the water table in the vicinity of the pit, and estimate how many wells are required to accomplish this task. Simulations are also used to assess groundwater impacts in the vicinity of the pit. As a result of pit dewatering, the groundwater is lowered in surrounding areas potentially impacting existing ponds, streams and wetlands. The results of model simulations provide a preliminary assessment of dewatering requirements and potential impacts to groundwater and surface water on the peninsula.

D.2 CONCEPTUAL MODEL

The site hydrogeology is a function of the geologic regime. The geological structure underlying the site consists of a syncline that is dipping to the southeast. The "nose" of the fold is located approximately 250 m northwest of the proposed pit location and forms a topographic high point. The Sokoman Formation is the principal target of the Joyce Lake DSO Project. The Sokoman Formation forms a continuous stratigraphic sequence of rock units varying in thickness as a result of folding and faulting. Based on current nomenclature and results from recent exploration drilling, the LCIO Joyce Lake Project recognises four iron-bearing subunits within the Sokoman Formation depending on the concentration of chert and iron-rich beds. In order from youngest to oldest they consist of the Upper Massive Hematite (UMH), the Red Chert (RC), the Lower Massive Hematite (LMH), the Lower Red Chert (LRC) and the Ruth Shale (RS).

Within the study area, the Sokoman Formation is overlain by the Menihek Shale (MSS) Formation and underlain by the Wishart and Dolly Formations. All these geologic formations are described in greater detail in Section 5.1 of the main report.

Hydrogeologic properties, and specifically the hydraulic conductivity, are assigned to each geologic layer for the purpose of groundwater modelling. The uppermost geologic layer within the study area is the MSS Formation. No field permeability data were collected for this formation; this unit was assumed to be an aquitard. The underlying Sokoman Formation is divided into four distinct geologic units within the boundaries of the detailed geologic model (extent of detailed three-dimensional geologic model is shown in Figure D.2). Permeability values obtained from packer testing were observed in the order of 10^{-6} m/s in the LMH and RC units. Although packer test results were not obtained in the UMH unit, core log reports reflect a unit that is highly fractured and therefore the UMH unit is considered as part of the upper permeable fractured zone along with LMH and RC units. The LRC unit showed variable results depending on its location with lower permeability at depth (approximately 10^{-8} m/s) and higher permeability upgradient along the flanks of the syncline (approximately 10^{-6} to 10^{-7} m/s). For the purpose of groundwater modelling, four separate units were defined for the Sokoman Formation based on the permeability results, these layers are: UMH, RC, a layer combining LRC and LMH, and RS.

Underlying the Sokomon Formation is the Wishart Sandstone and the Dolly Formation. The Wishart was found to have lower permeability in the vicinity of the RS contact (approximately 10^{-8} m/s) and in the lower portion displays moderate to high permeability in the range of 10^{-6} to 10^{-7} m/s. The upper and lower Wishart Formations are represented separately in the numerical model. Underlying the Wishart is the Dolly Formation. No field data were collected for the Dolly Formation, the hydraulic properties were determined through model calibration.

D.3 NUMERICAL MODEL

A numerical groundwater flow model was developed to represent the prevailing hydrogeologic conditions within the study area to simulate dewatering requirements for the mine. The model is constructed based on both data collected during previous studies (Stassinu Stantec, 2013a, 2013b and 2013c) and the recent field investigation (Section 5 of main report). The model domain comprises the bedrock geology and incorporates surface-water features (ponds, streams and wetlands) as shown in Figure D.2.

The numerical model assumes a continuum approach to represent the aggregate bedrock hydrogeologic conditions, which are represented as an equivalent porous medium (EPM). The use of this approach is assumed appropriate given the scale of observation is much greater than the scale of the individual fractures and the limited availability of detailed information of the fractures. The basic premise behind the EPM method is that the physical processes controlling groundwater flow within a network of fractures can be adequately represented as a porous medium at the scale of interest (i.e., tens to hundreds of metres).

Based on the local hydrogeological setting and study objectives, the MODFLOW-SURFACT version 3 code (HydroGeoLogic, 1996) was selected to simulate groundwater flow in the study area. MODFLOW-SURFACT is capable of simulating three-dimensional groundwater flow in saturated porous media. It is a widely used and well tested code that can effectively simulate both steady-state and transient groundwater flow of various degrees of complexity. Golden Software's Surfer, several Fortran programs, and Groundwater Vistas (GV) were used as the pre and post processing tools.

D.3.1. Numerical Model Assumptions:

The basic assumptions of the MODFLOW-SURFACT code are as follows:

1. Flow is laminar and Darcy's law is valid
2. Density of fluid is constant
3. Medium of flow is saturated
4. Principal direction of horizontal hydraulic conductivity or transmissivity is parallel to the model axes

Flow of groundwater is generally laminar unless large-aperture fractures or void spaces are present. The total area covered by this study is small enough to consider water has a constant density. Water level and transmissivity data of the immediate vicinity of the study area suggest that the groundwater flow patterns are mainly controlled by large-scale heterogeneities in transmissivity and not by the horizontal anisotropy in the aquifers.

D.3.2 Model Domain

The numerical model domain is divided into individual cells, each having specific physical characteristics representative of that location. The construction of the numerical model is described below.

The extent of the groundwater flow model domain is shown in Figure D2; the domain is 4,500 m wide and 10,000 m long, covering all the northern extent of the peninsula. As a result of dewatering the pit, groundwater elevations are expected to decrease at distances of kilometres from the pit and therefore the model domain is larger than the pit area. The traces of surface-water features are shown on Figure D2.

The cells of the model are uniformly spaced 50 by 50 m within each horizontal layer (Figure D.3a), and each layer is 20 m thick except the deepest layer, which is 70 m thick (Figure D.3b).

There are a total of 13 layers in the model ranging in elevation from 560 masl to 250 masl. The elevation of each layer is shown in Table D.1.

Table D.1: Layer Elevations

Model Layer	Top Elevation (masl)	Bottom Elevation (masl)
1	560	540
2	540	520
3	520	500
4	500	480
5	480	460
6	460	440
7	440	420
8	420	400
9	400	380
10	380	360
11	360	340
12	340	320
13	320	250

Each model layer represents a horizontal slice. Though the layers of the model are horizontal there is much topographic relief within the model domain (Figure D.4) and geologic formations are non-horizontal. As described in greater detail within the main report (Section 5.1) the geologic formations form a syncline, therefore any horizontal slice through the model domain will intersect various geologic units, and at higher elevations, will also include empty cells. A Fortran processor was used to identify the model layer in which the ground surface occurs for each model grid column, and to identify model grid cells above the ground surface as being inactive.

D.3.3 Model Boundary Conditions

The numerical model is constrained by assigning boundary conditions at specific locations in the model. These are described below.

Ideally, boundary conditions coincide with natural boundaries wherever possible. The most commonly used hydrogeologic boundaries are constant-head or general-head boundary. A constant-head boundary reflects a situation where the water table or potentiometric surface is pre-specified in time. The model will calculate the flux across this boundary assuming the pre-specified hydraulic head remains constant in time at that location. To simulate lakes, ponds or streams, a river boundary condition may be used. The river boundary condition is represented by cells that can be either discharging (water exiting the model domain and entering the surface water regime) or recharging (water entering the model domain). The river boundary condition presumes that there is always some flow in the cell, (i.e., that the hydraulic head in the river is always higher than the river bottom). The flux into or out of a river boundary cell is proportional to the specified conductance of the surface-water body sediments. This conductance is calculated using $C=LWK_{bed}/b$, where L and W are the length and width of the surface-water body in the model grid cell, K_{bed} is the hydraulic conductivity of sediments at the base of the surface-water body, and b is the thickness of these sediments. Another type of boundary condition is characterised as a drain. Where a cell is defined as a drain, the flux can only be a net discharge from the groundwater regime. When the water level in the model is below the elevation of the drain cell, there is no interaction between the drain cell and the model domain, and consequently the flux is 0 and the grid cell is dry.

In this model, the large water body of Attikamagen Lake, surrounding the peninsula on all sides, is assumed to have constant hydraulic head with an elevation of 470 masl. For the purpose of calibrating the model Joyce Lake was assumed to have a constant head of 505 masl and was assigned using the river package in MODFLOW-Surfact. Similarly, all ponds and streams were assigned river package boundary conditions. Wetlands were assigned drain conditions. The locations of streams were taken from the topographic map and refined based on information in Stassinu Stantec (2013c). Depending on the surrounding groundwater conditions, which are calculated by the model, the river cells have a positive or negative flux. Within the model domain there are a number of wetlands, which are characterised as drain cells.

The model boundary conditions are shown in figures D.5a to D.5e corresponding to the top five layers of the model (corresponding to elevations 460 to 560 masl). Figure D.5a shows the upper most layer in the numerical model. Most of the area is grey indicating that this area is inactive because the grid cells are above the ground surface. The features shown on the figures, pit limit, lakes, ponds, wetlands, are all traces of these features projected onto this layer, they do not necessarily intersect this particular layer. There are no boundary conditions assigned to cells in layer 1 (Figure D.5a). Figure D.5b identifies three ponds (i.e., Ponds A, B, and C) as boundary conditions in model layer 2. Figure D.5c shows the third layer of the model. Here boundary conditions are assigned at Joyce Lake, Pond E1, and a portion of a stream that intersects this model layer. Layer 4 (Figure D.5d) of the model has again more active cells and more boundary conditions assigned, boundary conditions are assigned to wetlands, ponds and streams. Layer 5, shown in Figure D.5e, is completely active within the model domain. The most significant boundary condition in this layer is Attikamagen Lake with a constant head of 470 masl. The constant-head boundary cells shown on Figure D.5e for model layer 5, are repeated through the remainder of the model layers 6 through 13 (not shown).

D.3.4 MODEL PHYSICAL PROPERTIES

The physical properties are assigned to each cell in the model. The following sections describe infiltration and hydraulic conductivity.

D.3.4.1 Infiltration

Net groundwater recharge from infiltration is one of the input parameters required for the numerical simulations, and represents the amount of water entering the top of the model. Richards (2007) discusses the difficulties associated with the reliable estimation of infiltration, and argues that because of the non-linear recharge response with time, "recharge cannot be described by a simple direct relationship to precipitation, since not all precipitation produces recharge". Rather, recharge is a component of the water budget that is typically derived from an array of measured and derived parameters.

Recharge is a small fraction of precipitation; a large portion of precipitation is diverted to evapotranspiration and surface-water runoff.

An estimated infiltration rate of 270 mm/yr (Stassinu Stantec, 2013c) was used for the purpose of this model; infiltration was assumed to be uniform across the entire model domain.

D.3.5 HYDRAULIC CONDUCTIVITY

Each cell is assigned to a geologic formation with its respective hydrogeologic properties. The geologic units must therefore be integrated into the model. The most detailed geologic data comes from the three-dimensional geologic model provided by LCIO. This three-dimensional geologic model encompasses only a very small portion of the numerical model domain (Figure D.2). To extrapolate beyond the boundaries of the detailed three-dimensional geologic model, the geometry of the geologic units (strike and dip) were extrapolated to match the surficial trace of the geologic formations as defined on the surface bedrock geology map (after Stassinu Stantec, 2013a).

There are eight distinct geologic layers represented in the numerical model. Starting at the bottom, these are the Dolly, Wishart (divided into two units, deep and shallow, representing different hydraulic conductivity regimes), the Sokoman (divided into four types: RS, LRC/LMH, RC and UMH) and the MSS. To simplify the geologic model outside the region of the detailed three-dimensional geologic model, the younger sub-units of the Sokoman formation are merged south of Joyce Lake to represent one aggregated formation, the Sokoman aquifer, this is denoted as “South LRC/LMH/RC/UMH”.

Hydraulic conductivity (K) zones are shown for all 13 model layers in Figures D.6a to D.6m ranging from highest elevation to the lowest. As seen in the previous figures (D.5a to D.5d), the first four layers, represented by Figure D.6a to D.6e, do not have active cells within the entire domain as a result of the topography of the site. The legend for the figures show the different types of geologic units represented in the model, and the successive figures show what units are intersected by each horizontal layer in the model. Beyond the extent of the detailed geologic model the Sokoman formation is represented by the “yellow” unit identified as “South LRC/LMH/RC/UMH”.

With depth, in the vicinity of the proposed pit, the layers illustrate the gradual disappearance of the UMH and RC until at elevation 320 masl all that remains at the bottom of the syncline is the LRC/LMH (Figures D.6e to D.6k).

The K zones represented by the numerical model are shown in cross section view in Figures D.7a and D.7b, first east-west and then north-south. Figure D.7a clearly illustrates the syncline at the location of the proposed pit. Figure D.7b clearly illustrates where the Sokoman Formation is more clearly defined (near the pit), and beyond this area the younger sub-units of the Sokoman Formation have been consolidated into one unit illustrated by the unit “South LRC/LMH/RC/UMH”.

D.4 CALIBRATION

Calibration is the process of adjusting the model parameters within reasonable limits to obtain a good match between the simulated model results and field observations.

To evaluate the model calibration, the simulated groundwater heads were compared to field measurements of the groundwater elevations representing current conditions (pre-pit development). Groundwater elevation data were measured in exploration drillholes during a synoptic monitoring event (Stassinu Stantec, 2013a) in October 2012. The locations of exploration drillholes with groundwater elevation measurements for this October 2012 event are shown on Figure D.8. The distribution of calibration points is concentrated in the vicinity of the proposed pit, there are no other groundwater monitoring points within the model domain. Selected anomalous observation points were removed from the data set. The mid-point of the saturated elevation of each hole was used to define the layer for which the calibration target applied. To quantify the degree of accuracy, we calculate the following statistics:

- Residual at each target well (R) - defined as the difference between the observed and simulated groundwater elevations. A positive residual indicates that the simulated groundwater elevation is less than observed, and a negative residual indicates that the simulated groundwater elevation is higher than observed.
- Absolute Residual at each target well (AR) – absolute value of the residual;
- Mean Residual (MR) – average of all target well residuals;
- Mean Absolute Residual (MAR) – average of all target well absolute residuals;
- Root Mean Square (RMS), an overall measure of the differences between values predicted using a model and the observed values. The RMS is calculated to be the square root of the sum of squared residual at each target well divided by the number of target wells. The RMS% is typically represented as a ratio of the RMS to the range in observed groundwater elevations.

During model calibration, other aspects were monitored to assess the "reasonableness" of the simulations. For example, it was assumed all wetlands were discharge features. The simulated elevation of groundwater in the vicinity of wetlands therefore needed to slightly exceed the ground elevation at these wetland locations. Another measure used to evaluate the model calibration was the simulated groundwater discharge to Joyce Lake. Based on the catchment drainage area of 1.82 km^2 (Stassinu Stantec, 2013a) and an infiltration rate of 270 mm/yr, the groundwater discharge rate to Joyce Lake is estimated to be approximately 1350 m^3/d. Simulated discharge rates were compared to this value during model calibration to validate that the calibration was reasonable.

Calibration was conducted by iterative trial and error, selected parameters are adjusted systematically within their reasonable limit until the overall solution improves (smaller RMS and appropriate water balance). The calibration target for RMS was 10%. To achieve this, the primary parameters adjusted in the model domain were hydraulic conductivity of the various geologic units. Given the potential range in lakebed sediment permeability for Joyce Lake, two calibration cases were simulated: Case 1 used a relatively low K_{bed} of 0.01 m/d (10^{-7} m/s), representative of silty lakebed sediments; and Case 2 used a relatively high K_{bed} of 10 m/d (10^{-4} m/s), representative of sandy lakebed sediments. Alternative sets of geologic unit hydraulic conductivity values were calibrated for each of these two cases.

Table D.2 presents the observed and calibrated hydraulic conductivity values for various geologic units. The observed values represent the geometric mean of hydraulic conductivity values determined by WESA based on packer tests conducted during the 2014 field season (Section 5.2 of main report).

Table D.2: Observed and Calibrated Hydraulic Conductivity Values

	Observed (Packer Tests)		Calibrated Model K (m/d)	
Unit	K (m/s)	K (m/d)	Case 1: Joyce Lake K_{bed} = 0.01 m/d	Case 2: Joyce Lake K_{bed} = 10 m/d
MSS	n/a	n/a	0.003	0.003
URC/UMH	2.E-06	0.2	0.4	0.4
LRC/LMH	4.E-07	0.03	0.03	0.03
Ruth	2.E-06	0.2	0.2	0.2
South LRC/LMH/URC/UMH	n/a	n/a	0.1	0.1
upper-Wishart	3.E-08	0.003	0.003	0.006
lower-Wishart	1.E-06	0.09	0.09	0.09
Dolly	n/a	n/a	0.0485	0.0453

The simulated groundwater elevations are compared to observed measurements in Table D.3 for the two respective calibration cases. The calibration target residuals are shown in plan view in Figures D.9a and D.9b (Cases 1 and 2, respectively). The symbols in these two figures represent the magnitude of the residual at specific target wells; the larger the dot the greater the residual. The colour of the dot represents whether the simulated result is lower (blue) or greater than (red) the observed groundwater elevation. These two figures shows that within the calibration set, there is a fairly even spatial distribution of values that were over- and under-estimated (different colour dots), which demonstrates that the calibration is not skewed spatially.

Table D.3: Calibration Residuals

					Case 1		Case 2	
Order	Name	Location	Layer	Observed Groundwater Elevation (masl)	Groundwater Elevation (masl)	Residual (m)	Groundwater Elevation (masl)	Residual (m)
1	12-98	Joy-12-98	4	505.40	506.42	-1.02	506.20	-0.80
2	12-96	Joy-12-96	5	505.80	506.34	-0.54	506.13	-0.33
3	12-95	Joy-12-95	6	506.20	506.25	-0.05	506.07	0.13
4	11-09	Joy-11-09	6	506.40	506.40	0.00	506.24	0.16
5	11-10	Joy-11-10	6	506.70	507.15	-0.45	507.17	-0.47
6	11-32	Joy-11-32	7	507.40	507.19	0.21	506.90	0.50
7	12-78	Joy-12-78	3	507.50	508.05	-0.55	507.64	-0.14
8	12-110A	Joy-12-110A	7	507.70	507.33	0.37	506.99	0.71
9	11-06	Joy-11-06	6	507.80	507.68	0.12	507.24	0.56
10	11-30	Joy-11-30	7	507.80	507.25	0.55	506.77	1.03
11	12-74	Joy-12-74	5	508.00	507.79	0.21	507.89	0.11
12	11-39	Joy-11-39	7	508.10	507.90	0.20	507.62	0.48
13	12-103	Joy-12-103	6	508.34	508.65	-0.31	508.44	-0.10
14	12-U1	Joy-12-U1	7	508.40	508.30	0.10	508.01	0.39
15	12-100	Joy-12-100	6	508.50	507.86	0.64	507.62	0.88
16	12-88	Joy-12-88	4	508.51	509.47	-0.96	509.44	-0.93
17	12-90	Joy-12-90	4	508.60	509.17	-0.57	509.14	-0.54
18	12-72	Joy-12-72	5	508.90	508.53	0.37	508.87	0.03
19	12-86	Joy-12-86	4	509.00	510.28	-1.28	510.24	-1.24
20	12-64	Joy-12-64	4	509.30	510.06	-0.76	510.13	-0.83
21	11-17	Joy-11-17	5	509.40	508.28	1.12	507.90	1.50
22	12-57	Joy-12-57	6	509.80	508.71	1.09	508.76	1.04
23	12-63	Joy-12-63	5	510.20	509.63	0.57	509.93	0.27
24	12-87	Joy-12-87	3	510.34	510.41	-0.07	510.58	-0.24
25	12-114	Joy-12-114	5	510.50	509.91	0.59	510.10	0.40
26	12-58	Joy-12-58	4	510.60	510.48	0.12	510.71	-0.11
27	12-62	Joy-12-62	4	510.60	510.57	0.03	511.24	-0.64
28	12-59	Joy-12-59	4	510.90	510.73	0.17	511.04	-0.14
29	12-102	Joy-12-102	4	511.87	511.47	0.40	511.38	0.49

The water balance inputs and outputs (water entering and leaving the modeling domain) were monitored for each model run to ensure that the overall mass balance error remained within approximately 1% or better, an indication that model convergence was achieved within acceptable accuracy (Anderson and Woessner, 1992).

Figures D.10a and D.10b present scatter plots showing the goodness of fit between the observed and simulated heads for Cases 1 and 2 respectively. The 45° line represents the perfect match between observed and simulated heads. The dots show the calibrated results compared to the perfect match. The randomness of the distribution of the points around the line indicates that the simulated heads are not over or under predicted across the study area.

For Case 1 (lower permeability lakebed sediments in Joyce Lake), the Mean Residual for the calibrated model was 0.01 m and the Mean Absolute Residual was 0.46 m. The resulting scaled Root Mean Square was 9.0% meeting the target requirement of 10%. The simulated Joyce Lake discharge was 1,370 m^3/day which is similar to the estimated discharge rate of 1,350 m^3/day. For Case 2 (i.e., higher permeability lakebed sediments), the Mean Residual was 0.08 m, the Mean Absolute Residual was 0.52 m, and the scaled Root Mean Square was 9.9% which also meets the target of 10%. The simulated discharge to Joyce Lake for the Case 2 calibration was 1,530 m^3/d which is approximately 30% higher than the estimated value. While the calibration statistics are slightly better for Case 1 (lower lakebed permeability), the Case 2 calibration with higher lakebed permeability is still a reasonable match. Either case is possible based on the results of the model calibration.

As part of the calibration exercise, hydraulic conductivity values were varied and some simulations included values similar to those attained in the field by Stassinu Stantec (2013a) with an average of 10^{-5} m/s (Stassinu Stantec, 2013a); these hydraulic conductivity values were approximately ten times greater than the values attained by WESA in 2014 (Section 5.2 of main report). Model calibration was not achieved using these higher values of hydraulic conductivity (i.e., RMS was higher than 10% of the observed range in groundwater elevations); Stassinu Stantec (2013a) had indicated that these relatively high values were approximate due to the nature of the field tests.

D.4.1 Calibration Sensitivity Analysis

A sensitivity analysis was conducted to evaluate the sensitivity of model calibration statistics to adjustments in various input parameters, including:

- Vertical hydraulic conductivity of all geologic units was defined to be 10 times lower than the horizontal hydraulic conductivity. (During model calibration it was assumed that hydraulic conductivity was isotropic, which means that hydraulic conductivity is uniform in all horizontal and vertical directions.)

- Hydraulic conductivity of various geologic units (multiplied and divided by a factor of 3);
- Infiltration rate adjustments (multiplied and divided by a factor of 2);
- Joyce Lake K_{bed} (multiplied and divided by a factor of 3);
- K_{bed} of all streams (multiplied and divided by a factor of 3); and
- Conductance of all drains used to represent wetlands (multiplied and divided by a factor of 3).

The Case 1 calibrated model (i.e., lower permeability in Joyce Lake sediments) was used to perform this sensitivity analysis. Table D.4 presents the adjustments that were made relative to the base case, and the resulting calibration statistics for each scenario (i.e., Mean Residual, Mean Absolute Residual, and Root Mean Square). Table D.5 shows that the model calibration is most sensitive to adjustments in the Dolly Formation hydraulic conductivity and the infiltration rate. The model calibration is least sensitive to adjustments in the MSS Formation hydraulic conductivity, and the conductance values used to represent streams and wetlands. Table D.4 indicates that using a larger hydraulic conductivity for the shallow portion of the Wishart Formation resulted in a slight improvement to the calibration statistics, although this change has negligible influence on model dewatering predictions.

Table D.4: Model Calibration Sensitivity Analysis (Case A)

Run ID	Parameter Adjusted	Multiplication Factor	Mean Residual, MR (m)	Mean Absolute Residual, MAR (m)	Root Mean Square, RMS%
Base case	n/a	n/a	0.01	0.46	9.0%
SA-01	Kz = Kx/10 (all units)	Kz x 0.1	-1.69	1.76	34.2%
SA-02a	Dolly Formation K	K x 3	6.93	6.93	118.0%
SA-02b		K / 3	-5.94	5.94	103.0%
SA-03a	Wishart (shallow) K	K x 3	0	0.46	8.7%
SA-03b		K / 3	-0.12	0.6	11.7%
SA-04a	Wishart (deeper) K	K x 3	1.47	1.54	26.9%
SA-04b		K / 3	0.83	0.97	17.9%
SA-05a	Sokoman Formation K (all sub-units)	K x 3	1.56	1.63	28.7%
SA-05b		K / 3	-2.59	2.59	43.8%
SA-06a	MSS Formation K	K x 3	0.05	0.47	9.2%
SA-06b		K / 3	-0.02	0.46	9.0%

Table D.4: Model Calibration Sensitivity Analysis (Case A) (Cont'd)

Run ID	Parameter Adjusted	Multiplication Factor	Mean Residual, MR (m)	Mean Absolute Residual, MAR (m)	Root Mean Square, RMS%
SA-07a	Infiltration rate	I x 2	6.4	0.46	109.5%
SA-07b		I / 2	3.82	3.82	65.3%
SA-08a	Joyce Lake sediment K	K_{bed} x 3	0.3	0.58	10.5%
SA-08b		K_{bed} x 3	-0.85	0.87	15.7%
SA-09a	Streambed K	K_{bed} x 3	0.02	0.47	9.0%
SA-09b		K_{bed} x 3	0.02	0.47	9.0%
SA-10a	Wetland conductance	C x 3	0.01	0.46	9.0%
SA-10b		C / 3	0.01	0.46	9.0%

D.4.2 Calibrated Model Water Balance Assessment

A water balance assessment was conducted for both Case 1 and Case 2 calibrated models, to estimate the pre-mine net discharge rate for various surface-water bodies in the vicinity of the proposed pit area. Groundwater Vistas was used to calculate the water balance for these two cases. Figure D.11 illustrates the extent of various water balance zones used to estimate groundwater discharge/recharge rates for various surface-water bodies, as shown by the zones with different colours in Figure D.11. A sub-domain water balance was conducted using Groundwater Vistas and the output files from the MODFLOW-SURFACT simulations, for each of the coloured zones shown on Figure D.11.

Table D.5 presents the simulated net discharge rates for various lakes, ponds, streams and wetlands for each of these two model cases. A positive net discharge rate indicates that the model simulates groundwater discharge to the surface-water body, and a negative value indicates that the model simulates a net recharge from the surface-water body to groundwater. The baseline discharge rates are compared to simulated discharge rates corresponding to various dewatering scenarios, to facilitate an evaluation of the potential influence that dewatering may have on these surface-water bodies (refer to Section D.5, below).

Table D.5: Net Discharge Rates for Various Lakes, Ponds, Streams and Wetlands

	Net Discharge (m^3/day)	
Description	Case 1	Case 2
Joyce Lake	1,374	1,533
Pond A	-509	-499
Pond B	-224	-301
Pond C	-209	-237
Pond D	301	283
Pond E	861	870
Pond E1 & Stream 4	87	104
Pond F	287	273
Ponds G,H,I,J & Stream 2	2,099	2,037
Stream 1	1,287	1,270
Stream 3	-184	-189
Wetlands 1	235	234
Wetlands 2	43	48
Wetlands 3	442	445
Wetlands 4	427	423
Wetlands 6	17	17

D.5 SIMULATED PREDICTIONS

Operation of the open pit mine will require dewatering to ensure that the water table is maintained below the bottom of the pit and more than 25 m from the pit walls. The calibrated groundwater model was used to evaluate various dewatering configurations. The objectives of these model simulations include the following:

- Facilitate an assessment of the minimum number of wells and total pumping rates required during various phases of mine operation; and
- Evaluate the influence of mine dewatering operations on recharge/discharge rates for nearby surface-water bodies including Joyce Lake, ponds, streams and wetlands.

Four phases of dewatering were considered: Phase I involves dewatering below a pit bottom elevation of 480 masl; Phases II, III and IV involved pit bottom elevations of 460, 420 and 380 masl, respectively. The final bottom elevation of the pit will be approximately 380 masl.

As shown on Figure D.1, the proposed open pit extends into the north portion of Joyce Lake. Thus two options were considered for future dewatering. The first option involved complete dewatering of Joyce Lake, and the second option involved partial dewatering of Joyce Lake with construction of a berm situated approximately 100 to 200 m from the limits of the open pit. As discussed in Section D.4, the permeability of sediments at the bottom of Joyce Lake has not been assessed in the field. Thus, the second option included the following two sets of simulations:

- Scenario 1 - silty sediments in Joyce Lake with a hydraulic conductivity of 0.01 m/d (1.2×10^{-7} m/s); and
- Scenario 2 - sandy sediments in Joyce Lake with a hydraulic conductivity of 10 m/d (1.2×10^{-4} m/s).

