Final

2013 Vangorda Creek Diversion Field Investigation Data and Analysis Report Faro Mine Remediation Project

Prepared for

Government of Yukon and Government of Canada as represented by Aboriginal Affairs and Northern Development Canada

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CH2MHILL®

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Acronyms and Abbreviations

ALS	ALS Laboratory Group
ARD	acid rock drainage
ASTM	ASTM International (formerly the American Society of Testing and Materials)
Aurora	Aurora Geosciences
ABA	acid–base accounting
AP	acid potential
CH2M HILL	CH2M HILL Limited Canada
CSSC	Canadian System of Soil Classification
DTM	digital terrain model
DQE	data quality evaluation
Golder	Golder Associates Ltd.
GPR	ground penetrating radar
FMC	Faro Mine Complex
FSP	field sampling plan
g/cm^3	grams per square centimetre
GPR	ground-penetrating radar
GW	groundwater
km	kilometres
km^2	square kilometres
kN	kilonewtons
m	metres
mbgs	metres below ground surface
MPa	megaPascals(s)
NNP	net neutralization potential
NP	neutralizing potential
QA/QC	quality assurance and quality control
QAPP	Quality Assurance Project Plan
RTK	real-time kinematic
SOP	standard operating procedure
SRK	SRK Consulting, Inc.
USCS	Unified Soil Classification System
WRD	waste rock dump
YG	Government of Yukon

SECTION 1

Introduction

CH2M HILL Limited Canada (CH2M HILL) was retained by the Government of Yukon (YG) and the Government of Canada as Represented by Aboriginal Affairs and Northern Development Canada to conduct remedial investigations and associated activities at the Faro Mine Complex (FMC), located near the town of Faro, Yukon. These phased activities are conducted to support the overall long-term goal of remediating the FMC and reducing environmental impacts associated with acid rock drainage entering nearby watercourses. This report presents field investigation data obtained for use in designing a replacement for the existing Vangorda Creek Diversion (VCD).

1.1 Site Description

The FMC is located at 62°18'39.74"N and 133°18'18.06"W in south-central Yukon, 15 kilometres (km) north of the town of Faro and nearly 200 km northeast of the city of Whitehorse (see Figure 1-1). The FMC has a footprint of over 25 square kilometres (km^2) and consists of three distinct areas:

- The Faro Mine Area, including Faro Pit, waste rock dumps, a disused mill, and associated buildings
- The Rose Creek Tailings Area including impoundment in Rose Creek Valley
- The Vangorda/Grum Area, which is located on the Vangorda Plateau and includes Grum Pit and Vangorda Pit, and associated waste dumps.

The Vangorda/Grum Area is approximately 10 km southeast of Faro Pit (see Figure 1-2). Vangorda Pit is approximately 1,150 metres (m) long and 200 to 350 m wide; the pit is oriented in a northwest–southeast direction along its longitudinal axis. Approximately 16 million tonnes of mine waste surround Vangorda Pit, covering approximately 0.4 km^2. Historical Vangorda Creek passed through what is now the Vangorda Pit site. The creek was diverted around the northern perimeter of the pit through the VCD, in an open corrugated metal flume. (CH2M HILL, 2012a)

1.2 Purpose

This report presents the results of 2013 Task Authorization 018 field reconnaissance. The purpose of the investigation was to collect geologic and hydraulic information to support the design of the replacement VCD.

1.3 Objectives

The objectives of the field investigation are as follows:

- Obtain additional information to support the evaluation of erosion potential, seepage, and slope stability for SRK's 2010 proposed VCD and associated components
- Collect flow information to update the regional hydrological analysis and refine peak instantaneous flood estimates
- Determine bedrock and overburden characteristics including bedrock topography
- Characterise the geochemical and geotechnical properties of potential construction materials

1.4 Scope of Work

The scope of work is defined in Task Authorisation Request (TAR) 007(I), Fiscal Year 2013–2014 Field (CH2M HILL, 2013a); details are provided in the document Construct the New Vangorda Creek Diversion, Field Sampling Plan (CH2M HILL, 2013b). The scope of work includes the following activities:

- Conduct geophysical surveys of the SRK-proposed VCD alignment, Granitic Rock Outcrop, and Grum Waste Rock Dump Quarry to determine bedrock profile and rock quality
- Complete a drilling program at the Granitic Rock Outcrop and the SRK-proposed VCD alignment
- Collect and log surface samples from the Granitic Rock Outcrop and Grum Waste Rock Dump Quarry
- Conduct topographic surveys of SRK's 2010 proposed VCD
- Preform fluvian geomorphic assessments of Vangorda Creek
- Inspect the meteorological stations
- Conduct a reconnaissance of SRK's 2010 proposed VCD alignment
- Install and collect data from stream gauges in Vangorda Creek
- Collect samples from proposed VCD, the Granitic Rock Outcrop, and the Grum Waste Rock Dump Quarry for laboratory analysis

SECTION 2

Background

The existing VCD diverts stream flow from the original Vangorda Creek channel around Vangorda Pit. The existing VCD, which was originally designed with a capacity to divert a 1-in-100-year flood event, is located immediately north of and adjacent to Vangorda Pit (see Figure 2-1). Although the existing VCD has generally been successful at diverting stream flow around the pit, the conveyance structure (consisting of half-round, corrugated steel pipe) has been damaged at several locations and has overflowed during extreme rainfall events. The structure is deteriorated because of corrosion, and it has been damaged by ice formation, ice movement, and the removal of ice and snow during winter maintenance (SRK 2010). The VCD has leaked but this has not resulted in excessive seepage to the Vangorda Pit wall. The Vangorda Pit walls adjacent to the VCD channel are showing signs of rock ravelling and slumping. Failure would result in Vangorda Creek being discharged to Vangorda Pit (CH2M HILL, 2013c).

The three primary performance objectives of the existing VCD design were to (1) convey diverted stream flow away from Vangorda Pit in a watertight structure, (2) reduce seepage from the VCD into Vangorda Pit, and (3) reduce the potential for instability and ravelling of the pit wall (CH2M HILL, 2013c).

2.1 Geochemical Screening Criteria

The following screening criteria were used to provide a context for laboratory data. These criteria were not used to identify regulatory exceedances.

2.1.1 Leach Data

Leachate analytical results presented in this report are compared with the Canadian Environmental Quality Guidelines (CEQG) (Canadian Council of Ministers of the Environment, 2007) for freshwater aquatic life. The CEQG is intended to protect freshwater and marine life from anthropogenic stressors, such as chemical inputs or changes to physical components. The CEQG provides numerical limits or narrative statements based on the most current, scientifically defensible toxicological data available for the parameters.

2.1.2 Total Metals

Samples were analyzed for total metals to evaluate the relative metal concentrations among the samples and identify samples with anomalous metal concentrations. Total metals concentrations were compared with the median concentrations in soil and elemental crustal abundance concentrations to identify relative elevated concentrations. The median soil concentrations were sourced from the *Global Acid Rock Drainage (GARD) Guide (*International Network for Acid Prevention, 2013). Elemental crustal abundance concentrations were sourced from Price (2009) and presented as 10 times the average value in the continental crust. Concentrations 12 to 24 times the median soil concentrations are considered elevated and have a geochemical abundance index (GAI) of 3, calculated by Equation 1:

$$GAI = \log_2(\text{element concentration}/1.5*\text{median soil concentration}) \quad (1)$$

Concentrations exceeding a GAI of 3 or 10 times the elemental crustal abundance concentrations are considered elevated.

2.1.3 Acid–Base Accounting

The acid–base accounting (ABA) analysis was performed on samples from the VCD investigation to assess the material's potential to produce or neutralise acid rock drainage (ARD). The evaluation will support the decision making process regarding construction material suitability. ABA testing is generally used to predict the tendency of a material to generate or neutralize acid by providing a "snapshot" of the balance between the acid production and acid neutralization, based on the sulphur content and presence of neutralizing species such as carbonate minerals. Indices used to evaluate ABA data include paste pH, neutralisation potential (NP) to acid production (AP) ratios, and net neutralization potential (NNP). For ABA characteristics, these criteria are categorized as: (1) potentially acid-generating, (2) non-acid-generating, and (3) intermediate. The following are the threshold values (United States Environmental Protection Agency [USEPA], 1999):

- NP:AP values greater than 3:1 suggest non-acid-generating material.
- NP:AP values less than 1:1 suggest potentially acid-generating material.
- NP:AP values between 1:1 and 3:1 suggest intermediate or "uncertain" material.
- NNP values greater than zero suggests net acid-neutralizing material.
- NNP values less than zero suggests net acid-generating material.

These criteria provide the basis for determining whether a particular rock type will be suitable borrow material for future construction.

SECTION 3

Field Investigation Activities

Field investigations and laboratory testing were completed in accordance with established field sampling plans (FSP): Construct New Vangorda Creek Diversion, Field Sampling Plan (CH2M HILL, 2013b) and Develop and Decommission Faro-Grum-Vangorda Borrow Sources (CH2M HILL, 2013d). See Section 1-4 for a complete list field activities.

The following standard operating procedures (SOP) were used for CH2M HILL investigation activities (SOP titles are provided only at first reference):

- Drilling was conducted in accordance with SOP INV001, Drilling (CH2M HILL, 2013f).
- Soil and bedrock cores were logged in accordance with SOP PCS001, Boring Logs Completion, Soil Classification, and Logging (CH2M HILL, 2013g).
- Soil and rock samples were collected for geochemical and geotechnical testing in accordance with SOP SMP006, Surface and Subsurface Soil Sampling (CH2M HILL, 2013h).
- Piezometers were installed and operated in accordance with SOP INL002, Monitoring Well or Piezometer Installation (CH2M HILL, 2013i).
- Soil and rock samples were collected and labelled in accordance with SOP SMP011, Sample Nomenclature (CH2M HILL, 2013j) and shipped to the testing laboratory in accordance with SOP PCS002, Sample Packing and Shipping – Environmental (CH2M HILL, 2013k) and SOP PCS016, Sample Packing, Shipping, and Storage (Geotechnical) (CH2M HILL, 2013l).

Table 3-1 lists relevant SOPs (tables are located at the end of this section).

3.1 Electronic Data Collection

Some of the field data measurements and observations gathered during the 2013 borrow investigation performed by CH2M HILL were recorded electronically by using Samsung Galaxy Tab 2 10.1 tablets with Android operating systems. The soil and rock characteristics were recorded on electronic forms generated using the Memento Database. These forms included fields for text, number, Boolean entry, and global positioning system (GPS) coordinate and photography capture functions. The collected data were uploaded to the project SharePoint site and quality assurance and quality control (QA/QC) checks were performed daily.

3.2 Vangorda Creek Diversion Activities

3.2.1 Geophysical Survey

CH2M HILL retained Aurora Geosciences (Aurora) of Whitehorse, Yukon, to conduct the geophysical investigations along SRK's 2010 proposed VCD alignment, at the Grump Dump Rock Quarry, and at the Granitic Rock Outcrop. The geophysical survey report (Aurora, 2013a) in Appendix A provides details about geophysical field layout, processing, and GPS measurements; Sections 4.1.1, 4.2.1, and 4.3.1 describe the results of the geophysical investigations. The following geophysical methods were used along the entire length of SRK's 2010 proposed VCD alignment:

- **Electrical resistivity (short dipole)** – an electrical method where direct current is injected into the ground and voltage measurements are recorded at varying distances from the current source. The result is a cross section of the electrical resistivity of the subsurface known as a pseudo-section. The resistivity variations shown on the pseudo-section can be interpreted to provide an estimate of geologic properties, such as lithology and groundwater saturation.

- **Ground-penetrating radar (GPR)** – a radar transceiver is moved along the ground surface to produce a radargram of the subsurface. In the case of the VCD investigation, several different frequency (25, 50, 100, and 500 megahertz) radar antennae were deployed. As a general rule, higher frequencies have higher resolution but lower penetrating power.
- **Seismic refraction** – an acoustic method that is useful for distinguishing depth to bedrock and bedrock rippability. A refraction survey produces a cross section of seismic velocities, which can be interpreted to estimate geologic properties, such as the interface between weathered and unweathered bedrock and bedrock competency.
- **Seismic reflection** – like refraction, this is an acoustic method. Although processed seismic reflection data resembles a GPR radargram in appearance, reflection data generally penetrates deeper than GPR. As with GPR, reflection was conducted for the purpose of evaluating bedrock competency.

3.2.2 Vangorda Creek Diversion Drilling Program

Drilling activities at SRK's 2010 proposed VCD consisted of drilling three boreholes and installing standpipe piezometers (CH13-303-BH001 – CH13-303-BH003). The borings were advanced between July 31 and August 8, 2013, by using a Fraste Mito, track-mounted, ODEX drill rig with capability to switch to rock coring (HQ size). The borings were drilled in accordance with SOP INV001 and logged in accordance with SOP PCS001. Piezometers were installed in accordance with SOP INL002. Twenty-two samples were collected in accordance with SOP SMP011 and shipped for laboratory analysis in accordance with SOP PCS002 or SOP PCS016. Appendix B contains the borehole logs, and Figure 2-1 shows the borehole locations (figures are located at the end of the section where they are first referenced).

3.2.3 In Situ Hydraulic Conductivity Testing

Field measurement of hydraulic conductivity (also referred to as coefficient of permeability) was performed in two of the borings at the SRK-proposed diversion using a cased borehole infiltration technique. This provides an approximate measurement of vertical hydraulic conductivity of the material in the immediate vicinity of the test zone.

3.3 Granitic Rock Outcrop Activities

3.3.1 Geophysical Survey

Aurora performed geophysical surveys at the Granitic Rock Outcrop; geophysical methods included short dipole resistivity, GPR, and seismic refraction. Results are presented in the geophysical survey report (Aurora, 2013b) (see Appendix A).

3.3.2 Granitic Rock Outcrop Borrow Area Drilling

Two boreholes were installed at the Granitic Rock Outcrop. The borings were advanced August 7–9, 2013, by Midnight Sun Drilling Inc., using a dual-rotary Foremost DR24 multipower, reverse-circulation ODEX/NQ triple-tube coring rig.

The borings were drilled in accordance with SOP INV001 and logged in accordance with SOP PCS001. Six samples were collected for laboratory analysis. The samples were collected in accordance with SOP SMP011 and shipped in accordance with SOP PCS002 or SOP PCS016. Appendix B contains the borehole logs, and Figure 3-1 shows the borehole locations; Appendix C includes photographs.

3.3.3 Geological Reconnaissance

CH2M HILL performed a geological reconnaissance at the Granitic Rock Outcrop on July 7–13, 2013. Geological characteristics of fresh rock specimens from outcrops and existing exposures were logged, photographed, and sampled. Six samples were collected in accordance with SOP SMP011 for laboratory analysis and shipped in accordance with SOP PCS002 or SOP PCS016. Appendix C includes photographs, and Figure 3-1 shows the borehole locations.

3.4 Grum Waste Rock Dump Quarry Activities

3.4.1 Geophysical Survey

Aurora conducted geophysical surveys at the Grum Waste Rock Dump Quarry; the methods used included short dipole resistivity, GPR, and seismic refraction. Results are presented in the geophysical survey report (Aurora, 2013c) (see Appendix A).

3.4.2 Geological Reconnaissance and Surface Rock Sampling

CH2M HILL performed a geological reconnaissance at the Grum Waste Rock Dump Quarry on July 7–13, 2013 to determine the extent and characteristics of the materials. Geological characteristics of fresh rock specimens from the existing quarry and nearby outcrops were logged, photographed, and sampled. Five samples were collected for laboratory analysis in accordance with SOP SMP011 and shipped in accordance with SOP PCS002 or SOP PCS016. Figure 3-2 shows sampling locations, and Appendix C includes photographs.

3.5 Mapping, Channel Morphology, and Hydrological Characterization

Challenger Geomatics Ltd. performed two topographic field surveys using real-time kinematic (RTK) GPS methods to improve topographic resolution in the vicinity of SRK's 2010 proposed VCD:

1. August 20–21, 2013: surveyed transects every 25 m within the existing VCD alignment. The survey area extended 200 m upstream and 500 m downstream from the tie-in of SRK's 2010 proposed VCD to the existing Vangorda Creek.
2. October 8–15, 2013: surveyed SRK's 2010 proposed VCD alignment. The survey was intended to refine the current topographic mapping that is obstructed by dense foliage.

For details regarding the previous 2012 mapping, refer to Mapping Development Report (CH2M HILL, 2013m). Results of the 2013 surveys are presented on Figure 3-3.

3.5.1 Fluvial Geomorphic Assessment

A fluvial geomorphic assessment of two specific reaches of Vangorda Creek was performed on August 31, 2013:

- Upstream from SRK's 2010 proposed VCD headworks recommended by SRK (2010)
- Downstream from where the existing VCD discharges to the natural channel below the Haul Road

Figure 3-4 shows these locations. Visual observations were made during clear weather conditions and with no precipitation. The assessment was performed in accordance with *Establishing Current 'Reference' Conditions* (Minnesota River Basin Data Centre, 2008) and *Vermont Stream Geomorphic Assessment Phase 2 Handbook Rapid Stream Assessment Field Protocols* (Vermont Agency of Natural Resources, 2009).

3.5.2 Vangorda Creek Diversion Alignment Reconnaissance

CH2M HILL inspected the existing and SRK's 2010 proposed VCD alignments September 10-12, 2013. Appendix C includes photographs. The purpose of this reconnaissance was to inspect the channel condition at both the existing and SRK 2010 proposed tie-in points at the upstream and downstream ends of the VCD and to observe surficial conditions along both alignments.

3.5.3 Meteorological Stations

Campbell Scientific inspected the Faro and Grum meteorological stations on July 17–18, 2013, to ensure the equipment was in working order. Appendix D contains the field report (Campbell Scientific, 2013).

3.5.4 Continuous Flow Monitoring

The FSP (CH2M HILL, 2013b) specified the installation and monitoring of continuous-flow monitoring equipment in the Vangorda watershed at Stations V1, V2, and V27.

3.6 Laboratory Testing Methodology

Twelve samples were collected between July 10 and August 8, 2013, and submitted to Golder in Burnaby, British Columbia, for geotechnical characterization of the rock. Thirty-three samples were collected between July 10 and August 9, 2013, and submitted to ALS for soil characterization. Appendix E includes the laboratory reports, and Tables 3-2 through 3-13 summarize the results.

3.6.1 Geotechnical Samples

3.6.1.1 Rock

Eleven samples were analyzed for specific gravity and absorption to evaluate rock porosity and durability. Analyses were performed in accordance with ASTM International (ASTM) *C127, 12 Standard Test Method for Specific Gravity and Absorption of Rock for Erosion Control* (ASTM, 2013a).

Four samples were examined for petrography to identify deleterious minerals. Analyses were performed in accordance with *ASTM C295, 12 Standard Guide for Petrographic Examination of Aggregates for Concrete* (ASTM, 2012).

Ten samples were tested for Unconfined Compressive Strength (UCS) to evaluate intact rock strength. Testing was performed in accordance with *ASTM D7012, 13 Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures* (ASTM, 2013b).

Three samples were evaluated for use as erosion control material under wetting and drying conditions. Testing was in accordance with *ASTM D5240, Testing of Rock Slabs to Evaluate Soundness of Riprap by use of Sodium Sulphate or Magnesium Sulphate* (ASTM, 2013c).

Three samples were evaluated use as erosion control under freezing and thawing conditions. Testing was in accordance with *ASTM D5313, Rock Durability under Freeze/Thaw Conditions* (ASTM, 2013d).

Soil samples were collected at various depths from borings CH13-303-BH001 through CH13-303-BH003 for geotechnical laboratory testing. Relatively undisturbed samples were collected from the borings by using a Standard Penetration Test split-spoon sampler. Soil samples were placed in bags; selected samples were submitted to the laboratory for the following analyses:

- Six samples for Atterberg limits tests (*ASTM D4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils* [ASTM, 2013e])
- Thirteen samples for gradation tests (ASTM D6913, *Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis* [ASTM, 2009])
- Fifteen samples for natural moisture content measurements (ASTM D2216, *Standard Test Methods for Laboratory Determination of Water [Moisture] Content of Soil and Rock by Mass* [1998])

3.6.2 Geochemical Samples

Soil and crushed rock samples from the Granitic Rock Outcrop and Grum Waste Rock Dump Quarry were submitted to ALS for analysis. Eleven samples were analyzed for the following:

- Total metal analysis (British Columbia Ministry of Environment, 2009a)
- pH (1:2, soil: water) (British Columbia Ministry of Environment, 2009b)

One sample was selected for the synthetic precipitation leaching procedure at pH 3, pH 4, and pH 5. The leachate was subsequently analysed for total metals (Method 1312).

Four samples were analyzed for ABA procedures, which included the following:

- Acid-soluble sulphate-S (Method E600/2-78-054)
- Barium sulphates (Li-Metaborate)
- Total sulphur (Leco combustion) (International Organization for Standardization, 2000)
- Neutralization potential (Method MOD-SOBEK-3.2.3) (MEND, 1991; Lawrence et al., 1988)
- Paste pH (Canadian Society of Soil Science, 1993 and APHA, 1992)

3.6.3 Quality Assurance and Quality Control

CH2M HILL incorporated a QAPP (CH2M HILL, 2012b) into the field sampling programs. QA/QC field samples were collected during soil sampling activities and used to evaluate the quality of the analytical data generated. QA/QC measures during the 2013 field program included the collection and submission of: (1) duplicate samples, amounting to at least 10 percent of the samples collected and (2) equipment blank samples. The laboratory data that CH2M HILL collected in 2013 was validated in accordance with the QAPP (CH2M HILL, 2012b). Analytical data are stored in the Environmental Quality Information System (EQuiS).

Field QA/QC samples were designed to identify potential matrix interferences; evaluate sources of sample contamination (equipment blanks), and variation introduced by the process of sample collection, handling, and analysis (duplicate field samples); and verify the effectiveness of analytical methods (matrix spike and matrix spike duplicate samples).

3.6.4 Sample Handling

The onsite sample manager, in coordination with the project chemist and project geotechnical and geochemistry teams, determined which samples were sent to the laboratory based on project needs.

Specific laboratory methods, bottle requirements, field preservation requirements, and sample volumes for the analyses are provided in the QAPP (CH2M HILL, 2012b). Samples were assigned a unique identifier (alpha-numeric code, following SOP SMP011). QA/QC samples were collected as specified in the QAPP.

Sample handling procedures followed SOPs PCS002 and PCS003. Soil samples for geochemical analysis collected in sealable plastic bags were placed in a second plastic bag after labelling to provide added protection from tears, label removal, and melted ice.

3.6.5 Data Quality Evaluation Report

A data quality evaluation (DQE) (see Appendix F) was prepared by the project chemist. The report summarizes the results of the QA/QC activities prescribed in the QAPP and provides a complete data usability assessment. The QAPP identifies the method-specific QC requirements for each analytical parameter and matrix and defines a plan to test that the correct sampling, analytical, and data reduction procedures are followed by using audits and data validation. The DQE is intended as a general data quality assessment designed to summarize data issues.

TABLE 3-1
CH2M HILL SOP List
Faro Mine Remediation Project

SOP Number	Title
INV001	Drilling
INL002	Monitoring Well or Piezometer Installation
MSR006	Geographic Land Surveying and Field Surveying Procedures
MSR030	Surface Water Gauging, Stream Flow Measurements, and Surface Water Sampling
PCS001	Boring Logs Completion, Soil Classification, and Logging
PCS002	Sample Packing and Shipping – Environmental
PCS003	Sample Custody
PCS006	Equipment Decontamination Procedures – Field and Personal Protective Equipment, Drill, and Heavy Equipment
PCS007	Documentation: Field Logbook, Field Forms, Data Entry, and Electronic Data Collection
PCS002	Sample Packing and Shipping – Environmental
PCS016	Sample Packing and Shipping – Geotechnical
SMP006	Surface and Subsurface Soil Sampling
SMP011	Sample Nomenclature
SMP017	Sample Storage

TABLE 3-2

Unconfined Compressive Strength of Intact Rock Core Specimens

Faro Mine Remediation Project

Sample ID	Sub Area	Diameter (mm)	Height (mm)	Area (cm^2)	Volume (cm^3)	Mass (g)	Wet Density (kg/m^3)	Moisture (%)	Dry Density (kg/m^3)	Maximum Load (kN)	Failure Stress (Mpa)	Failure Mode Type	Failure Mode (deg)
CH13-311-BH017_RKd	Granitic Rock Outcrop	44.77	95.25	15.74	149.94	398.50	2,658	0.06	2,656	210.70	133.8	2	NA
CH13-311-BH017_RKe	Granitic Rock Outcrop	44.75	93.66	15.73	147.31	391.10	2,655	0.05	2,654	160.70	102.2	2	NA
CH13-311-SS016_RKa	Granitic Rock Outcrop	45.69	95.69	16.40	156.89	415.10	1,646	0.27	2,639	110.10	67.2	4	23
CH13-311-SS017_RKa	Granitic Rock Outcrop	45.24	94.57	16.07	152.02	401.30	1,640	0.10	2,637	132.40	82.4	4	15
CH13-311-SS018_RKa	Granitic Rock Outcrop	45.67	92.07	16.38	150.82	415.40	2,754	0.03	2,754	272.50	166.3	2	NA
CH13-311-SS013_RKa	Granitic Rock Outcrop	45.23	94.31	16.07	151.53	402.90	2,659	0.15	2,655	194.50	121.1	2/1	26
CH13-311-SS015_RKa	Granitic Rock Outcrop	45.71	90.43	16.41	148.40	395.10	1,662	0.10	2,660	187.90	114.5	2	NA
CH13-311-SS001_RKa	Grum Waste Rock Dump Quarry	45.54	96.62	16.29	157.38	473.40	3,008	0.02	3,007	215.60	132.4	2/1	11
CH13-311-SS019_RKa	Grum Waste Rock Dump Quarry	45.85	94.31	16.51	155.71	465.00	2,986	0.04	2,985	223.30	135.2	2/1	16
CH13-311-SS026_RKa	Grum Waste Rock Dump Quarry	45.82	91.96	16.49	151.63	410.00	2,704	0.30	2,696	143.50	87.0	2/6	NA

Notes:

cm^2	=	squared centimetre
cm^3	=	cubic centimetre
deg	=	degrees measured from core axis
g	=	gram
ID	=	identifier
kg/m^3	=	kilogram per cubic metre
kN	=	kilonewton
mm	=	millimetre
MPa	=	megapascals
NA	=	not applicable

Failure Modes:

1. Diagonal shear plane(s)
2. Vertical fracture(s)
3. Vertical splitting
4. Shear along foliation/discontinuity
5. Conical
6. Spalling
7. Other

TABLE 3-3

Specific Gravity and Absorption of Rock for Erosion Control

Faro Mine Remediation Project

Sample ID	Sub Area	Rock Number	Mass (g)	Relative Density (Dry Basis) (g/cm³)	Relative Density (SSD Basis) (g/cm³)	Relative Density (Apparent) (g/cm³)	Absorption %
CH13-311-BH017_Rkd	Granitic Rock Outcrop	1	555.4	2.644	2.652	2.666	0.31
		2	564.1	2.644	2.652	2.665	0.3
		3	552.9	2.612	2.625	2.647	0.51
		4	422.1	2.621	2.636	2.662	0.6
		5	370.3	2.630	2.643	2.666	0.52
		Average	-	**2.630**	**2.642**	**2.661**	**0.45**
CH13-311-BH017_Rke	Granitic Rock Outcrop	1	1,136.7	2.657	2.664	2.675	0.25
		2	1,156.8	2.645	2.655	2.672	0.37
		3	868.7	2.655	2.662	2.674	0.27
		4	389.6	2.648	2.659	2.679	0.44
		Average	-	**2.651**	**2.660**	**2.675**	**0.33**
CH13-311-SS016_Rka	Granitic Rock Outcrop	1	4,106.5	2.570	2.597	2.640	1.02
		2	4,754.7	2.608	2.624	2.650	0.6
		3	2,222.0	2.618	2.631	2.653	0.51
		4	2,196.0	2.582	2.599	2.627	0.66
		5	2,564.0	2.576	2.599	2.637	0.89
		Average	-	**2.591**	**2.610**	**2.641**	**0.74**
CH13-311-SS017_Rka	Granitic Rock Outcrop	1	906.1	2.622	2.636	2.658	0.52
		2	1,205.5	2.575	2.604	2.651	1.11
		3	2,432.0	2.912	2.923	2.944	0.38
		4	3,283.8	2.606	2.625	2.656	0.73
		5	4,202.4	2.611	2.626	2.650	0.56
		Average	-	**2.665**	**2.683**	**2.712**	**0.66**
CH13-311-SS018_Rka	Granitic Rock Outcrop	1	1,740.0	2.639	2.647	2.661	0.32
		2	3,058.1	2.641	2.648	2.661	0.29
		3	2,016.9	2.614	2.629	2.653	0.57
		4	3,961.8	2.627	2.636	2.650	0.34
		5	2,567.5	2.557	2.591	2.646	1.31
		Average	-	**2.615**	**2.630**	**2.654**	**0.57**

TABLE 3-3
Specific Gravity and Absorption of Rock for Erosion Control
Faro Mine Remediation Project

Sample ID	Sub Area	Rock Number	Mass (g)	Relative Density (Dry Basis) (g/cm^3)	Relative Density (SSD Basis) (g/cm^3)	Relative Density (Apparent) (g/cm^3)	Absorption %
CH13-311-SS015_Rka	Granitic Rock Outcrop	1	2,829.0	2.618	2.629	2.647	0.42
		2	1,681.4	2.592	2.607	2.630	0.56
		3	1,320.3	2.605	2.621	2.647	0.62
		4	1,293.2	2.595	2.610	2.635	0.58
		5	1,442.5	2.603	2.619	2.645	0.6
		6	1,985.1	2.616	2.626	2.644	0.4
		Average		**2.605**	**2.619**	**2.641**	**0.53**
CH13-311-SS013_Rka	Granitic Rock Outcrop	1	1,948.2	2.595	2.610	2.635	0.58
		2	2,171.3	2.644	2.656	2.675	0.44
		3	5,555.0	2.606	2.625	2.655	0.7
		4	4,537.5	2.589	2.609	2.642	0.78
		5	8,581.1	2.638	2.652	2.674	0.51
		Average	-	**2.614**	**2.63**	**2.656**	**0.6**
CH13-311-SS001_Rka	Grum Waste Rock Dump Quarry	1	1,902.0	2.717	2.728	2.748	0.41
		2	2,378.3	2.670	2.681	2.699	0.41
		3	3,259.4	2.951	2.958	2.973	0.25
		4	3,326.4	2.976	2.980	2.986	0.11
		5	2,646.1	2.869	2.875	2.886	0.2
		Average	-	**2.837**	**2.844**	**2.858**	**0.28**
CH13-311-SS019_Rka	Grum Waste Rock Dump Quarry	1	4,609.3	2.897	2.916	2.955	0.68
		2	4,040.3	2.860	2.882	2.924	0.77
		3	4,336.8	2.913	2.928	2.957	0.51
		4	4,899.0	2.919	2.954	3.024	1.2
		Average	-	**2.897**	**2.920**	**2.965**	**0.79**
CH13-311-SS021_Rka	Grum Waste Rock Dump Quarry	1	2,141.6	2.972	2.991	3.028	0.62
		2	2,864.7	2.990	3.006	3.038	0.53
		3	2,497.7	3.008	3.016	3.031	0.25
		4	2,668.3	3.019	3.025	3.036	0.18
		5	2,179.9	3.003	3.010	3.024	0.23
		Average	-	**2.999**	**3.009**	**3.032**	**0.36**

TABLE 3-3
Specific Gravity and Absorption of Rock for Erosion Control
Faro Mine Remediation Project

Sample ID	Sub Area	Rock Number	Mass (g)	Relative Density (Dry Basis) (g/cm^3)	Relative Density (SSD Basis) (g/cm^3)	Relative Density (Apparent) (g/cm^3)	Absorption %
CH13-311-SS022_Rka	Grum Waste Rock Dump Quarry	1	1,525.2	3.027	3.033	3.047	0.22
		2	1,377.7	2.953	2.969	2.999	0.51
		3	1,500.8	3.003	3.015	3.039	0.39
		4	3,021.2	2.900	2.910	2.930	0.35
		5	2,843.1	2.907	2.915	2.929	0.25
		Average	**-**	**2.958**	**2.968**	**2.989**	**0.34**
CH13-311-SS026_Rka	Grum Waste Rock Dump Quarry	1	946.2	2.677	2.697	2.732	0.76
		2	2,926.2	2.562	2.598	2.658	1.41
		3	2,834.0	2.622	2.643	2.678	0.79
		4	3,479.8	2.922	2.942	2.980	0.66
		5	4,105.0	2.679	2.698	2.730	0.7
		Average	**-**	**2.693**	**2.716**	**2.756**	**0.87**

Notes:

g/cm^3 = gram per cubic centimetre

SSD = surface saturated dry

TABLE 3-4
Slab Soundness – Evaluation of Durability of Rock For Erosion Control under Wetting–Drying Conditions
Faro Mine Remediation Project

Sample ID		Boulder Number	Slab ID	Original Mass (g)	Final Mass (g)	Loss (%)
CH13-311-SS016_Rka	Granitic Rock Outcrop	1	16A1	3,203.5	3,203.5	0.00
		4	16A4	3,033.6	3,033.6	0.00
		5	16A5	3,398.1	3,398.1	0.00
		6	16A6	2,353.6	2,352.9	0.03
		7	16A7	3,646.3	3,630.9	0.42
					Final Average Loss (%)	**0.09**
CH13-311-SS017_Rka	Granitic Rock Outcrop	1	17A1	2,944.5	2,944.5	0.00
		2	17A2	3,317.5	3,317.2	0.01
		3	17A3	3,258.9	3,258.9	0.00
		4	17A4	3,013.3	3,013.3	0.00
		5	17A5	3,661.3	3,661.3	0.00
					Final Average Loss (%)	**0.00**
CH13-311-SS001_Rka	Grum Waste Rock Dump Quarry	1	01A1	4,023.1	4,022.0	0.03
		2	01A2	3,117.6	3,116.9	0.02
		3	01A3	2,983.1	2,981.5	0.05
		4	01A4	2,984.6	2,983.5	0.04
		5	01A5	3,013.9	3,012.9	0.03
					Final Average Loss (%)	**0.03**

TABLE 3-5

Petrographic Examination of Coarse Aggregate

Faro Mine Remediation Project Faro Mine Remediation Project

	Sample ID	CH13-311-SS001_Rka		
	Petrographic Description/Physical Quality	Grum Waste Rock Dump Quarry		
		Percent by Count (mm)		
		19 x 12.5	12.5 x 9.5	Total
Good	**Meta-gabbro 1** – medium-grained, white and dark green, strong	17.3	20.5	18.3
	Meta-gabbro 2 – medium-grained, light green and dark green, strong	1.7	5.0	2.8
	Meta-gabbro 3 – medium-grained, dark green, strong	30.5	23.0	28.0
	Meta-gabbro 4 – fine-grained, dark coloured, strong	14.9	13.7	14.5
	Veined meta-gabbro 1, 3 and 4 – crystalline calcite veins 1 to 15 mm thick, strong	10.5	9.9	10.3
	Oxidized meta-gabbro 1, 3 and 4 – orange oxidation staining on at least one surface, strong	11.5	9.0	10.7
	Oxidized and veined meta-gabbro 1, 3 and 4 – orange oxidation staining on at least one surface, oxidation product in veins, strong	6.5	9.6	7.5
	Subtotal	**92.9**	**90.7**	**92.1**
Fair	**Meta-gabbro 1** – brittle, pre-existing fractures	0.0	0.9	0.3
	Meta-gabbro 3 – brittle, moderate strength	1.0	1.2	1.1
	Meta-gabbro 4 – brittle, moderate strength, medium hard	0.7	1.3	0.9
	Veined meta-gabbro – brittle veins, moderate strength	1.7	1.9	1.8
	Oxidized meta-gabbro – weathered, moderate strength, oxidized pre-existing fractures	1.7	1.2	1.5
	Oxidized and veined meta-gabbro – moderate strength and brittle veins	2.0	2.8	2.3
	Subtotal	7.1	9.3	7.9
	TOTALS	**100.0**	**100.0**	**100.0**

TABLE 3-6

Petrographic Examination of Coarse Aggregate

Faro Mine Remediation Project

	Sample ID	CH13-311-SS016_Rka		
	Petrographic Description/Physical Quality	Granitic Rock Outcrop		
		Percent by Count (mm)		
		19 x 12.5	12.5 x 9.5	Total
Good	**Granodiorite 1** – medium-grained, moderately rough surface texture, dense, hard, strong	23.1	15.9	20.7
	Granodiorite 2 – fine-grained, smooth to moderately rough surface texture, dense, hard, strong	11.5	6.2	9.7
	Granodiorite 3 – cream coloured, low mafic content, medium grained, moderately rough surface texture, dense, hard, strong	14.3	17.3	15.3
	Oxidized granodiorite 1 and 2 – mostly medium-grained, orange oxidation staining/tint, some weathered portions, oxidation product throughout, strong	25.5	39.9	30.2
	Oxidized granodiorite 3 – low mafic content, medium-grained, orange oxidation staining/tint, some weathered portions, zones with oxidation product, strong	9.4	5.1	8.0
	Coated granodiorite – at least one particle surface thinly coated with silty product and/or concentrated band of biotite, strong	2.4	1.1	2.0
	Subtotal	**86.2**	**85.5**	**85.9**
Fair	**Granodiorite 1** – moderate strength, brittle, pre-existing discontinuities	2.7	2.6	2.7
	Granodiorite 3 – moderate strength, brittle	0.9	2.6	1.4
	Oxidized granodiorite 1 and 2 – weathered, moderate strength, brittle	3.9	5.4	4.4
	Oxidized granodiorite 3 – weathered, moderate strength, brittle	1.2	1.1	1.2
	Coated Granodiorite – at least one particle surface with thick band of biotite, particle surfaces coated with silty product, moderate strength	1.8	2.0	1.9
	Weathered Granodiorite – weathered, moderate mineral bond strength, oxidized, porous, moderate strength	3.3	0.8	2.5
	Subtotal	**13.8**	**14.5**	**14.1**
	TOTALS	**100.0**	**100.0**	**100.0**

TABLE 3-7
Petrographic Examination of Coarse Aggregate
Faro Mine Remediation Project

	Sample ID	CH13-311-SS017_Rka		
	Petrographic Description/Physical Quality	Granitic Rock Outcrop		
		Percent by Count (mm)		
		19 x 12.5	12.5 x 9.5	Total
Good	**Granite** – medium- to coarse-grained, cream with yellow speckles, dense, hard, strong	6.0	9.1	7.0
	Granodiorite 1 – slightly gneissic, white with black speckles, fine to medium grained, dense, hard, strong	25.0	18.7	22.9
	Granodiorite 2 – moderately gneissic, white with black speckles, some thin (<1 mm) bands of biotite, fine to medium grained, dense, hard, strong	15.4	18.1	16.3
	Granodiorite 3 – cream coloured, medium grained, dense, hard, strong	5.7	1.7	4.4
	Oxidized granodiorite 1 and 2 – orange oxidation staining/tint, some weathered portions, oxidation product throughout, strong	22.6	18.1	21.1
	Oxidized granodiorite 3 – cream coloured, medium-grained, orange oxidation staining/tint, some weathered portions, zones with oxidation product, strong	13.0	16.1	14.0
	Subtotal	**87.7**	**81.8**	**85.7**
Fair	**Granite** – moderate strength	2.1	1.4	1.9
	Granodiorite 1 – moderate strength, brittle	2.4	4.0	2.9
	Granodiorite 2 – moderate strength, brittle, fissile	1.2	2.3	1.6
	Oxidized granodiorite 1 and 2 – weathered, moderate strength, brittle	3.9	5.4	4.4
	Oxidized granodiorite 3 – weathered, moderate strength	2.7	5.1	3.5
	Subtotal	**12.3**	**18.2**	**14.3**
	TOTALS	**100.0**	**100.0**	**100.0**

TABLE 3-8

Petrographic Examination of Coarse Aggregate

Faro Mine Remediation Project

	Sample ID	CH13-311-SS026_Rka		
		Grum Waste Rock Dump Quarry		
	Petrographic Description/Physical Quality	**Percent by Count (mm)**		
		19 x 12.5	**12.5 x 9.5**	**Total**
Good	**Tonalite 1A** – speckled black and white, strong, fresh	28.3	35.0	31.7
	Tonalite 1B – as above, with yellow tint and occasional brown surfaces, strong	25.5	23.9	24.7
	Tonalite 2A – altered pinkish brown, one particle surface stained brown, strong	14.4	14.8	14.6
	Tonalite 2B – altered pinkish brown, one particle surface stained brown, strong	3.4	0.4	1.9
	Subtotal	**71.6**	**74.1**	**72.9**
Fair	**Tonalite 1A** – moderate strength	5.8	6.6	6.2
	Tonalite 1B – moderate strength	7.7	5.4	6.5
	Tonalite 2A – moderate strength	9.1	11.5	10.3
	Tonalite 2B – moderate strength	3.4	1.2	2.3
	Subtotal	**26.0**	**24.7**	**25.3**
Poor	**Tonalite 2A** – weak	2.4	0.8	1.6
	Tonalite 2B – weak	0.0	0.4	0.2
	Subtotal	**2.4**	**1.2**	**1.8**
	TOTALS	**100.0**	**100.0**	**100.0**

TABLE 3-9
Evaluation of Durability of Rock For Erosion Control Under Freezing and Thawing Conditions
Faro Mine Remediation Project

Sample ID		Boulder Number	Slab ID	Original Mass (g)	Final Mass (g)	Measured Loss (%)
CH13-311-SS016_Rka	Granitic Rock Outcrop	1	16B1	3,311.4	3,311.2	0.0001
		4	16B4	2,670.1	2,670.1	0
		5	16B5	3,504.8	3,503.6	0.0003
		6	16B6	2,421.7	2,421.6	0
		7	16B7	2,970.3	2,970.1	0.0001
					Final Average Loss (%)	<0.01%
CH13-311-SS017_Rka	Granitic Rock Outcrop	1	17B1	2,942.2	2,942.1	0
		2	17B2	2,687.9	2,687.7	0.0001
		3	17B3	2,692.5	2,692.5	0
		4	17B4	3036	3,035.4	0.0002
		5	17B5	3,493.5	3,491.7	0.0005
					Final Average Loss (%)	<0.02%
CH13-311-SS001_Rka	Grum Waste Rock Dump Quarry	1	01B1	3,008.2	3,007.9	0.01%
		2	01B2	3,065.5	3,065.5	0%
		3	01B3	2,997.4	2,997.1	0.01%
		4	01B4	2,983.7	2,983.6	0%
		5	01B5	2,742.7	2,742.6	0%
					Final Average Loss (%)	<0.01%

Note:
< = less than

TABLE 3-10

Gradation, Moisture and Atterberg Limits

Faro Mine Remediation Project

				Gradation[a] (mass %)										
Location	**Sample ID**	**Location**	**Sampling Date**	**Cobbles >3-inch**	**Gravel 4.75 mm – 3-inch**	**Coarse Sand 2.0 mm – 4.75 mm**	**Medium Sand 0.425 mm – 2.0 mm**	**Fine Sand 0.075 mm – 0.425 mm**	**Fines < 0.075 mm**	**Moisture (%)**	**Moisture at Liquid Limit (%)**	**Plastic Index (%)**	**% > 75um (%)**	**USCS[b]**
CH13-303-BH001	CH13-303-BH001_SOa	Vangorda Creek Diversion	7/31/2013	NA	NA	NA	NA	NA	NA	**9.76**	NA	NA	NA	NA
CH13-303-BH001	CH13-303-BH001_SOb	Vangorda Creek Diversion	7/31/2013	NA	2	8	9	20	61	**26.5**	NA	NA	NA	NA
CH13-303-BH001	CH13-303-BH001_SOc	Vangorda Creek Diversion	7/31/2013	NA	NA	NA	NA	NA	NA	**7.27**	NA	NA	**60.9**	NA
CH13-303-BH001	CH13-303-BH001_SOd	Vangorda Creek Diversion	7/31/2013	NA	33	17	24	14	11	**5.93**	NA	NA	NA	NA
CH13-303-BH001	CH13-303-BH001_SOe	Vangorda Creek Diversion	7/31/2013	NA	42	16	19	11.00	12	**8.41**	NA	NA	NA	NA
CH13-303-BH002	CH13-303-BH002_Soc	Vangorda Creek Diversion	8/2/2013	NA	10	8	14	19.00	48	NA	NA	NA	NA	Clayey sand (SM-SC)
CH13-303-BH002	CH13-303-BH002_Sod	Vangorda Creek Diversion	8/2/2013	NA	6.00	7.00	22.00	23	42	NA	NA	NA	NA	Silty clay sand (SC-SM)
CH13-303-BH002	CH13-303-BH002_Sof	Vangorda Creek Diversion	8/2/2013	NA	8.00	7.00	21.00	23.00	40	NA	NA	NA	NA	Silty clay sand (SC-SM)
CH13-303-BH002	CH13-303-BH002_Sog	Vangorda Creek Diversion	8/2/2013	NA	6.00	9.00	22.00	21.00	43	NA	NA	NA	NA	Silty sand (SM)
CH13-303-BH003	CH13-303-BH003_SOa	Vangorda Creek Diversion	8/5/2013	NA	NA	NA	NA	NA	NA	**4.78**	NA	NA	NA	NA
CH13-303-BH003	CH13-303-BH003_SOb	Vangorda Creek Diversion	8/5/2013	NA	7	9	21	17	46	**9.91**	**29**	**12**	NA	Clayey sand (SC)
CH13-303-BH003	CH13-303-BH003_SOc	Vangorda Creek Diversion	8/5/2013	NA	NA	NA	NA	NA	NA	**9.65**	NA	NA	NA	NA
CH13-303-BH003	CH13-303-BH003_SOd	Vangorda Creek Diversion	8/5/2013	NA	NA	NA	NA	NA	NA	**9.06**	**23**	**8**	NA	NA
CH13-303-BH003	CH13-303-BH003_SOe	Vangorda Creek Diversion	8/5/2013	NA	NA	NA	NA	NA	NA	**9.21**	**24**	**9**	NA	NA
CH13-303-BH003	CH13-303-BH003_SOf	Vangorda Creek Diversion	8/5/2013	NA	9	10	12	16	53	**10.4**	**24**	**7**	NA	Sandy silty clay (CL-ML)
CH13-303-BH003	CH13-303-BH003_SOg	Vangorda Creek Diversion	8/5/2013	NA	8.00	18	30	22	22	**9.49**	NA	NA	NA	Silty sand (SM)
CH13-303-BH003	CH13-303-BH003_SOh	Vangorda Creek Diversion	8/5/2013	NA	NA	NA	NA	NA	NA	NA	NA	NA	**48.9**	NA
CH13-303-BH003	CH13-303-BH003_SOi	Vangorda Creek Diversion	8/5/2013	NA	9	10	20	20	42	**9.05**	**22**	**6**	NA	Silty clayey sand (SC-SM)
CH13-303-BH003	CH13-303-BH003_SOj	Vangorda Creek Diversion	8/5/2013	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH13-303-BH003	CH13-303-BH003_SOk	Vangorda Creek Diversion	8/6/2013	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH13-303-BH003	CH13-303-BH003_SOl	Vangorda Creek Diversion	8/6/2013	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH13-303-BH003	CH13-303-BH003_SOm	Vangorda Creek Diversion	8/6/2013	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CH13-303-BH003	CH13-303-BH003_SOn	Vangorda Creek Diversion	8/6/2013	NA	4	5	7	9	75	**11.8**	**29**	**12**	NA	Lean clay with sand (CL)
CH13-303-BH003	CH13-303-BH903_SOg	Vangorda Creek Diversion	8/5/2013	NA	13	15	26	22	23	**11.6**	NA	NA	NA	Silty sand (SM)

[a] Gradation totals may not equal 100 because of rounding.

[b] Unified Soil Classification System Classification is based on laboratory sample and may not reflect larger particle sizes observed in the field.

Notes:

< = less than

ID = Identification

J = Analyte was present but the reported value may not be accurate or precise

mbgs = metres below ground surface

mm = millimetres

NA = Not analysed

TABLE 3-11

Metals and General Chemistry

Faro Mine Remediation Project

			Location	CH13-311-BH016				CH13-311-BH017				CH13-311-SS001	CH13-311-SS019	CH13-311-SS021	CH13-311-SS022	CH13-311-SS026
			Sample ID	CH13-311-BH016_RKc	CH13-311-BH016_RKa	CH13-311-BH016_RKb	CH13-311-BH916_RKb	CH13-311-BH017_RKa	CH13-311-BH017_RKc	CH13-311-BH917_RKc	CH13-311-BH017_RKb	CH13-311-SS001_RKa	CH13-311-SS019_RKa	CH13-311-SS021_RKa	CH13-311-SS022_RKa	CH13-311-SS026_RKa
			Sampling Depth (feet)	19.49–19.76	3.34–3.59	7.9–8.12	7.9–8.12	1.95–2.25	15.2–15.44	15.2–15.44	8.69–8.94	0–0.15	0–0.15	0–0.15	0–0.15	0–0.15
			Sample Date	8/9/2013	8/9/2013	8/9/2013	8/9/2013	8/7/2013	8/8/2013	8/8/2013	8/8/2013	7/10/2013	7/10/2013	7/12/2013	7/12/2013	7/15/2013
			Sub Area	Granitic Rock Outcrop	Granitic Rock Outcrop	Granitic Rock Outcrop	Granitic Rock Outcrop	Granitic Rock Outcrop	Granitic Rock Outcrop	Granitic Rock Outcrop	Granitic Rock Outcrop	Grum Waste Rock Dump Quarry	Grum Waste Rock Dump Quarry	Grum Waste Rock Dump Quarry	Grum Waste Rock Dump Quarry	Grum Waste Rock Dump Quarry
Analyte	Units	GARD[a]	MEND[b]													
Aluminum	mg/kg	852,000	823,000	2,590	1,960	1,340	1,540	7,790	7,360	9,160	9,540	24,800	29,300	19,400	18,500	18,200
Antimony	mg/kg	60	2	0.51	*4.19*	*24.4 J*	*10.5 J*	< 0.1	< 0.1	< 0.1	< 0.1	0.22	0.16	< 0.1	0.2	< 0.1
Arsenic	mg/kg	72	18	0.866	3.45	10.2 J	17.6 J	1.62	0.733	0.631	0.933	0.729	0.477	1.59	0.774	2.28
Barium	mg/kg	6,000	4,250	3.84	44	13	13	10.3	24	29.7	30.3	25.3	50.4	138	87.9	128
Beryllium	mg/kg	72	28	0.98	1.13	0.55	0.4	0.72	0.46	0.51	0.28	0.25	< 0.2	< 0.2	< 0.2	0.28
Bismuth	mg/kg	-	0.09	*2.26*	*0.21*	*0.61*	*0.41*	*< 0.2*	*< 0.2*	*0.5*	*0.59*	*< 0.2*	*< 0.2*	*< 0.2*	*< 0.2*	*< 0.2*
Boron	mg/kg	-	-	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Cadmium	mg/kg	4.2	1.5	0.087	0.152	0.106	0.072	0.079	< 0.05	< 0.05	< 0.05	0.078	0.055	0.133	0.113	< 0.05
Calcium	mg/kg	180,000	415,000	4,450	19,500	855	778	8,400	3,490	3,170	2,910	22,500	4,770	7,020	7,530	9,640
Chromium	mg/kg	840	1,020	4.34	2.82	2.21	1.66	11.4	4.83	7.31	8.79	253	382	275	90.4	16.2
Cobalt	mg/kg	96	250	1.29	6.39	1.27	1.85	2.53	2.73	3.52	3.45	27.6	36.4	23.7	25.7	6.68
Copper	mg/kg	360	600	2.27	35	34.9 J	14.8 J	< 0.5	2.33	2.78	6.44	94.1	84.4	96.6	170	3.18
Iron	mg/kg	480,000	563,000	5,750	30,300	11,700	13,000	12,300	12,400	15,000	15,300	41,000	41,500	33,300	30,900	21,400
Lead	mg/kg	420	140	18.1	16.6	51.1 J	24.7 J	15.4	6.15	6.11	5.66	1.24	1.71	3.6	2.03	10.1
Lithium	mg/kg	300	200	11.3	< 5	< 5	< 5	82.3	85	94.9	126	21.1	36.7	16.1	17.4	23.8
Magnesium	mg/kg	60,000	200,000	1,070	3,960	78	128	3,950	3,610	4,370	4,620	24,000	33,500	16,200	16,300	7,780
Manganese	mg/kg	12,000	9,500	217	928	7.1	6.7	197	209	244	229	620	641	562	451	298
Mercury	mg/kg	0.72	-	0.0221	0.0371	0.0201	0.0173	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Molybdenum	mg/kg	-	-	< 0.5	0.72	0.59	0.6	< 0.5	< 0.5	< 0.5	< 0.5	0.59	< 0.5	0.68	< 0.5	< 0.5
Nickel	mg/kg	24	12	1.79	2.72	0.76	1.47	2.48	1.3	1.82	1.74	*105*	*260*	*100*	*74.1*	3.6
Potassium	mg/kg	600	840	760	*1,260*	*1,310*	*1,240*	*1,670*	*5,120*	*6,220*	*6,580*	270	*1,220*	400	540	*1,530*
Selenium	mg/kg	-	-	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Silver	mg/kg	-	-	0.1	0.54	0.48	0.49	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Sodium	mg/kg			*< 100*	*< 100*	*< 100*	*< 100*	*170*	*< 100*	*120*	*160*	*210*	*< 100*	*110*	*130*	*860*
Strontium	mg/kg	168,000	200000	14.3	56.3	2.63	2.73	12.6	6.94	7.05	3.86	102	47.3	76.1	43.2	40.7
Thallium	mg/kg	4.8	0.5	0.158	*0.581*	*0.862*	*0.631*	0.198	*0.655*	*0.738*	*0.873*	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Tin	mg/kg	-	0.75	*< 2*	*< 2*	*< 2*	*< 2*	*< 2*	*4.4*	*4.9*	*4.8*	*< 2*	*< 2*	*< 2*	*< 2*	*< 2*
Titanium	mg/kg	60,000	236000	33.8	16.1	4.4	7.4	223	975	1,220	1,300	1,120	971	1,690	1,070	1,410
Uranium	mg/kg	3,000	3700	6.13	3.11	0.756	0.632	4.38	3.18 J	7.33 J	4.55	0.094	< 0.05	0.076	0.066	1.12
Vanadium	mg/kg	108	96	1.18	8.05	0.21	0.53	18.3	22.9	28.5	30.6	81.8	43.3	47.4	41	48.6
Zinc	mg/kg	48	23	*41.6*	*70.3*	*44.5 J*	20.5 J	*43.5*	*45.2*	*53.1*	*53.9*	*< 52.9*	*< 56.1*	*< 46.4*	*< 45.1*	*< 41.2*
Inorganic Carbon (as CACO3 Equivalent)	%	-	56,500	1.65	7.77	< 0.8	< 0.8	2.83	1.18	1.01	0.83	5.53	0.98	< 0.8	1.74	< 0.8
Moisture	%	-	-	0.3	0.63	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	NA	NA	NA	NA	NA
Total Inorganic Carbon	%	800	10,500	0.2	0.93	< 0.1	< 0.1	0.34	0.14	0.12	< 0.1	0.66	0.12	< 0.1	0.21	< 0.1
Paste pH	pH Units	24	27	7.55 J	7.32 J	*NA*	*NA*	7.03 J	NA	NA	7.26 J	7.95 J	7.64 J	7.71 J	8.07 J	7.76 J
pH (1:2 soil:water)		1,080	1,200	9.16	8.63	8.24	7.99	9.19	9.33	9.22	9.19	8.94 J	7.63 J	7.89	9.04	8.21
Total Phosphorus	mg/kg	1,080	700	402	654	348	280	501	438	552	599	*1,130*	*930*	*1,130*	*852*	480

[a] Median soil content reported from the GARD Guide (INAP, 2014).

[b] Values from Price, 1997

Notes:

Values indicated with shading were identified at concentrations which are 12 to 24 times the median soil content determined as having a geochemical abundance index (GAI) of 3 calculated by GAI = log2(conc/1.5*mean_soil_conc)

Values indicated with red italic were identified at concentrations that exceed 10 times the crustal abundance.

Bold indicates the analyte was detected

< = Denotes less than laboratory method detection limit

J = Analyte was present but the reported value may not be accurate or precise.

NA = not analyzed

TABLE 3-12
Summary of Acid Base Accounting
Faro Mine Remediation Project

	Location	CH13-311-BH016				CH13-311-BH017				CH13-311-SS001	CH13-311-SS019	CH13-311-SS021	CH13-311-SS022	CH13-311-SS026
	Sample ID	CH13-311-BH016_RKc	CH13-311-BH016_RKa	CH13-311-BH016_RKb	CH13-311-BH916_RKb	CH13-311-BH017_RKa	CH13-311-BH017_RKc	CH13-311-BH917_RKc	CH13-311-BH017_RKb	CH13-311-SS001_RKa	CH13-311-SS019_RKa	CH13-311-SS021_RKa	CH13-311-SS022_RKa	CH13-311-SS026_RKa
	Sampling Depth (feet)	19.49–19.76	3.34–3.59	7.9–8.12	7.9–8.12	1.95–2.25	15.2–15.44	15.2–15.44	8.69–8.94	0–0.15	0–0.15	0–0.15	0–0.15	0–0.15
	Sample Date	8/9/2013	8/9/2013	8/9/2013	8/9/2013	8/7/2013	8/8/2013	8/8/2013	8/8/2013	7/10/2013	7/10/2013	7/12/2013	7/12/2013	7/15/2013
Analyte	Sub Area	Granitic Rock Outcrop	Granitic Rock Outcrop	Granitic Rock Outcrop	Granitic Rock Outcrop	Granitic Rock Outcrop	Granitic Rock Outcrop	Granitic Rock Outcrop	Granitic Rock Outcrop	Grum Waste Rock Dump Quarry	Grum Waste Rock Dump Quarry	Grum Waste Rock Dump Quarry	Grum Waste Rock Dump Quarry	Grum Waste Rock Dump Quarry
NP (as $CaCO_3$ Eq.)	T CaCO3/1000 T	**12**	**77**	**2**	**2**	**17**	**10**	**9**	**7**	**45**	**12**	**14**	**14**	**4**
Barium	%	0.000384	0.0044	0.0013	0.0013	0.00103	0.0024	0.00297	0.00303	0.00253	0.00504	0.0138	0.00879	0.0128
Lead	%	0.00181	0.00166	0.00511	0.00247	0.00154	0.000615	0.000611	0.000566	0.000124	0.000171	0.00036	0.000203	0.00101
Zinc	%	0.00416	0.00703	0.00445	0.00205	0.00435	0.00452	0.00531	0.00539	0.002645	0.002805	0.00232	0.002255	0.00206
Sulphur	%	0.08	0.46	1.02	1.64	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.07	0.025
Acid Potential [a]		2.5	14.375	31.875	51.25	0.78125	0.78125	0.78125	0.78125	0.78125	0.78125	0.78125	2.1875	0.78125
NP:AP		4.8	5.356521739	0.062745098	0.03902439	21.76	12.8	11.52	8.96	57.6	15.36	17.92	6.4	5.12
NNP		**9.5**	**62.625**	**-29.875**	**-49.25**	**16.21875**	**9.21875**	**8.21875**	**6.21875**	**44.21875**	**11.21875**	**13.21875**	**11.8125**	**3.21875**

[a] AP assumes all sulphur is in the form of sulphide

Notes:

$CaCO_3$ Eq. = calcium carbonate equivalent
NA = not analyzed
NNP = net neutralization potential
NP:AP = ratio of neutralization potential to acid production
T $CaCO_3$/1000 T = tonnes calcium carbonate per tonnes of material

TABLE 3-13
Leachable Constituents
Faro Mine Remediation Project

		Location	CH13-311-BH016		CH13-311-BH017		
		Sample ID	**CH13-311-BH016_RKb**	**CH13-311-BH916_RKb**	**CH13-311-BH017_RKa**	**CH13-311-BH017_RKc**	**CH13-311-BH917_RKc**
		Sampling Depth (feet)	**7.9–8.12**	**7.9–8.12**	**1.95–2.25**	**15.2–15.44**	**15.2–15.44**
		Sample Date	**8/9/2013**	**8/9/2013**	**8/7/2013**	**8/8/2013**	**8/8/2013**
Analyte	**Units**	**Screening Level**					
Aluminum, SPLP3	mg/L	0.005 to 0.1 [a]	**1.45**	**1.49**	**0.175**	**0.168**	**0.176**
Aluminum, SPLP4	mg/L	0.005 to 0.1 [a]	**4.81**	**4.85**	**4.43**	**0.569 J**	**0.335 J**
Aluminum, SPLP5	mg/L	0.005 to 0.1 [a]	**4.65**	**4.51**	**1.4**	**0.556 J**	**1.01 J**
Antimony, SPLP3	mg/L	0.005 to 0.1 [a]	**0.00403**	**0.00514**	**0.000051**	**0.0001**	**0.000087**
Antimony, SPLP4	mg/L		**0.0046**	**0.00532**	**0.00008**	**0.000076**	**0.000087**
Antimony, SPLP5	mg/L		**0.00621**	**0.0058**	< 0.00005	**0.000077**	**0.000089**
Arsenic, SPLP3	mg/L	0.005	**0.0014**	**0.00218**	**0.00028**	**0.00015**	**0.00015**
Arsenic, SPLP4	mg/L	0.005	**0.00068 J**	**0.00162 J**	**0.00157**	**0.00049**	**0.00053**
Arsenic, SPLP5	mg/L	0.005	**0.00104 J**	**0.00189 J**	**0.00142**	**0.00064 J**	**0.00063**
Barium, SPLP3	mg/L		< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Barium, SPLP4	mg/L		< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Barium, SPLP5	mg/L		< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Beryllium, SPLP3	mg/L		**0.00603**	**0.00424**	< 0.0005	< 0.0005	< 0.0005
Beryllium, SPLP4	mg/L		< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Beryllium, SPLP5	mg/L		< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Bismuth, SPLP3	mg/L		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Bismuth, SPLP4	mg/L		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Bismuth, SPLP5	mg/L		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Boron, SPLP3	mg/L	1.5	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Boron, SPLP4	mg/L	1.5	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Boron, SPLP5	mg/L	1.5	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Cadmium, SPLP3	mg/L	Variable [b]	**0.000136 J**	**0.00037 J**	< 0.00002	< 0.00002	< 0.00002
Cadmium, SPLP4	mg/L	Variable [b]	< 0.00002	**0.000023**	**0.000039**	< 0.00002	< 0.00002
Cadmium, SPLP5	mg/L	Variable [b]	< 0.00002	**0.000027**	< 0.00002	< 0.00002	< 0.00002
Calcium, SPLP3	mg/L		**7.62**	**8.22**	**34.5**	**32.5**	**31.3**
Calcium, SPLP4	mg/L		**2.06**	**2.09**	**8.84**	**5.92 J**	**6.62**
Calcium, SPLP5	mg/L		**1.04**	**1.57**	**5.92**	**4.64 J**	**4.94**
Chromium, SPLP3	mg/L	0.0089	**0.00368 J**	**0.00148 J**	< 0.0005	< 0.0005	< 0.0005
Chromium, SPLP4	mg/L	0.0089	**0.00057**	**0.00079**	**0.00198**	< 0.0005	< 0.0005

TABLE 3-13
Leachable Constituents
Faro Mine Remediation Project

		Location	CH13-311-BH016		CH13-311-BH017		
		Sample ID	**CH13-311-BH016_RKb**	**CH13-311-BH916_RKb**	**CH13-311-BH017_RKa**	**CH13-311-BH017_RKc**	**CH13-311-BH917_RKc**
		Sampling Depth (feet)	**7.9–8.12**	**7.9–8.12**	**1.95–2.25**	**15.2–15.44**	**15.2–15.44**
		Sample Date	**8/9/2013**	**8/9/2013**	**8/7/2013**	**8/8/2013**	**8/8/2013**
Analyte	**Units**	**Screening Level**					
Chromium, SPLP5	mg/L	0.0089	**0.00052**	**0.00075**	< 0.0005	< 0.0005	< 0.0005
Cobalt, SPLP3	mg/L		**0.00312**	**0.00379**	< 0.0001	< 0.0001	< 0.0001
Cobalt, SPLP4	mg/L		**0.00016**	**0.00033**	**0.00033**	< 0.0001	< 0.0001
Cobalt, SPLP5	mg/L		**0.00022**	**0.00043**	< 0.0001	< 0.0001	**0.0001**
Copper, SPLP3	mg/L		**0.00077 J**	**0.00427 J**	< 0.0005	< 0.0005	< 0.0005
Copper, SPLP4	mg/L		**0.00158**	**0.00291**	< 0.0005	< 0.0005	< 0.0005
Copper, SPLP5	mg/L		**0.00194**	**0.00303**	< 0.0005	< 0.0005	< 0.0005
Iron, SPLP3	mg/L	0.3	**1.52**	**1.17**	< 0.03	< 0.03	< 0.03
Iron, SPLP4	mg/L	0.3	**0.54 J**	**1.06 J**	**1.41**	**0.193 J**	**0.081**
Iron, SPLP5	mg/L	0.3	**0.571 J**	**1.08 J**	**0.272**	**0.137 J**	**0.335 J**
Lead, SPLP3	mg/L	0.001	**0.00678**	**0.00417**	**0.0006**	**0.00014**	**0.00011**
Lead, SPLP4	mg/L	0.001	**0.00421**	**0.00521**	**0.00775**	**0.00103 J**	**0.0007**
Lead, SPLP5	mg/L	0.001	**0.00625**	**0.00725**	**0.00242**	**0.00052 J**	**0.00095 J**
Lithium, SPLP3	mg/L		**0.0051**	**0.006**	**0.0086**	**0.0119**	**0.0129**
Lithium, SPLP4	mg/L		**0.0025**	**0.003**	**0.0146**	**0.009 J**	**0.0089**
Lithium, SPLP5	mg/L		**0.0035**	**0.0039**	**0.0059**	**0.0093 J**	**0.0098**
Magnesium, SPLP3	mg/L		**1.15**	**1.15**	**0.719**	**2.3**	**2.67**
Magnesium, SPLP4	mg/L		**0.461**	**0.483**	**0.817**	**0.876 J**	**0.966**
Magnesium, SPLP5	mg/L		**0.327**	**0.382**	**0.391**	**0.676 J**	**0.818**
Manganese, SPLP3	mg/L		**0.0914**	**0.0791**	**0.0505**	**0.131**	**0.125**
Manganese, SPLP4	mg/L		< 0.00416	< 0.00601	**0.0283**	< 0.00329	< 0.00131
Manganese, SPLP5	mg/L		< 0.00497	< 0.00692	**0.00482**	< 0.00238	< 0.00515
Mercury, SPLP3	mg/L	0.000026	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001
Mercury, SPLP4	mg/L	0.000026	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001
Mercury, SPLP5	mg/L	0.000026	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001
Molybdenum, SPLP3	mg/L	0.073	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Molybdenum, SPLP4	mg/L	0.073	**0.00018**	**0.0002**	< 0.0001	< 0.0001	< 0.0001
Molybdenum, SPLP5	mg/L	0.073	**0.0002**	**0.00026**	< 0.0001	< 0.0001	< 0.0001
Nickel, SPLP3	mg/L	0.025	< 0.00334	< 0.0032	< 0.0005	< 0.0005	< 0.0005

TABLE 3-13
Leachable Constituents
Faro Mine Remediation Project

		Location	CH13-311-BH016		CH13-311-BH017		
		Sample ID	**CH13-311-BH016_RKb**	**CH13-311-BH916_RKb**	**CH13-311-BH017_RKa**	**CH13-311-BH017_RKc**	**CH13-311-BH917_RKc**
		Sampling Depth (feet)	**7.9–8.12**	**7.9–8.12**	**1.95–2.25**	**15.2–15.44**	**15.2–15.44**
		Sample Date	**8/9/2013**	**8/9/2013**	**8/7/2013**	**8/8/2013**	**8/8/2013**
Analyte	**Units**	**Screening Level**					
Nickel, SPLP4	mg/L	0.025	< 0.0005	< 0.00072	< 0.0005	< 0.0005	< 0.0005
Nickel, SPLP5	mg/L	0.025	< 0.0005	< 0.00066	< 0.0005	< 0.0005	< 0.0005
Phosphorus, SPLP3	mg/L		< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Phosphorus, SPLP4	mg/L		< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Phosphorus, SPLP5	mg/L		< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Potassium, SPLP3	mg/L		**9.01**	**9.42**	**3.28**	**2.93**	**3.07**
Potassium, SPLP4	mg/L		**6.77**	**6.63**	**2.95**	**2.04 J**	**2.07**
Potassium, SPLP5	mg/L		**6.13**	**5.7**	**1.95**	**2.01 J**	**2.04**
Selenium, SPLP3	mg/L	0.001	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Selenium, SPLP4	mg/L	0.001	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Selenium, SPLP5	mg/L	0.001	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Silicon, SPLP3	mg/L		**3.73**	**4.64**	**1.99**	**1.71**	**1.93**
Silicon, SPLP4	mg/L		**11.3**	**11.3**	**17.3**	**3.05 J**	**2.62**
Silicon, SPLP5	mg/L		**10.9**	**10.1**	**6.06**	**2.83 J**	**4.45**
Silver, SPLP3	mg/L	0.0001	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Silver, SPLP4	mg/L	0.0001	**0.000074**	**0.000094**	< 0.00005	< 0.00005	< 0.00005
Silver, SPLP5	mg/L	0.0001	**0.000106**	**0.000118**	< 0.00005	< 0.00005	< 0.00005
Sodium, SPLP3	mg/L		**2.5**	**2.1**	**2.3**	**2.8**	**3.2**
Sodium, SPLP4	mg/L		**2**	**2.1**	**5.3**	**1.6**	**1.8**
Sodium, SPLP5	mg/L		**1**	**1.8**	**3.3**	**1.5**	**1.9**
Strontium, SPLP3	mg/L		**0.0304**	**0.0332**	**0.0536**	**0.114**	**0.119**
Strontium, SPLP4	mg/L		**0.004**	**0.0043**	**0.0206**	**0.0277 J**	**0.0337**
Strontium, SPLP5	mg/L		**0.0024**	**0.003**	**0.0118**	**0.0232 J**	**0.026**
Thallium, SPLP3	mg/L	0.0008	**0.00036**	**0.00023**	< 0.0001	< 0.0001	< 0.0001
Thallium, SPLP4	mg/L	0.0008	**0.00034**	**0.00031**	**0.00012**	< 0.0001	< 0.0001
Thallium, SPLP5	mg/L	0.0008	**0.00038**	**0.0003**	< 0.0001	< 0.0001	< 0.0001
Tin, SPLP3	mg/L		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Tin, SPLP4	mg/L		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Tin, SPLP5	mg/L		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001

TABLE 3-13
Leachable Constituents
Faro Mine Remediation Project

		Location	CH13-311-BH016		CH13-311-BH017		
		Sample ID	**CH13-311-BH016_RKb**	**CH13-311-BH916_RKb**	**CH13-311-BH017_RKa**	**CH13-311-BH017_RKc**	**CH13-311-BH917_RKc**
		Sampling Depth (feet)	**7.9–8.12**	**7.9–8.12**	**1.95–2.25**	**15.2–15.44**	**15.2–15.44**
		Sample Date	**8/9/2013**	**8/9/2013**	**8/7/2013**	**8/8/2013**	**8/8/2013**
Analyte	**Units**	**Screening Level**					
Titanium, SPLP3	mg/L		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Titanium, SPLP4	mg/L		**0.053**	**0.057**	**0.372**	**0.031**	**0.014**
Titanium, SPLP5	mg/L		**0.062**	**0.057**	**0.039**	**0.022**	**0.043**
Uranium, SPLP3	mg/L		**0.00186 J**	**0.00062 J**	**0.00052**	**0.00116 J**	**0.00202 J**
Uranium, SPLP4	mg/L	0.015	**0.00086**	**0.00056**	**0.00056**	**0.00016 J**	**0.00028**
Uranium, SPLP5	mg/L	0.015	**0.00099**	**0.00076**	**0.00022**	< 0.0001	**0.0002**
Vanadium, SPLP3	mg/L	0.015	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Vanadium, SPLP4	mg/L		< 0.001	**0.0013**	**0.0047**	**0.0019**	**0.0017**
Vanadium, SPLP5	mg/L		< 0.001	**0.0013**	**0.0025**	**0.002**	**0.0026**
Zinc, SPLP3	mg/L	0.03	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Zinc, SPLP4	mg/L	0.03	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Zinc, SPLP5	mg/L	0.03	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05

[a] CEQG guideline is pH dependent; 0.005 mg/L if pH < 6.5, 0.1 mg/L if pH ≥ 6.5

[b] CEGQ guideline is hardness dependent; cadmium concentration = $10^{0.86[\log10(\text{hardness})]-3.2}$ / 1000 mg/L

Notes:

-- = no guideline
CEQG = Canadian Environmental Quality Guidelines
J = analyte was present but the reported value may not be accurate or precise
mg/L = milligrams per liter
pH in pH Units
U = analyte was analyzed for but not detected at the specified detection limit
Bold indicates the analyte was detected

SPLP3 = synthetic precipitation leaching procedure at a pH of 3

SPLP4 = synthetic precipitation leaching procedure at a pH of 4

SPLP5 = synthetic precipitation leaching procedure at a pH of 5
Shading indicates the results exceeds the screening criteria

SECTION 4
Data Summary

4.1 Vangorda Creek Diversion Activities

4.1.1 Vangorda Creek Diversion Geophysical Survey

Results of the geophysics surveys at SRK's 2010 proposed VCD suggest a bedrock depth up to 25 m below the original ground surface at the south end of the survey line. The depth to bedrock at CH13-303-BH003 was greater than 34 m because of the fill placed for the Haul Road. The bedrock gradually shallows to 1 to 5 mbgs in the vicinity of CH13-303-BH001. Proceeding northeast along the survey line, the depth to bedrock is generally within a few metres of the ground surface until northeast of Vangorda Pit, where it steeply dips to approximately 12 m deep, and then gradually shallows over the remainder of the survey line. The survey noted that the overburden is likely composed of a wet clay along the length of the survey line, with pockets of dry or frozen soil. Figure 2-1 shows the location details, and Appendix A contains the geophysical survey report (Aurora, 2013a).

4.1.2 Mapping

The field survey points were compared with LiDAR data to cross check accuracy. In most cases, the LiDAR data are accurate; however, in some areas the true ground was obscured by dense vegetation. Results are displayed on Figure 3-3.

4.1.3 Surface and Subsurface Conditions

Three boreholes were installed in the southwestern portion of the VCD area, along geophysical line CH13-303-GX001. The overburden generally consisted of silty, clayey sand with gravel, cobbles, and boulders (glacial till) that varies from 5.8 mbgs at CH13-303-BH001 to greater than 34 mbgs at CH13-303-BH003 where fill has been placed for the Haul Road. The glacial till overlays a weathered phyllite bedrock. Figure 2-1 shows the surveyed borehole locations, and Appendix B contains the borehole logs.

4.1.4 Geotechnical Results

This section discusses geotechnical results, including moisture content, Atterberg Limits, and grain size distribution.

4.1.4.1 Moisture Content and Atterberg Limits

Soil moisture content of the 22 samples ranged from 4.8 to 26.5 percent by weight. The average moisture was 10.2 percent by weight. The Plastic Index of the six samples tested ranged from 6 to 12 (average 9), indicating the soil is slightly plastic. The Liquid Limit of samples ranged from 22 to 29 (average 25).

4.1.4.2 Grain Size Distribution

Grain size analyses were conducted using the Canadian System of Soil Classification and Unified Soil Classification System methods. Analyzed samples indicated that the materials collected in the area of SRK's 2010 proposed VCD were generally fine-grained consisting mainly of silty, clayey sand (till). Analyses of samples collected during drilling tend to underestimate the coarse-grain fraction, which either does not fit in the drilling and sampling equipment or is fragmented during collection.

Table 3-10 (geotechnical results) presents in-situ moisture contents, Atterberg Limits, and gradation distributions of selected soil samples. Certified laboratory analytical results are provided in Appendix E. Geotechnical data are also presented in borehole logs in Appendix B. Location details are provided on Figure 2-1.

4.1.5 In Situ Hydraulic Conductivity Testing

The hydraulic conductivity testing at boring CH13-303-BH001 was performed at a depth of 4.6 m. Groundwater was generally only slightly above the bedrock, and the in situ hydraulic conductivity tests in the glacial till soil had to be performed above the groundwater level. Therefore, the saturated coefficient of permeability could not be calculated from the results. The rate of infiltration into the bottom of the borehole CH13-303-BH001 at a depth of 4.2 to 4.6 m was approximately 1.6 litres per minute under a constant water head of 5 m. The hydraulic conductivity of the silt sand material at this depth is estimated to be on the order of $1x10^{-3}$ to $1x10^{-4}$ centimetres per second.