Given the proximity of Pond A to the proposed open pit, it was assumed that this pond would be dewatered for all three options/scenarios.

The groundwater model was used to determine the minimum number of wells required to maintain the water table below the bottom of the pit for each of the four mining phases, for each of the options and scenarios discussed above. In each of these simulations, dewatering wells were simulated using constant-head boundary conditions within individual grid cells at proposed dewatering well locations. The constant-head values were specified at these proposed well grid cells to ensure that the water table around the pit would be sufficiently low for each phase of mining.

A water balance assessment was then conducted for each simulation to estimate the total pumping rate required to maintain the required heads at the dewatering well grid cells. Given the heterogeneous geology and hydraulic conductivity distribution, the use of constant-head cells at dewatering well locations was a more efficient approach than manually adjusting well-specific pumping rates for each simulated option/scenario and phase of mine dewatering.

Section D.5.1 presents the simulated minimum number of dewatering wells and associated pumping rates for each of the dewatering configuration simulations. Section D.5.2 presents the results of a water balance that indicates the change to recharge/discharge rates for nearby surface-water bodies associated with these dewatering configurations.

D.5.1 Simulated Number of Wells and Pumping Rates

Table D.6a presents the simulated numbers of wells and total pumping rates for each of the four mine dewatering phases associated with each of the three options/scenarios. The dewatering wells were simulated to be completed down to an elevation of 250 masl, which is a depth of between 240 and 290 m. The actual depth to be used for dewatering wells should be verified during future field tests.

Table D.6a: Summary of Simulated Pumping Rates for Mine Dewatering

Option	Scenario	Description	Phase	Pit Bottom Elevation (masl)	Simulated No. of Dewatering Wells	Total Pumping Rate (m^3/d)
1	n/a	Joyce Lake completely dewatered	I	480	7	2,642
			II	460	7	3,330
			III	420	7	4,866
			IV	380	7	5,714
2	1	Joyce Lake partially dewatered (silty sediments at bottom of lake)	I	480	7	2,868
			II	460	7	3,721
			III	420	7	5,552
			IV	380	9	6,764
2	2	Joyce Lake partially dewatered (sandy sediments at bottom of lake)	I	480	8	3,524
			II	460	8	4,623
			III	420	10	7,133
			IV	380	11	7,821

As shown in this table, the groundwater model suggests that at least seven to eleven dewatering wells are necessary. For practical reasons, it may be necessary to install more wells than the numbers that were simulated using the groundwater model, for reasons that may include the following:

- As back-up, in the event that pump failure or regular maintenance requires the shutdown of one or more dewatering wells for a period of time;
- The groundwater model simulated constant heads over 50 m x 50 m grid cells – the actual water table elevation outside the annulus of an individual well (with a diameter of only 0.15 to 0.3 m) will be lower than was simulated over the entire grid cell;
- The groundwater model does not consider well skin effects, which will further limit the available drawdown of individual wells; and/or
- Some wells may be installed at locations where the well yield is less than what was simulated due to local variations in hydraulic conductivity.

It is recommended that future field tests and a refined groundwater model be developed to optimise the number of dewatering wells needed for mine dewatering operations.

Table D.6a shows that the pumping rates for each of the three options/scenarios progressively increase with each phase of mining, corresponding to a deepening of the open pit with each phase. The maximum total pumping rates are associated with Phase IV (bottom elevation of 380 masl) and were simulated to be:

- Option 1 (base case - complete dewatering of Joyce Lake): 5,714 m^3/d;
- Option 2, Scenario 1 (partial dewatering of Joyce Lake, silty sediments): 6,764 m^3/d;
- Option 2, Scenario 2 (partial dewatering of Joyce Lake, sandy sediments): 7,821 m^3/d

As shown in Table D.6a, the Phase IV total pumping rates were simulated to be 2.2 to 2.3 times higher than the Phase I dewatering rates for all three options/scenarios. The highest pumping rates were simulated to occur for the scenario where Joyce Lake is only partially dewatered and lakebed sediments are sandy with a relatively high hydraulic conductivity. The higher pumping rates occur for this scenario because of enhanced recharge from Joyce Lake to the underlying water table during dewatering. The magnitude of recharge from Joyce Lake is discussed in Section D.5.2, below.

Table D.6b presents simulated individual dewatering well pumping rates for all four phases of the various dewatering options/scenarios that were modeled. As shown in Table D.6b, individual well pumping rates were simulated to have a large range for each simulation. For example, for Phase I of the base case dewatering configuration (i.e., Joyce Lake completely dewatered), the seven dewatering wells were simulated to have extraction rates ranging from 221 to 922 m^3/d (41 to 169 USgpm). This disparity in pumping rates at individual dewatering wells is caused by large differences in permeability in the formations through which each well was simulated to be completed. For comparison, the Phase IV simulation for this option resulted in a narrower relative range in pumping rates, from 619 to 1,003 m^3/d (114 to 184 USgpm). The deeper pit phases incorporated thinner saturated zones because of the corresponding increase in drawdown around the pit, resulting in less heterogeneity with the higher dewatering phases.

Table D.6b: Dewatering Well Pumping Rates (m³/d)

	Joyce Lake completely dewatered				Joyce Lake partially dewatered, silty lakebed sediments				Joyce Lake partially dewatered, sandy lakebed sediments			
Well ID	Phase I	Phase II	Phase III	Phase IV	Phase I	Phase II	Phase III	Phase IV	Phase I	Phase II	Phase III	Phase IV
DEW-1	327	451	705	886	338	474	755	942	327	453	778	896
DEW-2	221	297	496	619	228	311	531	649	218	297	560	627
DEW-3	258	372	697	880	269	399	777	948	263	387	807	906
DEW-4	257	344	608	822	277	375	648	585	274	389	728	853
DEW-5	922	1,075	1,055	771	1,073	1,327	1,441	701	946	1,203	574	534
DEW-6	362	416	703	1,003	378	439	746	1,015	862	1,101	818	639
DEW-7	294	375	604	733	305	397	655	794	341	414	894	1,084
DEW-8	n/a	n/a	n/a	n/a	n/a	n/a	n/a	594	293	378	701	756
DEW-9	n/a	n/a	n/a	n/a	n/a	n/a	n/a	536	n/a	n/a	668	686
DEW-10	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	605	433
DEW-11	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	407
Total:	2,642	3,330	4,866	5,714	2,868	3,721	5,552	6,764	3,524	4,623	7.131	7,821
Minimum:	221	297	496	619	228	311	531	536	218	297	560	407
Maximum:	922	1,075	1,055	1,003	1,073	1,327	1,441	1,015	946	1,203	894	1,084
Average:	377	476	695	816	410	532	793	752	441	578	713	711
Number of wells:	7	7	7	7	7	7	7	9	8	8	10	11

Table D.6b indicates that the highest individual dewatering well pumping rates were simulated to be up to 1,441 m^3/d (264 USgpm). Additional field work is required to confirm the maximum yield that may be anticipated for dewatering wells at the site. If dewatering wells to be installed in the field in future have a substantially lower capacity for pumping than was simulated in the groundwater model, then the final number of dewatering wells may be more than was simulated with the model.

Figures D.12 through D.15 present the simulated groundwater elevation contours for Phases I through IV, respectively, for the first option involving the complete dewatering of Joyce Lake. Seven dewatering wells were simulated at the outer pit limit for all four phases of this option as shown on Figures D.12 through D.15. Figure D.16 presents the simulated drawdown relative to pre-mine groundwater elevations for Phase IV of this option. Figure D.16 indicates that the highest drawdown occurs directly below the pit limit, and the drawdown due to mine dewatering decreases substantially with distance from the pit. Drawdowns are modeled to range from less than 0.1 m up to about 5 m at Timmins Bay northeast of the proposed mine and at Attikamagen Lake to the northwest. The drawdown at Iron Arm to the southwest is modeled to be less than 1 m. The influence of lower water levels on recharge/discharge rates to nearby surface-water bodies is discussed in Section D.5.2, below.

Figure D.17a shows simulated groundwater elevation contours for the base case simulation (i.e., Joyce Lake completely dewatered), corresponding to model layer 9 in the Phase IV dewatering simulation. This figure also shows the individual dewatering well simulated pumping rates for the Phase IV simulation. The location of two cross-section lines (C-C' is an east-west section line, and D-D' is a north-south section line) are also shown on Figure D.17a. These cross-section lines are situated between dewatering wells, where the water table is highest in the vicinity of the dewatering wells.

Cross-section C-C' is shown on Figure F.17b, and illustrates the proposed pit walls (black solid line), simulated water table elevation (solid blue line), and the geologic unit hydraulic conductivity zones intersected by the section line. This cross-section figure demonstrates that the water table was simulated to be successfully lowered below the pit floor for Phase IV, and that the water table is well below the pit walls in both the east and west directions. The north-south cross-section D-D' is shown on Figure D.17c. This figure illustrates that the water table is well below the pit on the north side, but is closer to the pit wall on the south side where dewatering was simulated to be the most challenging. The LRC/LMH K zone (shown in lighter green on Figure D.17c) on the south side of the pit has a hydraulic conductivity value that is lower than the Dolly Formation that is present on the north side of the pit. The groundwater model simulations indicate that dewatering this lower permeability zone on the south side of the pit, will be more challenging than dewatering the more permeable Dolly Formation north of the pit because the drawdown cone is steepest on the south side of the pit.

Figures D.18 and D.19 present the simulated groundwater elevation and drawdown contours for Phase IV of Scenario 1 in the second option (partial dewatering of Joyce Lake, silty lakebed sediments). Seven wells were simulated for the first three phases of this scenario, and nine wells were simulated for Phase IV given the additional challenge associated with dewatering when Joyce Lake is only partially dewatered.

Figures D.20 and D.21 present the simulated groundwater elevation and drawdown contours for Phase IV of Scenario 2 in the second option (partial dewatering of Joyce Lake, sandy lakebed sediments). As shown on Table D.6a, eight dewatering wells were simulated for Phases I and II, with ten wells required for Phase III and eleven wells required for Phase IV. As discussed above, the actual number of wells required for dewatering may be more than the simulated number of wells in the groundwater model due to complex field conditions that are not represented in the model.

Figures D.16, D.19 and D.21, which show the drawdown of groundwater (the difference in groundwater elevation between current conditions and final pit development), illustrate that the maximum drawdown is similar for all three options/scenarios (contours 160 to 170 m), which suggests that the influence of each of these scenarios outside of Joyce Lake are relatively similar.

D. 5.2. Water Balance Simulations

Table D.7a presents the simulated net discharge rates for various surface-water bodies near the proposed open pit area, including Joyce Lake, ponds, streams and wetlands. The pre-mine discharge rates are shown based on the calibrated model or "current conditions" (Case 1 with silty lakebed sediments in Joyce Lake). Positive values of discharge rates indicate that groundwater discharges into the surface-water body, and negative values of discharge rates indicate that the surface-water body is causing a net recharge to groundwater. The simulated net discharge rates for Phases I through IV of option 1 (i.e., Joyce Lake is completely dewatered) are also shown in Table D.7a, as well as the change in these discharge rates relative to the pre-mine rates shown in Table D.7a.

Table D.7a: Option 1 - Influence of Mine Dewatering on Recharge/Discharge at Various Surface-Water Features

			Flow Difference Relative to Pre-Mine				Net Groundwater Discharge (m³/d)				
Description	HSU ID	B.C.	Phase I	Phase II	Phase III	Phase IV	Pre-Dewatering	Phase I	Phase II	Phase III	Phase IV
Attikamagen Lake†	1, 8, 12	CH	-8%	-11%	-17%	-21%	15,484	14,198	13,774	12,786	12,218
Joyce Lake	2	RIV	n/a	n/a	n/a	n/a	1,533	0	0	0	0
Lake E	7	RIV	4%	1%	-6%	-9%	870	905	876	820	795
Pond A	3	RIV	n/a	n/a	n/a	n/a	-499	0	0	0	0
Pond B	4	RIV	8%	14%	26%	31%	-301	-325	-344	-379	-394
Pond C	5	RIV	4%	8%	15%	18%	-237	-248	-257	-274	-280
Pond D	6	RIV	-6%	-16%	-35%	-42%	283	265	237	185	164
Pond E1 & Stream 4	15	RIV	8%	4%	-4%	-7%	104	113	108	100	96
Pond F	9	RIV	2%	2%	2%	2%	273	278	278	278	278
Ponds G,H,I,J & Stream 2	8	RIV	4%	4%	3%	3%	2,037	2,120	2,115	2,107	2,104
Stream 1	12	RIV	-17%	-23%	-39%	-49%	1,270	1,058	972	769	648
Stream 3	16	RIV	29%	38%	55%	62%	-189	-244	-261	-292	-306
Wetland W-1	13	DRN	-7%	-11%	-19%	-24%	234	217	209	190	178
Wetland W-2	14	DRN	-15%	-20%	-33%	-40%	48	41	39	33	29
Wetland W-3	12	DRN	-11%	-17%	-29%	-36%	445	396	371	316	286
Wetland W-4	11	DRN	-8%	-10%	-14%	-16%	423	392	382	363	354
Wetland W-5	7	DRN	-18%	-22%	-30%	-34%	17	14	13	12	11
Wetland W-6	8	DRN	-9%	-13%	-20%	-22%	511	463	444	410	396

Note: negative discharge implies that surface-water body is a net recharge source to groundwater.
† Attikamagen Lake includes discharge to Timmins Bay, main body of Attikamagen Lake and Iron Arm.

Tables D.7b and D.7c present similar relative discharge rate changes for Option 2 (partial dewatering of Joyce Lake) for both Scenarios 1 and 2 (silty and sandy lakebed sediments), respectively. These two tables indicate that Scenario 1 (silty lakebed sediments) was simulated to result in enhanced recharge from the remaining portion of Joyce Lake, ranging from 366 to 1,550 m^3/d for Phases 1 through IV, respectively, and Scenario 2 (sandy sediments) results in enhanced recharge up to 2,897 m^3/d for Phase IV. The influence on other nearby surface-water features were simulated to be relatively similar to the simulated influence for Option 1 (complete dewatering of Joyce Lake).

These influences and potential mitigative measures are discussed further in Section 6.2 of the main report.

Table D.7b: Option 2a - Influence of Mine Dewatering on Recharge/Discharge at Various Surface-Water Features

			Flow Difference Relative to Pre-Mine				Net Groundwater Discharge (m^3/d)				
Description	HSU ID	B.C.	Phase I	Phase II	Phase III	Phase IV	Pre-Dewatering	Phase I	Phase II	Phase III	Phase IV
Attikamagen Lake†	1, 8, 12	CH	-8%	-10%	-17%	-20%	15,375	14,147	13,761	12,811	12,122
Joyce Lake	2	RIV	n/a	n/a	n/a	n/a	1,374	-366	-679	-1,188	-1,550
Lake E	7	RIV	-3%	-4%	-7%	-8%	861	836	826	804	845
Pond A	3	RIV	n/a	n/a	n/a	n/a	-509	0	0	0	0
Pond B	4	RIV	5%	6%	10%	12%	-224	-234	-238	-247	-261
Pond C	5	RIV	2%	3%	5%	6%	-209	-214	-216	-220	-227
Pond D	6	RIV	-5%	-7%	-12%	-15%	301	285	279	264	256
Pond E1 & Stream 4	15	RIV	-5%	-7%	-12%	-14%	87	82	81	77	86
Pond F	9	RIV	0%	0%	0%	0%	287	287	287	287	293
Ponds G,H,I,J & Stream 2	8	RIV	0%	0%	0%	0%	2,099	2,095	2,094	2,090	2,177
Stream 1	12	RIV	-17%	-23%	-39%	-49%	1,287	1,067	985	782	652
Stream 3	16	RIV	7%	9%	16%	19%	-184	-196	-201	-212	-259
Wetland W-1	13	DRN	-10%	-14%	-22%	-27%	235	211	203	183	175
Wetland W-2	14	DRN	-17%	-23%	-38%	-47%	43	35	33	26	23
Wetland W-3	12	DRN	-12%	-16%	-27%	-34%	442	390	370	322	296
Wetland W-4	11	DRN	-3%	-5%	-7%	-9%	427	414	408	396	376
Wetland W-5	7	DRN	-4%	-5%	-9%	-11%	17	16	16	15	13
Wetland W-6	8	DRN	-2%	-3%	-5%	-6%	575	562	557	544	505

Note: negative discharge implies that surface-water body is a net recharge source to groundwater.
† Attikamagen Lake includes discharge to Timmins Bay, main body of Attikamagen Lake and Iron Arm.

Table D.7c: Option 2b - Influence of Mine Dewatering on Recharge/Discharge at Various Surface Water Features

			Flow Difference Relative to Pre-Mine				Net Groundwater Discharge (m^3/d)				
Description	HSU ID	B.C.	Phase I	Phase II	Phase III	Phase IV	Pre-Dewatering	Phase I	Phase II	Phase III	Phase IV
Attikamagen Lake†	1, 8, 12	CH	-8%	-10%	-17%	-19%	15,484	14,261	13,910	12,849	12,538
Joyce Lake	2	RIV	n/a	n/a	n/a	n/a	1,533	-973	-1,582	-2,640	-2,897
Lake E	7	RIV	5%	4%	1%	0%	870	913	903	880	873
Pond A	3	RIV	n/a	n/a	n/a	n/a	-499	0	0	0	0
Pond B	4	RIV	6%	7%	10%	11%	-301	-319	-322	-331	-334
Pond C	5	RIV	4%	4%	5%	6%	-237	-246	-247	-251	-252
Pond D	6	RIV	-4%	-6%	-9%	-10%	283	271	267	258	255
Pond E1 & Stream 4	15	RIV	9%	8%	4%	3%	104	114	112	109	107
Pond F	9	RIV	2%	2%	2%	2%	273	278	278	278	278
Ponds G,H,I,J & Stream 2	8	RIV	4%	4%	4%	4%	2,037	2,121	2,120	2,117	2,116
Stream 1	12	RIV	-16%	-22%	-40%	-46%	1,270	1,063	986	758	687
Stream 3	16	RIV	27%	29%	33%	34%	-189	-240	-243	-252	-254
Wetland W-1	13	DRN	-7%	-11%	-21%	-24%	234	217	209	186	179
Wetland W-2	14	DRN	-15%	-20%	-36%	-40%	48	41	39	31	29
Wetland W-3	12	DRN	-10%	-14%	-25%	-29%	445	400	382	332	317
Wetland W-4	11	DRN	-7%	-8%	-11%	-12%	423	394	389	377	373
Wetland W-5	7	DRN	-17%	-18%	-20%	-21%	17	14	14	13	13
Wetland W-6	8	DRN	-9%	-9%	-11%	-11%	511	467	464	456	454

Note: negative discharge implies that surface-water body is a net recharge source to groundwater.
† Attikamagen Lake includes discharge to Timmins Bay, main body of Attikamagen Lake and Iron Arm.

D.6 SUMMARY

A three-dimensional groundwater flow model was constructed based on available geologic, hydrogeologic and hydrologic data. The purpose of this model was to facilitate an evaluation of dewatering system configurations needed for operation of the proposed open pit mine, and to evaluate potential influence on recharge/discharge rate for nearby surface-water bodies during future dewatering operations.

This model was successfully calibrated by matching the observed groundwater elevations and flow directions around Joyce Lake, matching the estimated groundwater discharge rate to Joyce Lake, and by simulating flow to all wetlands represented in the groundwater model. Two model scenarios were calibrated and shown to be reasonable possibilities: Case 1 incorporated a silty sediment base for Joyce Lake, and Case 2 incorporated a sandy sediment base. The actual sediment conditions in Joyce Lake will be verified in a future field investigation.

The calibrated models were used to evaluate the minimum number of dewatering wells and total pumping rates needed to lower the water table during four phases of mine operation. The pit area extends into the north portion of Joyce Lake. Two options were considered for dewatering operations: Option 1 (the base case) involved complete dewatering of Joyce Lake, and Option 2 involved partial dewatering of Joyce Lake with a berm installed approximately 100 to 200 m from the southern edge of the pit area. Two scenarios were simulated for this second option – one with a silty sediment base in Joyce Lake, and the other with a sandy sediment base.

Results of the simulated dewatering configurations suggest that at least seven to eleven dewatering wells may be required. Due to various factors that were not represented in the groundwater model, it is anticipated that the actual number of dewatering wells needed may be higher than the minimum number of wells simulated with the groundwater model (refer to Section 6.1 in the main report for further discussion.) The total pumping rate for Phase IV (i.e., final phase) of dewatering was simulated to be up to 7,821 m^3/d (1,435 USgpm). Additional field work and model refinement is needed to verify the number and depth of dewatering wells, and the estimated total pumping rates for each phase of mine operation.

D.7 REFERENCES

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Richards, P.A., 2007. *The Importance of Accurate Hydrogeological Conceptualization – Are we Correct?*, CGS/IAH Joint Conference Proceedings, Ottawa, ON, Oct. 2007, pp. 123-130.

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Stassinu Stantec Limited Partnership (2013b). *Direct Shipping Iron Ore Project, Site-Wide Water Balance Analysis Joyce Lake*, File No. 12180649.

Stassinu Stantec Limited Partnership (2013c). *Draft Direct Shipping Iron Ore Project, Surface Water Baseline Study* , File No. 12180649.

LIST OF FIGURES

LIST OF FIGURES

(Continued)

LEGEND

- Topology Contours (10m)
- Perimeter of Pit Bottom - Phase I (480masl)
- Perimeter of Pit Bottom - Phase II (460masl)
- Perimeter of Pit Bottom - Phase III (420masl)
- Perimeter of Pit Bottom - Phase IV (380masl)
- Perimeter of Pit at Surface
- Streams
- Waterbodies
- Wetlands

Stockpiles

- Waste Dump
- Overburden Stockpile
- Low Grade Stockpile Area

REFERENCES

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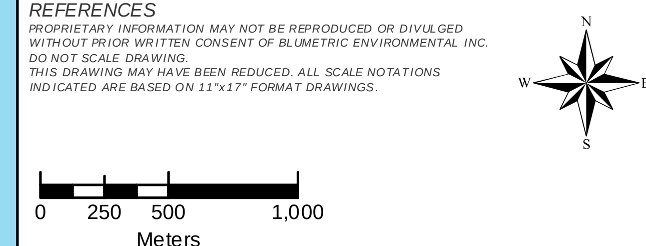


CLIENT

Labec Century Iron Ore Inc.

PROJECT

Joyce Lake and Area DSO Project Hydrogeological Study

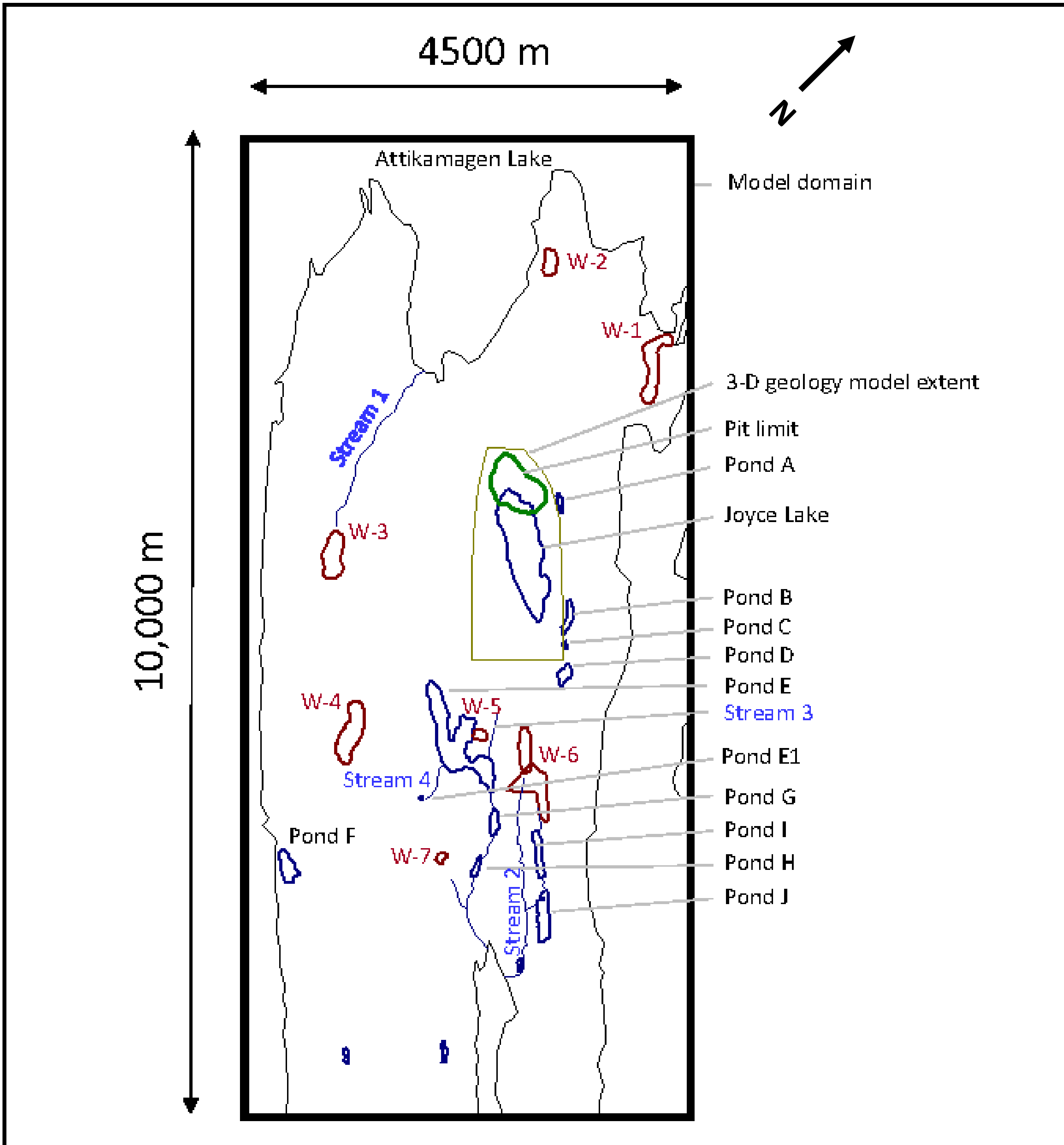
TITLE

Site Location – Joyce Lake Hydrogeological Study

BluMetric Environmental Inc.

3108 Carp Rd PO Box 430
Ottawa, Ontario K0A 1L0
TEL: (613) 839-3053
FAX: (613) 839-5376
Email: info@blumetric.ca
Web: http://www.blumetric.ca

PROJECT #	DATE		
S-B12738-05	November 28, 2014		
DRAWN	VERIFIED	FIG NO.	REV
IB	BOC	D.1	0



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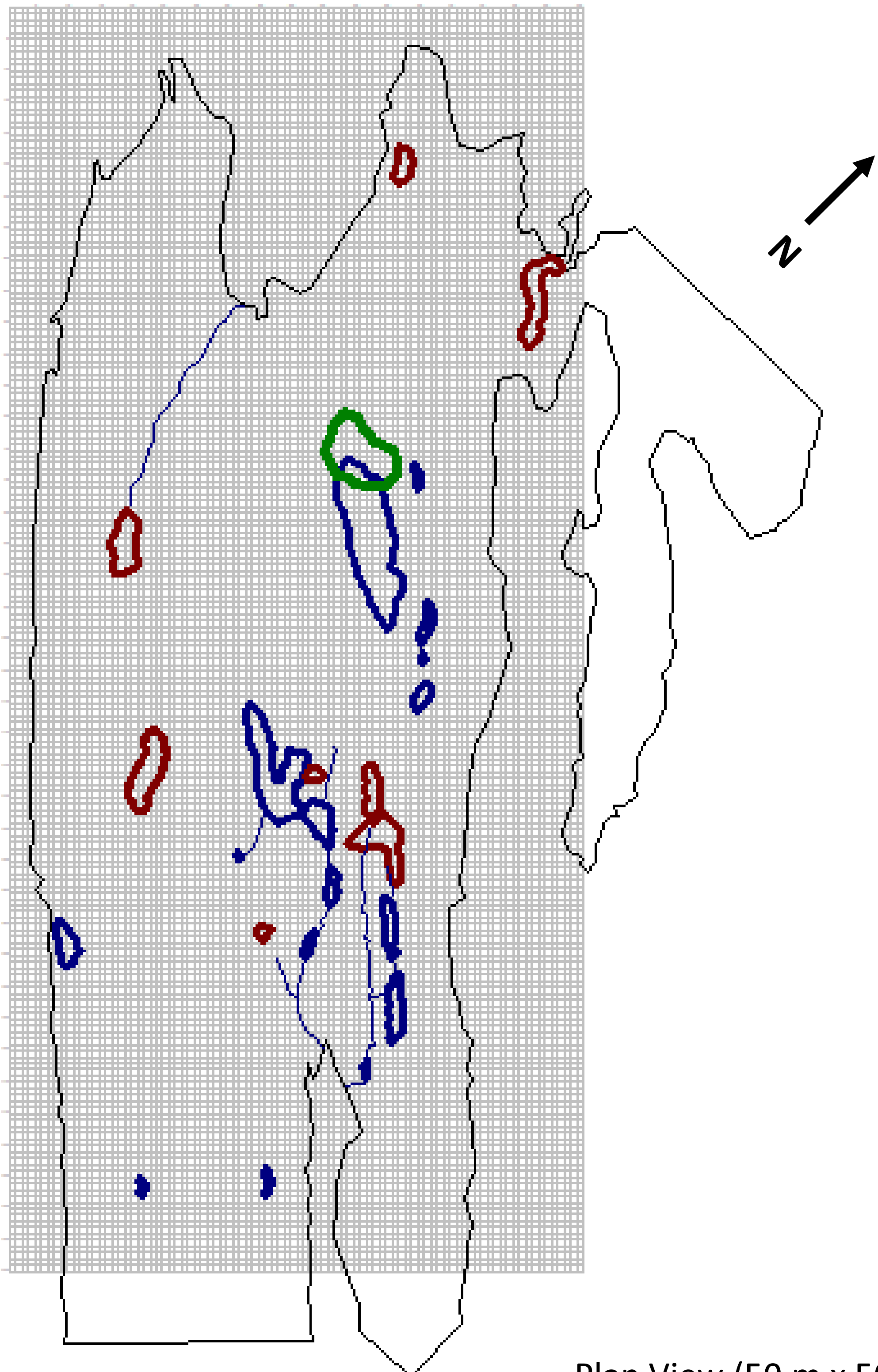
Model Domain Extent	LABEC CENTURY IRON ORE INC. 拉贝克世纪铁矿公司 / WESA a BluMetric company
Project No. S-B12738-00-00	
Created By: GC	28-Nov-14
Checked By: RTS	Figure D.2

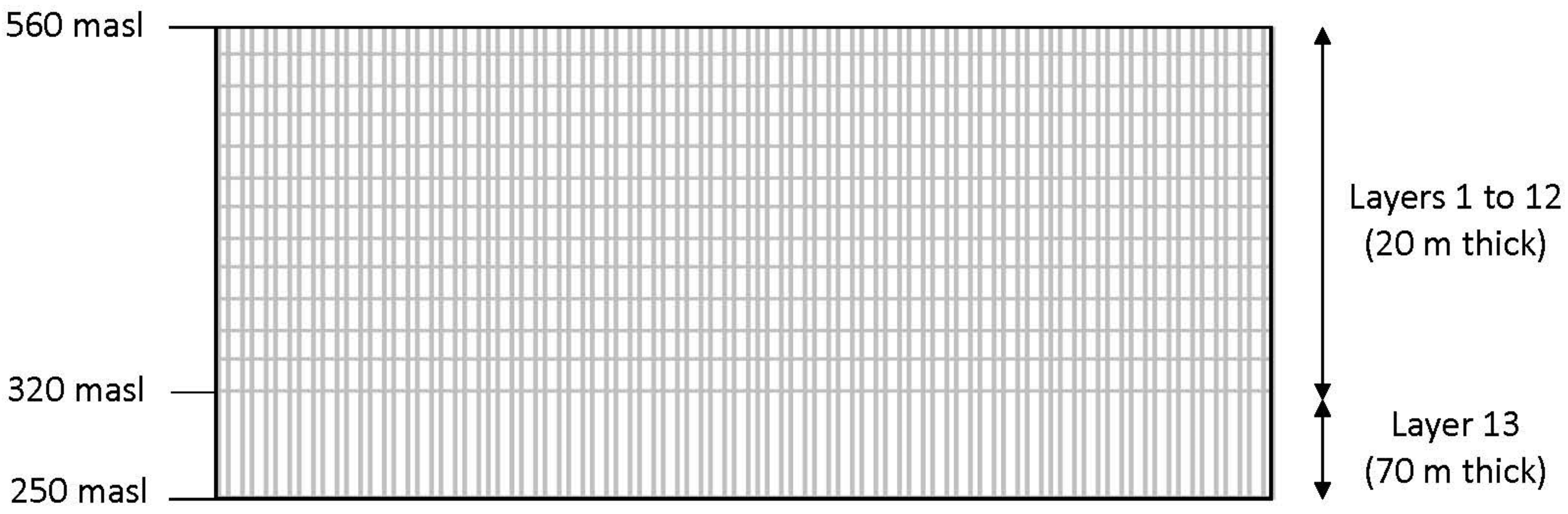


Plan View (50 m x 50 m spacing)

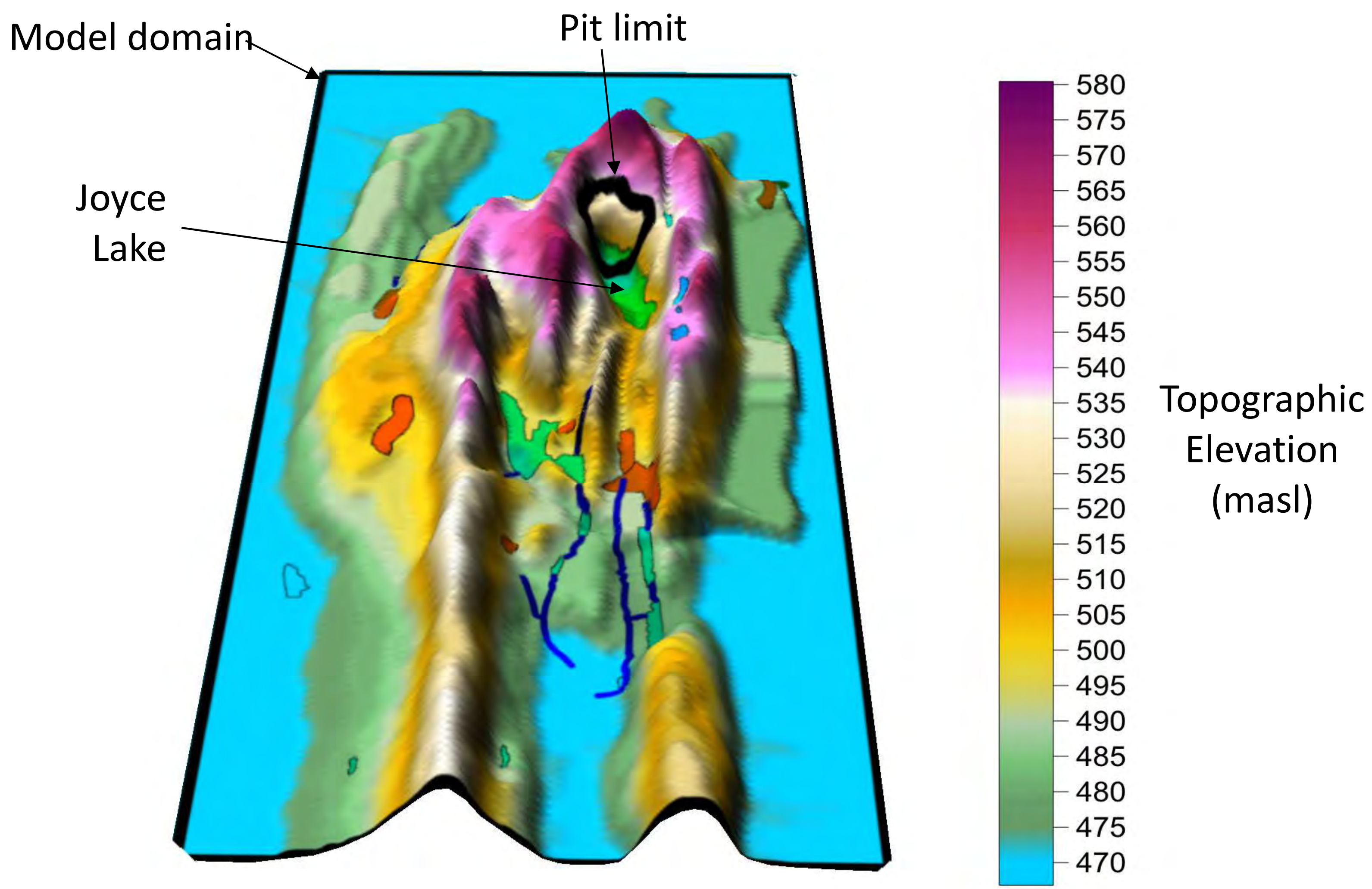
Legend

- Pit limit
- Lake or pond
- Stream
- Wetland

HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES JOYCE LAKE AND AREA DSO PROJECT	
Model Grid Discretization (Plan View)	LABEC CENTURY IRON ORE INC. 拉贝克世纪铁矿公司 / WESA a BluMetric company
Project No. S-B12738-00-00	
Created By: GC	27-Nov-14
Checked By: RTS	Figure D.3a



LABEC CENTURY IRON ORE INC. 拉贝克世纪铁矿公司 / WESA a BluMetric company	Model Grid Discretization (East-West Cross-Section)	HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES JOYCE LAKE AND AREA DSO PROJECT
	Project No. S-B12738-00-00	
	Created By: GC	27-Nov-14
	Checked By: RTS	Figure D.3b



LABEC CENTURY IRON ORE INC. 拉贝克世纪铁矿公司 / WESA a BluMetric company	Topographic Elevations	HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES JOYCE LAKE AND AREA DSO PROJECT
	Project No. S-B12738-00-00	
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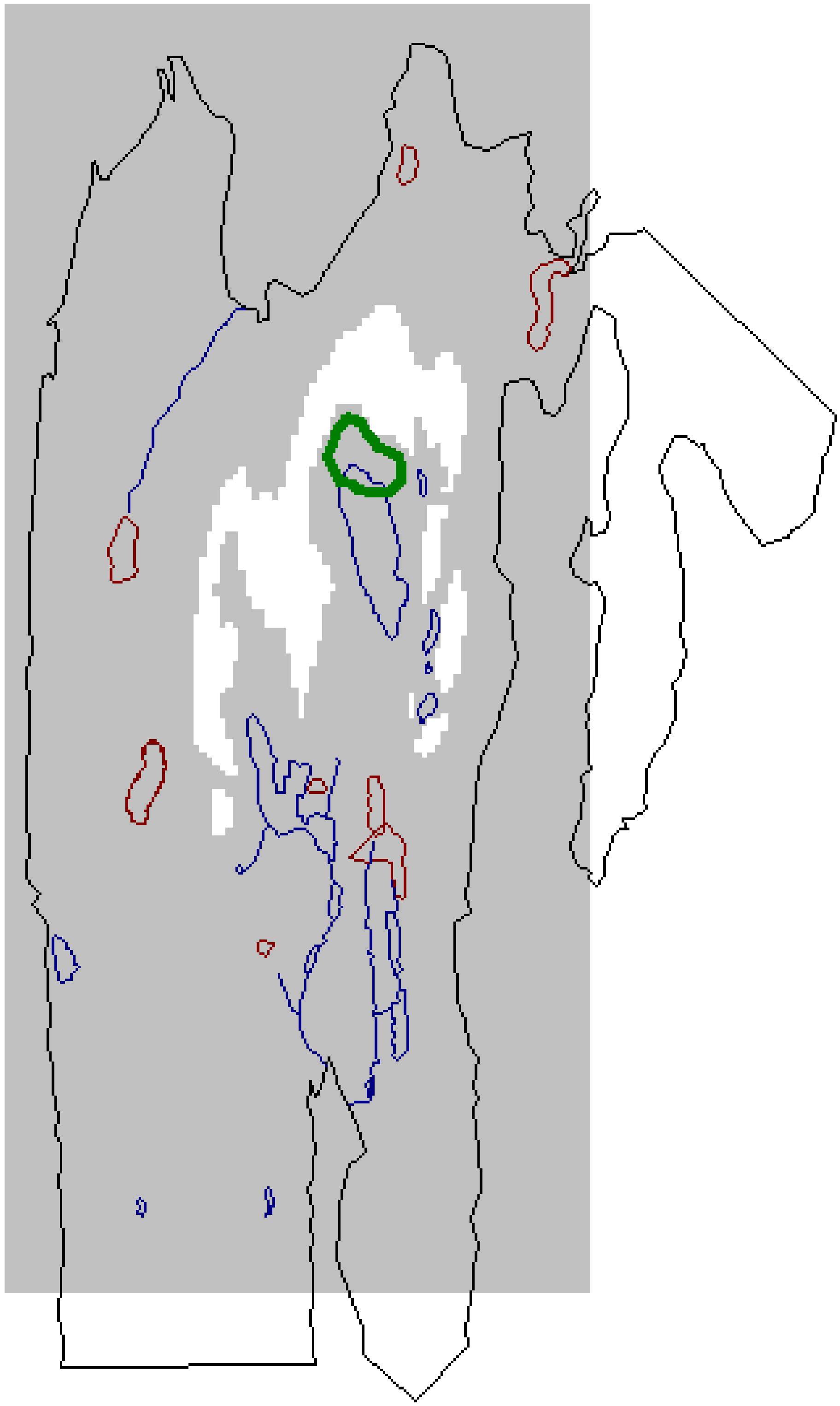
	Checked By: RTS	Figure D.4

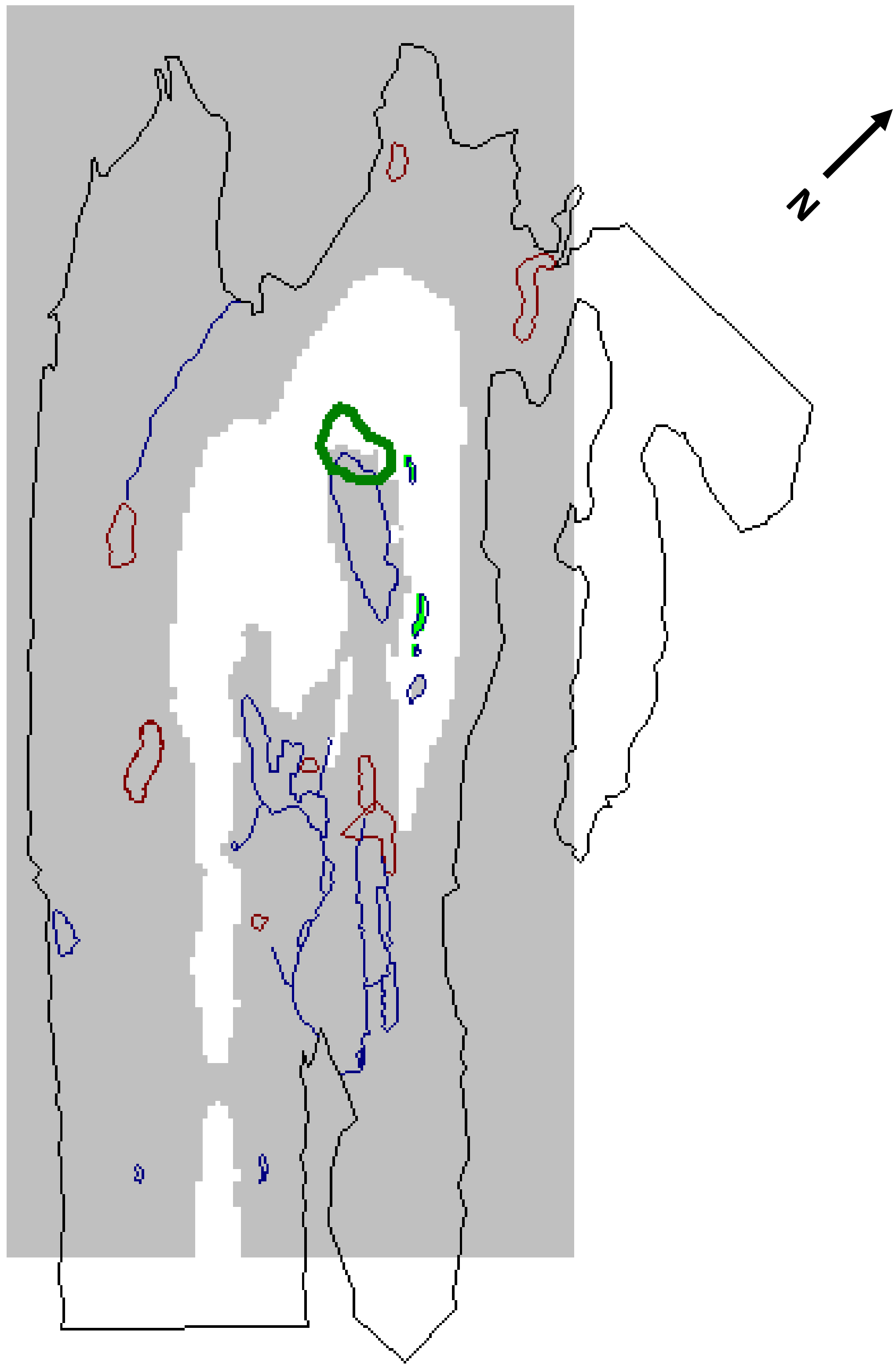


Note: Grid cells above the ground surface were defined as inactive

Legend

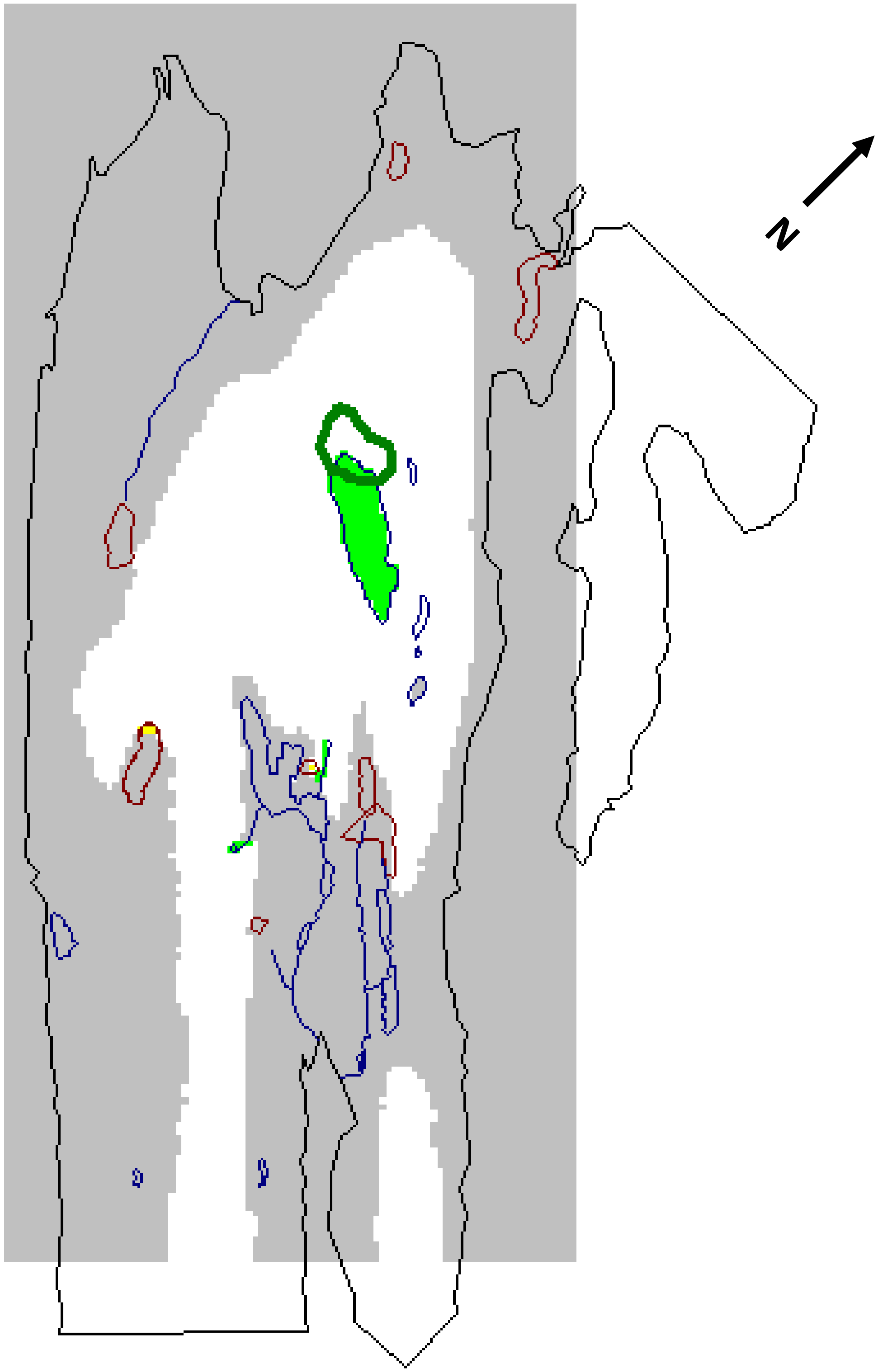
- Pit limit
- Lake or pond
- Stream
- Wetland
- Constant-head
- Inactive

HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES JOYCE LAKE AND AREA DSO PROJECT	
Boundary Conditions (Layer 1: 540 to 560 masl)	LABEC CENTURY IRON ORE INC. 拉贝克世纪铁矿公司 — WESA a BluMetric™ company
Project No. S-B12738-00-00	
Created By: GC	27-Nov-14
Checked By: RTS	Figure D.5a



Note: Grid cells above the ground surface were defined as inactive

Legend	HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES JOYCE LAKE AND AREA DSO PROJECT	
Pit limit Lake or pond Stream Wetland Constant-head Inactive	Boundary Conditions (Layer 2: 520 to 540 masl)	LABEC CENTURY IRON ORE INC. 拉贝克世纪铁矿公司 WESA a BluMetric company
	Project No. S-B12738-00-00	
	Created By: GC	27-Nov-14
	Checked By: RTS	Figure D.5b



Note: Grid cells above the ground surface were defined as inactive

Legend

- Pit limit
- Lake or pond
- Stream
- Wetland
- Constant-head
- Inactive

HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES
JOYCE LAKE AND AREA DSO PROJECT

Boundary Conditions (Layer 3: 500 to 520 masl)	LABEC CENTURY IRON ORE INC. 拉贝克世纪铁矿公司 / WESA a BluMetric company
Project No. S-B12738-00-00	
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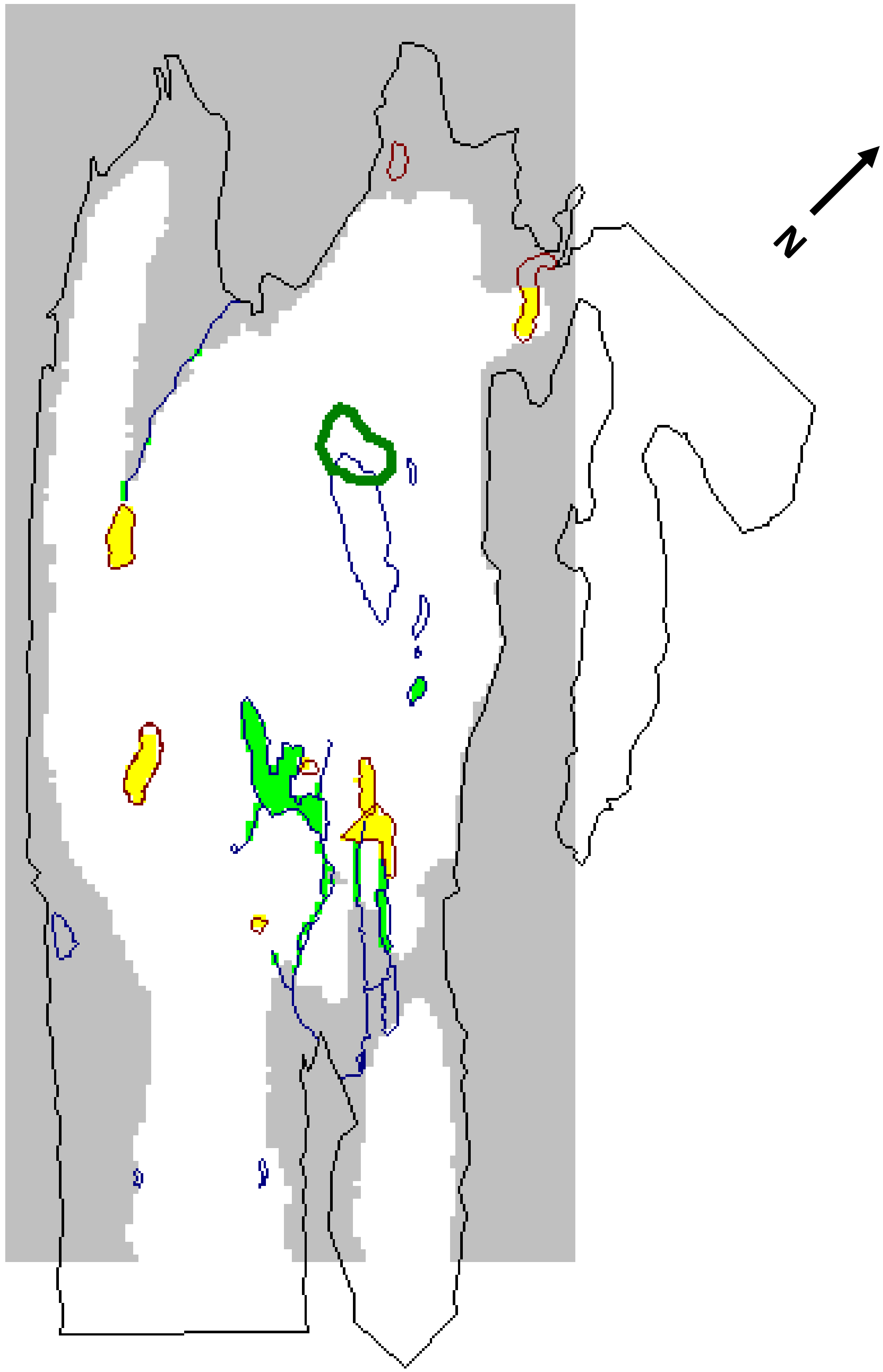
Checked By: RTS	Figure D.5c



Note: Grid cells above the ground surface were defined as inactive

Legend

- Pit limit
- Lake or pond
- Stream
- Wetland
- Constant-head
- Inactive

HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES
JOYCE LAKE AND AREA DSO PROJECT

Boundary Conditions
(Layer 4: 480 to 500 masl)

LABEC CENTURY IRON ORE INC.
拉贝克世纪铁矿公司

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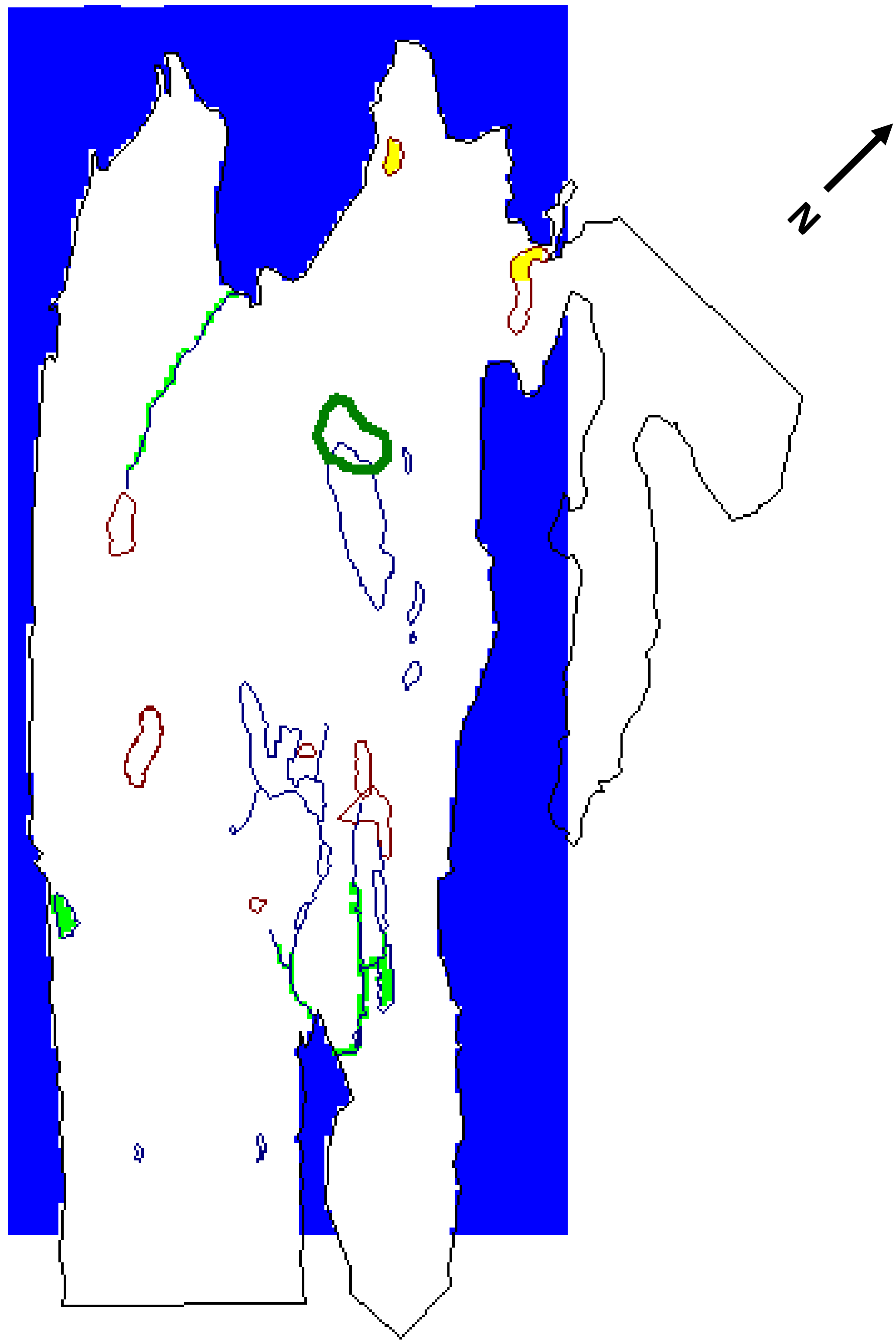
27-Nov-14