At boring CH13-303-BH002, a test was attempted at a depth of 7.6 feet; the soil consisted of clay with a hydraulic conductivity too low for borehole infiltration testing, and no infiltration was observed after 15 minutes. The estimated hydraulic conductivity is less than $1x10^{-6}$ centimetres per second.

4.2 Granitic Rock Outcrop

4.2.1 Geophysical Survey Interpretation

Results of the geophysics surveys at the Granitic Rock Outcrop suggest the depth to bedrock is shallow (less than 2 m) along the length of the survey. The interface between rippable bedrock and extremely strong bedrock, corresponding to a seismic velocity of 2,000 m per second, is variable along the length of the survey. The strong bedrock varies in depth from less than 1 m below top of rock near the Mine Access Road to 20 m below top of rock north of the Haul Road. Figure 3-1 shows the location details, and Appendix A contains the geophysical survey report (Aurora, 2013b).

4.2.2 Surface and Subsurface Conditions

A geological reconnaissance was carried out at the Granitic Rock Outcrop July 6–10, 2013, to delineate the quality and extent of the outcrop. CH2M HILL staff walked the boundaries of the outcrop and collected surface samples. The outcrop is bounded by the Mine Access Road to the southwest, a stream to the north, the Grum Access Road to the southeast. The outcrop extends 250 m past the Haul Road to the west. Rock at the surface was logged as a strong altered granite with slight to moderate weathering.

Rock coring and sampling at the Granitic Rock Outcrop was conducted August 7–9, 2013. CH13-311-BH016 was installed to 20 mbgs at the southern end of the Granitic Rock Outcrop off of the Mine Access Road (see Figure 3-1). Bedrock was encountered at 1 mbgs; the material encountered there is described as a highly fractured, greenish grey, poor to fair quality granite with a rock quality designation (RQD) ranging from 0 to 62.

BH13-311-BH017 was installed to 6 mbgs at the northern end of the Granitic Rock Outcrop (see Figure 3-1). Bedrock was encountered at 0.2 mbgs. The material encountered there was described as very hard, dark grey, fair to excellent quality granite with an RQD ranging from 40 to 100. Appendix B contains the borehole logs.

4.2.2.1 Geotechnical Results

Samples collected at the Granitic Rock Outcrop were submitted to ALS and Golder for geotechnical analysis. Laboratory results are summarized in the following subsections.

Moisture. Six rock samples from the Granitic Rock Outcrop were analyzed for moisture content. Moisture content ranged from non-detect (four of the six samples) to 0.63 percent.

Petrographic Analysis. Two samples from the Granitic Rock Outcrop were submitted for petrographic analysis, CH13-311-SS016_Rk1 and CH13-311-SS017_Rka. Results indicate that sample CH13-311-SS016_Rka was composed of crystalline igneous granodiorite with some weathered and oxidized varieties. The rock was analyzed for physical–mechanical quality and found to be 85 percent “good” and 15 percent “fair.”
Sample CH13-311-SS017_Rka was composed of slight to moderately gneissic varieties of crystalline igneous rock granodiorite with 86 percent of the material being classified as “good” and 14 percent classified as “fair.” Appendix E contains laboratory reports for the petrographic analysis.

Slab Soundness. Two samples from the Granitic Rock Outcrop were analyzed for slab soundness by using magnesium sulphate. After five cycles of soaking in a magnesium sulphate solution for 16 hours followed by 8 hours of drying in an oven, sample CH13-311-SS016_Rka measured an average loss of 0.09 percent by mass, with a high value of 0.42 percent and a low value of 0.00 percent. Some specimens from that sample had weathered and oxidized fractures that intersected thin portions of the slab along the perimeter and surface of the slabs and others did not. Most specimens did not exhibit formation of new fractures, widening, or lengthening or pre-existing fractures. Widening occurred in fractures that were significantly weathered, oxidized, and were intersecting thin portions of the slab; these fractures were judged to be moderate in strength prior to testing and poor strength after testing.

At the completion of the test, sample CH13-311-SS017 measured an average loss of 0.00 percent by mass, with a high value of 0.01 percent and a low value of 0.00 percent. Specimens from this sample were very resistant to stresses imposed by soundness testing using magnesium sulphate.

Unconfined Compressive Strength. Seven rock samples collected from the Granitic Rock Outcrop were analyzed for UCS, including five samples collected at the ground surface and two samples of rock core collected from borehole CH13-311-BH017. The five samples collected from the surface had an unconfined compressive strength of 67.2 to 166.3 megapascals (MPa). The rocks failed by vertical fracturing or by shears along foliation. Two rock core samples, CH13-311-BH017_RKd and CH13-311-BH017_RKe, failed under a maximum load of 210.70 and 160.70 kilonewtons (kN) with a stress of 133.8 and 102.2 MPa. Both specimens failed by vertical fracturing.

Specific Gravity and Absorption. Seven surface and core samples from the Granitic Rock Outcrop were analyzed for specific gravity and absorption of rock for erosion control. The apparent relative density ranged from 2.641 to 2.712 grams per square centimetre (g/cm^3) and absorption ranged from 0.33 to 0.74 percent.

Rock Durability: Freeze–Thaw. Two samples from the Granitic Rock Outcrop were analyzed for durability under freeze–thaw conditions. Sample H13-311-SS016_RKa had an average measured loss of 0.01 percent. Material loss appeared to be caused by dislodging of material that was only moderately well-adhered to pre-existing fracture surfaces prior to testing and generally consisted of the removal of small flakes, fragments and mineral grains. Specimens with more pre-existing fractures and more significant weathering and oxidation had an overall mineral bond strength that ranged from good to moderate and typically experienced a higher loss.

Formation of new fractures, widening, and lengthening of pre-existing fractures was observed to be very minor in the tested rock slabs and were typically associated with fractures that were open, weathered, oxidized, and coated. Some of the pre-existing fractures were interpreted to be of moderate strength and could be susceptible to fracturing if impacted with moderate force.

Specimens from CH13-311-SS017_RKa had an average measured loss of 0.02 percent. Specimen 17B5 consisted of a rock type inconsistent with the other four specimens and had an outlying result. Material loss appeared to be caused by dislodgment of material that was only moderately well-adhered to pre-existing fracture surfaces prior to testing and generally consisted of small fragments and mineral grains. The formation of new fractures and the widening, and lengthening of pre-existing fractures was observed to be very minor in the tested rock slabs and was typically associated with fractures that were open, weathered, oxidized, and coated.

Figure 3-1 provides location details, and laboratory analytical results are tabulated in Tables 3-2 through 3-10. Appendix E contains certified laboratory analytical results.

4.2.2.2 Geochemical Results

Eleven rock samples collected from the borings were submitted to ALS to be crushed and analyzed. Analytical results are summarized by parameter in the following sections.

Metals. Six samples from the Granitic Rock Outcrop were analyzed for whole-rock composition. The results of the analysis were compared to the GARD Guide (INAP, 2014) and MEND screening criteria (see Section 2.1.1) to identify potential sources of contaminants.

Relative to the GARD Guide, all samples had elevated concentrations of potassium, and two samples had elevated concentrations of zinc. Relative to MEND criteria, two samples had elevated concentrations of antimony, all samples had elevated concentrations of bismuth (the detection limit was higher than the screening value), five samples had elevated concentrations of potassium, all samples had elevated concentrations of tin (the detection limit was higher than the screening value), and all samples had elevated concentrations of zinc.

Acid–Base Accounting. Six samples from the Granitic Rock Outcrop were analyzed for ABA. The ABA analysis assumed all sulphur present is in the form sulphide. This assumption leads to a more conservative estimate of acid-generating potential. Three samples from each CH13-311-BH016 and CH13-311-BH017 from the Granitic Rock Outcrop were analyzed. The paste pH ranged from 7.02 to 7.55, with a median value of 7.29. No sulphur was detected at CH13-311-BH017; data show that the three samples from this boring were net acid-neutralizing. Results were variable at CH13-311-BH016; NP:AP values ranged from 0.04 (acid-generating) to 21.76 (non-acid generating) and NNP values ranged from -49.25 (net-acid generating) to 62.63 (net acid neutralizing). The median NP:AP was 7.16 and the median NNP was 8.72. Results from testing material from this location indicate some material is likely capable of generating ARD. Samples from two depths from this borehole were not likely acid generating while one sample (and its duplicate) is indicative of material that is likely to be acid generating.

Synthetic Precipitation Procedure. Five samples (including two field duplicates) were analyzed for dissolved metals by three-sample leach testing following a modification of the Method 1312 synthetic precipitation procedure using sulphuric acid (USEPA, 1994).The modified SPLP analysis was performed on three separate splits of the same sample, with a water-to-solids ratio of 20:1 for 16 to 20 hours and using three different extraction fluids (one for each split) at pH 3, pH 4, and pH 5. The extract was filtered through a 0.6- to 0.8-micromenter glass fibre filter before the analysis.

In the modified SPLP tests, adjustment of the pH of the extractant from pH 5 through pH 3 demonstrates the effect of different pH waters on the sample (e.g., from slightly acidic precipitation to more acidic mine drainage). The 20:1 ratio for the modified SPLP was selected to remain consistent with the traditional SPLP method. The higher dilution ratio prevents potential solubility limitations from affecting the results, and the high leachate-to-solid ratio limits the buffering capacity of the solid, thereby allowing a constant pH to be maintained during the extraction. In the Granitic Rock Outcrop material, general observations of the results suggest increasing concentrations of calcium, chromium, cobalt, iron, lithium, magnesium, sodium, and strontium, with decreasing pH. Aluminum, arsenic, and silicon concentrations decrease in the concentration extracted with decreases in pH.

Leachate from the SPLP tests exceeded the CEQG values for the protection of aquatic life for several parameters. Aluminum was elevated in all samples at all extraction pHs; cadmium was elevated in two samples at extraction pH 3; iron was elevated in four samples at extraction pH 3, 4, and 5; lead was elevated in three samples for extraction pH 3-5; and silver was elevated in one sample at extraction pH 5.

Figure 3-1 provides location details, and Tables 3-2 through 3-13 summarize the laboratory results. Appendix E provides certified laboratory analytical results.

4.3 Grum Waste Rock Dump Quarry Activities

4.3.1 Grum Waste Rock Dump Quarry Geophysical Survey Interpretation

The results of the geophysics surveys at the Grum Waste Rock Dump Quarry suggest the depth to bedrock to be 10 mbgs along the majority of the survey line, shallowing to approximately 5 m at the eastern end of the survey line, near the operating quarry. The depth between weathered and competent bedrock varies from 1 to 5 m along the survey line and is shallowest near the active quarry. Figure 3-2 shows the location details, and Appendix A contains the geophysical survey report (Aurora, 2013c).

4.3.2 Surface Conditions

A geological reconnaissance was carried out at the Grum Waste Rock Dump Quarry July 6–15, 2013, to delineate the quality and extent of the available material. CH2M HILL staff noted a rocky hilltop extending north of the existing quarry and west of the Grum Sulphide Cell. The reconnaissance found the outcrop is composed of gabbro and altered tonalite.

4.3.3 Geotechnical Results

Samples collected at the Grum Waste Rock Dump Quarry were submitted to ALS and Golder for geotechnical analysis. Laboratory results are summarized in the following sections.

4.3.3.1 Petrographic Analysis

Two samples from the Grum Waste Rock Dump Quarry underwent petrographic analysis (CH13-311-SS001_RKa and CH13-311-SS026 RKa). The results indicate CH13-311-SS001 is composed of meta-gabbro with weathered, oxidized, and veined varieties. Classification based on physical–mechanical properties show that 92 percent of the material is considered “good” and 8 percent is considered “fair.” The results indicate CH13-311-SS026 is composed of tonalite that is classified as 72.9 percent “good” and 25.3 percent “fair”.

4.3.3.2 Slab Soundness

One sample from the Grum Waste Rock Dump Quarry was analyzed for slab soundness by using magnesium sulphate. After five cycles of soaking in a magnesium sulphate solution for 16 hours followed by 8 hours of drying in an oven, specimen CH13-311-SS001_Rka measured an average loss of 0.03 percent by mass, with a high value of 0.05 percent and a low value 0.02 percent. Material loss appeared to be caused by dislodging of material that was only moderately well adhered to the slab prior to testing and generally consisted of small fragments and mineral grains.

Formation or growth of existing fractures was not observed. Several existing fractures were interpreted to be of moderate strength and could be susceptible to fracturing if impacted with moderate force. Many of the moderate strength fractures were coated with calcite and were slightly weathered.

4.3.3.3 Unconfined Compressive Strength

Three surface samples collected from the Grum Waste Rock Dump Quarry were analyzed for UCS. The specimens had an unconfined compressive strength of 87.0 to 135.2 MPa. The samples failed by a combination of vertical fracturing/diagonal shear planes, and vertical fracturing/spalling.

4.3.3.4 Specific Gravity and Absorption

Five surface samples collected from the Grum Waste Rock Dump Quarry analyzed for specific gravity and absorption. The apparent density of the specimens ranged from 2.756 to 3.032 g/cm^3, and specific absorption ranged from 0.28 to 0.87 percent. Laboratory results are provided in Table 3-3.

4.3.3.5 Rock Durability: Freeze–Thaw

One sample, CH13-311-SS001_Rka, from the Grum Waste Rock Dump Quarry was evaluated for durability under freeze–thaw conditions. The specimens had an average measured loss of 0.01 percent by mass. The samples were generally similar to each other with regard to resistance to the stresses generated by freezing and thawing actions. Material loss appeared to be caused by the dislodging of material that was only moderately well adhered to pre-existing fracture surfaces prior to testing and generally consisted of the removal of small flakes, fragments, and mineral grains.

The formation of new fractures and the widening and lengthening of pre-existing fractures was observed to be very minor in the tested rock slabs. Several of the pre-existing fractures were interpreted to be of moderate strength and could be susceptible to fracturing if impacted with moderate force. Many of the moderate-strength fractures were coated with calcite and were open prior to testing.

Figure 3-2 shows the location detail, and Tables 3-2 through 3-10 summarize the laboratory results. Appendix E provides certified laboratory analytical results.

4.3.4 Geochemical Results

Samples collected at the Grum Waste Rock Dump Quarry for geochemical analysis were submitted to ALS; results are summarized in the following sections.

Metals. Five samples from the Grump Dump Rock Quarry were analyzed for whole-rock composition. The results were compared to the GARD Guide (INAP, 2014) and MEND screening criteria (see Section 2.1.1) to highlight potential sources of contaminants. Relative to the GARD Guide, four samples had elevated concentrations of nickel, two samples had elevated concentrations of potassium, two samples had elevated concentrations of zinc (the detection limit is above the screening criteria), and two samples had elevated concentrations of phosphorus.

Relative to MEND criteria, all samples had elevated concentrations of bismuth (the detection limit is above the screening criteria), four samples had elevated concentrations of nickel, two samples had elevated concentrations of selenium, all samples had elevated concentrations of tin (the detection limit is above the screening criteria), all samples had elevated concentrations of zinc (the detection limit is above the screening criteria), and four samples had elevated concentrations of phosphorus.

Acid–Base Accounting. Five samples from the Grum Waste Rock Dump Quarry were analyzed for ABA. The ABA analysis assumed all sulphur present is in the form sulphide. This assumption overestimates the acid production potential and leads to a more conservative estimate of acid generation potential. No sulphur was detected in four of the five samples from the Grum Waste Rock Dump Quarry. The paste pH from this area ranged from 7.63 to 8.07, with a median value of 7.76; NP:AP values ranged from 5.12 to 57.6, with a median values of 15.36. NNP values ranged from 3.21 to 44.2, with a median value of 11.8. The results indicate that samples from this area are net acid-neutralizing and are unlikely to contribute to ARD.

Figure 3-2 show the location details, and Tables 3-11 through 3-13 summarize the laboratory results. Appendix E includes the certified laboratory analytical results.

4.4 Hydrology and Morphology Results

4.4.1 Fluvial Geomorphic Assessment

4.4.1.1 Upstream from Vangorda Creek Diversion Headworks

Information regarding the upstream reach of Vangorda Creek observed for rapid geomorphic assessment includes the following:

- Key plan of the Vangorda Creek area (see Figure 3-4)
- Plan up the upstream reach (see Figure 4-1)
- Profile of the upstream reach (see Figure 4-2)
- Representative cross sections of the upstream reach (see Figure 4-3)
- Photograph of Vangorda Creek upstream from the proposed headworks (see Figure 4-4)

A channel stability index analysis was completed for the upstream reach, as detailed in Appendix G. The channel stability index is the sum of the values obtained from the following nine criteria:

1. **Primary bed material** – the primary bed material appears to be bedrock, boulders, and cobbles [Score = 1]
2. **Bed and bank protection** – bed and banks are not artificially protected [Score = 1]
3. **Degree of incision** – calculated by measuring normal water depth at the deepest point across the channel divided by bank height from bank to top of bank base, the degree of incision is approximately 11 to 25 percent, with a maximum incision of 0 to 10 percent [Score = 4]
4. **Degree of constriction** – often only found where obstructions or artificial protection are present within the channel; the degree of construction was rated zero [Score = 0]
5. **Stream bank erosion** – on the right bank there appears to be fluvial to mass wasting [Score = 2]; it appears to be fluvial on the left bank [Score = 1]
6. **Stream bank instability** – the left bank appears to be stable [Score = 0]; mass wasting appears to be less than 50 percent of the right bank [Score = 1]

7. **Established riparian woody-vegetative cover** – Vegetative cover exists on the right bank generally above the incised portion of the reach [Score = 0.5]; the left bank has substantially more woody-vegetative cover along this reach [Score = 1]

8. **Occurrence of bank accretion** – neither the left bank [Score = 2] nor the right bank [Score = 2] had significant occurrence of bank accretion (i.e., evidence of fluvial deposition of materials)

9. **Stage of channel evolution** – the stage of channel evolution of this reach is estimated to be Stage IV [Score = 4]

The total score from the channel-stability ranking scheme for the upstream reach is 19.5. This indicates considerable instability in this reach. According to Simon and Hupp (1986) Stage IV channel evolution indicates the following conditions:

- Degradation and basal erosion
- Incision and active channel widening
- Mass wasting from banks and excessive undercutting
- Leaning and fallen vegetation
- Vertical face may be present

4.4.1.2 Downstream from Vangorda Creek Diversion Outlet

Information related to the downstream reach of Vangorda Creek observed for rapid geomorphic assessment includes the following:

- Key plan of the Vangorda Creek area (see Figure 3-4)
- Plan up the downstream reach (see Figure 4-5)
- Profile of the downstream reach (see Figure 4-6)
- Representative cross-sections of the downstream reach (see Figure 4-7)
- Photograph of Vangorda Creek downstream from the Haul Road at the VCD outlet (See Figure 4-8)

A channel stability index analysis was completed for the upstream reach, as detailed in Appendix G. The channel stability index is the sum of the values obtained from the following nine criteria:

1. **Primary bed material** – the primary bed material appears to be bedrock, boulders, and cobbles [Score = 1]

2. **Bed and bank protection** – bed and banks are not artificially protected [Score = 1]

3. **Degree of incision** – calculated by measuring normal water depth at the deepest point across the channel divided by bank height from bank to top of bank base, the degree of incision is approximately 17 percent [Score = 3]

4. **Degree of constriction** – often only found where obstructions or artificial protection are present within the channel; the degree of construction was rated as zero [Score = 0]

5. **Stream bank erosion** – on the left bank [Score = 1] and right bank [Score = 1] appears to be fluvial

6. **Stream bank instability** –on the left bank [Score = 0.5] and right bank [Score = 0.5] appears to be less than 25 percent, or stable

7. **Established riparian woody-vegetative cover** – the left bank [Score = 1] and right bank [Score = 1] had established riparian woody-vegetative cover

8. **Occurrence of bank accretion** – neither the left bank [Score = 2] nor the right bank [Score = 2] had significant occurrence of bank accretion (i.e., evidence of fluvial deposition of materials)

9. **Stage of channel evolution** – the stage of channel evolution of this reach is estimated to be Stage IV [Score = 4].

The total score from the channel-stability ranking scheme for the upstream reach is 18. This indicates considerable instability in this reach. According to Simon and Hupp (1986) Stage IV channel evolution indicates the following conditions:

- Degradation and basal erosion
- Incision and active channel widening
- Mass wasting from banks and excessive undercutting
- Leaning and fallen vegetation
- Vertical face may be present

4.4.2 Diversion Alignment Reconnaissance

Appendix C contains annotated photographs from the field reconnaissance activities conducted by CH2M HILL. Appendix C also contains a figure "General Arrangement," which was used as a baseline for station referencing purposes during reconnaissance.

4.4.3 Meteorological Stations Results

A report (Campbell Scientific, 2013) regarding the functioning of the two site meteorological stations and recommended future operations and maintenance is included in Appendix D. The two site meteorological stations have been operating for 10 years without calibration. The wind speed and direction, temperature, and relative humidity sensors were in excellent condition and were working within specifications. Snowfall and tipping bucket sensors were removed and inspected, and a new program was installed. In addition to routine cleaning and inspections of the sensors, calibration of the sensors should be completed within the next year.

4.4.4 Continuous Flow Monitoring

Station V2 is in Grum Creek, upstream from the outlet to Vangorda Creek. This station is a compliance point for site water quality monitoring. Spot flow measurements were made at this station at a v-notch weir installed in the creek. Continuous flow monitoring equipment was installed at Station V2 on October 24, 2013.

Station V27 is in Vangorda Creek, upstream from the confluence with Shrimp Creek. Flow monitoring was not completed at this station in 2013 because of unsafe conditions.

Station V1 is in Vangorda Creek, upstream from the existing VCD (see Figure 2-1). Data from this station is collected by the site care and maintenance contractor and transmitted to YG. YG is currently reviewing the need to gather additional instantaneous discharge measurements at high stages to improve the accuracy of Station V1 flow measurements, especially during high-flow events.

SECTION 5
Summary

The purpose of the 2013 VCD investigation was to collect geologic and hydraulic information to supplement existing data used to support the design of the VCD replacement. The findings in this report are summarized as follows:

- Subsurface investigations at SRK's 2010 proposed alignment indicate that the overburden in the lower end of the VCD is composed of a glacial till that ranges between 5.8 mbgs to greater than 34 mbgs (at the Haul Road embankment). The underlying bedrock is composed of weathered phyllite.
- The hydraulic at CH13-302-BH001 is estimated to be on the order of $1x10^{-3}$ to $1x10^{-4}$ centimetres per second, and the hydraulic conductivity at CH13-303-BH002 is estimated to be less than $1x10^{-6}$ centimetres per second.
- Supplemental mapping in the VCD area improved the accuracy of the DTM in areas with dense vegetation.
- Investigations at the Granitic Rock Outcrop found granodiorite bedrock approximately 1 mbgs that extends to the Haul Road to the north and the Mine Access Road to the south. Two boreholes were advanced in the area; one borehole returned a highly fractured, poor quality granite with RQD values ranging from 0 to 62. The material from the second borehole was very hard, dark grey, good to excellent quality granite, with an RQD ranging from 40 to 100. Laboratory testing indicated that samples from the area are resistant to weathering fail under maximum loads of 160.7 and 210.0 kN and have absorption values ranging from 0.33 to 0.74 percent.
- Reconnaissance at the Grum Waste Rock Dump Quarry found a rocky hilltop extending north of the existing quarry and west of the Grum Sulphide Cell. The material is composed of gabbro and tonalite that failed under maximum loads of 87.0 to 135.2 MPa. The material experienced minor weathering when subjected to laboratory durability testing and had absorption values of 0.28 to 0.87 percent.
- Additional instantaneous discharge data are required at Station V1 during high-flow events to supplement the rating curve and improve the accuracy of flow measurements at this station, particularly during peak flow events. YG is currently developing a field plan to obtain such data.
- The reach of Vangorda Creek downstream from the existing VCD outlet demonstrates the following instabilities: degradation and basal erosion, incision and active channel widening, mass wasting from banks and excessive undercutting, leaning and fallen vegetation, and a vertical face may be present.
- The reach of Vangorda Creek upstream from the existing VCD headworks demonstrates the following instabilities: degradation and basal erosion, incision and active channel widening, mass wasting from banks and excessive undercutting, leaning and fallen vegetation, and a vertical face may be present.
- The sensors at the two onsite meteorological stations require routine cleaning and inspections. The meteorological equipment should be calibrated within the next year.

SECTION 6

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Figures

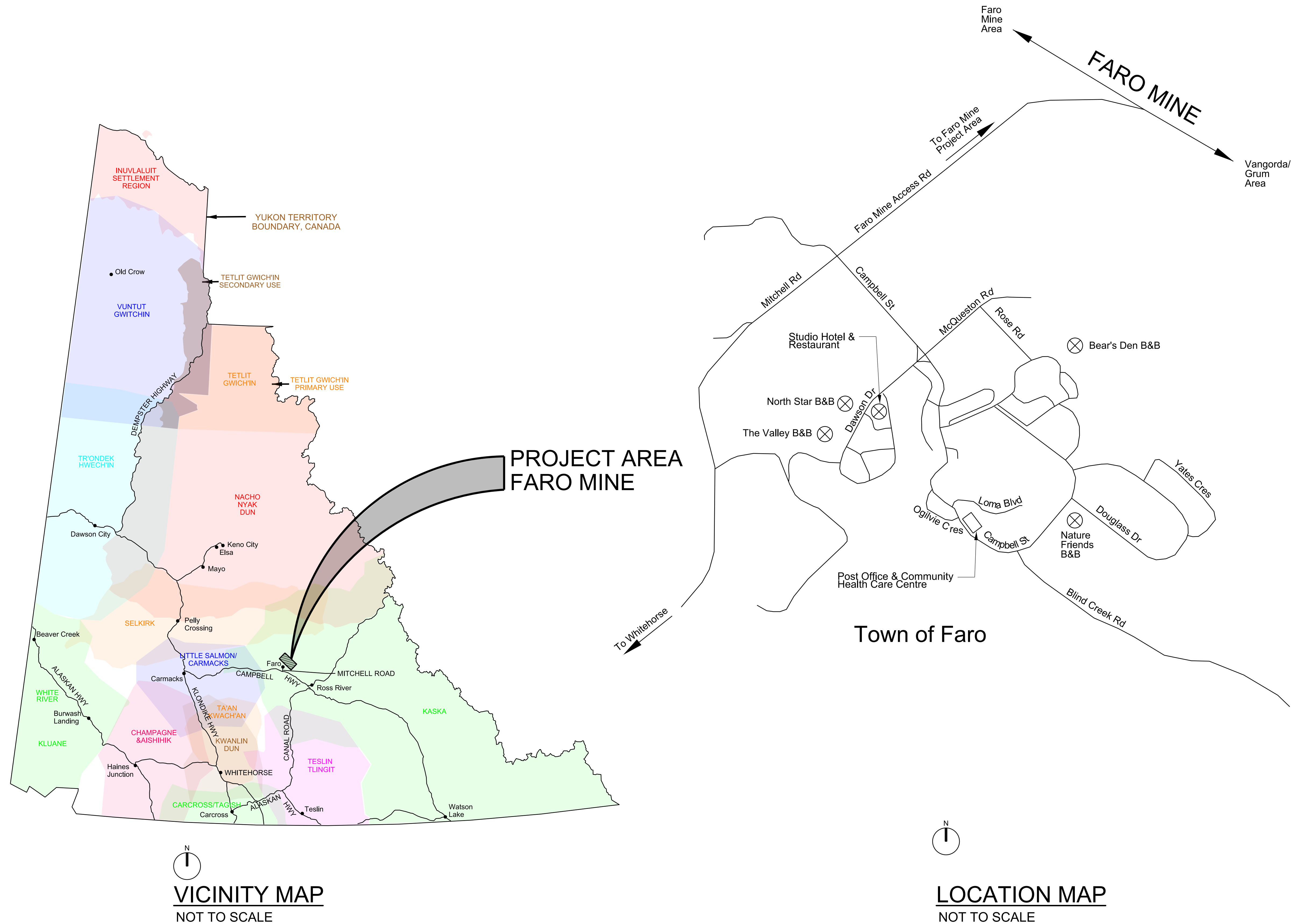
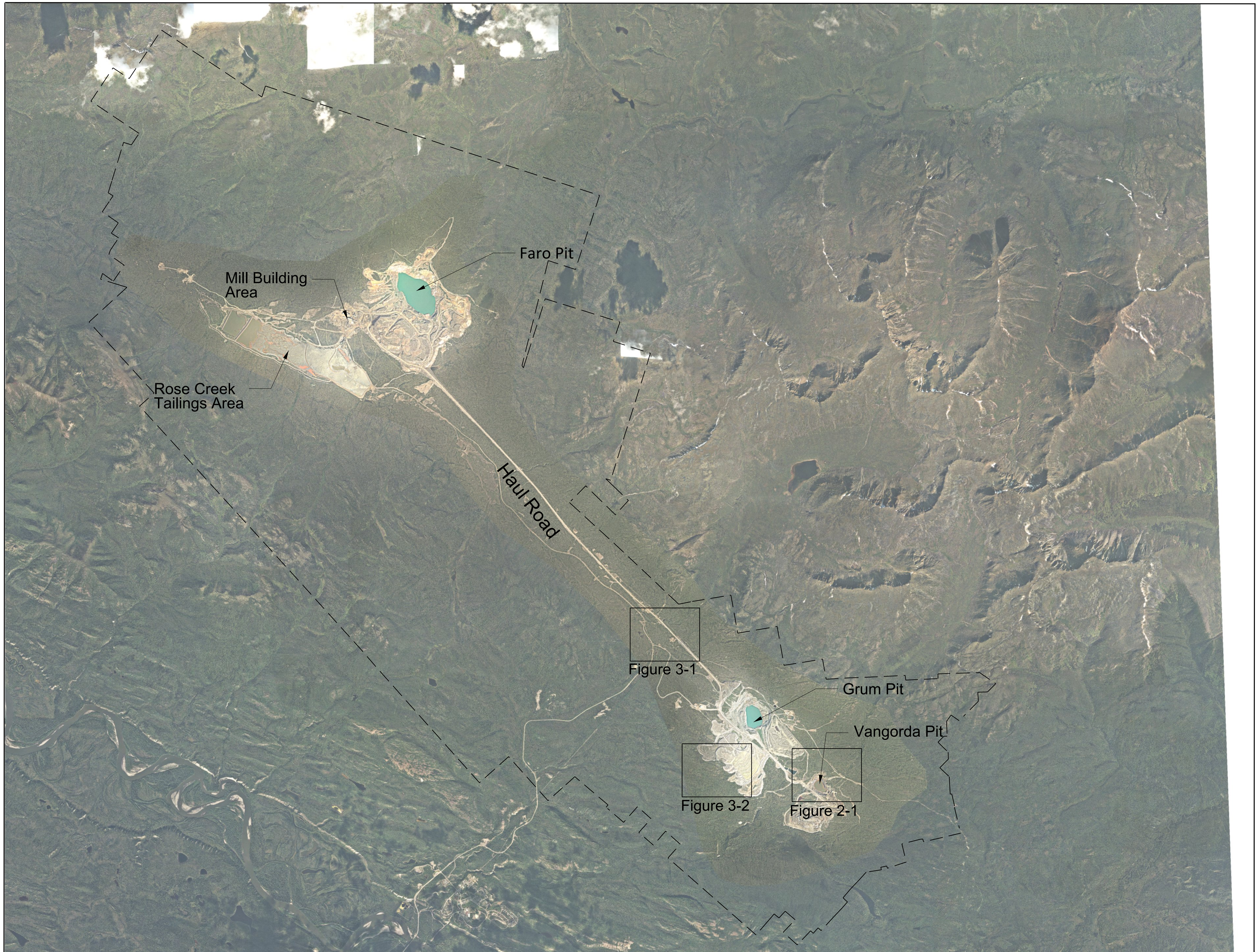


FIGURE 1-1
Vicinity and Location Map
Faro Mine Remediation Project

CH2MHILL.

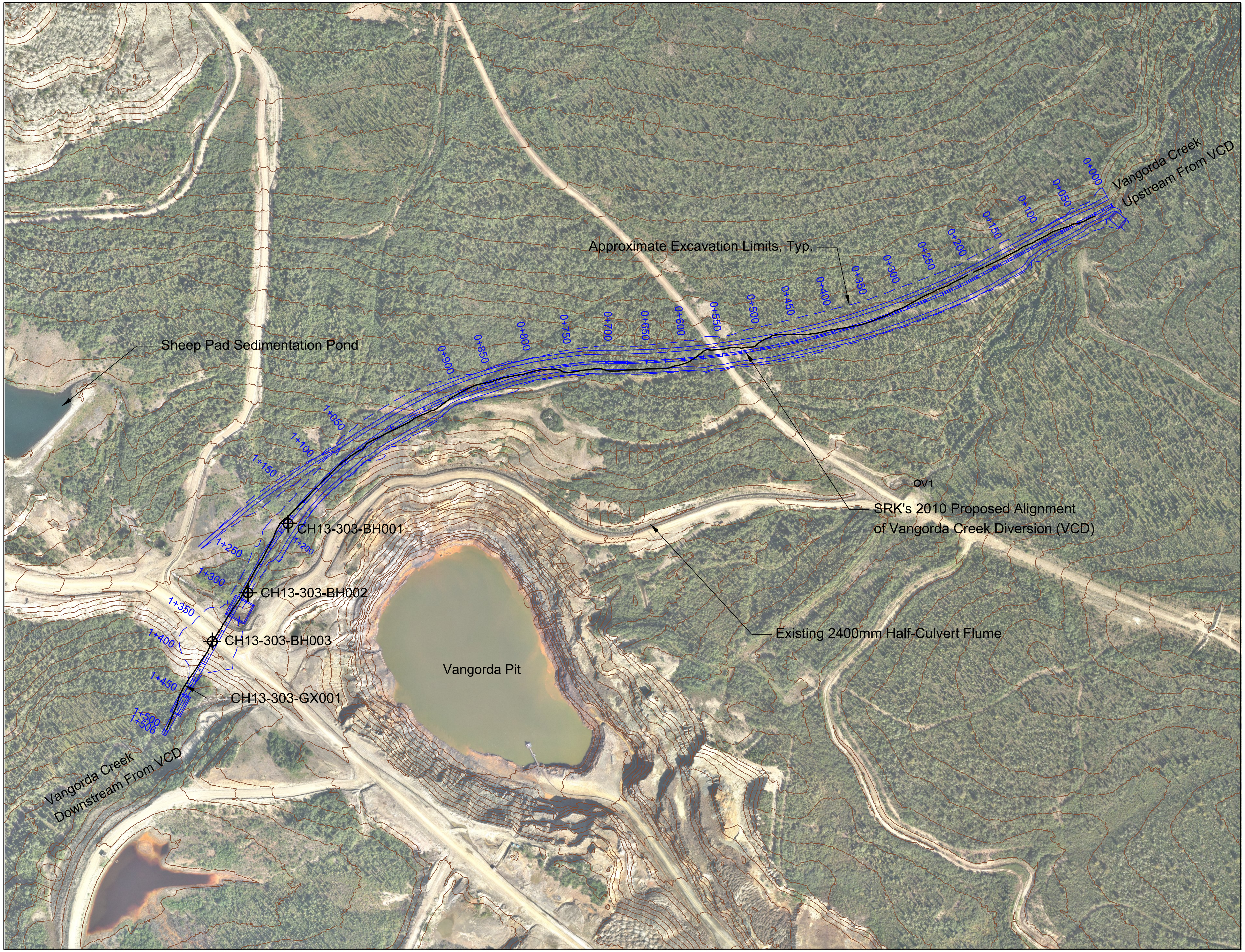


LEGEND

Area Withdrawn from Staking Mineral Claims (OIC #2008/168)

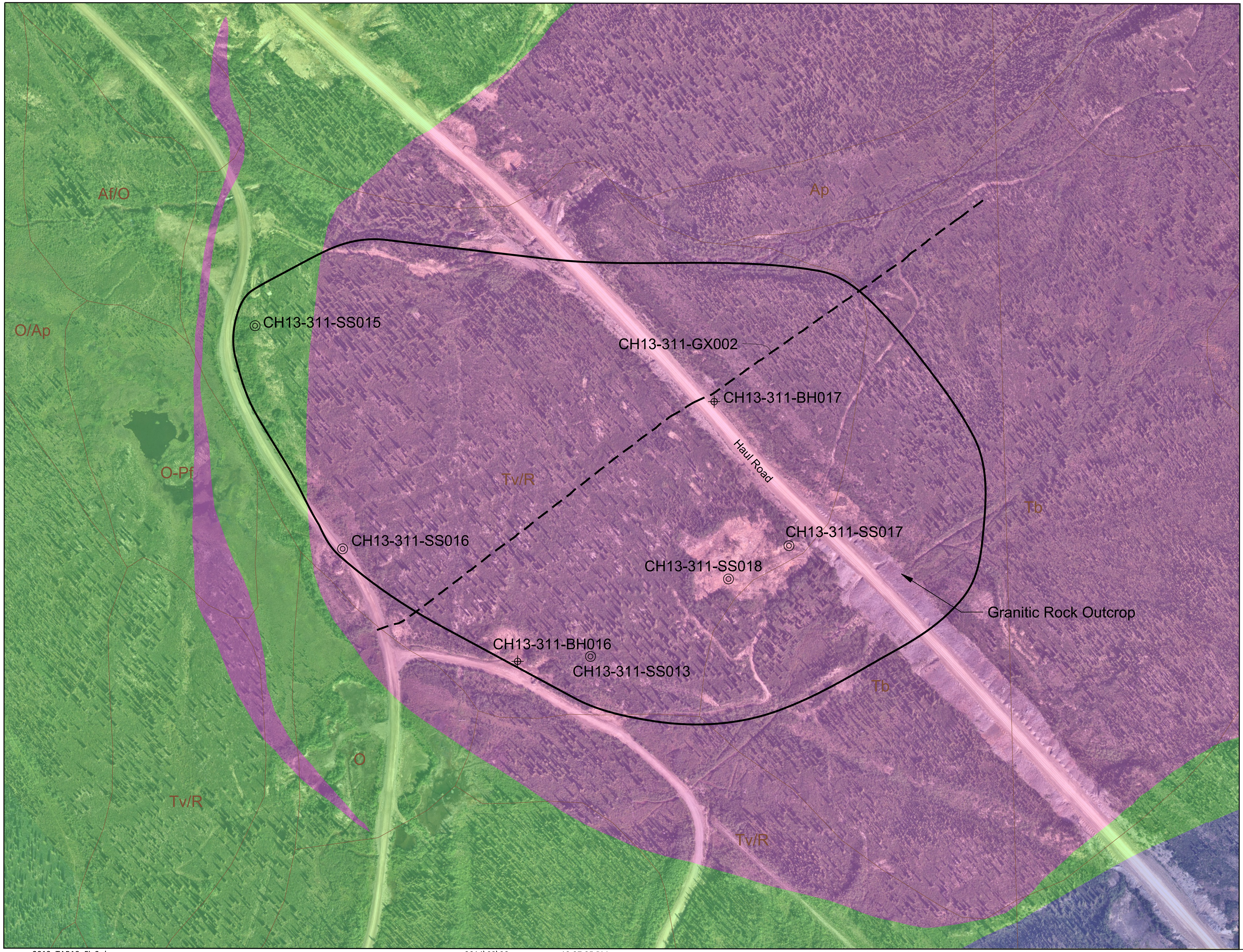
Note:
Aerial photo shown dated August 2012.

FIGURE 1-2
Keymap of Vangorda Diversion Sampling
Faro Mine Remediation Project



Notes:
1. Aerial Photo shown Dated August 2012.
2. Locations shown surveyed by Challenger Geomatics.

FIGURE 2-1
2013 Vangorda Creek Diversion Sample Locations
Faro Mine Remediation Project



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METRES

LEGEND

Surficial Geology (Note 2)
Seismic Refraction (Note 4)

Bedrock Geology (Pigage, 2004)

Biotite-Muscovite Granite (mKMMg)
Basalt (COVp)
Phyllite (ODDl)

2013 Borehole Location (Note 4)

2013 Shallow Test Pit Location (Note 3)

Surficial Geology (Bond, 1999)

QUATERNARY

HOLOCENE

MINE DISTURBANCE

MD- mine disturbance; consisting of an open-pit and stripped till and bedrock accumulations. Bedrock and surficial sediments exposed in open-pit.

MINE TAILINGS

MT - mine tailings; consisting of sand, silt and some clay.

ORGANIC DEPOSITS

O - organics; consisting of woody sedge peat, variable thickness. White River ash accumulations are commonly associated with poorly drained peaty areas.

ALLUVIAL DEPOSITS

Ap - alluvial plain; silt, sand and pebbles with reworked cobbles and boulders occurring as bars, overbank floodplain deposits, 0 - 10 m thick; floodplain subject to periodic floods. Small valley alluvial plains may not be mapped at this scale.

Ap (active) - alluvial plain; area of Pelly River floodplain that has been recently active.

At - alluvial terrace; silt, sand, and pebbles with reworked cobbles and boulders occurring as low terrace deposits, 0 - 10 m thick.

Af - alluvial fan; coarse sand, pebbles, cobbles and mudflow deposits, up to or >10 m thick. Appear as vegetated, often peat covered, landforms developed during post-glacial sedimentation.

Ax - complexes of Ap and Af undivided. Common when a stream is unconfined and also in narrow valleys where side-entry alluvial fans cannot be differentiated from an alluvial plain.

PLEISTOCENE AND HOLOCENE (UNDIVIDED)

COLLUVIAL DEPOSITS

Cv - colluvium veneer; conforms to bedrock topography, <1 m thick.

Ca - colluvium apron; coalescing colluvial fans at the base of a slope, >1 m thick.

Cz - mass wasting; includes slumping, debris slides and rockfalls. Slumping and rockfalls are Common on Mt. Mye.

LATE PLEISTOCENE (WISCONSINAN) - McCONNELL GLACIATION

GLACIOLACUSTRINE DEPOSITS

Lb - glaciolacustrine blanket; 1- 40 m thick.

GLACIOFLUVIAL DEPOSITS

Gp - glaciofluvial plain; 3 - 10 m thick.

Gt - glaciofluvial terrace; <10 m thick.

Gx - glaciofluvial complex; 1 - 30 m thick, composed of deposits of outwash, glaciolacustrine and minor till deposited in an ice contact environment. Hummocky topography is associated with this depositional setting. Crevasse fillings were mapped in the upper part of Vangorda Creek valley.

GLACIAL DEPOSITS

Tv - till veneer; conforms to underlying topography, <1 m thick.

Tb - till blanket; gently to moderately sloping plain controlled by bedrock or underlying surficial deposits, >1 m thick.

Tx - till complex; till blanket or veneer composed of meltout till and minor ice contact glaciofluvial deposits.

LOWER CAMBRIAN TO CRETACEOUS

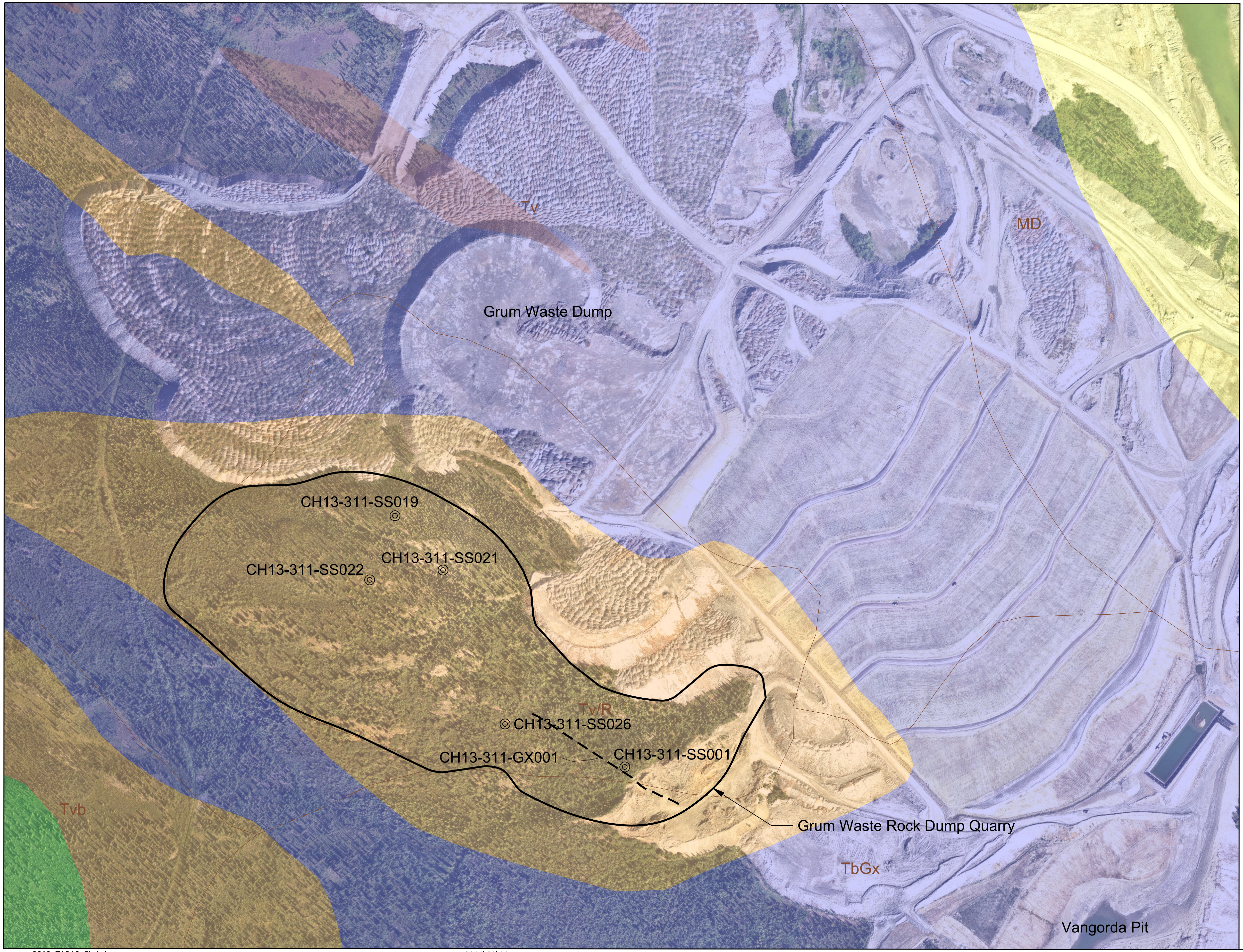
BEDROCK

R - bedrock; common on plateau summits and ridges on Mt. Mye and Sheep Mountain.

Notes:
1. Aerial photo shown dated August 2012.
2. Sources: Bond, 1999
Bond, 2001
Pigage, 2004
3. Locations shown based on Handheld GPS.
4. Locations shown surveyed by Challenger Geomatics.

FIGURE 3-1
2013 Granitic Rock Outcrop Borrow Source Search
Faro Mine Remediation Project

CH2MHILL.



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LEGEND

Surficial Geology (Note 2)
Seismic Refraction (Note 4)

Bedrock Geology (Pigage, 2004)

Gabbro (OSMg)
Basalt (COVp)
Phyllite (ODDl)
Shist (UPCMMs)

◎ 2013 Shallow Test Pit Location (Note 3)

Surficial Geology (Bond, 1999)

QUATERNARY

HOLOCENE

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MD- mine disturbance; consisting of an open-pit and stripped till and bedrock accumulations. Bedrock and surficial sediments exposed in open-pit.

MINE TAILINGS

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Ax - complexes of Ap and Af undivided. Common when a stream is unconfined and also in narrow valleys where side-entry alluvial fans cannot be differentiated from an alluvial plain.

PLEISTOCENE AND HOLOCENE (UNDIVIDED)

COLLUVIAL DEPOSITS

Cv - colluvium veneer; conforms to bedrock topography, <1 m thick.

Ca - colluvium apron; coalescing colluvial fans at the base of a slope, >1 m thick.

Cz - mass wasting; includes slumping, debris slides and rockfalls. Slumping and rockfalls are Common on Mt. Mye.

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Gt - glaciofluvial terrace; <10 m thick.

Gx - glaciofluvial complex; 1 - 30 m thick, composed of deposits of outwash, glaciolacustrine and minor till deposited in an ice contact environment. Hummocky topography is associated with this depositional setting. Crevasse fillings were mapped in the upper part of Vangorda Creek valley.

GLACIAL DEPOSITS

Tv - till veneer; conforms to underlying topography, <1 m thick.

Tb - till blanket; gently to moderately sloping plain controlled by bedrock or underlying surficial deposits, >1 m thick.

Tx - till complex; till blanket or veneer composed of meltout till and minor ice contact glaciofluvial deposits.

LOWER CAMBRIAN TO CRETACEOUS

BEDROCK

R - bedrock; common on plateau summits and ridges on Mt. Mye and Sheep Mountain.

Notes:
1. Aerial photo shown dated August 2012.
2. Sources: Bond, 1999
Bond, 2001
Pigage, 2004
3. Locations shown based on Handheld GPS.
4. Locations shown surveyed by Challenger Geomatics.

FIGURE 3-2
2013 Grum Waste Rock Dump Quarry
Faro Mine Remediation Project

CH2MHILL.

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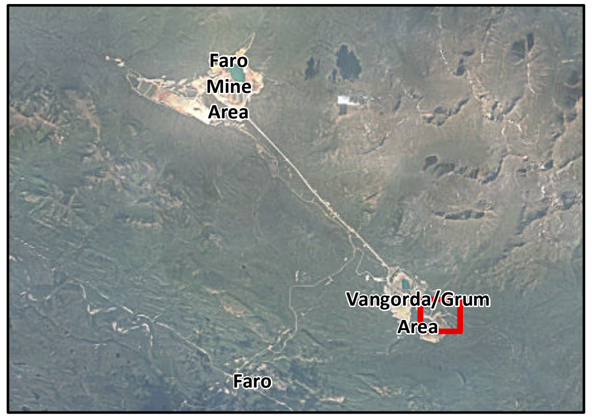
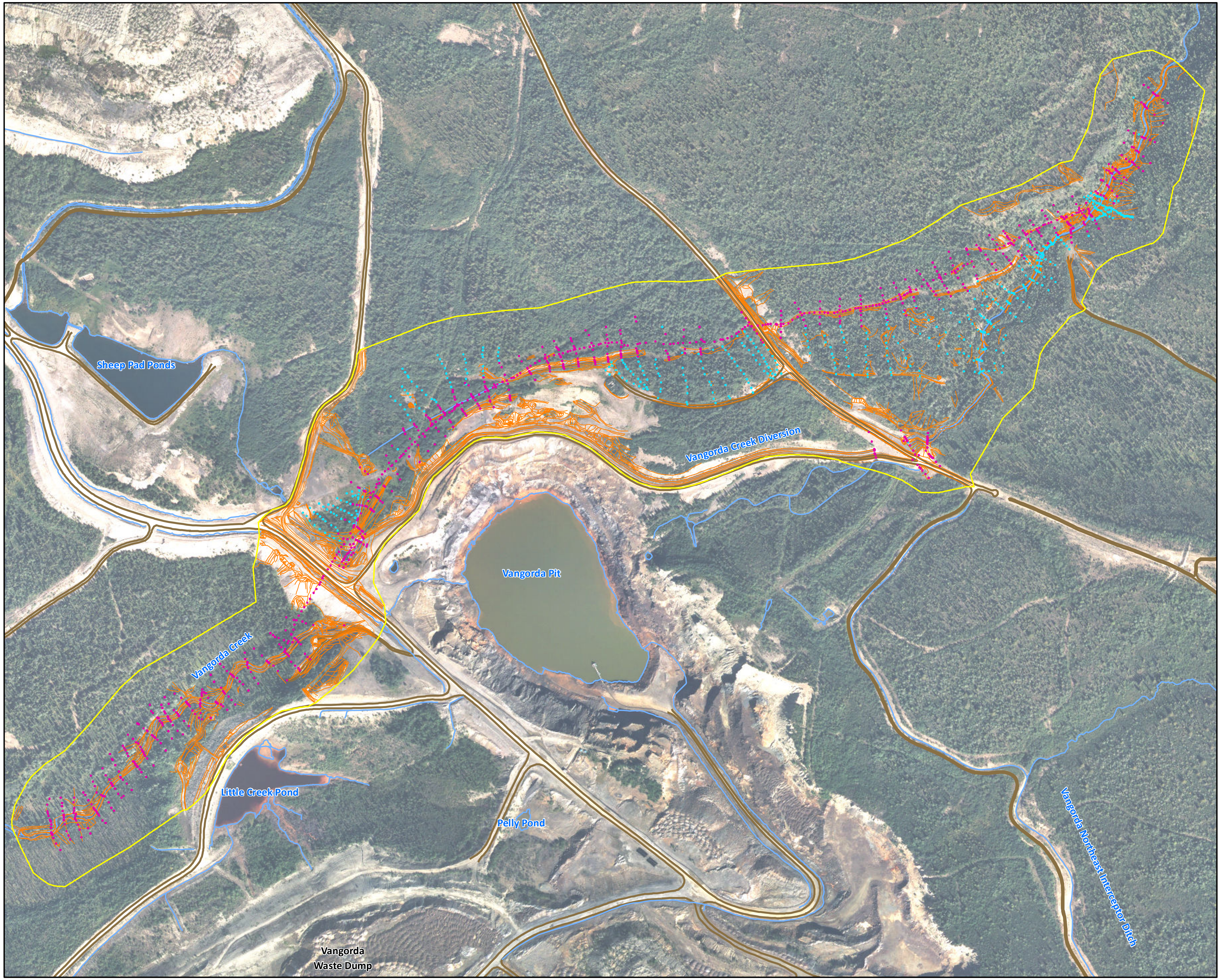
VICINITY MAP





LEGEND

- August 2013 RTK GPS Field Survey (Note 1)
- October 2013 RTK GPS Field Survey (Note 1)
- DTM Extent (Note 2)
- Stereo Breaklines (Note 3)

Notes:

1. Field Survey completed by Challenger Geomatics.
2. Limits of revised DTM - Digital Terrain Modell, updated using a combination of 2011 LiDAR, 2012 orthophoto augmented breaklines and field survey.
3. Stereo breaklines developed from 2012 orthophotos to augment 2011 LiDAR data for more accurate representation of steep rock outcroppings and other existing features. Aerial photography acquired by Peregrine Aerial Surveyors Inc. and Eagle Mapping in August 2012. Orthophotography prepared by Critigen Canada Corp. Rose Creek Tailings Area is also called Down Valley Tailings Area, and is where the Rose Creek Alluvial Aquifer is located.

N

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Created by:
CRITIGEN

FIGURE

Faro Mine Remediation Project

CH2MHILL.

FIGURE 3-4
Fluvial Geomorphic Assessment Reach Key Map
Faro Mine Remediation Project

CH2MHILL.

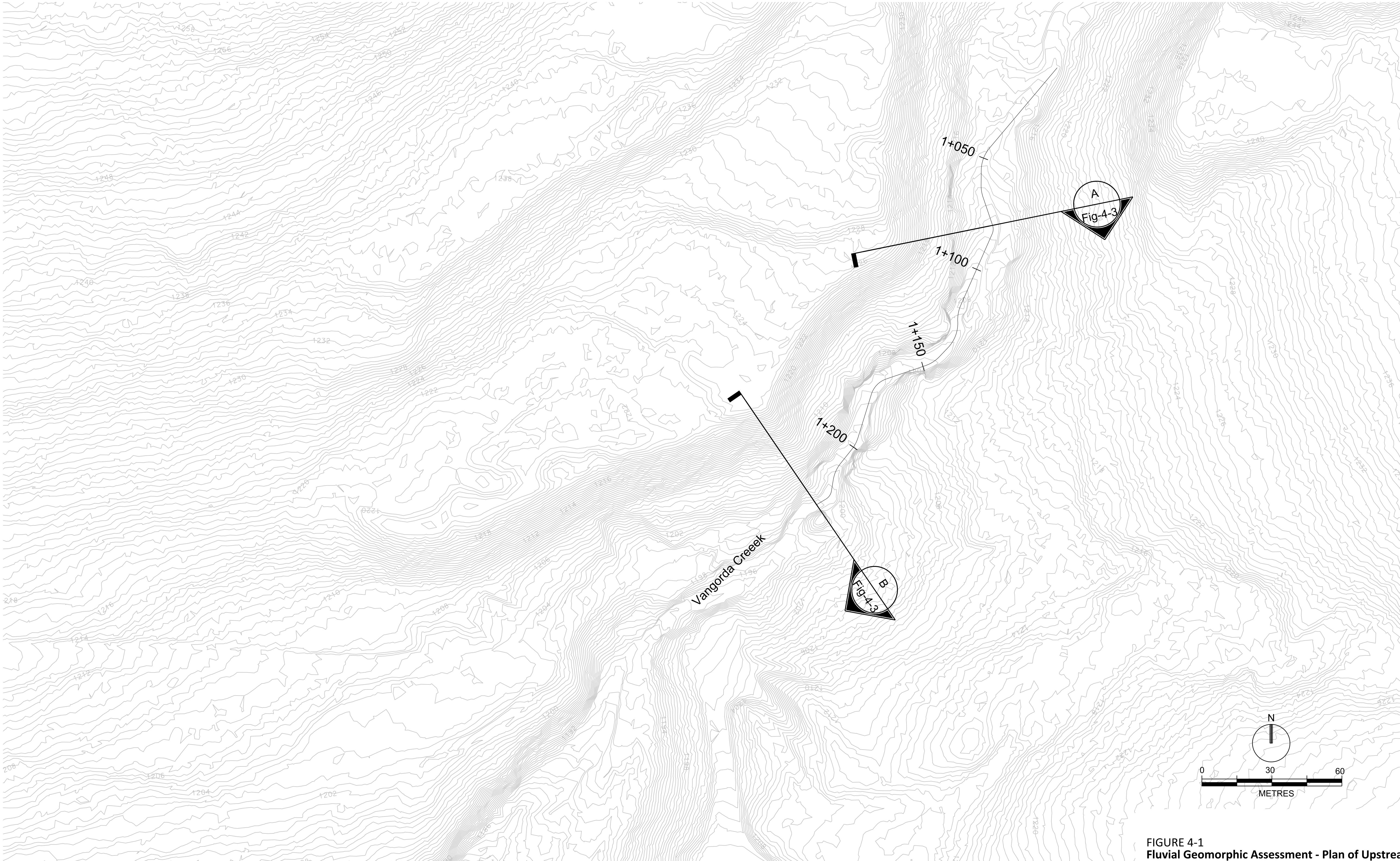
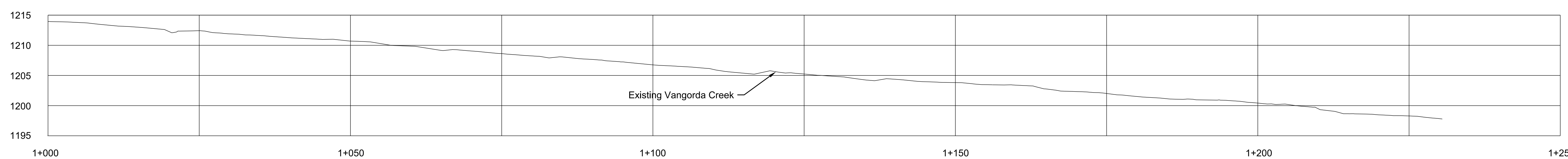


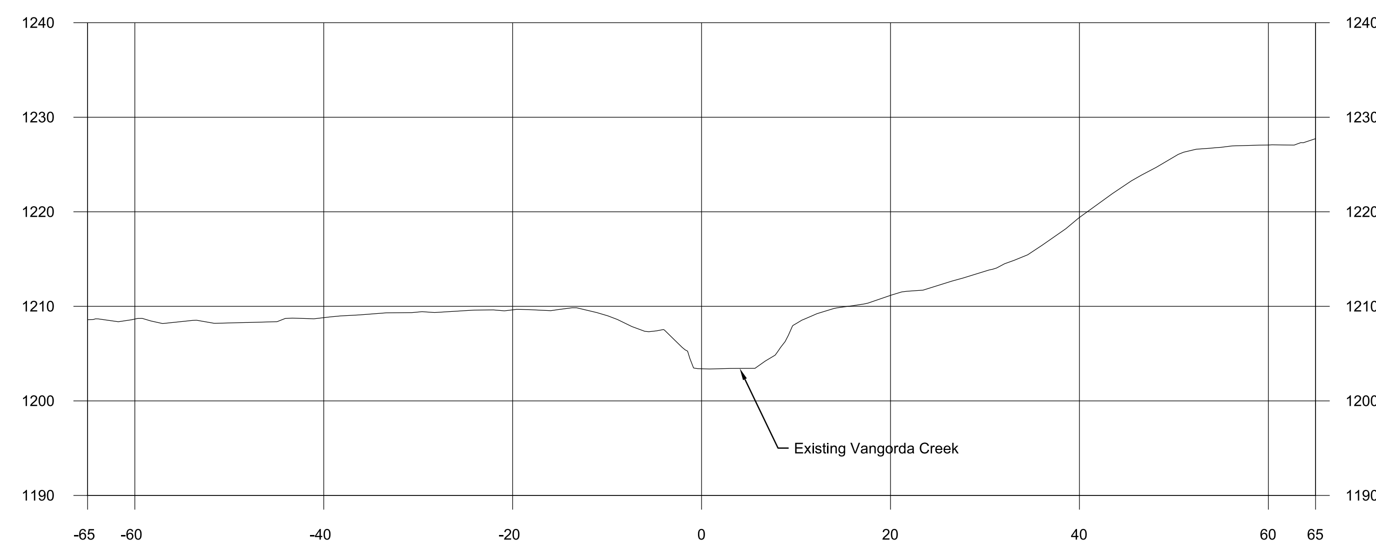
FIGURE 4-1
Fluvial Geomorphic Assessment - Plan of Upstream Reacl
Faro Mine Remediation Project



UP STREAM PROFILE
1:800

FIGURE 4-2
Fluvial Geomorphic Assessment - Upstream Profile
Faro Mine Remediation Project

CH2MHILL.



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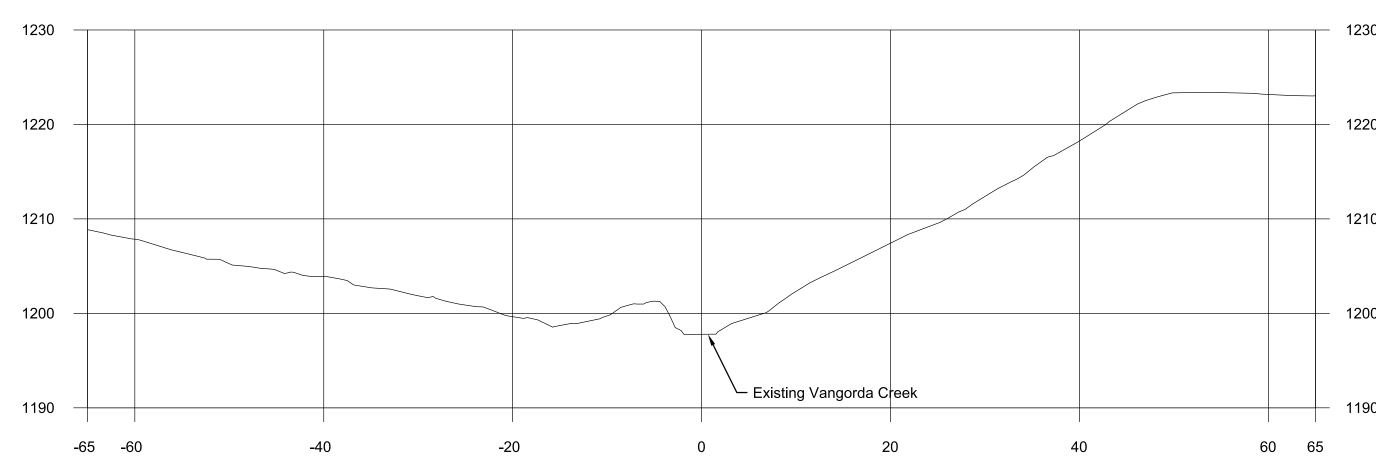
A SECTION
1:800
Fig-4-1



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B SECTION
1:800
Fig-4-1

FIGURE 4-3
Fluvial Geomorphic Assessment-Upstream Cross Sections
Faro Mine Remediation Project

CH2MHILL.

FIGURE ППП
Photograph of Vangorda Creek Upstream from Proposed Diversion Headworks (September 10, 2013)
Faro Mine Remediation Project

CH2MHILL®

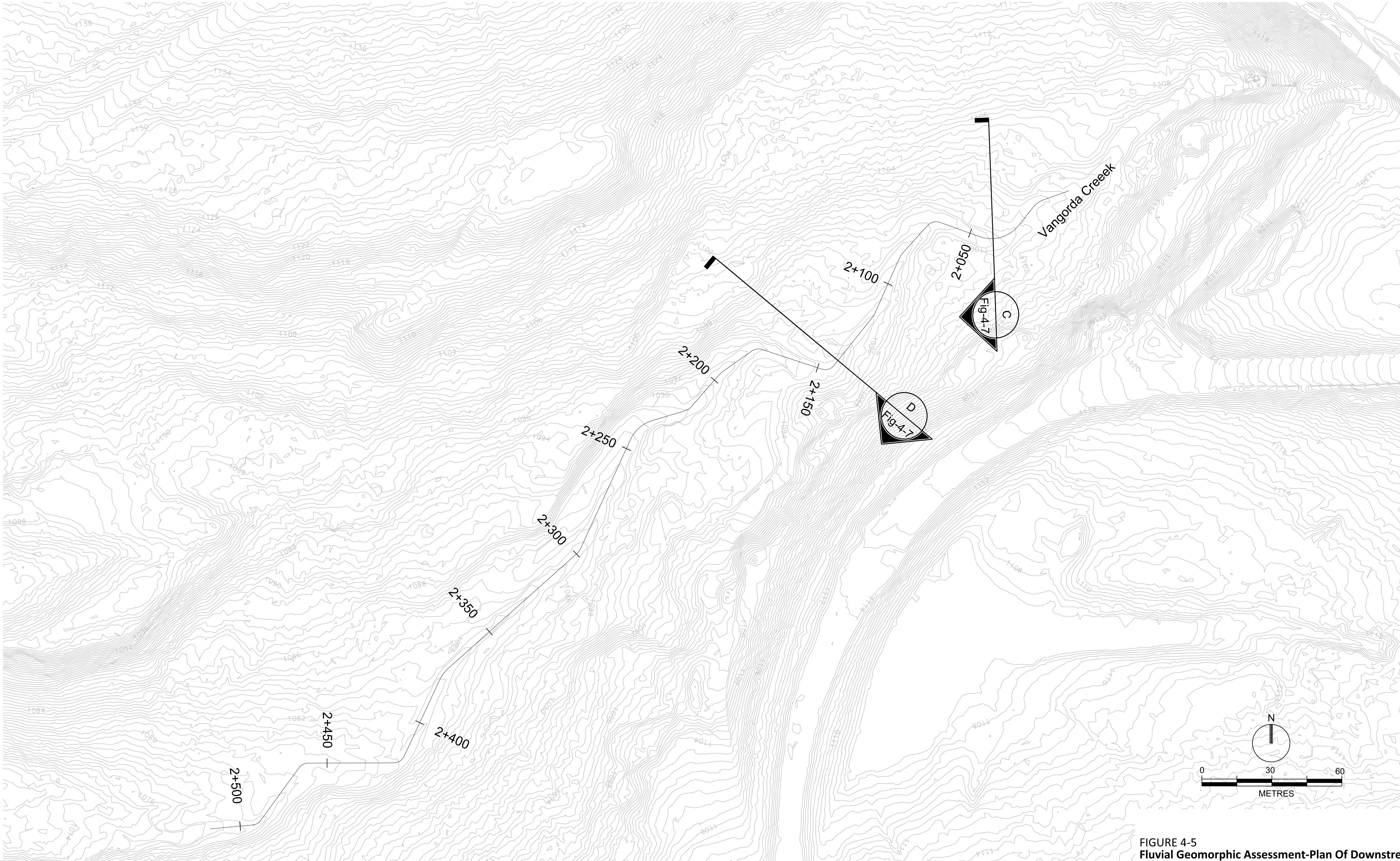
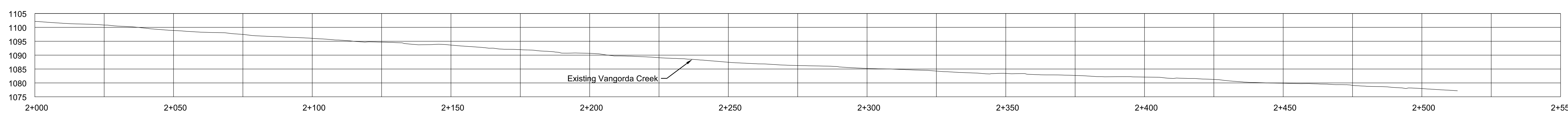


FIGURE 4-5
Fluvial Geomorphic Assessment-Plan Of Downstream Reac
Faro Mine Remediation Project

CH2MHILL.



DOWN STREAM PROFILE
1:1500

FIGURE 4-6
Fluvial Geomorphic Assessment - Downstream Profile
Faro Mine Remediation Project

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CH2MHILL.

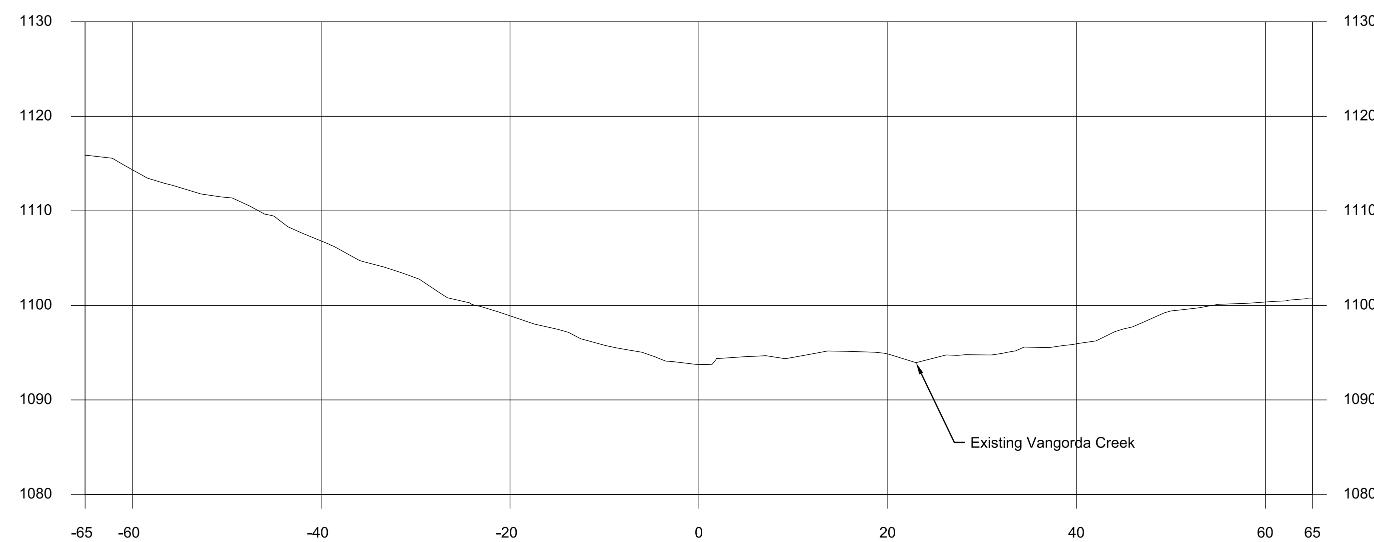

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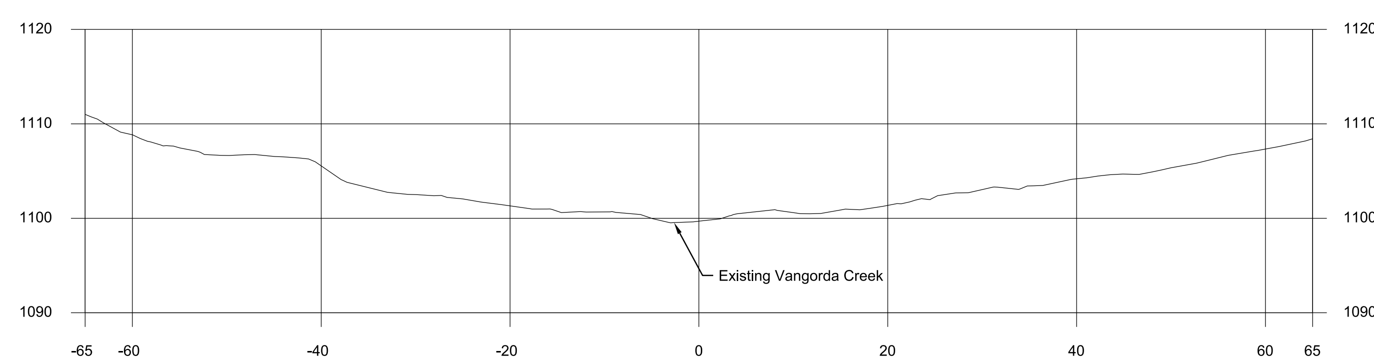
Fig 4-5



2+040
SECTION
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1:800
Fig 4-5

FIGURE 4-7
Fluvial Geomorphic Assessment - Downstream Cross-Sectior
Faro Mine Remediation Project

FIGURE пту
Photograph of Vangorda Creek 52øyẩŮŜl·Y
from Haul Road (September 10, 2013)
Faro Mine Remediation Project

Appendix A
Geophysical Survey Reports

Vangorda Creek Diversion Alignment Geophysics Report

(Appendix I, Project Log, is not included)

Geophysical Survey – Faro Mine Remediation – Vangorda Creek Diversion - VCD

NTS: 105K/06, Whitehorse Mining District, Yukon Territory, Canada

WORK PERFORMED:
July 7-August 18, 2013

Prepared for:
CH2MHILL

Prepared by:

AURORA GEOSCIENCES

TECHNICAL REPORT
Geophysical Survey – Faro Mine Remediation – Vangorda Creek Diversion - VCD

Prepared for:
CH2M Hill Canada Limited
Whitehorse, YT Y1A 4N2

Prepared by:
Aurora Geosciences Ltd.
34A Laberge Road, Whitehorse, Yukon, Y1A5Y9
Phone: (867) 668.7672 Fax: (867) 393.3577
www.aurorageosciences.com

Author
Phil Jackson, P.Geoph.

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1 SUMMARY

The geophysical investigations at the Vangorda Creek Diversion, located approximately 15 kilometers North of Faro, are a portion of a larger project at the Faro Mine, Faro, Yukon Territory. The purpose of the investigations at the Vangorda Creek Diversion was to assist in the design of environmental mitigation measures by identifying the depth from surface to the underlying bedrock contact along the length of the 1500 meter survey line.

This report describes procedures and results of line cutting, short-dipole resistivity, ground penetrating radar (GPR), seismic reflection and seismic refraction surveys conducted in the area between July 17th and August 12th, 2013.

Linecutting was required over the entire length of the survey line. Non-differential GPS waypoints were recorded at 50 meter stations. Topography was measured along the line using a laser range finder.

The short-dipole resistivity survey consists of an all-in-one multimode resistivity imaging system using multi-core cables. 72 electrodes are plugged in to the ground at fixed five meter spacing rolling forward by increments of 24 dipoles. Longer dipole spacings were used beyond n=10 where ground conditions produced unacceptable noise levels. Final data sets were compiled and inverted using RES2DINV Geotomo software.

The multi-frequency GPR survey was conducted with a Mala geosciences RAMAC GPR system operated at 25, 50, 100 and 500 MHz. Conventional GPR data processing was applied incorporating geometric registration, drift corrections, user gain, deconvolution, velocity analysis, and depth conversion.

The seismic refraction and reflection surveys were conducted with a 48 channel digital engineering seismograph using a four meter phone spacing and an ATV mounted hammer digipulse as the energy source, manual sledgehammer strikes were also used on occasion. The data was processed and interpreted primarily using the ReflexW, Pickwin™ and PlotRefa™ software packages. Refraction processing included initial data checks, topographic data reduction, first break picking, composite shot file assembly and inversion. Reflection processing included initial data checks, topographic data reductions, data import, registration and trimming, shot stack assembly, trace kills, band pass filters, gain, bottom mute, velocity analysis, normal move out correction, time depth conversion, static shifts and interpretation.

In general, the resistivity data effectively images zones of frozen topsoil, saturated overburden and elevated clay concentrations over the survey line. The GPR survey shows distinct zones of signal character change and some discontinuous reflectors attributed to the weathered bedrock. No single distinct reflector is interpreted as the bedrock interface. The seismic inversions provide the most useful tool in interpreting depths to the weathered and fresh bedrock contacts. Bedrock depths correlate with seismic velocities that range between 2500 and 3500 m/s. These velocities and associated reflectors are used as guides for the depth interpretation in the absence of additional supporting data. All final interpreted depths are superimposed on contoured seismic velocities and gridded resistivity to create the composite section for the survey line. Select locations along the survey line should be drill tested to verify and refine the interpretations included in this report.