Checked By: RTS

Figure D.5d



Note: Grid cells above the ground surface were defined as inactive

Legend

- Pit limit
- Lake or pond
- Stream
- Wetland
- Constant-head
- Inactive

HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES
JOYCE LAKE AND AREA DSO PROJECT

Boundary Conditions
(Layer 5: 460 to 480 masl)

LABEC CENTURY IRON ORE INC.
拉贝克世纪铁矿公司

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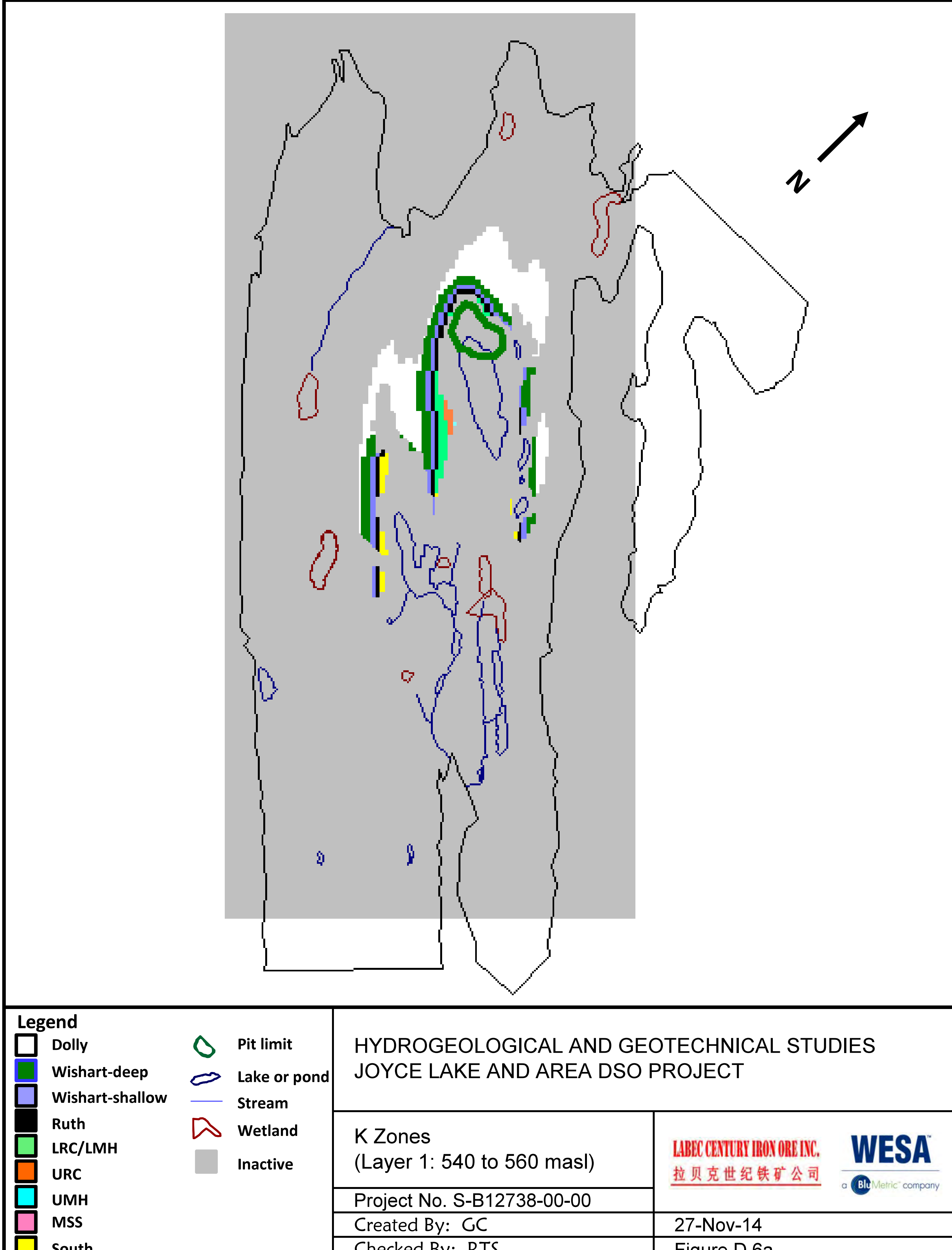

HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES
JOYCE LAKE AND AREA DSO PROJECT

K Zones
(Layer 1: 540 to 560 masl)

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拉贝克世纪铁矿公司

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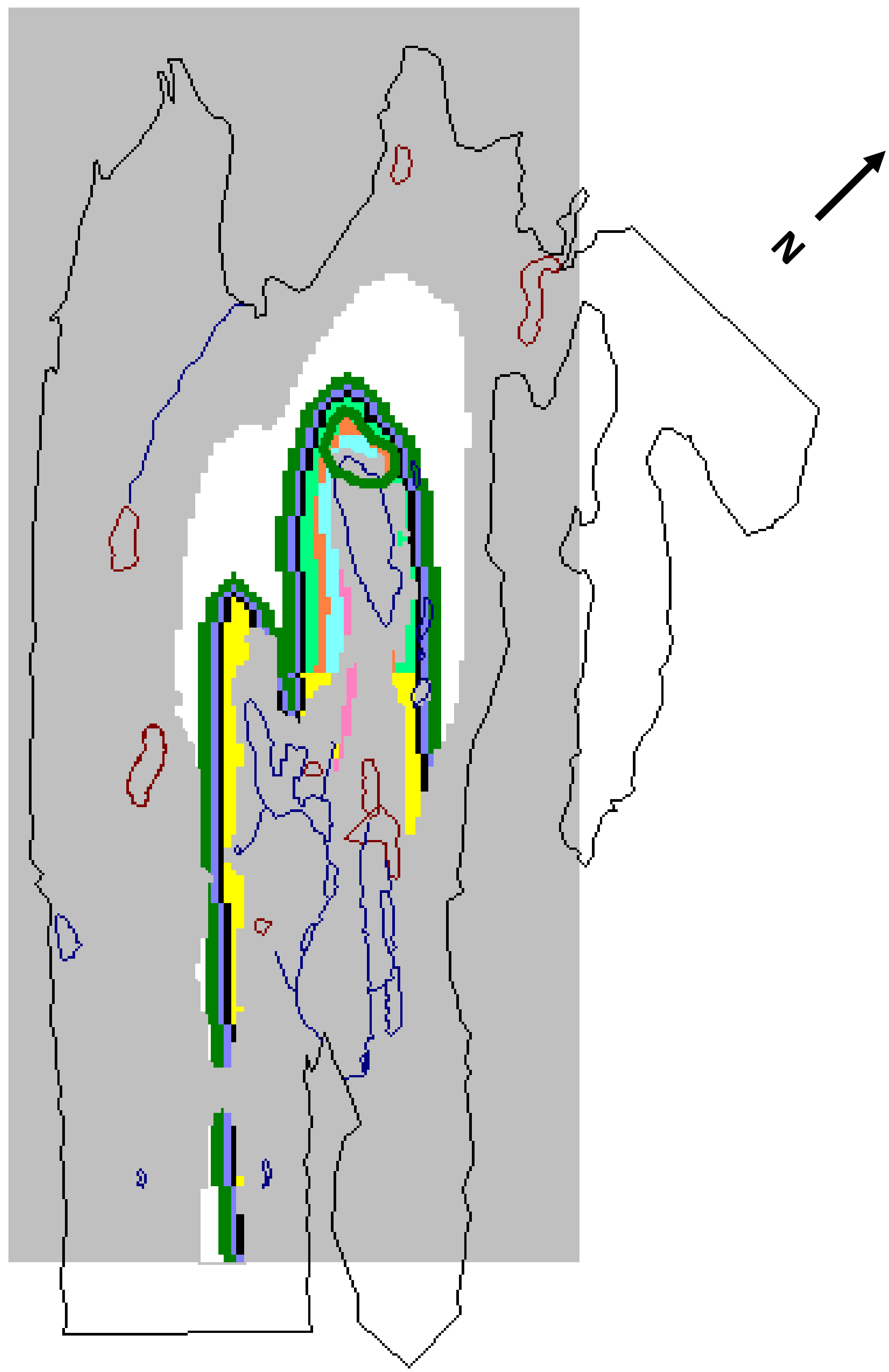

Legend

Dolly	Pit limit
Wishart-deep	Lake or pond
Wishart-shallow	Stream
Ruth	Wetland
LRC/LMH	Inactive
URC	
UMH	
MSS	
South	

HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES
JOYCE LAKE AND AREA DSO PROJECT

K Zones
(Layer 2: 520 to 540 masl)

LABEC CENTURY IRON ORE INC.
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27-Nov-14

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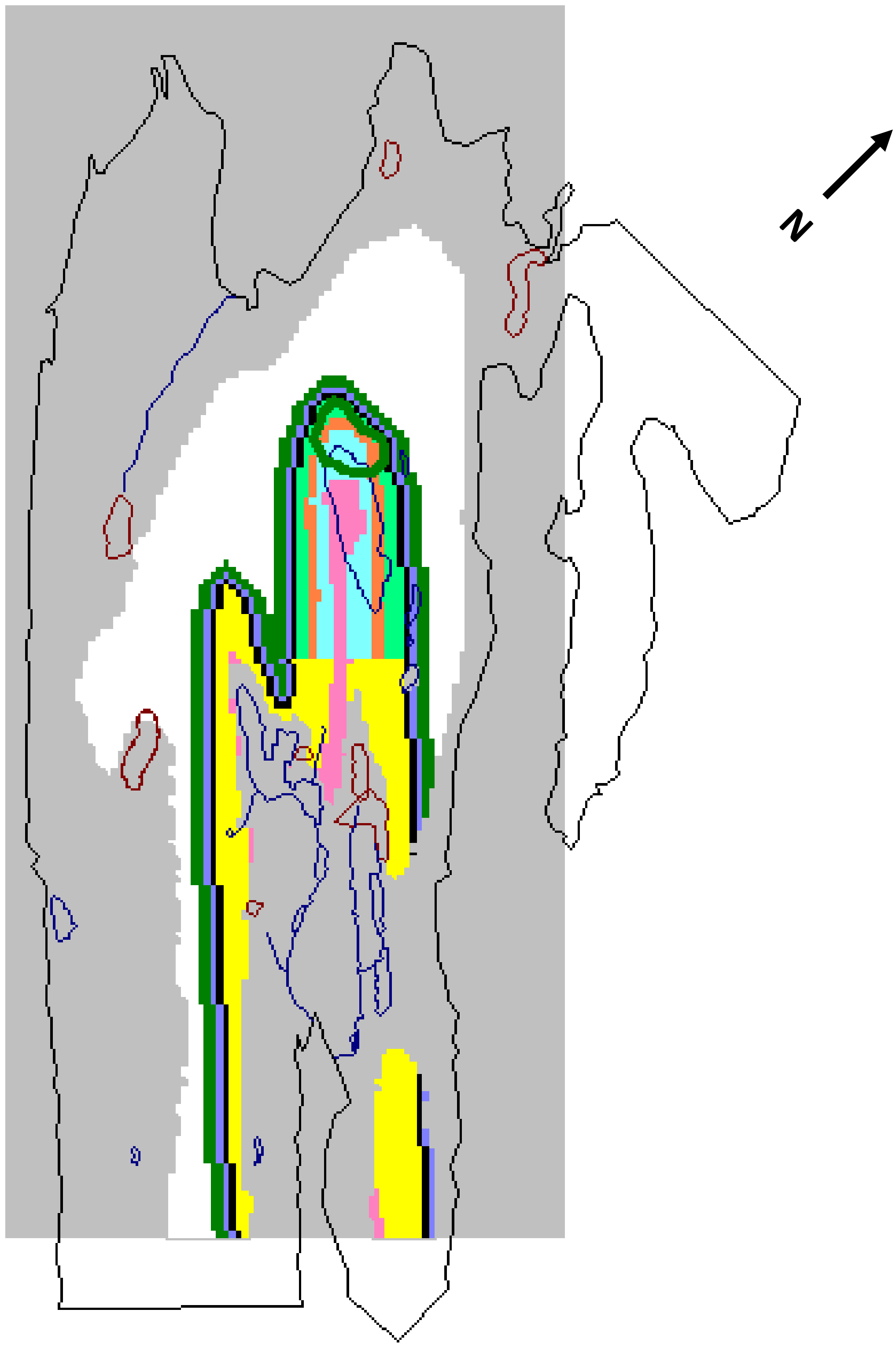
Figure D.6b



Legend

Dolly	Pit limit
Wishart-deep	Lake or pond
Wishart-shallow	Stream
Ruth	Wetland
LRC/LMH	Inactive
URC	
UMH	
MSS	
South	

HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES
JOYCE LAKE AND AREA DSO PROJECT

K Zones
(Layer 3: 500 to 520 masl)

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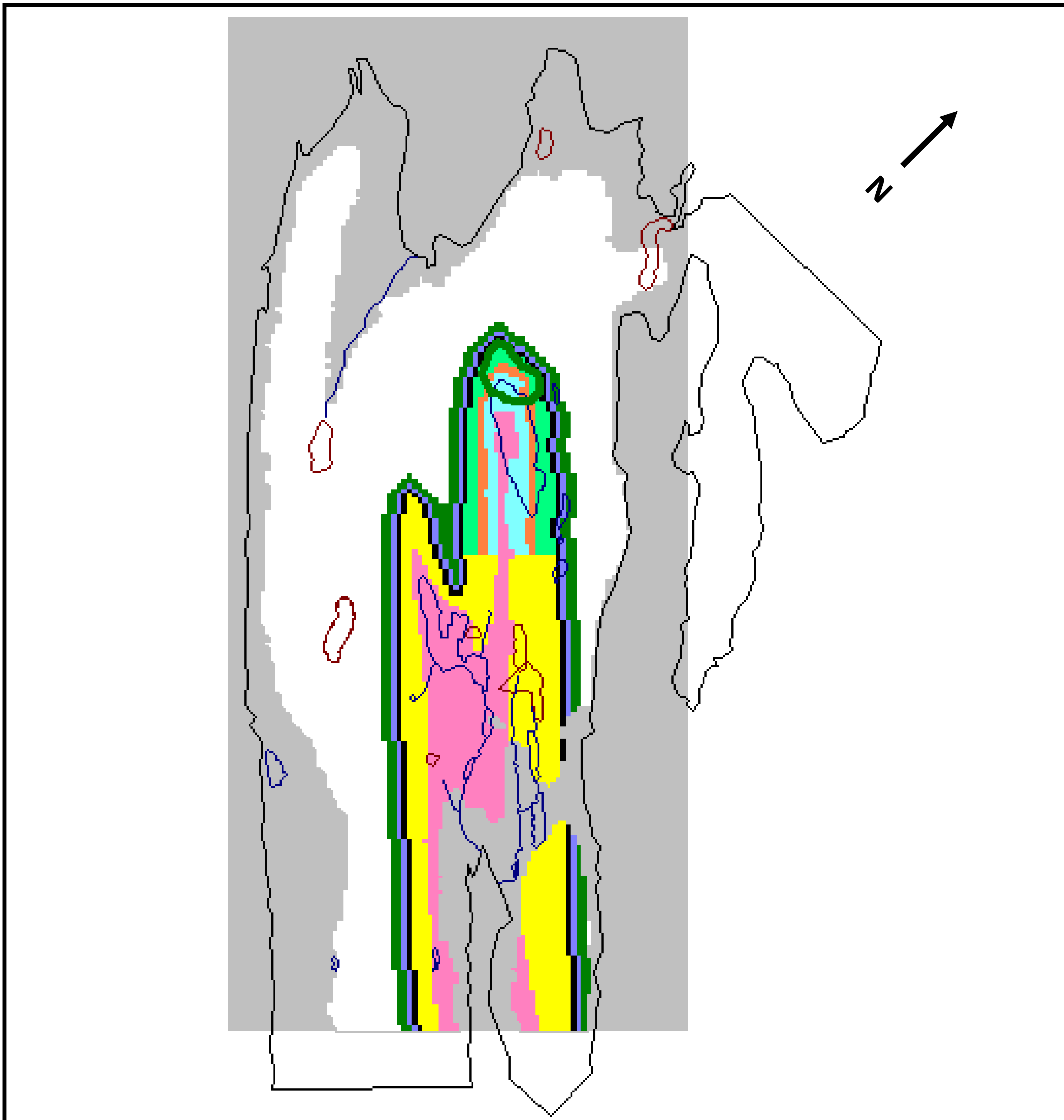

Legend

Dolly		Pit limit	
Wishart-deep		Lake or pond	
Wishart-shallow		Stream	
Ruth		Wetland	
LRC/LMH		Inactive	
URC			
UMH			
MSS			
South			

HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES
JOYCE LAKE AND AREA DSO PROJECT

K Zones
(Layer 4: 480 to 500 masl)

LABEC CENTURY IRON ORE INC.
拉贝克世纪铁矿公司

WESA
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Project No. S-B12738-00-00

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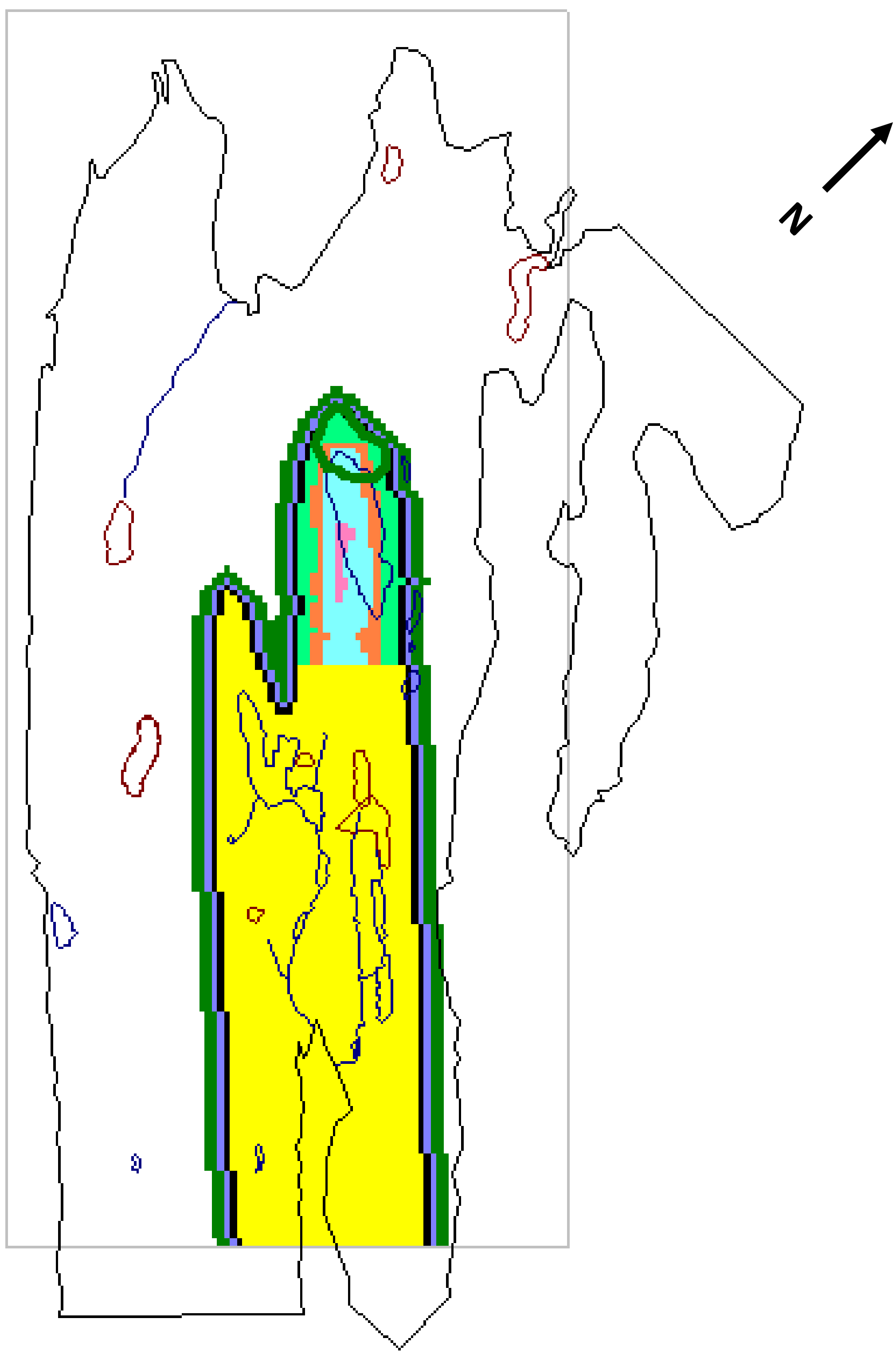

Legend

Dolly		Pit limit	
Wishart-deep		Lake or pond	
Wishart-shallow		Stream	
Ruth		Wetland	
LRC/LMH		Inactive	
URC			
UMH			
MSS			
South			

HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES
JOYCE LAKE AND AREA DSO PROJECT

K Zones
(Layer 5: 460 to 480 masl)

LABEC CENTURY IRON ORE INC.
拉贝克世纪铁矿公司

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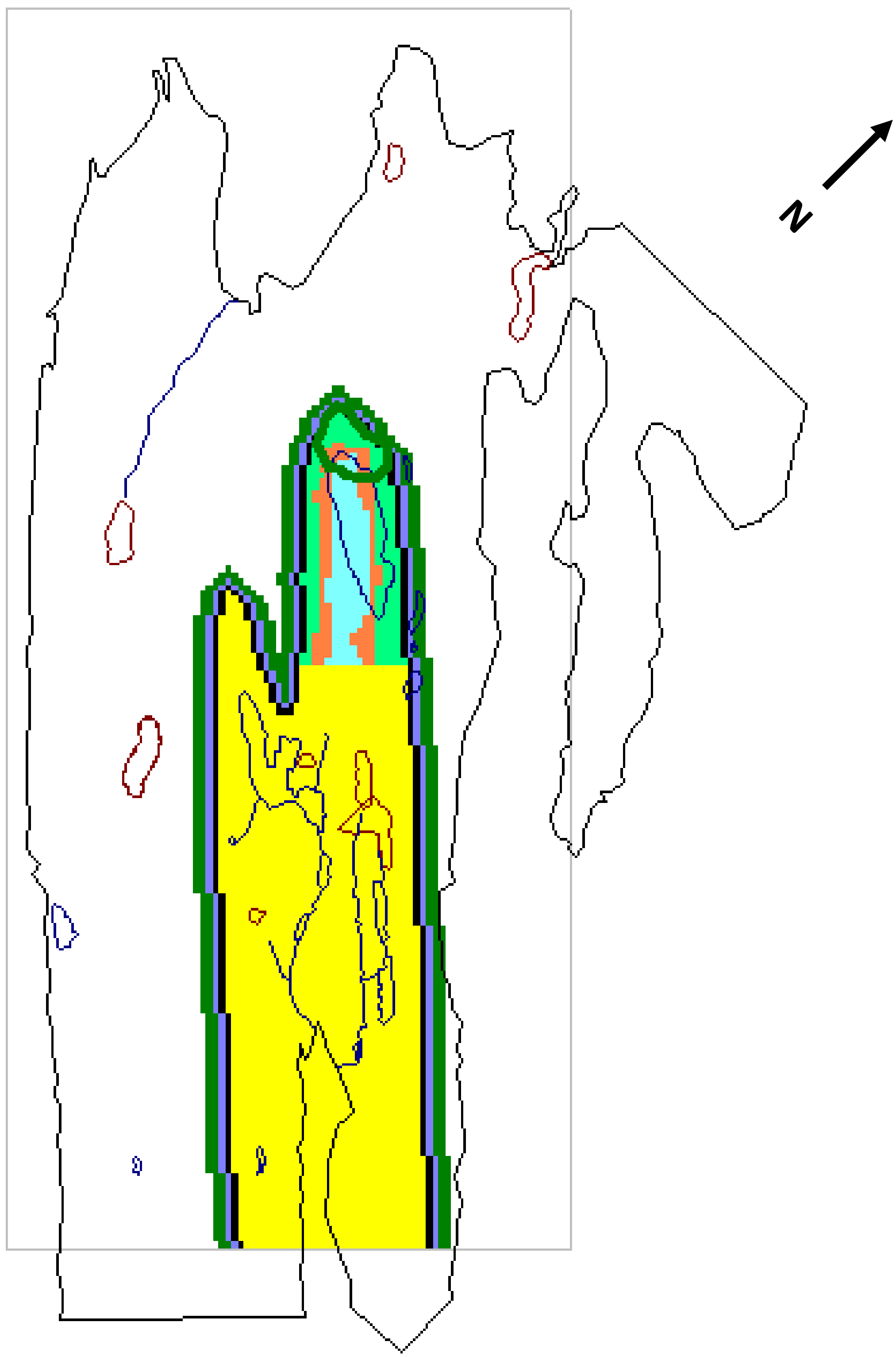

Legend

Dolly		Pit limit	
Wishart-deep		Lake or pond	
Wishart-shallow		Stream	
Ruth		Wetland	
LRC/LMH		Inactive	
URC			
UMH			
MSS			
South			

HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES
JOYCE LAKE AND AREA DSO PROJECT

K Zones
(Layer 6: 440 to 460 masl)