2 INTRODUCTION

Aurora Geosciences Ltd. was retained by CH2M Hill Canada Limited to conduct line cutting, short-dipole resistivity, ground penetrating radar (GPR), seismic refraction and seismic reflection surveys. The surveys at the Vangorda Creek Diversion (VCD) are a portion of a larger project at the Faro Mine, Faro, Yukon Territory, which included five separate areas:

- Cross Valley Dam (CVD)
- DVIHU (Down Valley / Rock Drain) Assessment (RCD)
- Borrow Search Investigations at Granitic Rock Outcrop
- Grum Waste Rock (WR) Quarry
- New Vangorda Creek Diversion (VCD)

The purpose of the investigations at the Vangorda Creek Diversion was to assist in the design of environmental mitigation measures by identifying the depth from surface to the underlying bedrock contact along the length of the 1500 meter survey line. Based on previous investigations, the local stratigraphy consists of a layer of glacial till overburden overlying weathered phyllite with some permafrost and ice lenses present in the area. The depth to competent bedrock is predicted to be in the range of 2 to 20 meters. All geographic locations in this report are relative to North American Datum 1983. Non-geodetic coordinates are expressed in Universal Transverse Mercator Zone 8N metric coordinates. All measurements are expressed in the metric system unless they are measurements quoted from historic reports expressed in other units of measure. All geophysical data units are in the metric SI system.

3 LOCATION & ACCESS

The geophysics crew was based in the town of Faro, YT for the duration of the project with all areas accessible by truck. The Vangorda Creek Diversion is approximately 15 kilometers north of Faro; a detailed map of the surveyed line is shown in Figure 1.

4 WORK PROGRAM

This section describes the work program conducted at Vangorda Creek Diversion in 2013. Line cutting, short-dipole resistivity, ground penetrating radar (GPR), seismic reflection and seismic refraction surveys were conducted on one 1500 meter survey line. Appendix I contains a project log.

4.1 Line cutting & gridding

Line cutting and grid installation were conducted on the property to facilitate accurate location control for the geophysical surveys.

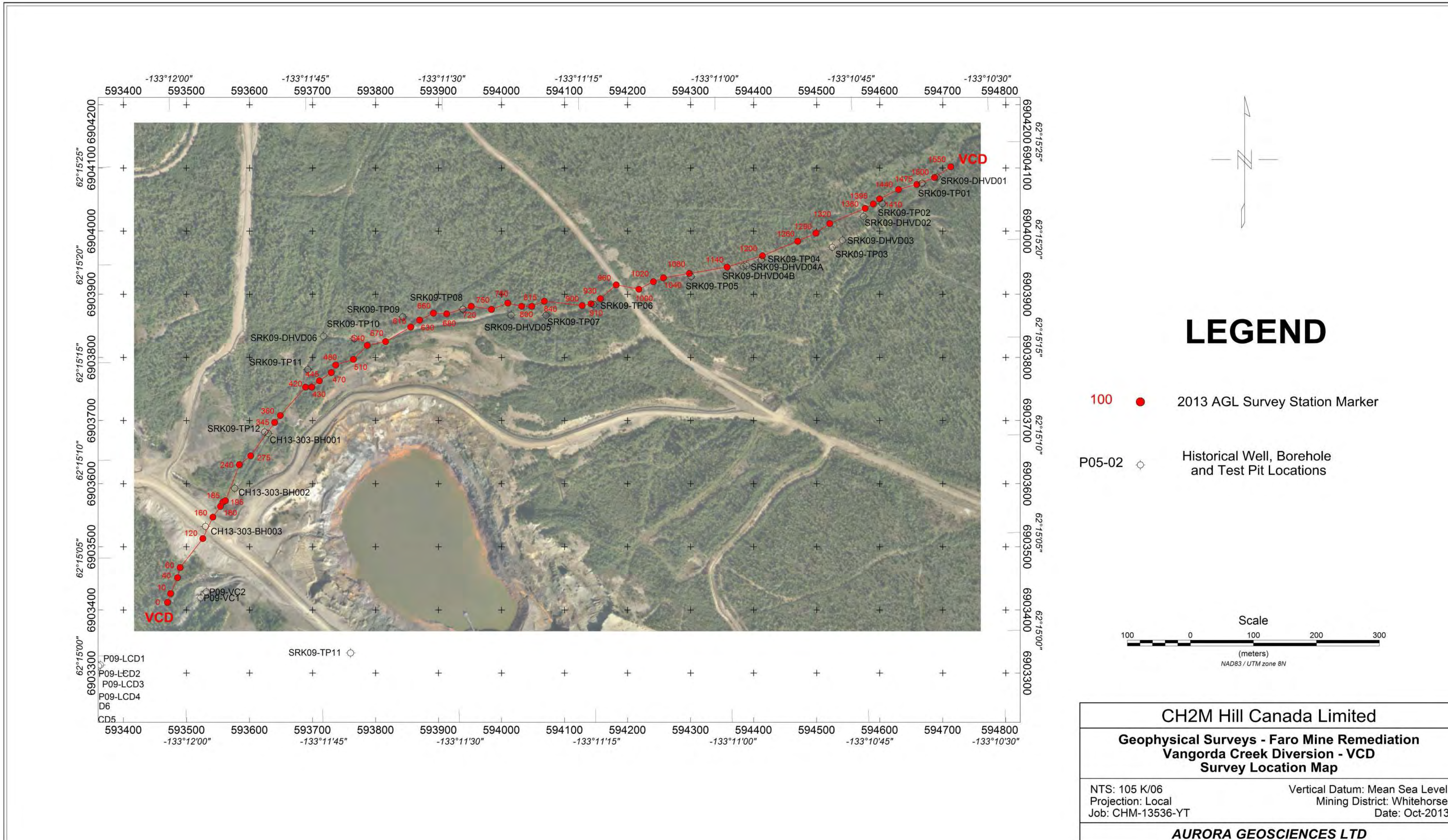


Figure 1. Survey Location Map

4.1.1 Equipment

The crew was equipped with the following instruments and equipment:

Equipment:	2 – Husqvarna 245 saws 2 – Sets brushing / chaining equipment 1 – Laser range finder
Communications:	1 – Satellite phone 2 – VHF radios
Vehicles:	1 – 1Ton truck 2 – Polaris ATV
Safety:	2 – Each of PPE including hard hat, safety glasses, steel-toed boots, hearing protection, long sleeved shirts, hip chaps (line cutting), hard hat with visor (line cutting), gloves, reflective vest and work pants as required by health and safety plans 1 – Each of fire extinguisher, first aid kit and potable water
Other:	3 – GPS receivers 1 - Laptop & color printer w/ Geosoft 1 - Field office equipment 1 - Repairs & tool kit 5 KV gas generator

4.1.2 Field Procedures

Line cutting was conducted according to the following specifications:

Station spacing:	50 meters
Chainage:	Stations: straight chained
Station marking:	Survey lines: Half-length pickets with metal tags
Registration:	Non-differential GPS measurements recorded at 50 m intervals. Horizontal and vertical distances measured between stations with a laser range finder

4.1.3 Products

Digital data included with this report comprises:

GPS measurements – station location	Topography\VCD GPS Waypoints.xls
Final data – laser range finder measurements	Topography\VCD Topography.xls

The survey grid is plotted on the location map shown in Figure 1.

4.2 Short-Dipole Resistivity Survey

A short-dipole resistivity survey was conducted on VCD between July 17th and 20th, 2013. The purpose of the survey was to distinguish layers of high and low relative permeability and identify the depth from surface to the underlying bedrock contact along the length of the 1500 meter survey line.

4.2.1 Equipment

The crew was equipped with the following instruments and equipment:

Instruments & Equipment	Syscal Pro Resistivity & IP System 72 including transmitter, receiver, switch, cables, battery and software
Communications:	1 – Satellite phone 2 – VHF radios
Vehicles:	1 – 1Ton truck 2 – Polaris ATV
Safety:	2 – Each of PPE including hard hat, safety glasses, steel-toed boots, hearing protection, long sleeved shirts, gloves, reflective vest and work pants as required by health and safety plans 1 – Each of fire extinguisher, first aid kit and potable water
Other:	3 – GPS receivers 1 - Laptop & color printer w/ Geosoft 1 - Field office equipment 1 - Repairs & tool kit 5 KV gas generator

4.2.2 Field Procedures

The resistivity survey consists of an all-in-one multimode resistivity imaging system using multi-core cables. 72 electrodes are plugged in to the ground at fixed five meter spacing rolling forward by increments of 24 dipoles. Longer dipole spacings were used beyond n=10 where ground conditions produced unacceptable noise levels

Resistivity surveying was conducted according to the following specifications and procedures:

Array:	dipole - dipole
Dipole Spacing:	a=5m (n= 1-32); In areas of high noise levels: a=5m (n=1-10), a=15m (n=11-20) & a=30m (n=21-32)
Separations Read:	n = 1 to 32 (maximum)
Tx mode / signal:	Standard time domain signal(0.5 s +on, 0.5 s off)
Parameters Read:	Contact Resistance Primary voltage Spontaneous Potential

4.2.3 Data processing and products

The resistivity survey data was processed and interpreted using the following procedures:

1. Download & archive: Data is downloaded from the field instruments and raw data files are archived.

2. Data review: The resistivity data is reviewed and edited prior to preparing pseudosections and datasets for inversion. Duplicate readings are averaged and duplicates removed from the database to leave only a single reading at each station and separation. Readings with large errors which did not repeat within 10% are deleted from the database.

3. Pseudosection plotting: Pseudosections of the apparent resistivity are prepared from the final edited data. Sections are scaled to the range on each line.

4. Data formatting: The resistivity (in normalized V/I) and topographic data are formatted for entry into the RES2DINV inversion program.

5. Image extraction: After the modelling is complete, data ranges are compiled and overall data scales are assigned for the resistivity model. A resistivity scale covering the range from 0 to 1500 ohm-m is used as a standard scale. Final images are generated with the inversion software and converted to JPEGs without further editing.

Final digital data is appended to this report in Excel spreadsheet format. All unacceptable or erroneous readings, and those which did not repeat, are deleted from this final data set. Also included are GPS position measurements taken along the survey lines. These show the averaged location of the survey point in UTM coordinates, NAD 1983 datum, Zone 7N projection. This data is contained in an ASCII text file (GPS Points.txt).

The inversion results are collated in Appendix II. These images show the observed data, the model generated response for comparison, and the 2D resistivity distribution in the final model. The missing data produces a stretched grid in both the measured and calculated apparent resistivity pseudosections; however this is observed in areas greater than 25 meters below the surface and beyond the area of interest.

Digital data included with this report comprises:

Final Quality controlled databases	Resistivity\VCD\Final data\VCD Res Final.xyz &.gdb
Raw Data	Resistivity\VCD\Raw data*.bin
Inversion results	Resistivity\VCD\Res2D Inversion*.*

4.3 Ground Penetrating Radar (GPR) Survey

A GPR survey was conducted on August 3rd and 7th, 2013. The purpose of the survey was to estimate the depth from surface to the underlying bedrock contact along the length of the 1500 meter survey line

4.3.1 Equipment

The crew was equipped with the following instruments and equipment:

Instruments & Equipment	1 – Ramac GPR Pro Ex Controller 1 – Ramac Pro Ex Optical Module 1 – Control Unit II (CUII) 1 – 25, 50, 100 MHz Rough Terrain & 500MHz shielded Antenna 1 – Monitor Rad Explorer Software
Communications:	1 – Satellite phone 2 – VHF radios
Vehicles:	1 – 1Ton truck 2 – Polaris ATV
Safety:	2 – Each of PPE including hard hat, safety glasses, steel-toed boots, hearing protection, long sleeved shirts, gloves, reflective vest and work pants as required by health and safety plans 1 – Each of fire extinguisher, first aid kit and potable water
Other:	3 – GPS receivers 1 - Laptop w/ Geosoft 1 - Field office equipment 1 - Repairs & tool kit 5 KV gas generator

4.3.2 Field Procedures

The GPR system is normally worn and operated by a single operator for high frequency surveys, or is carried and guided by several operators with the controller being either worn or towed. The transmitter and receiver electronics are mounted on their respective antennas and linked via fibre optic cables to the controller unit. Both the transmitter and receiver are controlled by the RAMAC monitor running interface software which configures the system, stores the collected data and allows the operator to view the radargrams in real time.

The line, read with successive passes for each individual frequency, was completed as a profile survey. The Rough Terrain Antenna (RTA) are oriented in-line with the survey direction and spaced a fixed distance apart. The survey is conducted by moving the antenna pair along the line. The data is then plotted using radargrams which show the centre of the antennas (x) on the horizontal axis and the signal on the y-axis as a function of time (t), with arrival time increasing vertically downward. The reflections appear at various distances below the time zero line at the top of the radargram. These distances below the time zero line are proportional to the arrival times which in turn are roughly proportional to the depth to target. Thus, the reflections display a pattern which generally correlates with their subsurface location. During data processing, the arrival times may be converted to depths and the reflections are then displayed at the apparent depths of the sources. Reflections are displayed as grey shade plots.

GPR surveying was conducted according to the following specifications and procedures:

Centre Frequency:	25, 50, 100 & 500 MHz
Measurement Interval:	10cm (maximum), determined by operating frequency.

Antenna Separation:	4m (25 MHz), 2m (50MHz), 1m (100MHz) and 0.5m (500MHz)
Triggering:	Time: 0.75s (25MHz), 0.5s (50MHz) and 0.25s (100MHz) and 0.1s (500MHz)
Station Registration:	The apparent horizontal distance at which each surveyed control line picket was encountered was recorded manually and used in the data processing to register the lines.

4.3.3 Data processing and products

The GPR survey data was processed and interpreted using the following procedures:

1. Download & archive: Data is downloaded from the field instruments and raw data files are archived.
2. Geometric registration: Trace coordinates are updated and interpolated to match recorded markers during data acquisition.
3. De-wow: Low frequency antenna to antenna reverberations are removed by cutting frequencies generally below ¼ of the centre frequency.
4. Trace kills: traces collected during static data collection time or outside survey markers are removed.
5. Drift removal and resetting of time zero: The time zero line on the radargrams is reset to the first arrival of the ground wave.
6. Gain: Compensation for damping losses is achieved by multiplication of linear, exponential and programmed gain functions where appropriate.
7. Deconvolution: Spiking deconvolution is applied to sharpen the reflections.
8. X-Flip: Applied to data acquired in opposite survey directions to achieve consistent viewing directions from west to east.
9. Depth conversion: using average ground velocity using measured diffraction hyperbolas
10. Printing: JPEG format showing the location of the line registration points and all picked reflectors.

The radargrams show the horizontal position along the x-axis in local station coordinates and both travel time and apparent depth along the y-axis. The radargrams have not been compensated for topography and are plotted with considerable vertical exaggeration. The reflections are plotted as alternating black (positive) and white (negative) bands. The first arrival - a triplet which is continuous across the section- is the ground wave between the antennas and not a feature of interest. Ringing is also present and is manifested by parallel bands of recurring reflections which tend to run across the section and obliterate any weaker reflections arriving in the same time window. A deep flat lying reflector is observed at approximately 40 meters below the surface between stations 300 and 400 on the 25 MHz radargram only. . This is interpreted to be a lithological change. The 500 MHz data showed no reflectors over the survey area and has been dismissed as unusable. Reflector picks are indicated on the radargrams and used in combination with other survey data to interpret the depth to bedrock. GPR signal attenuation is higher in more conductive ground. This is evident on all frequencies with distinct changes in signal characteristics observed between stations 100 and 700. The area exhibits strong signal attenuation and is interpreted to represent wet ground and or elevated clay content. Shallow, flat lying reflections are observed between stations 700 to 1000. The deeper discontinuous reflections observed from station 1200 to the end of the line are largely attributed to fractures within weathered bedrock. Depths to reflections occur over zones, indicative of frozen or resistive sediments, thus a velocity of 0.11 m/ns is applied to all radargrams.

Digital data included with this report comprises:

Raw and Processed GPR field data	Digital Data\GPR\"Frequency"*.*

Appendix II contains processed radargrams for all surveyed frequencies.

4.4 Seismic Refraction Survey

A seismic refraction survey was conducted between July 20th and August 12th, 2013. The purpose of the survey was to estimate the depth from surface to the underlying bedrock contact along the length of the 1500 meter survey line

4.4.1 Equipment

The crew was equipped with the following instruments and equipment:

Instruments & Equipment	2 - Geometrics Geode G24 seismographs 2 – 24 channel cable with 5m takeouts 48 – Mark Products 40Hz vertical component geophones ATV mounted source, sledge hammer and plate
Communications:	1 – Satellite phone 2 – VHF radios
Vehicles:	1 – 1Ton truck 2 – Polaris ATV
Safety:	2 – Each of PPE including hard hat, safety glasses, steel-toed boots, hearing protection, long sleeved shirts, gloves, reflective vest and work pants as required by health and safety plans 1 – Each of fire extinguisher, first aid kit and potable water
Other:	3 – GPS receivers 1 - Laptop w/ Geosoft 1 - Field office equipment 1 - Repairs & tool kit 5 KV gas generator

4.4.2 Survey specifications

The refraction seismic survey was performed according to the following specifications:

Channels:	48

Receiver spacing:	4 m
Shot locations:	Offset shots – 60 m off each end of line (nominal) End of line shots – Phones 1 and 48 Mid-spread – Phone 24
Record length:	512 ms
Sampling:	62 μs
Source effort:	Digipulse: 10 blows Hammer: 15 blows

4.4.3 Data processing

The refraction seismic survey data is processed primarily using the ReflexW, Pickwin™ and PlotRefa™ software packages. The following procedures and methods are used and described in order below:

1. Initial data checks: The seismic refraction data is of acceptable quality overall with some shot records containing unacceptable data. Bad data included shot records with a few dead traces and some shot records with very poor signal strength in portions of a spread due to bad ground or intervening geological features between the shot and geophones. The initial data checks begin with checking each data file against the observer's field records to verify that the receiver and shot locations were correct. In cases where there is a discrepancy between the observer's record of the receiver locations and the receiver locations in the file header, the file header was corrected if it can be conclusively established that the discrepancy resulted from a simple keying error; otherwise the shot record is rejected. End of line and mid-spread shots are recorded within a spread with the shot point at a geophone location. Consequently, it is easy to verify the shot location from the shot record as the shot occurs at the geophone with the near zero time arrival. In some cases there were obvious discrepancies between the observer's records and the observed shot location. In this instance, the shot location as indicated by the shot record is used to correct the observer's records. In cases where there is ambiguity, the observer's records are considered correct.

2. Topographic data reduction: The origin used for the seismic survey (station 0 in seismic coordinates) was station 1500 m in local coordinates (594687E, 6904085N, nominal elevation 289.6 m). The survey was run to the southwest, terminating at local station coordinate 0 m (593457E, 6903400N, nominal elevation 200.0 m). The seismic data processing for both the refraction and reflection surveys was done in acquisition or instrument coordinates which are the reverse of the line coordinates. Following processing, all final seismic images and data were flipped along the x-axis to match the conventional survey orientation. The seismic survey line has a nominal length of 1500 m and a surveyed horizontal length of 1471.3 m. Topographic reduction consisted of calculating the horizontal (line) coordinates and elevation of each shot and receiver, relative to acquisition coordinates. Local station coordinate 0 m on the seismic line has an assigned elevation of 200.0 m. This is the common elevation datum used in the

calculation of all other station elevations and in the reflection seismic processing. This datum was also used in the seismic refraction processing and modeling.

3. Pick first breaks: First arrivals are picked with Pickwin™ and stored in ASCII format *.vs files containing the shot location and the first arrivals by phone and x-coordinate. In making these picks, the interpreter is guided by knowledge of the expected pattern of arrivals from two or more refractors and the likely response of permafrost patches. The latter can produce anomalously fast and early first arrivals in groups of phones along a spread in a pattern which does not fit the expected sequence of progressively flattening first arrivals moving away from the shot location.

4. Composite shot file assembly: The first arrivals are assembled in a composite shot file in PlotRefa™ and inverted with the same software. After assembly, each shot is checked to ensure that the shot location is correct. Thereafter, first arrivals are examined and where necessary edited by the interpreter. Arrivals which could not be picked accurately are assigned a 0 arrival time during picking; these are removed after assembly in the composite shot file. Arrival times which are affected by receiver statics - typically a delay affecting arrival times from several shots at the same geophone – are corrected by moving them into line with neighboring arrival times. Minor smoothing is also done since random phone-to-phone variations do not normally reflect refractor topography but are primarily caused by noise in the shot record. Finally, the line topography is imported into the inversion package to correct the phone and shot elevations. The finite element inversion algorithm used in the inversion could not handle variations in horizontal (x) phone locations and the nominal phone locations (4 meters apart) were used for all subsequent processing.

5. Inversion: The data are inverted using a tomographic ray-tracing algorithm. A four meter (horizontal) cell size was used in the inversion. The initial model is a layered model with a vertical variation in seismic velocity parallel to surface topography of from 300 to 5,250 m/s over a depth of 20 to 30 meters. The inversion is allowed to run for 10 or 20 iterations, the model is adjusted to improve the fit between the predicted and observed data by varying the velocity in each cell along the modeled ray paths. Root mean square (RMS) misfit between the observed and measured data is taken as the indicator of goodness-of-fit and the algorithm sought to minimize the RMS error in successive iterations. The inversion algorithm is unable to model data from shots fired off either end of the seismic line. Upon completion of the inversion, a final ray-tracing is performed with a different algorithm to verify the robustness of the model. The final products of the inversion consist of: predicted and observed travel times for each shot and station (Inversion results) in a T-X (travel time / distance) plot; the velocity model (Final model); and the ray-traced model showing the final model with calculated ray paths(Ray traced model). This, together with a T-X plot of only the observed data (Travel time plot), is shown in the summary plots for each refraction survey for each line.

4.4.4 *Inversion results & products*

The data for Line VCD is generally good. There were problems reading the down line (decreasing stations) long-offset refraction shot with the first phone at station 1005; only half of the shot record could be picked. Minor smoothing is required together with the removal of travel times for geophones located at shot points.

Because the length of the line exceeded the limitations of the inversion software, the line is inverted in two sections: 0-1450 meters and 190 – 1500 meters. The two models are then joined at 800 meters where the difference between the results for cells at identical locations is less than 1%. The inversions are poor with a final RMS error after ray tracing of 4.03 ms (Panel 1) and 4.66 ms (Panel 2).

In general, the modeled data agrees with the observations and the final model is in agreement with features seen in the travel time curves. The down line (smaller station) first arrivals are quite fast relative to the up line first arrivals. The model results showing more slow material in this area are entirely consistent with the arrival time pattern. There is one notable discrepancy. The data for the shot at station 644 show low (V1) velocities of approximately 520 m/s but no low velocity material apparent in the model. The inversion results show cusps generated in the calculated first arrivals from the deeper refractors at stations 820 and 1005 meters. Only the cusp at 820 is associated with a feature in the final model. The low velocity depression between 800 to830 meters may be suspect.

Average velocity measurements taken from the observed arrivals in the T-X plot for the direct wave and first two apparent refractions - assuming a three-layer model - yielded an upper layer velocity of 434 m/s, a middle layer velocity of 1,320 m/s and a lower layer velocity of 4,873 m/s.

Digital data is appended to this report in the digital data archive, seismic refraction folder. This includes the raw shot files (*.dat / SEG2), the picked first arrival files (*.vs / ASCII) and the final inversion model in Excel format. The latter contains the coordinates (x,z) of the centre of each model cell in seismic acquisition coordinates together with the cell velocity in meters per second (m/s).

Appendix IV contains summary plots of the inversion results. These show, by line:

- Final inversion results (observed versus predicted travel times),
- Final model in color contour format,
- Ray-traced final model showing predicted ray paths in the final model and
- Observed travel times alone, after editing.

4.5 Seismic Reflection Survey

A seismic reflection survey was conducted between July 20th and August 12th, 2013. The purpose of the survey was to estimate the depth from surface to the underlying bedrock contact along the length of the 1500 meter survey line.

4.5.1 Survey specifications

The reflection seismic survey was performed according to the following specifications:

Channels:	48
Receiver spacing:	4 m
Shot spacing:	8 m
Minimum offset:	4 m
Maximum offset:	188 m
Nominal maximum fold:	24
Record length:	512 ms
Sampling:	62 ms
Source effort:	Digipulse: 10 blows
	Hammer: 15 blows

The nominal subsurface coverage with these survey parameters was eight meters.

4.5.2 Data processing

The reflection seismic survey data was processed primarily using the ReflexW™ software package. The following the procedures and methods were used, described in order below:

1. *Initial data checks.* The seismic reflection data is of acceptable quality overall with some shot records containing unacceptable data. Bad data included shot records with a few dead traces and some shot records with very poor signal strength in portions of a spread due to bad ground or intervening geological features between the shot and geophones. The initial data checks begin with checking each data file against the observer's field records to verify that the receiver and shot locations are correct. The receiver locations in the file header are compared against the observer's records. In cases where there is a discrepancy between the observer's record of the receiver locations and the receiver locations in the file header, the file header is corrected if it could be conclusively established that the discrepancy resulted from a simple keying error; otherwise the shot record is rejected. All of the reflection shots are recorded within a spread with the shot point at a geophone location. Consequently, it is easy to verify the shot location from the shot record as the shot occurs at the geophone with the zero time arrival. In some cases there are obvious discrepancies between the observer's records and the observed shot location. In this instance, the shot location as indicated by the shot record is used to correct the observer's records. In cases where there is ambiguity, the observer's records are taken as correct. At the end of this step, the checked data files are collected and renumbered in a sequential processing sequence in a raw file bin.

2. *Topographic data reduction.* The origin used for the seismic survey (station 0 in seismic coordinates) was station 1500 m in local coordinates (594687E, 6904085N, nominal elevation 289.6 m). The survey was run to the southwest, terminating at local station coordinate 0 m (593457E, 6903400N, nominal elevation 200.0 m). The seismic data processing for both the refraction and reflection surveys was done in acquisition or instrument coordinates which are

the reverse of the line coordinates. Following processing, all final seismic images and data were flipped along the x-axis to match the conventional survey orientation. The seismic survey line has a nominal length of 1500 m and a surveyed horizontal length of 1471.3 m. Topographic reduction consisted of calculating the horizontal (line) coordinates and elevation of each shot and receiver, relative to acquisition coordinates. Local station coordinate 0 m on the seismic line has an assigned elevation of 200.0 m. This is the common elevation datum used in the calculation of all other station elevations and in the reflection seismic processing. This datum was also used in the seismic refraction processing and modeling.

3. *Data import, registration and trimming.* A processing spreadsheet containing the shot records to be processed together with shot and receiver locations (horizontal / elevation coordinates) is assembled. From this, a line elevation file containing the surface topography is created in ASCII. In addition, geographic registration (.DST) files incorporating the shot and receiver geometry for each data file were created in the prescribed format in ASCII. A separate .DST file is required for each shot record. Once these files are prepared, the shot records are imported into the program and registered to geographic coordinates using the line elevation file and the .DST files. Thereafter, the shot records are trimmed to remove ground roll and all signal prior to the arrival of the head wave, leaving signal recorded in the *optimum window* after the first arriving energy and before the arrival of the slower ground roll. The ground roll is removed using a bottom mute with a 5 ms taper and a 400 m/s velocity. This removed all data which would have arrived after a ground roll wave travelling at 400 m/s away from the nominal shot location in the updated file header. Data recorded before the first arrival is noise and removed using an operator-specified top mute with a 5 ms taper. These first arrivals are coherent and display a predictable pattern in the shot record; the processor identifies the first arrivals and removes all data in the shot record arriving before them. Upon completion of this processing, each trimmed shot record is exported in SEG2 format to trimmed data file bin.

4. *Shot stack assembly.* All of the shot records to be processed are collected in a single shot stack file. Subsequent processing up to the CMP stack is performed on the shot stack.

5. *Trace kills.* The shot stack is examined in detail and trace kills are performed on dead traces only.

6. *Band pass filtering.* The F-k filter spectrum of the data is calculated and examined to characterize the frequency spectrum of the signal. The geophones have a nominal peak response at 30 Hz and reflection and refraction data is dominated by frequency response centred around 40 Hz, with little signal above 150 Hz. Several filter panels are created by applying band pass filters with varying specifications to determine which specifications produced the sharpest reflection parabolas after the first arrivals. A trapezoidal band pass filter with a pass region of 60 to 200 Hz, a low cut at 10 Hz and a high cut at 300 Hz is used in the final processing (Filter specifications: 10-60-200-300).

7. *Gain.* An exponential (energy) gain correction is applied to the data using an exponent of 8. No AGC or trace balancing gain is performed.

8. *Bottom mute.* The exponential gain creates signal in the muted regions below the optimum window records. This is removed with a bottom mute set at 400 m/s using a 5 ms taper and any gain generated signal in the ground roll noise cone, initially removed during the trimming of the shot records.

9. *Velocity analysis.* Because the shot stack is relatively small, velocity analysis is performed on the entire shot stack for Line VCD. Every 5th shot record is selected for velocity analysis and a 1-D common mid-point (CMP) stacking velocity model consisting of 11 velocity models is constructed from the analysis. The shot records are analyzed by calculating the semblance using NMO velocities ranging from 0 to 5000 m/s in 50 m/s increments. Reflection hyperbolas are interactively fit to each analyzed shot record and corresponding semblance plot, using reflection fit in the shot record and corresponding high amplitude responses in the semblance plot as a guide. This process is guided by the assumption that seismic velocities increased with depth and consisted of at least three reflections (low velocity layer, top of water table and one or more bedrock reflections). The number of fitted reflections and hence the complexity of the velocity model is minimized since velocity model complexity in a single shot can cause smearing when applied to correcting and stacking a larger number of surrounding shots. This is particularly troublesome with shallow reflection surveys where lateral inhomogeneities and reflector relief are high. Each 1D velocity model is saved in a separate file and these are amalgamated to create a two dimensional (offset distance, record time) velocity model for subsequent normal move-out correction, CMP sorting and stacking.

10. *Normal moveout correction, CMP sorting and stacking.* The 2D velocity model (CMP-11) is used to correct the shot stack for normal moveout. Thereafter, the records are sorted into common mid-point (CMP) bins and stacked to generate a brute stack containing a single trace for each CMP reflection point. The nominal fold of coverage is 24 fold.

11. *Band pass filtering.* CMP stacking can generate low frequencies because of stack smearing, which results from misfit between the velocity model in the sampled trace (every 5th shot in this instance) and the optimum velocity model for the adjoining shot records. The reflectors stack but because of residual moveout, the expected sharp reflection is smeared into a larger, lower frequency response. To mitigate this effect, the brute stack is band pass filtered using a 10-60-250-350 Hz filter, similar to that applied in step 6.

12. *Time-depth conversion.* The final stack is transformed into a depth section using a sparse version 2D velocity model with 1D velocity models spaced every 20 shots. This sparser version of the velocity model is used to minimize distortion in the depth section. Nonetheless, this transformation resulted in some stretching and compression of portions of the reflection section, depending upon the vagaries of the 2D velocity model.

13. *Static shift.* A final topographic correction is applied to the depth section based on the line elevation file. Each final stack trace is shifted so that its time-zero mark is coincident with the receiver elevation.

14. *Interpretation.* Several versions of the final section are created using various trace gains in order to image reflections with various amplitude responses. These are registered to geographic coordinates in ArcGIS and reflections are picked from them in a single shapefile. These data are in turn superimposed on the final refraction velocity model for final interpretation.

4.5.3 Inversion results & products

Several versions of the final section were created using various trace gains in order to image reflections with various amplitude responses. These are registered to geographic coordinates in ArcGIS and reflections are picked and recorded in a single shapefile. This data was in turn superimposed on the final refraction velocity model for final interpretation.

Digital data is appended to this report in the seismic reflection folder and includes the following products:

- Raw shot records in SEG2 format
- Final processed stacked section in SEG2 format
- Images of the final processed stacked reflection section in JPEG format
- Shapefile of the reflections (*VCD reflections.shp*)

The shapefile coordinates are relative to the seismic line with x=horizontal distance from Station 0, and y=elevation, both in meters. The elevation datum is Station 0 = 200.00 meters. Appendix V contains plots of the final reflection section wiggle trace, grey shade and colour contour display formats.

5 DISCUSSION AND INTERPRETATION

All estimations are completed through comparison of survey results together with drillhole information.

The GPR surveys show flat lying discontinuous reflectors imaged in the 50 and 100 MHz radargrams. These reflectors are attributed to the weathered bedrock and fractures with no single distinct reflector interpreted as the bedrock interface. Reflector picks are indicated on the radargrams and used in combination with other survey data to interpret the depth to bedrock.

A composite section showing the final interpretation is compiled from the resistivity and seismic survey results (Figure 2). Seismic velocity contours and reflectors and general drillhole information are superimposed on gridded resistivity. The section is compensated for topography with the x-axis registered to local station coordinates and depths in elevation with a 2:1 vertical exaggeration shown along the y-axis. In general, bedrock depths correlate well with seismic velocities that range between

2500 and 3500 m/s. These velocities and associated reflectors are used as guides for the depth interpretation in the absence of additional supporting data.

The resistivity shows a general low with subtle highs between station 0 and 800. The GPR results show strong signal attenuation in the area and is interpreted to represent wet ground and/or elevated clay content. This correlates well with the general increase in moisture and clay content noted in the drillhole logs. The shallow more resistive areas, most evident between stations 260 to 300 and 430 to 480, likely indicate dry resistive sediments above the water table or lenses of permafrost. The bedrock interface is interpreted to be at its deepest at approximately station 110 where it is estimated to be in excess of 40 meters. The bedrock depth is interpreted to gradually shallow to approximately ten meters at station 400, where it remains roughly constant over the next several hundred meters as indicated by the seismic velocities and reflectors. The bedrock contact continues to remain shallow (<5 meters) between stations 800 to 1150 with associated elevated resistivity attributed to dry weathered bedrock and zones of frozen topsoil. The depth to bedrock deepens dramatically at approximately station 1150 and then gradually shallows over the remainder of the survey line as suggested by the seismic velocity contours and confirmed with drillhole information. The broad resistivity high observed at depth from station 1250 through to the end of the line is interpreted to represent a zone of concentrated quartz veins or some resistive intrusive within the fresh phyllite as confirmed in drillhole SRK09-DHVD01. A distinct shallow resistivity high observed between stations 1280 and 1370 is attributed to permafrost and or a concentration of dry sand and cobbles with reduced clay content. This is followed by another shallow resistive low attributed to a clay rich zone between stations 1370 and 1425. The deeper discontinuous GPR reflections best observed in the 100 MHz radargram from station 1200 to the end of the line are attributed to fractures within weathered bedrock.

A combination of seismic velocities, seismic reflectors, resistivity boundaries, associated GPR reflectors and drillhole logs are used to select the interpreted depths to weathered and fresh bedrock. All depths derived herein should be drill tested at selected locations to verify and refine the interpretations included in this report.

Digital data included with this report comprises:

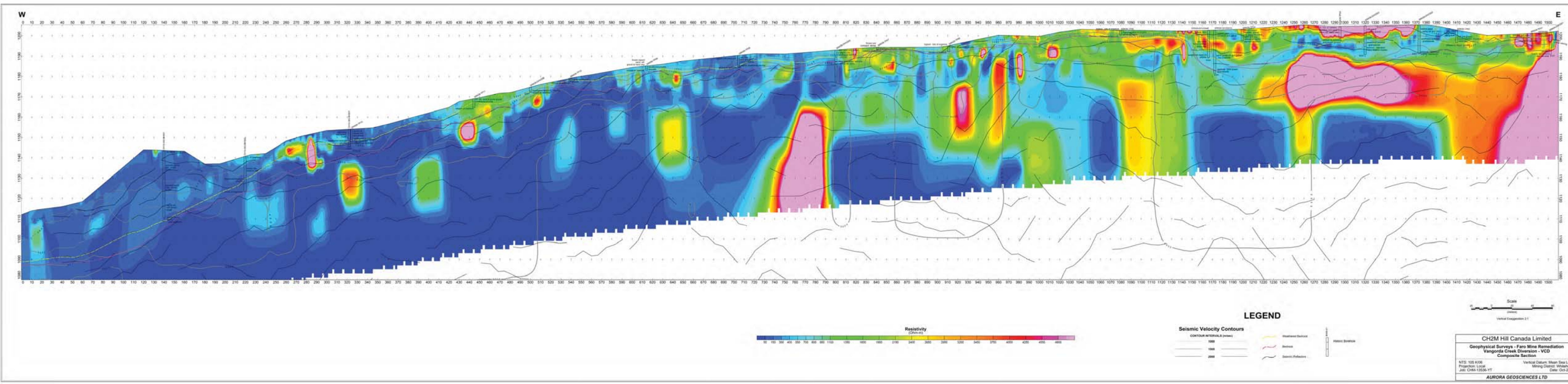
Composite Section Shape files	Digital Data\Composite Section*.shp
Composite Section Packed Maps	Digital Data\Composite Section\Composite Section.map

Respectfully submitted,

AURORA GEOSCIENCES LTD.

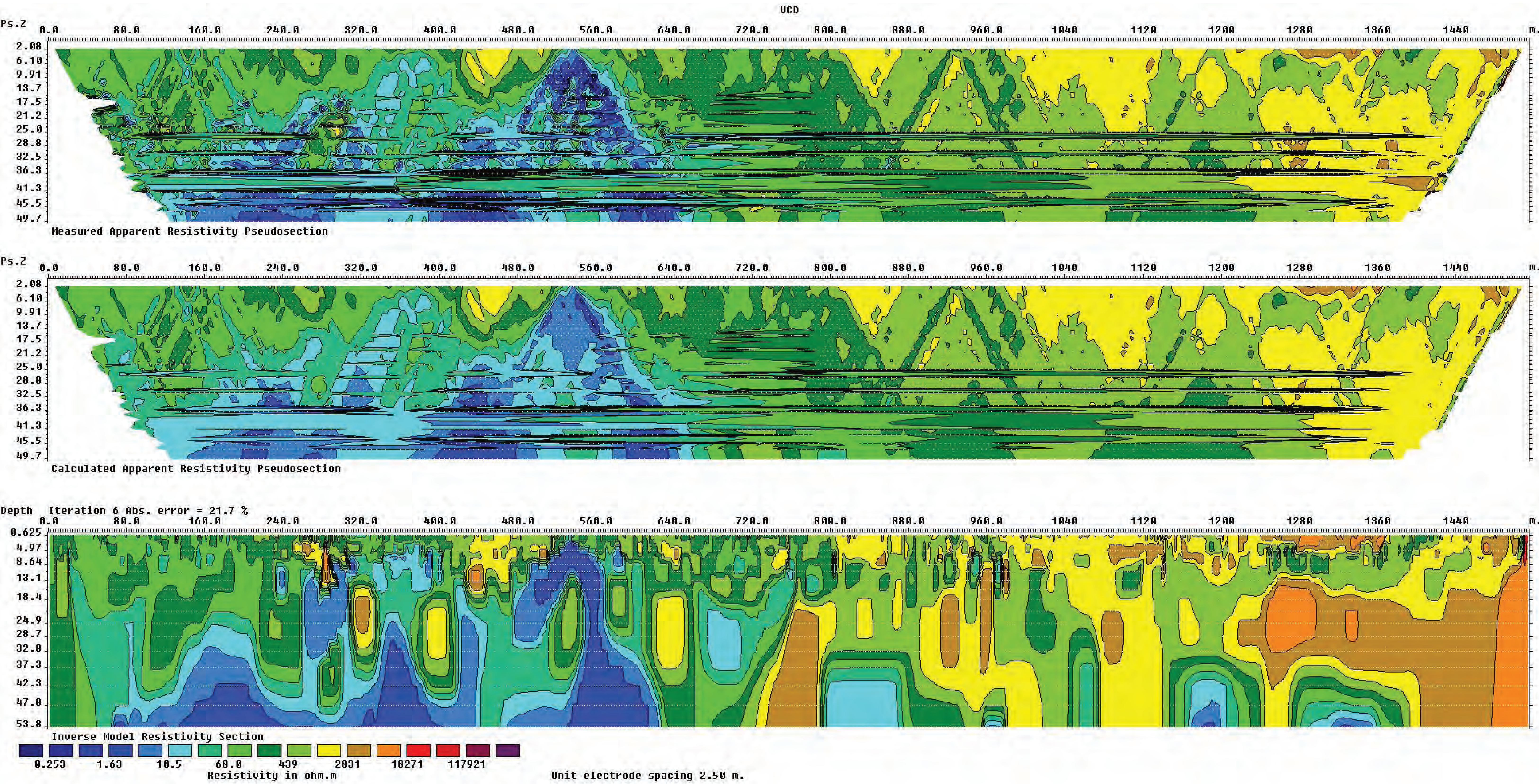
____

Phil Jackson, P.Geoph.
Geophysicist


W
E
LEGEND
Resistivity
Seismic Velocity Contours
Scale
CH2M Hill Canada Limited
Geophysical Surveys - Faro Mine Remediation
Vangorda Creek Diversion - VCD
Composite Section
NTS: 105 K/06
Projection: Local
Job: CHM-13536-YT
Vertical Datum: Mean Sea Level
Mining District: Whitehorse
Date: Oct-2013
AURORA GEOSCIENCES LTD

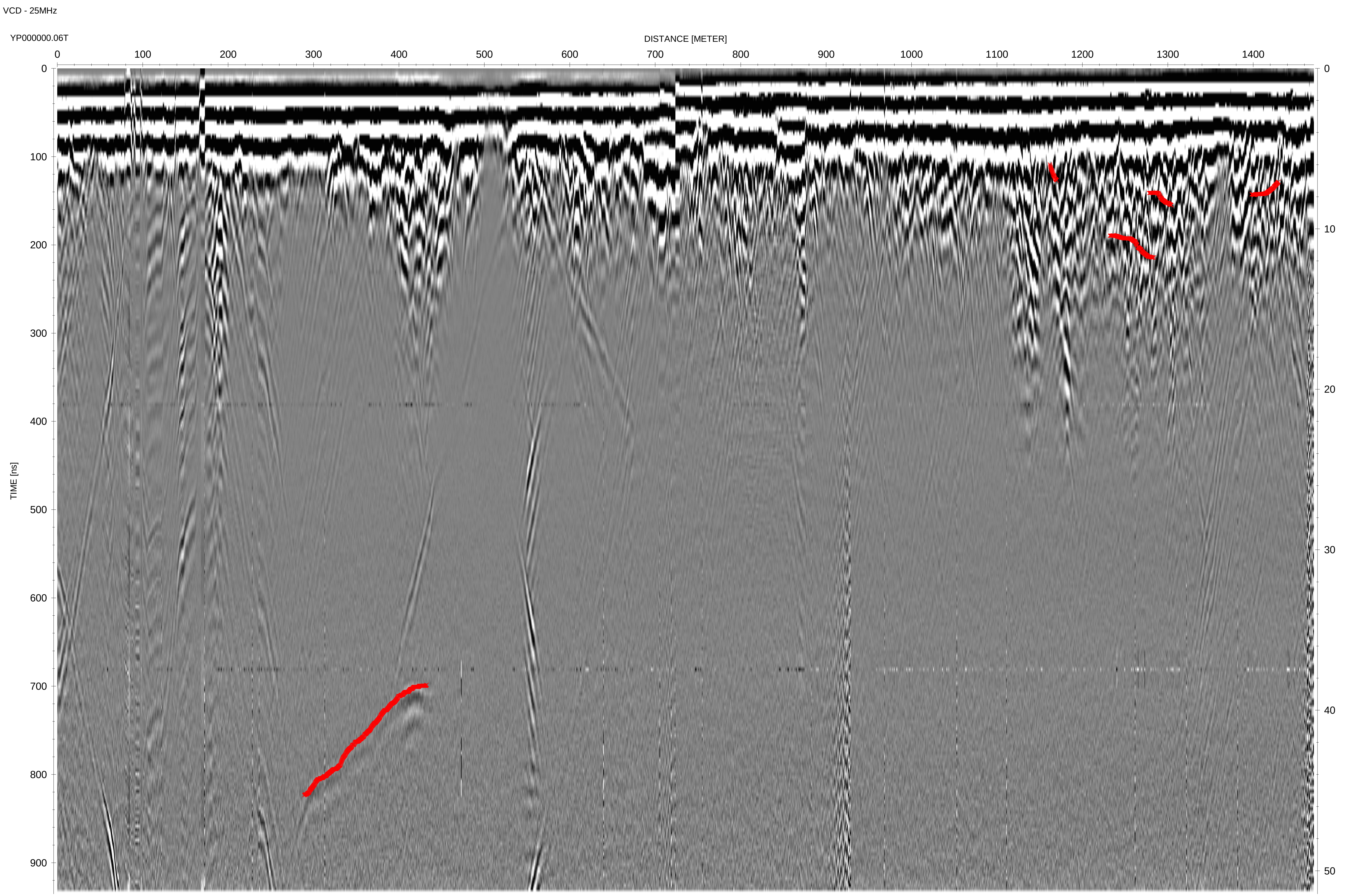
Appendix II

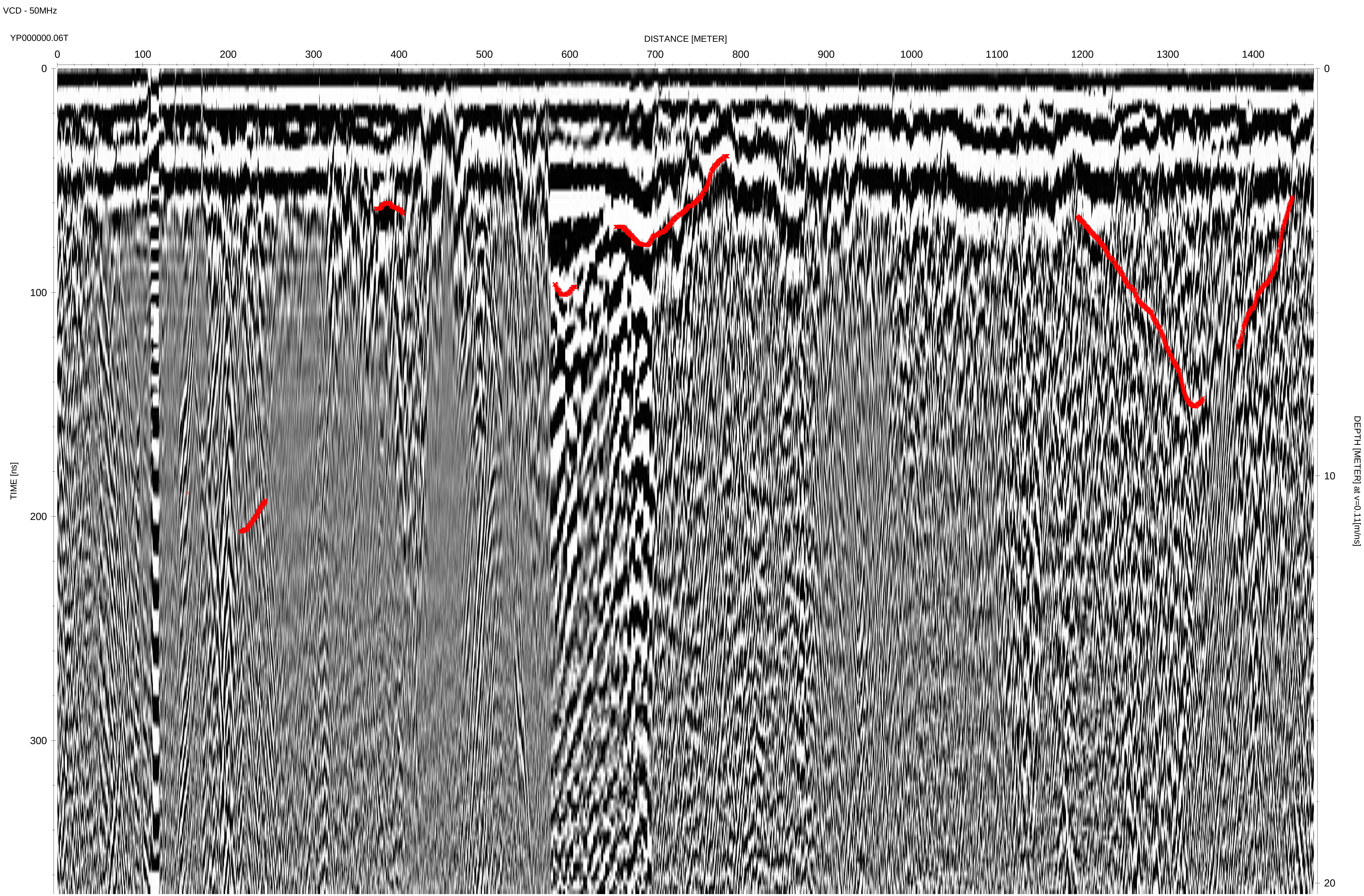
Resistivity Inversions


VCD
Ps.Z
0.0 80.0 160.0 240.0 320.0 400.0 480.0 560.0 640.0 720.0 800.0 880.0 960.0 1040 1120 1200 1280 1360 1440 m.
2.08 6.10 9.91 13.7 17.5 21.2 25.0 28.8 32.5 36.3 41.3 45.5 49.7
Measured Apparent Resistivity Pseudosection
Ps.Z
0.0 80.0 160.0 240.0 320.0 400.0 480.0 560.0 640.0 720.0 800.0 880.0 960.0 1040 1120 1200 1280 1360 1440 m.
2.08 6.10 9.91 13.7 17.5 21.2 25.0 28.8 32.5 36.3 41.3 45.5 49.7
Calculated Apparent Resistivity Pseudosection
Depth Iteration 6 Abs. error = 21.7 %
0.0 80.0 160.0 240.0 320.0 400.0 480.0 560.0 640.0 720.0 800.0 880.0 960.0 1040 1120 1200 1280 1360 1440 m.
0.625 4.97 8.64 13.1 18.4 24.9 28.7 32.8 37.3 42.3 47.8 53.8
Inverse Model Resistivity Section
0.253 1.63 10.5 68.0 439 2831 18271 117921
Resistivity in ohm.m
Unit electrode spacing 2.50 m.

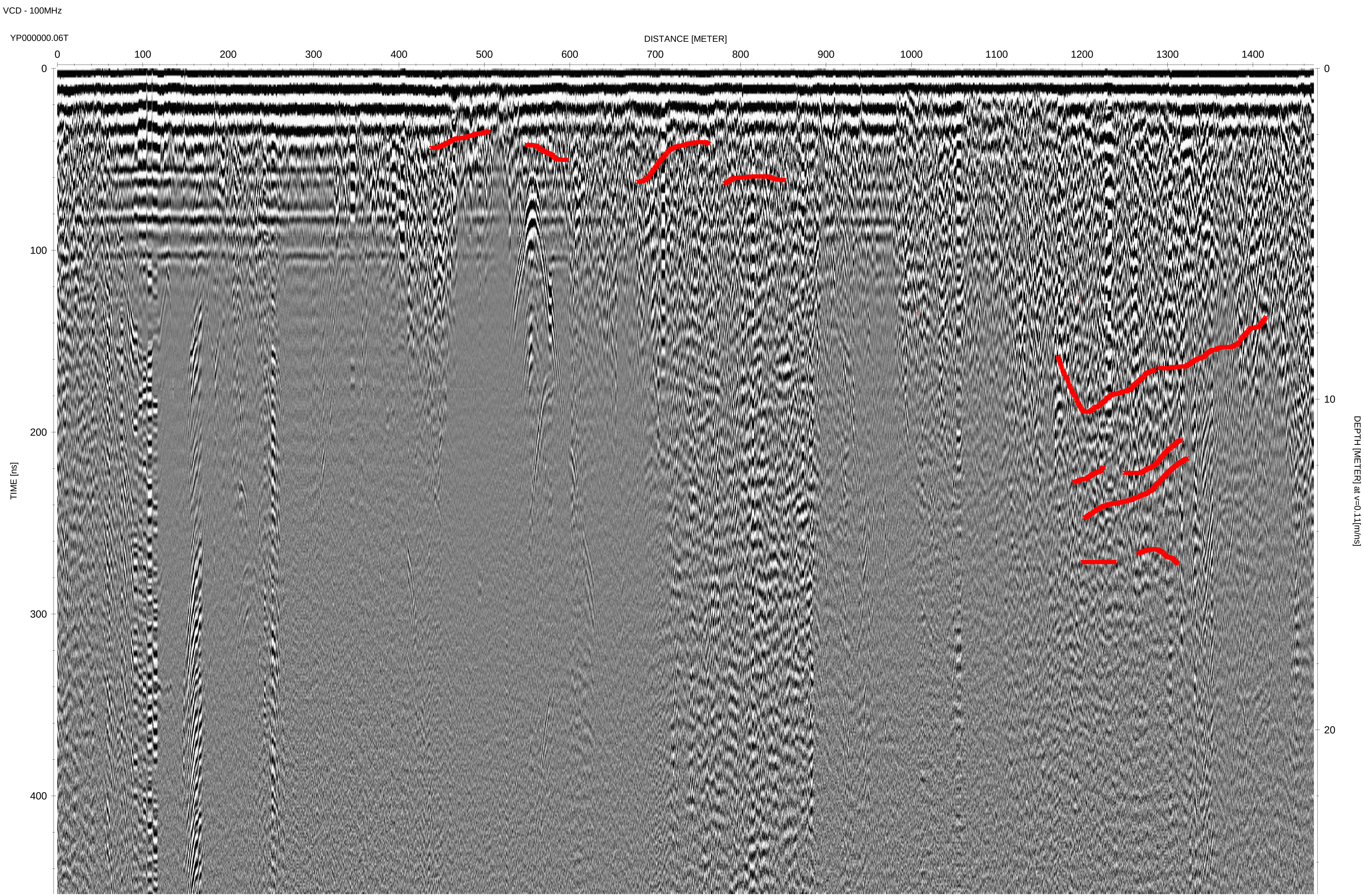
Appendix III

GPR Radargrams


VCD - 25MHz
YP000000.06T
DISTANCE [METER]
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
TIME [ns]
0
100
200
300
400
500
600
700
800
900
DEPTH [METER] at v=0.11[m/ns]
0
10
20
30
40
50



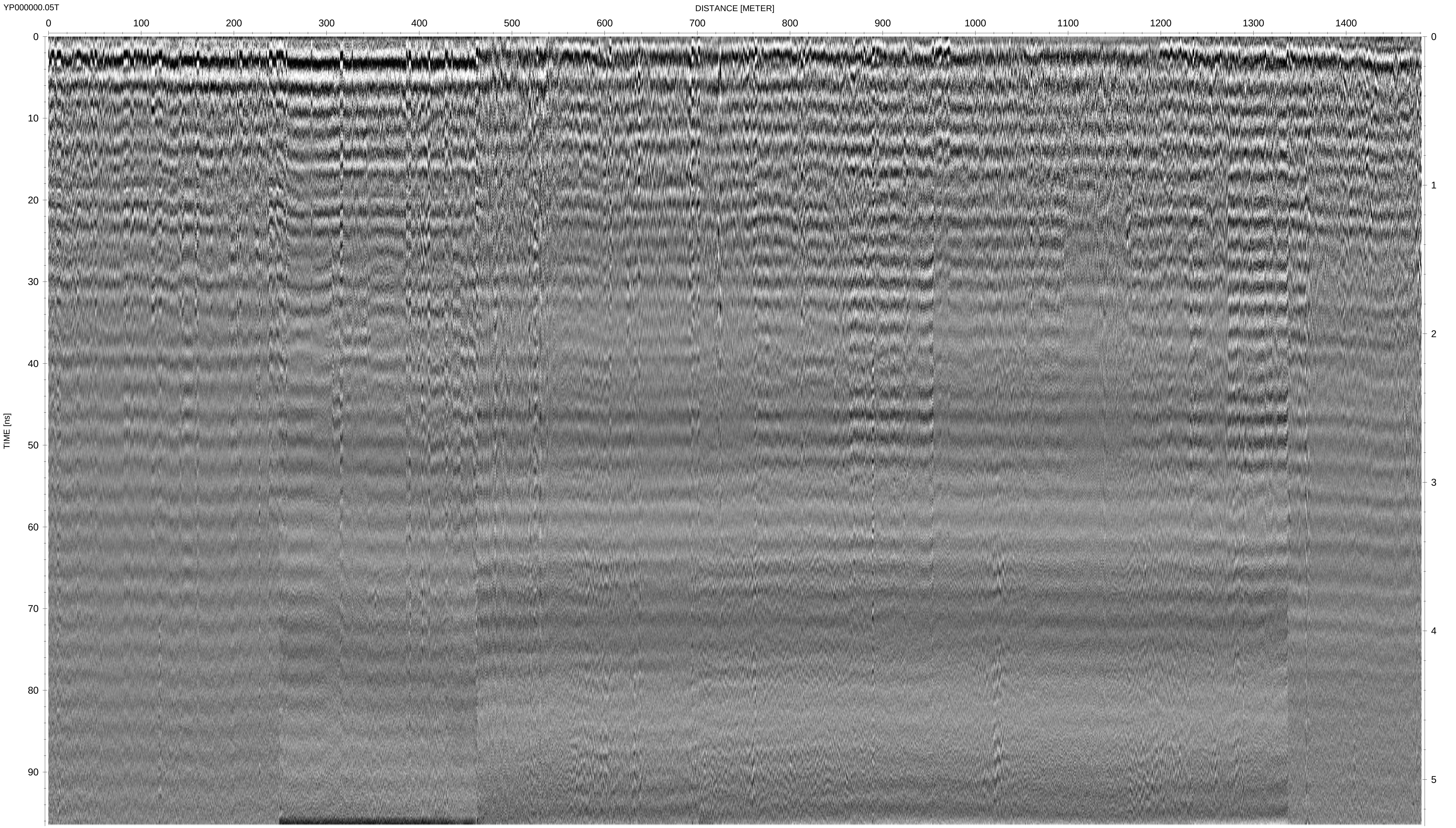
VCD - 50MHz
YP000000.06T
DISTANCE [METER]
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
TIME [ns]
0
100
200
300
DEPTH [METER] at v=0.11[m/ns]
0
10
20



VCD - 100MHz
YP000000.06T
DISTANCE [METER]
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
TIME [ns]
0
100
200
300
400
DEPTH [METER] at v=0.11[m/ns]
0
10
20

VCD - 500MHz

YP000000.05T

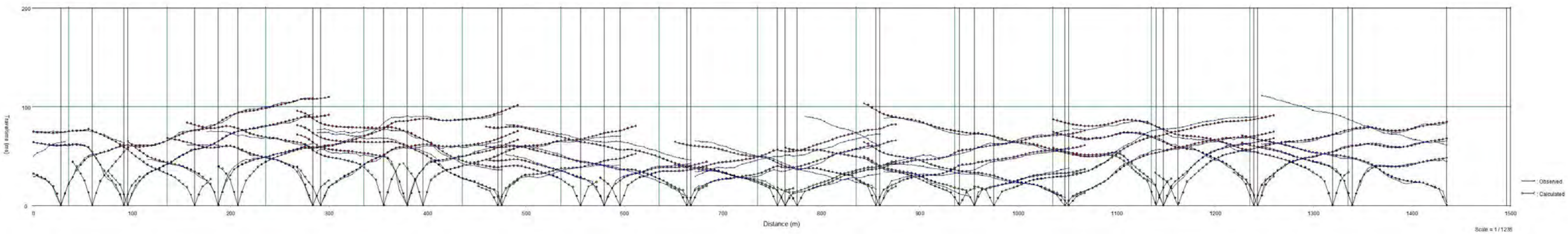


Appendix IV

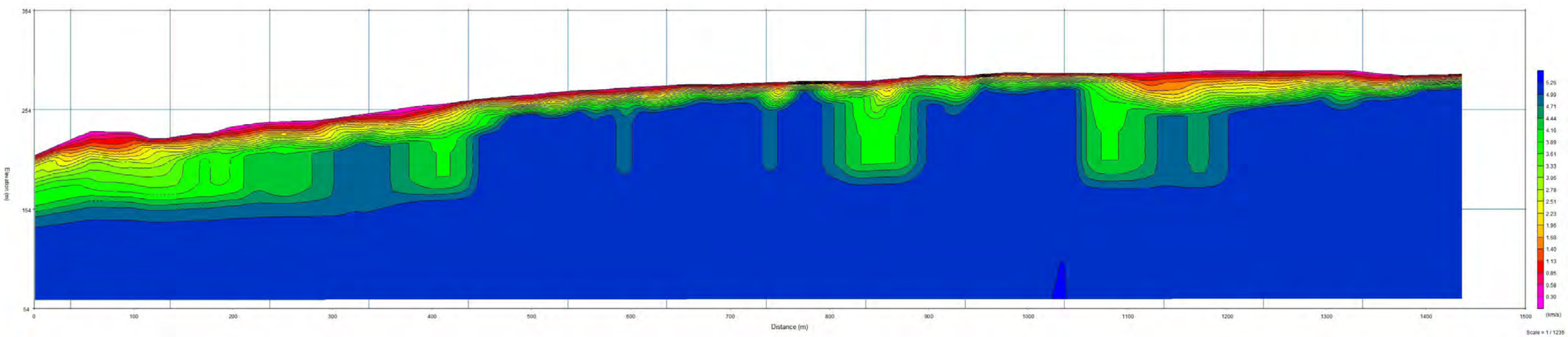
Seismic Refraction Sections

Line VCD – Panel 1

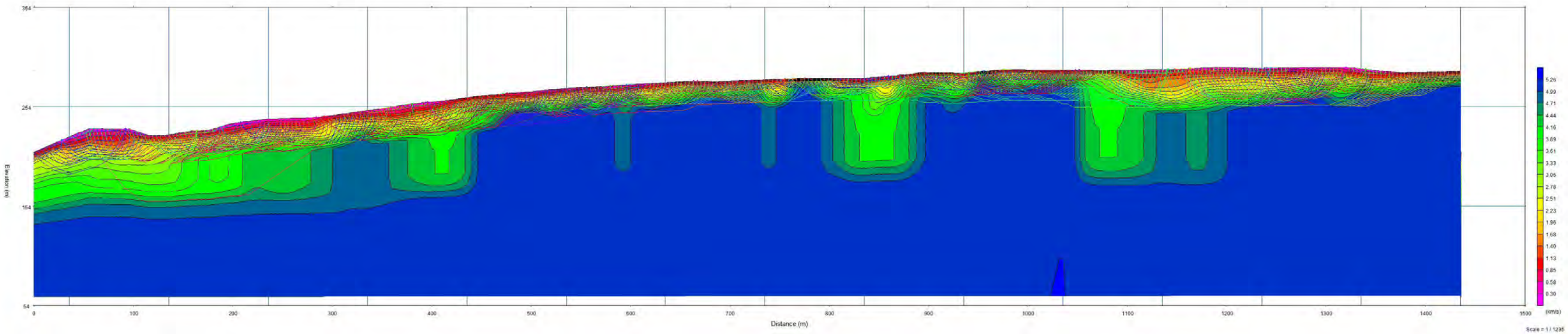
Inversion results - Final model



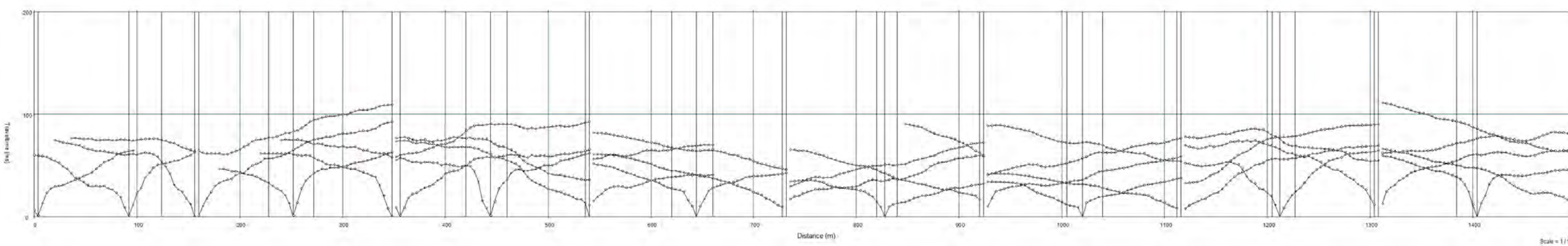
Final model



Ray tracing - Final model

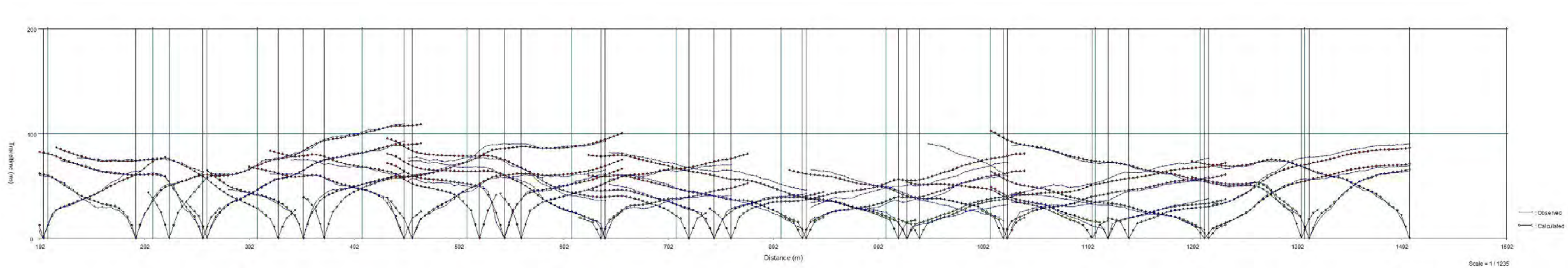


Travel times

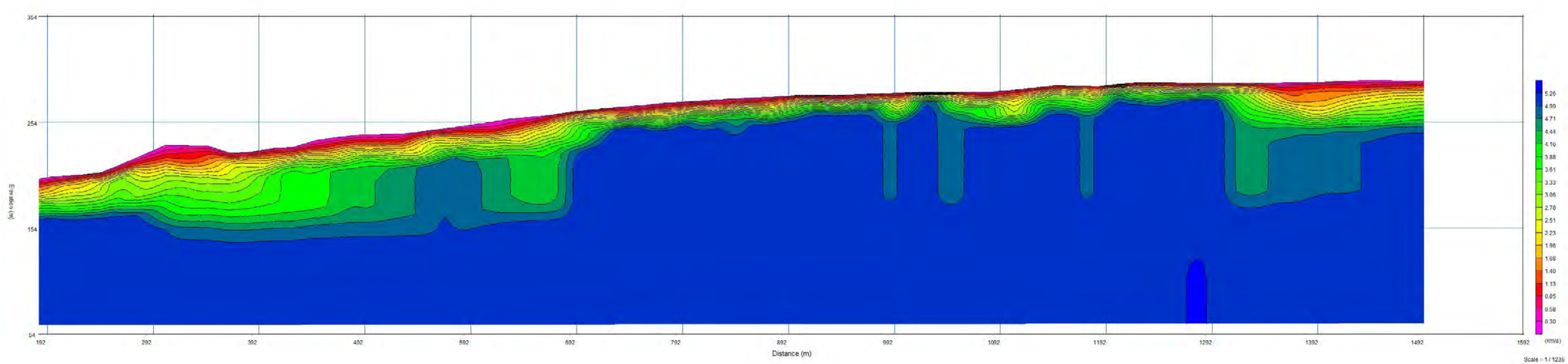


Line VCD – Panel 2

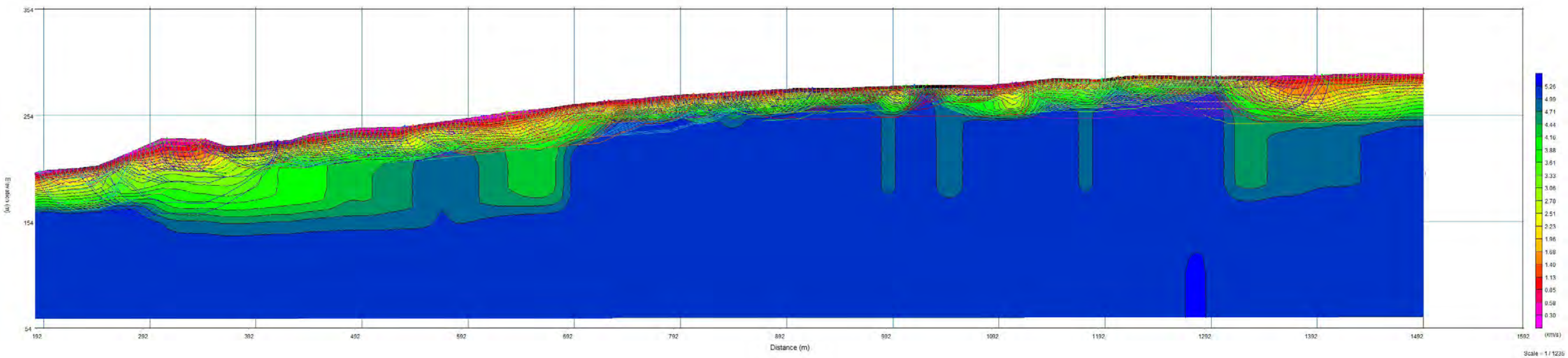
Inversion results - Final model



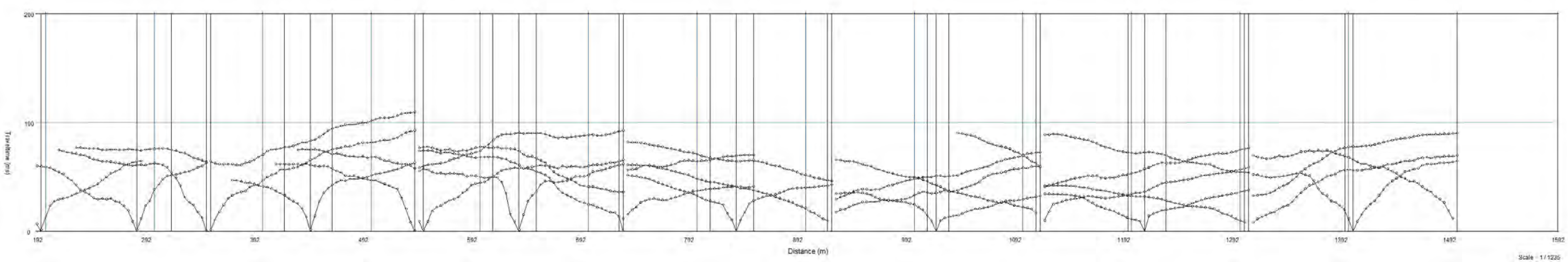
Final model

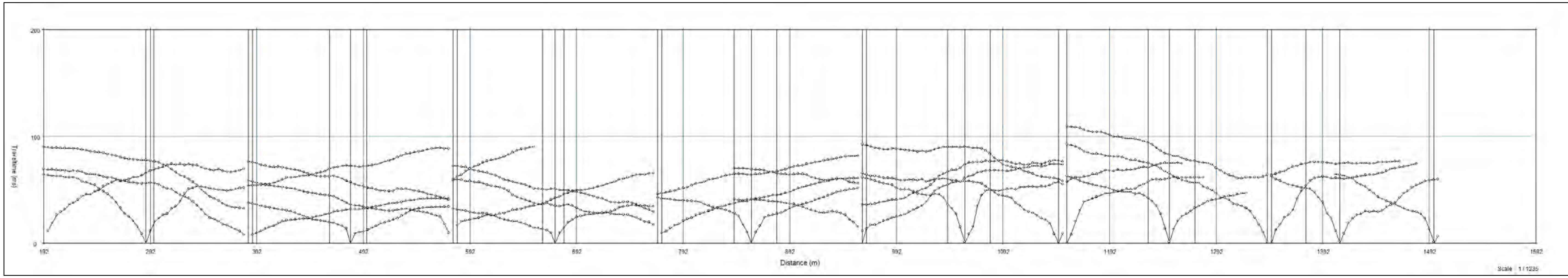


Ray tracing - Final model



Travel times

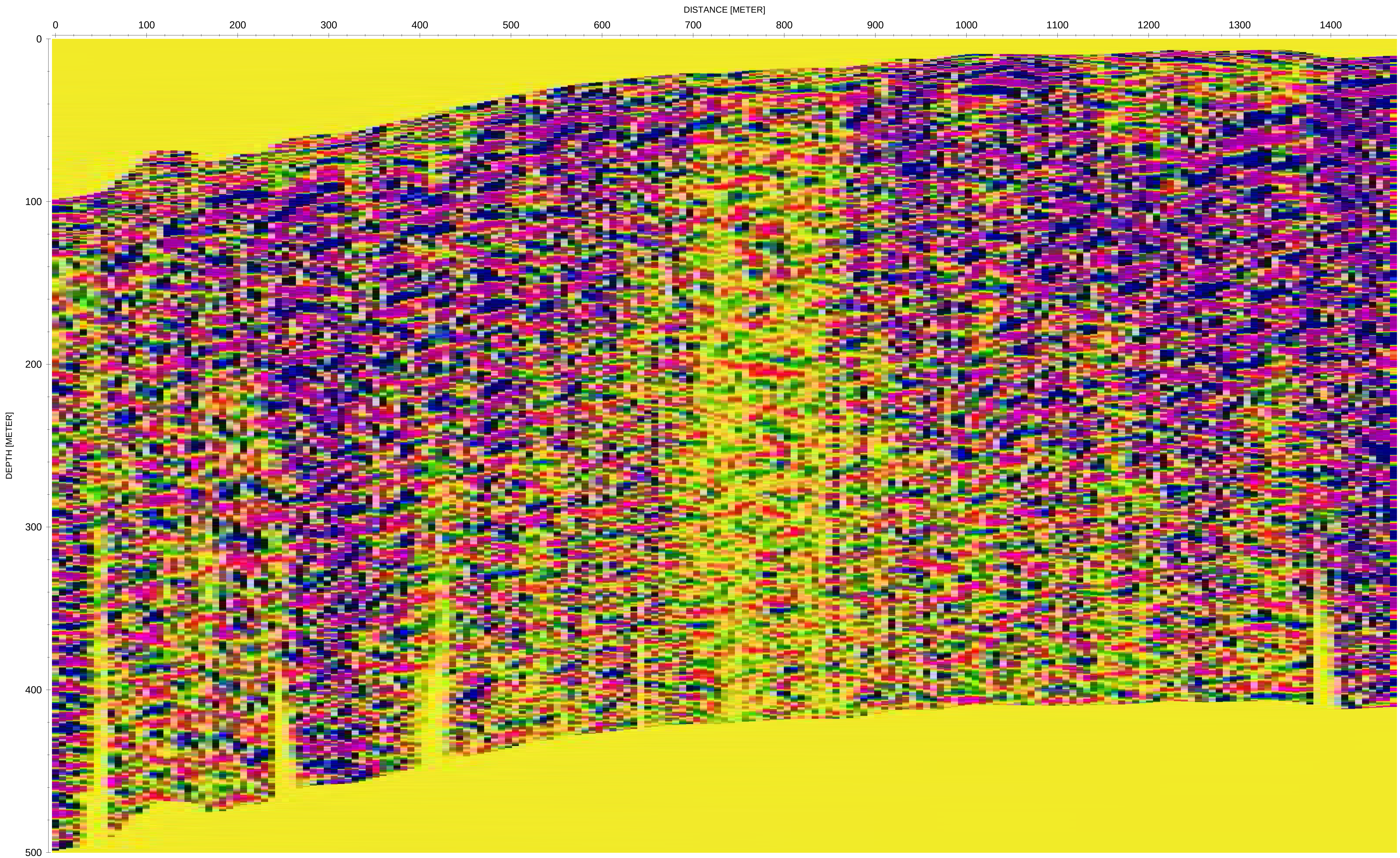


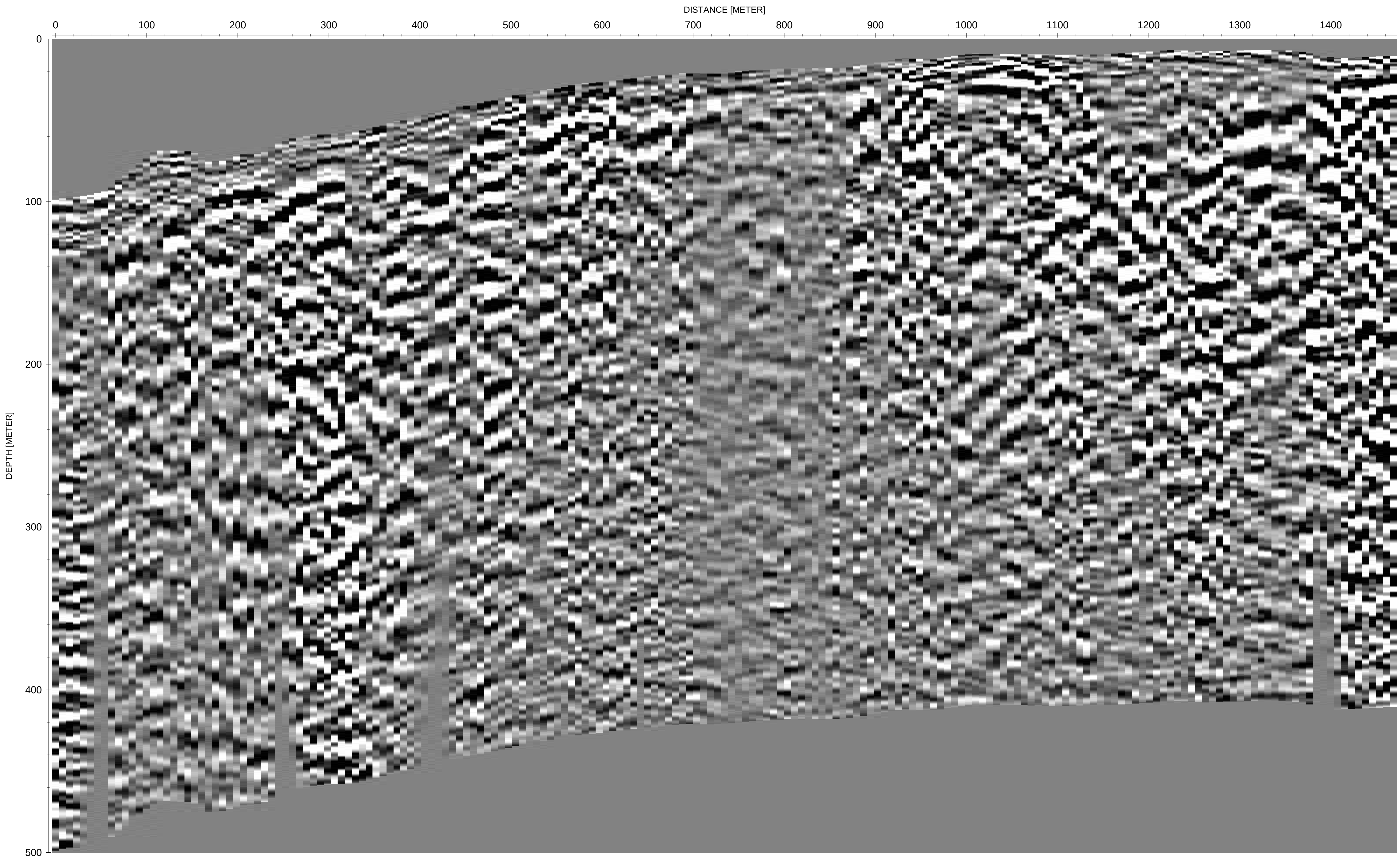


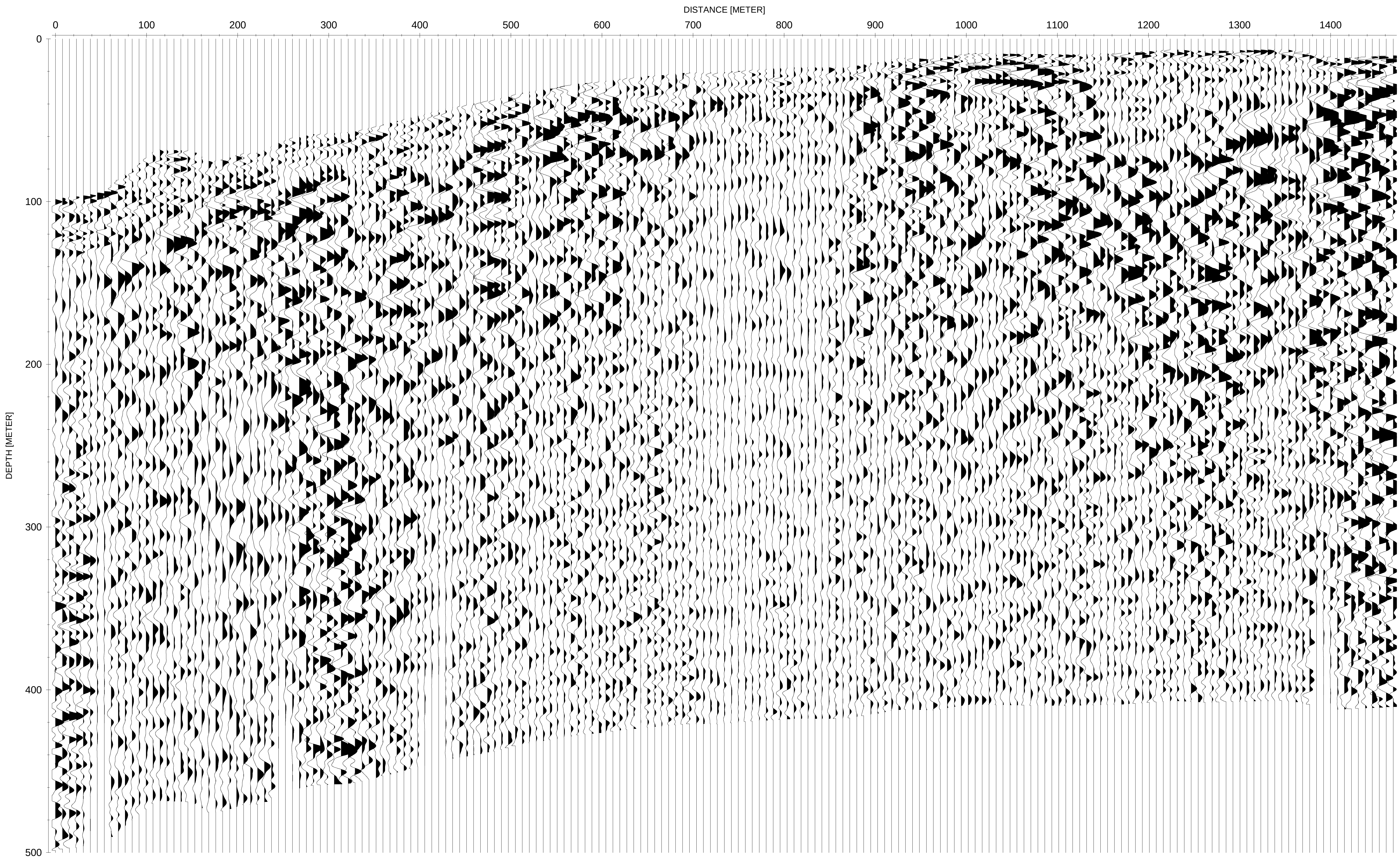
Traveltime (ms)
200
100
0
192
292
392
492
592
692
792
892
992
1092
1192
1292
1392
1492
1592
Distance (m)
Scale 1 / 1235

Appendix V

Seismic Reflection Sections


DISTANCE [METER]
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
DEPTH [METER]
0
100
200
300
400
500


DISTANCE [METER]
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
DEPTH [METER]
0
100
200
300
400
500



DISTANCE [METER]
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
DEPTH [METER]
0
100
200
300
400
500

Granitic Rock Outcrop Geophysics Report

(Appendix I, Project Log, is not included)

Geophysical Survey – Faro Mine Remediation – Borrow Search Investigations at Granitic Rock Outcrop

NTS: 105K/06, Whitehorse Mining District, Yukon Territory, Canada

WORK PERFORMED:
July 7-August 18, 2013

Prepared for:
CH2MHILL

Prepared by:

AURORA GEOSCIENCES

TECHNICAL REPORT

Geophysical Survey – Faro Mine Remediation – Borrow Search Investigations at Granitic Rock Outcrop

Prepared for:

CH2M Hill Canada Limited

Whitehorse, YT Y1A 4N2

Prepared by:

Aurora Geosciences Ltd.

Main Office: 3506 McDonald Drive, Yellowknife, NT, X1A 2H1

Phone: (867) 902.2729 Fax: (867) 920-2739

www.aurorageosciences.com

Author

Phil Jackson, P.Geoph.

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1 SUMMARY

The geophysical investigations at the Granitic Rock Outcrop, located approximately 10 kilometers Northeast of Faro, are a portion of a larger project at the Faro Mine, Faro, Yukon Territory. The purpose of the investigations was to assist in the design of environmental mitigation measures by identifying the depth from surface to the underlying bedrock contact along the length of the 1000 meter survey line.

This report describes procedures and results of line cutting, ground penetrating radar (GPR) and seismic refraction surveys conducted in the area between July 30th and August 16th, 2013.

Linecutting was required over most of the survey line. Non-differential GPS waypoints were recorded at 50m stations. Topography was measured along the line using a laser range finder.

The multi frequency GPR survey was conducted with a mala geosciences RAMAC GPR system operated at 25, 50 and 100 MHz. Conventional GPR data processing was applied incorporating geometric registration, drift corrections, user gain, deconvolution, velocity analysis, and depth conversion.

The seismic refraction survey was conducted with a 24 channel digital engineering seismograph using a 4 meter phone spacing and an ATV mounted hammer digipulse as the energy source. The data was processed and interpreted primarily using the Pickwin™ and PlotRefa™ software packages. Processing included initial data checks, topographic data reduction, first break picking, composite shot file assembly and inversion.

In general, the depth to bedrock is extremely shallow (<2 meters) and is not readily visible in either survey. The boundary between fresh and weathered bedrock is more readily interpreted by comparison of the refraction survey results with available outcrop, drill hole and GPR results. An interpolated discontinuous GPR reflector is identified over the majority of the survey line and superimposed on contoured seismic velocities to create a composite section. The apparent depth to the weathered and fresh bedrock boundary derived from the GPR and seismic refraction interpretation should be drill tested at selected locations to verify and refine the interpretations included in this report.

2 INTRODUCTION

Aurora Geosciences Ltd. was retained by CH2M Hill Canada Limited to conduct line cutting, Ground Penetrating Radar (GPR) and seismic refraction surveys. The surveys at the Granitic Rock Outcrop are a portion of a larger project at the Faro Mine, Faro, Yukon Territory, which included five separate areas:

- Cross Valley Dam (CVD)
- DVIHU (Down Valley / Rock Drain) Assessment (RCD)
- Borrow Search Investigations at Granitic Rock Outcrop
- Grum Waste Rock (WR) Quarry
- New Vangorda Creek Diversion (VCD)

The purpose of the investigations at the Granitic Rock Outcrop was to assist in the design of environmental mitigation measures by identifying the depth from surface to the underlying bedrock contact along the length of the 1000 meter survey line. Based on previous investigations, the local stratigraphy consists of a layer of glacial till overburden overlying bedrock. The depth to granitic bedrock varies from 0-10m. Permafrost conditions are unknown. All geographic locations in this report are relative to North American Datum 1983. Non-geodetic coordinates are expressed in Universal Transverse Mercator Zone 8N metric coordinates. All measurements are expressed in the metric system unless they are measurements quoted from historic reports expressed in other units of measure. All geophysical data units are in the metric SI system.

3 LOCATION & ACCESS

The geophysics crew was based in the town of Faro, YT for the duration of the project with all areas accessible by truck. The Granitic Rock Outcrop is approximately 10 kilometers Northeast of Faro, a detailed map of the surveyed line is shown in Figure 1.

4 WORK PROGRAM

This section describes the work program conducted at Granitic Rock Outcrop in 2013. Line cutting, Ground Penetrating Radar (GPR) and seismic refraction surveys were conducted on one survey line. These surveys are described in the following sections. Appendix I contains a project log.

4.1 Line cutting & gridding

Line cutting and grid installation was conducted on the property to facilitate accurate location control for the geophysical surveys.

Figure 1. Survey Location Map

4.1.1 Equipment

The crew was equipped with the following instruments and equipment:

Equipment:	2 – Husqvarna 245 saws 2 – Sets brushing / chaining equipment 1 – Laser range finder
Communications:	1 – Satellite phone 2 – VHF radios
Vehicles:	1 – 1Ton truck 2 – Polaris ATV
Safety:	2 – Each of PPE including hard hat, safety glasses, steel-toed boots, hearing protection, long sleeved shirts, hip chaps (line cutting), hard hat with visor (line cutting), gloves, reflective vest and work pants as required by health and safety plans 1 – Each of fire extinguisher, first aid kit and potable water
Other:	3 – GPS receivers 1 - Laptop & color printer w/ Geosoft 1 - Field office equipment 1 - Repairs & tool kit 5 KV gas generator

4.1.2 Field Procedures

Line cutting was conducted according to the following specifications:

Station spacing:	50 meters
Chainage:	Stations: straight chained
Station marking:	Survey lines: Half-length pickets with metal tags
Registration:	Non-differential GPS measurements recorded at 50 m intervals. Horizontal and vertical distances measured between stations with a laser range finder

4.1.3 Products

Digital data included with this report comprises:

GPS measurements – station location	Topography\Granite GPS Waypoints.xls
Final data – laser range finder measurements	Topography\Granite Topography.xls

The survey grid is plotted on the location map shown in Figure 1.

4.2 Ground Penetrating Radar (GPR) Survey

A GPR survey was conducted between August 13th and 16th, 2013. The purpose of the survey was to identify the depth to the underlying bedrock contact along the length of the 1000 meter line.

4.2.1 Equipment

The crew was equipped with the following instruments and equipment:

Instruments & Equipment	1 – Ramac GPR Pro Ex Controller 1 – Ramac Pro Ex Optical Module 1 – 25, 50 & 100 MHz Rough Terrain Antenna (RTA) 1 – Monitor Rad Explorer Software
Communications:	1 – Satellite phone 2 – VHF radios
Vehicles:	1 – 1Ton truck 2 – Polaris ATV
Safety:	2 – Each of PPE including hard hat, safety glasses, steel-toed boots, hearing protection, long sleeved shirts, gloves, reflective vest and work pants as required by health and safety plans 1 – Each of fire extinguisher, first aid kit and potable water
Other:	3 – GPS receivers 1 - Laptop & color printer w/ Geosoft 1 - Field office equipment 1 - Repairs & tool kit 5 KV gas generator

4.2.2 Field Procedures

The GPR system is normally worn and operated by a single operator for high frequency surveys, or is carried and guided by several operators with the controller being either worn or towed. The transmitter and receiver electronics are mounted on their respective antennas and linked via fibre optic cables to the controller unit. Both the transmitter and receiver are controlled by the RAMAC monitor running interface software which configures the system, stores the collected data and allows the operator to view the radargrams in real time.

The line, read with successive passes for each individual frequency, was completed as a profile survey. The Rough Terrain Antenna (RTA) are oriented in-line with the survey direction and spaced a fixed distance apart. The survey is conducted by moving the antenna pair along the line. The data is then plotted using radargrams which show the centre of the antennas (x) on the horizontal axis and the signal on the y-axis as a function of time (t), with arrival time increasing vertically downward. The reflections appear at various distances below the time zero line at the top of the radargram. These distances below the time zero line are proportional to the arrival times which in turn are roughly proportional to the depth to target. Thus, the reflections display a pattern which generally correlates with their subsurface location. During data processing, the arrival times may be converted to depths and the reflections are then displayed at the apparent depths of the sources. Reflections are displayed as grey shade plots.

GPR surveying was conducted according to the following specifications and procedures:

Centre Frequency:	25, 50 & 100 MHz
Time Window:	1000nS (25 MHz), 640 nS (50 Mhz) and 440 nS (100 MHz).
Measurement Interval:	10cm (maximum), determined by operating frequency.
Antenna Separation:	6m (25 Mhz), 4m (50 MHz), 2m (100MHz)
Triggering:	Time: 0.75s (25 MHz), 0.5s (50MHz) 0.25s (100MHz)
Station Registration:	The apparent horizontal distance at which each surveyed control line picket was encountered was recorded manually and used in the data processing to register the lines.

4.2.3 Data processing and products

The GPR survey data was processed and interpreted using the following procedures:

1. Download & archive: Data was downloaded from the field instruments and raw data files were archived.
2. Geometric registration: Trace coordinates were updated and interpolated to match recorded markers during data acquisition.
3. De-wow: Low frequency antenna to antenna reverberations were removed by cutting frequencies generally below ¼ of the centre frequency.
4. Trace kills: traces collected during static data collection time or outside survey markers were removed.
5. Drift removal and resetting of time zero: The time zero line on the radargrams was reset to the first arrival of the ground wave.
6. Gain: Compensation for damping losses was achieved by multiplication of linear, exponential and programmed gain functions where appropriate.
7. Deconvolution: Spiking deconvolution was applied to sharpen the reflections.
8. X-Flip: Applied to data acquired in opposite survey directions to achieve consistent viewing directions from west to east.
9. Depth conversion: using average ground velocity using measured diffraction hyperbolas
10. Printing: JPEG format showing the location of the line registration points and all picked reflectors.

Granite Outcrop was surveyed with 25, 50 and 100 MHz antenna. The radargrams show the horizontal position along the x-axis in local station coordinates and both travel time and apparent depth along the y-axis. The radargrams have not been compensated for topography and are plotted with considerable vertical exaggeration. The reflections are plotted as alternating black (positive) and white (negative) bands. The first arrival - a triplet which is continuous across the section- is the ground wave between the antennas and not a feature of interest. There are linear, sharp, moderately dipping linear arrivals common is most of the radargrams. Ringing is also present and is manifested by parallel bands of recurring reflections which tend to run across the section and obliterate any weaker reflections arriving in the same time window. The depth conversion was performed with a velocity of 0.11 m/ns, computed from an average of velocities determined by analysis of diffraction hyperbolas. Poor reflections were recorded on all frequencies with the top of weathered bedrock reflector largely being lost in the ground wave for the entire length of the survey line. Correlation with borehole data at station 550 guided intermittent reflector picks interpreted to be the boundary between weathered and fresh bedrock, however no continuous bedrock reflection is evident on any radargram. The 100MHz radargram contains an interpreted reflection section on which the apparent weathered/fresh bedrock reflection is indicated.

Digital data included with this report comprises:

Raw and Processed GPR field data	Granite\GPR\Raw data\”Frequency”\

Appendix II contains processed radargrams for all surveyed frequencies. These include:

- Granite Outcrop Radargram 25MHz
- Granite Outcrop Radargram 50MHz
- Granite Outcrop Radargram 100MHz with reflector picks

4.3 Seismic Refraction Survey

A seismic refraction survey was conducted between July 30th and August 3rd, 2013. The purpose of the survey was to identify the depth to the underlying bedrock contact along the length of the 1000 meter line.

4.3.1 Equipment

The crew was equipped with the following instruments and equipment:

<u>Instruments & Equipment</u>	1 - Geometrics Strataview R-48 digital engineering seismograph 1 – 24 channel cable with 5m takeouts 30 – Mark Products 40Hz vertical component geophones ATV mounted source, sledge hammer and plate
<u>Communications:</u>	1 – Satellite phone 2 – VHF radios
<u>Vehicles:</u>	1 – 1Ton truck 2 – Polaris ATV
<u>Safety:</u>	2 – Each of PPE including hard hat, safety glasses, steel-toed boots, hearing protection, long sleeved shirts, gloves, reflective vest and work pants as required by health and safety plans 1 – Each of fire extinguisher, first aid kit and potable water
<u>Other:</u>	3 – GPS receivers 1 - Laptop & color printer w/ Geosoft 1 - Field office equipment

1 - Repairs & tool kit
5 KV gas generator

4.3.2 Survey specifications

The refraction seismic survey was performed according to the following specifications:

Channels:	48
Receiver spacing:	4 m
Shot locations:	Offset shots – 60 m off each end of line (nominal) End of line shots – Phones 1 and 48 Mid-spread – Phone 24
Record length:	512 ms
Sampling:	62 µs
Source effort:	Digipulse: 10 blows Hammer: 15 blows

4.3.3 Data processing

The refraction seismic survey data was processed primarily using the Pickwin™ and PlotRefa™ software packages. The following procedures and methods were used and are described in order below:

1. *Initial data checks.* The seismic refraction data was of acceptable quality overall with some shot records containing unacceptable data. Bad data included shot records with a few dead traces and some shot records with very poor signal strength in portions of a spread due to bad ground or intervening geological features between the shot and geophones. The initial data checks began with checking each data file against the observer's field records to verify that the receiver and shot locations were correct. The receiver locations in the file header were compared against the observer's records. In cases where there was a discrepancy between the observer's record of the receiver locations and the receiver locations in the file header, the file header was corrected if it could be conclusively established that the discrepancy resulted from a simple keying error; otherwise the shot record was rejected. End of line and mid-spread shots were recorded within a spread with the shot point at a geophone location. Consequently, it is easy to verify the shot location from the shot record as the shot occurs at the geophone with the near zero time arrival. In some cases there were obvious discrepancies between the observer's records and the observed shot location. In this instance, the shot location as indicated by the shot record was used to correct the observer's records. In cases where there was ambiguity, the observer's records were taken as correct.

2. *Topographic data reduction.* The seismic refraction survey was run from station 40 (590009E, 6906828N) to station 1000 (590778E, 6907381N). The seismic survey line has a nominal length of 960 meters. Station 1000 on the seismic line has an assigned elevation of 200.0 meters. This

is the common elevation datum used in the calculation of all other station elevations and in the refraction seismic processing and modeling.

3. *Pick first breaks.* First arrivals were picked with Pickwin™ and stored in ASCII format *.vs files containing the shot location and the first arrivals by phone and x-coordinate. In making these picks, the interpreter was guided by knowledge of the expected pattern of arrivals from two or more refractors and the likely response of permafrost patches. The latter can produce anomalously fast and early first arrivals in groups of phones along a spread in a pattern which does not fit the expected sequence of progressively flattening first arrivals moving away from the shot location.

4. *Composite shot file assembly.* The first arrivals were assembled in a composite shot file in PlotRefa™ and inverted with the same software. After assembly, each shot was checked to ensure that the shot location was correct. Thereafter, first arrivals were examined and where necessary edited by the interpreter. Arrivals which could not be picked accurately were assigned a 0 arrival time during picking; these were removed after assembly in the composite shot file. Arrival times which were affected by receiver statics - typically a delay affecting arrival times from several shots at the same geophone – were corrected by moving them into line with neighboring arrival times. Minor smoothing was also done since random phone-to-phone variations do not normally reflect refractor topography but are primarily caused by noise in the shot record. Finally, the line topography was imported into the inversion package to correct the phone and shot elevations. The finite element inversion algorithm used in the inversion could not handle variations in horizontal (x) phone locations and the nominal phone locations (4 m apart) were used for all subsequent processing.

5. *Inversion.* The data was inverted using a tomography algorithm. A four metre (horizontal) cell size was used in the inversion. The initial model was a layered model with a vertical variation in seismic velocity parallel to surface topography of from 300 to 5,250 m/s over a depth of 20 to 30 meters. The inversion was allowed to run for 20 iterations, with the model being adjusted to improve the fit between the predicted and observed data by varying the velocity in each cell along the modeled ray paths. Root mean square (RMS) misfit between the observed and measured data was taken as the indicator of goodness-of-fit and the algorithm sought to minimize the RMS error in successive iterations. Upon completion of the inversion, a final ray-tracing was performed with a different algorithm to verify the robustness of the model. The final products of this inversion consist of predicted an observed travel times for each shot and station (Inversion results) in a T-X (travel time / distance) plot; the velocity model (Final model); and the ray-traced model showing the final model with calculated ray paths(Ray traced model). This together with a T-X plot of only the observed data (Travel time plot) is shown in the summary plots for each refraction survey, by line. The ray traced model indicates which areas of the final model are based on recorded data and which are artifacts of the inversion process.

4.3.4 Inversion results & products

The data was poor to acceptable. In the middle of the line, ground conditions are poor and only half of the offset shots could be read or picked. Travel times from offset shots 509 [Station 428 / read down-line] and 514 [Station 424 / read up-line] are erroneous and likely read from surface waves. The curves for these two shots range up to 150 ms and this data is not used in the inversion. They are shown for reference in the inversion results and the travel time curves. Portions of five long offset shots could also not be picked and this data was deleted from the data set on entry. Moderate smoothing was required together with the removal of travel times for geophones located at shot points.

The inversion yielded acceptable results with a final RMS error of 2.70 ms. Inversion convergence behaviour is shown in Figure 2:

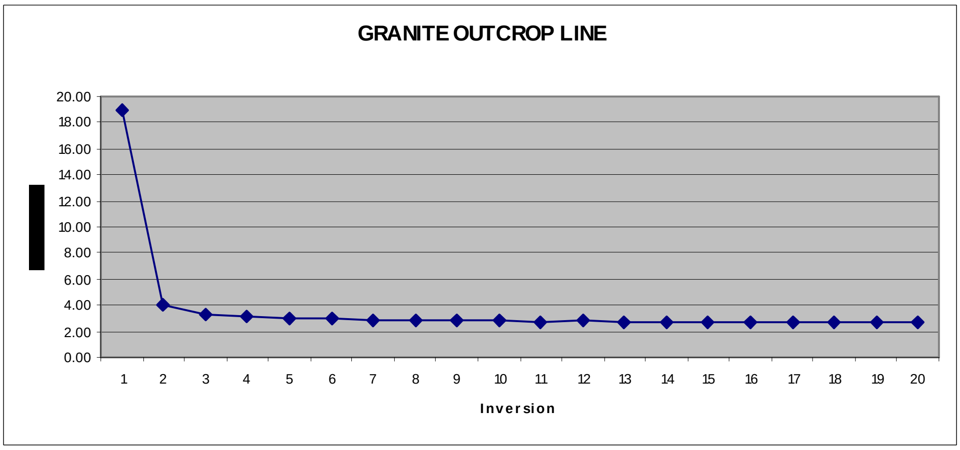


Figure 2. Granite Outcrop inversion convergence

Attempts to run ray tracing after tomographic inversion significantly increased the final RMS error to 10 ms. Consequently, the final model shown and used in the composite section is that defined before attempts to perform ray tracing. Average velocity measurements taken from the observed arrivals in the T-X plot for the direct wave and first two apparent refractions - assuming a three-layer model - yielded an upper layer velocity of 497 m/s, a middle layer velocity of 1,410 m/s and a lower layer velocity of 4,571 m/s. The selected refractor velocities were determined by comparison of the refraction survey results with available outcrop, drill hole and GPR results.

Digital data is appended to this report in the digital data archive, seismic refraction folder. This includes the raw shot files (*.dat / SEG2), the picked first arrival files (*.vs / ASCII) and the final inversion model in Excel format. The latter contains the coordinates (x,z) of the centre of each model cell in seismic acquisition coordinates together with the cell velocity in m/s.

Appendix III contains summary plots of the inversion results. These show, by line:

- the final inversion results (observed versus predicted travel times)
- the final model in color contour format

- the ray-traced final model showing predicted ray paths in the final model and
- the observed travel times alone, after editing.

5 DISCUSSION AND INTERPRETATION

The depth to the top of weathered bedrock is interpreted to be very shallow (<2 meters) over the entire length of the line. The interpretation of the depth to the boundary between weathered and fresh outcrop is supported by several factors. D9R rippable granite has an approximate seismic velocity of 2000 m/s (Caterpillar Performance Handbook – Edition 33). This is interpreted to represent the approximate depth of the bottom weathered bedrock. Borehole CH13-31-BH017, proximal to station 550, indicates an abrupt color change from N4 to N3, a competency change from R5 to R6 and is noted as extremely strong granite at 8.5 feet (2.6m) below surface. The GPR reflector profile also correlates well with this depth at station 550. Figure 3 is a composite section with the interpolated GPR reflector superimposed on the contoured seismic velocities. The section is compensated for topography with the x-axis registered to local station coordinates and depths in elevation with a 4:1 vertical exaggeration shown along the y-axis. The apparent bedrock depths derived from the GPR and seismic refraction interpretation should be drill tested at selected locations to verify and refine the interpretations included in this report.

Digital data included with this report comprises:

Elevation at GPR Reflector	Composite Section\Elevation at GPR Reflector.xls
Seismic Velocity Contours	Composite Section \”velocity” contour.shp

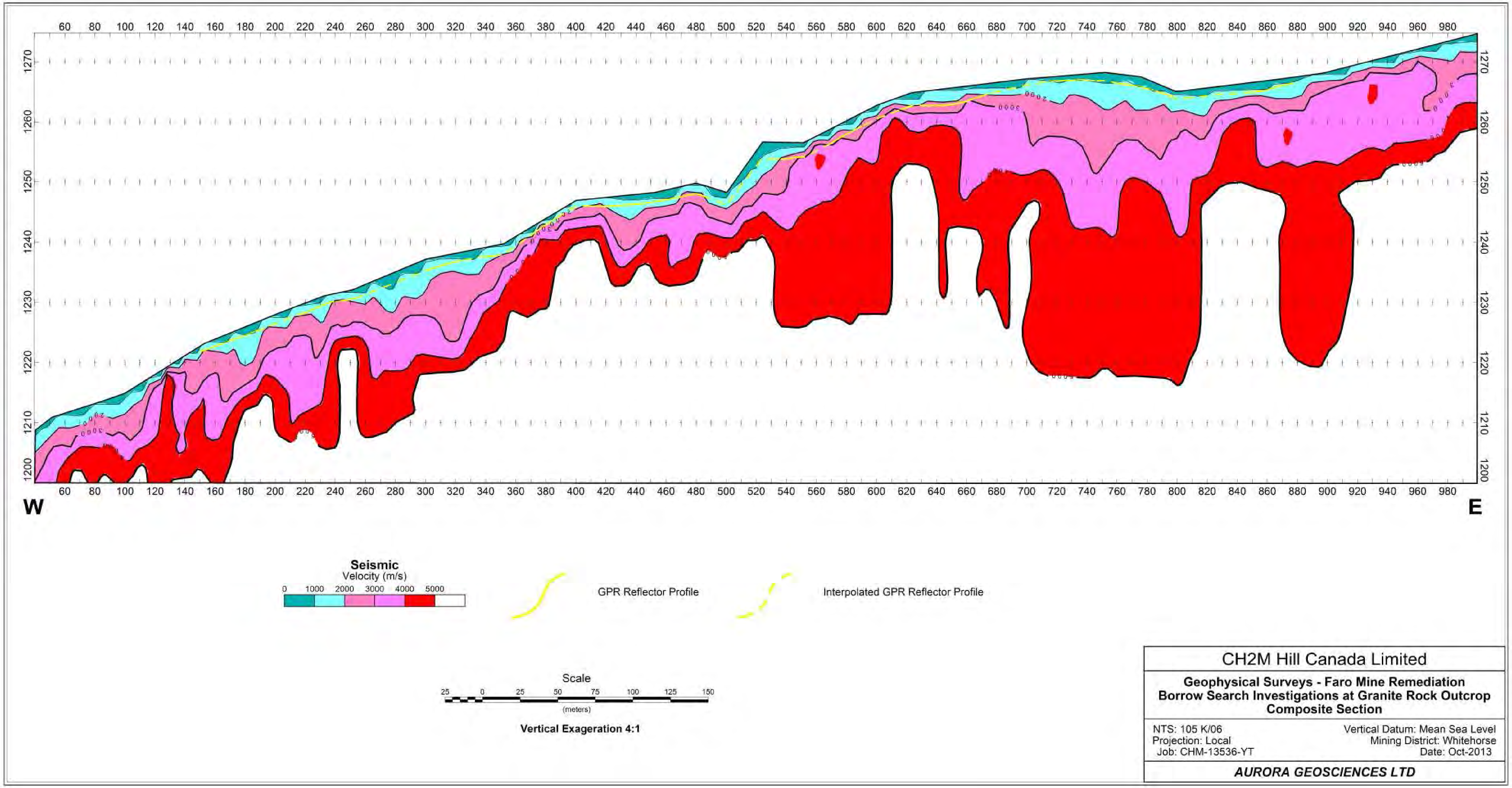
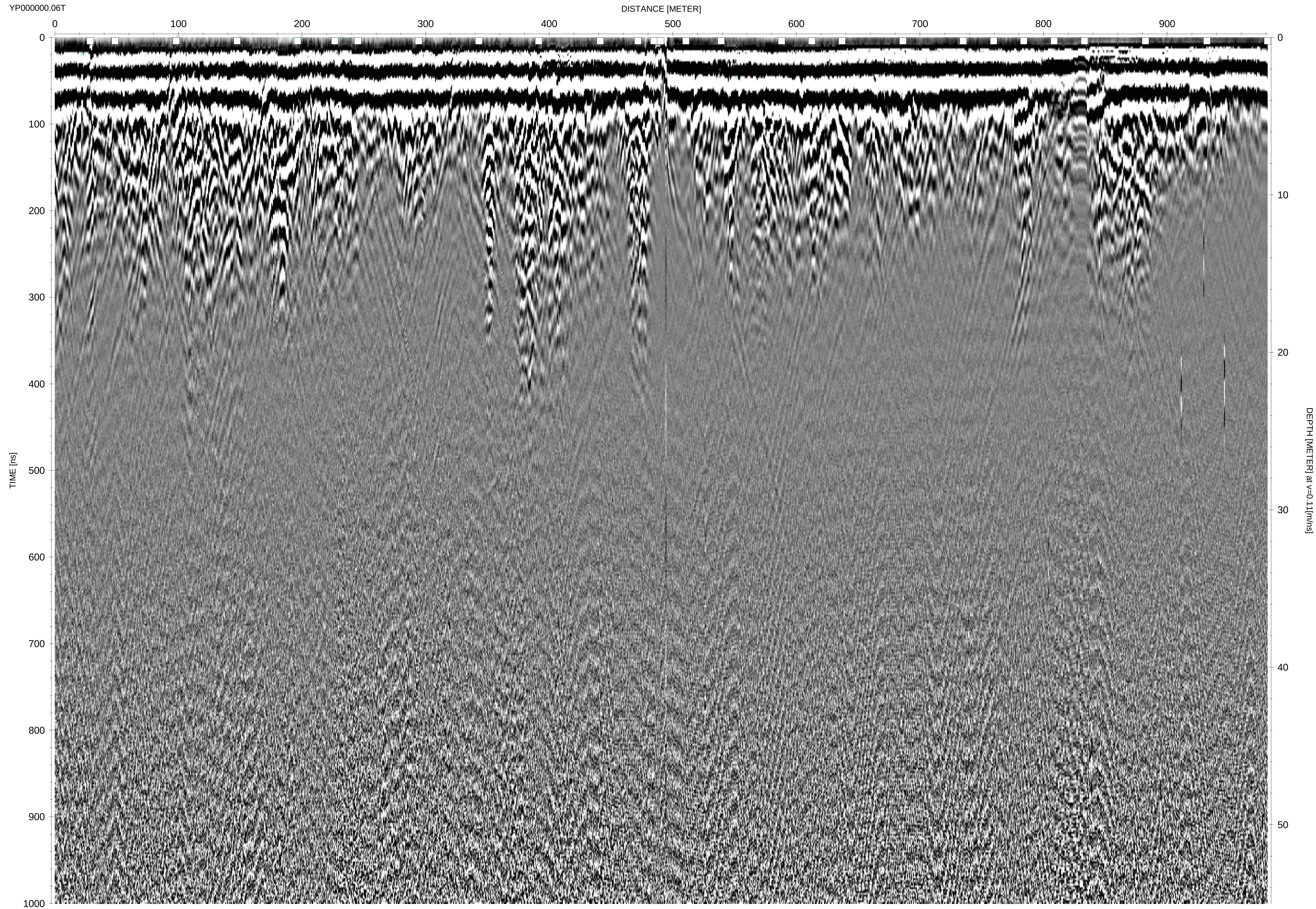


Figure 3. Granite Rock Outcrop composite section

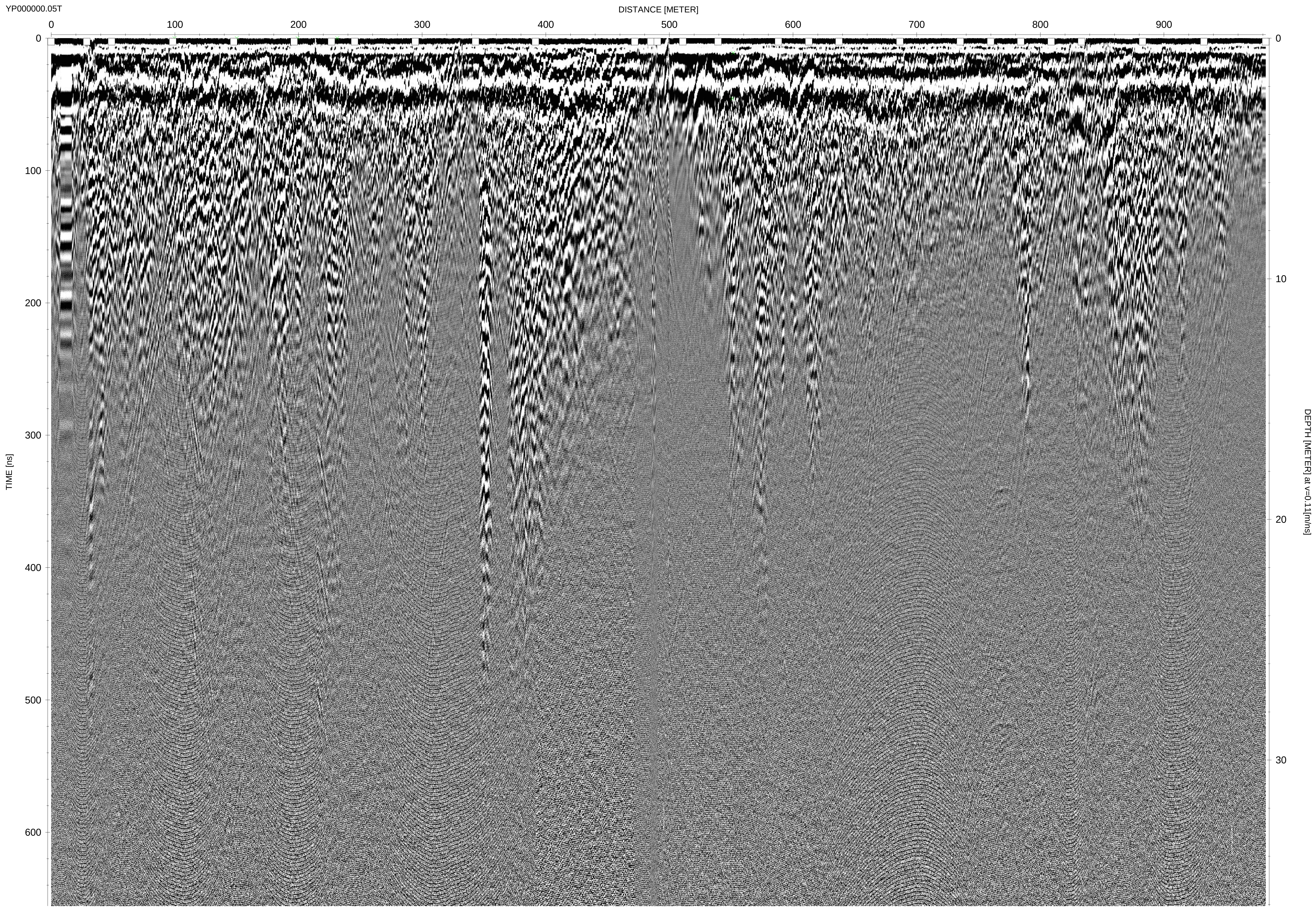
Appendix II

GPR Radargrams

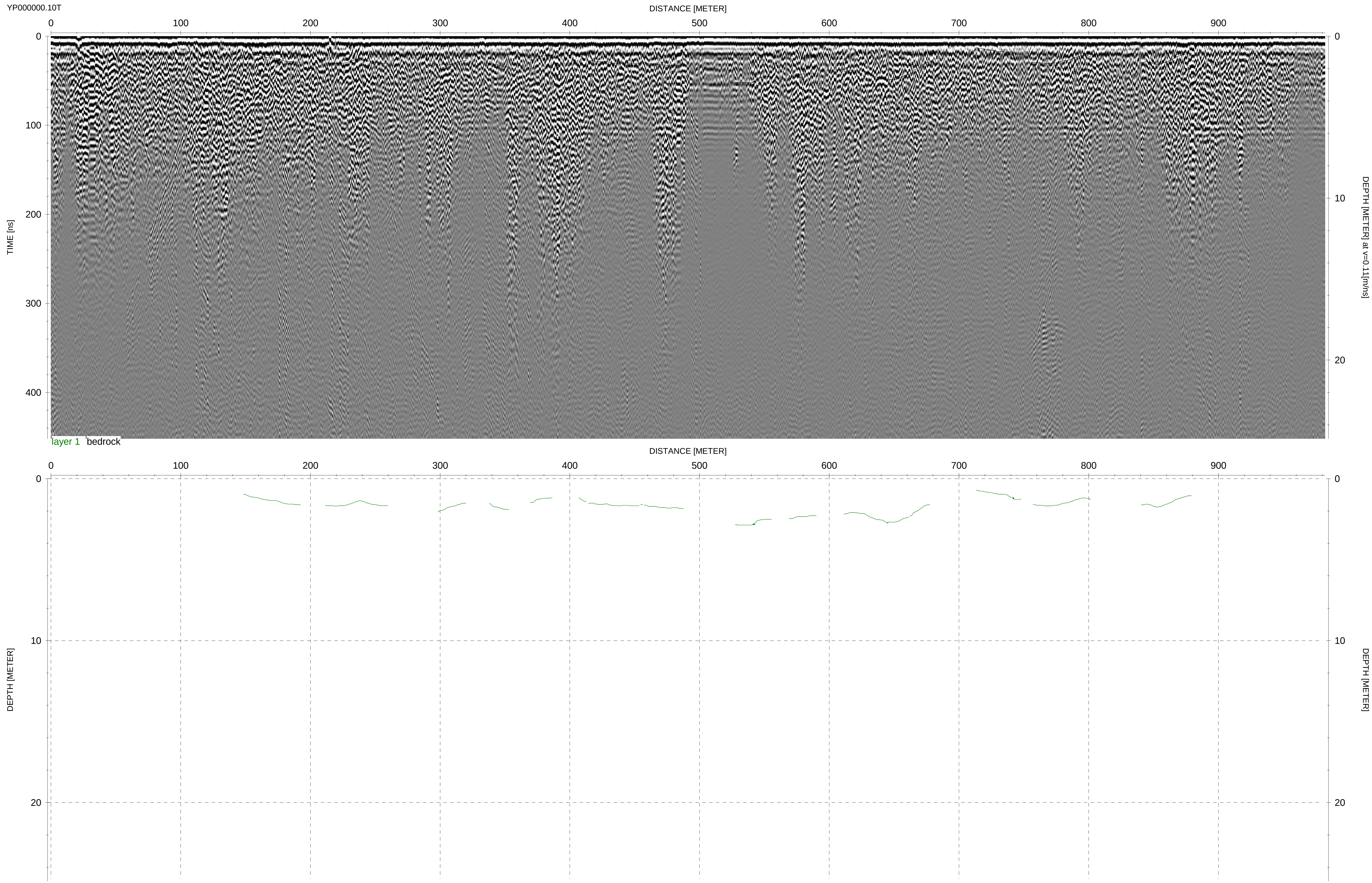
Granite - 25MHz



Granite - 50MHz



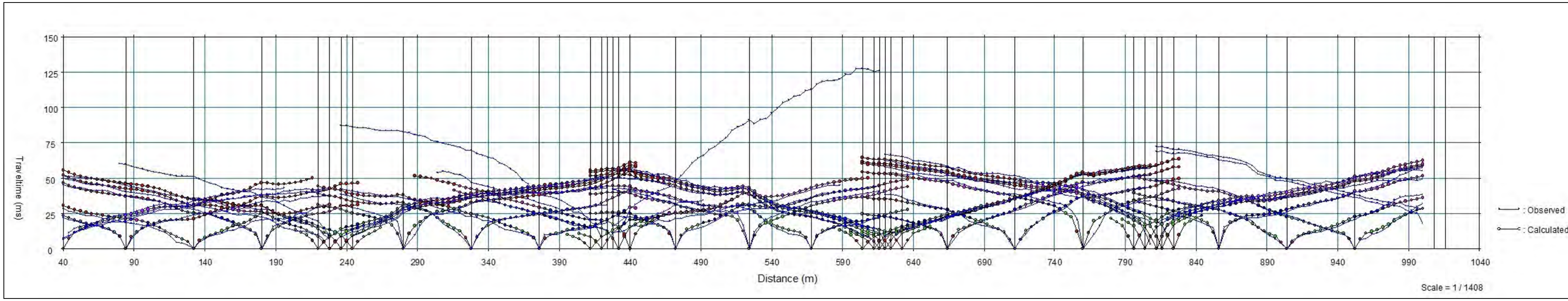
Granite - 100MHz



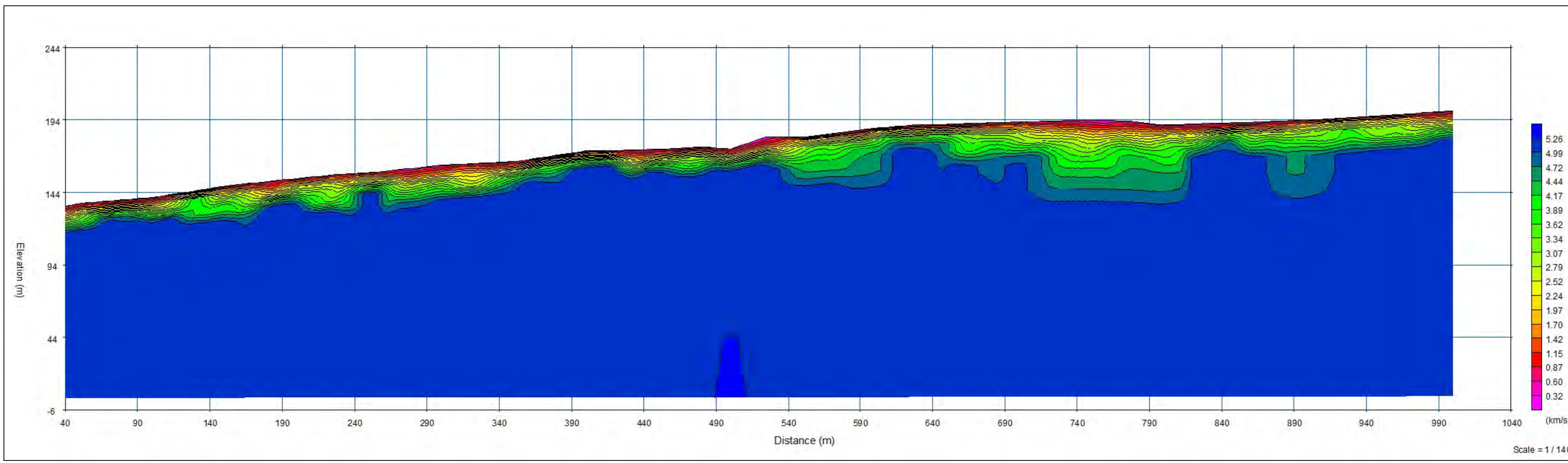
Appendix III

Seismic Summary Plots

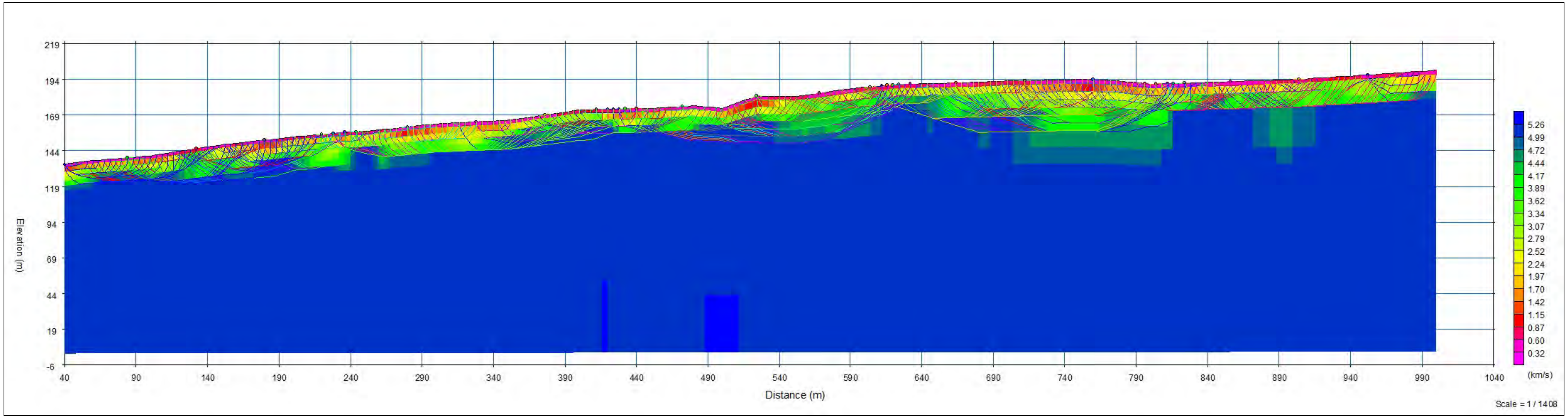
Granite Outcrop Line



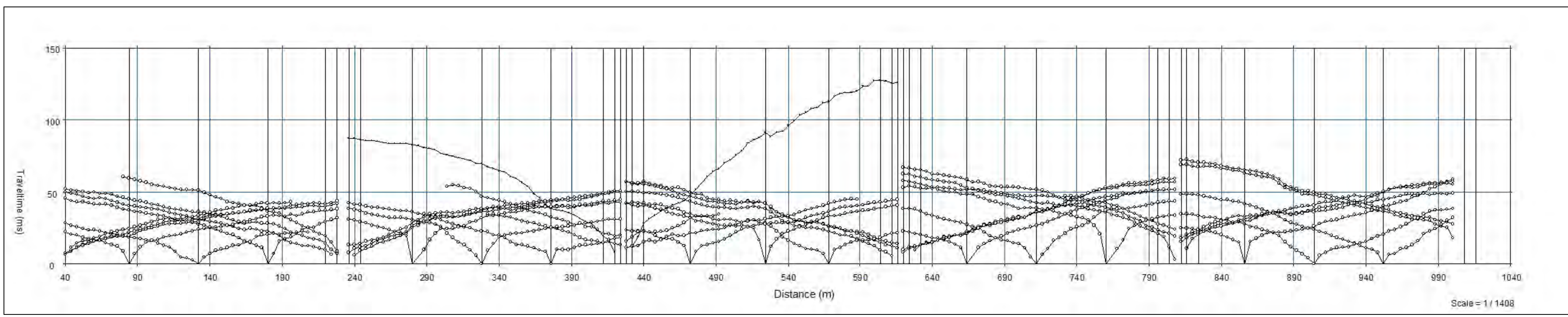
Inversion results - Final model



Final model



Ray tracing - Final model



Travel time curves

Grum Dump Rock Quarry Geophysics Report
(Appendix I, Project Log, is not included)

Geophysical Survey – Faro Mine Remediation – Grum Waste Rock Quarry - GWRQ

NTS: 105K/06, Whitehorse Mining District, Yukon Territory, Canada

WORK PERFORMED:
July 7-August 18, 2013

Prepared for:
CH2MHILL

Prepared by:

AURORA GEOSCIENCES

TECHNICAL REPORT
Geophysical Survey – Faro Mine Remediation – Grum Waste Rock Quarry - GWRQ

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Author
Phil Jackson, P.Geoph.

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1 SUMMARY

The geophysical investigations at the Grum Waste Rock Quarry (GWRQ), located approximately 10 kilometers northeast of Faro, are a portion of a larger project at the Faro Mine, Faro, Yukon Territory. The purpose of the investigations was to assist in the design of environmental mitigation measures by identifying the depth from surface to the underlying bedrock contact along the length of the 200 meter survey line.

This report describes procedures and results of line cutting, short-dipole resistivity, ground penetrating radar (GPR) and seismic refraction surveys conducted in the area between July 13th and August 10th, 2013.

Linecutting was required over the entire length of the survey line. Non-differential GPS waypoints were recorded at 50 meter stations. Topography was measured along the line using a laser range finder.

The short-dipole resistivity survey consists of an all-in-one multimode resistivity imaging system using multi-core cables. 72 electrodes are plugged in to the ground at fixed five meter spacing. Longer dipole spacings were used beyond n=10 where ground conditions produced unacceptable noise levels. Final data sets were compiled and inverted using RES2DINV Geotomo software.

The multi-frequency GPR survey was conducted with a Mala geosciences RAMAC GPR system operated at 50 and 100 MHz. Conventional GPR data processing is applied incorporating geometric registration, drift corrections, user gain, deconvolution, velocity analysis, and depth conversion.

The seismic refraction survey was conducted with a 48 channel digital engineering seismograph using a four meter phone spacing and an ATV mounted hammer digipulse as the energy source, manual sledgehammer strikes were also used on occasion. The data is processed and interpreted primarily using the ReflexW, Pickwin™ and PlotRefa™ software packages. Refraction processing included initial data checks, topographic data reduction, first break picking, composite shot file assembly and inversion.

In general, the resistivity data images lenses of frozen topsoil, elevated clay concentrations, and the contrast between overburden and underlying resistive bedrock well over the survey line. The GPR survey shows distinct signal character changes in areas of elevated clay concentration. A shallow GPR reflector at the west end of the survey line is interpreted as the base of frozen overburden and all remaining discontinuous reflectors are attributed to the weathered bedrock boundary. The seismic inversions are the most useful tool in interpreting depths to the weathered and fresh bedrock contacts. Bedrock depths correlate with seismic velocities that range between 2100 and 3200 m/s. All final interpreted depths are superimposed on contoured seismic velocities, GPR reflectors, drillhole information, and gridded resistivity to create the composite section for the survey line. Select locations along the survey line should be drill tested to verify and refine the interpretations included in this report.

2 INTRODUCTION

Aurora Geosciences Ltd. was retained by CH2M Hill Canada Limited to conduct line cutting, short-dipole resistivity, ground penetrating radar (GPR) and seismic refraction surveys. The surveys at the Grum Waste Rock Quarry (GWRQ) are a portion of a larger project at the Faro Mine, Faro, Yukon Territory, which included five separate areas:

- Cross Valley Dam (CVD)
- DVIHU (Down Valley / Rock Drain) Assessment (RCD)
- Borrow Search Investigations at Granitic Rock Outcrop
- Grum Waste Rock Quarry (GWRQ)
- New Vangorda Creek Diversion (VCD)

The purpose of the investigations at the GWRQ was to assist in the design of environmental mitigation measures by identifying the depth from surface to the underlying bedrock contact along the length of the 230 meter survey line. Based on previous investigations, the local stratigraphy consists of a layer of glacial till overburden overlying gabbro; permafrost conditions are unknown in the area. The depth to competent bedrock is predicted to be in the range of 0 to 10 meters. All geographic locations in this report are relative to North American Datum 1983. Non-geodetic coordinates are expressed in Universal Transverse Mercator Zone 8N metric coordinates. All measurements are expressed in the metric system unless they are measurements quoted from historic reports expressed in other units of measure. All geophysical data units are in the metric SI system.

3 LOCATION & ACCESS

The geophysics crew was based in the town of Faro, YT for the duration of the project with all areas accessible by truck. The Grum Waste Rock Quarry is approximately 10 kilometers northeast of Faro; a detailed map of the surveyed line is shown in Figure 1.

4 WORK PROGRAM

This section describes the work program conducted at GWRQ in 2013. Line cutting, short-dipole resistivity, ground penetrating radar (GPR) and seismic refraction surveys were conducted along a single 230 meter survey line. Appendix I contains a project log.

4.1 Line cutting & gridding

Line cutting and grid installation were conducted on the property to facilitate accurate location control for the geophysical surveys.

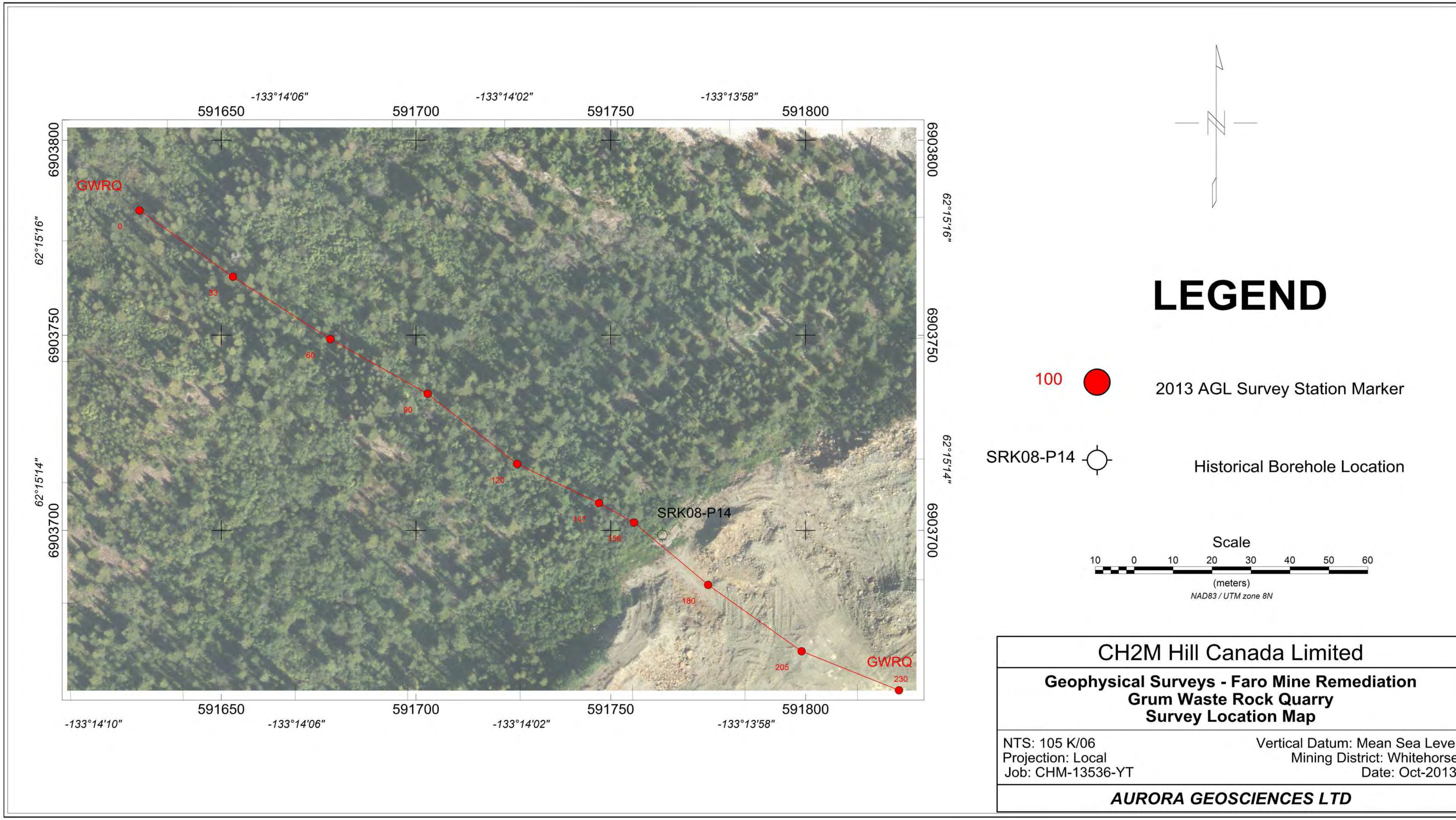


Figure 1. Survey Location Map

4.1.1 Equipment

The crew was equipped with the following instruments and equipment:

Equipment:	2 – Husqvarna 245 saws 2 – Sets brushing / chaining equipment 1 – Laser range finder
Communications:	1 – Satellite phone 2 – VHF radios
Vehicles:	1 – 1Ton truck 2 – Polaris ATV
Safety:	2 – Each of PPE including hard hat, safety glasses, steel-toed boots, hearing protection, long sleeved shirts, hip chaps (line cutting), hard hat with visor (line cutting), gloves, reflective vest and work pants as required by health and safety plans 1 – Each of fire extinguisher, first aid kit and potable water
Other:	3 – GPS receivers 1 - Laptop & color printer w/ Geosoft 1 - Field office equipment 1 - Repairs & tool kit 5 KV gas generator

4.1.2 Field Procedures

Line cutting was conducted according to the following specifications:

Station spacing:	50 meters
Chainage:	Stations: straight chained
Station marking:	Survey lines: Half-length pickets with metal tags
Registration:	Non-differential GPS measurements recorded at 50 m intervals. Horizontal and vertical distances measured between stations with a laser range finder

4.1.3 Products

Digital data included with this report comprises:

GPS measurements – station location	Topography\GWRQ GPS Waypoints.xls
Final data – laser range finder measurements	Topography\GWRQ Topography.xls

The survey grid is plotted on the location map shown in Figure 1.

4.2 Short-Dipole Resistivity Survey

A short-dipole resistivity survey was conducted on GWRQ on July 13th, 2013. The purpose of the survey was to distinguish layers of high and low relative permeability and identify the depth from surface to the underlying bedrock contact along the length of the 230 meter survey line. The anticipated high clay content along the line would likely provide a good resistivity contrast with the gabbroic bedrock.

4.2.1 Equipment

The crew was equipped with the following instruments and equipment:

Instruments & Equipment	Syscal Pro Resistivity & IP System 72 including transmitter, receiver, switch, cables, battery and software
Communications:	1 – Satellite phone 2 – VHF radios
Vehicles:	1 – 1Ton truck 2 – Polaris ATV
Safety:	2 – Each of PPE including hard hat, safety glasses, steel-toed boots, hearing protection, long sleeved shirts, gloves, reflective vest and work pants as required by health and safety plans 1 – Each of fire extinguisher, first aid kit and potable water
Other:	3 – GPS receivers 1 - Laptop & color printer w/ Geosoft 1 - Field office equipment 1 - Repairs & tool kit 5 KV gas generator

4.2.2 Field Procedures

The resistivity survey consists of an all-in-one multimode resistivity imaging system using multi-core cables. 72 electrodes are plugged in to the ground at fixed five meter dipoles, longer dipole spacings were used beyond n=10 where ground conditions produced unacceptable noise levels.

Resistivity surveying was conducted according to the following specifications and procedures:

Array:	dipole - dipole
Dipole Spacing:	a=5m (n= 1-32); and a=5m (n=1-10), a=15m (n=11-20) & a=30m (n=21-32)
Separations Read:	n = 1 to 32 (maximum)
Tx mode / signal:	Standard time domain signal(0.5 s +on, 0.5 s off)
Parameters Read:	Contact Resistance Primary voltage Spontaneous Potential

4.2.3 Data processing and products

The resistivity survey data was processed and interpreted using the following procedures:

1. Download & archive: Data is downloaded from the field instruments and raw data files are archived.

2. Data review: The resistivity data is reviewed and edited prior to preparing pseudosections and datasets for inversion. Duplicate readings are averaged and duplicates removed from the database to leave only a single reading at each station and separation. Readings which did not repeat within 10% are deleted from the database.

3. Pseudosection plotting: Pseudosections of the apparent resistivity are prepared from the final edited data. Sections are scaled to the range on each line.

4. Data formatting: The resistivity (in normalized V/I) and topographic data are formatted for entry into the RES2DINV inversion program.

5. Image extraction: After the modelling is complete, data ranges are compiled and overall data scales are assigned for the resistivity model. A resistivity scale covering the range from 0 to 5900 ohm-m is used as a standard scale. Final images are generated with the inversion software and converted to JPEGs without further editing.

Final digital data is appended to this report in Excel spreadsheet format. All unacceptable or erroneous readings, and those which did not repeat, are deleted from this final data set. Also included are GPS position measurements taken along the survey lines. These show the averaged location of the survey point in UTM coordinates, NAD 1983 datum, Zone 7N projection. This data is contained in an ASCII text file (GPS Points.txt).

The inversion results are collated in Appendix II. These images show the observed data, the model generated response for comparison and the 2D resistivity distribution in the final model. Missing data produces a stretched grid in both the measured and calculated apparent resistivity pseudosections, however this is observed in areas greater than 25 meters below the surface and beyond the area of interest.

Digital data included with this report comprises:

Final Quality controlled databases	Resistivity\GWRQ\Final data\GWRQ Res Final.xyz &.gdb
Raw Data	Resistivity\GWRQ\Raw data*.bin
Inversion results	Resistivity\GWRQ\Res2D Inversion*.*

4.3 Ground Penetrating Radar (GPR) Survey

A GPR survey was conducted on August 1st, 2013. The purpose of the survey was to estimate the depth from surface to the underlying bedrock contact along the length of the 230 meter survey line. The anticipated high clay content along the line is expected to complicate the interpretation.

4.3.1 Equipment

The crew was equipped with the following instruments and equipment:

Instruments & Equipment	1 – Ramac GPR Pro Ex Controller 1 – Ramac Pro Ex Optical Module 1 – Control Unit II (CUII) 1 – 50 & 100 MHz Rough Terrain Antenna 1 – Monitor Rad Explorer Software
Communications:	1 – Satellite phone 2 – VHF radios
Vehicles:	1 – 1Ton truck 2 – Polaris ATV
Safety:	2 – Each of PPE including hard hat, safety glasses, steel-toed boots, hearing protection, long sleeved shirts, gloves, reflective vest and work pants as required by health and safety plans 1 – Each of fire extinguisher, first aid kit and potable water
Other:	3 – GPS receivers 1 - Laptop w/ Geosoft 1 - Field office equipment 1 - Repairs & tool kit 5 KV gas generator

4.3.2 Field Procedures

The GPR system is normally worn and operated by a single operator for high frequency surveys, or is carried and guided by several operators with the controller being either worn or towed. The transmitter and receiver electronics are mounted on their respective antennas and linked via fibre optic cables to the controller unit. Both the transmitter and receiver are controlled by the RAMAC monitor running interface software which configures the system, stores the collected data and allows the operator to view the radargrams in real time.

The line, read with successive passes for each individual frequency, was completed as a profile survey. The Rough Terrain Antenna (RTA) are oriented in-line with the survey direction and spaced a fixed distance apart. The survey is conducted by moving the antenna pair along the line. The data is then plotted using radargrams which show the centre of the antennas (x) on the horizontal axis and the signal on the y-axis as a function of time (t), with arrival time increasing vertically downward. The reflections appear at various distances below the time zero line at the top of the radargram. These distances below the time zero line are proportional to the arrival times which in turn are roughly proportional to the depth to target. Thus, the reflections display a pattern which generally correlates with their subsurface location. During data processing, the arrival times may be converted to depths and the reflections are then displayed at the apparent depths of the sources. Reflections are displayed as grey shade plots.

GPR surveying was conducted according to the following specifications and procedures:

Centre Frequency:	50 & 100 MHz
Measurement Interval:	10cm (maximum), determined by operating frequency.

Antenna Separation:	2m (50MHz), 1m (100MHz)
Triggering:	Time: 0.5s (50MHz) and 0.25s (100MHz)
Station Registration:	The apparent horizontal distance at which each surveyed control line picket was encountered was recorded manually and used in the data processing to register the lines.

4.3.3 Data processing and products

The GPR survey data was processed and interpreted using the following procedures:

1. Download & archive: Data is downloaded from the field instruments and raw data files are archived.
2. Geometric registration: Trace coordinates are updated and interpolated to match recorded markers during data acquisition.
3. De-wow: Low frequency antenna to antenna reverberations are removed by cutting frequencies generally below ¼ of the centre frequency.
4. Trace kills: traces collected during static data collection time or outside survey markers are removed.
5. Drift removal and resetting of time zero: The time zero line on the radargrams is reset to the first arrival of the ground wave.
6. Gain: Compensation for damping losses is achieved by multiplication of linear, exponential and programmed gain functions where appropriate.
7. Deconvolution: Spiking deconvolution is applied to sharpen the reflections.
8. X-Flip: Applied to data acquired in opposite survey directions to achieve consistent viewing directions from west to east.
9. Depth conversion: using average ground velocity deduced by measured diffraction hyperbolas
10. Printing: JPEG format showing the location of the line registration points and all picked reflectors.

The radargrams show the horizontal position along the x-axis in local station coordinates and both travel time and apparent depth along the y-axis. The radargrams have not been compensated for topography and are plotted with considerable vertical exaggeration. The reflections are plotted as alternating black (positive) and white (negative) bands. The first arrival - a triplet which is continuous across the section- is the ground wave between the antennas and not a feature of interest. Ringing is also present and is manifested by parallel bands of recurring reflections which tend to run across the section and obliterate any weaker reflections arriving in the same time window. Reflector picks for the frequency shown in the radargram are indicated in red and associated picks from the complimentary frequency are indicated in black on each of the radargrams. The picks are used in combination with other survey data to interpret the depth to bedrock. GPR signal attenuation is higher in more conductive ground. This is evident primarily on the 100 MHz radargram. Distinct changes in signal characteristics observed between stations 140 and 200 are the result of strong signal attenuation consistent with elevated clay content in the overburden as confirmed by drillhole SRK08-P14. Bedrock reflectors are best observed on the 50 MHz radargram. A shallow reflector between stations 0 and 100 is attributed to the base of frozen overburden. Shallow, flat-lying discontinuous reflections observed between stations 80 and the east end of the survey line are attributed to the top of weathered bedrock. These reflectors correlate well with the resistivity inversion and available borehole information. A velocity of 0.11 m/s is selected based on diffraction hyperbolas and reported sediments in drillhole logs.

Digital data included with this report comprises:

Raw and Processed GPR field data	Digital Data\GPR\"Frequency"*.*

Appendix II contains processed radargrams for all surveyed frequencies

4.4 Seismic Refraction Survey

A seismic refraction survey was conducted on August 10th, 2013. The purpose of the survey was to estimate the depth from surface to the underlying bedrock contact along the length of the 230 meter survey line.

4.4.1 Equipment

The crew was equipped with the following instruments and equipment:

Instruments & Equipment	2 - Geometrics Geode G24 seismographs 2 – 24 channel cable with 5m takeouts 48 – Mark Products 40Hz vertical component geophones ATV mounted source, sledge hammer and plate
Communications:	1 – Satellite phone 2 – VHF radios
Vehicles:	1 – 1Ton truck 2 – Polaris ATV
Safety:	2 – Each of PPE including hard hat, safety glasses, steel-toed boots, hearing protection, long sleeved shirts, gloves, reflective vest and work pants as required by health and safety plans 1 – Each of fire extinguisher, first aid kit and potable water
Other:	3 – GPS receivers 1 - Laptop w/ Geosoft 1 - Field office equipment 1 - Repairs & tool kit 5 KV gas generator

4.4.2 Survey specifications

The refraction seismic survey was performed according to the following specifications:

Channels: 48

Receiver spacing:	4 m
Shot locations:	Offset shots – 60 m off each end of line (nominal) End of line shots – Phones 1 and 48 Mid-spread – Phone 24
Record length:	512 ms
Sampling:	62 μs
Source effort:	Digipulse: 10 blows Hammer: 15 blows

4.4.3 Data processing

The refraction seismic survey data is processed primarily using the ReflexW, Pickwin™ and PlotRefa™ software packages. The following procedures and methods are used and described in order below:

1. Initial data checks: The seismic refraction data is of acceptable quality overall with some shot records containing unacceptable data. Bad data included shot records with a few dead traces and some shot records with very poor signal strength in portions of a spread due to bad ground or intervening geological features between the shot and geophones. The initial data checks begin with checking each data file against the observer's field records to verify that the receiver and shot locations were correct. In cases where there is a discrepancy between the observer's record of the receiver locations and the receiver locations in the file header, the file header was corrected if it can be conclusively established that the discrepancy resulted from a simple keying error; otherwise the shot record is rejected. End of line and mid-spread shots are recorded within a spread with the shot point at a geophone location. Consequently, it is easy to verify the shot location from the shot record as the shot occurs at the geophone with the near zero time arrival. In some cases there were obvious discrepancies between the observer's records and the observed shot location. In this instance, the shot location as indicated by the shot record is used to correct the observer's records. In cases where there is ambiguity, the observer's records are considered correct.

2. Topographic data reduction: Topographic reduction consisted of calculating the horizontal (line) coordinates and elevation of each shot and receiver, relative to acquisition coordinates. The seismic refraction survey was run from station 0 (591626E, 6903796N) to station 188 (591781E, 6903680N). The seismic survey line has a nominal length of 188 m. Station 0 on the seismic line has an assigned elevation of 125.5 m. This is the common elevation datum used in the calculation of all other station elevations and in the refraction seismic processing and modeling.

3. Pick first breaks: First arrivals are picked with Pickwin™ and stored in ASCII format *.vs files containing the shot location and the first arrivals by phone and x-coordinate. In making these picks, the interpreter is guided by knowledge of the expected pattern of arrivals from two or more refractors and the likely response of permafrost patches. The latter can produce anomalously fast and early first arrivals in groups of phones along a spread in a pattern which

does not fit the expected sequence of progressively flattening first arrivals moving away from the shot location.

4. Composite shot file assembly: The first arrivals are assembled in a composite shot file in PlotRefa™ and inverted with the same software. After assembly, each shot is checked to ensure that the shot location is correct. Thereafter, first arrivals are examined and where necessary edited by the interpreter. Arrivals which could not be picked accurately are assigned a 0 arrival time during picking; these are removed after assembly in the composite shot file. Arrival times which are affected by receiver statics - typically a delay affecting arrival times from several shots at the same geophone – are corrected by moving them into line with neighboring arrival times. Minor smoothing is also done since random phone-to-phone variations do not normally reflect refractor topography but are primarily caused by noise in the shot record. Finally, the line topography is imported into the inversion package to correct the phone and shot elevations. The finite element inversion algorithm used in the inversion could not handle variations in horizontal (x) phone locations and the nominal phone locations (4 m apart) are used for all subsequent processing.

5. Inversion: The data is inverted using a tomographic ray-tracing algorithm. A four meter (horizontal) cell size is used in the inversion. The initial model is a layered model with a vertical variation in seismic velocity parallel to surface topography of from 300 to 5,250 m/s over a depth of 20 to 30 meters. The inversion algorithm is unable to model data from shots fired off either end of the seismic line. The inversion is allowed to run for 20 iterations, the model is adjusted to improve the fit between the predicted and observed data by varying the velocity in each cell along the modeled ray paths. Root mean square (RMS) misfit between the observed and measured data is taken as the indicator of goodness-of-fit and the algorithm sought to minimize the RMS error in successive iterations. Upon completion of the inversion, a final ray-tracing is performed with a different algorithm to verify the robustness of the model. The final products of the inversion consist of: predicted and observed travel times for each shot and station (Inversion results) in a T-X (travel time / distance) plot; the velocity model (Final model); and the ray-traced model showing the final model with calculated ray paths(Ray traced model). This, together with a T-X plot of only the observed data (Travel time plot), is shown in the summary plots for the survey.

4.4.4 Inversion results & products

The data for the GWRQ line is good with no areas where signals could not be read. Only minor smoothing was required. The inversion yielded good results with a final RMS error of 1.33 ms. Inversion convergence behaviour is shown in Figure 2.

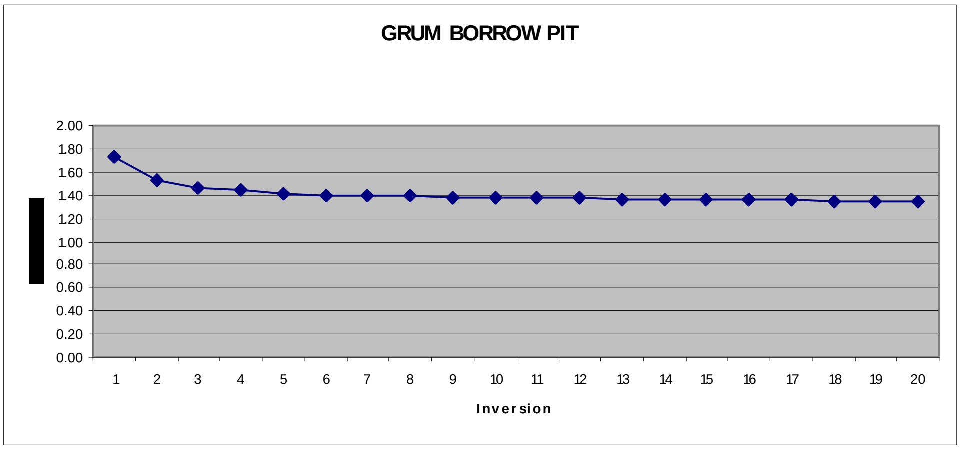


Figure 2. GWRQ inversion convergence

Average velocity measurements taken from the observed arrivals in the T-X plot for the direct wave and first two apparent refractions - assuming a three-layer model - yielded an upper layer velocity of 541 m/s, a middle layer velocity of 1,406 m/s and a lower layer velocity of 3,811 m/s.

Appendix IV contains summary plots of the inversion results. These show:

- Final inversion results (observed versus predicted travel times)
- Final model in color contour format
- Ray-traced final model showing predicted ray paths in the final model
- Observed travel times alone, after editing.