LABEC CENTURY IRON ORE INC.
拉贝克世纪铁矿公司

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Project No. S-B12738-00-00

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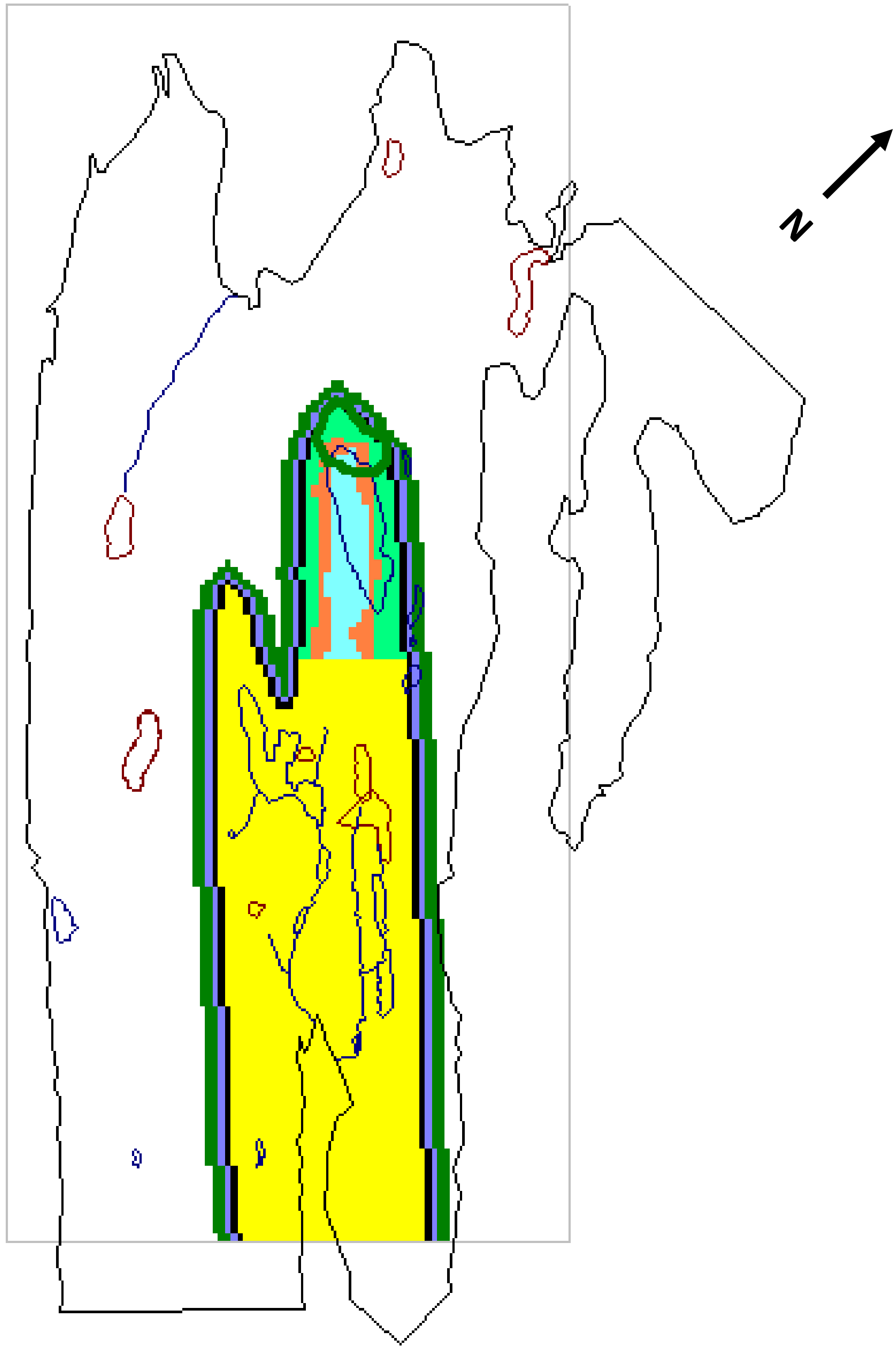


Legend

Dolly		Pit limit	
Wishart-deep		Lake or pond	
Wishart-shallow		Stream	
Ruth		Wetland	
LRC/LMH		Inactive	
URC			
UMH			
MSS			
South			

HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES
JOYCE LAKE AND AREA DSO PROJECT

K Zones
(Layer 7: 420 to 440 masl)

LABEC CENTURY IRON ORE INC.
拉贝克世纪铁矿公司

WESA
a BluMetric company

Project No. S-B12738-00-00

Created By: GC | 27-Nov-14

Checked By: RTS | Figure D.6g

Legend

- Dolly
- Wishart-deep
- Wishart-shallow
- Ruth
- LRC/LMH
- URC
- UMH
- MSS
- South
- Pit limit
- Lake or pond
- Stream
- Wetland
- Inactive

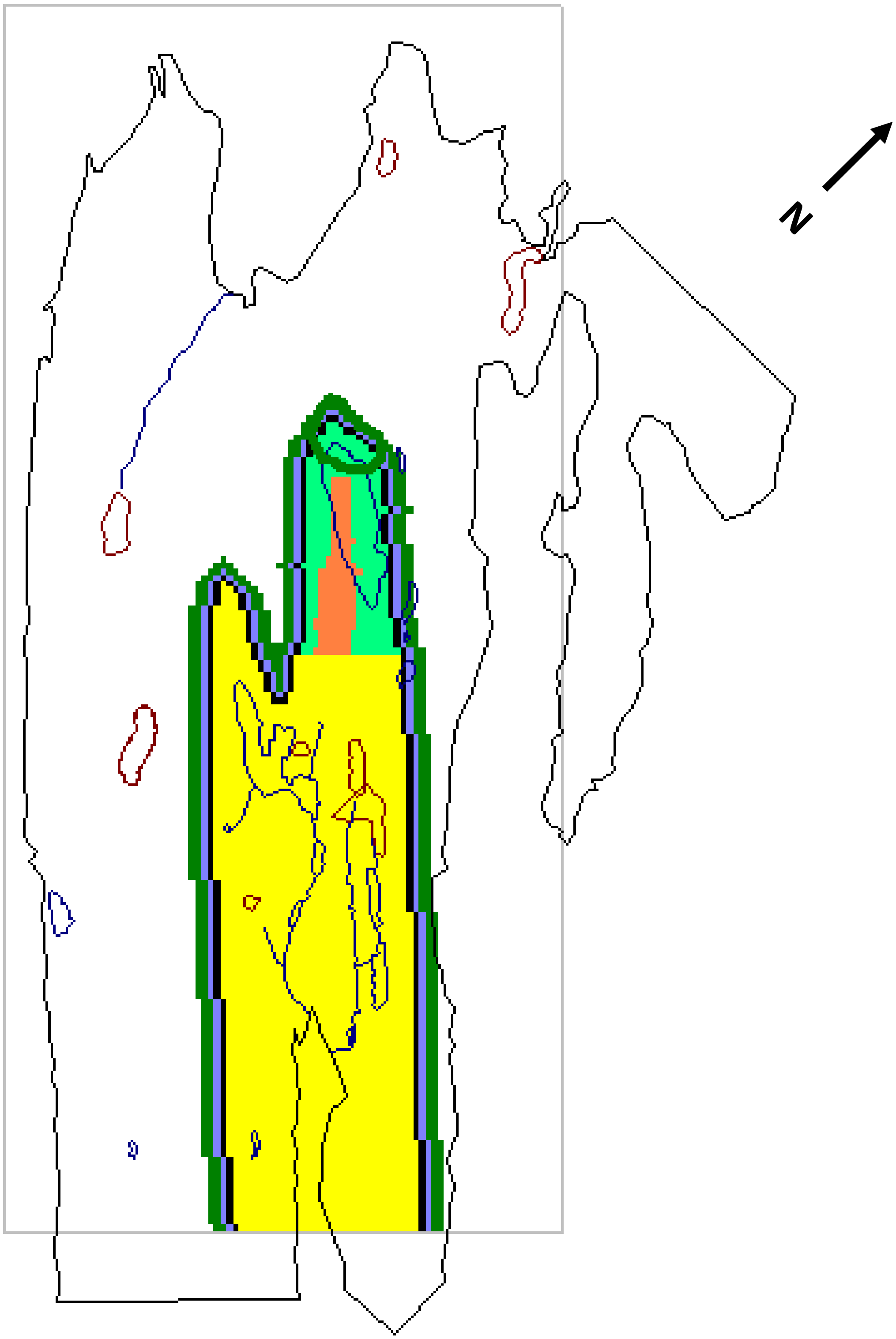
HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES
JOYCE LAKE AND AREA DSO PROJECT

K Zones
(Layer 8: 400 to 420 masl)

LABEC CENTURY IRON ORE INC.
拉贝克世纪铁矿公司

WESA
a BluMetric company

Project No. S-B12738-00-00	
Created By: GC	27-Nov-14
Checked By: RTS	Figure D.6h



Legend

	Dolly		Pit limit
	Wishart-deep		Lake or pond
	Wishart-shallow		Stream
	Ruth		Wetland
	LRC/LMH		Inactive
	URC		
	UMH		
	MSS		
	South		

HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES
JOYCE LAKE AND AREA DSO PROJECT

K Zones
(Layer 9: 380 to 400 masl)

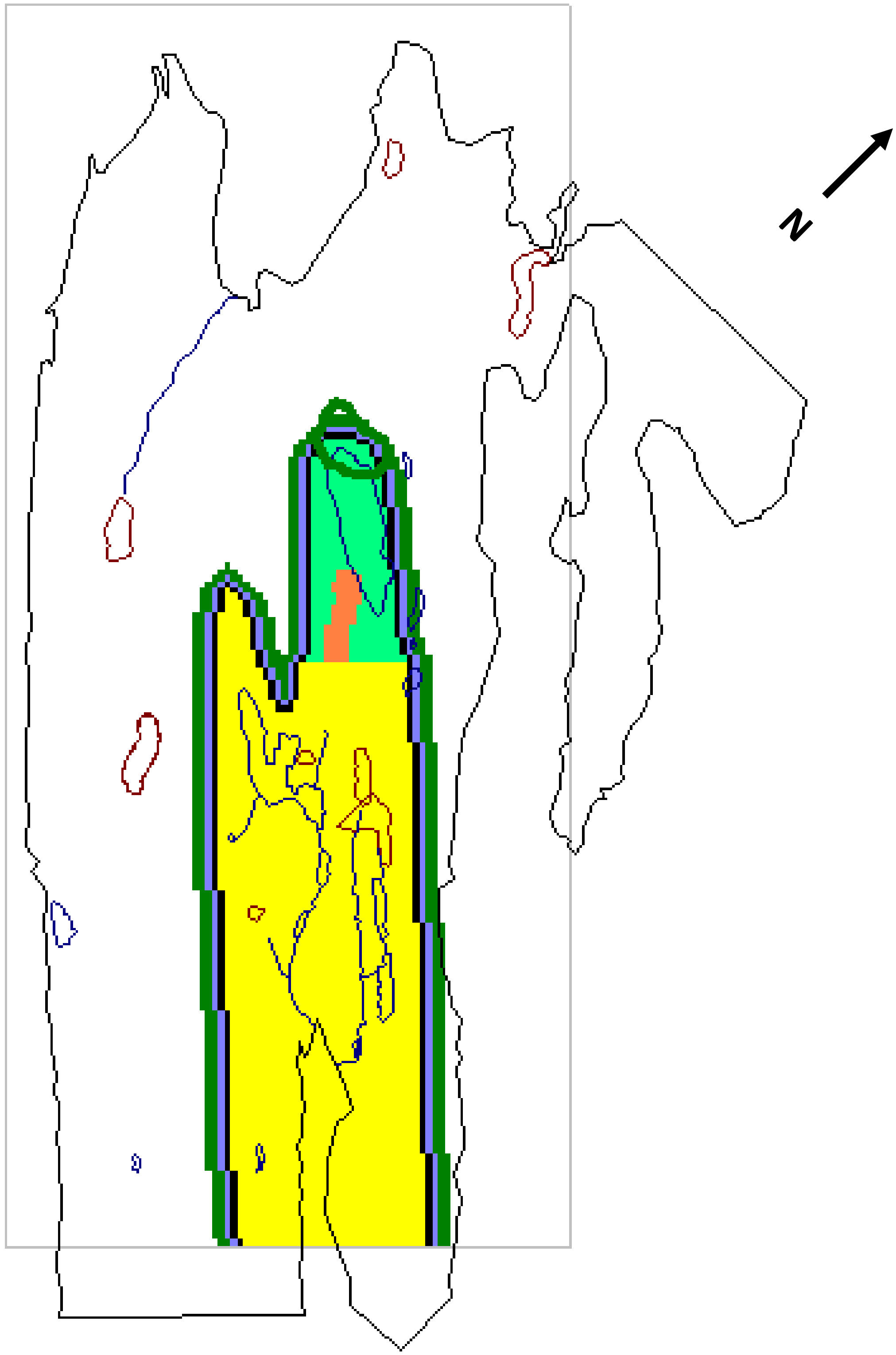
LABEC CENTURY IRON ORE INC.
拉贝克世纪铁矿公司

WESA
a BluMetric company

Project No. S-B12738-00-00

Created By: GC | 27-Nov-14

Checked By: RTS | Figure D.6i



Legend

Dolly	Pit limit
Wishart-deep	Lake or pond
Wishart-shallow	Stream
Ruth	Wetland
LRC/LMH	Inactive
URC	
UMH	
MSS	
South	

HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES
JOYCE LAKE AND AREA DSO PROJECT

K Zones
(Layer 10: 360 to 380 masl)

LABEC CENTURY IRON ORE INC.
拉贝克世纪铁矿公司

WESA
a BluMetric company

Project No. S-B12738-00-00

Created By: GC | 27-Nov-14

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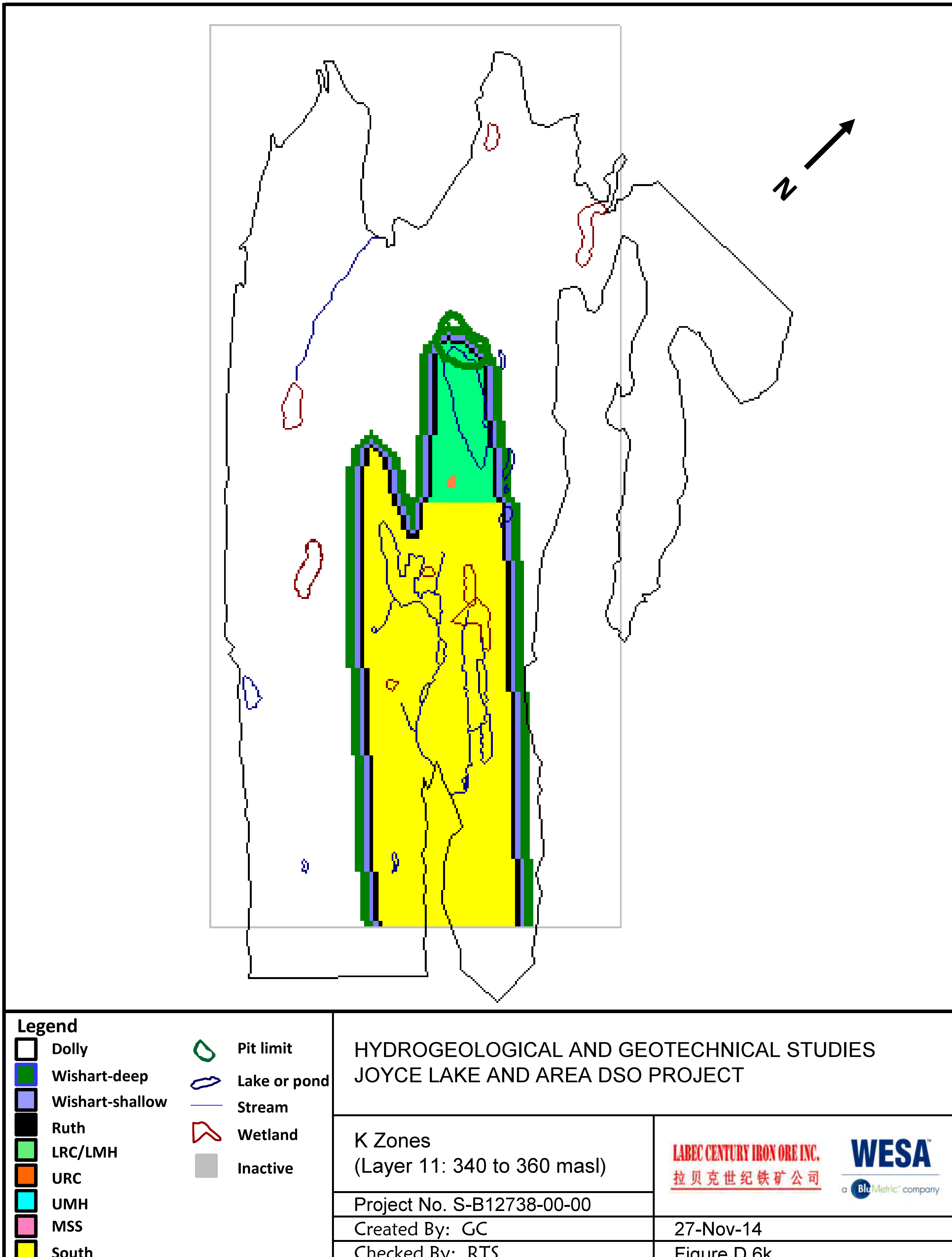

HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES
JOYCE LAKE AND AREA DSO PROJECT

K Zones
(Layer 11: 340 to 360 masl)

LABEC CENTURY IRON ORE INC.
拉贝克世纪铁矿公司

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Project No. S-B12738-00-00

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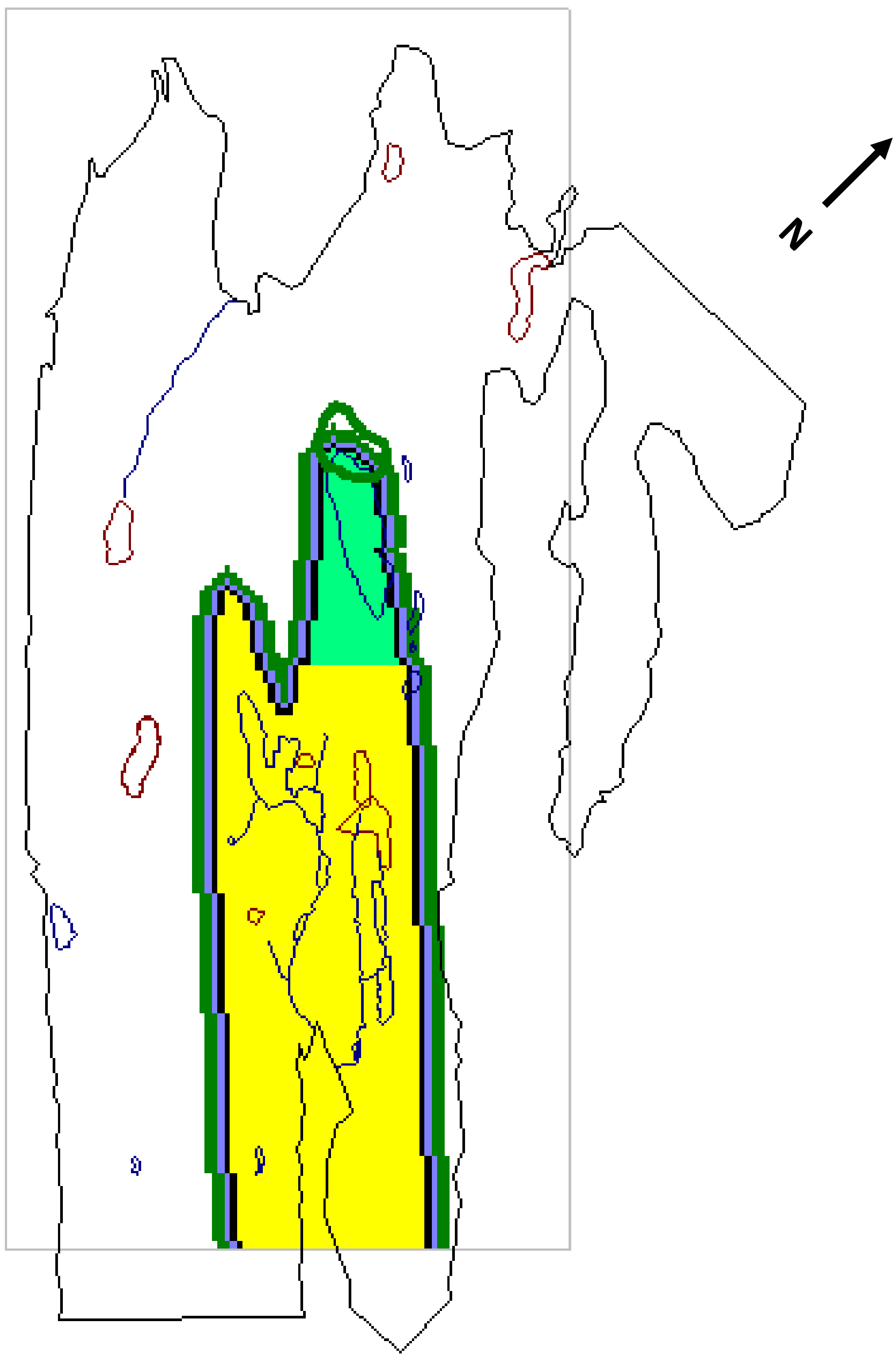


Legend

Dolly	Pit limit
Wishart-deep	Lake or pond
Wishart-shallow	Stream
Ruth	Wetland
LRC/LMH	Inactive
URC	
UMH	
MSS	
South	

HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES
JOYCE LAKE AND AREA DSO PROJECT

K Zones
(Layer 12: 320 to 340 masl)

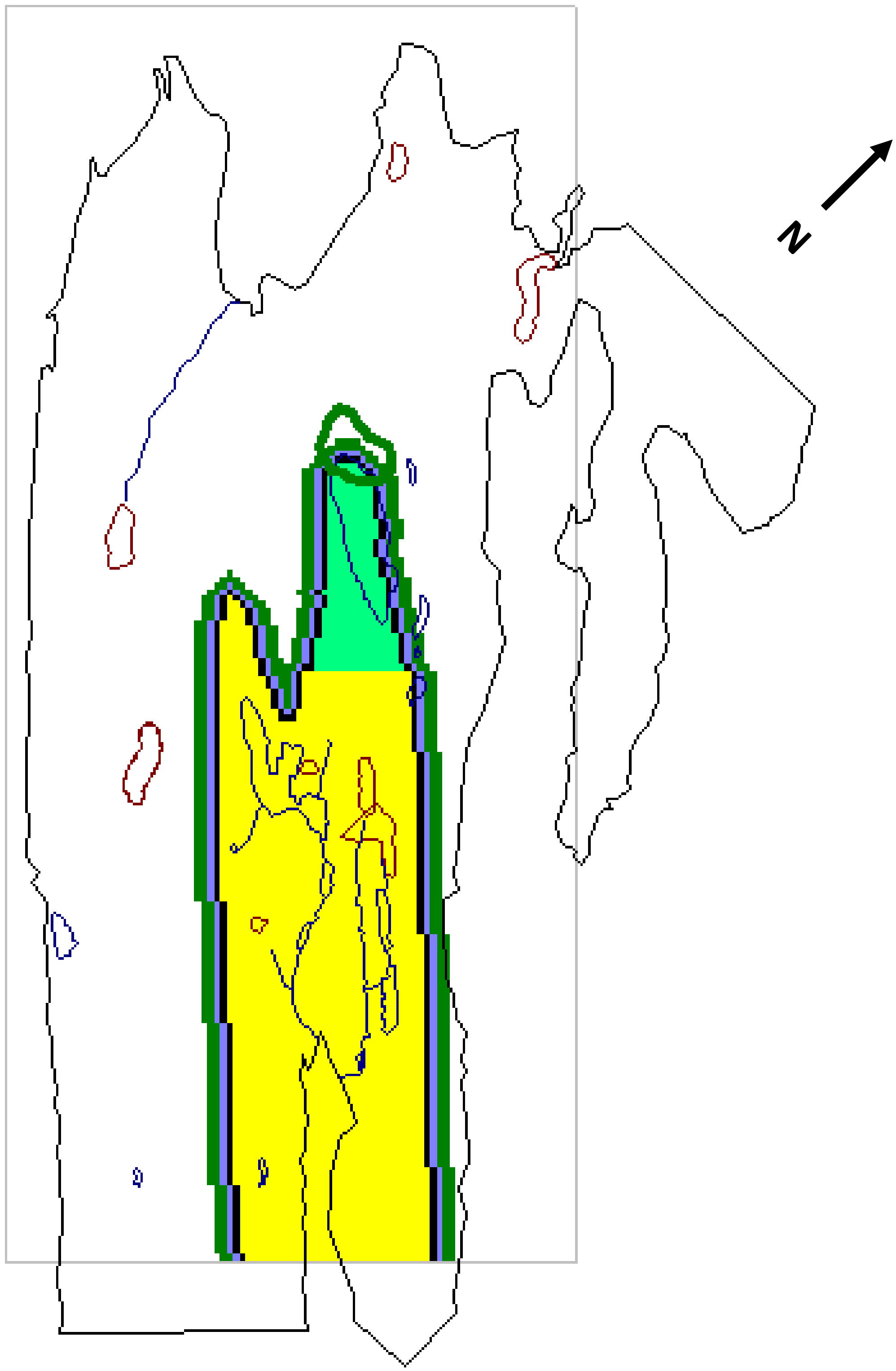
LABEC CENTURY IRON ORE INC.
拉贝克世纪铁矿公司

WESA
a BluMetric company

Project No. S-B12738-00-00

Created By: GC | 27-Nov-14

Checked By: RTS | Figure D.6l



Legend

- Dolly
- Wishart-deep
- Wishart-shallow
- Ruth
- LRC/LMH
- URC
- UMH
- MSS
- South
- Pit limit
- Lake or pond
- Stream
- Wetland
- Inactive

HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES
JOYCE LAKE AND AREA DSO PROJECT

K Zones
(Layer 13: 250 to 320 masl)

LABEC CENTURY IRON ORE INC.
拉贝克世纪铁矿公司

WESA
a BluMetric company

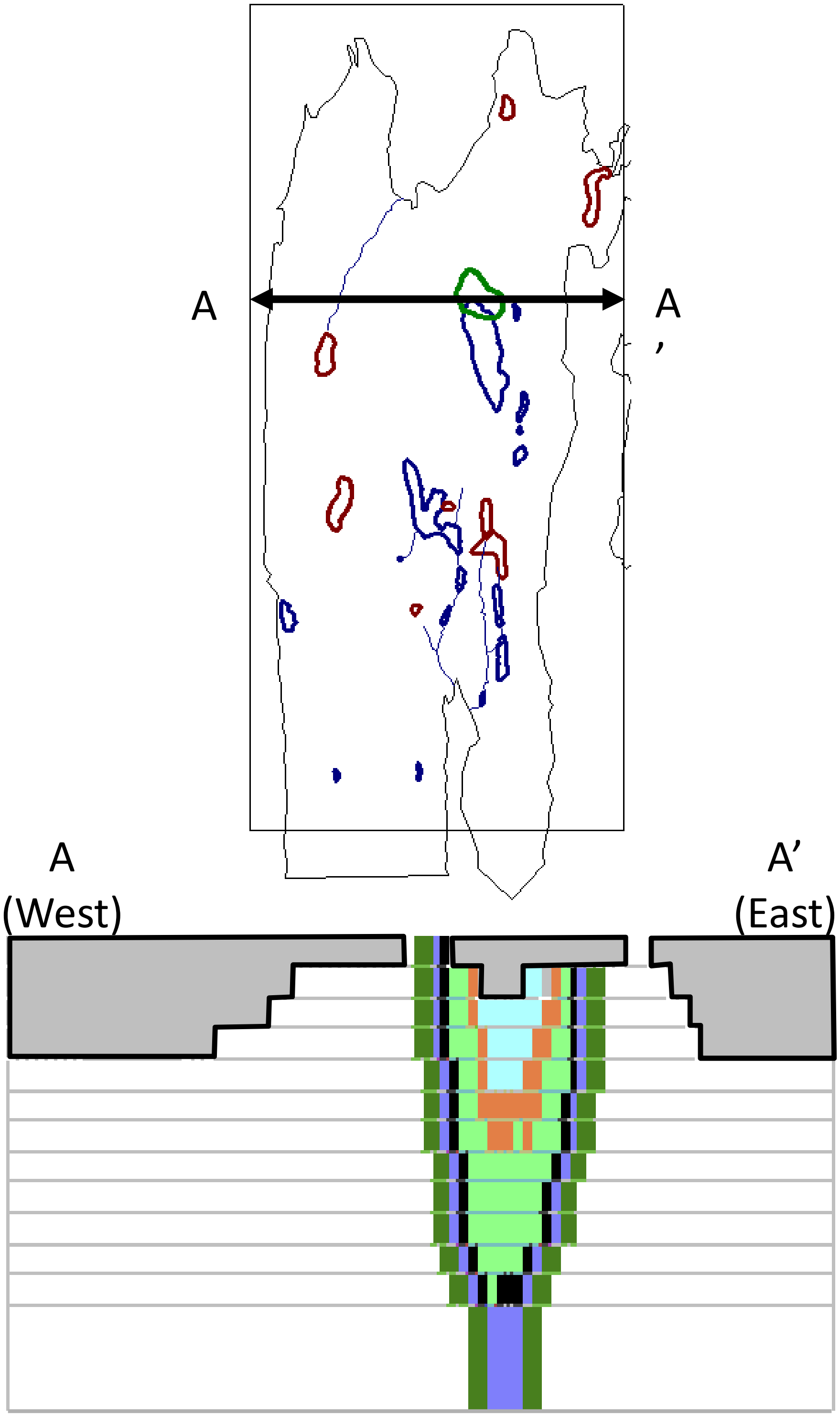
Project No. S-B12738-00-00

Created By: GC

27-Nov-14

Checked By: RTS

Figure D.6m



Legend

- Dolly
- Wishart-deep
- Wishart-shallow
- Ruth
- LRC/LMH
- URC
- UMH
- MSS
- South
- Pit limit
- Lake or pond
- Stream
- Wetland
- Inactive

HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES
JOYCE LAKE AND AREA DSO PROJECT

K Zones
Cross-Section A-A' (East-West)