5 DISCUSSION AND INTERPRETATION

All estimations are completed through comparison of survey results together with drillhole information. A composite section showing the final interpretation is compiled from survey results (Figure 3). Seismic velocity contours, GPR reflectors and generalized drillhole information are superimposed on gridded resistivity. The section is compensated for topography with the x-axis registered to local station coordinates and depths in elevation with a 2:1 vertical exaggeration shown along the y-axis.

The resistivity data show a layer of low resistivity with overlying subtle highs between station 10 and 70, associated with frozen overburden or reduced clay content within the overburden. A shallow distinct band of low resistivity is observed between station 0 and 140. The band deepens between station 20 and 80 and is interpreted as a zone of increased permeability or weathered bedrock. The pervious material has multiple associated flat-lying GPR reflectors most evident on the 100 MHz radargram. An increased concentration of diffraction trails is also observed and indicates a layer of weathered bedrock or highly permeable sediments.

A shallow, distinct GPR reflector observed from stations 0 to 30 on the 50 MHz radargram continues to station 100 on the 100 MHz radargram. The reflector is associated with low seismic velocities and the base of a subtle resistivity high; therefore, it is interpreted to be the base of frozen or semi-pervious overburden.

In general, the depth to fresh bedrock is approximately ten meters between stations 0 to 190 with a thicker, distinct zone of pervious material observed between stations 20 and 70. The bedrock interface is interpreted to be deepest at approximately station 50 where it is estimated to be in excess of 13 meters. East of station 190, the bedrock boundary gradually shallows to approximately five meters at the end of the survey line. There is a relatively constant thickness of weathered bedrock (~3 to 5 meters) between stations 0 to 190. The layer of weathered bedrock gradually thins to approximately one meter at the east end of the survey line.

The top of weathered bedrock has an associated seismic velocity of approximately 2100 m/s, discontinuous GPR reflectors between station 30 and 230, and increased resistivity over the length of the survey line with the exception of the low resistivity zone between stations 140 and 190. The top of fresh bedrock has an interpreted seismic velocity of approximately 3200 m/s and a more distinct resistivity contrast is observed over the line with the exception of the zone of low resistivity between stations 140 and 190. No distinct GPR reflectors are attributed directly to the weathered and fresh bedrock boundary; however multiple discontinuous reflectors and changes in signal characteristics contribute to the interpreted depth.

The strongly attenuated GPR signal and associated zone of lower resistivity surrounding drillhole SRK08-P14 is attributed to a zone of elevated clay content. The broad resistivity highs observed at depth from station 60 to 90, 110 to 140 and again from 210 to 230 likely represent a zone of resistive material within the fresh bedrock.

A combination of seismic velocities, resistivity boundaries, associated GPR reflectors and drillhole logs are used to select the interpreted depths to weathered and fresh bedrock. All depths derived herein should be drill tested at select locations to verify and refine the interpretations included in this report.

Digital data included with this report comprises:

Composite Section Shape files	Digital Data\Composite Section*.shp
Composite Section Packed Maps	Digital Data\Composite Section\Composite Section.map

Respectfully submitted,

AURORA GEOSCIENCES LTD.

Phil Jackson, P.Geoph.
Geophysicist

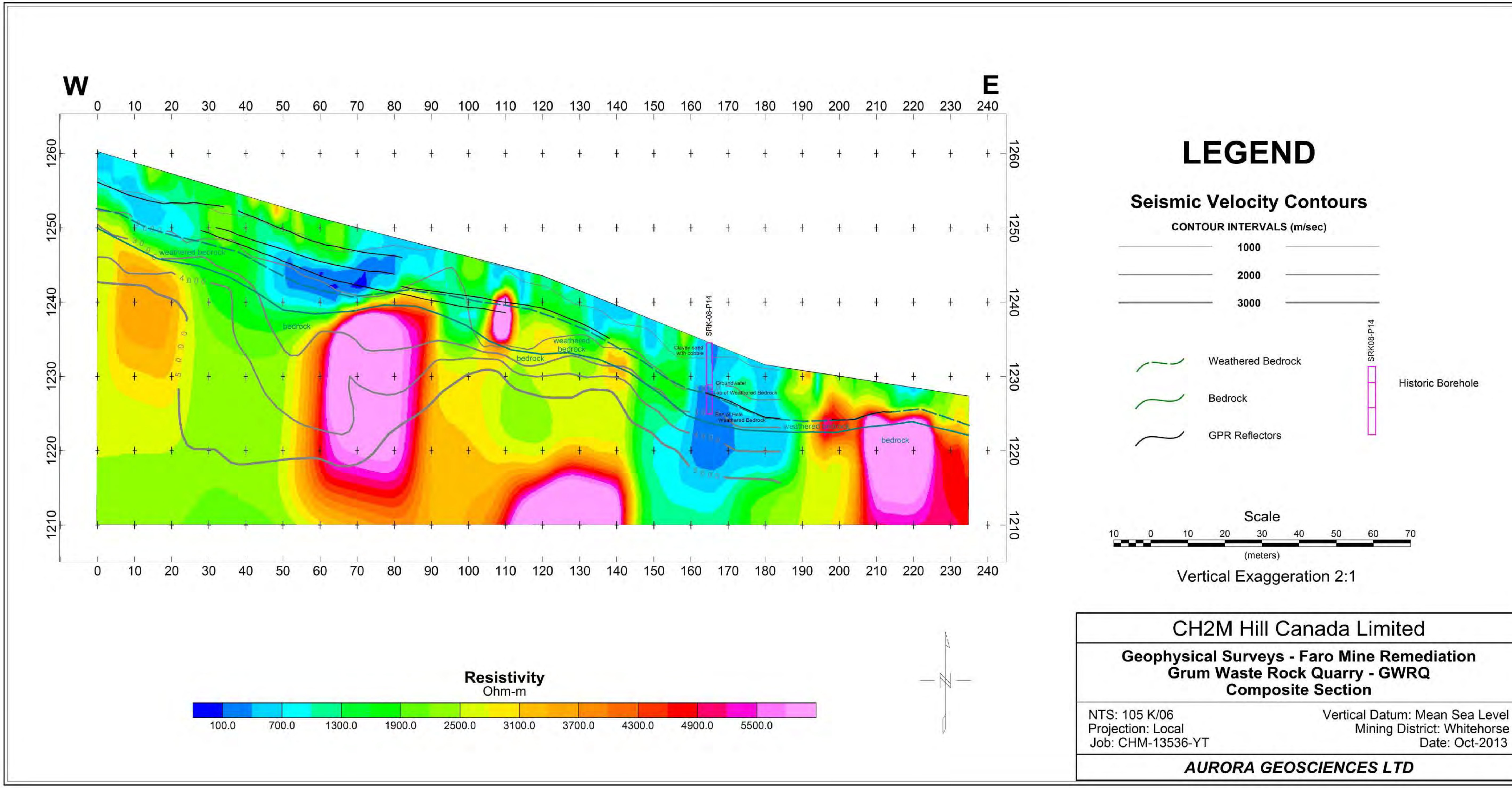
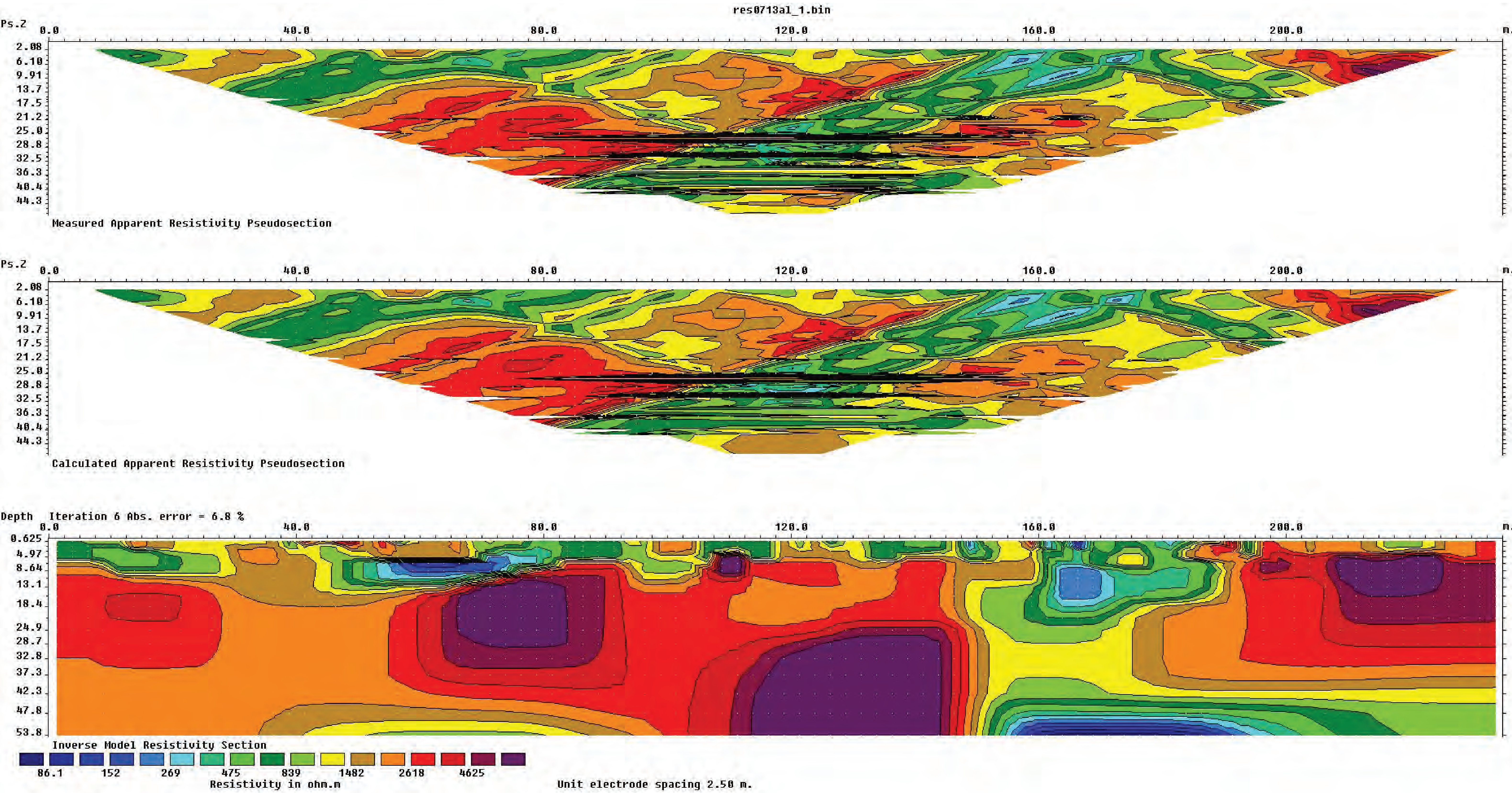


Figure 3. Composite Section

Appendix II

Resistivity Inversions

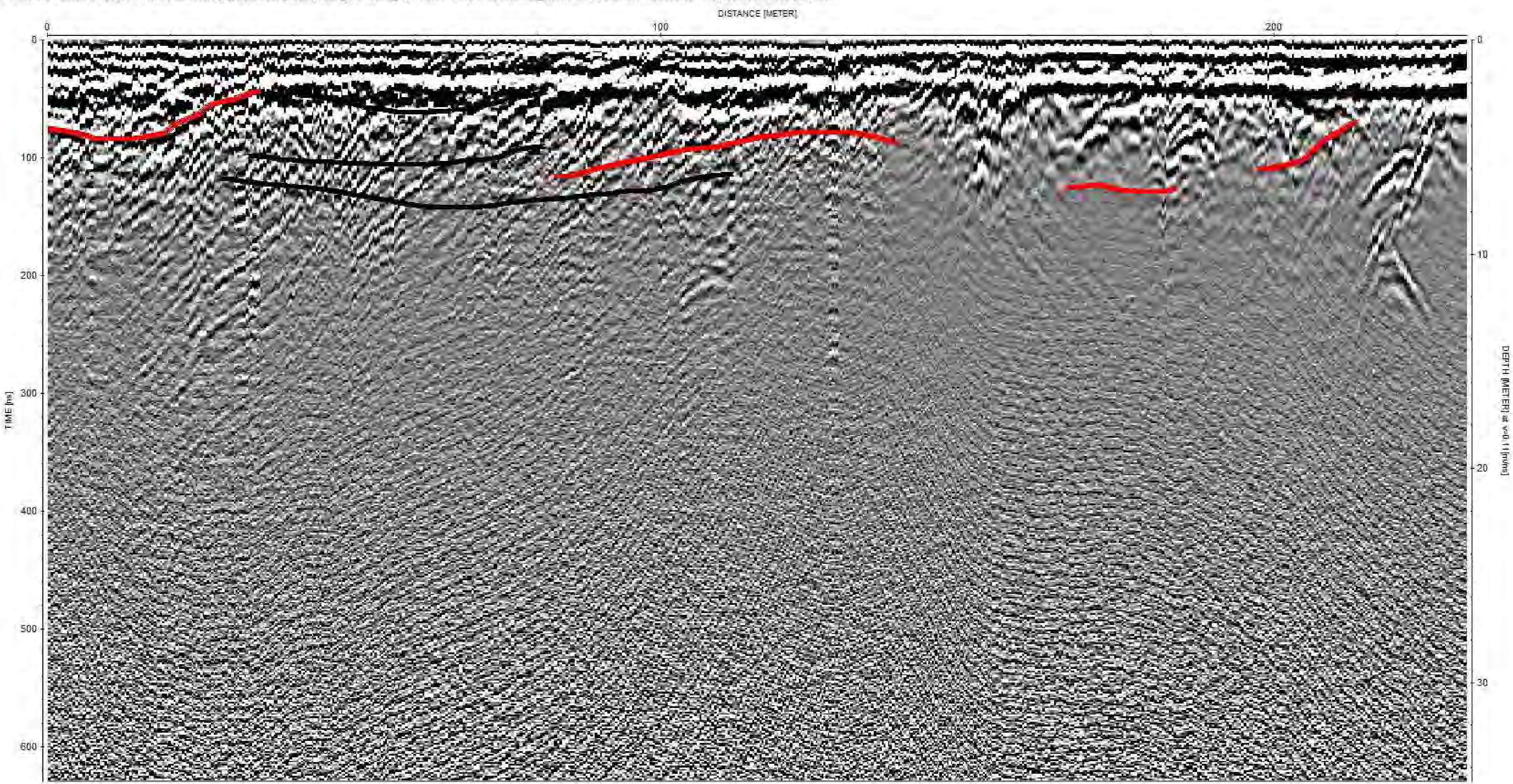


res0713al_1.bin
Ps.Z
0.0
40.0
80.0
120.0
160.0
200.0
m.
2.08
6.10
9.91
13.7
17.5
21.2
25.0
28.8
32.5
36.3
40.4
44.3
Measured Apparent Resistivity Pseudosection
Calculated Apparent Resistivity Pseudosection
Depth Iteration 6 Abs. error = 6.8 %
0.625
4.97
8.64
13.1
18.4
24.9
28.7
32.8
37.3
42.3
47.8
53.8
Inverse Model Resistivity Section
86.1
152
269
475
839
1482
2618
4625
Resistivity in ohm.m
Unit electrode spacing 2.50 m.

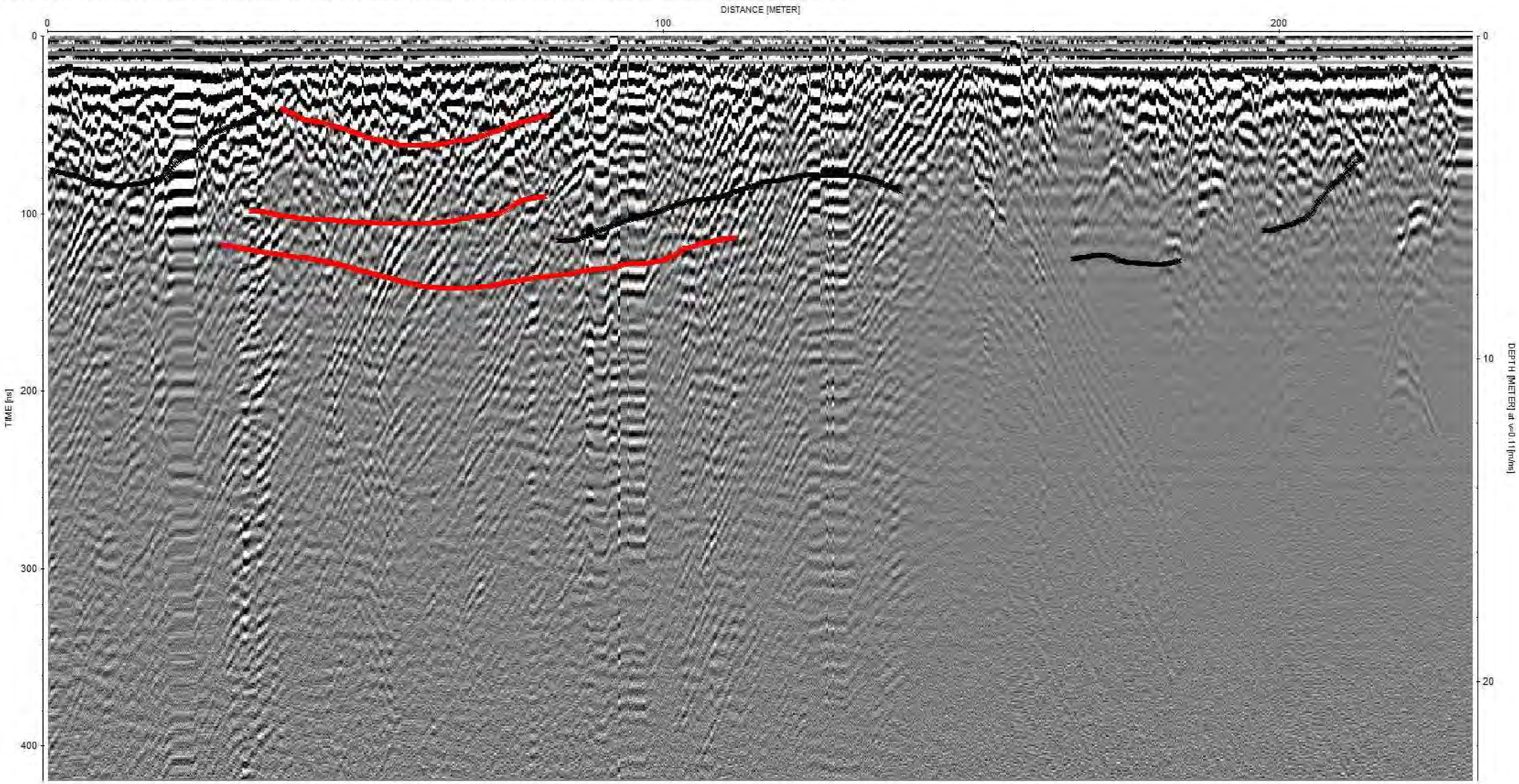
Appendix III

GPR Radargrams

1. L:\CH2M Hill\CHM-13536-YT-Faro Shallow Geophysics\Geophysics\Working\PJ working\GPR\GWRQ\GPR\50\GWRQ_50MHz\PROCDATA\YP000000.07T / traces: 2315 / samples: 452



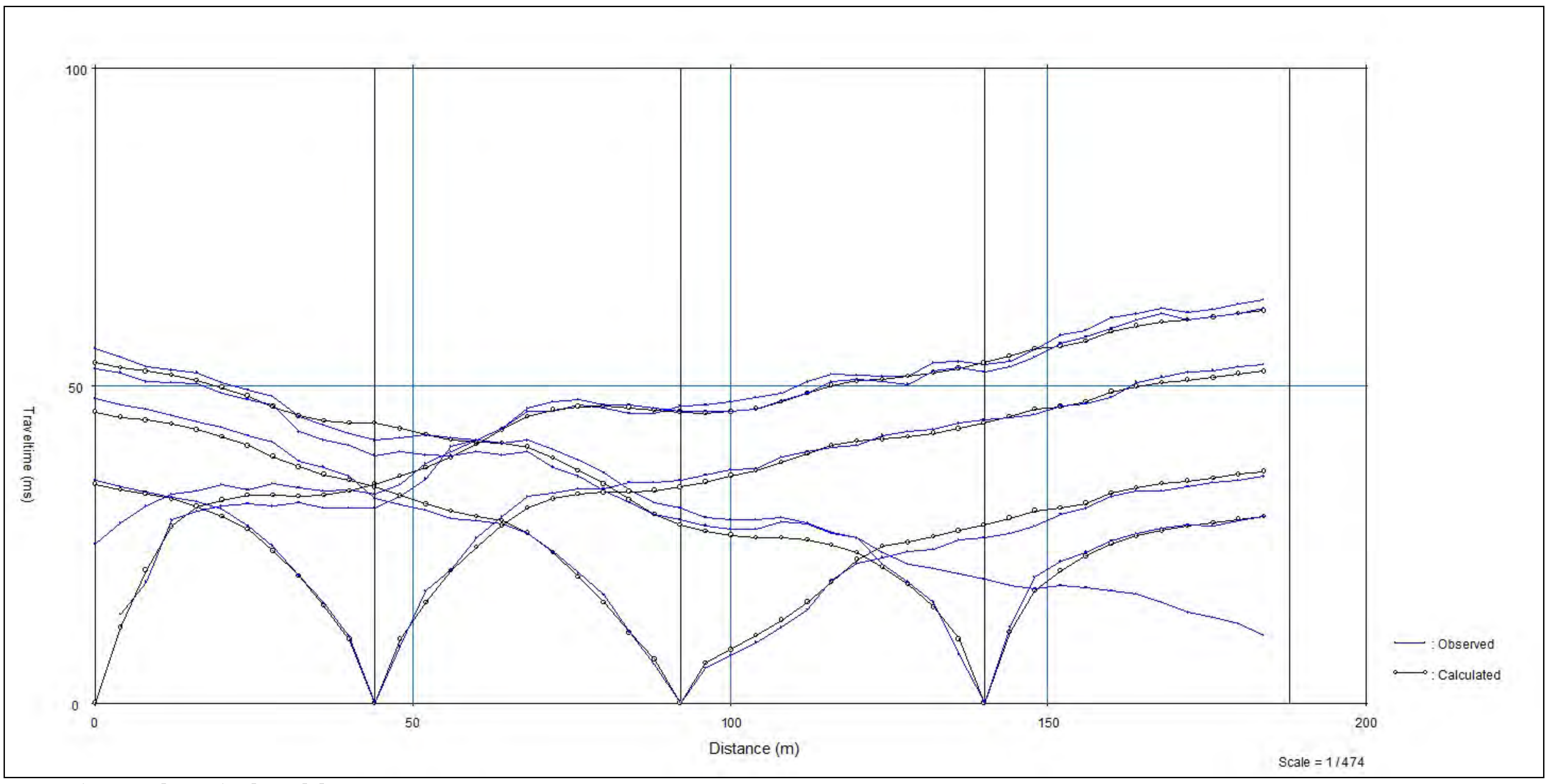
1. L:\CH2M Hill\CHM-13536-YT-Faro Shallow Geophysics\Geophysics\Working\PJ working\GPR\GWRQ\GPR\100\GWRQ_100MHz\PROCDATA\YP000000.07T / traces: 2315 / samples: 472



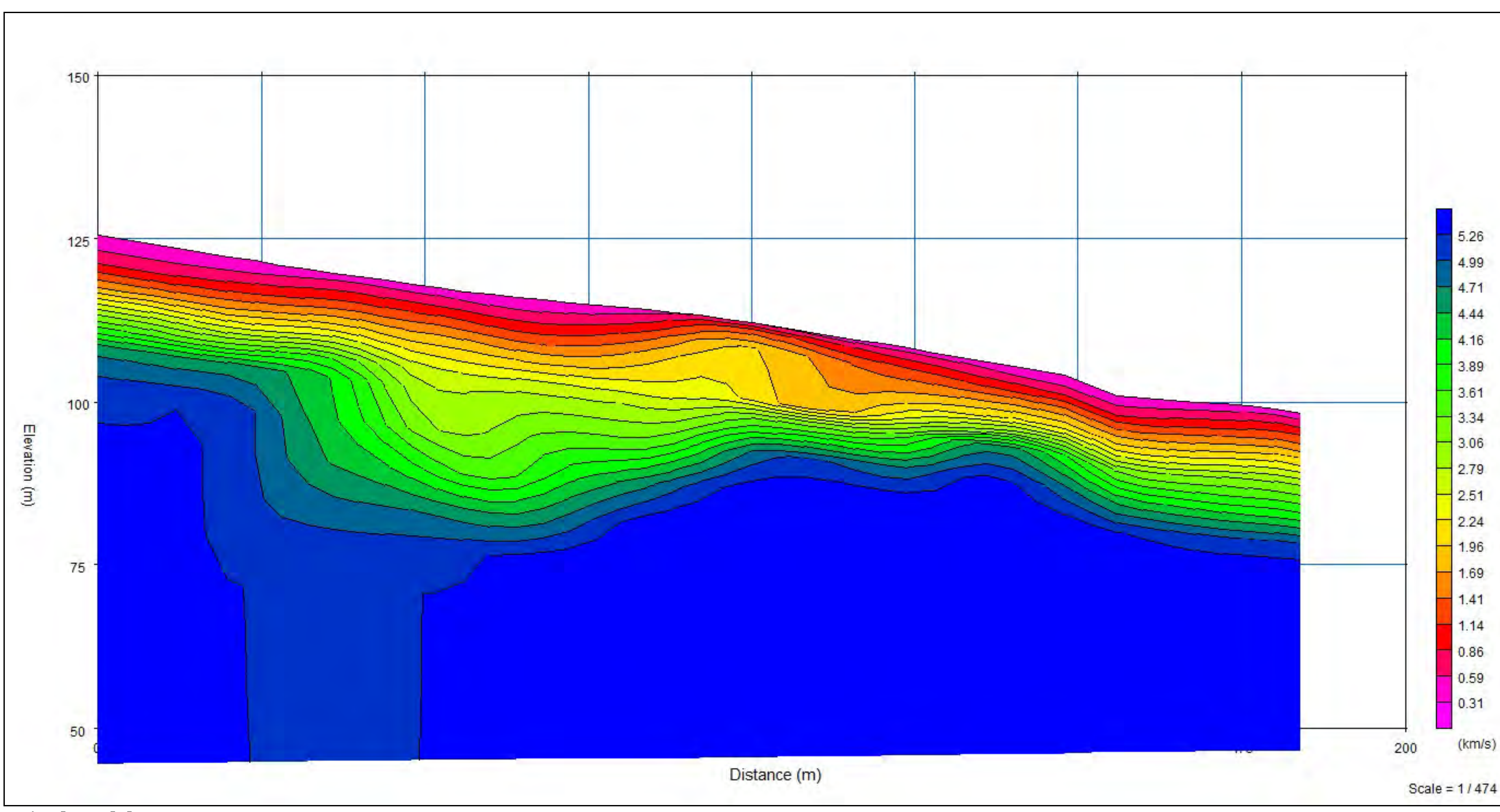
Appendix IV

Seismic Refraction Sections

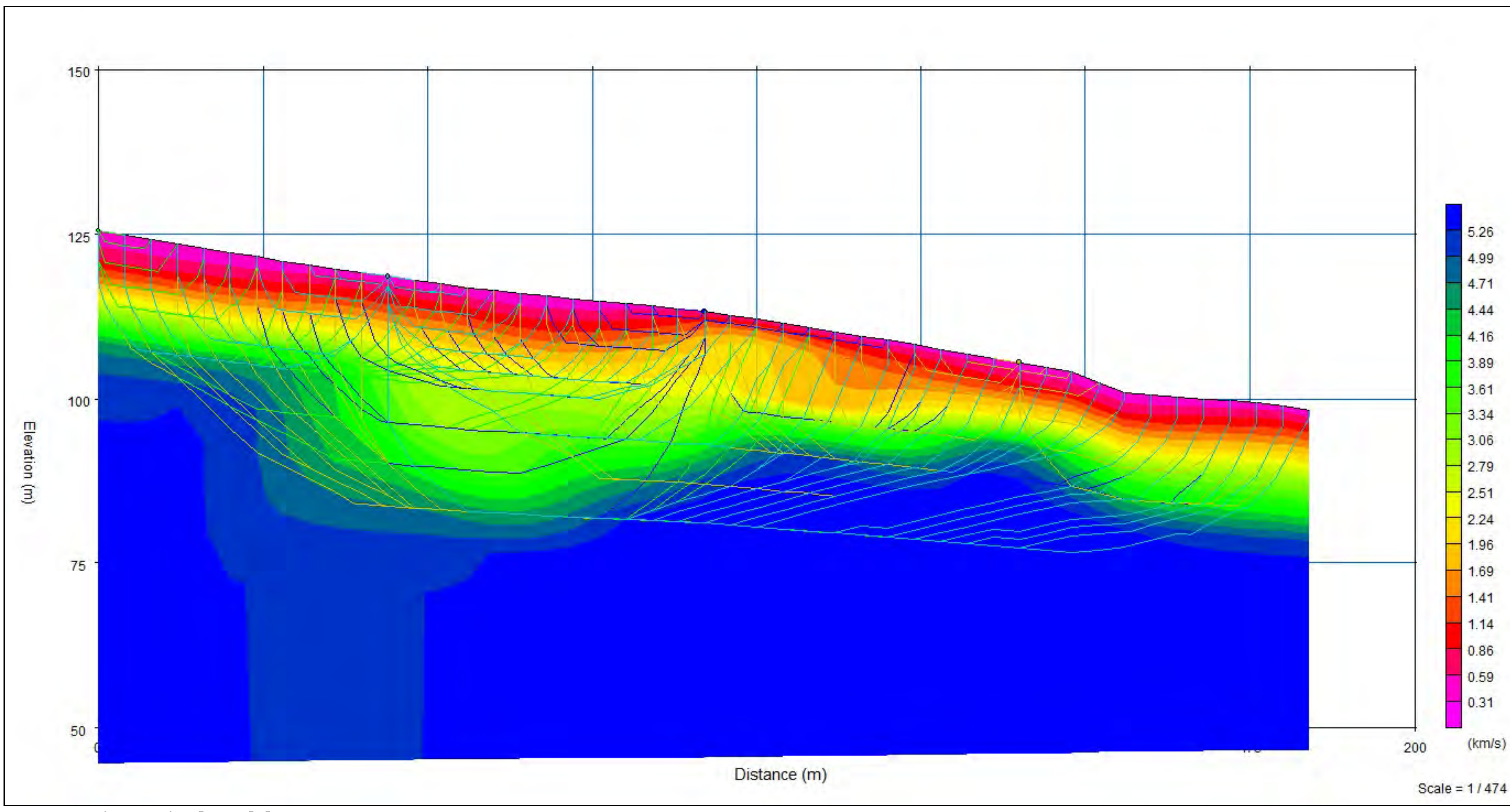
Line Grum Borrow



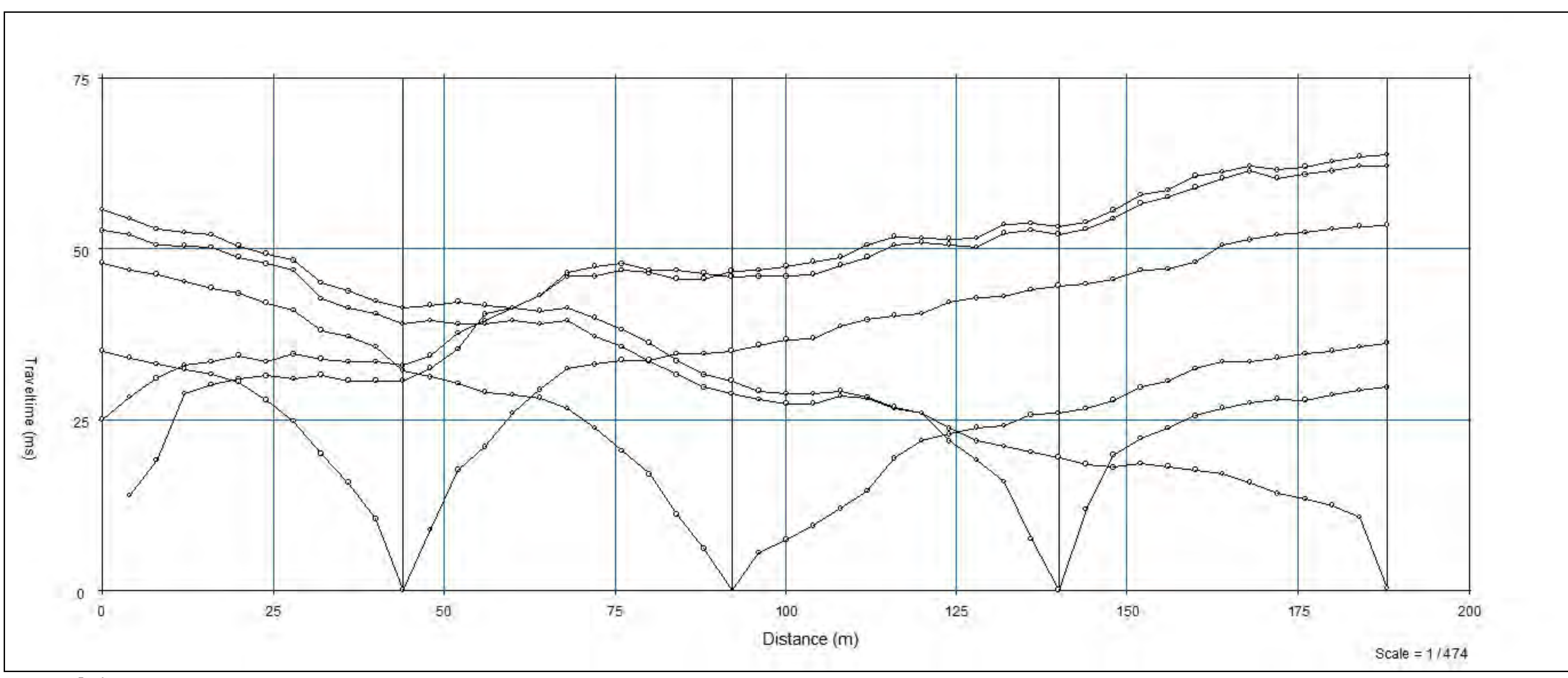
Inversion results - Final model



Final model



Ray tracing - Final model



Travel times

Appendix B
Borehole Logs

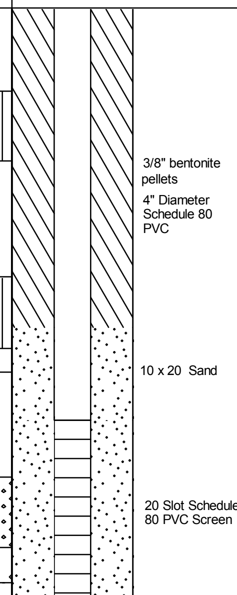
SHEET 1 of 1

PROJECT NUMBER:	BORING NUMBER:
472645	*CH13-303-BH001*

SOIL BORING LOG

PROJECT NAME:	HOLE DEPTH (m):	DRILLING CONTRACTOR:	
Faro Mine Remediation Project	5.79	Geotech Drilling	
TOP OF CASING ELEVATION: 1150.700	**NORTHING:** 6903682.103	**EASTING:** 593630.086	**DATE STARTED:** 7/31/2013 — **DATE COMPLETED:** 8/1/2013
WATER LEVEL: --	**DATUM:** NAD83 CSRS/Field Survey by Challenger Geomatic		**DRILLING EQUIPMENT:** Fraste Mito HWT ODEX; HQ triple tube in Rock
LOCATION: SRK's 2010 Proposed VCD Alignment			**LOGGED BY:** M. Kacmarcik

DEPTH (m bgs)	RECOVERY (%)	TYPE	SPT RESULTS 6"-6"-6"-6" (N)	SIZE DISTRIBUTION %G	%S	%F	Moisture Content	Liquid Limit	Plasticity Index	SOIL DESCRIPTION	Graphic Log	Well Construction/Well Details	COMMENTS (e.g.: DRILLING FLUID LOSS, TESTS, OR DRILLER COMMENTS, ETC.)
										Ground surface is old gravel road.			-- Groundwater level available in equis. at 14:45 begin drilling with ODEX bit.
1			5-5-5-7 (10)							**(FILL) SANDY SILT with GRAVEL (ML)**, dark olive brown, moist, stiff, estimated +/- 30% fine to coarse angular sand, +/- 15% rounded to angular gravel up to 20mm diameter, organics and roots present.			at 14:58 1-SS, suspect larger material in-situ
			7-4-3-1 (7)							No recovery.		3/8" bentonite pellets; 4" Diameter Schedule 80 PVC	at 15:05 2-SS, decreasing density across sample zone
2			1-2-3-6 (5)							**SANDY SILT (ML)**			at 15:16 3-SS, suspect bottom of fill at 2.3m bgs SOb
3			7-7-10-12 (17)							No recovery.		10 x 20 Sand	at 15:23 4-SS
4			10-21-20-27 (41)							**WELL-GRADED SAND WITH SILT AND GRAVEL (SW-SM)**		20 Slot Schedule 80 PVC Screen	SOd at 15:35 5-SS, drill out hole to 4.6m and conduct permeability test
			28-50/5"-(>50)							**WELL-GRADED SAND WITH SILT AND GRAVEL (SW-SM)**			at 16:01 6-MCS, attempt MCS test at 4.6m, becomes wet at 4.7m
5										**SILTY SAND (SM)**, orange-brown to brown, moist becoming wet, very dense, estimated +/- 60% fine to coarse sand, 25% gravel and cobbles, 15% medium plasticity silt, max size observed is +/- 2 inch diameter rounded granite gravel, orange iron oxide staining, switch to rock coring.			SOe Driller notes hard drill and hard black rock chips at 4.9m



CH2MHILL

PROJECT NUMBER:	BORING NUMBER:
437783	CH13-303-BH001 SHEET 2 OF 2

ROCK CORE LOG

PROJECT : Faro Mine Remediation Project — LOCATION : SRK's 2010 Proposed VCD Alignment (6903682.1 N, 593630.1 E)

ELEVATION : 1150.7 ft — DRILLING CONTRACTOR : Geotech Drilling

CORING EQUIPMENT AND METHOD : Fraste Mito HWT ODEX; HQ triple tube in Rock — ORIENTATION : vertical

WATER LEVELS : -- — START : 7/31/2013 — END : 8/1/2013 — LOGGER : M. Kacmarcik

DEPTH AND ELEVATION BELOW SURFACE (m)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES: R Q D (%)	DISCONTINUITIES: FRACTURES PER FOOT	DISCONTINUITIES: DESCRIPTION (DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS)	SYMBOLIC LOG	LITHOLOGY (ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS)	COMMENTS (SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.)
	0 0 100 100					Switch to Rock Coring. See log CH13-303-BH001 for 0-5.79m details. **(BEDROCK) WEATHERED PHYLLITE**, dark gray (N3) with brown staining and pyrite. Rock had metallic lustre. fine grained foliated metamorphic rock. From SPT samples, rock is comprised of paper thin laminations perpendicular to borehole sample. Crumbles easily in the hand and can be worked into a gray paste. (RO) Bottom of Core at 5.79 metres bgs	at 17:53 to 18:06 7-HQ, no recovery, attempt 0.6m follow-up run 8-HQ Take SPT at 8:30 8/1/2013, 58bl/6in, 100% recovery Core from 26.5m to 27.5m, no recovery at 11:23 50/5" (>50), 100% recovery
10 1140.7							
15 1135.7							
20 1130.7							
25 1125.7							
30 1120.7							
35 1115.7							

PROJECT NUMBER: 472645

BORING NUMBER: *CH13-303-BH002*

SOIL BORING LOG

PROJECT NAME:		HOLE DEPTH (m):	DRILLING CONTRACTOR:	
Faro Mine Remediation Project		17.53	Geotech Drilling	
TOP OF CASING ELEVATION: 1133.470	**NORTHING:** 6903591.661	**EASTING:** 593577.668	**DATE STARTED:** 8/2/2013	**DATE COMPLETED:** 8/2/2013
WATER LEVEL: --	**DATUM:** NAD83 CSRS/Field Survey by Challenger Geomatic		**DRILLING EQUIPMENT:** Fraste Mito HWT ODEX; HQ triple tube in Rock	
LOCATION: SRK's 2010 Proposed VCD Alignment			**LOGGED BY:** M. Kacmarcik	

DEPTH (m bgs)	RECOVERY (%)	TYPE	SPT RESULTS 6"-6"-6"-6" (N)	SIZE DISTRIBUTION %G	%S	%F	Moisture Content	Liquid Limit	Plasticity Index
~2.6	35	SS	6-8-5-4 (13)				10		
~3.2	35	SS	2-2-3-3 (5)				9		
~4.1	100	CA	4-4-6-7 (10)	10	42	48	12	22	6
~4.7	100	B		6	52	42	12	22	6
~5.3	100	ST		8	52	40	7	24	8
~5.9	75	SS	1-5-8-9 (13)				13		
~7.1	55	SS	5-8-9-11 (17)	6	51	43	10		
~7.7	60	SS	3-14-10-14 (24)				11	20	5
~9.3	65	SS	6-17-11-12 (28)				11		
~10.8	40	SS	22-50/2" (50/2"")				10		
~11.4	25	SS							

SOIL DESCRIPTION

GRAVEL ROAD BASE (GW-GM)

BOULDER

BOULDER

COBBLES

SILTY GRAVEL (GM), brown with orange iron oxide staining, moist, medium dense, max gravel size is 1 broken to fit inside of sampler. Sand is fine to coarse, sub-angular, estimated 40% plastic silt, 10% well-graded sand, 50% gravel.

CLAYEY SAND (SM-SC), brown, wet, loose, estimated +/- 50% elastic/plastic silt/clay, +/- 50% well-graded sand, trace gravels.

SILTY CLAY SAND (SC-SM), olive brown, wet, soft, estimated +/- 60% fat clay, +/- 40% well-graded sand and gravel.

SILTY CLAY SAND (SC-SM), olive brown, wet, very soft, estimated +/- 40% well-graded sand and fine gravel, +/- 60% fat clay (near LL). PP ~ 0 tsf. No recovery in shelby tube. Overdrive with push CA sampler to retrieve bulk sample. (100% recovery)

SILTY SAND (SM), olive brown, moist, medium dense, estimated +/- 50% sand, +/- 10% subrounded gravel up to 25mm diameter, +/- 40% fat clay.

SILTY SAND (SM), gray, moist, medium dense, estimated +/- 50% well-graded sand, +/- 40% fat clay. Many gravels appear to be phyllite.

SANDY CLAY WITH GRAVEL (CL-CH), dark gray, moist to wet, hard, estimated +/- 50% fat clay, 35% fine to medium sand, 15% fine sub-angular to sub-rounded gravel.

(TILL) CLAYEY SAND WITH GRAVEL (SC), dark gray, moist, medium dense, estimated +/- 50% fine to coarse sand, +/- 30% fat clay, +/- 20% sub-rounded to sub-angular gravel. Max gravel size is +/- 20mm diameter. Clay is high plasticity.

(BEDROCK) WEATHERED PHYLLITE, dark gray, wet, very dense, orange-brown iron oxide staining. Sample appears compromised of paper thin layers and easily disintegrates. Very intense foliation.

Well Construction/Well Details

1" Diameter Schedule 40 PVC

3/8" bentonite pellets

10 x 20 Sand

10 Slot Schedule 40 PVC Screen

COMMENTS (e.g.: DRILLING FLUID LOSS, TESTS, OR DRILLER COMMENTS, ETC.)

-- Groundwater level available in equis.
Ground surface is overgrown gravel road with adjacent VCD flume.
at 10:15 begin ODEX drilling through boulder 0.15m to 1.07m
Notes: HWT Casing, Auto-Trip SPT hammer, NWJ rods

Drill rig mast is +/- 5 degrees off vertical
at 11:31 1-SS, suspect larger particles in loose matrix
SOa
at 11:45 2-SS
SOb

SOc
at 12:18 3-CA, driven with SPT hammer, brass liners, and off-vertical drill string heat exhaustion in drillers helper and small hydraulic fluid leak on support vehicle
SOd
at 12:30 stop for the day
at 13:15 8/3/13 resume
SOe
at 13:25 4-ST, no recovery, very high dry strength
at 13:56 5-ST, much stiffer, bottom 1/3 of tube is dented
SOf
at 14:16 6-SS, very high dry strength
driller notes denser gravelly material below 6.9m
at 14:40 7-SS, much less moisture than above
SOg
at 7.6m bgs, aquifer test in HWT casing, 15 minutes with no measurable head drop
SOh
at 16:26 8-SS
at 16:57 9-SS

at 17:45 10-SS
SOj
at +/- 11.0m bgs, top of bedrock (wx. Phyllite)
at 18:00 done for day (8/3)

at 08:40 8/4/13 resume drilling

CH2MHILL

PROJECT NUMBER: 472645

BORING NUMBER: *CH13-303-BH002*

SOIL BORING LOG

PROJECT NAME: Faro Mine Remediation Project		**HOLE DEPTH (m):** 17.53	**DRILLING CONTRACTOR:** Geotech Drilling
TOP OF CASING ELEVATION: 1133.470	**NORTHING:** 6903591.661	**EASTING:** 593577.668	**DATE STARTED:** 8/2/2013 / **DATE COMPLETED:** 8/2/2013
WATER LEVEL: --	**DATUM:** NAD83 CSRS/Field Survey by Challenger Geomatic		**DRILLING EQUIPMENT:** Fraste Mito HWT ODEX; HQ triple tube in Rock
LOCATION: SRK's 2010 Proposed VCD Alignment			**LOGGED BY:** M. Kacmarcik

DEPTH (m bgs)	RECOVERY (%)	TYPE	SPT RESULTS 6"-6"-6"-6" (N)	SIZE DISTRIBUTION %G	%S	%F	Moisture Content	Liquid Limit	Plasticity Index	SOIL DESCRIPTION	Graphic Log	Well Construction/Well Details	COMMENTS (e.g.: DRILLING FLUID LOSS, TESTS, OR DRILLER COMMENTS, ETC.)
													at 9:10 11-SS, too soft to core slow steady drillings, cuttings are dark grey phyllite chips
13	25	SS											at 9:46 12-SS, much water produced during drilling
14	15	SS											at 10:36 13-SS, phyllite arranged in approximate horizontal sheets, pulverizes easily into grey paste much water produced during drilling
15													
16	0	SS											at 11:27 14-SS cuttings are dark grey, wet, flakes of phyllite, bedrock
17	0	SS											at 17.0m cuttings change to salicaceous fragments at 12:41 15-SS
										Boring Terminated at 17.53 metres bgs			at 17.43m bgs bottom of borehole , construct piezometer

CH2MHILL

PROJECT NUMBER: 472645

BORING NUMBER: *CH13-303-BH003*

SOIL BORING LOG

PROJECT NAME: Faro Mine Remediation Project		**HOLE DEPTH (m):** 33.53	**DRILLING CONTRACTOR:** Geotech Drilling
TOP OF CASING ELEVATION: 1135.110	**NORTHING:** 6903528.005	**EASTING:** 593531.002	**DATE STARTED:** 8/5/2013 — **DATE COMPLETED:** 8/8/2013
WATER LEVEL: --	**DATUM:** NAD83 CSRS/Field Survey by Challenger Geomatic		**DRILLING EQUIPMENT:** Fraste Mito HWT ODEX; HQ triple tube in Rock
LOCATION: SRK's 2010 Proposed VCD Alignment			**LOGGED BY:** M. Kacmarcik

DEPTH (m bgs)	RECOVERY (%)	TYPE	SPT RESULTS 6"-6"-6"-6" (N)	SIZE DISTRIBUTION %G	%S	%F	Moisture Content	Liquid Limit	Plasticity Index	SOIL DESCRIPTION	Graphic Log	Well Construction/Well Details	COMMENTS (e.g.: DRILLING FLUID LOSS, TESTS, OR DRILLER COMMENTS, ETC.)
0										Ground surface is active haul road.			-- Groundwater level available in equis. at 10:24 begin drilling
1	100	SS	34-21-28-32 (49)				5						at 10:34 1-SS
	50	SS	25-32-23-27 (55)				15	16	5			1" Diameter Schedule 40 PVC	at 10:46 2-SS SOa
3	15	SS	5-14-12-13 (26)				18	16	1	**(TILL) SANDY SILT WITH GRAVEL (ML)**, brown, moist, stiff, estimated +/- 50% silt, 30% well-graded sand, 20% sub-angular gravel, suspect larger granula material in-situ.			at 11:01 3-SS, low recovery
							21	16	3				
5	100	SS	9-9-8-9 (17)	7	47	46	10	29	12	**CLAYEY SAND (SC)**, brown, moist, very stiff, estimated +/- 60% medium plasticity brown silt, 30% fine to coarse well-graded sand, 20% sub-angular to rounded fine gravel.			SOb at 11:17 4-SS, very high dry strength
6	70	SS	5-7-8-8 (15)				10			**(TILL) GRAVELLY SANDY SILT (ML-MH)**, similar to above, except olive brown.			at 11:35 5-SS, sample appears very tight and low permeability, very high dry strength SOc
8	25	SS	7-7-7-8 (14)				9	23	8	**(TILL) SANDY SILT WITH GRAVEL (ML-MH)**, olive-brown, moist, stiff, estimated +/- 60% medium plasticity olive-brown silt, 30% fine to coarse well-graded sand, 20% angular to sub-rounded gravel.			at 11:59 6-SS, 1.5" angular gravel lodged in shoe SOd
9	55	SS	5-6-6-7 (12)				9	24	9	**(TILL) GRAVELLY SILT WITH SAND (MH)**, dark gray, moist to wet, stiff, estimated +/- 30% angular to sub-rounded gravel, 60% medium plasticity silt, 20% fine to coarse sand.			at 12:15 7-SS, similar to above, but more moist, more gravel, darker color, may be clayey, plasticity seems to increase with depth SOe
11	30	SS	3-5-6-8 (11)							**(TILL) SANDY SILT/CLAY WITH GRAVEL (CH-MH)**, dark gray, moist to wet, stiff. fines are medium to high plasticity.			at 12:32 8-SS
12													

PROJECT NUMBER: 472645

BORING NUMBER: *CH13-303-BH003*

SOIL BORING LOG

PROJECT NAME: Faro Mine Remediation Project		**HOLE DEPTH (m):** 33.53	**DRILLING CONTRACTOR:** Geotech Drilling
TOP OF CASING ELEVATION: 1135.110	**NORTHING:** 6903528.005	**EASTING:** 593531.002	**DATE STARTED:** 8/5/2013 / **DATE COMPLETED:** 8/8/2013
WATER LEVEL: --	**DATUM:** NAD83 CSRS/Field Survey by Challenger Geomatic		**DRILLING EQUIPMENT:** Fraste Mito HWT ODEX; HQ triple tube in Rock
LOCATION: SRK's 2010 Proposed VCD Alignment			**LOGGED BY:** M. Kacmarcik

DEPTH (m bgs)	RECOVERY (%)	TYPE	SPT RESULTS 6"-6"-6"-6" (N)	SIZE DISTRIBUTION %G	%S	%F	Moisture Content	Liquid Limit	Plasticity Index	SOIL DESCRIPTION	Well Construction/Well Details	COMMENTS (e.g.: DRILLING FLUID LOSS, TESTS, OR DRILLER COMMENTS, ETC.)
13	85	SS	3-5-7-9 (12)	9	38	53	10	24	7	**SANDY SILTY CLAY (CL-ML)**, dark gray, moist to wet, stiff. fines are medium to high plasticity.		at 12:55 9-SS SOf
14 15	45	SS	13-13-9-9 (22)							**(TILL) SANDY CLAY (CL)**, dark gray, moist, very stiff, angular gravel up to inner diameter of sampler observed.	3/8" bentonite pellets	at 13:16 10-SS, drier and stiffer than above driller notes brown fibrous peat cuttings, dry
16	100	SS	9-10-10-13 (20)	8	70	22	8			**SILTY SAND (SM)**, dark olive brown, moist, medium dense, estimated +/- 60% well-graded sand, +/- 20% silt, 20% sub-angular gravel.		at 13:43 11-SS SOg Alluvial Zone 14.9m bgs to 18.3m bgs
17 18	94	SS	6-8-7-12 (15)							**(ALLUVIUM) SANDY SILT / SILTY SAND (ML-SM)**, brown, moist to wet, stiff, medium dense, estimated +/- 50% sand, +/- 50% silt, small rounded gravels present. Reddish brown ferrous nodules.		at 14:18 12-SS, siltier than above, appear very tight, material in shoe is silty sand (+/- 70% sand), wet SOh
19	85	SS	4-7-21-14 (28)	9	49	42	9	22	6	**SILTY CLAYEY SAND (SC-SM)**, brown, moist to wet, very stiff, estimated +/- 60% fat clay, +/- 30% fine to coarse sand, +/- 10% sub-angular to sub-rounded fine gravel.		at 15:00 13-SS SOi
20 21	60	SS	7-11-14-19 (25)							**(TILL) SANDY CLAY (CH)**, olive-gray, moist to wet, very stiff.		at 15:32 14-SS, very high dry strength
22	55	SS	4-8-14-19 (22)				11			**(TILL) SANDY CLAY (CH)**, olive-gray, moist to wet, very stiff.		at 16:04 15-SS SOj at 16:30 done for the day 8/5/13, resume at 08:00 8/6/13
23 24	75	SS	14-13-16-25 (29)					22	7	**(TILL) SANDY CLAY WITH GRAVEL (CH)**, dark gray, wet, very stiff. finer than soils above, top 50% of sample softer than bottom. 50% sands fine to coarse, sub-rounded to sub-angular.		at 09:23 16-SS, drill cuttings are dark grey, sandy, fat clay---fewer, gravels and finer sand than above SOk

PROJECT NUMBER: 472645

BORING NUMBER: *CH13-303-BH003*

SOIL BORING LOG

PROJECT NAME: Faro Mine Remediation Project		HOLE DEPTH (m): 33.53	DRILLING CONTRACTOR: Geotech Drilling	
TOP OF CASING ELEVATION: 1135.110	NORTHING: 6903528.005	EASTING: 593531.002	DATE STARTED: 8/5/2013	DATE COMPLETED: 8/8/2013
WATER LEVEL: --	DATUM: NAD83 CSRS/Field Survey by Challenger Geomatic		DRILLING EQUIPMENT: Fraste Mito HWT ODEX; HQ triple tube in Rock	
LOCATION: SRK's 2010 Proposed VCD Alignment			LOGGED BY: M. Kacmarcik	

DEPTH (m bgs)	RECOVERY (%)	TYPE	SPT RESULTS 6"-6"-6" (N)	SIZE DISTRIBUTION %G	%S	%F	Moisture Content	Liquid Limit	Plasticity Index	SOIL DESCRIPTION	Well Construction/Well Details	COMMENTS (e.g.: DRILLING FLUID LOSS, TESTS, OR DRILLER COMMENTS, ETC.)
	55	SS	10-17-22-18 (39)				10					at 10:02 17-SS (gravel only), SPT anvil breaks, large gravel in shoe SOl
25										**(TILL) CLAYEY GRAVEL (GC)**, dark gray, wet, dense, estimated +/- 50% sub-angular gravel, 20% fines, 30% fine to coarse sand.		estimated top of gravel driller notes gravelly cuttings and fluid (water) return
26	70	SS	17-35-47 (82)				9	20	5	**(TILL) SANDY SILT WITH GRAVEL (ML)**, olive gray, moist, hard, lower plasticity than till above. Trace gravels up to inner diameter of sampler. Estimated 60% fines.		at 11:01 18-SS, sand is fine to coarse, sub-rounded to sub-angular SOm
27	62	SS	28-50 (50")									at 12:55 19-SS, most gravels black or white, some iron oxide staining observed, very high, dry strength
28				4	21	75				**LEAN CLAY WITH SAND (CL)**, dark gray, moist, hard, estimated +/-20% very fine sand, +/- 15% coarse sub-angular to sub-rounded sand and fine gravel.		
29	96	SS	23-38-45 (83)				12	29	12			at 14:06 20-SS SOn
30										**SILT WITH SAND AND GRAVEL (ML)**, dark gray, moist, hard, estimated +/-10% very find sand, 20% coarse sand and fine gravel.	10 x 20 Sand	
31	0	SS								**NO RECOVERY**	10 Slot Schedule 40 PVC Screen	driller notes hard strata impenetrable by ODEX, stop drilling for day, clean out hole for SPT/Core tomorrow, resume drilling at 09:30 8/7/13 cutting are gravelly clayey sand, gravels have variable geology (not bedrock)
32	30	SS										at 16:00 22-SS (time is approximate)
33										**CLAYEY GRAVEL WITH SAND (GC)**, dark gray, wet, hard, very dense, estimated +/- 50% fine to coarse gravels, 20% fine to coarse sand, 30% hard gray clay. Sand is yellow. Gravels appear angular to rounded. Phyllite pieces observed in samples.		Note: SPT for 22-SS and 23-SS do not follow ASTM. Dense material and rig problems. Pound sampler to obtain sample.
	30	SS								*Boring Terminated at 33.53 metres bgs*		at 17:00 23-SS (time is approximate) at 33.5m bgs bottom of hole. Install piezometer (1" diameter) with flush mount surface monument. See well completion diagram.

PROJECT NUMBER: 472645

BORING NUMBER: *CH13-311-BH016*

SOIL BORING LOG

PROJECT NAME: Faro Mine Remediation Project		**HOLE DEPTH (m):** 19.80	**DRILLING CONTRACTOR:** Midnight Sun	
TOP OF CASING ELEVATION: 1205.030	**NORTHING:** 6906774.557	**EASTING:** 590160.595	**DATE STARTED:** 8/9/2013	**DATE COMPLETED:** 8/9/2013
WATER LEVEL: --	**DATUM:** NAD83 CSRS/Field Survey by Challenger Geomatic		**DRILLING EQUIPMENT:** Multipower Reverse circulation; ODEX / NQ Triple Multipower Reverse	
LOCATION: Granitic Rock Outcrop			**LOGGED BY:** J. Baak	

DEPTH (m bgs)	RECOVERY (%)	SAMPLE TYPE	SPT RESULTS 6"-6"-6"-6" (N)	SIZE DISTRIBUTION %G	%S	%F	Moisture Content	Liquid Limit	Plasticity Index	SOIL DESCRIPTION	Graphic Log	COMMENTS (e.g.: DRILLING FLUID LOSS, TESTS, OR DRILLER COMMENTS, ETC.)
0										Overburden.		start at 08:39 through overburden -- Depth to groundwater not measured or not encountered
1												
2												
3										Core rock and cobble/boulder. Primarily granite. Bedrock interface at 4.6m bgs.		
							1			Begin Rock Coring at 3.4 ft bgs See the next sheet for the rock core log		RKa
4												
5												
6												
7												
8												
9												
10												
11												
12												

PROJECT NUMBER: 437783	BORING NUMBER: CH13-311-BH016 SHEET 2 OF 2

ROCK CORE LOG

PROJECT : Faro Mine Remediation Project — LOCATION : Granitic Rock Outcrop (6906774.6 N, 590160.6 E)

ELEVATION : 1205.0 ft — DRILLING CONTRACTOR : Midnight Sun

CORING EQUIPMENT AND METHOD : Foremost reverse-circulation ODEX/NQ triple-tube coring rig — ORIENTATION : vertical

WATER LEVELS : -- — START : 8/9/2013 — END : 8/9/2013 — LOGGER : J. Baak

DEPTH AND ELEVATION BELOW SURFACE (m)	CORE RUN, LENGTH, AND RECOVERY (%)	DISCONTINUITIES: R Q D (%)	DISCONTINUITIES: FRACTURES PER FOOT	DISCONTINUITIES: DESCRIPTION — DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS	SYMBOLIC LOG	LITHOLOGY: ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS	COMMENTS: SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.
		48	>10, >10	0 - 3 joint, rough planar fracture zone, multiple fractures 60°, some mechanical breaks, moderate staining, very close joints.		**GRANITE**, greenish gray (5GY 6/1), medium grained, poor quality (R4).	-- Groundwater not measured or not encountered.
5 / 1200.0		11	4	Same as above, fracture zone low RQD, brown staining.		Same as above. Fractured granite, greenish gray (5GY 6/1), (R4).	at 09:24 begin coring
		35	>10, >10, >10	Same as above, heavily fractured, weathered.		Same as above. Poor quality.	at 09:24 begin coring 3.4m to 3.6m removed for testing
		11	>10, >10	Same as above, highly fractured, brown staining throughout, trace clay, some mechanical breakage, round undulating.		Same as above. Granite, greenish gray (5GY 6/1), weathered slightly fine grained, poor quality hardness (R4).	at 09:51 1-NQ at 09:51 1-NQ
		45	>10, >10, >10, >10, >10, >10, >10, >10	7.6 to 8.1m - fracture zone. Multiple fractures, rough planar , brown staining indicating slight weathering. 8.2m - mech fracture range planar 45°. 8.6 - same mech fracture. 8.4m - mech fracture rough stopped. 8.78 - fracture zone poor quality.		Change in color from above to 5YR 6/1 with increased quartz content in filling.	at 10:36 2-NQ, poor quality at 10:45 3-NQ, poor quality some light brown-grey mottling 5YR(6/1) some light brown-grey mottling 5YR(6/1)
10 / 1195.0		0	>10, 3, 6	Same as 7.6 to 9.1m bgs. Poor recovery, multiple fractures. 0% RQD. Fracture zone.		No recovery.	RKb
		0	2, >10	Heavily fractured run, rough planar and undulating fractures, no infilling identified, some mechanized fracturing, very close joints.		Core mineral type granite, fine grained, slightly weathered, greenish gray (5GY 6/1), poor quality, R2 to R3 hardness.	7.9m to 8.1m removed for testing 7.9m to 8.1m removed for testing
		0	>10, >10, >10, >10	Same as 12.2 to 13.7m bgs, heavily fractured both natural and mechanical, rough planar, some rough undulating, no infilling, brown staining.		**GRANITE**, greenish gray (5GY 6/1), fine grained, moderate weathering, very poor quality.	
15 / 1190.0		62	>10, >10, >10	Better core recovery, 45°, rough planar, no infilling, mechanical fracture. At 15.3m bgs: fracture zone, multiple fractures, natural and mechanical, brown staining. At 16.37m: 30°, rough planar, mechanical fracture. At 15.58m: fracture zone mechanical		**GRANITE**, greenish gray (5GY 6/1), fine grained, moderate weathering, very poor quality, hardness (R2).	at 12:55 and 15.2m switch to coring with sleeve to see if it improves recovery
		45	>10, >10, >10, 1			**GRANITE**, color change to medium gray (N5), slightly weathered, firm. From 51.6 to 52m bgs: rest of core is trash. At 16.5m bgs: return color to greenish gray (5GY 6/1).	Driller begins using brass plug to extrude core. Improved core quality for logging
		38	>10, 7, 1	Heavily fractured planar, rough to undulating to stepped rough, infilled with quartz, brown staining, poor quality.		**GRANITE**, greenish gray (5GY 6/1), fresh, hardness R4. At 17.19: medium light gray (N6). At 17.5m: very light gray (N8). At 17.68m: moderate weathering.	Better recovery to 19.8m Better recovery to 19.8m
20 / 1185.0			6, 7, >10, 4, >10, >10, 0, 3, 4, 2, 3	Mechanized fracture, 80°, rough planar. At 18.71m: fracture zone, rough planar, brown staining, some mechanized breakage. At 19.29m: fracture, 10°, rough planar, laminated, brown staining.		**GRANITE**, light gray (N7), fine grained, fresh. At 18.84m: moderate weathering. At 19.48m: fresh, hardness R3, poor quality. Bottom of Core at 19.8 metres bgs	RKc 19.5m to 19.8m removed for testing 19.5m to 19.8m removed for testing at 19.8m core completed, tremmie grout to surface, marked and labeled in field
25 / 1180.0							
30 / 1175.0							

PROJECT NUMBER: 472645

BORING NUMBER: *CH13-311-BH017*

SOIL BORING LOG

PROJECT NAME: Faro Mine Remediation Project		**HOLE DEPTH (m):** 15.85	**DRILLING CONTRACTOR:** Midnight Sun
TOP OF CASING ELEVATION: 1257.640	**NORTHING:** 6907114.638	**EASTING:** 590417.934	**DATE STARTED:** 8/7/2013 — **DATE COMPLETED:** 8/8/2013
WATER LEVEL: --	**DATUM:** NAD83 CSRS/Field Survey by Challenger Geomatic		**DRILLING EQUIPMENT:** Multipower Reverse circulation; ODEX / NQ Triple Tube Coring
LOCATION: Granitic Rock Outcrop			**LOGGED BY:** M. Kacmarcik

DEPTH (m bgs)	RECOVERY (%)	SAMPLE TYPE	SPT RESULTS 6"-6"-6"-6" (N)	SIZE DISTRIBUTION %G	%S	%F	Moisture Content	Liquid Limit	Plasticity Index	SOIL DESCRIPTION	Graphic Log	COMMENTS (e.g.: DRILLING FLUID LOSS, TESTS, OR DRILLER COMMENTS, ETC.)
										Overburden.		8/7/13 begin advancing NW casing, approximately 3.7m north of haul road
	100	1-NQ								**GRANITE**, Dark grey (N3), coarse grained, fresh to slightly weathered, joints medium to closely spaced, very strong (R5).		-- Depth to groundwater not measured or not encountered
1										Begin Rock Coring at 0.7 ft bgs See the next sheet for the rock core log		
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												

CH2MHILL

PROJECT NUMBER:	BORING NUMBER:
437783	**CH13-311-BH017** SHEET 2 OF 2

ROCK CORE LOG

PROJECT : Faro Mine Remediation Project — LOCATION : Granitic Rock Outcrop (6907114.6 N, 590417.9 E)

ELEVATION : 1257.6 ft — DRILLING CONTRACTOR : Midnight Sun

CORING EQUIPMENT AND METHOD : Reverse-circulation ODEX/NQ triple-tube coring rig — ORIENTATION : vertical

WATER LEVELS : -- — START : 8/7/2013 — END : 8/8/2013 — LOGGER : M. Kacmarcik

Column headings: DEPTH AND ELEVATION BELOW SURFACE (m) | CORE RUN, LENGTH, AND RECOVERY (%) | DISCONTINUITIES: R Q D (%); FRACTURES PER FOOT; DESCRIPTION — DEPTH, TYPE, ORIENTATION, ROUGHNESS, PLANARITY, INFILLING MATERIAL AND THICKNESS, SURFACE STAINING, AND TIGHTNESS | SYMBOLIC LOG | LITHOLOGY — ROCK TYPE, COLOR, MINERALOGY, TEXTURE, WEATHERING, HARDNESS, AND ROCK MASS CHARACTERISTICS | COMMENTS — SIZE AND DEPTH OF CASING, FLUID LOSS, CORING RATE AND SMOOTHNESS, CAVING ROD DROPS, TEST RESULTS, ETC.

Depth / Elevation: 5 / 1252.6; 10 / 1247.6; 15 / 1242.6; 20 / 1237.6; 25 / 1232.6; 30 / 1227.6

Core Run Recovery (%)	RQD (%)
97	40
93	40
100	100
99	100
100	67
100	92
100	90
99	88
100	85
99	100
100	48
100	91

Fractures per foot: 0, 3, 0, 3, >10, 3, 2, 1, 1, 1, 1, 1, 0, 0, 0, 2, 1, 0, 2, 0, 1, 0, 1, 0, 0, 1, 0, 1, 0, 0, 2, 0, 2, 2, 5, 1, 1, 1, 0, 1, 0, 0, 0, 2, >10, >10, 7, >10, >10, 5

Discontinuities – Description:

Machine break, 0°
Joint, 60°, rough, undulating to planar, light brown surface stain, open
Joint, 55°, rough, planar, light brown surface stain, open
Joint, 15°, rough, undulating, light brown stain, open
Fracture, 0°, rough, stepped, open
Joint, 45°, rough, undulating, brown stain, open
Joint, 60°, rough, planar to stepped, open
Joint, 60°, rough, planar, brown stain, open (parallel)
Joint, 60°, rough, planar, brown stain, open (parallel)
2.0m-2.2m, Fracture zone
Joint, 45°, planar to stepped, brown stain, open
Joint, 10°, rough, stepped, brown stain, open
2.3m-2.5m, near vertical joint, 90°, rough, planar, brown stain and white mineral scale, open
Joint, 10°, rough, stepped, color change
Fresh, machine break, 5°
1.5m continuous core
Machine break, 60°, rough, planar, brown stain
Machine break, 0°, rough, planar
Machine break, 40°, rough, planar
Machine break, 0°, rough, planar
Joint, 60°, rough, planar, brown stain
Joint, 60°, rough, planar, brown stain
Machine Break, 60°, rough, planar, brown stain
Machine Break, 60°, rough, planar, brown stain
Joint, 90°, rough, planar
Joint, 60°, rough, planar
Mechanical Break, 30°, rough, planar
Mechanical Break, 0°, rough, planar
Joint, 60°, rough, planar
Mechanical Break, 0°, rough, planar
Joint, 0°, rough, stepped
Joint, 45°, rough, planar
Mechanical Break, 0°, rough, planar
Fracture zone, 70°, brown stain, infilling
Mechanical fracture, rough, stepped
Mechanical Break, 0°, rough, planar
Fracture, 85°, brown stain
Fracture zone, brown stain, rough, planar
Mechanical fracture, rough, stepped
Mechanical Fracture, 10°, rough, planar
Mechanical Fracture, 45°, rough, planar
Fracture, 85°, infilled, intact, laminated, no staining
Fracture zone, including mechanical breakage, brown stain from 14m to 14.3m and at 14.7m
Fracture zone, mechanical breakage, multiple angular
Fracture zone, including mechanical breakage, brown stain from 15.6m to 15.8m

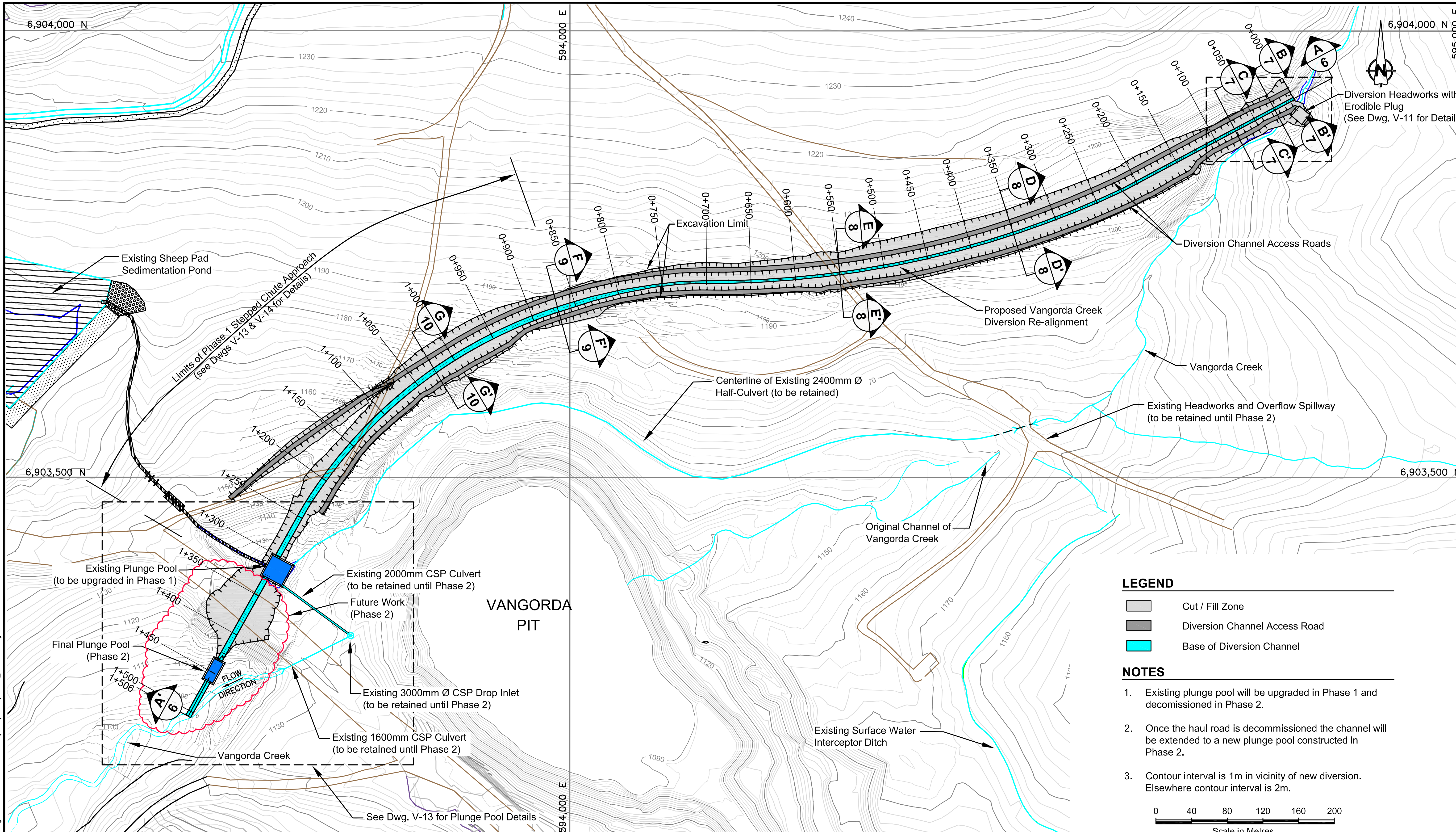
Lithology:

At 1.8m gradual color change to medium dark grey (N4).
At 2.6m abrupt color change to dark grey (N3), extremely strong (R6).
GRANITE, Dark grey (N3), extremely strong, very hard (R5), excellent quality.
GRANITE, Dark grey (N3), very hard (R5), excellent quality.
GRANITE, Dark grey (N3), very hard (R5), fair quality.
Dark grey (N3), very hard (R5), excellent quality.
GRANITE, Dark grey (N3), very hard (R5), good quality.
at 10.2m to 10.3m slightly weathered
GRANITE, Dark grey (N3), very hard (R5), good quality.
at 10.9m to 11.2m slightly weathered.
GRANITE, Dark grey (N3), very hard (R5), excellent quality, no weathering.
GRANITE, Dark grey (N3), very hard (R5), poor quality.
at 14.0m to 14.7m slight weathering, remaining core fresh.
GRANITE, Dark grey (N3), very hard (R5).
at 15.6m and 15.8m weathered.
Bottom of Core at 15.85 metres bgs

Comments:

-- Groundwater not measured or not encountered.
at 16:30 to 16:48 1-NQ
at 16:30 to 16:48 1-NQ
at 17:10 to 17:17 2-NQ
at 1.95m to 2.25m bgs sample removed for testing RKa
at 1.95m to 2.25m bgs sample removed for testing RKa
driller experimenting with different bits
driller experimenting with different bits
at 17:?? To 18:07 3-NQ
driller note extremely hard drilling below 2.6m
driller note extremely hard drilling below 2.6m
at 19:00 and 3.048m done for day (8/7/13)
at 8:40 to 9:45 4-NQ, extremely tough drilling
at 9:45 to 10:35 5-NQ, tough drilling
RKb
at 8.7m to 8.8m sample removed for testing
RKc
at 15.2m to 15.5m sample removed for testing RKC
completion - Tremmie grout to surface, marked location in field
completion - Tremmie grout to surface, marked location in field

Appendix C
Photograph Log



LEGEND

- Cut / Fill Zone
- Diversion Channel Access Road
- Base of Diversion Channel

NOTES

1. Existing plunge pool will be upgraded in Phase 1 and decomissioned in Phase 2.
2. Once the haul road is decommissioned the channel will be extended to a new plunge pool constructed in Phase 2.
3. Contour interval is 1m in vicinity of new diversion. Elsewhere contour interval is 2m.

0 40 80 120 160 200
Scale in Metres

SRK Consulting
Engineers and Scientists
Vancouver B.C.