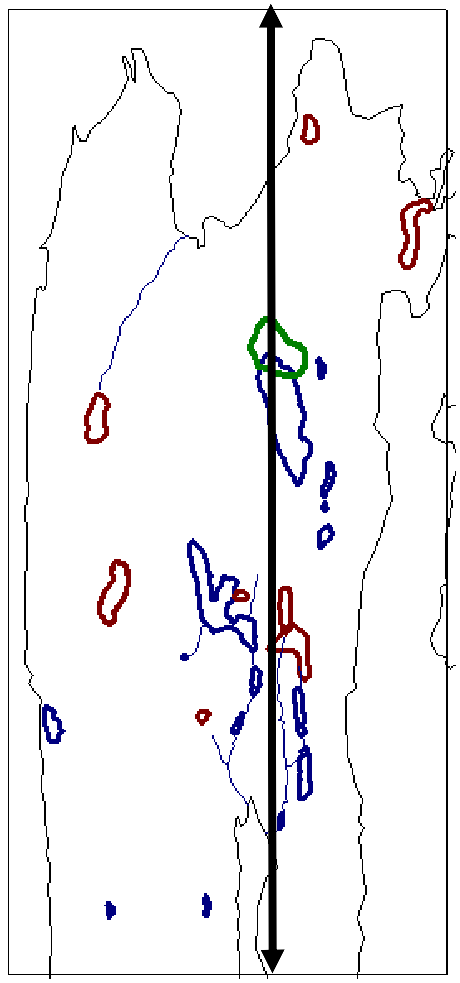
LABEC CENTURY IRON ORE INC.
拉贝克世纪铁矿公司

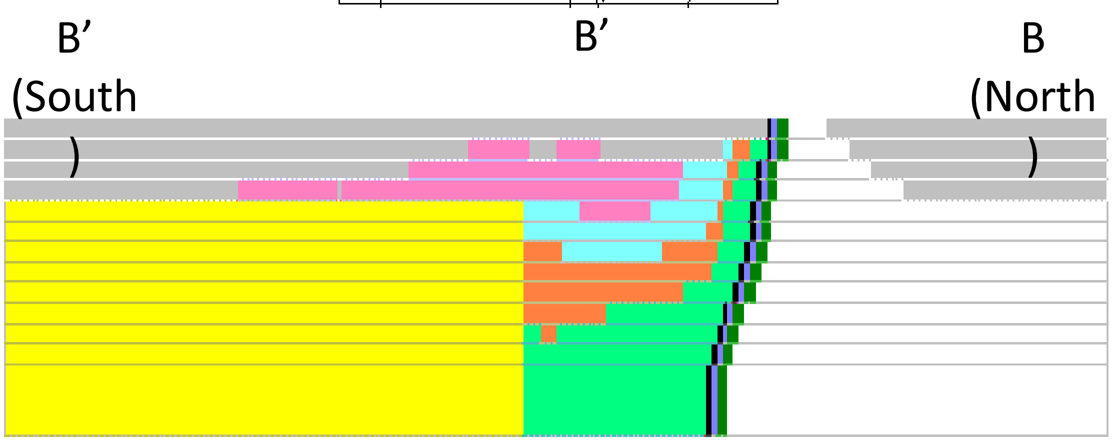
WESA
a BluMetric company

Project No. S-B12738-00-00

Created By: GC | 27-Nov-14

Checked By: RTS | Figure D.7a





Legend

Dolly		Pit limit	
Wishart-deep		Lake or pond	
Wishart-shallow		Stream	
Ruth		Wetland	
LRC/LMH		Inactive	
URC			
UMH			
MSS			
South			

HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES
JOYCE LAKE AND AREA DSO PROJECT

K Zones
Cross-Section B-B'
(North-South)

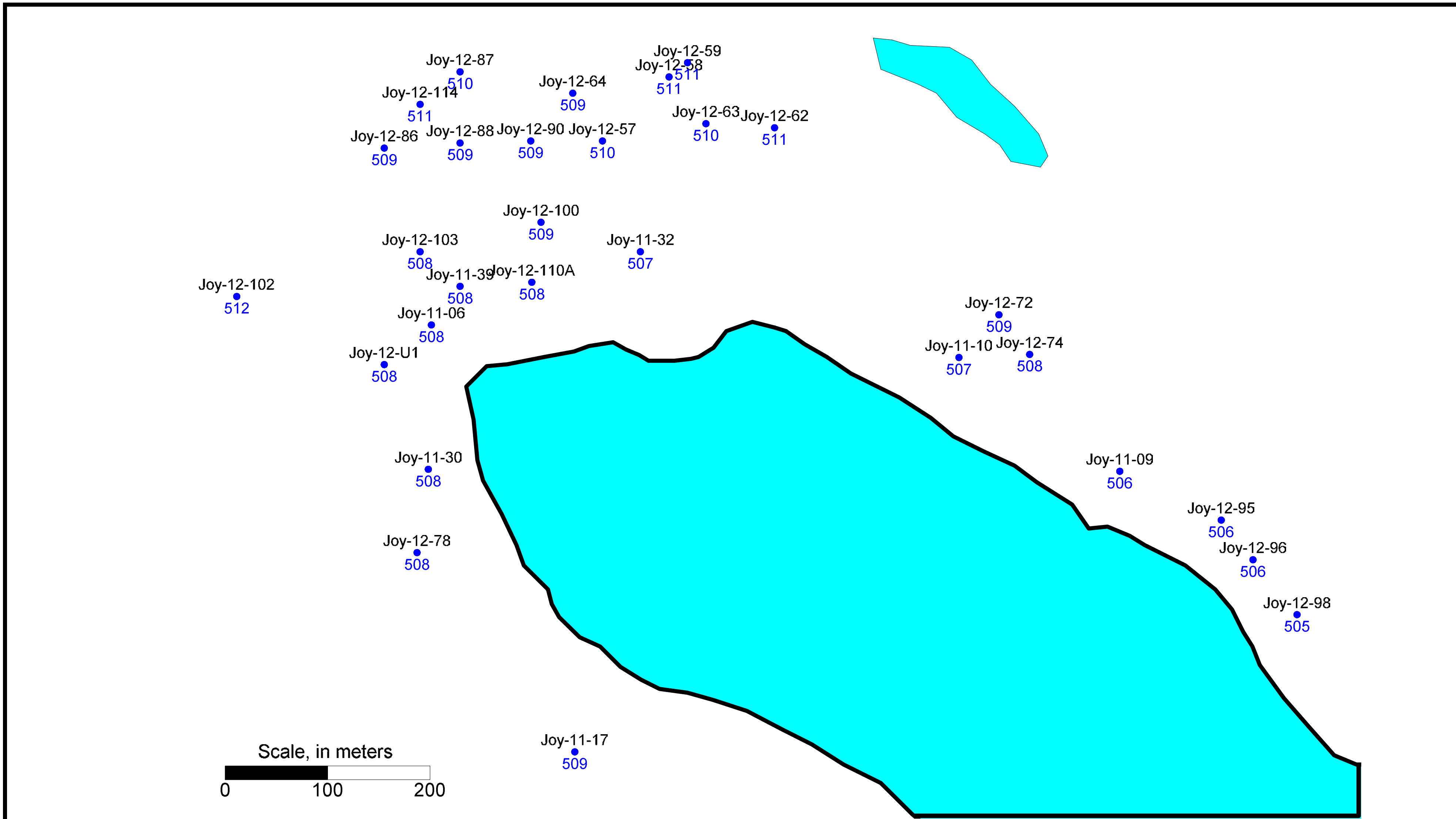
LABEC CENTURY IRON ORE INC.
拉贝克世纪铁矿公司

WESA
a BluMetric company

Project No. S-B12738-00-00

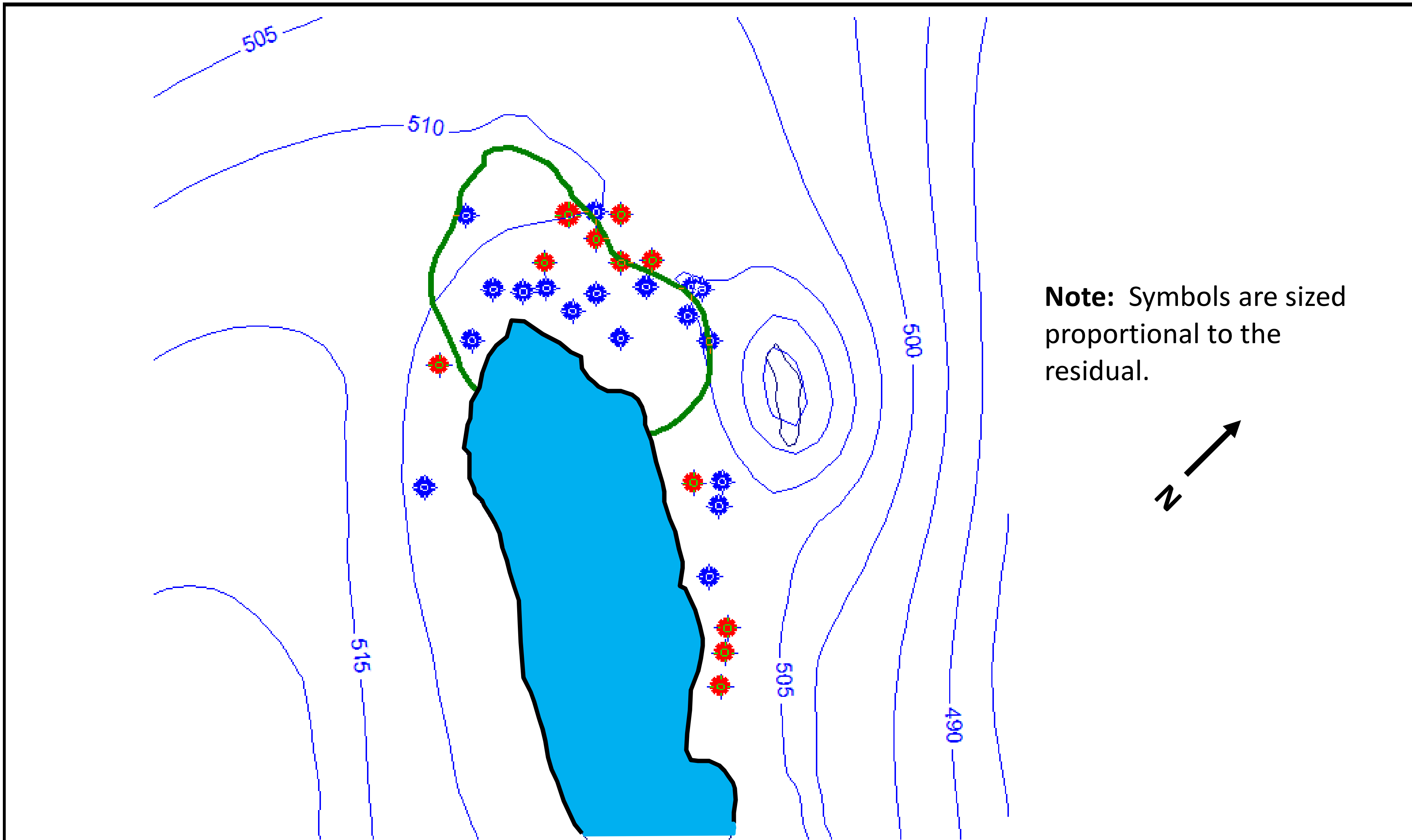
Created By: GC | 27-Nov-14

Checked By: RTS | Figure D.7b



Note: calibration target monitoring wells are shown with the October 2012 synoptic groundwater elevation measurements.

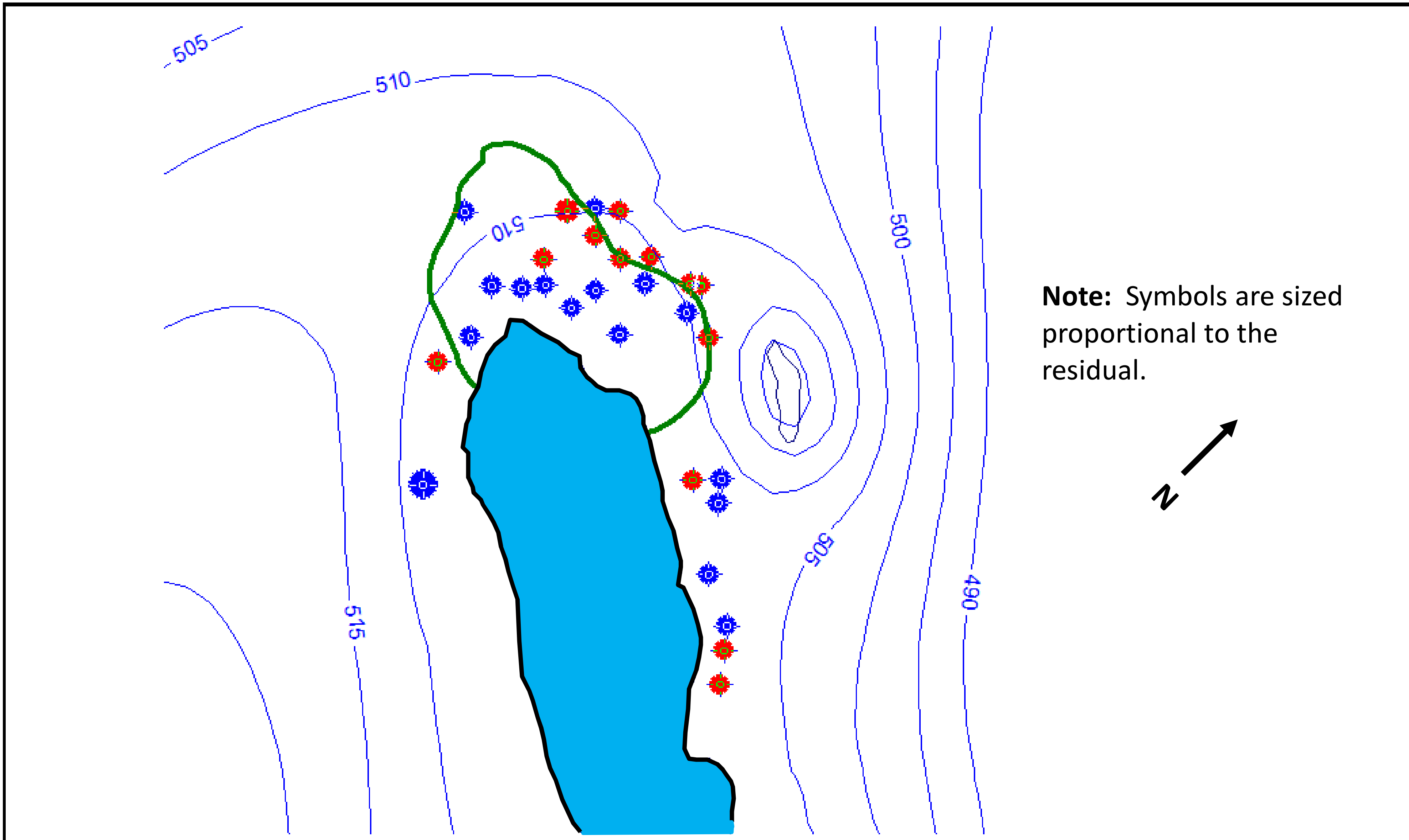
LABEC CENTURY IRON ORE INC. 拉贝克世纪铁矿公司 / WESA a BluMetric company	Calibration Target Well Locations (all layers)	HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES JOYCE LAKE AND AREA DSO PROJECT
	Project No. S-B12738-00-00	
	Created By: GC	28-Nov-14
	Checked By: RTS	Figure D.8



Legend

- Target Well (model lower than observed head)
- Target Well (model higher than observed head)

HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES JOYCE LAKE AND AREA DSO PROJECT	
Residual Bubble Plots (Layer 5, Case 1 – Silty sediments in Joyce Lake)	LABEC CENTURY IRON ORE INC. 拉贝克世纪铁矿公司 WESA a BluMetric company
Project No. S-B12738-00-00	
Created By: GC	27-Nov-14
Checked By: RTS	Figure D.9a

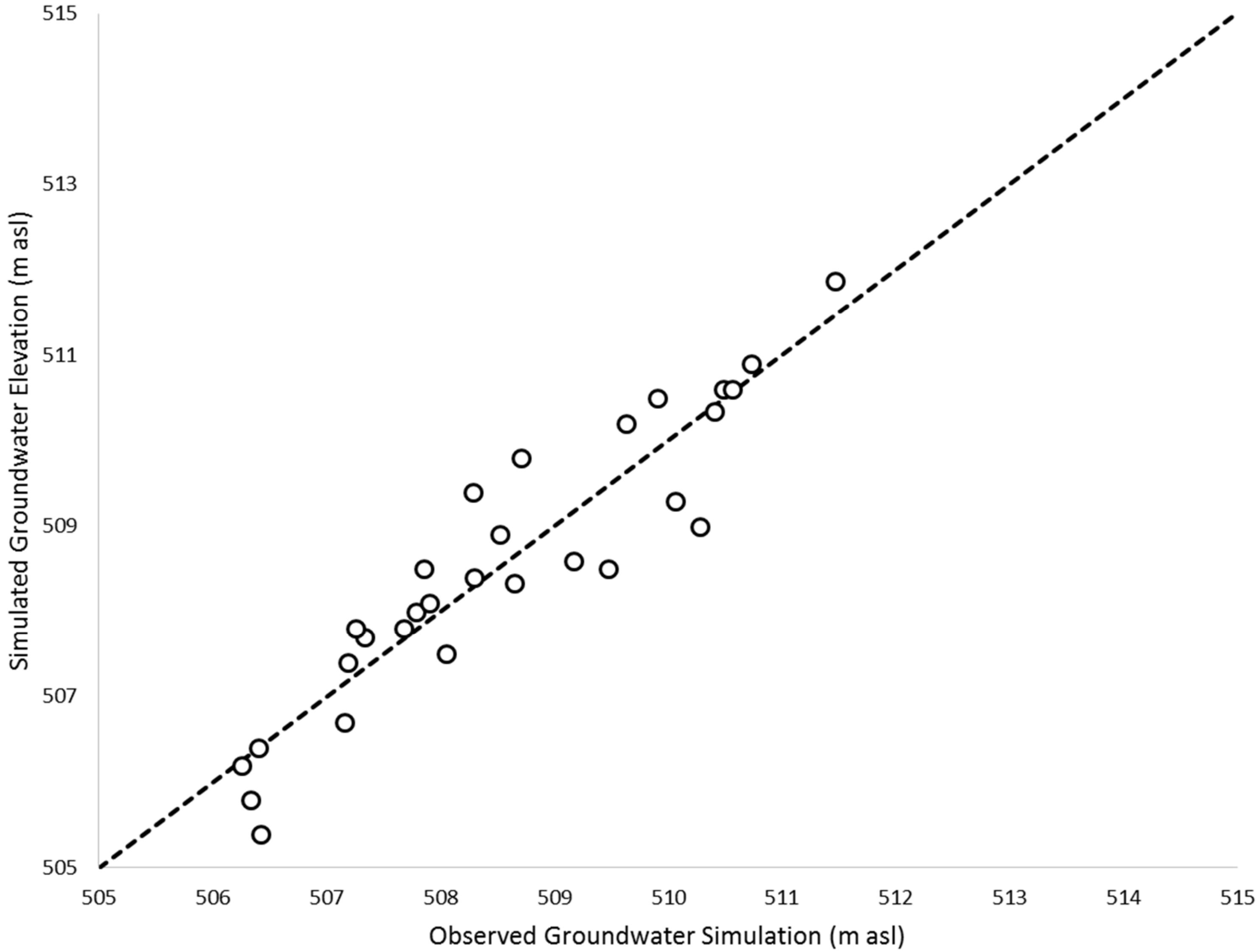


Note: Symbols are sized proportional to the residual.

Legend

- Target Well (model lower than observed head)
- Target Well (model higher than observed head)

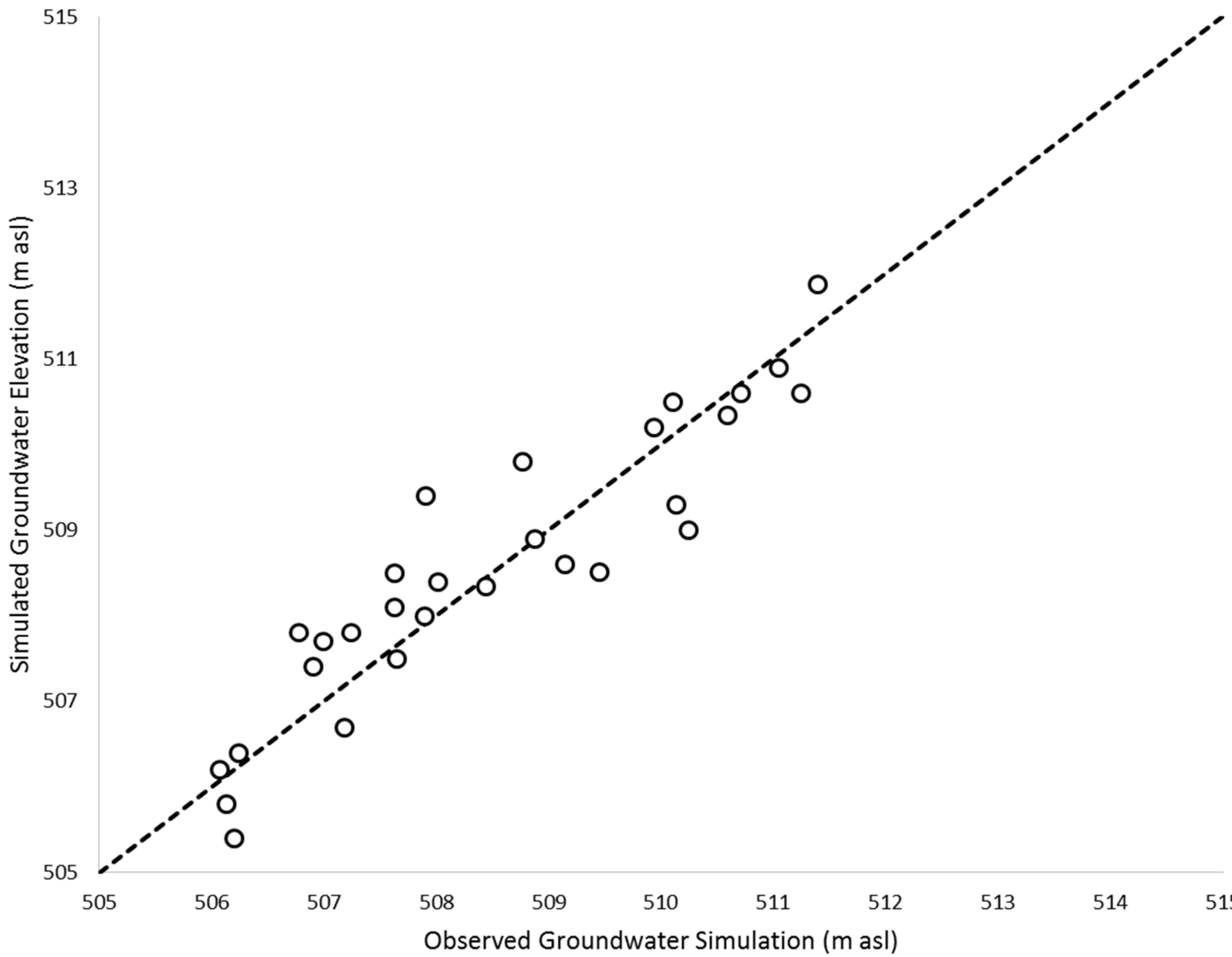
HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES JOYCE LAKE AND AREA DSO PROJECT	
Residual Bubble Plots (Layer 5, Case 2 – Sandy sediments in Joyce Lake)	LABEC CENTURY IRON ORE INC. 拉贝克世纪铁矿公司 / WESA a BluMetric company
Project No. S-B12738-00-00	
Created By: GC	27-Nov-14
Checked By: RTS	Figure D.9b



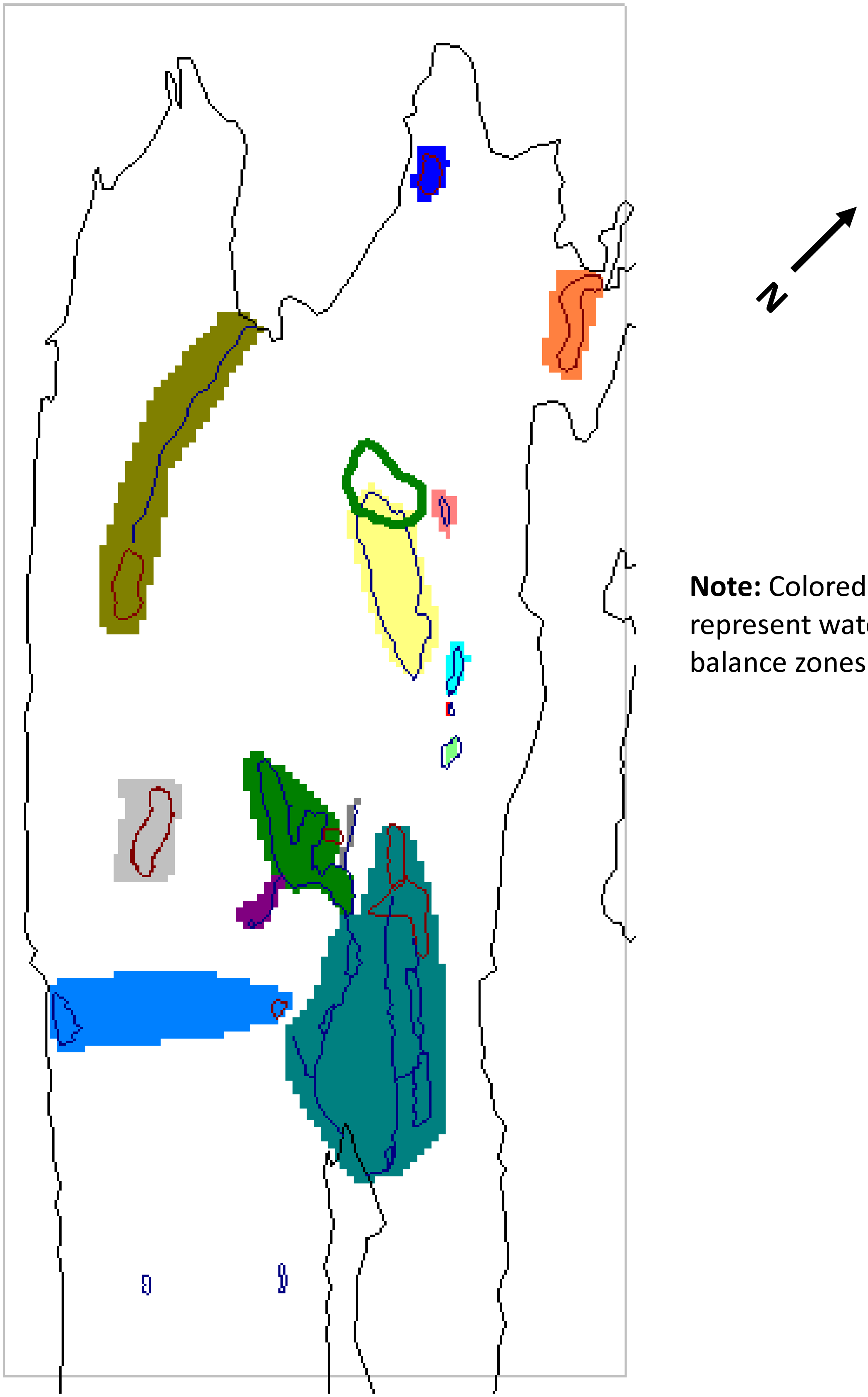
LABEC CENTURY IRON ORE INC.
拉贝克世纪铁矿公司

WESA
a BluMetric company

Scatter Plot (Case 1 – Silty sediments in Joyce Lake)	HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES JOYCE LAKE AND AREA DSO PROJECT
Project No. S-B12738-00-00	
Created By: GC	27-Nov-14
Checked By: RTS	Figure D.10a



LABEC CENTURY IRON ORE INC. 拉贝克世纪铁矿公司 WESA a BluMetric company	Scatter Plot (Case 2 – Sandy sediments in Joyce Lake)	HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES JOYCE LAKE AND AREA DSO PROJECT
	Project No. S-B12738-00-00	
	Created By: GC	27-Nov-14
	Checked By: RTS	Figure D.10b

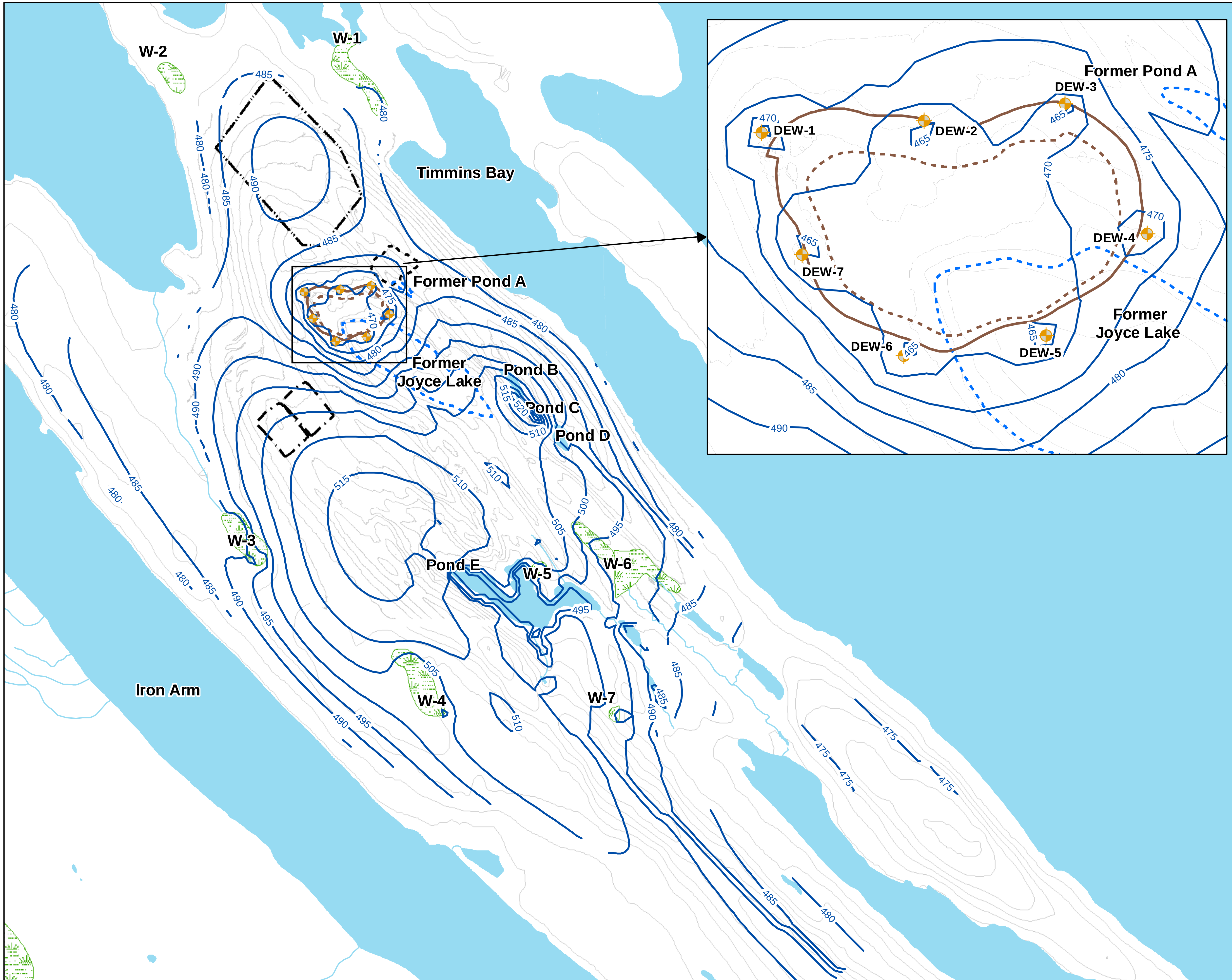


Note: Colored regions represent water balance zones.