Faro Mine Closure
Fermeture de la mine Faro

SRK JOB NO.: 1CY001.031
FILE NAME: 1CY001_031-3-D.dwg

FARO MINE COMPLEX
FINAL CLOSURE AND REMEDIATION PLAN

Vangorda Diversion Channel

General Arrangement

DATE:	APPROVED:	FIGURE:
Feb. 2010	PMH	4

J:\01_SITES\FARO\1.165_1CY001.031_Vangorda Creek Diversion Channel\Acad\Rev D\1CY001_031-3-D.dwg

Photograph 1: *Looking at VCD Plunge Pool – 09-10-2013*

Photograph 2: *Looking at the Plunge Pool from half-round 2,400 diameter CSP Culvert – 09-10-2013*

Photograph 3: *Looking at the Plunge Pool from half-round 2,400 diameter CSP Culvert – 09-10-2013*

Photograph 4: *Looking at the unprotected banks on one side of the Plunge Pool – 09-11-2013*

	
Photograph 5: *Looking at the downstream of half-round 2,400 diameter CSP Culvert – 09-10-2013*	***Photograph 6:*** *Close by at the downstream of half-round 2,400 diameter CSP Culvert – 09-10-2013*
	
Photograph 7: *Looking at half-round 2,400 diameter CSP Culvert discharging to plunge pool – 09-10-2013*	***Photograph 8:*** *Looking half-round 2,400 diameter CSP Culvert discharging to plunge pool at the culvert end – 09-10-2013*

	
Photograph 9: *Looking at the half-round 2,400 diameter CSP Culvert – 09-10-2013*	***Photograph 10:*** *Looking at half-round 2,400 diameter CSP Culvert, showing instability and failure at some locations – 09-10-2013*
	
Photograph 11: *Looking at large sized rock placed at the Plunge Pool, at station 1+1300 – 09-10-2013*	***Photograph 12:*** *Looking at large sized rock at Plunge Pool estimated at 1.5 m diameter, at station 1+1300 – 09-10-2013*

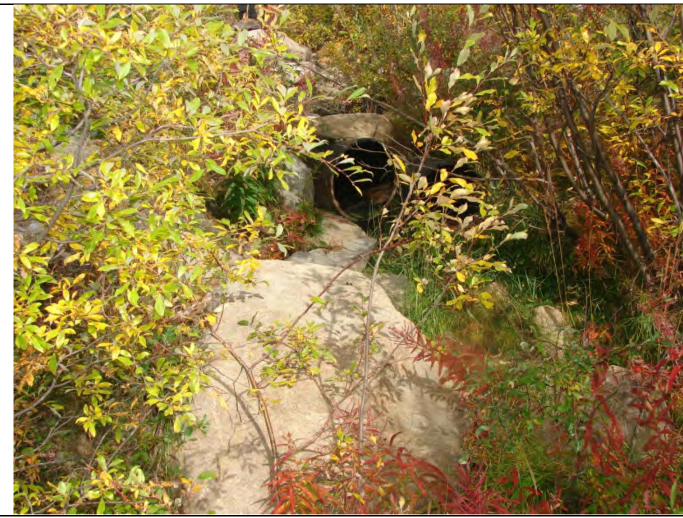
Photograph 13: *Looking at the Plunge Pool on a 1,800 mm diameter CSP Culvert inlet, at station 1+1300 – 09-10-2013*

Photograph 14: *Looking south at the Plunge Pool on a 1,800 mm diameter CSP Culvert inlet, at station 1+1300 – 09-10-2013*

Photograph 15: *Looking at the existing channel west of SRK proposed alignment, between station 1+050 and 1+1200 (1) – 09-10-2013*

Photograph 16: *Looking at the existing channel west of SRK proposed alignment, between station 1+050 and 1+1200, there is a presence of large rocks (2) – 09-10-2013*

Photograph 17: *Looking at the existing channel west of SRK proposed alignment, between station 1+050 and 1+1200 (3) – 09-10-2013*



Photograph 18: *Looking at the culvert outlet on existing channel west of SRK proposed alignment, between station 1+000 and 1+1050 (4) – 09-10-2013*

Photograph 19: *Looking at the existing channel west of SRK proposed alignment, downstream of the culvert, between station 1+000 and 1+1050 (5) – 09-10-2013*

Photograph 20: *Looking at the existing channel west of SRK proposed alignment, downstream of the culvert, between station 1+000 and 1+1050 (6) – 09-10-2013*

Photograph 21: *Looking at the existing channel south of SRK proposed alignment, between station 0+900 and 1+000 – 09-10-2013*

Photograph 22: *Looking at the existing channel south of SRK proposed alignment, close to Geophysical Survey station marker CH13-303-GX001 – 09-10-2013*

Photograph 23: *Looking at the existing access road south of SRK proposed alignment, between station 0+800 and 0+900 – 09-10-2013*

Photograph 24: *Looking at the existing channel south of SRK proposed alignment, between station 0+600 and 0+800 (1) – 09-10-2013*

Photograph 25: *Looking at the existing channel south of SRK proposed alignment, between station 0+600 and 0+800 (2) – 09-10-2013*

Photograph 26: *Looking at the Rock outcrop on existing Vangorda Creek at the proposed SRK head pond works on station 0+000 (1) – 09-10-2013*

Photograph 27: *Looking at the Rock outcrop on existing Vangorda Creek at the proposed SRK head pond works on station 0+000 (2) – 09-10-2013*

Photograph 28: *Looking at the Rock outcrop on existing Vangorda Creek at the proposed SRK head pond works on station 0+000 (3) – 09-10-2013*

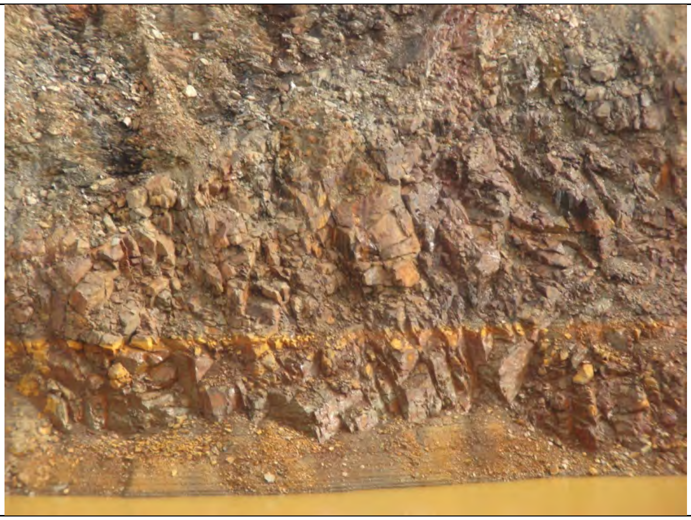
	
Photograph 29: *Looking at the existing channel south of SRK proposed alignment, between station 0+600 and 0+800 (4) – 09-10-2013*	***Photograph 30:*** *Looking at the Rock outcrop on existing Vangorda Creek at the proposed SRK head pond works on station 0+000 (5) – 09-10-2013*
	
Photograph 31: *Looking at the existing 1,500 mm culvert inlet on Vangorda Creek north of access road (1) – 09-10-2013*	***Photograph 32:*** *Looking at the existing 1,500 mm culvert inlet on Vangorda Creek north of access road (2) – 09-10-2013*

Photograph 33: *Looking at the existing 1,500 mm CSP culvert inlet on Vangorda Creek north of access road, large rock riprap (3) – 09-10-2013*

Photograph 34: *Looking downstream of existing 1,500 mm CSP culvert and upstream of half-round 2,400 diameter CSP Culvert on existing VCD – 09-10-2013*

Photograph 35: *Looking at Vangorda Pit side walls, showing rock raveling and slumping failures (1) – 09-10-2013*

Photograph 36: *Looking at Vangorda Pit side walls, showing rock raveling and slumping failures (2) – 09-10-2013*



Photograph 37: *Looking at Vangorda Pit side walls, showing rock raveling and slumping failures (3) – 09-10-2013*

Photograph 38: *Looking at Vangorda Pit side walls, showing rock raveling and slumping failures (4) – 09-10-2013*

Photograph 39: *Looking at Vangorda Pit side walls, showing rock raveling and slumping failures (5) – 09-10-2013*

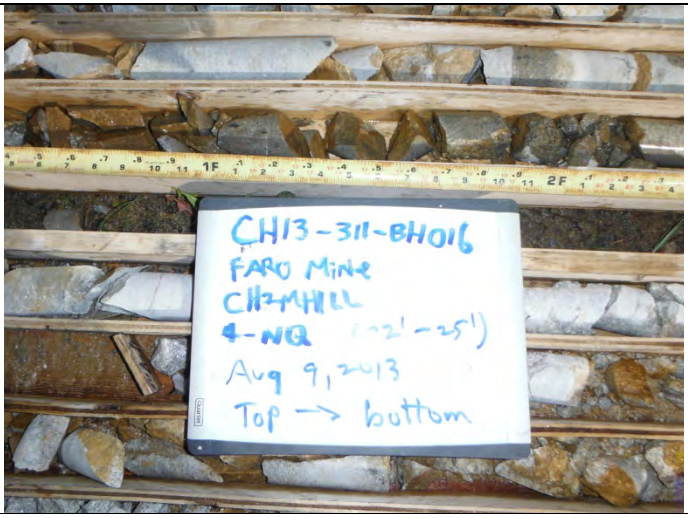
Photograph 40: *Looking at Vangorda Pit side walls, showing rock raveling and slumping failures (6) – 09-10-2013*

Photograph 41: *Showing the set up for borehole CH13-303-BH001*

Photograph 42: *A rock sample from borehole CH13-303-BH001*

Photograph 43: *A rock sample from borehole CH13-303-BH001*

Photograph 44: *A rock sample from borehole CH13-303-BH002*

	
Photograph 45: *Rock core from run 1 of CH13-311-BH016*	***Photograph 46:*** *Rock core from run 2 of CH13-311-BH016*
	
Photograph 47: *Rock core from run 3 of CH13-311-BH016*	***Photograph 48:*** *Rock core from run 4 of CH13-311-BH016*

Photograph 49: *Rock core from run 6 of CH13-311-BH016*

Photograph 50: *Rock core from run 6 of CH13-311-BH016*

Photograph 51: *Rock core from run 7 of CH13-311-BH016*

Photograph 52: *Rock core from run 7 of CH13-311-BH016*

Photograph 53: *Rock core from run 11 of CH13-311-BH016*

Photograph 54: *Rock core from run 1 of CH13-311-BH017*

Photograph 55: *Rock core from run 2 of CH13-311-BH017*

Photograph 56: *Rock outcrop in Granitic Rock Outcrop, sample CH13-311-SS016*

	
Photograph 57: *Rock sample CH13-311-SS012 from the Granitic Rock Outcrop*	***Photograph 58:*** *Rock sample CH13-311-SS013 from the Granitic Rock Outcrop*
	
Photograph 59: *Rock sample CH13-311-SS015 from the Granitic Rock Outcrop*	***Photograph 60:*** *Rock samples from the active Grum Waste Rock Dump Quarry, CH13-311-SS001.*

Photograph 61: *Rock sample CH13-311-SS021 from the Grum Waste Rock Dump Quarry*

Photograph 62: *Rock sample CH13-311-SS021 from the Grum Waste Rock Dump Quarry*

Photograph 63: *Location CH13-311-SS021, Grum Waste Rock Dump Quarry*

Photograph 64: *Location CH13-311-SS022,the Grum Waste Rock Dump Quarry*

Photograph 65: *Location CH13-311-SS022, Grum Waste Rock Dump Quarry*

Photograph 66: *A sample from location CH13-311-SS022, Grum Waste Rock Dump Quarry*

Photograph 67: *A sample from location CH13-311-SS026, Grum Waste Rock Dump Quarry*

Photograph 68: *Location CH13-311-SS026, Grum Waste Rock Dump Quarry*

	
***Photograph 69:** The Grum Waste Rock Dump Quarry, sledge hammer for perspective*	***Photograph 70:** Rock Sample from the Grum Waste Rock Dump Quarry*

Appendix D
Meteorological Station Inspection Reports

Faro Mine Weather Station Evaluation Trip by Campbell Scientific

Eric Courtin, Applications Technician

Overview:

The Faro and Grum weather stations were evaluated during a maintenance visit on July 17th and 18th, 2013. Our records show the equipment was purchased in May 2003 by the Yukon Department of the Environment. The serial numbers of the equipment were checked against our repair records, and the equipment has never come to our facility for calibration. It therefore likely that it has never been calibrated, and likely that the equipment was installed shortly after purchase, meaning the equipment has been running for 10 years with no maintenance. The goal of the visit was to establish the current state of the weather station operation, in order to give assurance on data quality going forward and on what has already been collected.

Equipment installed:

The equipment installed is as follows:

<u>CR10X-2M-55 datalogger</u>
Faro serial # 25744
Grum serial # 25745

<u>HMP45CF air temperature and relative humidity</u>
Faro serial # C1287
Grum serial # C1288

<u>CS616 water content reflectometer</u>
(not serialized)
Identifying information for both:
*298057
Job 10417850
Order 134160

<u>CM3 (x2) solar radiation sensors in albedometer configuration</u>
Faro serial # (upper, lower) 036670, 036671

- Sensitivity 17.52x10-6 V/Wm^2, 22.73x10-6 V/Wm^2

Grum serial # (upper, lower) 036672, 036673

- Sensitivity 21.84x10-6 V/Wm^2, 19.98x10-6 V/Wm^2

05103 wind speed and direction sensor
Faro serial # 58388
Grum serial # 58387

NR Lite net radiation sensor
Faro serial # 031401
Grum serial # 031402

107B soil temperature probes
Faro serial # C5653, C5654, C5655
Grum serial # C5656, C5657, C5658

T200B precipitation weighing gauge
Faro serial # 38007
Grum serial # 38107

HFT3 soil heat flux plate
Faro serial # H033252
Grum serial # H033253

SR50-45 snow depth sensor
Faro serial # C3507
Grum serial # C3806

TE525WS tipping-bucket rain gauge
Faro serial # 33575-903
Grum serial # 33571-903

Calibration and field work summary:

The 05103 wind speed and direction sensors were removed from the station first, and a performance test was done. The speeds were tested with an anemometer drive that rotates the propeller shaft at a precise speed. All speed readings for both sensors were exact from 200 to 10000 rpm (precision is 10 rpm) with no exceptions. The accuracy spec is +/- 0.3 m/s or 1% of the reading. The direction was tested by using a bench stand which allows the sensor to be rotated and the angle read. The direction readings were for the most part within around 0.5 degrees, and at the most were off by around 2 degrees. The direction spec is +/- 3 degrees. After this performance test was done, the 05103s were set aside.

The HMP45CF temperature and relative humidity sensors were performance tested in the field, as I found upon arrival that the stations had QDP connections. This means that there are connectors built into the bottom of the enclosure. An essential part of the HMP45CF is in a circuit board which is between the datalogger and the enclosure; therefore it was not possible to test the HMP45CF in the lab without that part. Testing equipment was therefore setup on a small platform on a ladder next to the station.

First, some qualitative testing was done, exposing the sensors to ambient environmental conditions. The HMP45CFs were in turn each connected to the Faro site datalogger, and compared to the HMP45C reference sensor connected to a separate datalogger. This sensor was calibrated at the office days before the trip for this purpose. The relative humidity was found to be within around 2% for RH and within a degree or so for temperature.

The HMK11 field calibration kit was also used, which has two solutions of salts in water that come to a precise relative humidity when left in a controlled environment and allowed to stabilize. The HMP45C was used to first read the RH in the salt chamber, then the HMP45CFs were each measured in turn. An interval of 5 minutes was used between connection of the sensor to the reading. This is less time than recommended to allow the RH to stabilize, but was necessary due to time constraints. In order to control environmental conditions as much as possible, the sensors were placed inside the car, with all doors and windows closed except for the driver's side window to allow the cables through. It was judged to be a valid method for the following reasons:

1. By allowing the RH to stabilize for precisely 5 minutes every time, it seems reasonable to assume that it reached the same value every time.

2. The HMP45C had been previously calibrated with the HMK11 kit exactly as per the manual, and was used as a control to confirm the RH over the salt solutions.

The accuracies were within 1-2% for all readings for NaCl and LiCl. The accuracy of the sensor is +/-2% between 0% and 90% RH and +/- 3% between 90% and 100% RH. The HMP45CF were in excellent shape physically. All three O-rings were replaced, however only the large one on both sensors were slightly cracked.

HMP45CF Data:

5 minute LiCl (lithium chloride test)

HMP45CF C1288: 13.3%

HMP45CF C1287: 13.4%

HMP45C (control): 12.6%

5 minute NaCl (sodium chloride test)

HMP45CF C1288: 75.4%

HMP45CF C1287: 75.5%

HMP45C (control): 76.6%

Testing conclusions:

We can conclude that the 05103 wind speed and direction sensors and HMP45CF temperature and relative humidity sensors were operating within specification at the time of the visit. Although the procedure followed for the HMP45CF was non-standard, the correlation between the sensors and to the control sensor was excellent.

If it is indeed the case that the sensors were installed 10 years ago, and never maintained, it is unfortunately not possible to say whether or not they have been working within specifications since then. However, given that all sensors were in excellent physical shape and the environment is low humidity, there is a good chance that the historical data is good. The sensors should also continue working within spec for the near future. For the next maintenance visit, another performance test should be performed, then complete maintenance and replacement of parts, then another performance test.

Further work:

The 2008 revision of the program by Elaine included removing one of the three 107B soil temperature probes from the logger in order to make room for the one-sensor Geonor. However, the programming data tables were not altered, such that sensor 1 only output zeroes (the wires were loose in the enclosure). Also, at the Grum station, sensor 3 was outputting around -50 degrees, which turned out to be caused by a broken cable (possible damage either from a shovel or an animal).

The client decided that the depth of sensor 3 was more desirable than sensor 1. Therefore, at Grum the broken sensor 3 was dug up and thrown out, and the previously unused sensor 1 was wired and buried in its place. At Faro, sensor 1 was removed and brought back as a spare to the office, and sensor 3 was left in place.

The CS705 snowfall adapters were removed from the TE525WS tipping buckets for summer operation, and the tipping bucket's operation was verified.

A new program will be written shortly with modifications as per meetings with the client to determine need. The extra soil sensor output will be removed, and a flag will be added to signify when the CS705 is attached or removed seasonally. The program will also incorporate error codes that will allow the client to quickly determine program errors.

Other general maintenance items were checked:

- The levelling of both sites was checked. This was found to be good as expected, due to the stability of the rock/gravel base.
- Guy wire tension was found to be good.
- Alignement of the wind sensors accounting for magnetic declination was found to be good.
- The radiometer surfaces were found to be clean.
- The wires were found to be reasonably secure in the datalogger and were tightened gently as required.
-

Recommendations:

Immediate maintenance items that could be taken care of my personel on site includes:

- Cleaning tipping buckets. There is some grime on these.
- Checking on the T200-B weighing gauge, for debris in the bucket.
- Zip tie cables behind the enclosure and wires in the enclosure.

For next year's visit, the following should be considered.

- Complete maintenance and calibration of temp/rh and wind sensors
- Calibration of tipping buckets
- Performance test of weighing gauge, and snow depth sensor

- Suggest sending radiometers and dataloggers in for calibration. Spares could be purchased and installed during the visit, for no downtime.

- HFT3 soil heat flux sensor calibration is recommended every two years, however it may be cost prohibitive to send it to the manufacturer. It may be suggested to purchase new ones and keep existing ones as spares.
- SR50 snow depth sensor transducer kit can be brought and replaced if needed.

Appendix E
Laboratory Reports

CH2M HILL, INC
ATTN: Bernice Kidd
2525 Airpark Drive
Redding CA 96001

Date Received: 25-JUL-13
Report Date: 25-OCT-13 10:30 (MT)
Version: FINAL REV. 2

Client Phone: 530-229-3203

Certificate of Analysis

Lab Work Order #: L1338738

Project P.O. #:	472645.18.VG.DF PO=604564
Job Reference:	BSI GRUM DUMP ROCK QUARRY 2013 311.5D.
C of C Numbers:	ALS07231301, ALS07231301H, ALS07231301R
Legal Site Desc:	

Comments:

25-OCT-13: Additional QC data has been included.

Amber Springer
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1338738-1	L1338738-2	L1338738-3	L1338738-4	L1338738-5
	Description	soil	soil	soil	soil	soil
	Sampled Date	10-JUL-13	10-JUL-13	12-JUL-13	12-JUL-13	15-JUL-13
	Sampled Time	17:00	17:00	13:00	13:00	11:00
	Client ID	CH13-311-SS001_RKA	CH13-311-SS019_RKA	CH13-311-SS021_RKA	CH13-311-SS022_RKA	CH13-311-SS026_RKA
SOIL						
Physical Tests	pH (1:2 soil:water) (pH)	8.94	7.63	7.89	9.04	8.21
Organic / Inorganic Carbon	Inorganic Carbon (%)	0.66	0.12	<0.10	0.21	<0.10
	Inorganic Carbon (as CaCO3 Equivalent) (%)	5.53	0.98	<0.80	1.74	<0.80
Saturated Paste Extractables	Paste pH (pH)	7.95	7.64	7.71	8.07	7.76
Acid Base Accounting	Neutralization Potential (NP) (tCaCO3/1Kt)	45.0	12.0	14.0	14.0	4.0
Metals	Aluminum (Al) (mg/kg)	24800	29300	19400	18500	18200
	Antimony (Sb) (mg/kg)	0.22	0.16	<0.10	0.20	<0.10
	Arsenic (As) (mg/kg)	0.729	0.477	1.59	0.774	2.28
	Barium (Ba) (mg/kg)	25.3	50.4	138	87.9	128
	Beryllium (Be) (mg/kg)	0.25	<0.20	<0.20	<0.20	0.28
	Bismuth (Bi) (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Boron (B) (mg/kg)	<10	<10	<10	<10	<10
	Cadmium (Cd) (mg/kg)	0.078	0.055	0.133	0.113	<0.050
	Calcium (Ca) (mg/kg)	22500	4770	7020	7530	9640
	Chromium (Cr) (mg/kg)	253	382	275	90.4	16.2
	Cobalt (Co) (mg/kg)	27.6	36.4	23.7	25.7	6.68
	Copper (Cu) (mg/kg)	94.1	84.4	96.6	170	3.18
	Iron (Fe) (mg/kg)	41000	41500	33300	30900	21400
	Lead (Pb) (mg/kg)	1.24	1.71	3.60	2.03	10.1
	Lithium (Li) (mg/kg)	21.1	36.7	16.1	17.4	23.8
	Magnesium (Mg) (mg/kg)	24000	33500	16200	16300	7780
	Manganese (Mn) (mg/kg)	620	641	562	451	298
	Mercury (Hg) (mg/kg)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
	Molybdenum (Mo) (mg/kg)	0.59	<0.50	0.68	<0.50	<0.50
	Nickel (Ni) (mg/kg)	105	260	100	74.1	3.60
	Phosphorus (P) (mg/kg)	1130	930	1130	852	480
	Potassium (K) (mg/kg)	270	1220	400	540	1530
	Selenium (Se) (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Silver (Ag) (mg/kg)	<0.10	<0.10	<0.10	<0.10	<0.10
	Sodium (Na) (mg/kg)	210	<100	110	130	860
	Strontium (Sr) (mg/kg)	102	47.3	76.1	43.2	40.7
	Sulfur (S)-Total (mg/kg)	<500	<500	<500	700	<500
	Thallium (Tl) (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
	Tin (Sn) (mg/kg)	<2.0	<2.0	<2.0	<2.0	<2.0
	Titanium (Ti) (mg/kg)	1120	971	1690	1070	1410

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1338738-1	L1338738-2	L1338738-3	L1338738-4	L1338738-5
	Description	soil	soil	soil	soil	soil
	Sampled Date	10-JUL-13	10-JUL-13	12-JUL-13	12-JUL-13	15-JUL-13
	Sampled Time	17:00	17:00	13:00	13:00	11:00
	Client ID	CH13-311-SS001_RKA	CH13-311-SS019_RKA	CH13-311-SS021_RKA	CH13-311-SS022_RKA	CH13-311-SS026_RKA
Grouping	**Analyte**					
SOIL						
Metals	Uranium (U) (mg/kg)	0.094	<0.050	0.076	0.066	1.12
	Vanadium (V) (mg/kg)	81.8	43.3	47.4	41.0	48.6
	Zinc (Zn) (mg/kg)	52.9	56.1	46.4	45.1	41.2

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Method Blank	Zinc (Zn)	B	L1338738-1, -2, -3, -4, -5

Qualifiers for Individual Parameters Listed:

Qualifier	Description
B	Method Blank exceeds ALS DQO. All associated sample results are at least 5 times greater than blank levels and are considered reliable.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
B-200.2-CCMS-VA	Soil	Boron in Soil by CRC ICPMS	EPA 200.2/6020A

"This analysis is carried out using procedures from CSR Analytical Method: ""Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, 26 June 2009, and procedures adapted from EPA Method 200.2. The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve (this sieve step is omitted for international soil samples), and a representative subsample of the dry material is weighed. The sample is then digested at 95 degrees Celsius for 2 hours by block digester using concentrated nitric and hydrochloric acids. Instrumental analysis of the digested extract is by collision cell inductively coupled plasma - mass spectrometry (modifed from EPA Method 6020A).

Method Limitation: This method is not a total digestion technique. It is a very strong acid digestion that is intended to dissolve those metals that may be environmentally available. By design, elements bound in silicate structures are not normally dissolved by this procedure as they are not usually mobile in the environment."

ALS Test Code	Matrix	Test Description	Method Reference**
C-INORG-SK	Soil	Inorganic Carbon / Calcium Carbonate	SSSA (1996) P455-456

When carbonates are decomposed with acid in an open system, carbon dioxide is released to the atmosphere. The decrease in sample weight resulting from CO2 loss is proportional to the carbonate content of the soil.

Reference:
Loeppert, R.H. and Suarez, D.L. 1996. Gravimetric Method for Loss of Carbon Dioxide. P. 455-456 In: J.M. Bartels et al. (ed.) Methods of soil analysis: Part 3 Chemical methods. (3rd ed.) ASA and SSSA, Madison, WI. Book series no. 5

ALS Test Code	Matrix	Test Description	Method Reference**
HG-WW-200.2-CVAF-VA	Soil	Hg in Soil by CVAFS	EPA 200.2/245.7

This analysis is carried out using procedures from CSR Analytical Method: "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, 26 June 2009, and procedures adapted from EPA Method 200.2. The sample is manually homogenized, sieved (wet sample) through a 2 mm (10 mesh) sieve, and a representative subsample of the material is weighed. The sample is then digested at 95 degrees Celsius for 2 hours by block digester using concentrated nitric and hydrochloric acids. Instrumental analysis is by atomic fluorescence spectrophotometry or atomic absorption spectrophotometry (EPA Method 245.7).

Method Limitation: This method is not a total digestion technique. It is a very strong acid digestion that is intended to dissolve those metals that may be environmentally available. By design, elements bound in silicate structures are not normally dissolved by this procedure as they are not usually mobile in the environment.

ALS Test Code	Matrix	Test Description	Method Reference**
IC-CACO3-CALC-SK	Soil	Inorganic Carbon as CaCO3 Equivalent	Calculation
MET-WW-200.2-CCMS-VA	Soil	Metals in Soil by CRC ICPMS	EPA 200.2/6020A

This analysis is carried out using procedures from CSR Analytical Method: "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, 26 June 2009, and procedures adapted from EPA Method 200.2. The sample is manually homogenized, sieved (wet sample) through a 2 mm (10 mesh) sieve, and a representative subsample of the material is weighed. The sample is then digested at 95 degrees Celsius for 2 hours by block digester using concentrated nitric and hydrochloric acids. Instrumental analysis is by collision cell inductively coupled plasma - mass spectrometry (modifed from EPA Method 6020A).

Method Limitation: This method is not a total digestion technique. It is a very strong acid digestion that is intended to dissolve those metals that may be environmentally available. By design, elements bound in silicate structures are not normally dissolved by this procedure as they are not usually mobile in the environment.

ALS Test Code	Matrix	Test Description	Method Reference**
MOISTURE-SIEVE-VA	Soil	Moisture for CSR Metals Calculations	ASTM D2974-00 Method A

This analysis is carried out gravimetrically by drying the sample at 105 C for a minimum of six hours.

ALS Test Code	Matrix	Test Description	Method Reference**
NP-TU	Soil	Neutralization Potential (NP)	Sobek 3.2.3, MOD
PH-PASTE-VA	Soil	pH in Soil (Paste) by Meter	Carter-CSSS / APHA 4500 H

A soil extract produced by the saturated paste extraction procedure is analyzed by pH meter.

Reference Information

PH-WW-1:2-DI-MAN-VA	Soil	pH in Soil (1:2 Soil:Water Ext.) (WET)	BC WLAP METHOD: PH, ELECTROMETRIC, SOIL

This analysis is carried out in accordance with procedures described in the pH, Electrometric in Soil and Sediment method - Section B Physical/Inorganic and Misc. Constituents, BC Environmental Laboratory Manual 2007. The procedure involves mixing the wet sieved (No. 10 / 2mm) sample with deionized/distilled water at a 1:2 ratio of sediment to water, where the samples moisture is accounted for. The pH of the solution is then measured using a standard pH probe.

S-TOT-LECO-SK	Soil	Total Sulphur by combustion method	ISO 15178:2000

The sample is ignited in a combustion analyzer where sulfur in the reduced SO2 gas is determined using a thermal conductivity detector.

SAT-PCNT-VA	Soil	Saturation Percentage	Carter-CSSS

Saturation Percentage (SP) is the total volume of water present in a saturated paste (in mL) divided by the dry weight of the sample (in grams), expressed as a percentage, as described in "Soil Sampling and Methods of Analysis" by M. Carter.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
SK	ALS ENVIRONMENTAL - SASKATOON, SASKATCHEWAN, CANADA
TU	ALS ENVIRONMENTAL - TUCSON, ARIZONA, USA
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

ALS07231301 ALS07231301H ALS07231301R

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: CH2M HILL, INC
2525 Airpark Drive
Redding CA 96001

Contact: Bernice Kidd

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
B-200.2-CCMS-VA	**Soil**							
Batch R2668168								
WG1722165-5 CRM		**VA-CANMET-TILL1**						
Boron (B)			4		mg/kg		0-13	07-AUG-13
WG1722165-6 DUP		**L1338738-5**						
Boron (B)		<10	<10	RPD-NA	mg/kg	N/A	30	07-AUG-13
WG1722165-4 MB								
Boron (B)			<10		mg/kg		10	07-AUG-13
C-INORG-SK	**Soil**							
Batch R2661480								
WG1715241-2 IRM		**0.1%IC**						
Inorganic Carbon			131.8		%		60-140	30-JUL-13
WG1715241-3 IRM		**0.4%IC**						
Inorganic Carbon			111.0		%		80-120	30-JUL-13
WG1715241-4 MB								
Inorganic Carbon			<0.10		%		0.1	30-JUL-13
HG-WW-200.2-CVAF-VA	**Soil**							
Batch R2668391								
WG1722165-5 CRM		**VA-CANMET-TILL1**						
Mercury (Hg)			107.7		%		70-130	08-AUG-13
WG1722165-6 DUP		**L1338738-5**						
Mercury (Hg)		<0.0050	<0.0050	RPD-NA	mg/kg	N/A	40	08-AUG-13
WG1722165-4 MB								
Mercury (Hg)			<0.0050		mg/kg		0.005	08-AUG-13
MET-WW-200.2-CCMS-VA	**Soil**							
Batch R2668168								
WG1722165-5 CRM		**VA-CANMET-TILL1**						
Aluminum (Al)			98.0		%		70-130	07-AUG-13
Antimony (Sb)			90.1		%		70-130	07-AUG-13
Arsenic (As)			104.4		%		70-130	07-AUG-13
Barium (Ba)			95.3		%		70-130	07-AUG-13
Beryllium (Be)			0.49		mg/kg		0.34-0.74	07-AUG-13
Bismuth (Bi)			94.8		%		70-130	07-AUG-13
Cadmium (Cd)			91.9		%		70-130	07-AUG-13
Calcium (Ca)			105.1		%		70-130	07-AUG-13
Chromium (Cr)			104.5		%		70-130	07-AUG-13
Cobalt (Co)			103.1		%		70-130	07-AUG-13
Copper (Cu)			96.8		%		70-130	07-AUG-13
Iron (Fe)			100.2		%		70-130	07-AUG-13

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-WW-200.2-CCMS-VA	**Soil**							
Batch R2668168								
WG1722165-5 CRM		**VA-CANMET-TILL1**						
Lead (Pb)			87.8		%		70-130	07-AUG-13
Lithium (Li)			105.1		%		70-130	07-AUG-13
Magnesium (Mg)			103.3		%		70-130	07-AUG-13
Manganese (Mn)			99.3		%		70-130	07-AUG-13
Molybdenum (Mo)			0.72		mg/kg		0.24-1.24	07-AUG-13
Nickel (Ni)			102.4		%		70-130	07-AUG-13
Phosphorus (P)			99.7		%		70-130	07-AUG-13
Potassium (K)			115.1		%		70-130	07-AUG-13
Selenium (Se)			0.34		mg/kg		0.12-0.52	07-AUG-13
Silver (Ag)			0.21		mg/kg		0.12-0.32	07-AUG-13
Sodium (Na)			121.4		%		70-130	07-AUG-13
Strontium (Sr)			104.3		%		70-130	07-AUG-13
Thallium (Tl)			0.110		mg/kg		0.075-0.175	07-AUG-13
Tin (Sn)			1.0		mg/kg		0-3	07-AUG-13
Titanium (Ti)			102.4		%		70-130	07-AUG-13
Uranium (U)			97.9		%		70-130	07-AUG-13
Vanadium (V)			105.7		%		70-130	07-AUG-13
Zinc (Zn)			97.5		%		70-130	07-AUG-13
WG1722165-6 DUP		**L1338738-5**						
Aluminum (Al)		18200	17200		mg/kg	5.9	40	07-AUG-13
Antimony (Sb)		<0.10	<0.10	RPD-NA	mg/kg	N/A	30	07-AUG-13
Arsenic (As)		2.28	1.95		mg/kg	16	30	07-AUG-13
Barium (Ba)		128	117		mg/kg	9.0	40	07-AUG-13
Beryllium (Be)		0.28	0.22		mg/kg	24	30	07-AUG-13
Bismuth (Bi)		<0.20	<0.20	RPD-NA	mg/kg	N/A	30	07-AUG-13
Cadmium (Cd)		<0.050	<0.050	RPD-NA	mg/kg	N/A	30	07-AUG-13
Calcium (Ca)		9640	7620		mg/kg	23	30	07-AUG-13
Chromium (Cr)		16.2	15.6		mg/kg	3.6	30	07-AUG-13
Cobalt (Co)		6.68	6.76		mg/kg	1.2	30	07-AUG-13
Copper (Cu)		3.18	3.11		mg/kg	2.0	30	07-AUG-13
Iron (Fe)		21400	23400		mg/kg	8.7	30	07-AUG-13
Lead (Pb)		10.1	10.5		mg/kg	3.7	40	07-AUG-13
Lithium (Li)		23.8	24.7		mg/kg	3.4	30	07-AUG-13
Magnesium (Mg)		7780	8090		mg/kg	3.9	30	07-AUG-13

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-WW-200.2-CCMS-VA	**Soil**							
Batch R2668168								
WG1722165-6 DUP		**L1338738-5**						
Manganese (Mn)		298	307		mg/kg	2.8	30	07-AUG-13
Molybdenum (Mo)		<0.50	<0.50	RPD-NA	mg/kg	N/A	40	07-AUG-13
Nickel (Ni)		3.60	3.60		mg/kg	0.1	30	07-AUG-13
Phosphorus (P)		480	418		mg/kg	14	30	07-AUG-13
Potassium (K)		1530	1410		mg/kg	8.6	40	07-AUG-13
Selenium (Se)		<0.20	<0.20	RPD-NA	mg/kg	N/A	30	07-AUG-13
Silver (Ag)		<0.10	<0.10	RPD-NA	mg/kg	N/A	40	07-AUG-13
Sodium (Na)		860	650		mg/kg	28	40	07-AUG-13
Strontium (Sr)		40.7	31.2		mg/kg	26	40	07-AUG-13
Thallium (Tl)		<0.050	<0.050	RPD-NA	mg/kg	N/A	30	07-AUG-13
Tin (Sn)		<2.0	<2.0	RPD-NA	mg/kg	N/A	40	07-AUG-13
Titanium (Ti)		1410	1060		mg/kg	28	40	07-AUG-13
Uranium (U)		1.12	1.11		mg/kg	1.0	30	07-AUG-13
Vanadium (V)		48.6	44.8		mg/kg	8.2	30	07-AUG-13
Zinc (Zn)		41.2	41.6		mg/kg	1.0	30	07-AUG-13
WG1722165-4 MB								
Aluminum (Al)			<50		mg/kg		50	07-AUG-13
Antimony (Sb)			<0.10		mg/kg		0.1	07-AUG-13
Arsenic (As)			<0.050		mg/kg		0.05	07-AUG-13
Barium (Ba)			<0.50		mg/kg		0.5	07-AUG-13
Beryllium (Be)			<0.20		mg/kg		0.2	07-AUG-13
Bismuth (Bi)			<0.20		mg/kg		0.2	07-AUG-13
Cadmium (Cd)			<0.050		mg/kg		0.05	07-AUG-13
Calcium (Ca)			<50		mg/kg		50	07-AUG-13
Chromium (Cr)			<0.50		mg/kg		0.5	07-AUG-13
Cobalt (Co)			<0.10		mg/kg		0.1	07-AUG-13
Copper (Cu)			<0.50		mg/kg		0.5	07-AUG-13
Iron (Fe)			<50		mg/kg		50	07-AUG-13
Lead (Pb)			<0.50		mg/kg		0.5	07-AUG-13
Lithium (Li)			<5.0		mg/kg		5	07-AUG-13
Magnesium (Mg)			<20		mg/kg		20	07-AUG-13
Manganese (Mn)			<1.0		mg/kg		1	07-AUG-13
Molybdenum (Mo)			<0.50		mg/kg		0.5	07-AUG-13
Nickel (Ni)			<0.50		mg/kg		0.5	07-AUG-13

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-WW-200.2-CCMS-VA	**Soil**							
Batch R2668168								
WG1722165-4 MB								
Phosphorus (P)			<50		mg/kg		50	07-AUG-13
Potassium (K)			<100		mg/kg		100	07-AUG-13
Selenium (Se)			<0.20		mg/kg		0.2	07-AUG-13
Silver (Ag)			<0.10		mg/kg		0.1	07-AUG-13
Sodium (Na)			<100		mg/kg		100	07-AUG-13
Strontium (Sr)			<0.50		mg/kg		0.5	07-AUG-13
Thallium (Tl)			<0.050		mg/kg		0.05	07-AUG-13
Tin (Sn)			<2.0		mg/kg		2	07-AUG-13
Titanium (Ti)			<1.0		mg/kg		1	07-AUG-13
Uranium (U)			<0.050		mg/kg		0.05	07-AUG-13
Vanadium (V)			<0.20		mg/kg		0.2	07-AUG-13
Zinc (Zn)			2.4	B	mg/kg		1	07-AUG-13
PH-WW-1:2-DI-MAN-VA	**Soil**							
Batch R2668134								
WG1722165-6 DUP		**L1338738-5**						
pH (1:2 soil:water)		8.21	8.16	J	pH	0.05	0.3	08-AUG-13
S-TOT-LECO-SK	**Soil**							
Batch R2660400								
WG1715237-4 IRM		**1646A_SOIL**						
Sulfur (S)-Total			3300		mg/kg		2500-4600	29-JUL-13
WG1715237-5 MB								
Sulfur (S)-Total			<500		mg/kg		500	29-JUL-13

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
B	Method Blank exceeds ALS DQO. All associated sample results are at least 5 times greater than blank levels and are considered reliable.
J	Duplicate results and limits are expressed in terms of absolute difference.
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Quality Control Report

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Organic / Inorganic Carbon							
Inorganic Carbon / Calcium Carbonate							
	1	10-JUL-13 17:00	30-JUL-13 00:00	14	19	days	EHTR
	2	10-JUL-13 17:00	30-JUL-13 00:00	14	19	days	EHTR
	3	12-JUL-13 13:00	30-JUL-13 00:00	14	17	days	EHTL
	4	12-JUL-13 13:00	30-JUL-13 00:00	14	17	days	EHTL
	5	15-JUL-13 11:00	30-JUL-13 00:00	14	15	days	EHT
Inorganic Carbon as CaCO3 Equivalent							
	1	10-JUL-13 17:00	30-JUL-13 15:21	14	20	days	EHTR
	2	10-JUL-13 17:00	30-JUL-13 15:21	14	20	days	EHTR
	3	12-JUL-13 13:00	30-JUL-13 15:21	14	18	days	EHTL
	4	12-JUL-13 13:00	30-JUL-13 15:21	14	18	days	EHTL
	5	15-JUL-13 11:00	30-JUL-13 15:21	14	15	days	EHT

Legend & Qualifier Definitions:

EHTR-FM:	Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR:	Exceeded ALS recommended hold time prior to sample receipt.
EHTL:	Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT:	Exceeded ALS recommended hold time prior to analysis.
Rec. HT:	ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L1338738 were received on 25-JUL-13 14:35.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Environmental

August 28, 2013

Client: ALS Environmental- Canada
8081 Lougheed Hwy, Ste 100
Burnaby, BC V5A 1W9
CANADA
Attn: Amber Springer
Project: L1338738 Date Received: August 6, 2013

Certificate of Analysis

Client ID:	Sample Date:	Lab #:		Moisture, Total 3.1 wt%	Neutralization Potential Sobek 3.2.3, MOD $tCaCO_3/1,000t$
L1338738- 1	7/10/2013	T1301137- 001		0.17	45
L1338738- 2	7/10/2013	T1301137- 002		0.36	12
L1338738- 3	7/12/2013	T1301137- 003		0.18	14
L1338738- 4	7/12/2013	T1301137- 004		0.16	14
L1338738- 5	7/15/2013	T1301137- 005		0.29	4

Notes:
Samples were air dried then ground to < 60 mesh.

W. Hyatt
Digitally signed by Wendy Hyatt
Date: 2013.08.28 16:07:33 -07'00'

Wendy Hyatt, Project Chemist

ADDRESS 3860 S. Palo Verde Road, Suite 302, Tucson, AZ 85714
PHONE +1 520 573 1061
FAX +1 520 573 1063

ALS Environmental

August 28, 2013

Client: ALS Environmental- Canada
8081 Lougheed Hwy, Ste 100
Burnaby, BC V5A 1W9
CANADA

Attn: Amber Springer

Project: L1338738 **Date Received:** August 6, 2013

Quality Control

				Moisture, Total 3.1 wt%	Neutralization Potential Sobek 3.2.3, MOD $tCaCO_3/1,000t$
Prep Blank				<0.01	< 1
Laboratory Control Sample (LCS) - Rice Flour CN 3451			Observed Value	9.52	n/a
			True Value	9.50	
			%R	**100**	
Laboratory Control Sample (LCS) - Na_2CO3 CN 1045			Observed Value	n/a	981
			True Value		1,000
			%R		**98**
Laboratory Control Sample (LCS) - Na_2CO3 CN 1045			Observed Value	n/a	976
			True Value		1,000
			%R		**98**
Duplicate Results			T1301137-001	0.13 **	
			Duplicate	0.09 **	
			%R	**36**	
Duplicate Results				*T1301138-001	65
				Duplicate	65
				%RPD	**0**

* Sample from the same batch, but a different project.

**Residual moisture - does not include air dry moisture.

CH2MHILL

CHAIN OF CUSTODY RECORD

7/22/2013 5:57:45 PM

Project Name Faro
Location Faro Mine Complex - Faro YK
Project Number 472645.18.VG.DF
Project Manager Heather MacDonald
Sample Manager Charles Shewen

Task Order 311.5D.
Project BSI GRUM DUMP ROCK QUARRY 2013
Turnaround Time 10 Days
Shipping Date: 7/22/2013
COC Number: ALS07231301

L1338738-COFC

Container:				1 Gallon	1 Gallon	1 Gallon	1 Gallon		
Preservatives:				4'C	4'C	4'C	4'C		
Filtered:				NA	NA	NA	NA		
Holding Time:				28	14	28	28		
	DATE	TIME	Matrix	(CSSS/APHA4500H) Paste pH	(EPA200.0/245.7/SW6020A) Total Metals Table 1	(ModifiedSobek) Mod Neutralization Potential	(SSSA (1996) P455-456) TIC	Number of Containers	COMMENTS
CH13-311-SS001_RKa	7/10/2013	17:00	Soil	X	X	X	X	2	
CH13-311-SS019_RKa	7/10/2013	17:00	Soil	X	X	X	X	2	
CH13-311-SS021_RKa	7/12/2013	13:00	Soil	X	X	X	X	2	
CH13-311-SS022_RKa	7/12/2013	13:00	Soil	X	X	X	X	2	
CH13-311-SS026_RKa	7/15/2013	11:00	Soil	X	X	X	X	2	
TOTAL NUMBER OF CONTAINERS								10	

TN July 25 14:35 14/15/18/12°

	Signatures	Date/Time
Approved by		
Sampled by		
Relinquished by	[signature]	7/23/13 1700
Received by		
Relinquished by		
Received by		

Shipping Details

Method of Shipment: FedEx
On Ice: yes / no
Airbill No:
Lab Name: ALS Vancouver
Lab Phone: (604) 253-4188

ATTN:
Sample Custody
and
Amber Springer

Special Instructions:
Tar18 PO:604564 Metals Table1 Perform Lab Dup/MS on samples

Report Copy to
Bernice Kidd
(530) 229-3203

CH2MHILL

CHAIN OF CUSTODY RECORD

7/22/2013 5:58:02 PM

Project Name Faro
Location Faro Mine Complex - Faro YK
Project Number 472645.18.VG.DF
Project Manager Heather MacDonald
Sample Manager Charles Shewen

Task Order 311.5D.
Project BSI GRUM DUMP ROCK QUARRY 2013
Turnaround Time 10 Days
Shipping Date: 7/22/2013
COC Number: ALS07231301H

			Container:	1 Gallon	1 Gallon	1 Gallon	1 Gallon	1 Gallon	1 Gallon	1 Gallon	1 Gallon	1 Gallon	1 Gallon		
			Preservatives:	4'C	4'C	4'C	4'C	4'C	4'C	4'C	4'C	4'C	4'C		
			Filtered:	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
			Holding Time:	14	14	14	14	180	180	14	14	14	14		
	DATE	TIME	Matrix	(DI/APHA2510) DI Conductivity	(DI/APHA4500H) DI pH	(DI/ASTMD1498) DI ORP	(DI/E245.7) DI Diss Mercury	(DI/E300) DI Sulphate	(DI/EPA600/2-78-054) Acid Soluable Sulfate	(DI/SM2310) DI Acidity	(DI/SM2320) DI Alkalinity	(DI/SW6020A) DI Diss Metals	(SW6020A) Ba(Li) Metaborate	Number of Containers	COMMENTS
CH13-311-SS001_RKa	7/10/2013	17:00	Soil	X	X	X	X	X	X	X	X	X	X	3	HOLD
CH13-311-SS019_RKa	7/10/2013	17:00	Soil	X	X	X	X	X	X	X	X	X	X	3	
CH13-311-SS021_RKa	7/12/2013	13:00	Soil	X	X	X	X	X	X	X	X	X	X	3	
CH13-311-SS022_RKa	7/12/2013	13:00	Soil	X	X	X	X	X	X	X	X	X	X	3	
CH13-311-SS026_RKa	7/15/2013	11:00	Soil	X	X	X	X	X	X	X	X	X	X	3	
													TOTAL NUMBER OF CONTAINERS	15	

TN July 25 14:35 14/15/18/12

L1338738-COFC

	Signatures	Date/Time
Approved by		
Sampled by		
Relinquished by	[signature]	7/23/13 1700
Received by		
Relinquished by		
Received by		

Shipping Details

Method of Shipment: FedEx
On Ice: yes / no
Airbill No:
Lab Name: ALS Vancouver
Lab Phone: (604) 253-4188

ATTN:

Sample Custody
and
Amber Springer

Special Instructions:

Tar18 PO:604564 Metals Table1 Perform Lab Dup/MS on samples

Report Copy to
Bernice Kidd
(530) 229-3203

CH2MHILL

CHAIN OF CUSTODY RECORD

7/22/2013 5:58:17 PM

Project Name Faro
Location Faro Mine Complex - Faro YK
Project Number 472645.18.VG.DF
Project Manager Heather MacDonald
Sample Manager Charles Shewen

Container: 1 Gallon
Preservatives: 4'C
Filtered: NA
Holding Time: 180

Task Order 311.5D
Project BSI GRUM DUMP ROCK QUARRY 2013
Turnaround Time 3 Days
Shipping Date: 7/22/2013
COC Number: ALS07231301R

	DATE	TIME	Matrix	(ISO 15178-2000) Total Sulphur	Number of Containers	COMMENTS
CH13-311-SS001_RKa	7/10/2013	17:00	Soil	x	1	RUSH
CH13-311-SS019_RKa	7/10/2013	17:00	Soil	x	1	↓
CH13-311-SS021_RKa	7/12/2013	13:00	Soil	x	1	↓
CH13-311-SS022_RKa	7/12/2013	13:00	Soil	x	1	↓
CH13-311-SS026_RKa	7/15/2013	11:00	Soil	x	1	↓
				TOTAL NUMBER OF CONTAINERS	5	

TN July 25 14:35 14/15/18/12°

RUSH

Priority processing

L1338738-COFC

	Signatures	Date/Time
Approved by		
Sampled by		
Relinquished by	[signature]	7/23/13 1700
Received by		
Relinquished by		
Received by	[signature]	23-Jul-13 5:05 73, 6.4 °C

Shipping Details

Method of Shipment: FedEx
On Ice: yes / no
Airbill No:
Lab Name: ALS Vancouver
Lab Phone: (604) 253-4188

ATTN:
Sample Custody and Amber Springer

Special Instructions:
Tar18 PO:604564 Metals Table1 Perform Lab Dup/MS on samples

Report Copy to
Bernice Kidd
(530) 229-3203

CH2M HILL, INC
ATTN: Bernice Kidd
2525 Airpark Drive
Redding CA 96001

Date Received: 05-AUG-13
Report Date: 19-AUG-13 14:13 (MT)
Version: FINAL

Client Phone: 530-229-3203

Certificate of Analysis

Lab Work Order #: L1342690

Project P.O. #: 472645.18.VG.DF "PO=604564"
Job Reference: CONSTRUCT NEW VCD 2013 303.1/2
C of C Numbers: ALS08041301
Legal Site Desc:

Amber Springer
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1342690-1	L1342690-2	L1342690-3	L1342690-4	L1342690-5
	Description	Soil	Soil	Soil	Soil	Soil
	Sampled Date	31-JUL-13	31-JUL-13	31-JUL-13	31-JUL-13	31-JUL-13
	Sampled Time	14:58	15:16	15:23	15:35	16:01
	Client ID	CH13-303-BH001_SOA	CH13-303-BH001_SOB	CH13-303-BH001_SOC	CH13-303-BH001_SOD	CH13-303-BH001_SOE
Grouping	**Analyte**					
SOIL						
Physical Tests	Grain Size Curve		SEE ATTACHED		SEE ATTACHED	SEE ATTACHED
	Loss on Ignition @ 375 C (%)		7.6			
	Moisture (%)	9.76	26.5	7.27	5.93	8.41
	Organic Matter (%)		6.2			
Particle Size	MUST PSA % > 75um (%)			60.9		

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
GRAIN SIZE-SK	Soil	Grain Size Analysis	SSIR-51 METHOD 3.2.1

Particle size distribution is determined by a combination of techniques. Dry sieving is performed for coarse particles, wet sieving for sand particles and the pipette sedimentation method for clay particles.

Reference:

Burt, R. (2009). Soil Survey Field and Laboratory Methods Manual. Soil Survey Investigations Report No. 5. Method 3.2.1.2.2. United States Department of Agriculture Natural Resources Conservation Service.

ALS Test Code	Matrix	Test Description	Method Reference**
MOISTURE-VA	Soil	Moisture content	ASTM D2974-00 Method A

This analysis is carried out gravimetrically by drying the sample at 105 C for a minimum of six hours.

ALS Test Code	Matrix	Test Description	Method Reference**
OM-LOI-SK	Soil	Organic Matter by LOI at 375 deg C.	CSSS (1978) p. 160

The dry-ash method involves the removal of organic matter by combustion at 375 degrees C for a minimum of 16 hours. Samples are dried prior to combustion.

Reference: McKeague, J.A. Soil Sampling and Methods of Analysis. Can. Soc. Soil Sci.(1978) method 4.23

ALS Test Code	Matrix	Test Description	Method Reference**
PSA-MUST-SK	Soil	% Particles > 75um (Coarse/Fine)	ASTM D422-63-SIEVE

An air-dried sample is reduced to < 2 mm size and mixed with a dispersing agent (Calgon solution). The sample is washed through a 200 mesh (75 µm) sieve. The retained mass of sample is used to determine % sand fraction.

Reference: ASTM D422-63

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
SK	ALS ENVIRONMENTAL - SASKATOON, SASKATCHEWAN, CANADA
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

ALS08041301

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Workorder: L1342690 Report Date: 19-AUG-13

Client: CH2M HILL, INC
2525 Airpark Drive
Redding CA 96001

Contact: Bernice Kidd

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MOISTURE-VA	**Soil**							
Batch R2671787								
WG1726012-3 DUP		**L1342690-5**						
Moisture		8.41	8.46		%	0.6	20	13-AUG-13
WG1726012-2 LCS								
Moisture			99.7		%		70-130	13-AUG-13
WG1726012-1 MB								
Moisture			<0.25		%		0.25	13-AUG-13
OM-LOI-SK	**Soil**							
Batch R2671228								
WG1723464-1 DUP		**L1342690-2**						
Organic Matter		6.2	6.3		%	0.6	20	13-AUG-13
Loss on Ignition @ 375 C		7.6	7.7		%	0.6	25	13-AUG-13
WG1723464-3 IRM		**FARM2009**						
Organic Matter			4.8		%		3-5	13-AUG-13
Loss on Ignition @ 375 C			5.7		%		4.2-6.2	13-AUG-13
WG1723464-2 MB								
Organic Matter			<1.0		%		1	13-AUG-13
Loss on Ignition @ 375 C			<1.0		%		1	13-AUG-13

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
J	Duplicate results and limits are expressed in terms of absolute difference.

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

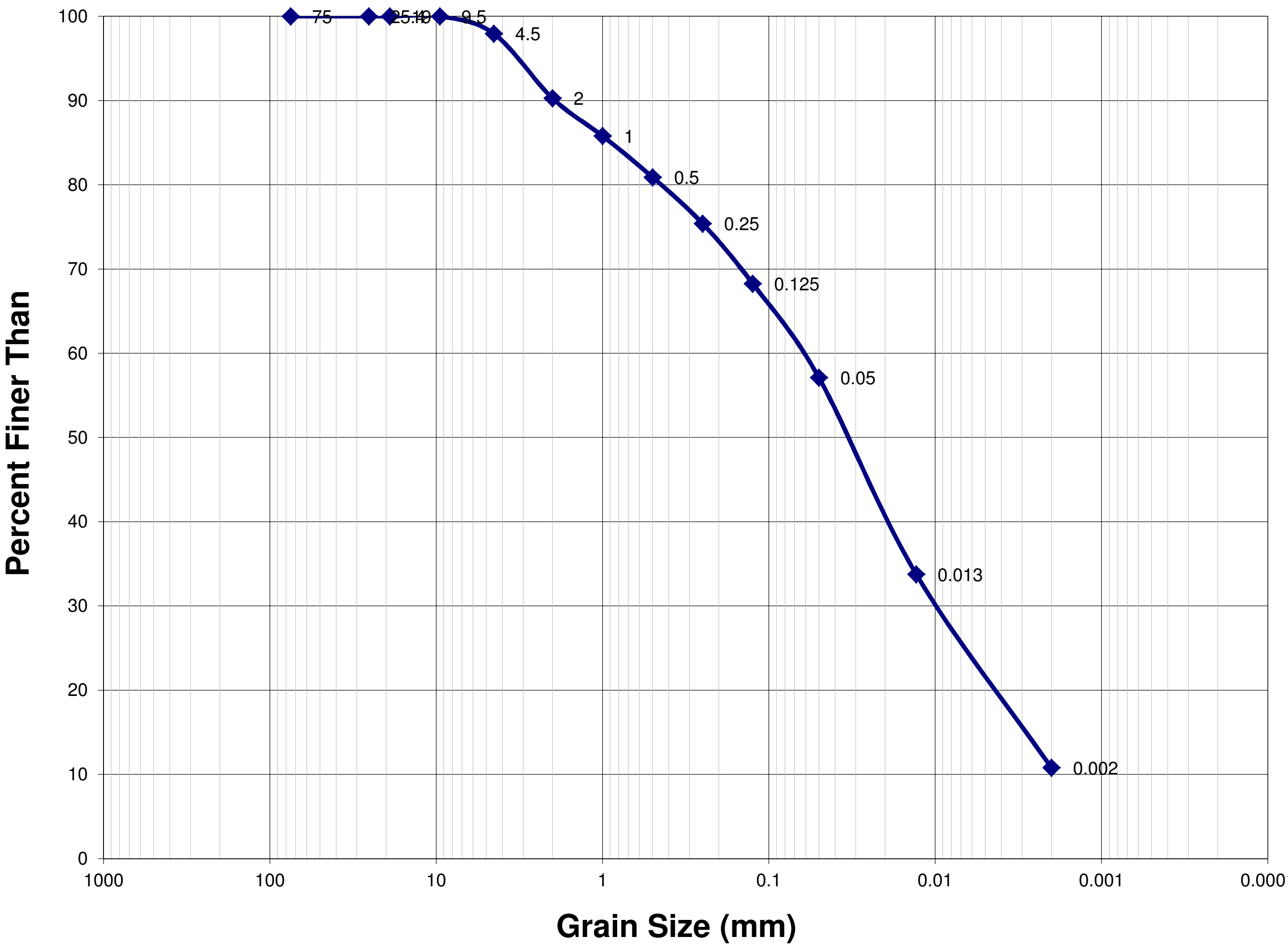
Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

819-58th Street, Saskatoon, SK S7K 6X5

Client Name: CH2M HILL, INC
Project: CHM400-CHM200-VA
Sample ID: CH13-303-BH001_SOB
Lab ID: L1342690-2

Particle Size Distribution Curve



Summary of Results

Unified Soil Classification System (USCS)

Size Class	Size Range	Wt. (%)
Cobbles	> 3"	0
Gravel	4.75mm - 3"	2
Coarse Sand	2.0mm - 4.75mm	8
Medium Sand	0.425mm - 2.0mm	9
Fine Sand	0.075mm - 0.425mm	20
Fines	< 0.075mm	61

Canadian Soil Survey Committee (CSSC)

Size Class	Size Range	Wt. (%)
Cobbles	> 3"	0
Gravel	2mm - 3"	10
Sand	0.05mm - 2mm	33
Silt	0.002mm - 0.05mm	46
Clay	< 0.002mm	11

Texture Silt loam

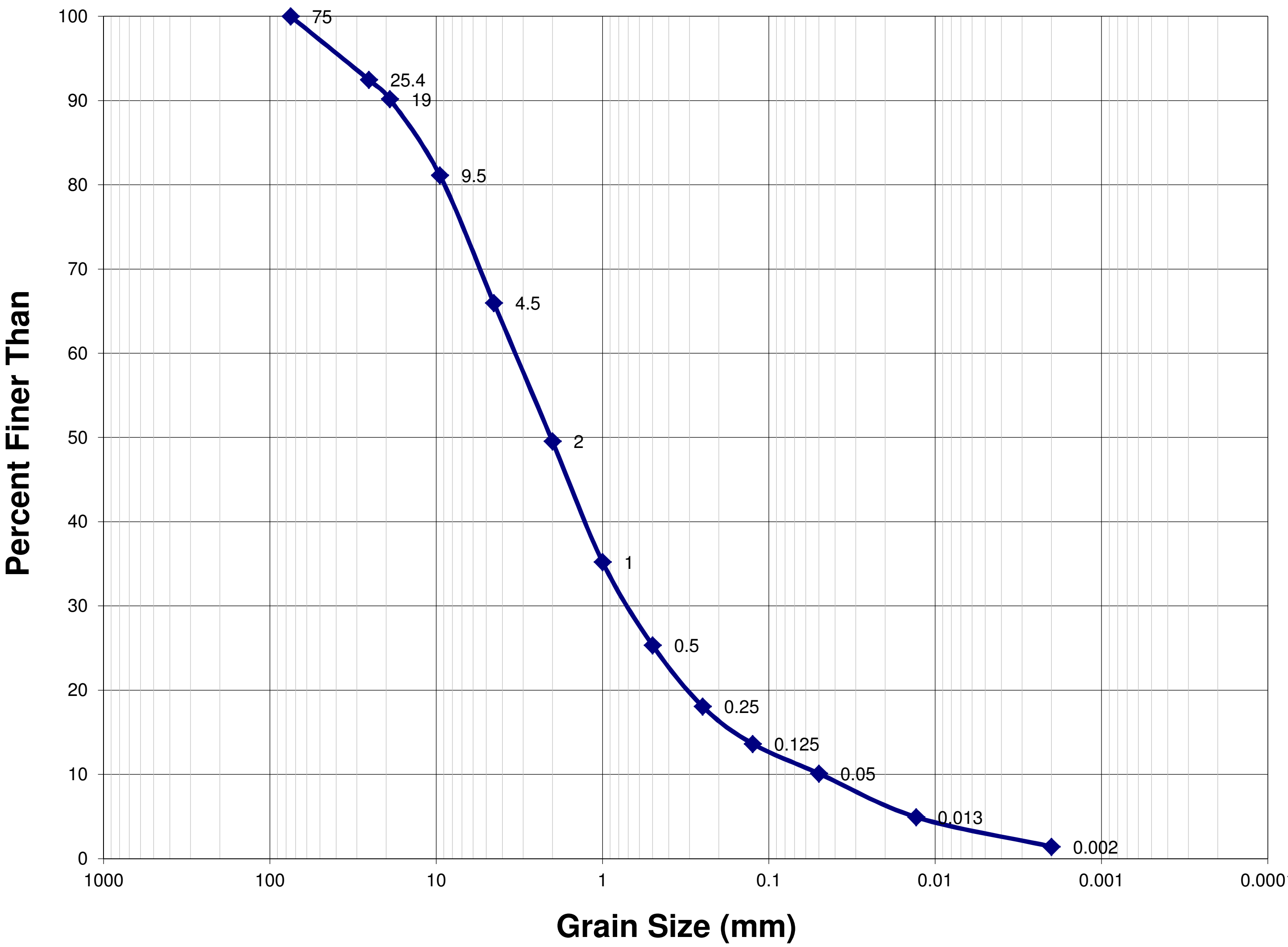
Method Reference: Can. Soc. Soil Sci. (1993) Method 47.2

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

819-58th Street, Saskatoon, SK S7K 6X5

Client Name: CH2M HILL, INC
Project: CHM400-CHM200-VA
Sample ID: CH13-303-BH001_SOD
Lab ID: L1342690-4

Particle Size Distribution Curve



Summary of Results

Unified Soil Classification System (USCS)

Size Class	Size Range	Wt. (%)
Cobbles	> 3"	0
Gravel	4.75mm - 3"	33
Coarse Sand	2.0mm - 4.75mm	17
Medium Sand	0.425mm - 2.0mm	24
Fine Sand	0.075mm - 0.425mm	14
Fines	< 0.075mm	11

Canadian Soil Survey Committee (CSSC)

Size Class	Size Range	Wt. (%)
Cobbles	> 3"	0
Gravel	2mm - 3"	50
Sand	0.05mm - 2mm	39
Silt	0.002mm - 0.05mm	9
Clay	< 0.002mm	1

Texture Loamy sand

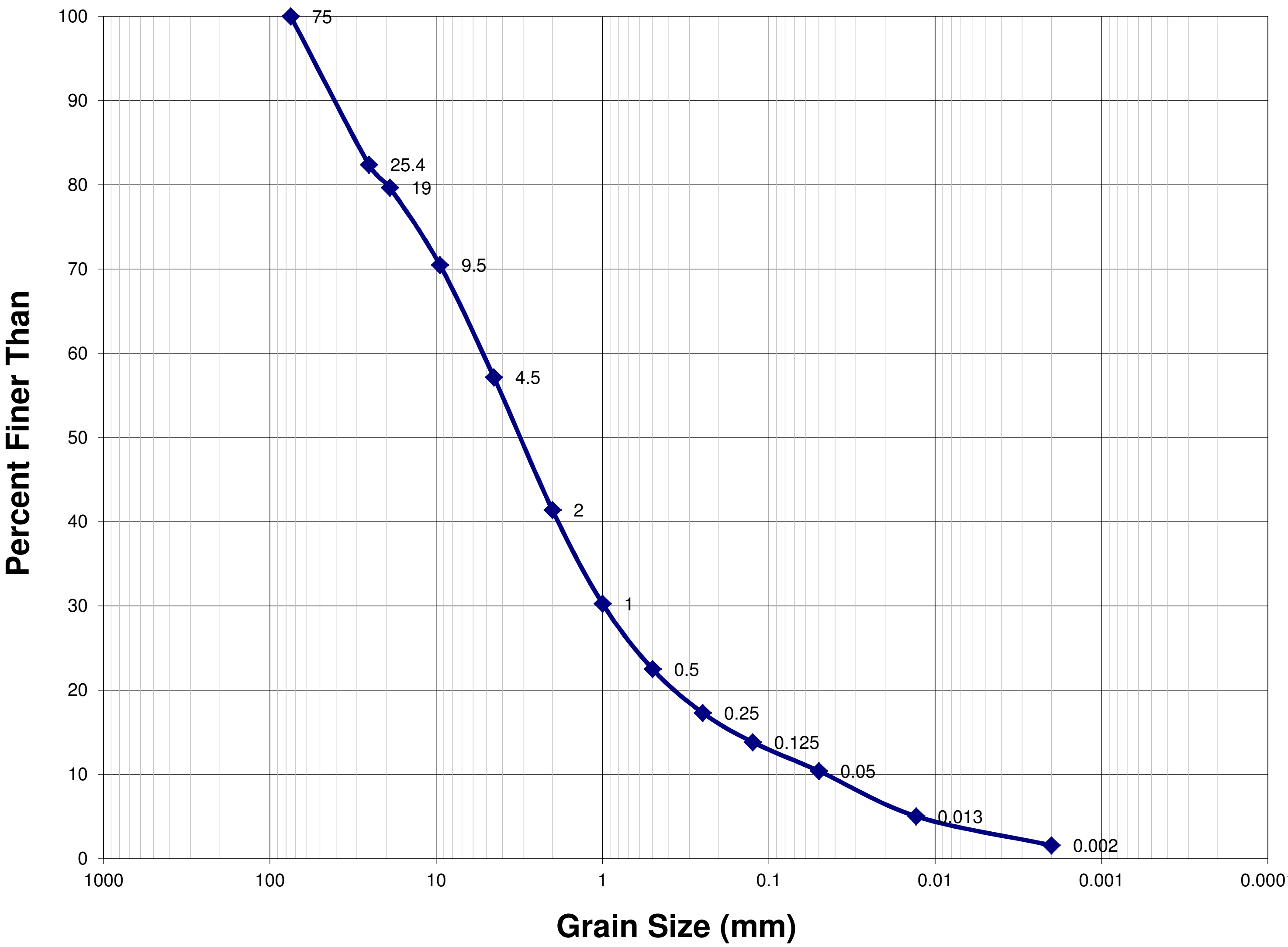
Method Reference: Can. Soc. Soil Sci. (1993) Method 47.2

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

819-58th Street, Saskatoon, SK S7K 6X5

Client Name: CH2M HILL, INC
Project: CHM400-CHM200-VA
Sample ID: CH13-303-BH001_SOE
Lab ID: L1342690-5

Particle Size Distribution Curve



Summary of Results

Unified Soil Classification System (USCS)

Size Class	Size Range	Wt. (%)
Cobbles	> 3"	0
Gravel	4.75mm - 3"	42
Coarse Sand	2.0mm - 4.75mm	16
Medium Sand	0.425mm - 2.0mm	19
Fine Sand	0.075mm - 0.425mm	11
Fines	< 0.075mm	12

Canadian Soil Survey Committee (CSSC)

Size Class	Size Range	Wt. (%)
Cobbles	> 3"	0
Gravel	2mm - 3"	59
Sand	0.05mm - 2mm	31
Silt	0.002mm - 0.05mm	9
Clay	< 0.002mm	2

Texture Loamy sand

Method Reference: Can. Soc. Soil Sci. (1993) Method 47.2

CH2MHILL

CHAIN OF CUSTODY RECORD

8/4/2013 8:49:27 AM

Project Name Faro
Location Faro Mine Complex - Faro YK
Project Number 472645.18.VG.DF
Project Manager Jaco Esterhuizen
Sample Manager Charles Shewen

Task Order 303.1/2
Project CONSTRUCT NEW VCD 2013
Turnaround Time 10 Days
Shipping Date: 8/4/2013
COC Number: ALS08041301

				(ASTM 2216) Moisture	(ASTM D1140) Percent Fines Determination	(ASTM D2974) Organic Content Determination	(ASTM D422) Gradation	Number of Containers	COMMENTS
			Container:	4oz jar	1 Gallon	1 Gallon	1 Gallon		
			Preservatives:	4'C	4'C	4'C	4'C		
			Filtered:	NA	NA	NA	NA		
			Holding Time:	14	NA	NA	NA		
	DATE	TIME	Matrix						
CH13-303-BH001_SOa	7/31/2013	14:58	Soil	X				1	
CH13-303-BH001_SOb	7/31/2013	15:16	Soil	X		X	X	3	
CH13-303-BH001_SOc	7/31/2013	15:23	Soil	X	X			2	
CH13-303-BH001_SOd	7/31/2013	15:35	Soil	X			X	2	
CH13-303-BH001_SOe	7/31/2013	16:01	Soil	X			X	2	
							TOTAL NUMBER OF CONTAINERS	10	

L1342690-COFC

	Signatures	Date/Time
Approved by		
Sampled by		8/4/13
Relinquished by	Travis Gouveia	0850
Received by	[signature]	8/5/13
Relinquished by		9:15
Received by		13.7

Shipping Details

Method of Shipment: FedEx
On Ice: yes / no
Airbill No:
Lab Name: ALS Vancouver
Lab Phone: (604) 253-4188

ATTN:

Sample Custody and Amber Springer

Special Instructions:

Tar18 PO:604564 Metals Table1 Perform Lab Dup/M on samples

Report Copy to
Bernice Kidd
(530) 229-3203

CH2M HILL, INC
ATTN: Bernice Kidd
2525 Airpark Drive
Redding CA 96001

Date Received: 09-AUG-13
Report Date: 03-OCT-13 14:17 (MT)
Version: FINAL

Client Phone: 530-229-3203

Certificate of Analysis

Lab Work Order #: L1345512

Project P.O. #:	472645.18.VG.DF PO=604564
Job Reference:	CONSTRUCT NEW VCD 2013 303.1/2
C of C Numbers:	ALS08071301
Legal Site Desc:	

Amber Springer
Account Manager

ADDRESS: 8081 Lougheed Hwy, Suite 100, Burnaby, BC V5A 1W9 Canada | Phone: +1 604 253 4188 | Fax: +1 604 253 6700
ALS CANADA LTD Part of the ALS Group A Campbell Brothers Limited Company

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1345512-1	L1345512-2	L1345512-3	L1345512-4	L1345512-5
	Description	Soil	Soil	Soil	Soil	Soil
	Sampled Date	02-AUG-13	02-AUG-13	02-AUG-13	02-AUG-13	03-AUG-13
	Sampled Time	11:31	11:45	12:18	13:25	13:56
	Client ID	CH13-303-BH002_SOA	CH13-303-BH002_SOB	CH13-303-BH002_SOC	CH13-303-BH002_SOD	CH13-303-BH002_SOE
Grouping	**Analyte**					
SOIL						
Physical Tests	Grain Size Curve			SEE ATTACHED		
	% Moisture (%)					7.07
	Moisture (%)	9.61	9.19	12.3	12.2	
	Liquid Limit (LL) (%)			22	22	24
	Plasticity Index (PI) (%)			6	6	8
Particle Size	MUST PSA % > 75um (%)		51.5			43.0

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1345512-6	L1345512-7	L1345512-8	L1345512-9	L1345512-10
	Description	Soil	Soil	Soil	Soil	Soil
	Sampled Date	03-AUG-13	03-AUG-13	03-AUG-13	03-AUG-13	03-AUG-13
	Sampled Time	14:16	14:40	16:26	16:57	17:45
	Client ID	CH13-303-BH002_SOF	CH13-303-BH002_SOG	CH13-303-BH002_SOH	CH13-303-BH002_SOI	CH13-303-BH002_SOJ
Grouping	**Analyte**					
SOIL						
Physical Tests	Grain Size Curve					
	% Moisture (%)					
	Moisture (%)	13.2	9.72	11.1	10.9	9.57
	Liquid Limit (LL) (%)			20		
	Plasticity Index (PI) (%)			5		
Particle Size	MUST PSA % > 75um (%)				48.7	52.4

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ATTERBERG-SK	Soil	Atterberg limits	CARTER CSSS 58

The liquid limit (or upper plastic limit) is the point at which the soil becomes semifluid, like softened butter. In operational terms, the liquid limit is defined as the water content at which a trapezoidal groove cut in moist soil is closed after 25 taps on a hard rubber plate (ASTM D-18, 1958).

The plastic limit (or lower plastic limit) is defined as the water content at which soil begins to crumble on being rolled into a thread 1/8 inch (or 3 mm) in diameter. It represents the lowest water content at which soil can be deformed readily without cracking.

The plastic index (which is the difference between the liquid and plastic limits) gives an indication of the "clayeyness" or plasticity of a clay and is employed in engineering classification systems for soils.

References: McKeague, J.A. 1978. Atterberg Limits pp 50 - 55 In: Soil Sampling and Methods of Analysis. Can. Soc. Soil Sci. p. 50 - 55

ALS Test Code	Matrix	Test Description	Method Reference**
GRAIN SIZE-SK	Soil	Grain Size Analysis	SSIR-51 METHOD 3.2.1

Particle size distribution is determined by a combination of techniques. Dry sieving is performed for coarse particles, wet sieving for sand particles and the pipette sedimentation method for clay particles.

Reference:

Burt, R. (2009). Soil Survey Field and Laboratory Methods Manual. Soil Survey Investigations Report No. 5. Method 3.2.1.2.2. United States Department of Agriculture Natural Resources Conservation Service.

ALS Test Code	Matrix	Test Description	Method Reference**
MOIST-SK	Soil	Moisture Content	ASTM D2216-80

The weighed portion of soil is placed in a 105°C oven overnight. The dried soil is allowed to cooled to room temperature, weighed and the % moisture is calculated.

Reference: ASTM D2216-80

ALS Test Code	Matrix	Test Description	Method Reference**
MOISTURE-VA	Soil	Moisture content	ASTM D2974-00 Method A

This analysis is carried out gravimetrically by drying the sample at 105 C for a minimum of six hours.

ALS Test Code	Matrix	Test Description	Method Reference**
PSA-MUST-SK	Soil	% Particles > 75um (Coarse/Fine)	ASTM D422-63-SIEVE

An air-dried sample is reduced to < 2 mm size and mixed with a dispersing agent (Calgon solution). The sample is washed through a 200 mesh (75 µm) sieve. The retained mass of sample is used to determine % sand fraction.

Reference: ASTM D422-63

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
SK	ALS ENVIRONMENTAL - SASKATOON, SASKATCHEWAN, CANADA
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

ALS08071301

Reference Information

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Workorder: L1345512 Report Date: 03-OCT-13

Client: CH2M HILL, INC
2525 Airpark Drive
Redding CA 96001

Contact: Bernice Kidd

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MOIST-SK	**Soil**							
Batch R2706902								
WG1759786-1 DUP		**L1345512-5**						
% Moisture		7.07	7.38		%	4.3	25	02-OCT-13
MOISTURE-VA	**Soil**							
Batch R2674267								
WG1728557-2 LCS								
Moisture			100.4		%		70-130	16-AUG-13
WG1728557-1 MB								
Moisture			<0.25		%		0.25	16-AUG-13
Batch R2674296								
WG1728528-3 DUP		**L1345512-10**						
Moisture		9.57	10.8		%	12	20	16-AUG-13
WG1728528-2 LCS								
Moisture			99.6		%		70-130	16-AUG-13
WG1728528-1 MB								
Moisture			<0.25		%		0.25	16-AUG-13
Batch R2674627								
WG1728967-2 LCS								
Moisture			99.1		%		70-130	18-AUG-13
WG1728967-1 MB								
Moisture			<0.25		%		0.25	18-AUG-13
PSA-MUST-SK	**Soil**							
Batch R2672284								
WG1725843-1 DUP		**L1345512-10**						
MUST PSA % > 75um		52.4	53.1	J	%	0.66	5	13-AUG-13
Batch R2707404								
WG1759830-1 DUP		**L1345512-5**						
MUST PSA % > 75um		43.0	43.5	J	%	0.48	5	03-OCT-13

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
J	Duplicate results and limits are expressed in terms of absolute difference.