Water Balance Zones	GEOTECHNICAL STUDIES JOYCE LAKE AND AREA DSO PROJECT
Project No. S-B12738-00-00	
Created By: GC	27-Nov-14
Checked By: RTS	Figure D.11

LABEC CENTURY IRON ORE INC. 拉贝克世纪铁矿公司

WESA a BluMetric company



LEGEND

- Dewatering Wells
- Topographic Contours (10m)
- Simulated Groundwater Elevation Contour
- Perimeter of Pit Bottom (480masl)
- Perimeter of Pit at Surface
- Streams
- Dewatered Waterbodies
- Waterbodies
- Wetlands (W-5)

Stockpiles

- Waste Dump
- Overburden Stockpile
- Low Grade Stockpile Area

Note: Former Pond A will be dewatered during mine operations

REFERENCES

N W E S

0 250 500 1,000
Meters

CLIENT

Labec Century Iron Ore Inc.

PROJECT

Joyce Lake and Area DSO Project
Hydrogeological Study

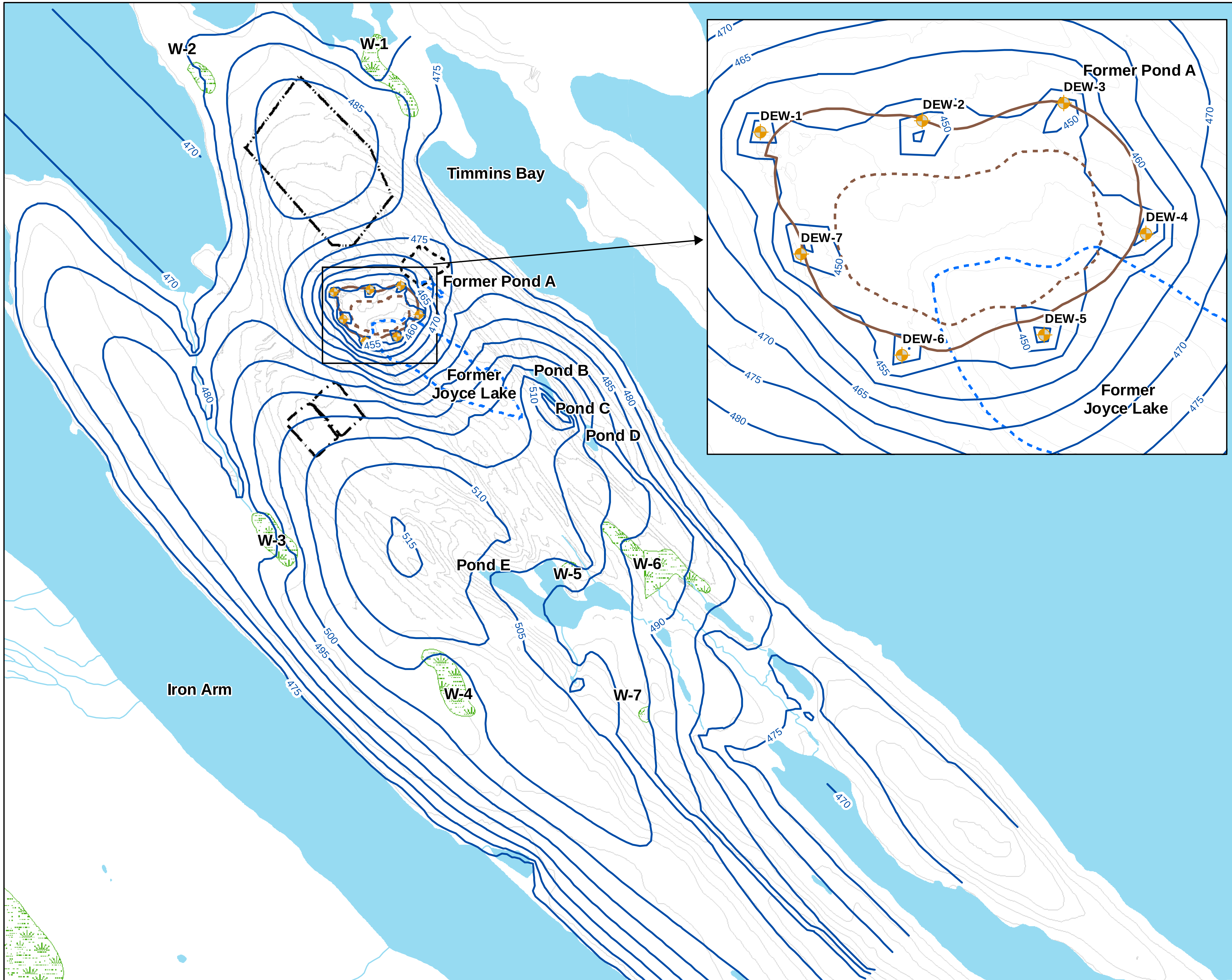
TITLE

Perdicted Groundwater Elevations
Joyce Lake Dewatered and
Pit Development -
Ground Surface to 480 masl

BluMetric Environmental Inc.

3108 Carp Rd PO Box 430
Ottawa, Ontario K0A 1L0
TEL: (613) 839-3053
FAX: (613) 839-5376
Email: info@blumetric.ca
Web: http://www.blumetric.ca

PROJECT #	DATE		
S-B12738-05	November 28, 2014		
DRAWN	VERIFIED	FIG NO.	REV
IB	BOC	D.12	0



LEGEND

- Dewatering Wells
- Topographic Contours (10m)
- Simulated Groundwater Elevation Contour
- Perimeter of Pit Bottom (460masl)
- Perimeter of Pit at Surface
- Streams
- Dewatered Waterbodies
- Waterbodies
- Wetlands (W-5)

Stockpiles

- Waste Dump
- Overburden Stockpile
- Low Grade Stockpile Area

Note: Former Pond A will be dewatered during mine operations

REFERENCES

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0 250 500 1,000
Meters

CLIENT

Labec Century Iron Ore Inc.

PROJECT

Joyce Lake and Area DSO Project Hydrogeological Study

TITLE **Predicted Groundwater Elevations Joyce Lake Dewatered and Pit Development – 480 masl - 460 masl**

BluMetric Environmental Inc.

3108 Carp Rd PO Box 430
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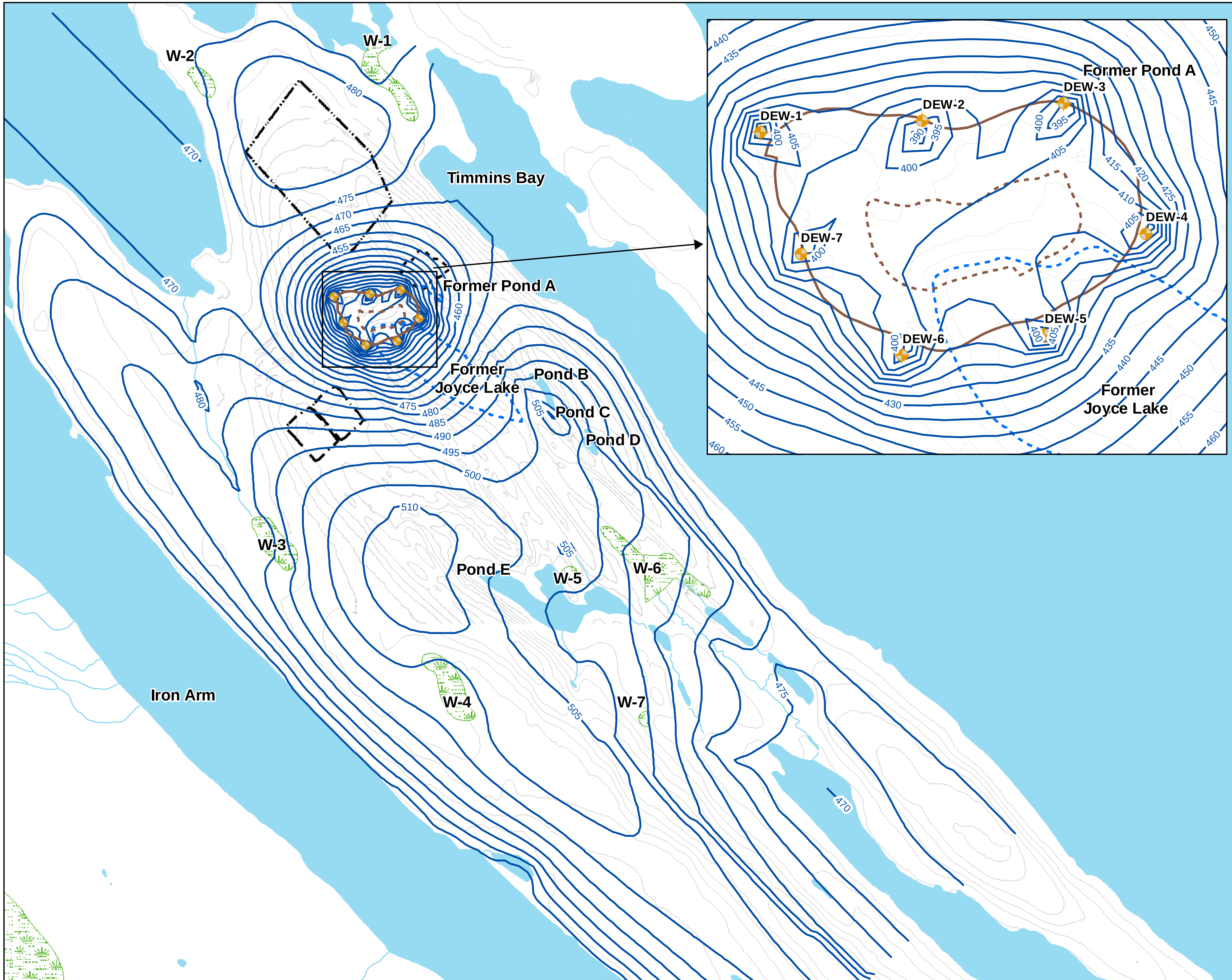
Web: http://www.blumetric.ca

PROJECT #	DATE		
S-B12738-05	November 28, 2014		
DRAWN	VERIFIED	FIG NO.	REV
IB	BOC	D.13	0



LEGEND

- Dewatering Wells
- Topographic Contours (10m)
- Simulated Groundwater Elevation Contour
- Perimeter of Pit Bottom (420masl)
- Perimeter of Pit at Surface
- Streams
- Dewatered Waterbodies
- Waterbodies
- Wetlands (W-5)

Stockpiles

- Waste Dump
- Overburden Stockpile
- Low Grade Stockpile Area

Note: Former Pond A will be dewatered during mine operations

REFERENCES

0 250 500 1,000
Meters

CLIENT

Labec Century Iron Ore Inc.

PROJECT

Joyce Lake and Area DSO Project
Hydrogeological Study

TITLE **Predicted Groundwater Elevations Joyce Lake Dewatered and Pit Development – 460 masl - 420 masl**

BluMetric Environmental Inc.

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Ottawa, Ontario K0A 1L0
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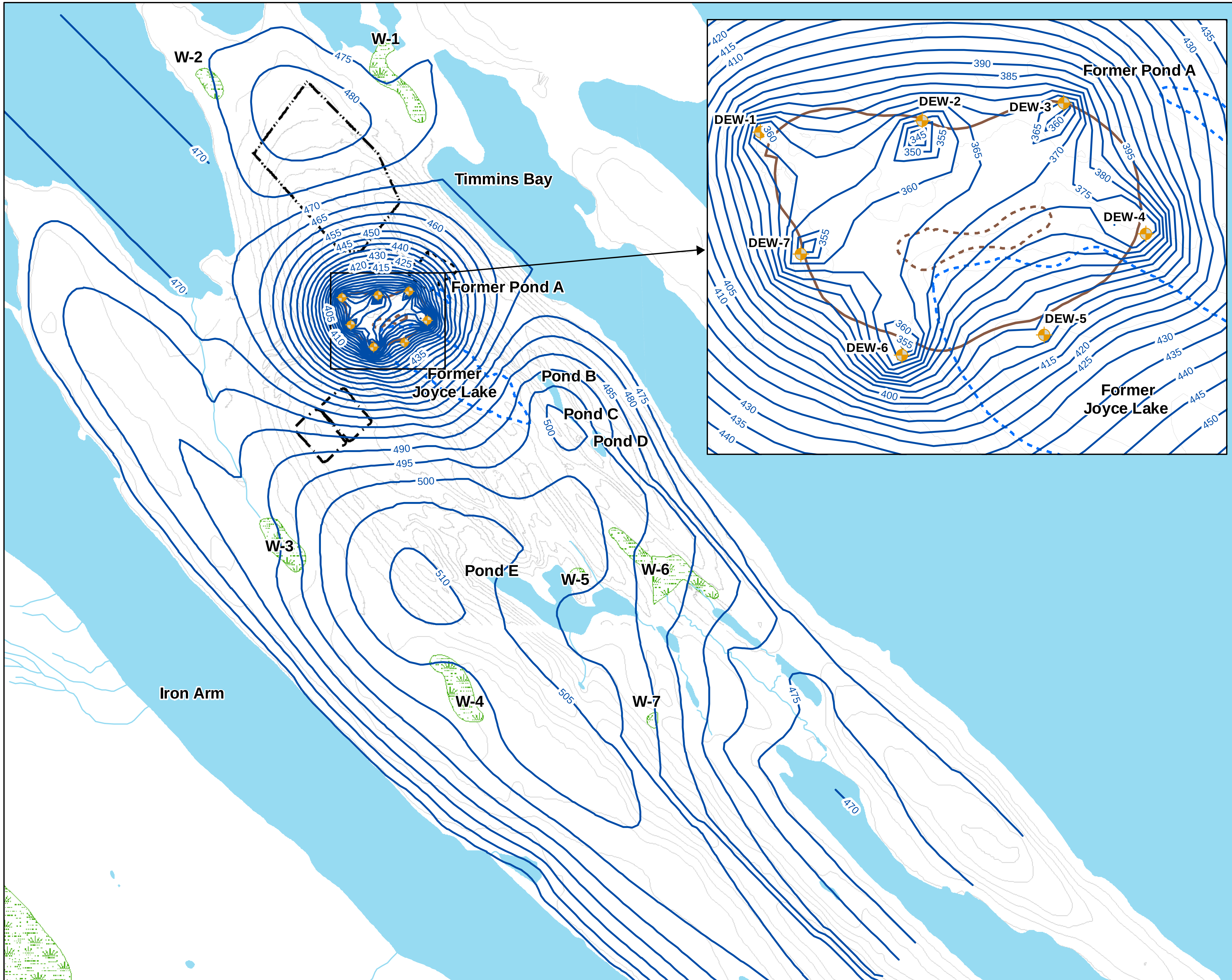
Web: http://www.blumetric.ca

PROJECT #	DATE		
S-B12738-05	November 28, 2014		
DRAWN	VERIFIED	FIG NO.	REV
IB	BOC	D.14	0



LEGEND

- Dewatering Wells
- Topographic Contours (10m)
- Simulated Groundwater Elevation Contour
- Perimeter of Pit Bottom (380 masl)
- Perimeter of Pit at Surface
- Streams
- Dewatered Waterbodies
- Waterbodies
- Wetlands (W-5)

Stockpiles

- Waste Dump
- Overburden Stockpile
- Low Grade Stockpile Area

Note: Former Pond A will be dewatered during mine operations

REFERENCES

PROPRIETARY INFORMATION MAY NOT BE REPRODUCED OR DIVULGED WITHOUT PRIOR WRITTEN CONSENT OF BLUMETRIC ENVIRONMENTAL INC.
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0 250 500 1,000
Meters

CLIENT

Labec Century Iron Ore Inc.

PROJECT

Joyce Lake and Area DSO Project
Hydrogeological Study

TITLE **Predicted Groundwater Elevations Joyce Lake Dewatered and Pit Development – 420 masl - 380 masl**

BluMetric Environmental Inc.

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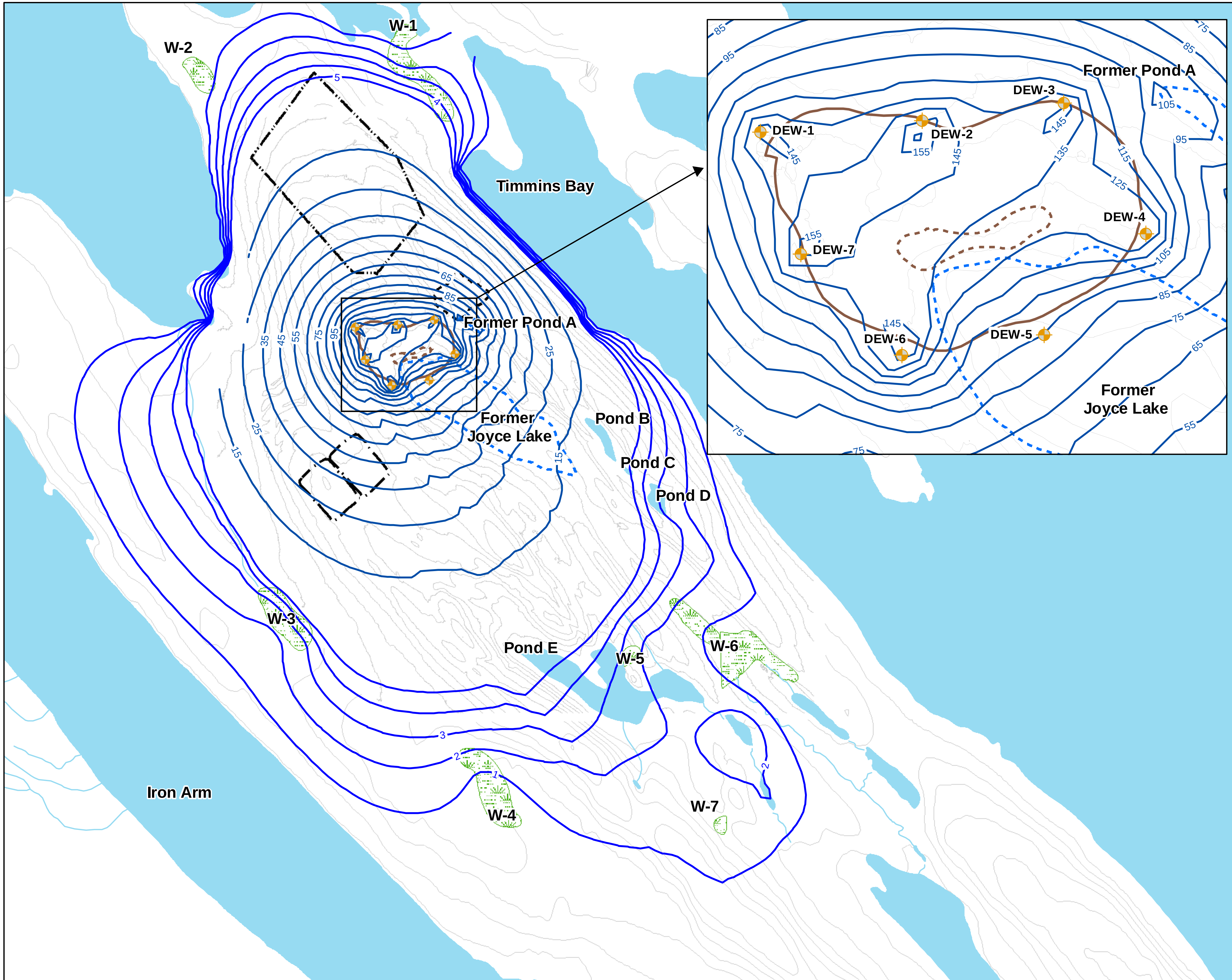
FAX: (613) 839-5376
Email: info@blumetric.ca
Web: http://www.blumetric.ca

PROJECT #	DATE		
S-B12738-05	November 28, 2014		
DRAWN	VERIFIED	FIG NO.	REV
IB	BOC	D.15	0



LEGEND

- Dewatering Wells
- Topographic Contours (10m)
- Simulated Drawdown Contour (1 m)
- Simulated Drawdown Contour (10 m)
- Perimeter of Pit Bottom (380masl)
- Perimeter of Pit at Surface
- Streams
- Dewatered Waterbodies
- Waterbodies
- Wetlands (W-5)

Stockpiles

- Waste Dump
- Overburden Stockpile
- Low Grade Stockpile Area

Note: Former Pond A will be dewatered during mine operations

REFERENCES

0 250 500 1,000
Meters

CLIENT

Labec Century Iron Ore Inc.

PROJECT

Joyce Lake and Area DSO Project Hydrogeological Study

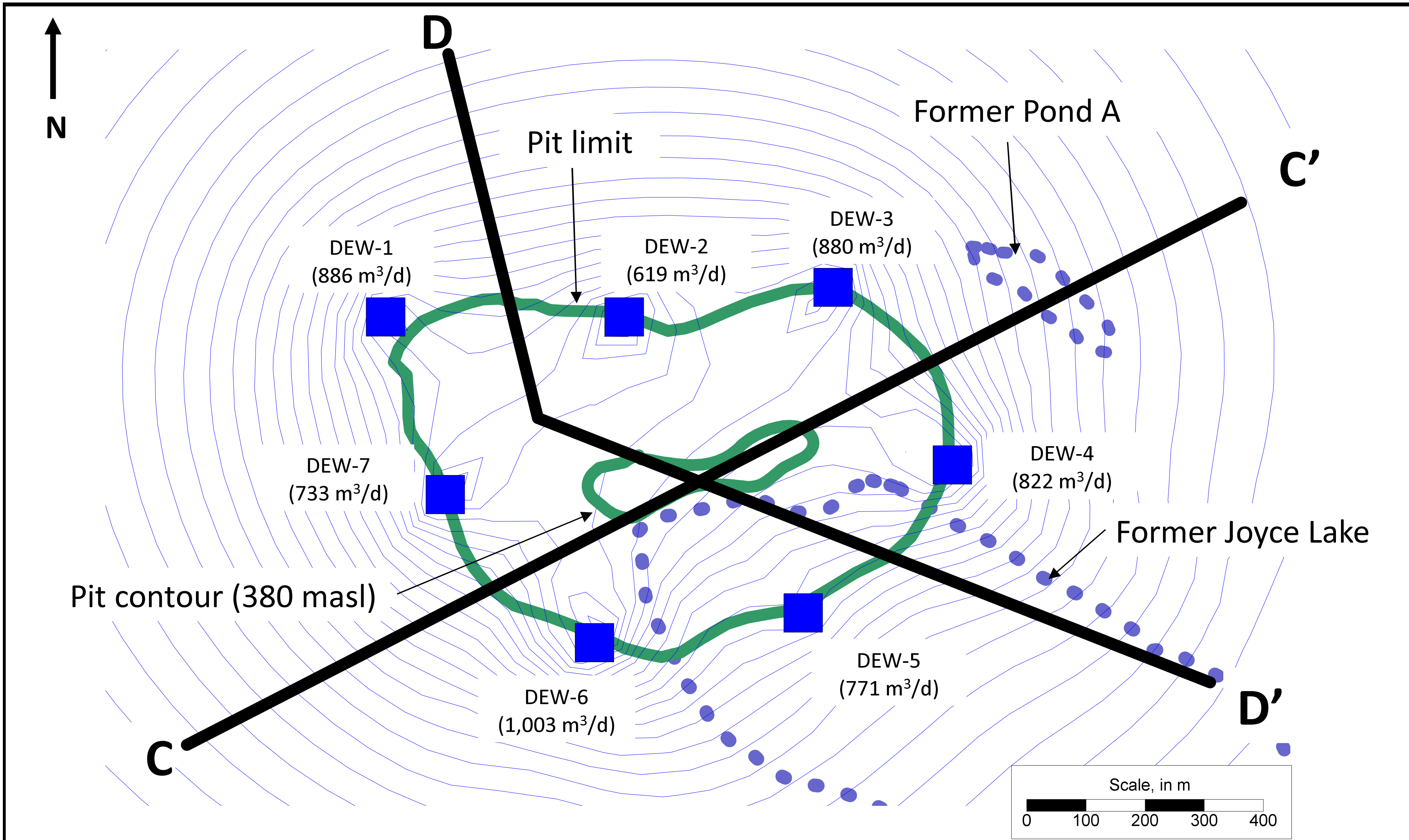
TITLE

Predicted Groundwater Elevations Joyce Lake Dewatered and Pit Development – Groundwater Drawdown 380 masl

BluMetric Environmental Inc.