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Physical Tests							
Moisture Content							
	5	03-AUG-13 13:56	02-OCT-13 00:00	14	59	days	EHT
Moisture content							
	3	02-AUG-13 12:18	18-AUG-13 07:45	14	16	days	EHT

Legend & Qualifier Definitions:

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR: Exceeded ALS recommended hold time prior to sample receipt.
EHTL: Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT: Exceeded ALS recommended hold time prior to analysis.
Rec. HT: ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L1345512 were received on 09-AUG-13 13:25.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

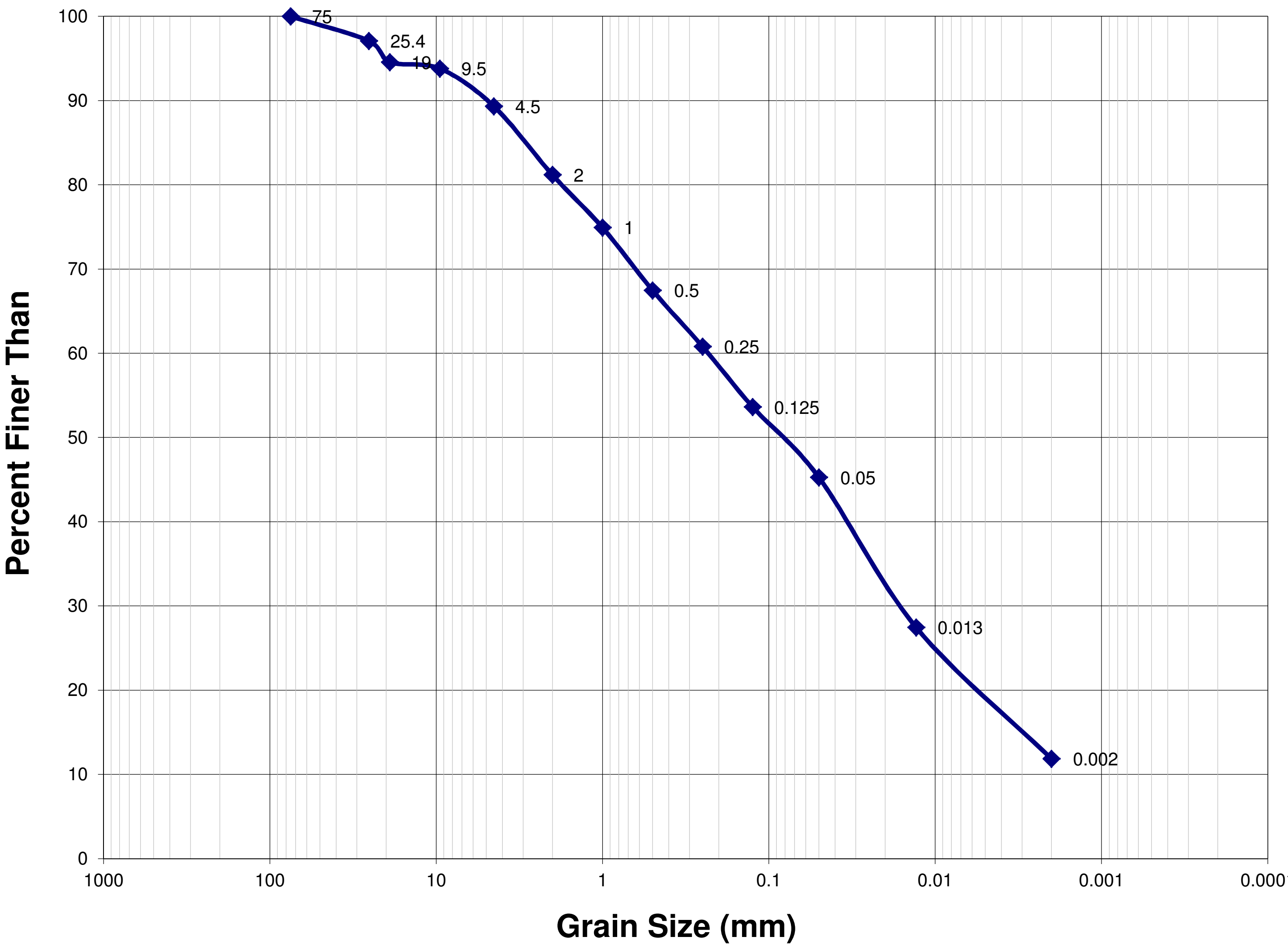
Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

819-58th Street, Saskatoon, SK S7K 6X5

Client Name: CH2M HILL, INC
Project: CHM400-CHM200-VA
Sample ID: CH13-303-BH002_SOC
Lab ID: L1345512-3

Particle Size Distribution Curve



Summary of Results

Unified Soil Classification System (USCS)

Size Class	Size Range	Wt. (%)
Cobbles	> 3"	0
Gravel	4.75mm - 3"	10
Coarse Sand	2.0mm - 4.75mm	8
Medium Sand	0.425mm - 2.0mm	14
Fine Sand	0.075mm - 0.425mm	19
Fines	< 0.075mm	48

Canadian Soil Survey Committee (CSSC)

Size Class	Size Range	Wt. (%)
Cobbles	> 3"	0
Gravel	2mm - 3"	19
Sand	0.05mm - 2mm	36
Silt	0.002mm - 0.05mm	33
Clay	< 0.002mm	12

Texture Loam

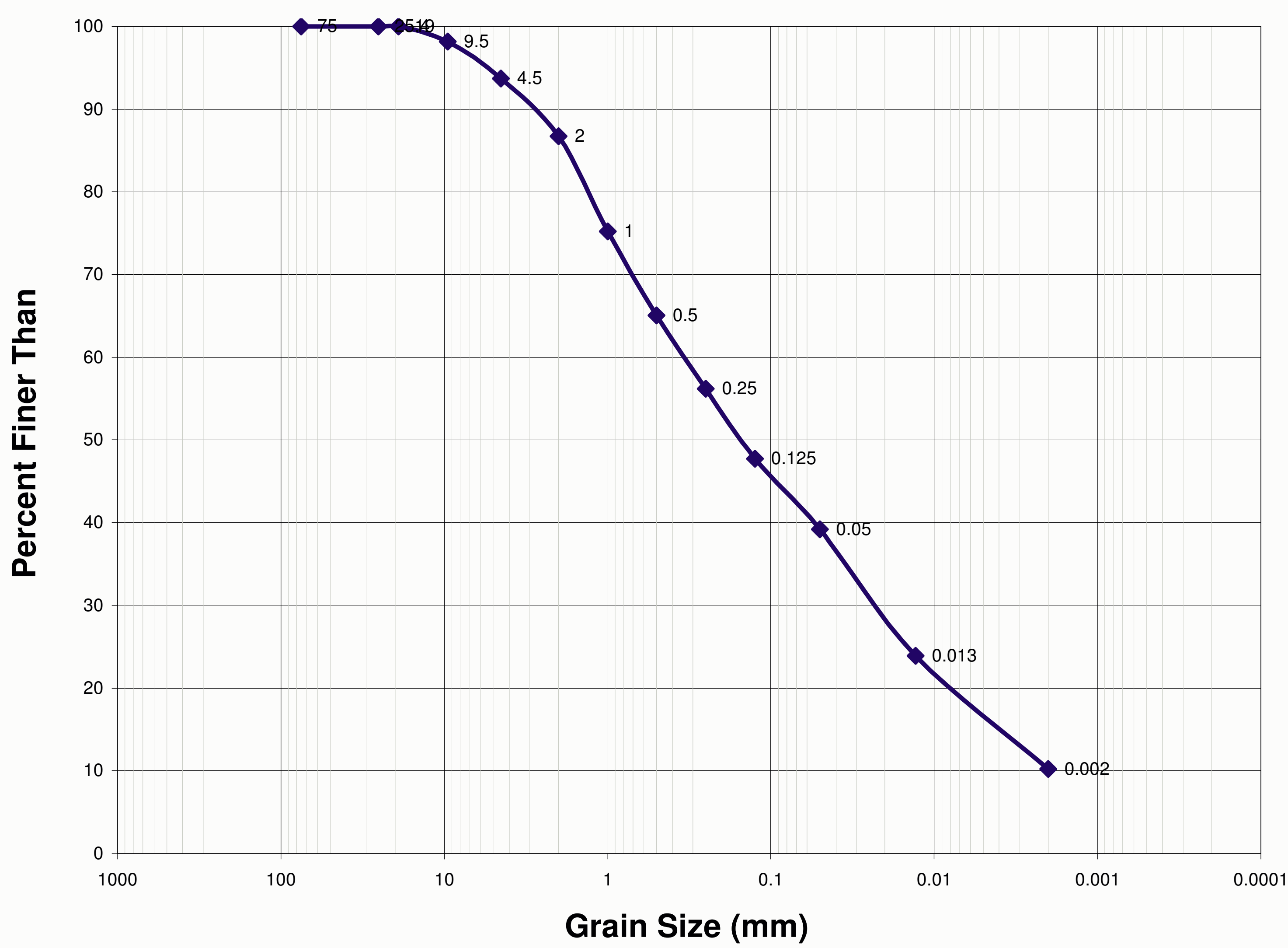
Method Reference: Can. Soc. Soil Sci. (1993) Method 47.2

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

819-58th Street, Saskatoon, SK S7K 6X5

Client Name: CH2M HILL, INC
Project: CHM400-CHM200-VA
Sample ID: CH13-303-BH002_SOD
Lab ID: L1345512-4

Particle Size Distribution Curve



Summary of Results

Unified Soil Classification System (USCS)

Size Class	Size Range	Wt. (%)
Cobbles	> 3"	0
Gravel	4.75mm - 3"	6
Coarse Sand	2.0mm - 4.75mm	7
Medium Sand	0.425mm - 2.0mm	22
Fine Sand	0.075mm - 0.425mm	23
Fines	< 0.075mm	42

Canadian Soil Survey Committee (CSSC)

Size Class	Size Range	Wt. (%)
Cobbles	> 3"	0
Gravel	2mm - 3"	13
Sand	0.05mm - 2mm	48
Silt	0.002mm - 0.05mm	29
Clay	< 0.002mm	10

Texture Sandy loam

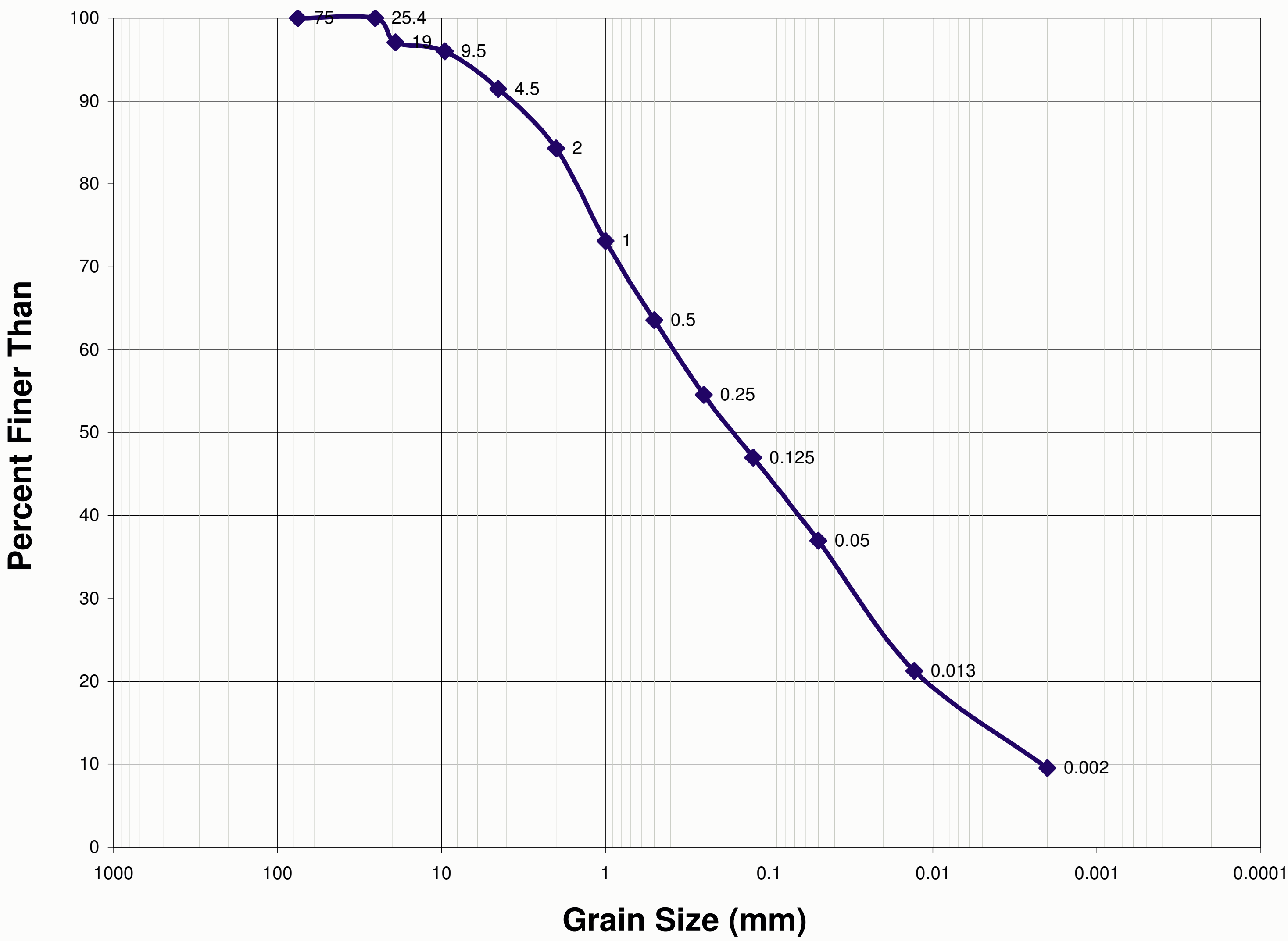
Method Reference: Can. Soc. Soil Sci. (1993) Method 47.2

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

819-58th Street, Saskatoon, SK S7K 6X5

Client Name: CH2M HILL, INC
Project: CHM400-CHM200-VA
Sample ID: CH13-303-BH002_SOF
Lab ID: L1345512-6

Particle Size Distribution Curve



Summary of Results

Unified Soil Classification System (USCS)

Size Class	Size Range	Wt. (%)
Cobbles	> 3"	0
Gravel	4.75mm - 3"	8
Coarse Sand	2.0mm - 4.75mm	7
Medium Sand	0.425mm - 2.0mm	21
Fine Sand	0.075mm - 0.425mm	23
Fines	< 0.075mm	40

Canadian Soil Survey Committee (CSSC)

Size Class	Size Range	Wt. (%)
Cobbles	> 3"	0
Gravel	2mm - 3"	16
Sand	0.05mm - 2mm	47
Silt	0.002mm - 0.05mm	27
Clay	< 0.002mm	10

Texture Sandy loam

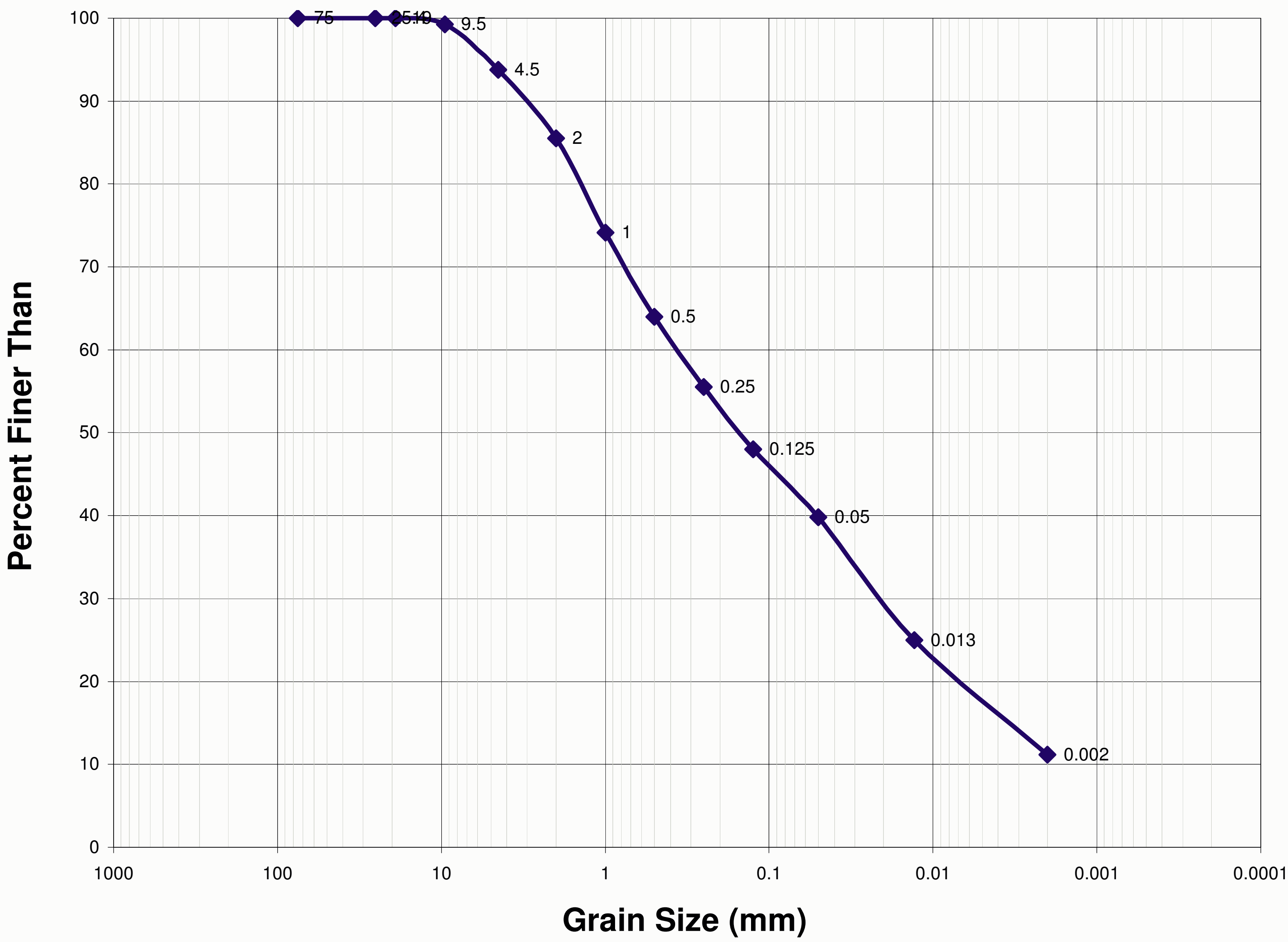
Method Reference: Can. Soc. Soil Sci. (1993) Method 47.2

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

Client Name: CH2M HILL, INC
Project: CHM400-CHM200-VA
Sample ID: CH13-303-BH002_SOG
Lab ID: L1345512-7

819-58th Street, Saskatoon, SK S7K 6X5

Particle Size Distribution Curve



Summary of Results

Unified Soil Classification System (USCS)

Size Class	Size Range	Wt. (%)
Cobbles	> 3"	0
Gravel	4.75mm - 3"	6
Coarse Sand	2.0mm - 4.75mm	9
Medium Sand	0.425mm - 2.0mm	22
Fine Sand	0.075mm - 0.425mm	21
Fines	< 0.075mm	43

Canadian Soil Survey Committee (CSSC)

Size Class	Size Range	Wt. (%)
Cobbles	> 3"	0
Gravel	2mm - 3"	15
Sand	0.05mm - 2mm	46
Silt	0.002mm - 0.05mm	29
Clay	< 0.002mm	11

Texture Sandy loam

Method Reference: Can. Soc. Soil Sci. (1993) Method 47.2

L1345512

CH2MHILL

CHAIN OF CUSTODY RECORD

8/7/2013 1:02:34 PM

Project Name Faro
Location Faro Mine Complex - Faro YK
Project Number 472645.18.VG.DF
Project Manager Jaco Esterhuizen
Sample Manager Charles Shewen

Task Order 303.1/2
Project CONSTRUCT NEW VCD 2013
Turnaround Time 10 Days
Shipping Date: 8/8/2013
COC Number: ALS08071301

L1345512-COFC

				(ASTM 2216) Moisture	(ASTM 4318) Atterberg limits	(ASTM D1140) Percent Fines Determination	(ASTM D3080) Direct Shear Test	(ASTM D422) Gradation	Number of Containers	COMMENTS
			Container:	4oz jar	1 Gallon	1 Gallon	1 Gallon	1 Gallon		
			Preservatives:	4'C	4'C	4'C	4'C	4'C		
			Filtered:	NA	NA	NA	NA	NA		
			Holding Time:	14	NA	NA	NA	NA		
	DATE	TIME	Matrix							
CH13-303-BH002_SOa	8/2/2013	11:31	Soil	x					1	
CH13-303-BH002_SOb	8/2/2013	11:45	Soil	x		x			2	
CH13-303-BH002_SOc	8/2/2013	12:18	Soil	x	x			x	3	
CH13-303-BH002_SOd	8/2/2013	13:25	Soil	x	x			x	3	
CH13-303-BH002_SOe	8/3/2013	13:56	Soil	x	x	x	x		4	
CH13-303-BH002_Sof	8/3/2013	14:16	Soil	x				x	2	
CH13-303-BH002_SOg	8/3/2013	14:40	Soil	x				x	2	
CH13-303-BH002_SOh	8/3/2013	16:26	Soil	x	x				2	
CH13-303-BH002_SOi	8/3/2013	16:57	Soil	x		x			2	
CH13-303-BH002_SOj	8/3/2013	17:45	Soil	x		x			2	
								TOTAL NUMBER OF CONTAINERS	23	

	Signatures	Date/Time
Approved by		
Sampled by		
Relinquished by	Travis Howell	8/8/13 0815
Received by		
Relinquished by	[signature]	2:20 8-Aug-13 8.9°C
Received by		

Shipping Details
Method of Shipment: FedEx
On Ice: yes / no
Airbill No:
Lab Name: ALS Vancouver
Lab Phone: (604) 253-4188

ATTN:
Sample Custody
and
Amber Springer

Special Instructions:
Tar18 PO:604564 Metals Table1 Perform Lab Dup/N on samples

Report Copy to
Bernice Kidd
(530) 229-3203

Elise Aug 9 13:25 12.7°C

CH2M HILL, INC
ATTN: Bernice Kidd
2525 Airpark Drive
Redding CA 96001

Date Received: 12-AUG-13
Report Date: 25-OCT-13 10:36 (MT)
Version: FINAL REV. 2

Client Phone: 530-229-3203

Certificate of Analysis

Lab Work Order #: L1346114

Project P.O. #:	472645.18.VG.DF, PO=604564
Job Reference:	BSI ACCESS ROAD GRANITIC OUTCROP 2013 311.5D.
C of C Numbers:	ALS08111303, ALS08111303H, ALS08111303R
Legal Site Desc:	

Comments: Paste pH could not be provided for some samples due to volume constraints.
25-OCT-13: Additional QC data has been included.

Amber Springer
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1346114-1	L1346114-2	L1346114-3	L1346114-4	L1346114-5
	Description	Soil	Soil	Soil	Soil	Soil
	Sampled Date	07-AUG-13	08-AUG-13	08-AUG-13	08-AUG-13	09-AUG-13
	Sampled Time	18:15	10:30	14:00	14:10	10:00
	Client ID	CH13-311-BH017_RKA	CH13-311-BH017_RKB	CH13-311-BH017_RKC	CH13-311-BH917_RKC	CH13-311-BH016_RKA
SOIL						
Physical Tests	Moisture (%)	<0.25	<0.25	<0.25	<0.25	0.63
	pH (1:2 soil:water) (pH)	9.19	9.19	9.33	9.22	8.63
Organic / Inorganic Carbon	Inorganic Carbon (%)	0.34	<0.10	0.14	0.12	0.93
	Inorganic Carbon (as CaCO3 Equivalent) (%)	2.83	0.83	1.18	1.01	7.77
Saturated Paste Extractables	Paste pH (pH)	7.03	7.26			7.32
Acid Base Accounting	Neutralization Potential (NP) (tCaCO3/1Kt)	17.0	7.0	10.0	9.0	77.0
Metals	Aluminum (Al) (mg/kg)	7790	9540	7360	9160	1960
	Antimony (Sb) (mg/kg)	<0.10	<0.10	<0.10	<0.10	4.19
	Arsenic (As) (mg/kg)	1.62	0.933	0.733	0.631	3.45
	Barium (Ba) (mg/kg)	10.3	30.3	24.0	29.7	44.0
	Beryllium (Be) (mg/kg)	0.72	0.28	0.46	0.51	1.13
	Bismuth (Bi) (mg/kg)	<0.20	0.59	<0.20	0.50	0.21
	Boron (B) (mg/kg)	<10	<10	<10	<10	<10
	Cadmium (Cd) (mg/kg)	0.079	<0.050	<0.050	<0.050	0.152
	Calcium (Ca) (mg/kg)	8400	2910	3490	3170	19500
	Chromium (Cr) (mg/kg)	11.4	8.79	4.83	7.31	2.82
	Cobalt (Co) (mg/kg)	2.53	3.45	2.73	3.52	6.39
	Copper (Cu) (mg/kg)	<0.50	6.44	2.33	2.78	35.0
	Iron (Fe) (mg/kg)	12300	15300	12400	15000	30300
	Lead (Pb) (mg/kg)	15.4	5.66	6.15	6.11	16.6
	Lithium (Li) (mg/kg)	82.3	126	85.0	94.9	<5.0
	Magnesium (Mg) (mg/kg)	3950	4620	3610	4370	3960
	Manganese (Mn) (mg/kg)	197	229	209	244	928
	Mercury (Hg) (mg/kg)	<0.0050	<0.0050	<0.0050	<0.0050	0.0371
	Molybdenum (Mo) (mg/kg)	<0.50	<0.50	<0.50	<0.50	0.72
	Nickel (Ni) (mg/kg)	2.48	1.74	1.30	1.82	2.72
	Phosphorus (P) (mg/kg)	501	599	438	552	654
	Potassium (K) (mg/kg)	1670	6580	5120	6220	1260
	Selenium (Se) (mg/kg)	<0.20	<0.20	<0.20	<0.20	<0.20
	Silver (Ag) (mg/kg)	<0.10	<0.10	<0.10	<0.10	0.54
	Sodium (Na) (mg/kg)	170	160	<100	120	<100
	Strontium (Sr) (mg/kg)	12.6	3.86	6.94	7.05	56.3
	Sulfur (S)-Total (mg/kg)	<500	<500	<500	<500	4600
	Thallium (Tl) (mg/kg)	0.198	0.873	0.655	0.738	0.581
	Tin (Sn) (mg/kg)	<2.0	4.8	4.4	4.9	<2.0

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1346114-6	L1346114-7	L1346114-8	L1346114-9	L1346114-10
	Description	Soil	Soil	Soil	Soil	Soil
	Sampled Date	09-AUG-13	09-AUG-13	09-AUG-13	07-AUG-13	07-AUG-13
	Sampled Time	12:00	13:34	12:10	18:15	18:15
	Client ID	CH13-311-BH016_RKB	CH13-311-BH016_RKC	CH13-311-BH916_RKB	CH13-311-BH017_RKA PH3	CH13-311-BH017_RKA PH4
Grouping	**Analyte**					
SOIL						
Physical Tests	Moisture (%)	<0.25	0.30	<0.25		
	pH (1:2 soil:water) (pH)	8.24	9.16	7.99		
Organic / Inorganic Carbon	Inorganic Carbon (%)	<0.10	0.20	<0.10		
	Inorganic Carbon (as CaCO3 Equivalent) (%)	<0.80	1.65	<0.80		
Saturated Paste Extractables	Paste pH (pH)		7.55			
Acid Base Accounting	Neutralization Potential (NP) (tCaCO3/1Kt)	2.0	12.0	2.0		
Metals	Aluminum (Al) (mg/kg)	1340	2590	1540		
	Antimony (Sb) (mg/kg)	24.4	0.51	10.5		
	Arsenic (As) (mg/kg)	10.2	0.866	17.6		
	Barium (Ba) (mg/kg)	13.0	3.84	13.0		
	Beryllium (Be) (mg/kg)	0.55	0.98	0.40		
	Bismuth (Bi) (mg/kg)	0.61	2.26	0.41		
	Boron (B) (mg/kg)	<10	<10	<10		
	Cadmium (Cd) (mg/kg)	0.106	0.087	0.072		
	Calcium (Ca) (mg/kg)	855	4450	778		
	Chromium (Cr) (mg/kg)	2.21	4.34	1.66		
	Cobalt (Co) (mg/kg)	1.27	1.29	1.85		
	Copper (Cu) (mg/kg)	34.9	2.27	14.8		
	Iron (Fe) (mg/kg)	11700	5750	13000		
	Lead (Pb) (mg/kg)	51.1	18.1	24.7		
	Lithium (Li) (mg/kg)	<5.0	11.3	<5.0		
	Magnesium (Mg) (mg/kg)	78	1070	128		
	Manganese (Mn) (mg/kg)	7.1	217	6.7		
	Mercury (Hg) (mg/kg)	0.0201	0.0221	0.0173		
	Molybdenum (Mo) (mg/kg)	0.59	<0.50	0.60		
	Nickel (Ni) (mg/kg)	0.76	1.79	1.47		
	Phosphorus (P) (mg/kg)	348	402	280		
	Potassium (K) (mg/kg)	1310	760	1240		
	Selenium (Se) (mg/kg)	<0.20	<0.20	<0.20		
	Silver (Ag) (mg/kg)	0.48	0.10	0.49		
	Sodium (Na) (mg/kg)	<100	<100	<100		
	Strontium (Sr) (mg/kg)	2.63	14.3	2.73		
	Sulfur (S)-Total (mg/kg)	10200	800	16400		
	Thallium (Tl) (mg/kg)	0.862	0.158	0.631		
	Tin (Sn) (mg/kg)	<2.0	<2.0	<2.0		

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID Description Sampled Date Sampled Time Client ID	L1346114-11 Soil 07-AUG-13 18:15 CH13-311-BH017_RKA PH5	L1346114-12 Soil 08-AUG-13 14:00 CH13-311-BH017_RKC PH3	L1346114-13 Soil 08-AUG-13 14:00 CH13-311-BH017_RKC PH4	L1346114-14 Soil 08-AUG-13 14:00 CH13-311-BH017_RKC PH5	L1346114-15 Soil 08-AUG-13 14:10 CH13-311-BH917_RKC PH3
Grouping	**Analyte**					
SOIL						
Physical Tests	Moisture (%)					
	pH (1:2 soil:water) (pH)					
Organic / Inorganic Carbon	Inorganic Carbon (%)					
	Inorganic Carbon (as CaCO3 Equivalent) (%)					
Saturated Paste Extractables	Paste pH (pH)					
Acid Base Accounting	Neutralization Potential (NP) (tCaCO3/1Kt)					
Metals	Aluminum (Al) (mg/kg)					
	Antimony (Sb) (mg/kg)					
	Arsenic (As) (mg/kg)					
	Barium (Ba) (mg/kg)					
	Beryllium (Be) (mg/kg)					
	Bismuth (Bi) (mg/kg)					
	Boron (B) (mg/kg)					
	Cadmium (Cd) (mg/kg)					
	Calcium (Ca) (mg/kg)					
	Chromium (Cr) (mg/kg)					
	Cobalt (Co) (mg/kg)					
	Copper (Cu) (mg/kg)					
	Iron (Fe) (mg/kg)					
	Lead (Pb) (mg/kg)					
	Lithium (Li) (mg/kg)					
	Magnesium (Mg) (mg/kg)					
	Manganese (Mn) (mg/kg)					
	Mercury (Hg) (mg/kg)					
	Molybdenum (Mo) (mg/kg)					
	Nickel (Ni) (mg/kg)					
	Phosphorus (P) (mg/kg)					
	Potassium (K) (mg/kg)					
	Selenium (Se) (mg/kg)					
	Silver (Ag) (mg/kg)					
	Sodium (Na) (mg/kg)					
	Strontium (Sr) (mg/kg)					
	Sulfur (S)-Total (mg/kg)					
	Thallium (Tl) (mg/kg)					
	Tin (Sn) (mg/kg)					

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1346114-16	L1346114-17	L1346114-18	L1346114-19	L1346114-20
	Description	Soil	Soil	Soil	Soil	Soil
	Sampled Date	08-AUG-13	08-AUG-13	09-AUG-13	09-AUG-13	09-AUG-13
	Sampled Time	14:10	14:10	12:00	12:00	12:00
	Client ID	CH13-311-BH917_RKC PH4	CH13-311-BH917_RKC PH5	CH13-311-BH016_RKB PH3	CH13-311-BH016_RKB PH4	CH13-311-BH016_RKB PH5
Grouping	**Analyte**					
SOIL						
Physical Tests	Moisture (%)					
	pH (1:2 soil:water) (pH)					
Organic / Inorganic Carbon	Inorganic Carbon (%)					
	Inorganic Carbon (as CaCO3 Equivalent) (%)					
Saturated Paste Extractables	Paste pH (pH)					
Acid Base Accounting	Neutralization Potential (NP) (tCaCO3/1Kt)					
Metals	Aluminum (Al) (mg/kg)					
	Antimony (Sb) (mg/kg)					
	Arsenic (As) (mg/kg)					
	Barium (Ba) (mg/kg)					
	Beryllium (Be) (mg/kg)					
	Bismuth (Bi) (mg/kg)					
	Boron (B) (mg/kg)					
	Cadmium (Cd) (mg/kg)					
	Calcium (Ca) (mg/kg)					
	Chromium (Cr) (mg/kg)					
	Cobalt (Co) (mg/kg)					
	Copper (Cu) (mg/kg)					
	Iron (Fe) (mg/kg)					
	Lead (Pb) (mg/kg)					
	Lithium (Li) (mg/kg)					
	Magnesium (Mg) (mg/kg)					
	Manganese (Mn) (mg/kg)					
	Mercury (Hg) (mg/kg)					
	Molybdenum (Mo) (mg/kg)					
	Nickel (Ni) (mg/kg)					
	Phosphorus (P) (mg/kg)					
	Potassium (K) (mg/kg)					
	Selenium (Se) (mg/kg)					
	Silver (Ag) (mg/kg)					
	Sodium (Na) (mg/kg)					
	Strontium (Sr) (mg/kg)					
	Sulfur (S)-Total (mg/kg)					
	Thallium (Tl) (mg/kg)					
	Tin (Sn) (mg/kg)					

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1346114-21	L1346114-22	L1346114-23		
	Description	Soil	Soil	Soil		
	Sampled Date	09-AUG-13	09-AUG-13	09-AUG-13		
	Sampled Time	12:10	12:10	12:10		
	Client ID	CH13-311-BH916_RKB PH3	CH13-311-BH916_RKB PH4	CH13-311-BH916_RKB PH5		
Grouping	**Analyte**					
SOIL						
Physical Tests	Moisture (%)					
	pH (1:2 soil:water) (pH)					
Organic / Inorganic Carbon	Inorganic Carbon (%)					
	Inorganic Carbon (as CaCO3 Equivalent) (%)					
Saturated Paste Extractables	Paste pH (pH)					
Acid Base Accounting	Neutralization Potential (NP) (tCaCO3/1Kt)					
Metals	Aluminum (Al) (mg/kg)					
	Antimony (Sb) (mg/kg)					
	Arsenic (As) (mg/kg)					
	Barium (Ba) (mg/kg)					
	Beryllium (Be) (mg/kg)					
	Bismuth (Bi) (mg/kg)					
	Boron (B) (mg/kg)					
	Cadmium (Cd) (mg/kg)					
	Calcium (Ca) (mg/kg)					
	Chromium (Cr) (mg/kg)					
	Cobalt (Co) (mg/kg)					
	Copper (Cu) (mg/kg)					
	Iron (Fe) (mg/kg)					
	Lead (Pb) (mg/kg)					
	Lithium (Li) (mg/kg)					
	Magnesium (Mg) (mg/kg)					
	Manganese (Mn) (mg/kg)					
	Mercury (Hg) (mg/kg)					
	Molybdenum (Mo) (mg/kg)					
	Nickel (Ni) (mg/kg)					
	Phosphorus (P) (mg/kg)					
	Potassium (K) (mg/kg)					
	Selenium (Se) (mg/kg)					
	Silver (Ag) (mg/kg)					
	Sodium (Na) (mg/kg)					
	Strontium (Sr) (mg/kg)					
	Sulfur (S)-Total (mg/kg)					
	Thallium (Tl) (mg/kg)					
	Tin (Sn) (mg/kg)					

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1346114-1	L1346114-2	L1346114-3	L1346114-4	L1346114-5
	Description	Soil	Soil	Soil	Soil	Soil
	Sampled Date	07-AUG-13	08-AUG-13	08-AUG-13	08-AUG-13	09-AUG-13
	Sampled Time	18:15	10:30	14:00	14:10	10:00
	Client ID	CH13-311-BH017_RKA	CH13-311-BH017_RKB	CH13-311-BH017_RKC	CH13-311-BH917_RKC	CH13-311-BH016_RKA
Grouping	**Analyte**					
SOIL						
Metals	Titanium (Ti) (mg/kg)	223	1300	975	1220	16.1
	Uranium (U) (mg/kg)	4.38	4.55	3.18	7.33	3.11
	Vanadium (V) (mg/kg)	18.3	30.6	22.9	28.5	8.05
	Zinc (Zn) (mg/kg)	43.5	53.9	45.2	53.1	70.3
SPLP Metals	Aluminum (Al)-Leachable (mg/L)					
	Antimony (Sb)-Leachable (mg/L)					
	Arsenic (As)-Leachable (mg/L)					
	Barium (Ba)-Leachable (mg/L)					
	Beryllium (Be)-Leachable (mg/L)					
	Bismuth (Bi)-Leachable (mg/L)					
	Boron (B)-Leachable (mg/L)					
	Cadmium (Cd)-Leachable (mg/L)					
	Calcium (Ca)-Leachable (mg/L)					
	Chromium (Cr)-Leachable (mg/L)					
	Cobalt (Co)-Leachable (mg/L)					
	Copper (Cu)-Leachable (mg/L)					
	Iron (Fe)-Leachable (mg/L)					
	Lead (Pb)-Leachable (mg/L)					
	Lithium (Li)-Leachable (mg/L)					
	Magnesium (Mg)-Leachable (mg/L)					
	Manganese (Mn)-Leachable (mg/L)					
	Mercury (Hg)-Leachable (mg/L)					
	Molybdenum (Mo)-Leachable (mg/L)					
	Nickel (Ni)-Leachable (mg/L)					
	Phosphorus (P)-Leachable (mg/L)					
	Potassium (K)-Leachable (mg/L)					
	Selenium (Se)-Leachable (mg/L)					
	Silicon (Si)-Leachable (mg/L)					
	Silver (Ag)-Leachable (mg/L)					
	Sodium (Na)-Leachable (mg/L)					
	Strontium (Sr)-Leachable (mg/L)					
	Thallium (Tl)-Leachable (mg/L)					
	Tin (Sn)-Leachable (mg/L)					
	Titanium (Ti)-Leachable (mg/L)					
	Uranium (U)-Leachable (mg/L)					
	Vanadium (V)-Leachable (mg/L)					
	Zinc (Zn)-Leachable (mg/L)					

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1346114-6	L1346114-7	L1346114-8	L1346114-9	L1346114-10
	Description	Soil	Soil	Soil	Soil	Soil
	Sampled Date	09-AUG-13	09-AUG-13	09-AUG-13	07-AUG-13	07-AUG-13
	Sampled Time	12:00	13:34	12:10	18:15	18:15
	Client ID	CH13-311-BH016_RKB	CH13-311-BH016_RKC	CH13-311-BH916_RKB	CH13-311-BH017_RKA PH3	CH13-311-BH017_RKA PH4
Grouping	**Analyte**					
SOIL						
Metals	Titanium (Ti) (mg/kg)	4.4	33.8	7.4		
	Uranium (U) (mg/kg)	0.756	6.13	0.632		
	Vanadium (V) (mg/kg)	0.21	1.18	0.53		
	Zinc (Zn) (mg/kg)	44.5	41.6	20.5		
SPLP Metals	Aluminum (Al)-Leachable (mg/L)				0.175	4.43
	Antimony (Sb)-Leachable (mg/L)				0.000051	0.000080
	Arsenic (As)-Leachable (mg/L)				0.00028	0.00157
	Barium (Ba)-Leachable (mg/L)				<0.10	<0.10
	Beryllium (Be)-Leachable (mg/L)				<0.00050	<0.00050
	Bismuth (Bi)-Leachable (mg/L)				<0.0010	<0.0010
	Boron (B)-Leachable (mg/L)				<0.10	<0.10
	Cadmium (Cd)-Leachable (mg/L)				<0.000020	0.000039
	Calcium (Ca)-Leachable (mg/L)				34.5	8.84
	Chromium (Cr)-Leachable (mg/L)				<0.00050	0.00198
	Cobalt (Co)-Leachable (mg/L)				<0.00010	0.00033
	Copper (Cu)-Leachable (mg/L)				<0.00050	<0.00050
	Iron (Fe)-Leachable (mg/L)				<0.030	1.41
	Lead (Pb)-Leachable (mg/L)				0.00060	0.00775
	Lithium (Li)-Leachable (mg/L)				0.0086	0.0146
	Magnesium (Mg)-Leachable (mg/L)				0.719	0.817
	Manganese (Mn)-Leachable (mg/L)				0.0505	0.0283
	Mercury (Hg)-Leachable (mg/L)				<0.000010	<0.000010
	Molybdenum (Mo)-Leachable (mg/L)				<0.00010	<0.00010
	Nickel (Ni)-Leachable (mg/L)				<0.00050	<0.00050
	Phosphorus (P)-Leachable (mg/L)				<0.30	<0.30
	Potassium (K)-Leachable (mg/L)				3.28	2.95
	Selenium (Se)-Leachable (mg/L)				<0.00050	<0.00050
	Silicon (Si)-Leachable (mg/L)				1.99	17.3
	Silver (Ag)-Leachable (mg/L)				<0.000050	<0.000050
	Sodium (Na)-Leachable (mg/L)				2.3	5.3
	Strontium (Sr)-Leachable (mg/L)				0.0536	0.0206
	Thallium (Tl)-Leachable (mg/L)				<0.00010	0.00012
	Tin (Sn)-Leachable (mg/L)				<0.0010	<0.0010
	Titanium (Ti)-Leachable (mg/L)				<0.010	0.372
	Uranium (U)-Leachable (mg/L)				0.00052	0.00056
	Vanadium (V)-Leachable (mg/L)				<0.0010	0.0047
	Zinc (Zn)-Leachable (mg/L)				<0.050	<0.050

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID / Description / Sampled Date / Sampled Time / Client ID		L1346114-11 Soil 07-AUG-13 18:15 CH13-311-BH017_RKA PH5	L1346114-12 Soil 08-AUG-13 14:00 CH13-311-BH017_RKC PH3	L1346114-13 Soil 08-AUG-13 14:00 CH13-311-BH017_RKC PH4	L1346114-14 Soil 08-AUG-13 14:00 CH13-311-BH017_RKC PH5	L1346114-15 Soil 08-AUG-13 14:10 CH13-311-BH917_RKC PH3
Grouping	**Analyte**					
SOIL						
Metals	Titanium (Ti) (mg/kg)					
	Uranium (U) (mg/kg)					
	Vanadium (V) (mg/kg)					
	Zinc (Zn) (mg/kg)					
SPLP Metals	Aluminum (Al)-Leachable (mg/L)	1.40	0.168	0.569	0.556	0.176
	Antimony (Sb)-Leachable (mg/L)	<0.000050	0.000100	0.000076	0.000077	0.000087
	Arsenic (As)-Leachable (mg/L)	0.00142	0.00015	0.00049	0.00064	0.00015
	Barium (Ba)-Leachable (mg/L)	<0.10	<0.10	<0.10	<0.10	<0.10
	Beryllium (Be)-Leachable (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Bismuth (Bi)-Leachable (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Boron (B)-Leachable (mg/L)	<0.10	<0.10	<0.10	<0.10	<0.10
	Cadmium (Cd)-Leachable (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
	Calcium (Ca)-Leachable (mg/L)	5.92	32.5	5.92	4.64	31.3
	Chromium (Cr)-Leachable (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Cobalt (Co)-Leachable (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Copper (Cu)-Leachable (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Iron (Fe)-Leachable (mg/L)	0.272	<0.030	0.193	0.137	<0.030
	Lead (Pb)-Leachable (mg/L)	0.00242	0.00014	0.00103	0.00052	0.00011
	Lithium (Li)-Leachable (mg/L)	0.0059	0.0119	0.0090	0.0093	0.0129
	Magnesium (Mg)-Leachable (mg/L)	0.391	2.30	0.876	0.676	2.67
	Manganese (Mn)-Leachable (mg/L)	0.00482	0.131	0.00329	0.00238	0.125
	Mercury (Hg)-Leachable (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Molybdenum (Mo)-Leachable (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Nickel (Ni)-Leachable (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Phosphorus (P)-Leachable (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Leachable (mg/L)	1.95	2.93	2.04	2.01	3.07
	Selenium (Se)-Leachable (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Silicon (Si)-Leachable (mg/L)	6.06	1.71	3.05	2.83	1.93
	Silver (Ag)-Leachable (mg/L)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
	Sodium (Na)-Leachable (mg/L)	3.3	2.8	1.6	1.5	3.2
	Strontium (Sr)-Leachable (mg/L)	0.0118	0.114	0.0277	0.0232	0.119
	Thallium (Tl)-Leachable (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
	Tin (Sn)-Leachable (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Titanium (Ti)-Leachable (mg/L)	0.039	<0.010	0.031	0.022	<0.010
	Uranium (U)-Leachable (mg/L)	0.00022	0.00116	0.00016	<0.00010	0.00202
	Vanadium (V)-Leachable (mg/L)	0.0025	<0.0010	0.0019	0.0020	<0.0010
	Zinc (Zn)-Leachable (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

Grouping	Analyte	L1346114-16	L1346114-17	L1346114-18	L1346114-19	L1346114-20
	Description	Soil	Soil	Soil	Soil	Soil
	Sampled Date	08-AUG-13	08-AUG-13	09-AUG-13	09-AUG-13	09-AUG-13
	Sampled Time	14:10	14:10	12:00	12:00	12:00
	Client ID	CH13-311-BH917_RKC PH4	CH13-311-BH917_RKC PH5	CH13-311-BH016_RKB PH3	CH13-311-BH016_RKB PH4	CH13-311-BH016_RKB PH5
SOIL						
Metals	Titanium (Ti) (mg/kg)					
	Uranium (U) (mg/kg)					
	Vanadium (V) (mg/kg)					
	Zinc (Zn) (mg/kg)					
SPLP Metals	Aluminum (Al)-Leachable (mg/L)	0.335	1.01	1.45	4.81	4.65
	Antimony (Sb)-Leachable (mg/L)	0.000087	0.000089	0.00403	0.00460	0.00621
	Arsenic (As)-Leachable (mg/L)	0.00053	0.00063	0.00140	0.00068	0.00104
	Barium (Ba)-Leachable (mg/L)	<0.10	<0.10	<0.10	<0.10	<0.10
	Beryllium (Be)-Leachable (mg/L)	<0.00050	<0.00050	0.00603	<0.00050	<0.00050
	Bismuth (Bi)-Leachable (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Boron (B)-Leachable (mg/L)	<0.10	<0.10	<0.10	<0.10	<0.10
	Cadmium (Cd)-Leachable (mg/L)	<0.000020	<0.000020	0.000136	<0.000020	<0.000020
	Calcium (Ca)-Leachable (mg/L)	6.62	4.94	7.62	2.06	1.04
	Chromium (Cr)-Leachable (mg/L)	<0.00050	<0.00050	0.00368	0.00057	0.00052
	Cobalt (Co)-Leachable (mg/L)	<0.00010	0.00010	0.00312	0.00016	0.00022
	Copper (Cu)-Leachable (mg/L)	<0.00050	<0.00050	0.00077	0.00158	0.00194
	Iron (Fe)-Leachable (mg/L)	0.081	0.335	1.52	0.540	0.571
	Lead (Pb)-Leachable (mg/L)	0.00070	0.00095	0.00678	0.00421	0.00625
	Lithium (Li)-Leachable (mg/L)	0.0089	0.0098	0.0051	0.0025	0.0035
	Magnesium (Mg)-Leachable (mg/L)	0.966	0.818	1.15	0.461	0.327
	Manganese (Mn)-Leachable (mg/L)	0.00131	0.00515	0.0914	0.00416	0.00497
	Mercury (Hg)-Leachable (mg/L)	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
	Molybdenum (Mo)-Leachable (mg/L)	<0.00010	<0.00010	<0.00010	0.00018	0.00020
	Nickel (Ni)-Leachable (mg/L)	<0.00050	<0.00050	0.00334	<0.00050	<0.00050
	Phosphorus (P)-Leachable (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Leachable (mg/L)	2.07	2.04	9.01	6.77	6.13
	Selenium (Se)-Leachable (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Silicon (Si)-Leachable (mg/L)	2.62	4.45	3.73	11.3	10.9
	Silver (Ag)-Leachable (mg/L)	<0.000050	<0.000050	<0.000050	0.000074	0.000106
	Sodium (Na)-Leachable (mg/L)	1.8	1.9	2.5	2.0	1.0
	Strontium (Sr)-Leachable (mg/L)	0.0337	0.0260	0.0304	0.0040	0.0024
	Thallium (Tl)-Leachable (mg/L)	<0.00010	<0.00010	0.00036	0.00034	0.00038
	Tin (Sn)-Leachable (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Titanium (Ti)-Leachable (mg/L)	0.014	0.043	<0.010	0.053	0.062
	Uranium (U)-Leachable (mg/L)	0.00028	0.00020	0.00186	0.00086	0.00099
	Vanadium (V)-Leachable (mg/L)	0.0017	0.0026	<0.0010	<0.0010	<0.0010
	Zinc (Zn)-Leachable (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.050

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1346114-21	L1346114-22	L1346114-23		
	Description	Soil	Soil	Soil		
	Sampled Date	09-AUG-13	09-AUG-13	09-AUG-13		
	Sampled Time	12:10	12:10	12:10		
	Client ID	CH13-311-BH916_RKB PH3	CH13-311-BH916_RKB PH4	CH13-311-BH916_RKB PH5		
Grouping	**Analyte**					
SOIL						
Metals	Titanium (Ti) (mg/kg)					
	Uranium (U) (mg/kg)					
	Vanadium (V) (mg/kg)					
	Zinc (Zn) (mg/kg)					
SPLP Metals	Aluminum (Al)-Leachable (mg/L)	1.49	4.85	4.51		
	Antimony (Sb)-Leachable (mg/L)	0.00514	0.00532	0.00580		
	Arsenic (As)-Leachable (mg/L)	0.00218	0.00162	0.00189		
	Barium (Ba)-Leachable (mg/L)	<0.10	<0.10	<0.10		
	Beryllium (Be)-Leachable (mg/L)	0.00424	<0.00050	<0.00050		
	Bismuth (Bi)-Leachable (mg/L)	<0.0010	<0.0010	<0.0010		
	Boron (B)-Leachable (mg/L)	<0.10	<0.10	<0.10		
	Cadmium (Cd)-Leachable (mg/L)	0.000370	0.000023	0.000027		
	Calcium (Ca)-Leachable (mg/L)	8.22	2.09	1.57		
	Chromium (Cr)-Leachable (mg/L)	0.00148	0.00079	0.00075		
	Cobalt (Co)-Leachable (mg/L)	0.00379	0.00033	0.00043		
	Copper (Cu)-Leachable (mg/L)	0.00427	0.00291	0.00303		
	Iron (Fe)-Leachable (mg/L)	1.17	1.06	1.08		
	Lead (Pb)-Leachable (mg/L)	0.00417	0.00521	0.00725		
	Lithium (Li)-Leachable (mg/L)	0.0060	0.0030	0.0039		
	Magnesium (Mg)-Leachable (mg/L)	1.15	0.483	0.382		
	Manganese (Mn)-Leachable (mg/L)	0.0791	0.00601	0.00692		
	Mercury (Hg)-Leachable (mg/L)	<0.000010	<0.000010	<0.000010		
	Molybdenum (Mo)-Leachable (mg/L)	<0.00010	0.00020	0.00026		
	Nickel (Ni)-Leachable (mg/L)	0.00320	0.00072	0.00066		
	Phosphorus (P)-Leachable (mg/L)	<0.30	<0.30	<0.30		
	Potassium (K)-Leachable (mg/L)	9.42	6.63	5.70		
	Selenium (Se)-Leachable (mg/L)	<0.00050	<0.00050	<0.00050		
	Silicon (Si)-Leachable (mg/L)	4.64	11.3	10.1		
	Silver (Ag)-Leachable (mg/L)	<0.000050	0.000094	0.000118		
	Sodium (Na)-Leachable (mg/L)	2.1	2.1	1.8		
	Strontium (Sr)-Leachable (mg/L)	0.0332	0.0043	0.0030		
	Thallium (Tl)-Leachable (mg/L)	0.00023	0.00031	0.00030		
	Tin (Sn)-Leachable (mg/L)	<0.0010	<0.0010	<0.0010		
	Titanium (Ti)-Leachable (mg/L)	<0.010	0.057	0.057		
	Uranium (U)-Leachable (mg/L)	0.00062	0.00056	0.00076		
	Vanadium (V)-Leachable (mg/L)	<0.0010	0.0013	0.0013		
	Zinc (Zn)-Leachable (mg/L)	<0.050	<0.050	<0.050		

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

QC Samples with Qualifiers & Comments:

QC Type Description	Parameter	Qualifier	Applies to Sample Number(s)
Method Blank	Manganese (Mn)-Leachable	MB-LOR	L1346114-12, -13, -14, -15, -16, -17, -18, -19, -20, -21, -22, -23
Method Blank	Nickel (Ni)-Leachable	MB-LOR	L1346114-12, -13, -14, -15, -16, -17, -18, -19, -20, -21, -22, -23
Method Blank	Manganese (Mn)-Leachable	MB-LOR	L1346114-12, -13, -14, -15, -16, -17, -18, -19, -20, -21, -22, -23
Method Blank	Manganese (Mn)-Leachable	MB-LOR	L1346114-12, -13, -14, -15, -16, -17, -18, -19, -20, -21, -22, -23
Matrix Spike	Calcium (Ca)	MS-B	L1346114-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Iron (Fe)	MS-B	L1346114-1, -2, -3, -4, -5, -6, -7, -8
Matrix Spike	Silicon (Si)-Leachable	MS-B	L1346114-9
Matrix Spike	Iron (Fe)-Leachable	MS-B	L1346114-10
Matrix Spike	Silicon (Si)-Leachable	MS-B	L1346114-10
Matrix Spike	Calcium (Ca)-Leachable	MS-B	L1346114-9
Matrix Spike	Magnesium (Mg)-Leachable	MS-B	L1346114-9
Matrix Spike	Aluminum (Al)-Leachable	MS-B	L1346114-10
Matrix Spike	Calcium (Ca)-Leachable	MS-B	L1346114-10
Matrix Spike	Magnesium (Mg)-Leachable	MS-B	L1346114-10
Matrix Spike	Silicon (Si)-Leachable	MS-B	L1346114-11
Matrix Spike	Calcium (Ca)-Leachable	MS-B	L1346114-11
Matrix Spike	Magnesium (Mg)-Leachable	MS-B	L1346114-11
Matrix Spike	Iron (Fe)-Leachable	MS-B	L1346114-12, -13, -14, -15, -16, -17, -18, -19, -20, -21, -22, -23
Matrix Spike	Silicon (Si)-Leachable	MS-B	L1346114-12, -13, -14, -15, -16, -17, -18, -19, -20, -21, -22, -23
Matrix Spike	Aluminum (Al)-Leachable	MS-B	L1346114-12, -13, -14, -15, -16, -17, -18, -19, -20, -21, -22, -23
Matrix Spike	Calcium (Ca)-Leachable	MS-B	L1346114-12, -13, -14, -15, -16, -17, -18, -19, -20, -21, -22, -23
Matrix Spike	Magnesium (Mg)-Leachable	MS-B	L1346114-12, -13, -14, -15, -16, -17, -18, -19, -20, -21, -22, -23

Qualifiers for Individual Parameters Listed:

Qualifier	Description
MB-LOR	Method Blank exceeds ALS DQO. Limits of Reporting have been adjusted for samples with positive hits below 5x blank level.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ACY-SHKFL96-PCT-VA	Soil	Acidity by PCT (96 hour SHAKEFLASK)	BC MINISTRY OF ENERGY AND MINES

"This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 96 hours using deionized water . The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysed using procedures adapted from APHA Method 2310 "Acidity".

ALS Test Code	Matrix	Test Description	Method Reference**
ALK-SHKFL96-PCT-VA	Soil	Alkalinity by PCT (96 hour SHAKEFLASK)	BC MINISTRY OF ENERGY AND MINES

"This analysis is based upon the extraction procedure outlined in ""Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia"" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 96 hours using deionized water . The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysed using procedures adapted from APHA Method 2320 "Alkalinity"

ALS Test Code	Matrix	Test Description	Method Reference**
B-200.2-CCMS-VA	Soil	Boron in Soil by CRC ICPMS	EPA 200.2/6020A

"This analysis is carried out using procedures from CSR Analytical Method: ""Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, 26 June 2009, and procedures adapted from EPA Method 200.2. The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve (this sieve step is omitted for international soil samples), and a representative subsample of the dry material is weighed. The sample is then digested at 95 degrees Celsius for 2 hours by block digester using concentrated nitric and hydrochloric acids. Instrumental analysis of the digested extract is by collision cell inductively coupled plasma - mass spectrometry (modifed from EPA Method 6020A).

Method Limitation: This method is not a total digestion technique. It is a very strong acid digestion that is intended to dissolve those metals that may be environmentally available. By design, elements bound in silicate structures are not normally dissolved by this procedure as they are not usually mobile in the environment."

Reference Information

C-INORG-SK	Soil	Inorganic Carbon / Calcium Carbonate	SSSA (1996) P455-456

When carbonates are decomposed with acid in an open system, carbon dioxide is released to the atmosphere. The decrease in sample weight resulting from CO2 loss is proportional to the carbonate content of the soil.

Reference:
Loeppert, R.H. and Suarez, D.L. 1996. Gravimetric Method for Loss of Carbon Dioxide. P. 455-456 In: J.M. Bartels et al. (ed.) Methods of soil analysis: Part 3 Chemical methods. (3rd ed.) ASA and SSSA, Madison, WI. Book series no. 5

EC-SHKFL96-PCT-VA	Soil	EC by PCT (96 hour SHAKEFLASK)	BC MINISTRY OF ENERGY AND MINES

"This analysis is based upon the extraction procedure outlined in ""Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 96 hours using deionized water. The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysed using procedures adapted from APHA Method 2510 "Conductivity".

HG-200.2-CVAF-VA	Soil	Mercury in Soil by CVAFS	EPA 200.2/245.7

This analysis is carried out using procedures from CSR Analytical Method: "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, 26 June 2009, and procedures adapted from EPA Method 200.2. The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve (this sieve step is omitted for international soil samples), and a representative subsample of the dry material is weighed. The sample is then digested at 95 degrees Celsius for 2 hours by block digester using concentrated nitric and hydrochloric acids. Instrumental analysis is by atomic fluorescence spectrophotometry or atomic absorption spectrophotometry(EPA Method 245.7).

Method Limitation: This method is not a total digestion technique. It is a very strong acid digestion that is intended to dissolve those metals that may be environmentally available. By design, elements bound in silicate structures are not normally dissolved by this procedure as they are not usually mobile in the environment.

HG-SHKFL96-CVAFS-VA	Soil	Mercury by CVAFS (96 hour SHAKEFLASK)	BC MINISTRY OF ENERGY AND MINES

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 96 hours using deionized water . The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysed using cold vapour atomic fluorescence spectrophotometry or atomic absorption spectrophotometry (EPA Method 245.7).

HG-SPLP-L-CVAF-VA	Soil	Low Level Mercury by CVAFS (SPLP)	EPA 1312/245.7

This analysis is carried out in accordance with the extraction procedure outlined in "Test Methods for Evaluating Solid Waste - Physical/Chemical Methods Volume 1C" SW-846 EPA Method 1312, published by the United States Environmental Protection Agency (EPA). In summary, the sample is extracted at a 20:1 liquid to solids ratio for 16 to 20 hours using water adjusted to pH 5.0 or pH 4.20 (Depending of the sampling location relative to the Mississippi river) by adding drops of 60/40 weight percent mixture of sulfuric and nitric acids. The extract is then filtered through a 0.6 to 0.8 micron glass fibre filter and analysed using atomic fluorescence spectrophotometry or atomic absorption spectrophotometry (EPA Method 245.7).

IC-CACO3-CALC-SK	Soil	Inorganic Carbon as CaCO3 Equivalent	Calculation
ME-MS81-AX	Soil		ME-MS81
MET-200.2-CCMS-VA	Soil	Metals in Soil by CRC ICPMS	EPA 200.2/6020A

This analysis is carried out using procedures from CSR Analytical Method: "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, 26 June 2009, and procedures adapted from EPA Method 200.2. The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve (this sieve step is omitted for international soil samples), and a representative subsample of the dry material is weighed. The sample is then digested at 95 degrees Celsius for 2 hours by block digester using concentrated nitric and hydrochloric acids. Instrumental analysis of the digested extract is by collision cell inductively coupled plasma - mass spectrometry (modifed from EPA Method 6020A).

Method Limitation: This method is not a total digestion technique. It is a very strong acid digestion that is intended to dissolve those metals that may be environmentally available. By design, elements bound in silicate structures are not normally dissolved by this procedure as they are not usually mobile in the environment.

MET-SHKFL96-CCMS-VA	Soil	Metals by CCMS (SHAKEFLASK - 96hours)	BC MINISTRY OF ENERGY AND MINES

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 96 hours using deionized water . The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysed using inductively coupled plasma - mass spectrophotometry (EPA Method 6020A).

Reference Information

MET-SHKFL96-ICP-VA	Soil	Metals by ICPOES (SHAKEFLASK - 96Hours)	BC MINISTRY OF ENERGY AND MINES

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines,
(Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 96 hours using deionized water . The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysed using inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-SPLP-ICP-VA	Soil	Metals by ICPOES (SPLP)	EPA 1312/6010B

This analysis is carried out in accordance with the extraction procedure outlined in "Test Methods for Evaluating Solid Waste - Physical/Chemical Methods Volume 1C" SW-846 EPA Method 1312, published by the United States Environmental Protection Agency (EPA). In summary, the sample is extracted at a 20:1 liquid to solids ratio for 16 to 20 hours using water adjusted to pH 5.0 or pH 4.20 (Depending of the sampling location relative to the Mississippi river) by adding drops of 60/40 weight percent mixture of sulfuric and nitric acids. The extract is then filtered through a 0.6 to 0.8 micron glass fiber filter and analyzed using inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-SPLP-MS-VA	Soil	Metals by ICPMS (SPLP)	EPA 1312/6020A

This analysis is carried out in accordance with the extraction procedure outlined in "Test Methods for Evaluating Solid Waste - Physical/Chemical Methods Volume 1C" SW-846 EPA Method 1312, published by the United States Environmental Protection Agency (EPA). In summary, the sample is extracted at a 20:1 liquid to solids ratio for 16 to 20 hours using water adjusted to pH 5.0 or pH 4.20 (Depending of the sampling location relative to the Mississippi river) by adding drops of 60/40 weight percent mixture of sulfuric and nitric acids. The extract is then filtered through a 0.6 to 0.8 micron glass fibre filter and analysed using inductively coupled plasma - mass spectrometry (EPA Method 6020A).

MOISTURE-VA	Soil	Moisture content	ASTM D2974-00 Method A

This analysis is carried out gravimetrically by drying the sample at 105 C for a minimum of six hours.

NP-TU	Soil	Neutralization Potential (NP)	Sobek 3.2.3, MOD
ORP-SHKFL96-VA	Soil	ORP by Electrode (96 hour SHAKEFLASK)	BC MIN. OF ENERGY AND MINES

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 96 hours using deionized water . The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysed using procedures carried out in accordance "ASTM" method D1498-00 "Oxidation-Reduction Potential of Water" published by the American Society for Testing and Materials (ASTM), May 2000. Results are reported as observed oxidation-reduction potential of the platinum metal-reference electrode employed, in mV.

PH-1:2-VA	Soil	pH in Soil (1:2 Soil:Water Extraction)	BC WLAP METHOD: PH, ELECTROMETRIC, SOIL

This analysis is carried out in accordance with procedures described in the pH, Electrometric in Soil and Sediment method - Section B Physical/Inorganic and Misc. Constituents, BC Environmental Laboratory Manual 2007. The procedure involves mixing the dried (at <60°C) and sieved (No. 10 / 2mm) sample with deionized/distilled water at a 1:2 ratio of sediment to water. The pH of the solution is then measured using a standard pH probe.

PH-PASTE-VA	Soil	pH in Soil (Paste) by Meter	Carter-CSSS / APHA 4500 H

A soil extract produced by the saturated paste extraction procedure is analyzed by pH meter.

PH-SHKFL96-MAN-VA	Soil	pH by Manual Meter (96 HOUR SHAKEFLASK)	BC MINISTRY OF ENERGY AND MINES

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 96 hours using deionized water . The extract is then allowed to settle and subsequently analysed using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

S-TOT-LECO-SK	Soil	Total Sulphur by combustion method	ISO 15178:2000

The sample is ignited in a combustion analyzer where sulfur in the reduced SO2 gas is determined using a thermal conductivity detector.

SO4-SHKFL96-TURB-VA	Soil	SO4 by Turbidimetric(96 hour SHAKEFLASK)	BC MINISTRY OF ENERGY AND MINES

This analysis is based upon the extraction procedure outlined in "Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia" BC Ministry of Energy and Mines, (Dr. William A. Price, 1997). In summary, the sample is extracted at a 3:1 liquid to solids ratio for 96 hours using deionized water. The extract is then allowed to settle and subsequently filtered through a 0.45 micron membrane filter and analysed using procedures adapted from APHA Method 4500-SO4 "Sulfate". Sulfate is determined using the turbidimetric method."