3108 Carp Rd PO Box 430
Ottawa, Ontario K0A 1L0
TEL: (613) 839-3053
FAX: (613) 839-5376
Email: info@blumetric.ca
Web: http://www.blumetric.ca

PROJECT #	DATE		
S-B12738-05	November 28, 2014		
DRAWN	VERIFIED	FIG NO.	REV
IB	BOC	D.16	0

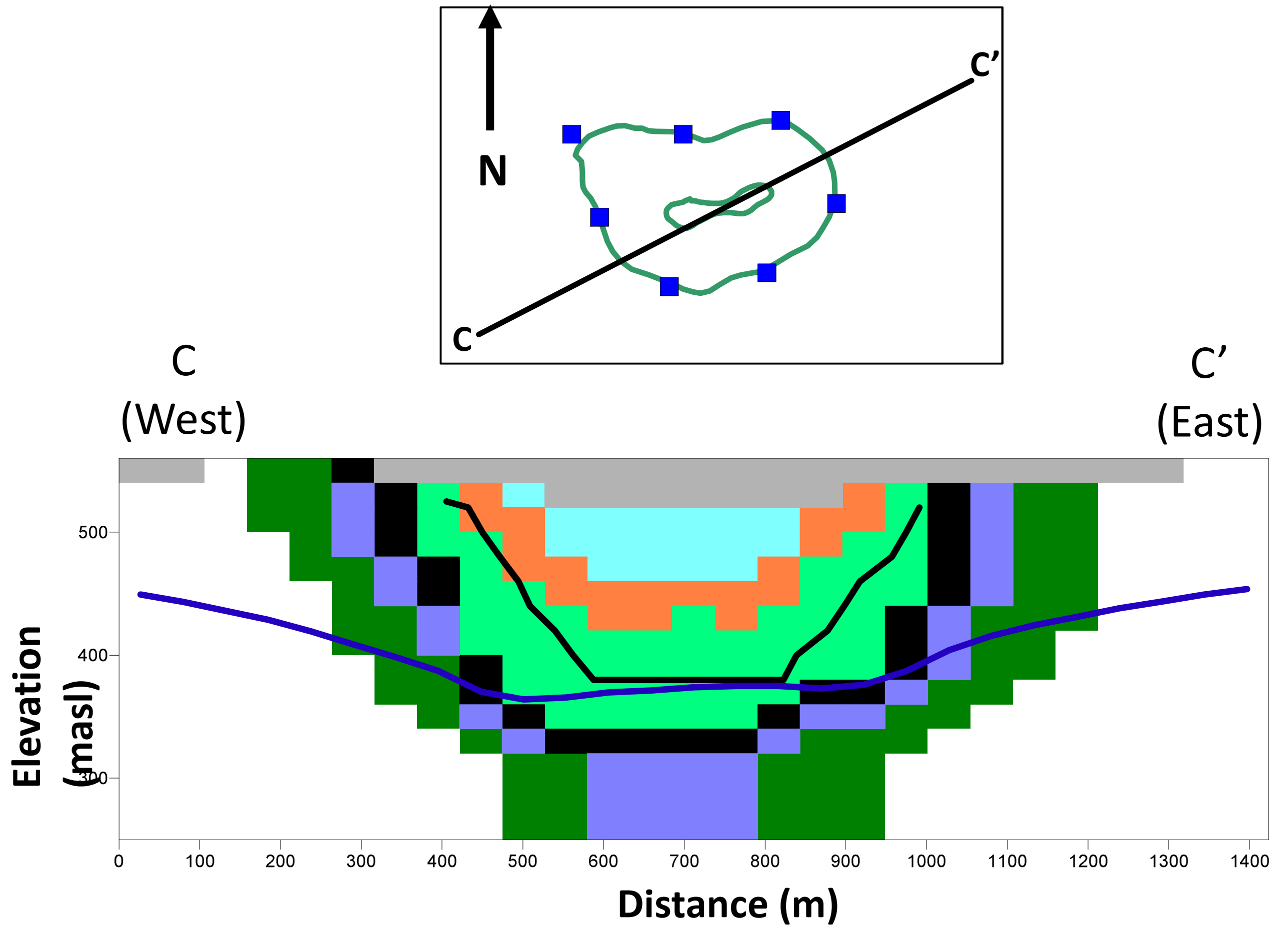


Legend

Dewatering well location and pumping rate (Option 1, Phase IV)

Simulated groundwater elevation contour (Option 1, Phase IV)

HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES JOYCE LAKE AND AREA DSO PROJECT	
Cross-section C-C' Location (Through Open Pit)	LABEC CENTURY IRON ORE INC. 拉贝克世纪铁矿公司 WESA a BluMetric company
Project No. S-B12738-00-00	
Created By: GC	30-Nov-14
Checked By: RTS	Figure D.17a



Legend

- Dolly
- Wishart-deep
- Wishart-shallow
- Ruth
- LRC/LMH
- URC
- UMH
- MSS
- Inactive

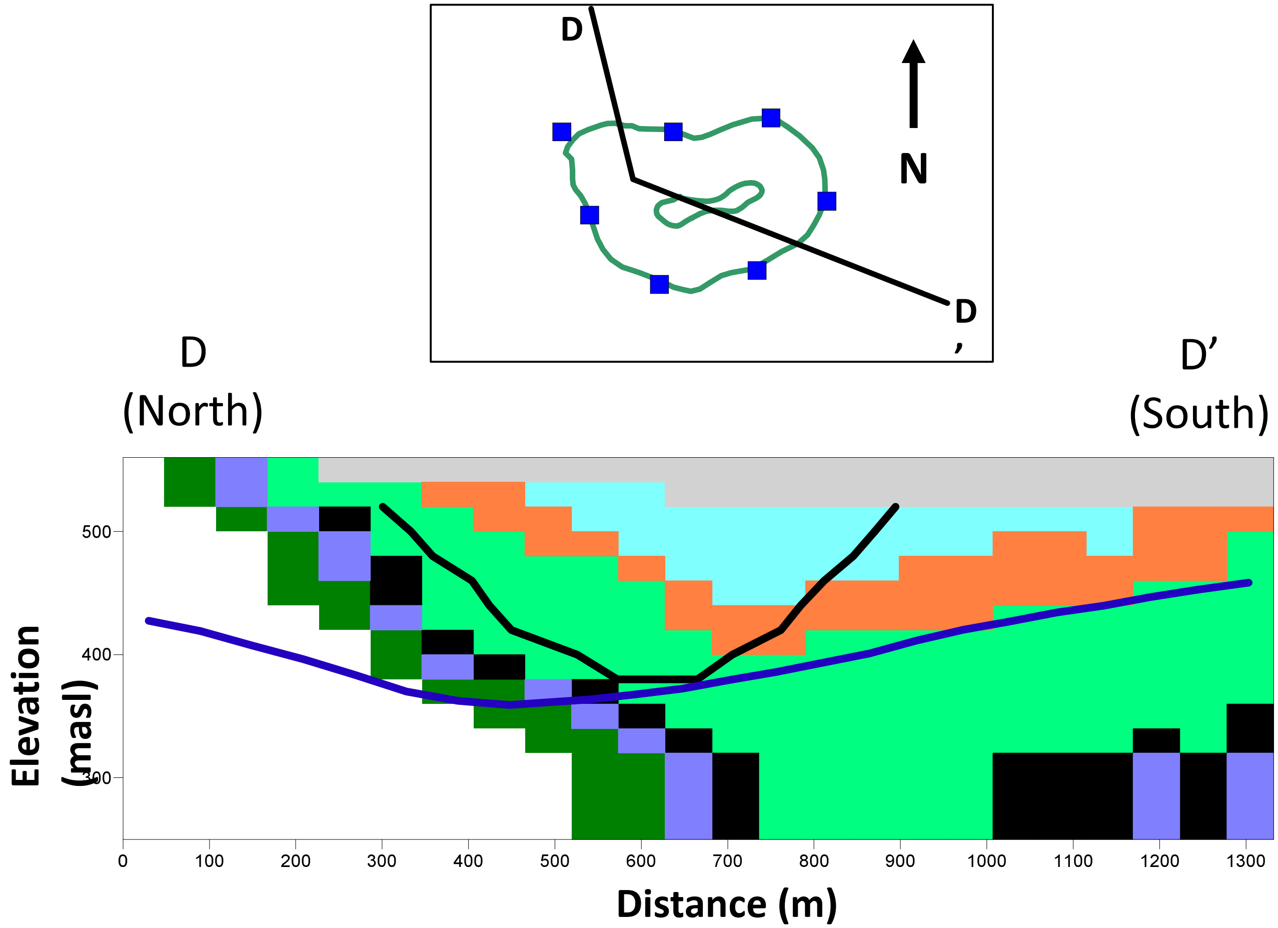
HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES
JOYCE LAKE AND AREA DSO PROJECT

LABEC CENTURY IRON ORE INC.
拉贝克世纪铁矿公司

WESA
a BluMetric company

Simulated Water Table Profile in Cross-Section C-C' (Joyce Lake Completely Dewatered, Phase IV, Model Layer 9)

Project No. S-B12738-00-00	
Created By: GC	30-Nov-14
Checked By: RTS	Figure D.17b



Legend

- Dolly
- Wishart-deep
- Wishart-shallow
- Ruth
- LRC/LMH
- URC
- UMH
- MSS
- Inactive

HYDROGEOLOGICAL AND GEOTECHNICAL STUDIES
JOYCE LAKE AND AREA DSO PROJECT

LABEC CENTURY IRON ORE INC.
拉贝克世纪铁矿公司

WESA
a BluMetric company

Simulated Water Table Profile in Cross-Section D-D' (Joyce Lake Completely Dewatered, Phase IV, Model Layer 9)

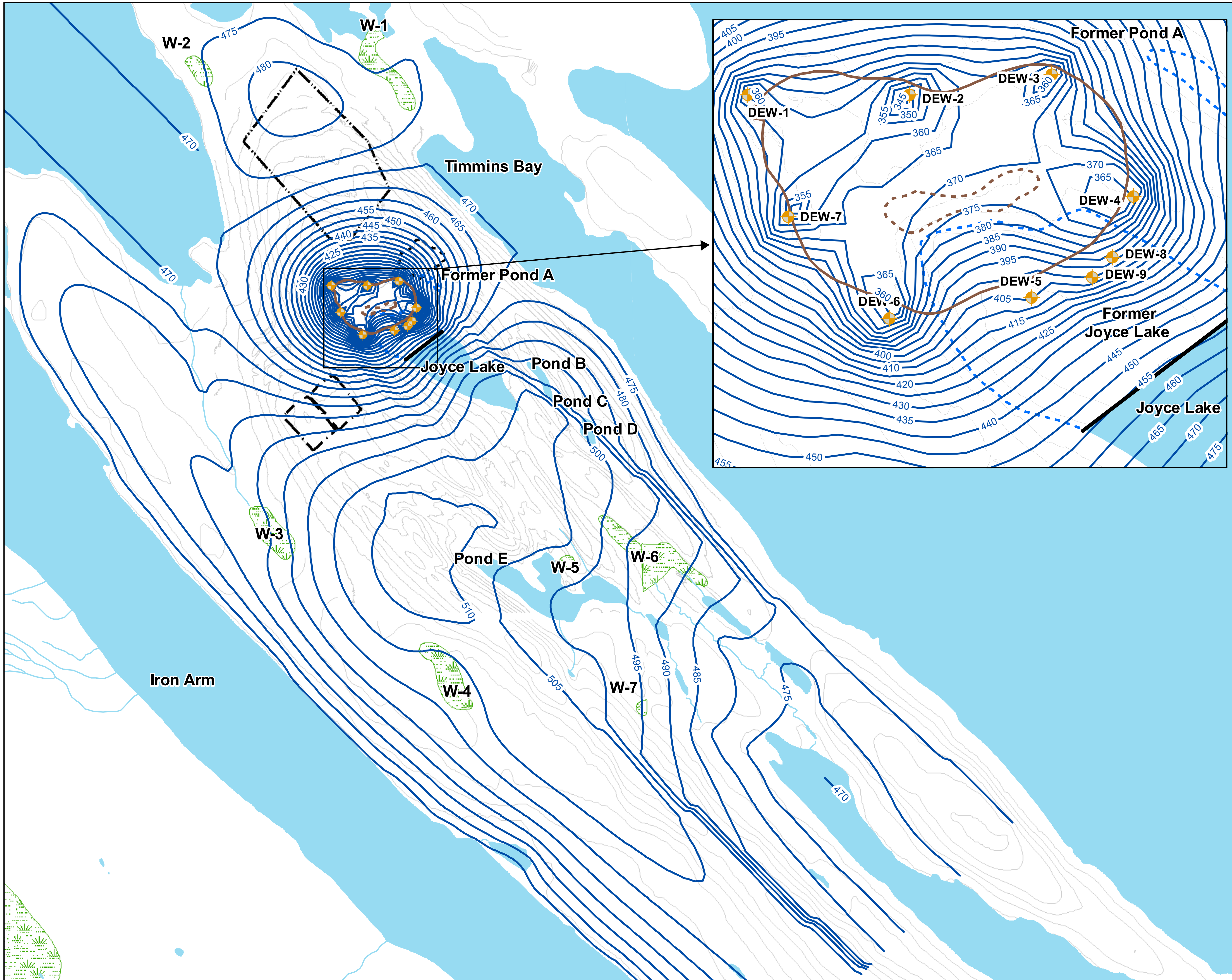
Project No. S-B12738-00-00

Created By: GC

Checked By: RTS

30-Nov-14

Figure D.17c



LEGEND

- Dewatering Wells
- Topographic Contours (10m)
- Proposed Berm
- Perimeter of Pit Bottom (380masl)
- Perimeter of Pit at Surface
- Simulated Groundwater Elevation Contours
- Streams
- Dewatered Waterbodies
- Waterbodies
- Wetlands (W-5)

Stockpiles

- Waste Dump
- Overburden Stockpile
- Low Grade Stockpile Area

Note: Former Pond A will be dewatered during mine operations

REFERENCES

0 250 500 1,000
Meters

CLIENT

Labec Century Iron Ore Inc.

PROJECT

Joyce Lake and Area DSO Project Hydrogeological Study

TITLE

Predicted Groundwater Elevations Joyce Lake Partially Dewatered and Pit Development – Groundwater Surface 420 - 380 masl (Senario 1)

BluMetric Environmental Inc.

3108 Carp Rd PO Box 430
Ottawa, Ontario K0A 1L0
TEL: (613) 839-3053
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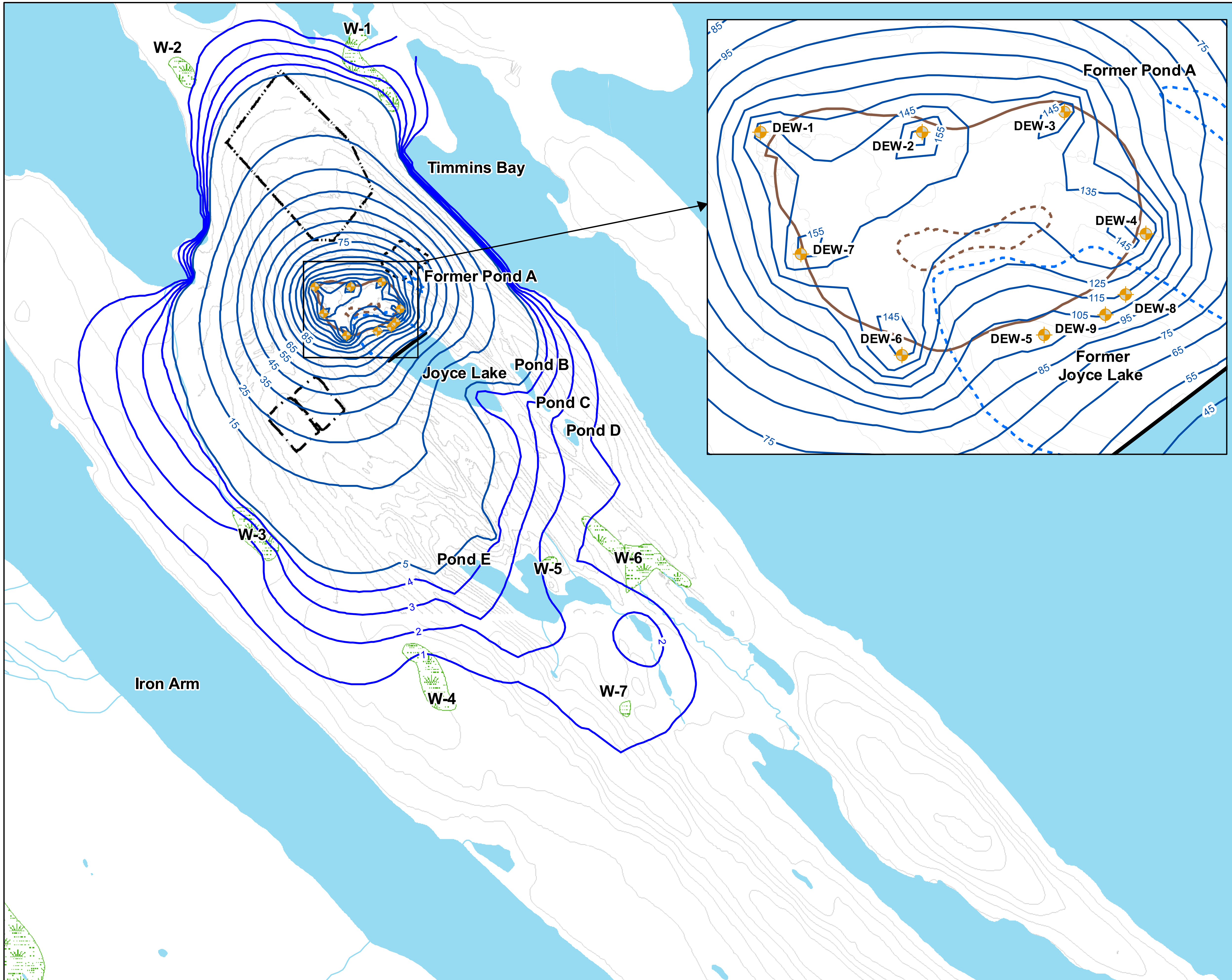
Email: info@blumetric.ca
Web: http://www.blumetric.ca

PROJECT #	DATE		
S-B12738-05	December 23, 2014		
DRAWN	VERIFIED	FIG NO.	REV
IB	BOC	D.18	0



LEGEND

- Dewatering Wells
- Topographic Contours (10m)
- Simulated Drawdown Contour (1m)
- Simulated Drawdown Contour (10m)
- Proposed Berm
- Perimeter of Pit Bottom (380masl)
- Perimeter of Pit at Surface
- Streams
- Dewatered Waterbodies
- Waterbodies
- Wetlands (W-5)

Stockpiles

- Waste Dump
- Overburden Stockpile
- Low Grade Stockpile Area

Note: Former Pond A will be dewatered during mine operations

REFERENCES

0 250 500 1,000
Meters

N E S W

CLIENT

Labec Century Iron Ore Inc.

PROJECT

Joyce Lake and Area DSO Project Hydrogeological Study

TITLE **Predicted Groundwater Elevations Joyce Lake Partially Dewatered and Pit Development – Groundwater Drawdown 380 masl (Scenario 1)**

BluMetric Environmental Inc.

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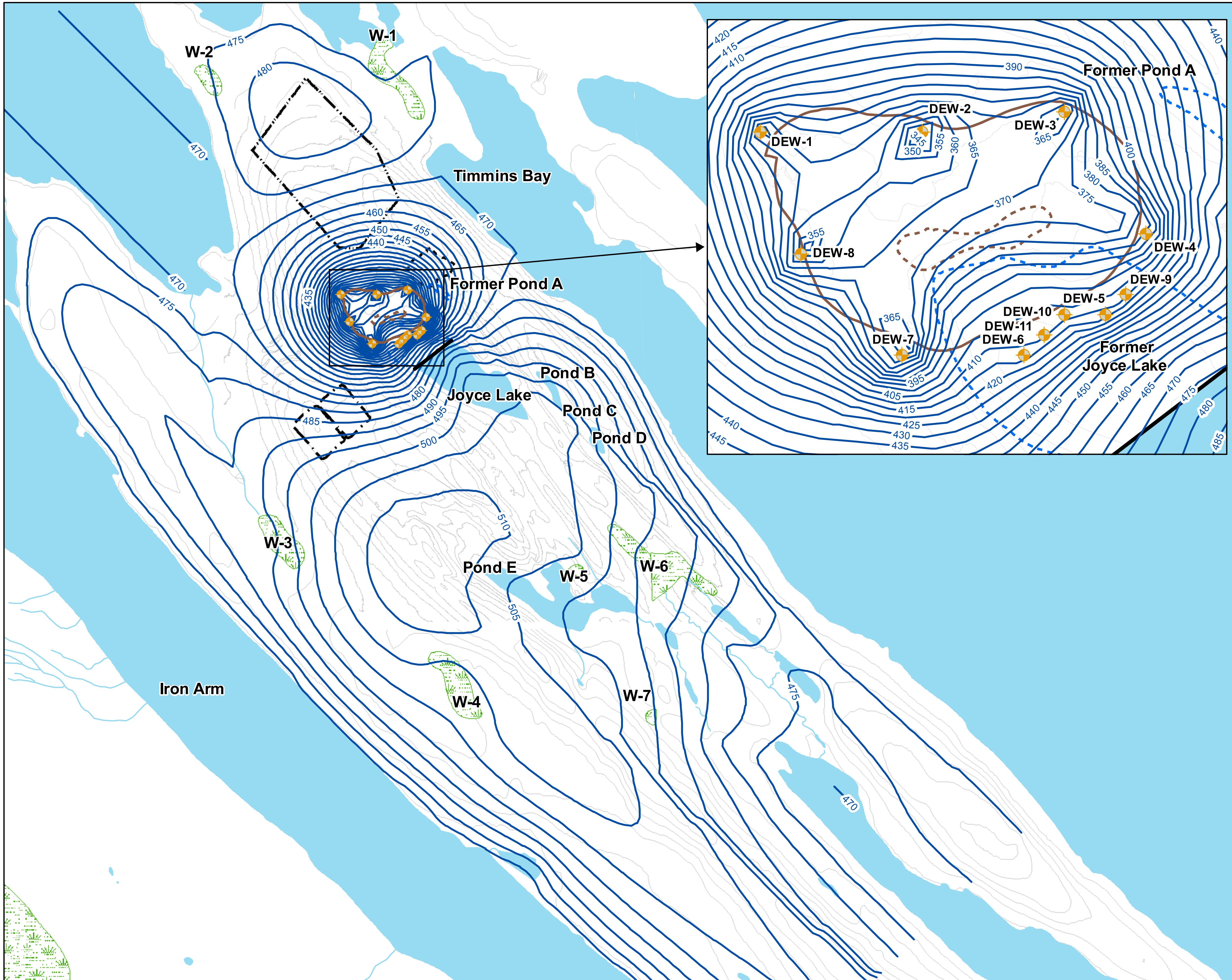
Web: http://www.blumetric.ca

PROJECT #		DATE	
S-B12738-05		December 23, 2014	
DRAWN	VERIFIED	FIG NO.	REV
IB	BOC	D.19	0



LEGEND

- Dewatering Wells
- Topographic Contours (10m)
- Proposed Berm
- Simulated Groundwater Elevation Contour
- Perimeter of Pit Bottom (380masl)
- Perimeter of Pit at Surface
- Streams
- Dewatered Waterbodies
- Waterbodies
- Wetlands (W-5)

Stockpiles

- Waste Dump
- Overburden Stockpile
- Low Grade Stockpile Area

Note: Former Pond A will be dewatered during mine operations

REFERENCES

N W E S

0 250 500 1,000
Meters

CLIENT

Labec Century Iron Ore Inc.

PROJECT

Joyce Lake and Area DSO Project
Hydrogeological Study

TITLE

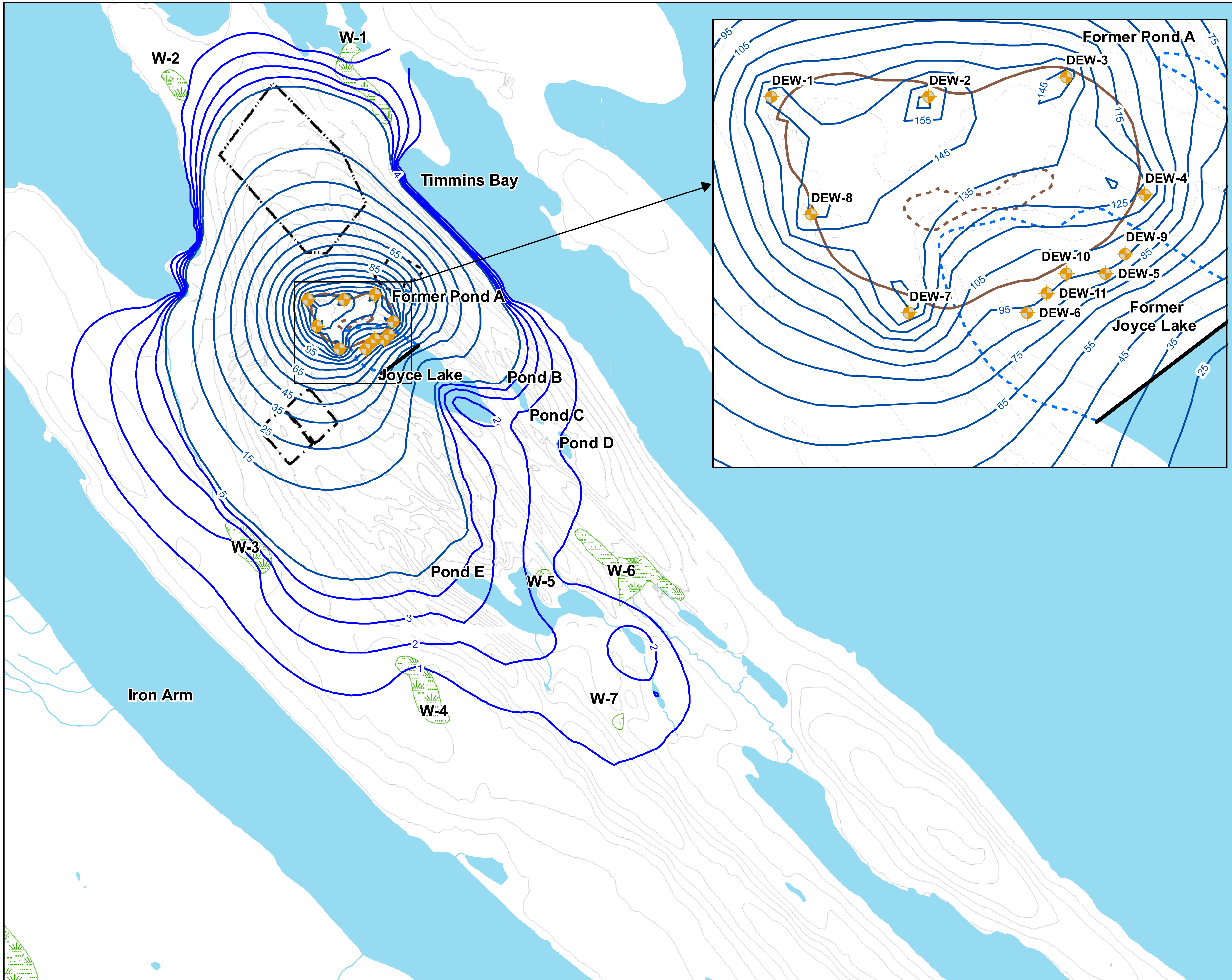
Predicted Groundwater Elevations Joyce Lake Partially Dewatered and Pit Development – Ground Surface 420 masl - 380 masl (Scenario 2)

BluMetric Environmental Inc.

BluMetric™

3108 Carp Rd PO Box 430
Ottawa, Ontario K0A 1L0
TEL: (613) 839-3053
FAX: (613) 839-5376
Email: info@blumetric.ca
Web: http://www.blumetric.ca

PROJECT #	DATE		
S-B12738-05	December 23, 2014		
DRAWN	VERIFIED	FIG NO.	REV
IB	BOC	D.20	0



LEGEND

- Dewatering Wells
- Proposed Berm
- Topographic Contours (10m)
- Simulated Drawdown Contour (1m)
- Simulated Drawdown Contour (10m)
- Perimeter of Pit Bottom (380masl)
- Perimeter of Pit at Surface
- Streams
- Dewatered Waterbodies
- Waterbodies
- Wetlands (W-5)

Stockpiles

- Waste Dump
- Overburden Stockpile
- Low Grade Stockpile Area

Note: Former Pond A will be dewatered during mine operations

REFERENCES

0 250 500 1,000
Meters

N S W E

CLIENT

Labec Century Iron Ore Inc.

PROJECT

Joyce Lake and Area DSO Project Hydrogeological Study

TITLE

Predicted Groundwater Elevations Joyce Lake Partially Dewatered and Pit Development – Groundwater Drawdown 380 masl (Scenario 2)

BluMetric Environmental Inc.

3108 Carp Rd PO Box 430
Ottawa, Ontario K0A 1L0
TEL: (613) 839-3053
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Email: info@blumetric.ca
Web: http://www.blumetric.ca

PROJECT #		DATE	
S-B12738-05		December 23, 2014	
DRAWN	VERIFIED	FIG NO.	REV
IB	BOC	D.21	0

Division of BluMetric Environmental Inc.

Envir-Eau

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Canada J8T 8J1
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Seprotech

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Fax: (613) 731-0851
contact@seprotech.com

WESA Tecnologias S.A. de C.V.

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