SULPHUR-S-GRA06A-AX	Soil	Sulphur (S)	S-GRA06a

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Reference Information

Laboratory Definition Code	Laboratory Location
SK	ALS ENVIRONMENTAL - SASKATOON, SASKATCHEWAN, CANADA
TU	ALS ENVIRONMENTAL - TUCSON, ARIZONA, USA
AX	ALS MINERALS - VANCOUVER, B.C., CANADA
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

ALS08111303	ALS08111303H	ALS08111303R

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: CH2M HILL, INC
2525 Airpark Drive
Redding CA 96001

Contact: Bernice Kidd

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
B-200.2-CCMS-VA	**Soil**							
Batch R2681368								
WG1732891-3 CRM		**VA-CANMET-TILL1**						
Boron (B)			3		mg/kg		0-13	27-AUG-13
WG1732891-5 CRM		**VA-CANMET-TILL1**						
Boron (B)			3		mg/kg		0-13	27-AUG-13
WG1732891-1 MB								
Boron (B)			<10		mg/kg		10	27-AUG-13
C-INORG-SK	**Soil**							
Batch R2679156								
WG1732388-10 IRM		**0.4%IC**						
Inorganic Carbon			111.7		%		80-120	24-AUG-13
WG1732388-2 IRM		**0.1%IC**						
Inorganic Carbon			122.2		%		60-140	24-AUG-13
WG1732388-3 IRM		**0.4%IC**						
Inorganic Carbon			110.2		%		80-120	24-AUG-13
WG1732388-6 IRM		**0.1%IC**						
Inorganic Carbon			80.5		%		60-140	24-AUG-13
WG1732388-7 IRM		**0.4%IC**						
Inorganic Carbon			102.3		%		80-120	24-AUG-13
WG1732388-11 MB								
Inorganic Carbon			<0.10		%		0.1	24-AUG-13
WG1732388-4 MB								
Inorganic Carbon			<0.10		%		0.1	24-AUG-13
WG1732388-8 MB								
Inorganic Carbon			<0.10		%		0.1	24-AUG-13
HG-200.2-CVAF-VA	**Soil**							
Batch R2680755								
WG1732891-3 CRM		**VA-CANMET-TILL1**						
Mercury (Hg)			102.6		%		70-130	27-AUG-13
WG1732891-1 MB								
Mercury (Hg)			<0.0050		mg/kg		0.005	27-AUG-13
HG-SPLP-L-CVAF-VA	**Soil**							
Batch R2684668								
WG1738448-1 MB								
Mercury (Hg)-Leachable			<0.000010		mg/L		0.00001	03-SEP-13
WG1738448-2 MS		**L1346114-9**						
Mercury (Hg)-Leachable			100.9		%		70-130	03-SEP-13

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
HG-SPLP-L-CVAF-VA	**Soil**							
Batch R2685406								
WG1738457-1 MB								
Mercury (Hg)-Leachable			<0.000010		mg/L		0.00001	03-SEP-13
WG1738457-2 MS		**L1346114-10**						
Mercury (Hg)-Leachable			97.8		%		70-130	03-SEP-13
Batch R2687592								
WG1739166-2 DUP		**L1346114-12**						
Mercury (Hg)-Leachable		<0.000010	<0.000010	RPD-NA	mg/L	N/A	30	05-SEP-13
WG1739166-1 MB								
Mercury (Hg)-Leachable			<0.000010		mg/L		0.00001	05-SEP-13
WG1739166-4 MB								
Mercury (Hg)-Leachable			<0.000010		mg/L		0.00001	05-SEP-13
WG1739166-5 MB								
Mercury (Hg)-Leachable			<0.000010		mg/L		0.00001	05-SEP-13
WG1739977-1 MB								
Mercury (Hg)-Leachable			<0.000010		mg/L		0.00001	05-SEP-13
WG1739977-3 MS		**L1351297-44**						
Mercury (Hg)-Leachable			89.2		%		70-130	05-SEP-13
Batch R2688499								
WG1739166-6 MS		**L1346114-20**						
Mercury (Hg)-Leachable			103.8		%		70-130	05-SEP-13
Batch R2692231								
WG1739166-2 DUP		**L1346114-12**						
Mercury (Hg)-Leachable		<0.000010	<0.000010	RPD-NA	mg/L	N/A	30	12-SEP-13
MET-200.2-CCMS-VA	**Soil**							
Batch R2681368								
WG1732891-3 CRM		**VA-CANMET-TILL1**						
Aluminum (Al)			96.1		%		70-130	27-AUG-13
Antimony (Sb)			112.1		%		70-130	27-AUG-13
Arsenic (As)			101.8		%		70-130	27-AUG-13
Barium (Ba)			98.7		%		70-130	27-AUG-13
Beryllium (Be)			0.55		mg/kg		0.34-0.74	27-AUG-13
Bismuth (Bi)			109.7		%		70-130	27-AUG-13
Cadmium (Cd)			87.9		%		70-130	27-AUG-13
Calcium (Ca)			115.9		%		70-130	27-AUG-13
Chromium (Cr)			105.5		%		70-130	27-AUG-13

ALS Environmental

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-200.2-CCMS-VA	**Soil**							
Batch R2681368								
WG1732891-3 CRM		**VA-CANMET-TILL1**						
Cobalt (Co)			101.1		%		70-130	27-AUG-13
Copper (Cu)			97.9		%		70-130	27-AUG-13
Iron (Fe)			97.7		%		70-130	27-AUG-13
Lead (Pb)			99.0		%		70-130	27-AUG-13
Lithium (Li)			114.0		%		70-130	27-AUG-13
Magnesium (Mg)			97.4		%		70-130	27-AUG-13
Manganese (Mn)			97.0		%		70-130	27-AUG-13
Molybdenum (Mo)			0.74		mg/kg		0.24-1.24	27-AUG-13
Nickel (Ni)			101.0		%		70-130	27-AUG-13
Phosphorus (P)			105.7		%		70-130	27-AUG-13
Potassium (K)			109.0		%		70-130	27-AUG-13
Selenium (Se)			0.33		mg/kg		0.12-0.52	27-AUG-13
Silver (Ag)			0.24		mg/kg		0.12-0.32	27-AUG-13
Sodium (Na)			112.9		%		70-130	27-AUG-13
Strontium (Sr)			120.0		%		70-130	27-AUG-13
Thallium (Tl)			0.132		mg/kg		0.075-0.175	27-AUG-13
Tin (Sn)			1.0		mg/kg		0-3	27-AUG-13
Titanium (Ti)			112.7		%		70-130	27-AUG-13
Uranium (U)			117.3		%		70-130	27-AUG-13
Vanadium (V)			105.8		%		70-130	27-AUG-13
Zinc (Zn)			100.5		%		70-130	27-AUG-13
WG1732891-1 MB								
Aluminum (Al)			<50		mg/kg		50	27-AUG-13
Antimony (Sb)			<0.10		mg/kg		0.1	27-AUG-13
Arsenic (As)			<0.050		mg/kg		0.05	27-AUG-13
Barium (Ba)			<0.50		mg/kg		0.5	27-AUG-13
Beryllium (Be)			<0.20		mg/kg		0.2	27-AUG-13
Bismuth (Bi)			<0.20		mg/kg		0.2	27-AUG-13
Cadmium (Cd)			<0.050		mg/kg		0.05	27-AUG-13
Calcium (Ca)			<50		mg/kg		50	27-AUG-13
Chromium (Cr)			<0.50		mg/kg		0.5	27-AUG-13
Cobalt (Co)			<0.10		mg/kg		0.1	27-AUG-13
Copper (Cu)			<0.50		mg/kg		0.5	27-AUG-13
Iron (Fe)			<50		mg/kg		50	27-AUG-13

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-200.2-CCMS-VA	**Soil**							
Batch R2681368								
WG1732891-1 MB								
Lead (Pb)			<0.50		mg/kg		0.5	27-AUG-13
Lithium (Li)			<5.0		mg/kg		5	27-AUG-13
Magnesium (Mg)			<20		mg/kg		20	27-AUG-13
Manganese (Mn)			<1.0		mg/kg		1	27-AUG-13
Molybdenum (Mo)			<0.50		mg/kg		0.5	27-AUG-13
Nickel (Ni)			<0.50		mg/kg		0.5	27-AUG-13
Phosphorus (P)			<50		mg/kg		50	27-AUG-13
Potassium (K)			<100		mg/kg		100	27-AUG-13
Selenium (Se)			<0.20		mg/kg		0.2	27-AUG-13
Silver (Ag)			<0.10		mg/kg		0.1	27-AUG-13
Sodium (Na)			<100		mg/kg		100	27-AUG-13
Strontium (Sr)			<0.50		mg/kg		0.5	27-AUG-13
Thallium (Tl)			<0.050		mg/kg		0.05	27-AUG-13
Tin (Sn)			<2.0		mg/kg		2	27-AUG-13
Titanium (Ti)			<1.0		mg/kg		1	27-AUG-13
Uranium (U)			<0.050		mg/kg		0.05	27-AUG-13
Vanadium (V)			<0.20		mg/kg		0.2	27-AUG-13
Zinc (Zn)			<1.0		mg/kg		1	27-AUG-13
WG1732891-4 MS		**L1346114-6**						
Aluminum (Al)			95.1		%		70-130	27-AUG-13
Antimony (Sb)			105.0		%		70-130	27-AUG-13
Arsenic (As)			95.3		%		70-130	27-AUG-13
Barium (Ba)			98.8		%		70-130	27-AUG-13
Beryllium (Be)			100.3		%		70-130	27-AUG-13
Bismuth (Bi)			104.0		%		70-130	27-AUG-13
Cadmium (Cd)			98.1		%		70-130	27-AUG-13
Calcium (Ca)			N/A	MS-B	%		-	27-AUG-13
Chromium (Cr)			97.7		%		70-130	27-AUG-13
Cobalt (Co)			97.7		%		70-130	27-AUG-13
Copper (Cu)			91.4		%		70-130	27-AUG-13
Iron (Fe)			N/A	MS-B	%		-	27-AUG-13
Lead (Pb)			100.3		%		70-130	27-AUG-13
Lithium (Li)			100.0		%		70-130	27-AUG-13
Magnesium (Mg)			103.8		%		70-130	27-AUG-13

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-200.2-CCMS-VA	**Soil**							
Batch R2681368								
WG1732891-4 MS		**L1346114-6**						
Manganese (Mn)			97.0		%		70-130	27-AUG-13
Molybdenum (Mo)			97.9		%		70-130	27-AUG-13
Nickel (Ni)			96.5		%		70-130	27-AUG-13
Phosphorus (P)			97.6		%		70-130	27-AUG-13
Potassium (K)			98.8		%		70-130	27-AUG-13
Selenium (Se)			90.8		%		70-130	27-AUG-13
Silver (Ag)			89.3		%		70-130	27-AUG-13
Sodium (Na)			96.5		%		70-130	27-AUG-13
Strontium (Sr)			98.4		%		70-130	27-AUG-13
Thallium (Tl)			102.0		%		70-130	27-AUG-13
Titanium (Ti)			92.3		%		70-130	27-AUG-13
Vanadium (V)			98.3		%		70-130	27-AUG-13
Zinc (Zn)			96.4		%		70-130	27-AUG-13
MET-SPLP-ICP-VA	**Soil**							
Batch R2685462								
WG1738448-1 MB								
Iron (Fe)-Leachable			<0.030		mg/L		0.03	03-SEP-13
Phosphorus (P)-Leachable			<0.30		mg/L		0.3	03-SEP-13
Silicon (Si)-Leachable			<0.050		mg/L		0.05	03-SEP-13
Titanium (Ti)-Leachable			<0.010		mg/L		0.01	03-SEP-13
WG1738457-1 MB								
Iron (Fe)-Leachable			<0.030		mg/L		0.03	03-SEP-13
Phosphorus (P)-Leachable			<0.30		mg/L		0.3	03-SEP-13
Silicon (Si)-Leachable			<0.050		mg/L		0.05	03-SEP-13
Titanium (Ti)-Leachable			<0.010		mg/L		0.01	03-SEP-13
WG1738448-2 MS		**L1346114-9**						
Iron (Fe)-Leachable			117.6		%		70-130	03-SEP-13
Phosphorus (P)-Leachable			102.6		%		70-130	03-SEP-13
Silicon (Si)-Leachable			N/A	MS-B	%		-	03-SEP-13
Titanium (Ti)-Leachable			104.8		%		70-130	03-SEP-13
WG1738457-2 MS		**L1346114-10**						
Iron (Fe)-Leachable			N/A	MS-B	%		-	03-SEP-13
Phosphorus (P)-Leachable			102.2		%		70-130	03-SEP-13
Silicon (Si)-Leachable			N/A	MS-B	%		-	03-SEP-13
Titanium (Ti)-Leachable			96.1		%		70-130	03-SEP-13

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-SPLP-ICP-VA	**Soil**							
Batch R2688277								
WG1739166-1 MB								
Iron (Fe)-Leachable			<0.030		mg/L		0.03	05-SEP-13
Phosphorus (P)-Leachable			<0.30		mg/L		0.3	05-SEP-13
Silicon (Si)-Leachable			<0.050		mg/L		0.05	05-SEP-13
Titanium (Ti)-Leachable			<0.010		mg/L		0.01	05-SEP-13
WG1739166-4 MB								
Iron (Fe)-Leachable			<0.030		mg/L		0.03	05-SEP-13
Phosphorus (P)-Leachable			<0.30		mg/L		0.3	05-SEP-13
Silicon (Si)-Leachable			<0.050		mg/L		0.05	05-SEP-13
Titanium (Ti)-Leachable			<0.010		mg/L		0.01	05-SEP-13
WG1739166-5 MB								
Iron (Fe)-Leachable			<0.030		mg/L		0.03	05-SEP-13
Phosphorus (P)-Leachable			<0.30		mg/L		0.3	05-SEP-13
Silicon (Si)-Leachable			<0.050		mg/L		0.05	05-SEP-13
Titanium (Ti)-Leachable			<0.010		mg/L		0.01	05-SEP-13
WG1739977-1 MB								
Iron (Fe)-Leachable			<0.030		mg/L		0.03	05-SEP-13
Phosphorus (P)-Leachable			<0.30		mg/L		0.3	05-SEP-13
Silicon (Si)-Leachable			<0.050		mg/L		0.05	05-SEP-13
Titanium (Ti)-Leachable			<0.010		mg/L		0.01	05-SEP-13
Batch R2689280								
WG1739166-2 DUP		**L1346114-12**						
Iron (Fe)-Leachable		<0.030	<0.030	RPD-NA	mg/L	N/A	30	08-SEP-13
Phosphorus (P)-Leachable		<0.30	<0.30	RPD-NA	mg/L	N/A	30	08-SEP-13
Silicon (Si)-Leachable		1.71	1.76		mg/L	2.9	30	08-SEP-13
Titanium (Ti)-Leachable		<0.010	<0.010	RPD-NA	mg/L	N/A	30	08-SEP-13
Batch R2689399								
WG1739977-3 MS		**L1351297-44**						
Iron (Fe)-Leachable			89.8		%		70-130	06-SEP-13
Phosphorus (P)-Leachable			104.6		%		70-130	06-SEP-13
Silicon (Si)-Leachable			N/A	MS-B	%		-	06-SEP-13
Titanium (Ti)-Leachable			103.8		%		70-130	06-SEP-13
Batch R2694426								
WG1739166-6 MS		**L1346114-20**						
Iron (Fe)-Leachable			N/A	MS-B	%		-	13-SEP-13
Phosphorus (P)-Leachable			100.2		%		70-130	13-SEP-13

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-SPLP-ICP-VA	**Soil**							
Batch R2694426								
WG1739166-6 MS		**L1346114-20**						
Silicon (Si)-Leachable			N/A	MS-B	%		-	13-SEP-13
Titanium (Ti)-Leachable			103.9		%		70-130	13-SEP-13
MET-SPLP-MS-VA	**Soil**							
Batch R2686815								
WG1738448-1 MB								
Aluminum (Al)-Leachable			<0.020		mg/L		0.02	04-SEP-13
Antimony (Sb)-Leachable			<0.000050		mg/L		0.00005	04-SEP-13
Arsenic (As)-Leachable			<0.00010		mg/L		0.0001	04-SEP-13
Barium (Ba)-Leachable			<0.10		mg/L		0.1	04-SEP-13
Beryllium (Be)-Leachable			<0.00050		mg/L		0.0005	04-SEP-13
Bismuth (Bi)-Leachable			<0.0010		mg/L		0.001	04-SEP-13
Boron (B)-Leachable			<0.10		mg/L		0.1	04-SEP-13
Cadmium (Cd)-Leachable			<0.000020		mg/L		0.00002	04-SEP-13
Calcium (Ca)-Leachable			<0.10		mg/L		0.1	04-SEP-13
Chromium (Cr)-Leachable			<0.00050		mg/L		0.0005	04-SEP-13
Cobalt (Co)-Leachable			<0.00010		mg/L		0.0001	04-SEP-13
Copper (Cu)-Leachable			<0.00050		mg/L		0.0005	04-SEP-13
Lead (Pb)-Leachable			<0.00010		mg/L		0.0001	04-SEP-13
Lithium (Li)-Leachable			<0.0010		mg/L		0.001	04-SEP-13
Magnesium (Mg)-Leachable			<0.050		mg/L		0.05	04-SEP-13
Manganese (Mn)-Leachable			<0.00010		mg/L		0.0001	04-SEP-13
Molybdenum (Mo)-Leachable			<0.00010		mg/L		0.0001	04-SEP-13
Nickel (Ni)-Leachable			<0.00050		mg/L		0.0005	04-SEP-13
Potassium (K)-Leachable			<0.050		mg/L		0.05	04-SEP-13
Selenium (Se)-Leachable			<0.00050		mg/L		0.0005	04-SEP-13
Silver (Ag)-Leachable			<0.000050		mg/L		0.00005	04-SEP-13
Sodium (Na)-Leachable			<1.0		mg/L		1	04-SEP-13
Strontium (Sr)-Leachable			<0.0010		mg/L		0.001	04-SEP-13
Thallium (Tl)-Leachable			<0.00010		mg/L		0.0001	04-SEP-13
Tin (Sn)-Leachable			<0.0010		mg/L		0.001	04-SEP-13
Uranium (U)-Leachable			<0.00010		mg/L		0.0001	04-SEP-13
Vanadium (V)-Leachable			<0.0010		mg/L		0.001	04-SEP-13
Zinc (Zn)-Leachable			<0.050		mg/L		0.05	04-SEP-13
WG1738448-2 MS		**L1346114-9**						

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-SPLP-MS-VA	**Soil**							
Batch R2686815								
WG1738448-2 MS		**L1346114-9**						
Aluminum (Al)-Leachable			95.1		%		70-130	04-SEP-13
Antimony (Sb)-Leachable			105.5		%		70-130	04-SEP-13
Arsenic (As)-Leachable			104.5		%		70-130	04-SEP-13
Barium (Ba)-Leachable			104.0		%		70-130	04-SEP-13
Beryllium (Be)-Leachable			103.5		%		70-130	04-SEP-13
Bismuth (Bi)-Leachable			97.1		%		70-130	04-SEP-13
Boron (B)-Leachable			93.8		%		70-130	04-SEP-13
Cadmium (Cd)-Leachable			97.3		%		70-130	04-SEP-13
Calcium (Ca)-Leachable			N/A	MS-B	%		-	04-SEP-13
Chromium (Cr)-Leachable			98.8		%		70-130	04-SEP-13
Cobalt (Co)-Leachable			99.4		%		70-130	04-SEP-13
Copper (Cu)-Leachable			99.1		%		70-130	04-SEP-13
Lead (Pb)-Leachable			99.99		%		70-130	04-SEP-13
Lithium (Li)-Leachable			97.8		%		70-130	04-SEP-13
Magnesium (Mg)-Leachable			N/A	MS-B	%		-	04-SEP-13
Manganese (Mn)-Leachable			93.8		%		70-130	04-SEP-13
Molybdenum (Mo)-Leachable			95.8		%		70-130	04-SEP-13
Nickel (Ni)-Leachable			97.8		%		70-130	04-SEP-13
Potassium (K)-Leachable			95.5		%		70-130	04-SEP-13
Selenium (Se)-Leachable			93.8		%		70-130	04-SEP-13
Silver (Ag)-Leachable			100.4		%		70-130	04-SEP-13
Sodium (Na)-Leachable			94.8		%		70-130	04-SEP-13
Strontium (Sr)-Leachable			88.0		%		70-130	04-SEP-13
Thallium (Tl)-Leachable			99.9		%		70-130	04-SEP-13
Tin (Sn)-Leachable			77.4		%		70-130	04-SEP-13
Vanadium (V)-Leachable			106.6		%		70-130	04-SEP-13
Zinc (Zn)-Leachable			99.2		%		70-130	04-SEP-13
Batch R2687530								
WG1738457-1 MB								
Aluminum (Al)-Leachable			<0.020		mg/L		0.02	04-SEP-13
Antimony (Sb)-Leachable			<0.000050		mg/L		0.00005	04-SEP-13
Arsenic (As)-Leachable			<0.00010		mg/L		0.0001	04-SEP-13
Barium (Ba)-Leachable			<0.10		mg/L		0.1	04-SEP-13
Beryllium (Be)-Leachable			<0.00050		mg/L		0.0005	04-SEP-13

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-SPLP-MS-VA	**Soil**							
Batch R2687530								
WG1738457-1 MB								
Bismuth (Bi)-Leachable			<0.0010		mg/L		0.001	04-SEP-13
Boron (B)-Leachable			<0.10		mg/L		0.1	04-SEP-13
Cadmium (Cd)-Leachable			<0.000020		mg/L		0.00002	04-SEP-13
Calcium (Ca)-Leachable			<0.10		mg/L		0.1	04-SEP-13
Chromium (Cr)-Leachable			<0.00050		mg/L		0.0005	04-SEP-13
Cobalt (Co)-Leachable			<0.00010		mg/L		0.0001	04-SEP-13
Copper (Cu)-Leachable			<0.00050		mg/L		0.0005	04-SEP-13
Lead (Pb)-Leachable			<0.00010		mg/L		0.0001	04-SEP-13
Lithium (Li)-Leachable			<0.0010		mg/L		0.001	04-SEP-13
Magnesium (Mg)-Leachable			<0.050		mg/L		0.05	04-SEP-13
Manganese (Mn)-Leachable			<0.00010		mg/L		0.0001	04-SEP-13
Molybdenum (Mo)-Leachable			<0.00010		mg/L		0.0001	04-SEP-13
Nickel (Ni)-Leachable			<0.00050		mg/L		0.0005	04-SEP-13
Potassium (K)-Leachable			<0.050		mg/L		0.05	04-SEP-13
Selenium (Se)-Leachable			<0.00050		mg/L		0.0005	04-SEP-13
Silver (Ag)-Leachable			<0.000050		mg/L		0.00005	04-SEP-13
Sodium (Na)-Leachable			<1.0		mg/L		1	04-SEP-13
Strontium (Sr)-Leachable			<0.0010		mg/L		0.001	04-SEP-13
Thallium (Tl)-Leachable			<0.00010		mg/L		0.0001	04-SEP-13
Tin (Sn)-Leachable			<0.0010		mg/L		0.001	04-SEP-13
Uranium (U)-Leachable			<0.00010		mg/L		0.0001	04-SEP-13
Vanadium (V)-Leachable			<0.0010		mg/L		0.001	04-SEP-13
Zinc (Zn)-Leachable			<0.050		mg/L		0.05	04-SEP-13
WG1738457-2 MS		**L1346114-10**						
Aluminum (Al)-Leachable			N/A	MS-B	%		-	04-SEP-13
Antimony (Sb)-Leachable			106.0		%		70-130	04-SEP-13
Arsenic (As)-Leachable			102.0		%		70-130	04-SEP-13
Barium (Ba)-Leachable			128.1		%		70-130	04-SEP-13
Beryllium (Be)-Leachable			104.5		%		70-130	04-SEP-13
Bismuth (Bi)-Leachable			94.1		%		70-130	04-SEP-13
Boron (B)-Leachable			94.3		%		70-130	04-SEP-13
Cadmium (Cd)-Leachable			104.1		%		70-130	04-SEP-13
Calcium (Ca)-Leachable			N/A	MS-B	%		-	04-SEP-13
Chromium (Cr)-Leachable			97.6		%		70-130	04-SEP-13

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-SPLP-MS-VA	**Soil**							
Batch R2687530								
WG1738457-2 MS		**L1346114-10**						
Cobalt (Co)-Leachable			101.9		%		70-130	04-SEP-13
Copper (Cu)-Leachable			97.8		%		70-130	04-SEP-13
Lead (Pb)-Leachable			96.4		%		70-130	04-SEP-13
Lithium (Li)-Leachable			95.4		%		70-130	04-SEP-13
Magnesium (Mg)-Leachable			N/A	MS-B	%		-	04-SEP-13
Manganese (Mn)-Leachable			95.3		%		70-130	04-SEP-13
Molybdenum (Mo)-Leachable			98.8		%		70-130	04-SEP-13
Nickel (Ni)-Leachable			98.5		%		70-130	04-SEP-13
Potassium (K)-Leachable			99.4		%		70-130	04-SEP-13
Selenium (Se)-Leachable			96.5		%		70-130	04-SEP-13
Silver (Ag)-Leachable			99.1		%		70-130	04-SEP-13
Sodium (Na)-Leachable			95.4		%		70-130	04-SEP-13
Strontium (Sr)-Leachable			94.8		%		70-130	04-SEP-13
Thallium (Tl)-Leachable			95.8		%		70-130	04-SEP-13
Tin (Sn)-Leachable			79.2		%		70-130	04-SEP-13
Vanadium (V)-Leachable			100.9		%		70-130	04-SEP-13
Zinc (Zn)-Leachable			106.3		%		70-130	04-SEP-13
Batch R2690609								
WG1739166-2 DUP		**L1346114-12**						
Antimony (Sb)-Leachable		0.000100	0.000082		mg/L	5.2	30	06-SEP-13
Arsenic (As)-Leachable		0.00015	0.00014		mg/L	7.3	30	06-SEP-13
Barium (Ba)-Leachable		<0.10	<0.10	RPD-NA	mg/L	N/A	30	06-SEP-13
Beryllium (Be)-Leachable		<0.00050	<0.00050	RPD-NA	mg/L	N/A	30	06-SEP-13
Bismuth (Bi)-Leachable		<0.0010	<0.0010	RPD-NA	mg/L	N/A	30	06-SEP-13
Boron (B)-Leachable		<0.10	<0.10	RPD-NA	mg/L	N/A	30	06-SEP-13
Cadmium (Cd)-Leachable		<0.000020	<0.000020	RPD-NA	mg/L	N/A	30	06-SEP-13
Calcium (Ca)-Leachable		32.5	30.8		mg/L	5.5	30	06-SEP-13
Chromium (Cr)-Leachable		<0.00050	<0.00050	RPD-NA	mg/L	N/A	30	06-SEP-13
Cobalt (Co)-Leachable		<0.00010	<0.00010	RPD-NA	mg/L	N/A	30	06-SEP-13
Copper (Cu)-Leachable		<0.00050	<0.00050	RPD-NA	mg/L	N/A	30	06-SEP-13
Lead (Pb)-Leachable		0.00014	0.00016		mg/L	16	30	06-SEP-13
Lithium (Li)-Leachable		0.0119	0.0121		mg/L	1.5	30	06-SEP-13
Magnesium (Mg)-Leachable		2.30	2.20		mg/L	4.3	30	06-SEP-13
Manganese (Mn)-Leachable		0.131	0.149		mg/L	13	30	06-SEP-13

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-SPLP-MS-VA	**Soil**							
Batch R2690609								
WG1739166-2 DUP		**L1346114-12**						
Molybdenum (Mo)-Leachable		<0.00010	<0.00010	RPD-NA	mg/L	N/A	30	06-SEP-13
Nickel (Ni)-Leachable		<0.00050	<0.00050	RPD-NA	mg/L	N/A	30	06-SEP-13
Potassium (K)-Leachable		2.93	3.52		mg/L	18	30	06-SEP-13
Selenium (Se)-Leachable		<0.00050	<0.00050	RPD-NA	mg/L	N/A	30	06-SEP-13
Silver (Ag)-Leachable		<0.000050	<0.000050	RPD-NA	mg/L	N/A	30	06-SEP-13
Sodium (Na)-Leachable		2.8	1.0	J	mg/L	1.8	2	06-SEP-13
Strontium (Sr)-Leachable		0.114	0.111		mg/L	2.1	30	06-SEP-13
Thallium (Tl)-Leachable		<0.00010	<0.00010	RPD-NA	mg/L	N/A	30	06-SEP-13
Tin (Sn)-Leachable		<0.0010	<0.0010	RPD-NA	mg/L	N/A	30	06-SEP-13
Uranium (U)-Leachable		0.00116	0.00115		mg/L	0.5	30	06-SEP-13
Vanadium (V)-Leachable		<0.0010	<0.0010	RPD-NA	mg/L	N/A	30	06-SEP-13
Zinc (Zn)-Leachable		<0.050	<0.050	RPD-NA	mg/L	N/A	30	06-SEP-13
WG1739166-1 MB								
Aluminum (Al)-Leachable			<0.020		mg/L		0.02	06-SEP-13
Antimony (Sb)-Leachable			<0.000050		mg/L		0.00005	06-SEP-13
Arsenic (As)-Leachable			<0.00010		mg/L		0.0001	06-SEP-13
Barium (Ba)-Leachable			<0.10		mg/L		0.1	06-SEP-13
Beryllium (Be)-Leachable			<0.00050		mg/L		0.0005	06-SEP-13
Bismuth (Bi)-Leachable			<0.0010		mg/L		0.001	06-SEP-13
Boron (B)-Leachable			<0.10		mg/L		0.1	06-SEP-13
Cadmium (Cd)-Leachable			<0.000020		mg/L		0.00002	06-SEP-13
Calcium (Ca)-Leachable			<0.10		mg/L		0.1	06-SEP-13
Chromium (Cr)-Leachable			<0.00050		mg/L		0.0005	06-SEP-13
Cobalt (Co)-Leachable			<0.00010		mg/L		0.0001	06-SEP-13
Copper (Cu)-Leachable			<0.00050		mg/L		0.0005	06-SEP-13
Lead (Pb)-Leachable			<0.00010		mg/L		0.0001	06-SEP-13
Lithium (Li)-Leachable			<0.0010		mg/L		0.001	06-SEP-13
Magnesium (Mg)-Leachable			<0.050		mg/L		0.05	06-SEP-13
Manganese (Mn)-Leachable			0.00289	MB-LOR	mg/L		0.0001	06-SEP-13
Molybdenum (Mo)-Leachable			<0.00010		mg/L		0.0001	06-SEP-13
Nickel (Ni)-Leachable			0.00069	MB-LOR	mg/L		0.0005	06-SEP-13
Potassium (K)-Leachable			<0.050		mg/L		0.05	06-SEP-13
Selenium (Se)-Leachable			<0.00050		mg/L		0.0005	06-SEP-13
Silver (Ag)-Leachable			<0.000050		mg/L		0.00005	06-SEP-13

ALS Environmental

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-SPLP-MS-VA	**Soil**							
Batch R2690609								
WG1739166-1 MB								
Sodium (Na)-Leachable			<1.0		mg/L		1	06-SEP-13
Strontium (Sr)-Leachable			<0.0010		mg/L		0.001	06-SEP-13
Thallium (Tl)-Leachable			<0.00010		mg/L		0.0001	06-SEP-13
Tin (Sn)-Leachable			<0.0010		mg/L		0.001	06-SEP-13
Uranium (U)-Leachable			<0.00010		mg/L		0.0001	06-SEP-13
Vanadium (V)-Leachable			<0.0010		mg/L		0.001	06-SEP-13
Zinc (Zn)-Leachable			<0.050		mg/L		0.05	06-SEP-13
WG1739166-4 MB								
Aluminum (Al)-Leachable			<0.020		mg/L		0.02	06-SEP-13
Antimony (Sb)-Leachable			<0.000050		mg/L		0.00005	06-SEP-13
Arsenic (As)-Leachable			<0.00010		mg/L		0.0001	06-SEP-13
Barium (Ba)-Leachable			<0.10		mg/L		0.1	06-SEP-13
Beryllium (Be)-Leachable			<0.00050		mg/L		0.0005	06-SEP-13
Bismuth (Bi)-Leachable			<0.0010		mg/L		0.001	06-SEP-13
Boron (B)-Leachable			<0.10		mg/L		0.1	06-SEP-13
Cadmium (Cd)-Leachable			<0.000020		mg/L		0.00002	06-SEP-13
Calcium (Ca)-Leachable			<0.10		mg/L		0.1	06-SEP-13
Chromium (Cr)-Leachable			<0.00050		mg/L		0.0005	06-SEP-13
Cobalt (Co)-Leachable			<0.00010		mg/L		0.0001	06-SEP-13
Copper (Cu)-Leachable			<0.00050		mg/L		0.0005	06-SEP-13
Lead (Pb)-Leachable			<0.00010		mg/L		0.0001	06-SEP-13
Lithium (Li)-Leachable			<0.0010		mg/L		0.001	06-SEP-13
Magnesium (Mg)-Leachable			<0.050		mg/L		0.05	06-SEP-13
Manganese (Mn)-Leachable			0.00102	MB-LOR	mg/L		0.0001	06-SEP-13
Molybdenum (Mo)-Leachable			<0.00010		mg/L		0.0001	06-SEP-13
Nickel (Ni)-Leachable			<0.00050		mg/L		0.0005	06-SEP-13
Potassium (K)-Leachable			<0.050		mg/L		0.05	06-SEP-13
Selenium (Se)-Leachable			<0.00050		mg/L		0.0005	06-SEP-13
Silver (Ag)-Leachable			<0.000050		mg/L		0.00005	06-SEP-13
Sodium (Na)-Leachable			<1.0		mg/L		1	06-SEP-13
Strontium (Sr)-Leachable			<0.0010		mg/L		0.001	06-SEP-13
Thallium (Tl)-Leachable			<0.00010		mg/L		0.0001	06-SEP-13
Tin (Sn)-Leachable			<0.0010		mg/L		0.001	06-SEP-13
Uranium (U)-Leachable			<0.00010		mg/L		0.0001	06-SEP-13

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-SPLP-MS-VA	**Soil**							
Batch R2690609								
WG1739166-4 MB								
Vanadium (V)-Leachable			<0.0010		mg/L		0.001	06-SEP-13
Zinc (Zn)-Leachable			<0.050		mg/L		0.05	06-SEP-13
WG1739166-5 MB								
Aluminum (Al)-Leachable			<0.020		mg/L		0.02	06-SEP-13
Antimony (Sb)-Leachable			<0.000050		mg/L		0.00005	06-SEP-13
Arsenic (As)-Leachable			<0.00010		mg/L		0.0001	06-SEP-13
Barium (Ba)-Leachable			<0.10		mg/L		0.1	06-SEP-13
Beryllium (Be)-Leachable			<0.00050		mg/L		0.0005	06-SEP-13
Bismuth (Bi)-Leachable			<0.0010		mg/L		0.001	06-SEP-13
Boron (B)-Leachable			<0.10		mg/L		0.1	06-SEP-13
Cadmium (Cd)-Leachable			<0.000020		mg/L		0.00002	06-SEP-13
Calcium (Ca)-Leachable			<0.10		mg/L		0.1	06-SEP-13
Chromium (Cr)-Leachable			<0.00050		mg/L		0.0005	06-SEP-13
Cobalt (Co)-Leachable			<0.00010		mg/L		0.0001	06-SEP-13
Copper (Cu)-Leachable			<0.00050		mg/L		0.0005	06-SEP-13
Lead (Pb)-Leachable			<0.00010		mg/L		0.0001	06-SEP-13
Lithium (Li)-Leachable			<0.0010		mg/L		0.001	06-SEP-13
Magnesium (Mg)-Leachable			<0.050		mg/L		0.05	06-SEP-13
Manganese (Mn)-Leachable			0.00081	MB-LOR	mg/L		0.0001	06-SEP-13
Molybdenum (Mo)-Leachable			<0.00010		mg/L		0.0001	06-SEP-13
Nickel (Ni)-Leachable			<0.00050		mg/L		0.0005	06-SEP-13
Potassium (K)-Leachable			<0.050		mg/L		0.05	06-SEP-13
Selenium (Se)-Leachable			<0.00050		mg/L		0.0005	06-SEP-13
Silver (Ag)-Leachable			<0.000050		mg/L		0.00005	06-SEP-13
Sodium (Na)-Leachable			<1.0		mg/L		1	06-SEP-13
Strontium (Sr)-Leachable			<0.0010		mg/L		0.001	06-SEP-13
Thallium (Tl)-Leachable			<0.00010		mg/L		0.0001	06-SEP-13
Tin (Sn)-Leachable			<0.0010		mg/L		0.001	06-SEP-13
Uranium (U)-Leachable			<0.00010		mg/L		0.0001	06-SEP-13
Vanadium (V)-Leachable			<0.0010		mg/L		0.001	06-SEP-13
Zinc (Zn)-Leachable			<0.050		mg/L		0.05	06-SEP-13
WG1739977-1 MB								
Aluminum (Al)-Leachable			<0.020		mg/L		0.02	06-SEP-13
Antimony (Sb)-Leachable			<0.000050		mg/L		0.00005	06-SEP-13
Arsenic (As)-Leachable			<0.00010		mg/L		0.0001	06-SEP-13

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-SPLP-MS-VA	**Soil**							
Batch R2690609								
WG1739977-1 MB								
Barium (Ba)-Leachable			<0.10		mg/L		0.1	06-SEP-13
Beryllium (Be)-Leachable			<0.00050		mg/L		0.0005	06-SEP-13
Bismuth (Bi)-Leachable			<0.0010		mg/L		0.001	06-SEP-13
Boron (B)-Leachable			<0.10		mg/L		0.1	06-SEP-13
Cadmium (Cd)-Leachable			<0.000020		mg/L		0.00002	06-SEP-13
Calcium (Ca)-Leachable			<0.10		mg/L		0.1	06-SEP-13
Chromium (Cr)-Leachable			<0.00050		mg/L		0.0005	06-SEP-13
Cobalt (Co)-Leachable			<0.00010		mg/L		0.0001	06-SEP-13
Copper (Cu)-Leachable			<0.00050		mg/L		0.0005	06-SEP-13
Lead (Pb)-Leachable			<0.00010		mg/L		0.0001	06-SEP-13
Lithium (Li)-Leachable			<0.0010		mg/L		0.001	06-SEP-13
Magnesium (Mg)-Leachable			<0.050		mg/L		0.05	06-SEP-13
Manganese (Mn)-Leachable			<0.00010		mg/L		0.0001	06-SEP-13
Molybdenum (Mo)-Leachable			<0.00010		mg/L		0.0001	06-SEP-13
Nickel (Ni)-Leachable			<0.00050		mg/L		0.0005	06-SEP-13
Potassium (K)-Leachable			<0.050		mg/L		0.05	06-SEP-13
Selenium (Se)-Leachable			<0.00050		mg/L		0.0005	06-SEP-13
Silver (Ag)-Leachable			<0.000050		mg/L		0.00005	06-SEP-13
Sodium (Na)-Leachable			<1.0		mg/L		1	06-SEP-13
Strontium (Sr)-Leachable			<0.0010		mg/L		0.001	06-SEP-13
Thallium (Tl)-Leachable			<0.00010		mg/L		0.0001	06-SEP-13
Tin (Sn)-Leachable			<0.0010		mg/L		0.001	06-SEP-13
Uranium (U)-Leachable			<0.00010		mg/L		0.0001	06-SEP-13
Vanadium (V)-Leachable			<0.0010		mg/L		0.001	06-SEP-13
Zinc (Zn)-Leachable			<0.050		mg/L		0.05	06-SEP-13
WG1739977-3 MS		**L1351297-44**						
Aluminum (Al)-Leachable			96.4		%		70-130	06-SEP-13
Antimony (Sb)-Leachable			104.1		%		70-130	06-SEP-13
Arsenic (As)-Leachable			98.9		%		70-130	06-SEP-13
Barium (Ba)-Leachable			109.2		%		70-130	06-SEP-13
Beryllium (Be)-Leachable			108.7		%		70-130	06-SEP-13
Bismuth (Bi)-Leachable			97.0		%		70-130	06-SEP-13
Boron (B)-Leachable			88.9		%		70-130	06-SEP-13
Cadmium (Cd)-Leachable			101.6		%		70-130	06-SEP-13

Quality Control Report

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-SPLP-MS-VA	**Soil**							
Batch R2690609								
WG1739977-3 MS		**L1351297-44**						
Calcium (Ca)-Leachable			N/A	MS-B	%		-	06-SEP-13
Chromium (Cr)-Leachable			97.3		%		70-130	06-SEP-13
Cobalt (Co)-Leachable			99.1		%		70-130	06-SEP-13
Copper (Cu)-Leachable			98.4		%		70-130	06-SEP-13
Lead (Pb)-Leachable			99.1		%		70-130	06-SEP-13
Lithium (Li)-Leachable			102.1		%		70-130	06-SEP-13
Magnesium (Mg)-Leachable			N/A	MS-B	%		-	06-SEP-13
Manganese (Mn)-Leachable			97.2		%		70-130	06-SEP-13
Molybdenum (Mo)-Leachable			101.3		%		70-130	06-SEP-13
Nickel (Ni)-Leachable			96.4		%		70-130	06-SEP-13
Potassium (K)-Leachable			94.8		%		70-130	06-SEP-13
Selenium (Se)-Leachable			98.1		%		70-130	06-SEP-13
Silver (Ag)-Leachable			101.5		%		70-130	06-SEP-13
Sodium (Na)-Leachable			89.9		%		70-130	06-SEP-13
Strontium (Sr)-Leachable			98.9		%		70-130	06-SEP-13
Thallium (Tl)-Leachable			98.4		%		70-130	06-SEP-13
Vanadium (V)-Leachable			104.8		%		70-130	06-SEP-13
Zinc (Zn)-Leachable			103.9		%		70-130	06-SEP-13
Batch R2691278								
WG1739166-2 DUP		**L1346114-12**						
Aluminum (Al)-Leachable		0.168	0.168		mg/L	0.2	30	10-SEP-13
Batch R2694449								
WG1739166-6 MS		**L1346114-20**						
Aluminum (Al)-Leachable			N/A	MS-B	%		-	16-SEP-13
Antimony (Sb)-Leachable			103.4		%		70-130	16-SEP-13
Arsenic (As)-Leachable			100.3		%		70-130	16-SEP-13
Barium (Ba)-Leachable			125.5		%		70-130	16-SEP-13
Beryllium (Be)-Leachable			102.7		%		70-130	16-SEP-13
Bismuth (Bi)-Leachable			102.1		%		70-130	16-SEP-13
Boron (B)-Leachable			100.3		%		70-130	16-SEP-13
Cadmium (Cd)-Leachable			104.3		%		70-130	16-SEP-13
Calcium (Ca)-Leachable			N/A	MS-B	%		-	16-SEP-13
Chromium (Cr)-Leachable			101.1		%		70-130	16-SEP-13
Cobalt (Co)-Leachable			103.4		%		70-130	16-SEP-13

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-SPLP-MS-VA	**Soil**							
Batch R2694449								
WG1739166-6 MS		**L1346114-20**						
Copper (Cu)-Leachable			100.3		%		70-130	16-SEP-13
Lead (Pb)-Leachable			103.5		%		70-130	16-SEP-13
Lithium (Li)-Leachable			93.5		%		70-130	16-SEP-13
Magnesium (Mg)-Leachable			N/A	MS-B	%		-	16-SEP-13
Manganese (Mn)-Leachable			100.3		%		70-130	16-SEP-13
Molybdenum (Mo)-Leachable			97.2		%		70-130	16-SEP-13
Nickel (Ni)-Leachable			98.2		%		70-130	16-SEP-13
Potassium (K)-Leachable			98.6		%		70-130	16-SEP-13
Selenium (Se)-Leachable			95.2		%		70-130	16-SEP-13
Silver (Ag)-Leachable			88.9		%		70-130	16-SEP-13
Sodium (Na)-Leachable			95.5		%		70-130	16-SEP-13
Strontium (Sr)-Leachable			95.0		%		70-130	16-SEP-13
Thallium (Tl)-Leachable			102.4		%		70-130	16-SEP-13
Tin (Sn)-Leachable			71.9		%		70-130	16-SEP-13
Vanadium (V)-Leachable			104.4		%		70-130	16-SEP-13
Zinc (Zn)-Leachable			103.1		%		70-130	16-SEP-13
MOISTURE-VA	**Soil**							
Batch R2679009								
WG1733279-3 DUP		**L1346114-1**						
Moisture		<0.25	<0.25	RPD-NA	%	N/A	20	23-AUG-13
WG1733279-2 LCS								
Moisture			99.4		%		70-130	23-AUG-13
WG1733279-1 MB								
Moisture			<0.25		%		0.25	23-AUG-13
S-TOT-LECO-SK	**Soil**							
Batch R2679089								
WG1733301-1 DUP		**L1346114-5**						
Sulfur (S)-Total		4600	4900		mg/kg	6.4	30	24-AUG-13
WG1733301-2 IRM		**1646A_SOIL**						
Sulfur (S)-Total			3600		mg/kg		2500-4600	24-AUG-13
WG1733301-3 MB								
Sulfur (S)-Total			<500		mg/kg		500	24-AUG-13

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
J	Duplicate results and limits are expressed in terms of absolute difference.
MB-LOR	Method Blank exceeds ALS DQO. Limits of Reporting have been adjusted for samples with positive hits below 5x blank level.
MS-B	Matrix Spike recovery could not be accurately calculated due to high analyte background in sample.
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Physical Tests							
Moisture content							
	1	07-AUG-13 18:15	23-AUG-13 10:53	14	16	days	EHT
	2	08-AUG-13 10:30	23-AUG-13 10:53	14	15	days	EHT
	3	08-AUG-13 14:00	23-AUG-13 10:53	14	15	days	EHT
	4	08-AUG-13 14:10	23-AUG-13 10:53	14	15	days	EHT
Organic / Inorganic Carbon							
Inorganic Carbon / Calcium Carbonate							
	1	07-AUG-13 18:15	24-AUG-13 00:00	14	16	days	EHT
	2	08-AUG-13 10:30	24-AUG-13 00:00	14	16	days	EHT
	3	08-AUG-13 14:00	24-AUG-13 00:00	14	15	days	EHT
	4	08-AUG-13 14:10	24-AUG-13 00:00	14	15	days	EHT
	5	09-AUG-13 10:00	24-AUG-13 00:00	14	15	days	EHT
	6	09-AUG-13 12:00	24-AUG-13 00:00	14	15	days	EHT
Inorganic Carbon as CaCO3 Equivalent							
	1	07-AUG-13 18:15	24-AUG-13 18:10	14	17	days	EHT
	2	08-AUG-13 10:30	24-AUG-13 18:10	14	16	days	EHT
	3	08-AUG-13 14:00	24-AUG-13 18:10	14	16	days	EHT
	4	08-AUG-13 14:10	24-AUG-13 18:10	14	16	days	EHT
	5	09-AUG-13 10:00	24-AUG-13 18:10	14	15	days	EHT
	6	09-AUG-13 12:00	24-AUG-13 18:10	14	15	days	EHT
	7	09-AUG-13 13:34	24-AUG-13 18:10	14	15	days	EHT
	8	09-AUG-13 12:10	24-AUG-13 18:10	14	15	days	EHT
SPLP Metals							
Low Level Mercury by CVAFS (SPLP)							
	11	07-AUG-13 18:15	05-SEP-13 11:52	28	29	days	EHT
	12	08-AUG-13 14:00	07-SEP-13 16:28	28	30	days	EHT

Legend & Qualifier Definitions:

EHTR-FM:	Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR:	Exceeded ALS recommended hold time prior to sample receipt.
EHTL:	Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT:	Exceeded ALS recommended hold time prior to analysis.
Rec. HT:	ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L1346114 were received on 12-AUG-13 10:15.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Environmental

September 19, 2013

Client: ALS Environmental- Canada
8081 Lougheed Hwy, Ste 100
Burnaby, BC V5A 1W9
CANADA

Attn: Amber Springer

Project: L1346114

Date Received: August 23, 2013

Certificate of Analysis

Client ID:	Sample Date:		Lab #:		Moisture, Total 3.1 wt%	Neutralization Potential Sobek 3.2.3, MOD $tCaCO_3/1,000t$
L1346114- 1	8/7/2013	0000	T1301245- 001		0.27	17
L1346114- 2	8/8/2013	0000	T1301245- 002		0.17	7
L1346114- 3	8/8/2013	0000	T1301245- 003		0.19	10
L1346114- 4	8/8/2013	0000	T1301245- 004		0.32	9
L1346114- 5	8/9/2013	0000	T1301245- 005		0.70	77
L1346114- 6	8/9/2013	0000	T1301245- 006		0.26	2
L1346114- 7	8/9/2013	0000	T1301245- 007		0.74	12
L1346114- 8	8/9/2013	0000	T1301245- 008		0.09	2

Notes:
Samples were air dried then ground to < 60 mesh.

W. Hyatt
Digitally signed by Wendy Hyatt
Date: 2013.09.19 09:27:07 -07'00'

Wendy Hyatt, Project Chemist

ADDRESS 3860 S. Palo Verde Road, Suite 302, Tucson, AZ 85714
PHONE +1 520 573 1061
FAX +1 520 573 1063

ALS Environmental

September 19, 2013

Client: ALS Environmental- Canada
8081 Lougheed Hwy, Ste 100
Burnaby, BC V5A 1W9
CANADA
Attn: Amber Springer
Project: L1346114 Date Received: August 23, 2013

Quality Control

		Moisture, Total	Neutralization Potential
		3.1	Sobek 3.2.3, MOD
		wt%	$tCaCO_3/1,000t$
Prep Blank		0.03	< 1
Laboratory Control Sample (LCS) - Rice Flour CN 3451	Observed Value	9.67	n/a
	True Value	9.50	
	%R	**102**	
Laboratory Control Sample (LCS) - Na_2CO3 CN 1045	Observed Value	n/a	998
	True Value		1,000
	%R		**100**
Laboratory Control Sample (LCS) - Na_2CO3 CN 1045	Observed Value	n/a	966
	True Value		1,000
	%R		**97**
Duplicate Results	T1301245- 001	0.08 **	
	Duplicate	0.05 **	
	%R	**46**	
Duplicate Results		*T1301229- 006	22
		Duplicate	23
		%RPD	**4**
Duplicate Results		T1301245- 002	7
		Duplicate	6
		%RPD	**15**

September 19, 2013

Client: ALS Environmental- Canada
8081 Lougheed Hwy, Ste 100
Burnaby, BC V5A 1W9
CANADA
Attn: Amber Springer
Project: L1346114

Date Received: August 23, 2013

Quality Control

				Moisture, Total	Neutralization Potential
				3.1	Sobek 3.2.3, MOD
				wt%	$tCaCO_3/1,000t$

* Sample from the same batch, but a different project.

**Residual moisture - does not include air dry moisture.

CH2MHILL

CHAIN OF CUSTODY RECORD

8/11/2013 8:40:25 AM

Project Name Faro
Location Faro Mine Complex - Faro YK
Project Number 472645.18.VG.DF
Project Manager Heather MacDonald
Sample Manager Charles Shewen

Container: 1 Gallon
Preservatives: 4'C
Filtered: NA
Holding Time: 180

Task Order 311.5D.
Project BSI ACCESS ROAD GRANITIC OUTCROP 2013
Turnaround Time 3 Days
Shipping Date: 8/11/2013
COC Number: ALS08111303R

L1346114-COFC

	DATE	TIME	Matrix	(ISO 15178-2000) Total Sulphur	Number of Containers	COMMENTS
CH13-311-BH017_RKa	8/7/2013	18:15	Soil	X	1	
CH13-311-BH017_RKb	8/8/2013	10:30	Soil	X	1	
CH13-311-BH017_RKc	8/8/2013	14:00	Soil	X	1	
CH13-311-BH917_RKc	8/8/2013	14:10	Soil	X	1	
CH13-311-BH016_RKa	8/9/2013	10:00	Soil	X	1	
CH13-311-BH016_RKb	8/9/2013	12:00	Soil	X	1	
CH13-311-BH016_RKc	8/9/2013	13:34	Soil	X	1	
CH13-311-BH916_RKb	8/9/2013	12:10	Soil	X	1	
TOTAL NUMBER OF CONTAINERS					8	

	Signatures	Date/Time
Approved by		
Sampled by	[signature]	8/11/13 1200
Relinquished by		
Received by		
Relinquished by		
Received by		

Shipping Details
Method of Shipment: FedEx
On Ice: yes / no
Airbill No:
Lab Name: ALS Vancouver
Lab Phone: (604) 253-4188

ATTN:
Sample Custody
and
Amber Springer

Special Instructions:
Tar18 PO:604564 Metals Table1 Perform Lab Dup/MS on samples

Report Copy to
Bernice Kidd
(530) 229-3203

CH2MHILL

CHAIN OF CUSTODY RECORD

Project Name Faro
Location Faro Mine Complex - Faro YK
Project Number 472645.18.VG.DF
Project Manager Heather MacDonald
Sample Manager Charles Shewen

Task Order 311.5D.
Project BSI ACCESS ROAD GRANITIC OUTCROP 2013
Turnaround Time 10 Days
Shipping Date: 8/11/2013
COC Number: ALS08111303

			Container:	1 Gallon	1 Gallon	1 Gallon	1 Gallon	1 Gallon	
			Preservatives:	4'C	4'C	4'C	4'C	4'C	
			Filtered:	NA	NA	NA	NA	NA	
			Holding Time:	28	14	28	28	14	
	DATE	TIME	Matrix	(CSSS/APHA4500H) Paste pH	(EPA200.0/245.7/SW6020A) Total Metals Table 1	(ModifiedSobek) Mod Neutralization Potential	(SSSA (1996) P455-456) TIC	(SW1312/245.7/6020) SPLP Leach/Dissolved Metals	Number of Containers
CH13-311-BH017_RKa	8/7/2013	18:15	Soil	X	X	X	X	X	2
CH13-311-BH017_RKb	8/8/2013	10:30	Soil	X	X	X	X		2
CH13-311-BH017_RKc	8/8/2013	14:00	Soil	X	X	X	X	X	2
CH13-311-BH917_RKc	8/8/2013	14:10	Soil	X	X	X	X	X	2
CH13-311-BH016_RKa	8/9/2013	10:00	Soil	X	X	X	X		2
CH13-311-BH016_RKb	8/9/2013	12:00	Soil	X	X	X	X	X	2
CH13-311-BH016_RKc	8/9/2013	13:34	Soil	X	X	X	X		2
CH13-311-BH916_RKb	8/9/2013	12:10	Soil	X	X	X	X	X	2
								TOTAL NUMBER OF CONTAINERS	16

L1346114-COFC

COMMENTS

	Signatures	Date/Time
Approved by		
Sampled by		
Relinquished by	[signature]	8/11/13 1200
Received by		
Relinquished by		
Received by		

Shipping Details
Method of Shipment: FedEx
On Ice: yes / no
Airbill No:
Lab Name: ALS Vancouver
Lab Phone: (604) 253-4188

ATTN:
Sample Custody and Amber Springer

Special Instructions:
Tar18 PO:604564 Metals Table1 Perform Lab Dup/MS on samples

Report Copy to
Bernice Kidd
(530) 229-3203

CH2MHILL

CHAIN OF CUSTODY RECORD

8/11/2013 8:40:10 AM

Project Name Faro
Location Faro Mine Complex - Faro YK
Project Number 472645.18.VG.DF
Project Manager Heather MacDonald
Sample Manager Charles Shewen

Task Order 311.5D.
Project BSI ACCESS ROAD GRANITIC OUTCROP 2013
Turnaround Time 10 Days
Shipping Date: 8/11/2013
COC Number: ALS08111303H

L1346114-COFC

				(DI/APHA2510) DI Conductivity	(DI/APHA4500H) DI pH	(DI/ASTMD1498) DI ORP	(DI/E245.7) DI Diss Mercury	(DI/E300) DI Sulphate	(DI/EPA600/2-78-054) Acid Soluable Sulfate	(DI/SM2310) DI Acidity	(DI/SM2320) DI Alkalinity	(DI/SW6020A) DI Diss Metals	(SW6020A) Ba(Li) Metaborate	Number of Containers	COMMENTS
			Container:	1 Gallon	1 Gallon	1 Gallon	1 Gallon	1 Gallon	1 Gallon	1 Gallon	1 Gallon	1 Gallon	1 Gallon		
			Preservatives:	4'C	4'C	4'C	4'C	4'C	4'C	4'C	4'C	4'C	4'C		
			Filtered:	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA		
			Holding Time:	14	14	14	14	180	180	14	14	14	14		
	DATE	TIME	Matrix												
CH13-311-BH017_RKa	8/7/2013	18:15	Soil	X	X	X	X	X	X	X	X	X	X	3	
CH13-311-BH017_RKb	8/8/2013	10:30	Soil	X	X	X	X	X		X	X	X		3	
CH13-311-BH017_RKc	8/8/2013	14:00	Soil	X	X	X	X	X	X	X	X	X	X	3	
CH13-311-BH917_RKc	8/8/2013	14:10	Soil	X	X	X	X	X	X	X	X	X	X	3	
CH13-311-BH016_RKa	8/9/2013	10:00	Soil	X	X	X	X	X		X	X	X		3	
CH13-311-BH016_RKb	8/9/2013	12:00	Soil	X	X	X	X	X	X	X	X	X	X	3	
CH13-311-BH016_RKc	8/9/2013	13:34	Soil	X	X	X	X	X		X	X	X		3	
CH13-311-BH916_RKb	8/9/2013	12:10	Soil	X	X	X	X	X	X	X	X	X	X	3	
													TOTAL NUMBER OF CONTAINERS	24	

	Signatures	Date/Time
Approved by	[signature]	8/11/13 1200
Sampled by		
Relinquished by		
Received by		
Relinquished by		
Received by		

Shipping Details

Method of Shipment: FedEx
On Ice: yes / no
Airbill No:
Lab Name: ALS Vancouver
Lab Phone: (604) 253-4188

ATTN:

Sample Custody
and
Amber Springer

Special Instructions:

Tar18 PO:604564 Metals Table1 Perform Lab Dup/MS on samples

Report Copy to
Bernice Kidd
(530) 229-3203

CH2M HILL, INC
ATTN: Bernice Kidd
2525 Airpark Drive
Redding CA 96001

Date Received: 13-AUG-13
Report Date: 22-AUG-13 12:28 (MT)
Version: FINAL

Client Phone: 530-229-3203

Certificate of Analysis

Lab Work Order #: L1347043

Project P.O. #:	472645.18.VG.DF PO=604564
Job Reference:	CONSTRUCT NEW VCD 2013 303. 1/2
C of C Numbers:	ALS08111301
Legal Site Desc:	

Amber Springer
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID Description Sampled Date Sampled Time Client ID	L1347043-1 SOIL 05-AUG-13 10:46 CH13-303-BH003_SOA	L1347043-2 SOIL 05-AUG-13 11:17 CH13-303-BH003_SOB	L1347043-3 SOIL 05-AUG-13 11:35 CH13-303-BH003_SOC	L1347043-4 SOIL 05-AUG-13 11:59 CH13-303-BH003_SOD	L1347043-5 SOIL 05-AUG-13 12:15 CH13-303-BH003_SOE
Grouping	**Analyte**					
SOIL						
Physical Tests	Grain Size Curve		SEE ATTACHED			
	Moisture (%)	4.78	9.91	9.65	9.06	9.21
	Liquid Limit (LL) (%)		29		23	24
	Plasticity Index (PI) (%)		12		8	9
Particle Size	MUST PSA % > 75um (%)					

ALS ENVIRONMENTAL ANALYTICAL REPORT

		L1347043-6	L1347043-7	L1347043-8	L1347043-9	L1347043-10
	Description	SOIL	SOIL	SOIL	SOIL	SOIL
	Sampled Date	05-AUG-13	05-AUG-13	05-AUG-13	05-AUG-13	05-AUG-13
	Sampled Time	12:55	13:43	14:18	15:00	16:04
	Client ID	CH13-303-BH003_SOF	CH13-303-BH003_SOG	CH13-303-BH003_SOH	CH13-303-BH003_SOI	CH13-303-BH003_SOJ
Grouping	**Analyte**					
SOIL						
Physical Tests	Grain Size Curve	SEE ATTACHED	SEE ATTACHED		SEE ATTACHED	
	Moisture (%)	10.4	9.49		9.05	10.5
	Liquid Limit (LL) (%)	24			22	
	Plasticity Index (PI) (%)	7			6	
Particle Size	MUST PSA % > 75um (%)			48.9		

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1347043-11	L1347043-12	L1347043-13	L1347043-14	L1347043-15
	Description	SOIL	SOIL	SOIL	SOIL	SOIL
	Sampled Date	05-AUG-13	06-AUG-13	06-AUG-13	06-AUG-13	06-AUG-13
	Sampled Time	13:53	09:23	10:02	11:01	14:06
	Client ID	CH13-303-BH903_SOG	CH13-303-BH003_SOK	CH13-303-BH003_SOL	CH13-303-BH003_SOM	CH13-303-BH003_SON
Grouping	**Analyte**					
SOIL						
Physical Tests	Grain Size Curve	SEE ATTACHED				SEE ATTACHED
	Moisture (%)	11.6		9.60	9.32	11.8
	Liquid Limit (LL) (%)		22		20	29
	Plasticity Index (PI) (%)		7		5	12
Particle Size	MUST PSA % > 75um (%)					

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ATTERBERG-SK	Soil	Atterberg limits	CARTER CSSS 58

The liquid limit (or upper plastic limit) is the point at which the soil becomes semifluid, like softened butter. In operational terms, the liquid limit is defined as the water content at which a trapezoidal groove cut in moist soil is closed after 25 taps on a hard rubber plate (ASTM D-18, 1958).

The plastic limit (or lower plastic limit) is defined as the water content at which soil begins to crumble on being rolled into a thread 1/8 inch (or 3 mm) in diameter. It represents the lowest water content at which soil can be deformed readily without cracking.

The plastic index (which is the difference between the liquid and plastic limits) gives an indication of the "clayeyness" or plasticity of a clay and is employed in engineering classification systems for soils.

References: McKeague, J.A. 1978. Atterberg Limits pp 50 - 55 In: Soil Sampling and Methods of Analysis. Can. Soc. Soil Sci. p. 50 - 55

ALS Test Code	Matrix	Test Description	Method Reference**
GRAIN SIZE-SK	Soil	Grain Size Analysis	SSIR-51 METHOD 3.2.1

Particle size distribution is determined by a combination of techniques. Dry sieving is performed for coarse particles, wet sieving for sand particles and the pipette sedimentation method for clay particles.

Reference:

Burt, R. (2009). Soil Survey Field and Laboratory Methods Manual. Soil Survey Investigations Report No. 5. Method 3.2.1.2.2. United States Department of Agriculture Natural Resources Conservation Service.

ALS Test Code	Matrix	Test Description	Method Reference**
MOISTURE-VA	Soil	Moisture content	ASTM D2974-00 Method A

This analysis is carried out gravimetrically by drying the sample at 105 C for a minimum of six hours.

ALS Test Code	Matrix	Test Description	Method Reference**
PSA-MUST-SK	Soil	% Particles > 75um (Coarse/Fine)	ASTM D422-63-SIEVE

An air-dried sample is reduced to < 2 mm size and mixed with a dispersing agent (Calgon solution). The sample is washed through a 200 mesh (75 µm) sieve. The retained mass of sample is used to determine % sand fraction.

Reference: ASTM D422-63

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
SK	ALS ENVIRONMENTAL - SASKATOON, SASKATCHEWAN, CANADA
VA	ALS ENVIRONMENTAL - VANCOUVER, BRITISH COLUMBIA, CANADA

Chain of Custody Numbers:

ALS08111301

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: CH2M HILL, INC
2525 Airpark Drive
Redding CA 96001

Contact: Bernice Kidd

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MOISTURE-VA	**Soil**							
Batch R2675482								
WG1729621-3 DUP		**L1347043-2**						
Moisture		9.91	9.34		%	6.0	20	19-AUG-13
WG1729621-2 LCS								
Moisture			99.6		%		70-130	19-AUG-13
WG1729621-1 MB								
Moisture			<0.25		%		0.25	19-AUG-13
PSA-MUST-SK	**Soil**							
Batch R2676346								
WG1728486-1 DUP		**L1347043-8**						
MUST PSA % > 75um		48.9	49.1	J	%	0.20	5	20-AUG-13

Quality Control Report

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
J	Duplicate results and limits are expressed in terms of absolute difference.

Hold Time Exceedances:

All test results reported with this submission were conducted within ALS recommended hold times.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

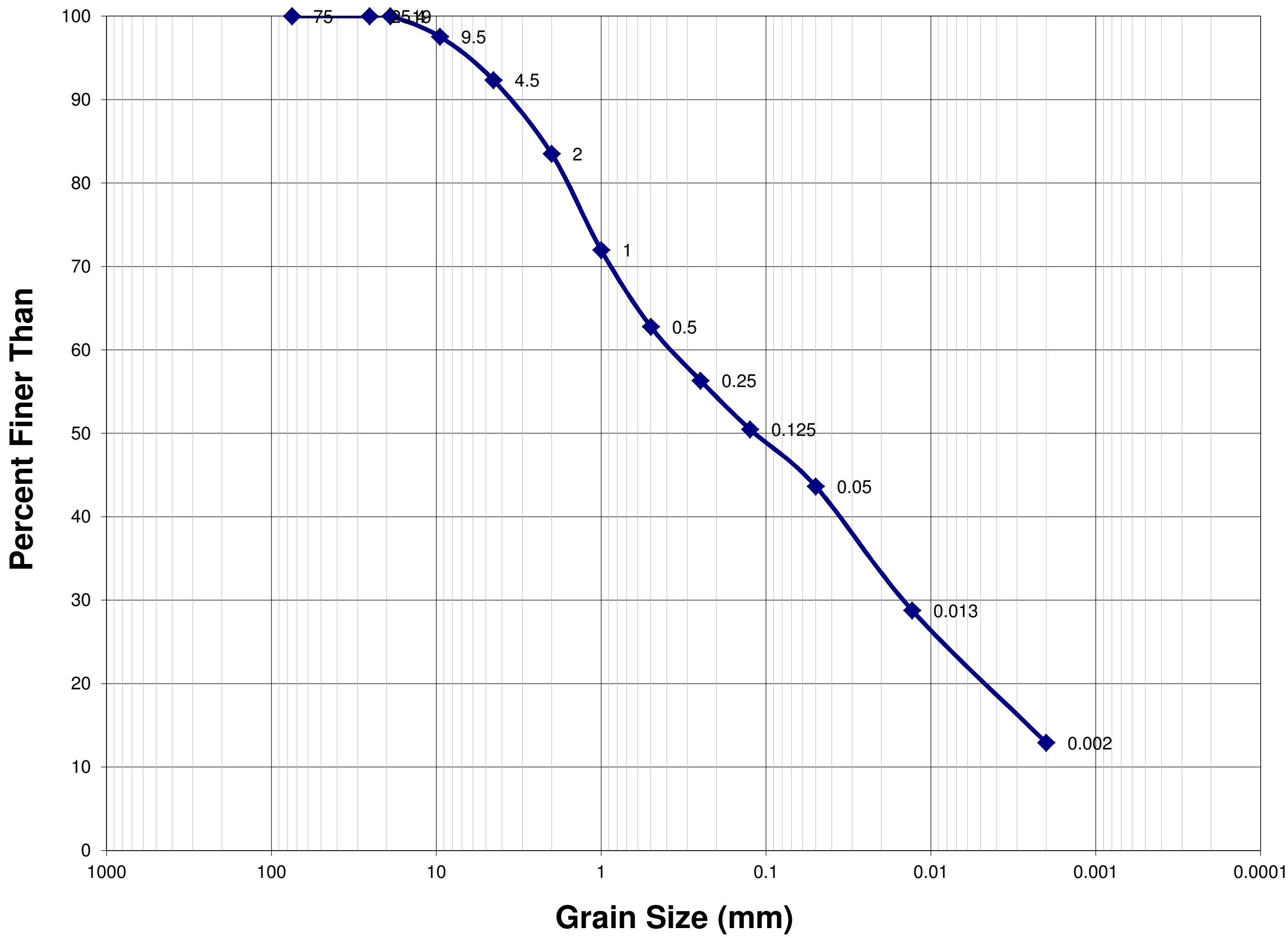
Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

819-58th Street, Saskatoon, SK S7K 6X5

Client Name: CH2M HILL, INC
Project: CHM400-CHM200-VA
Sample ID: CH13-303-BH003_SOB
Lab ID: L1347043-2

Particle Size Distribution Curve



Summary of Results

Unified Soil Classification System (USCS)

Size Class	Size Range	Wt. (%)
Cobbles	> 3"	0
Gravel	4.75mm - 3"	7
Coarse Sand	2.0mm - 4.75mm	9
Medium Sand	0.425mm - 2.0mm	21
Fine Sand	0.075mm - 0.425mm	17
Fines	< 0.075mm	46

Canadian Soil Survey Committee (CSSC)

Size Class	Size Range	Wt. (%)
Cobbles	> 3"	0
Gravel	2mm - 3"	16
Sand	0.05mm - 2mm	40
Silt	0.002mm - 0.05mm	31
Clay	< 0.002mm	13

Texture Loam

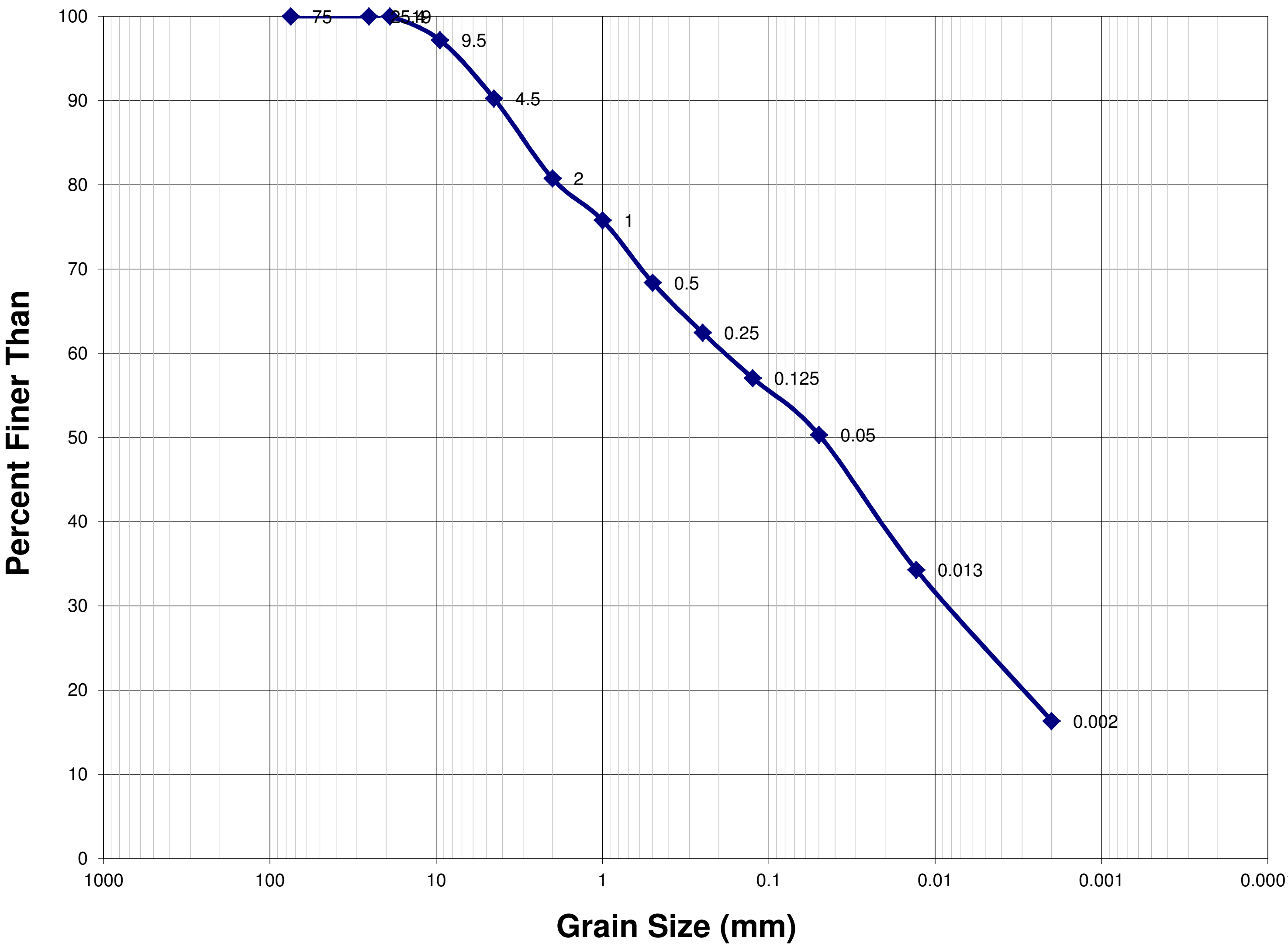
Method Reference: Can. Soc. Soil Sci. (1993) Method 47.2

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

819-58th Street, Saskatoon, SK S7K 6X5

Client Name: CH2M HILL, INC
Project: CHM400-CHM200-VA
Sample ID: CH13-303-BH003_SOF
Lab ID: L1347043-6

Particle Size Distribution Curve



Summary of Results

Unified Soil Classification System (USCS)

Size Class	Size Range	Wt. (%)
Cobbles	> 3"	0
Gravel	4.75mm - 3"	9
Coarse Sand	2.0mm - 4.75mm	10
Medium Sand	0.425mm - 2.0mm	12
Fine Sand	0.075mm - 0.425mm	16
Fines	< 0.075mm	53

Canadian Soil Survey Committee (CSSC)

Size Class	Size Range	Wt. (%)
Cobbles	> 3"	0
Gravel	2mm - 3"	19
Sand	0.05mm - 2mm	30
Silt	0.002mm - 0.05mm	34
Clay	< 0.002mm	16

Texture   Loam

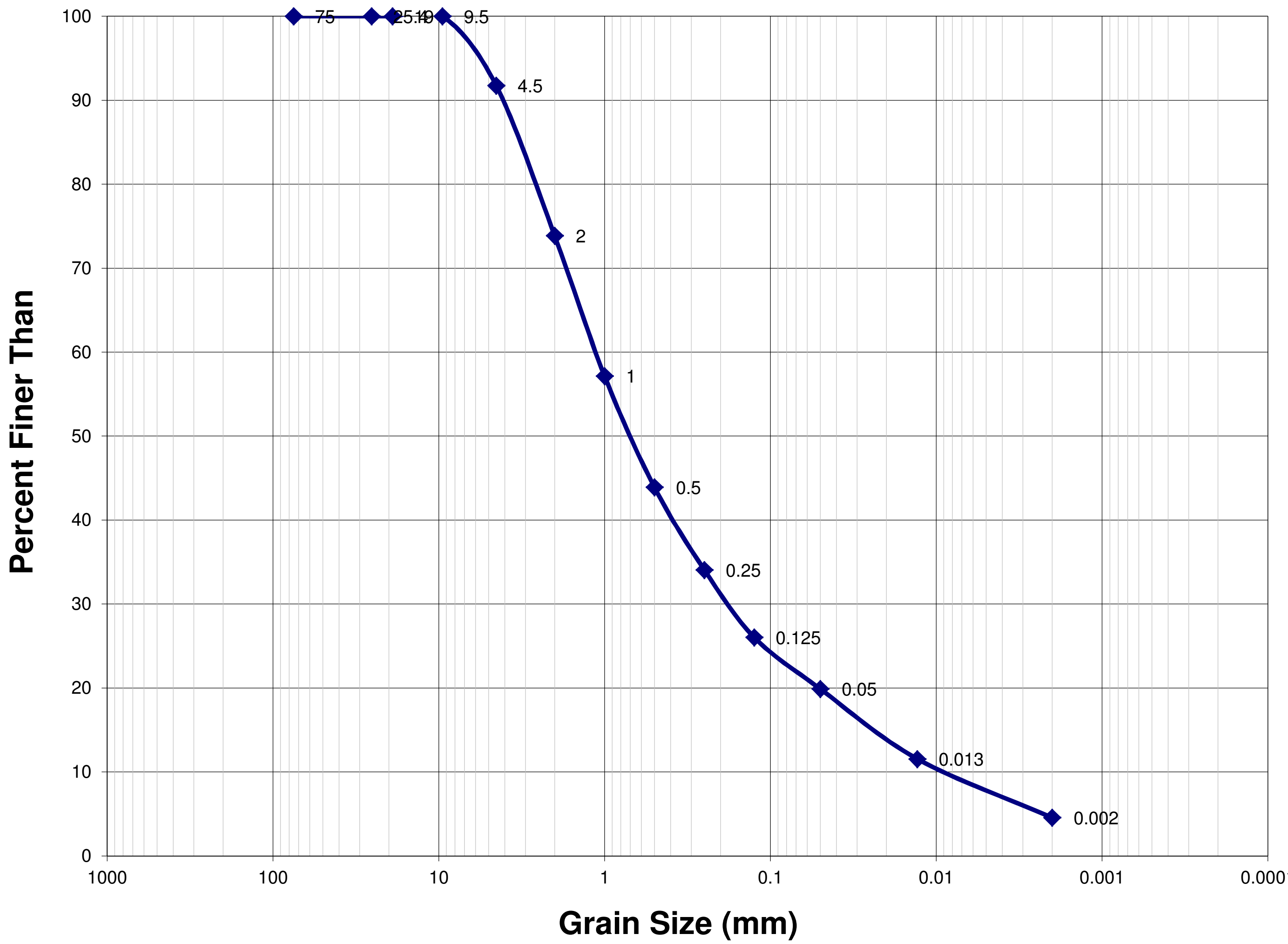
Method Reference: Can. Soc. Soil Sci. (1993) Method 47.2

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

819-58th Street, Saskatoon, SK S7K 6X5

Client Name: CH2M HILL, INC
Project: CHM400-CHM200-VA
Sample ID: CH13-303-BH003_SOG
Lab ID: L1347043-7

Particle Size Distribution Curve



Summary of Results

Unified Soil Classification System (USCS)

Size Class	Size Range	Wt. (%)
Cobbles	> 3"	0
Gravel	4.75mm - 3"	8
Coarse Sand	2.0mm - 4.75mm	18
Medium Sand	0.425mm - 2.0mm	30
Fine Sand	0.075mm - 0.425mm	22
Fines	< 0.075mm	22

Canadian Soil Survey Committee (CSSC)

Size Class	Size Range	Wt. (%)
Cobbles	> 3"	0
Gravel	2mm - 3"	26
Sand	0.05mm - 2mm	54
Silt	0.002mm - 0.05mm	15
Clay	< 0.002mm	5

Texture Sandy loam

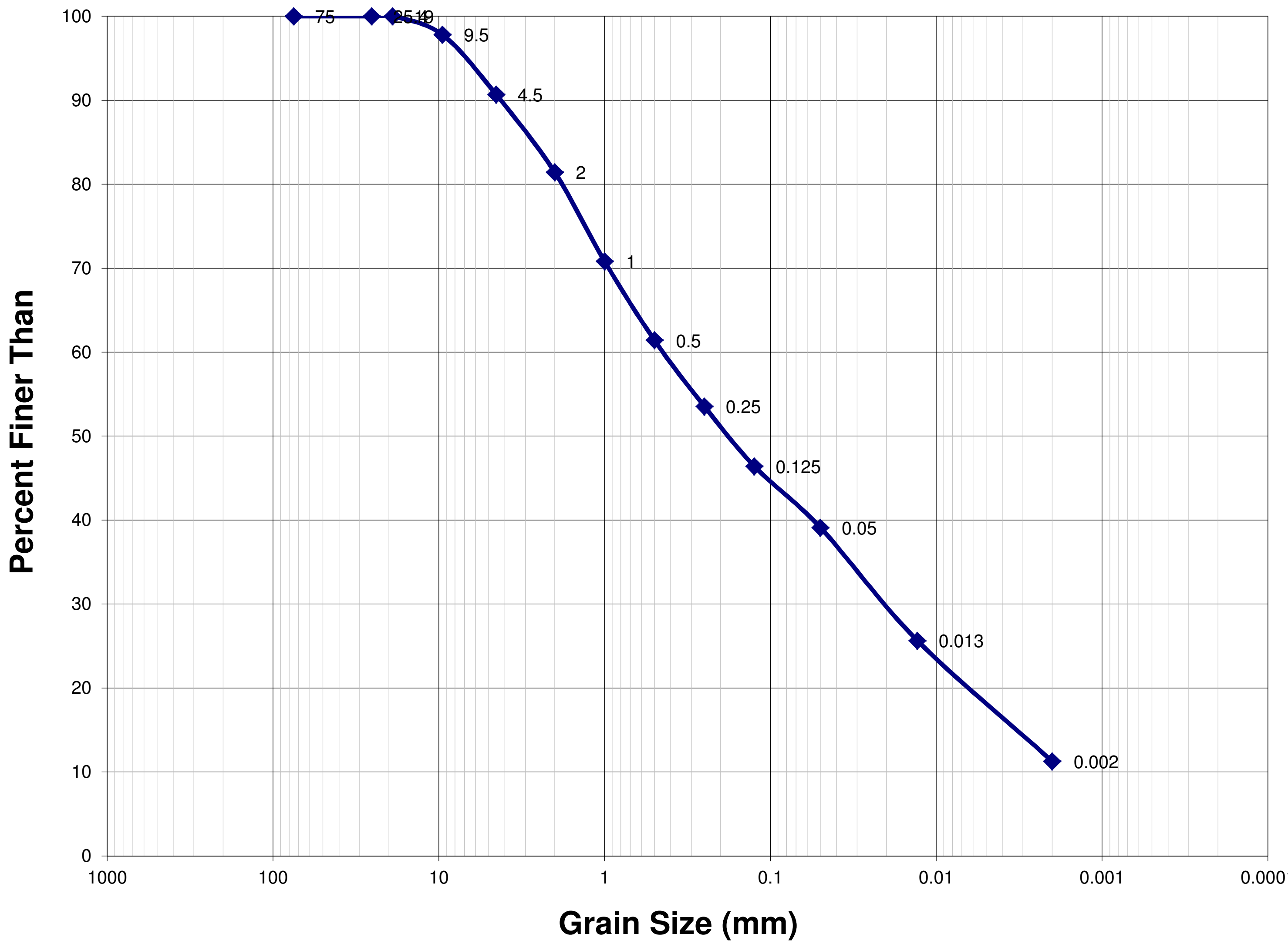
Method Reference: Can. Soc. Soil Sci. (1993) Method 47.2

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

819-58th Street, Saskatoon, SK S7K 6X5

Client Name: CH2M HILL, INC
Project: CHM400-CHM200-VA
Sample ID: CH13-303-BH003_SOI
Lab ID: L1347043-9

Particle Size Distribution Curve



Summary of Results

Unified Soil Classification System (USCS)

Size Class	Size Range	Wt. (%)
Cobbles	> 3"	0
Gravel	4.75mm - 3"	9
Coarse Sand	2.0mm - 4.75mm	10
Medium Sand	0.425mm - 2.0mm	20
Fine Sand	0.075mm - 0.425mm	20
Fines	< 0.075mm	42

Canadian Soil Survey Committee (CSSC)

Size Class	Size Range	Wt. (%)
Cobbles	> 3"	0
Gravel	2mm - 3"	19
Sand	0.05mm - 2mm	42
Silt	0.002mm - 0.05mm	28
Clay	< 0.002mm	11

Texture Loam

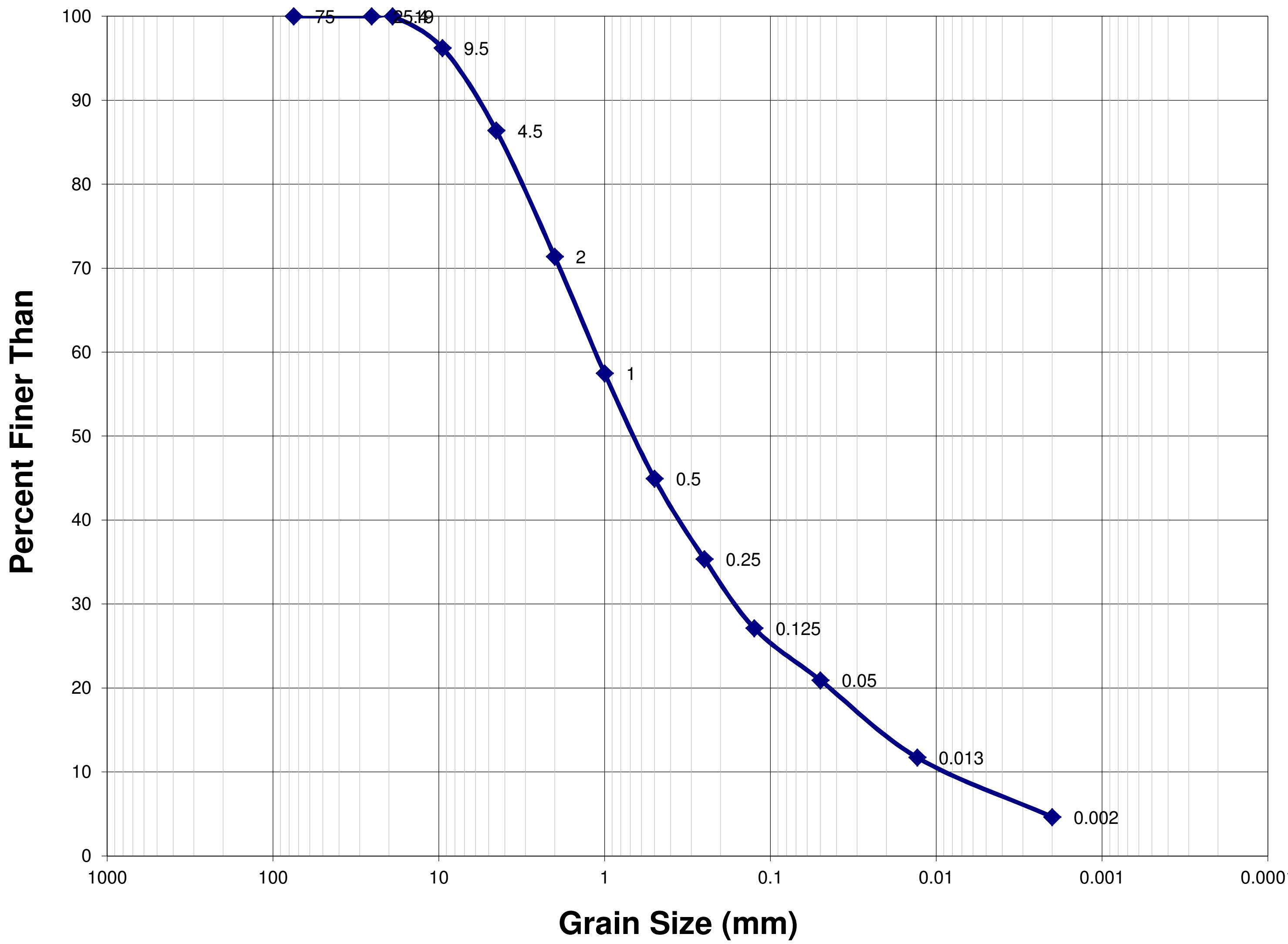
Method Reference: Can. Soc. Soil Sci. (1993) Method 47.2

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

819-58th Street, Saskatoon, SK S7K 6X5

Client Name: CH2M HILL, INC
Project: CHM400-CHM200-VA
Sample ID: CH13-303-BH903_SOG
Lab ID: L1347043-11

Particle Size Distribution Curve



Summary of Results

Unified Soil Classification System (USCS)

Size Class	Size Range	Wt. (%)
Cobbles	> 3"	0
Gravel	4.75mm - 3"	13
Coarse Sand	2.0mm - 4.75mm	15
Medium Sand	0.425mm - 2.0mm	26
Fine Sand	0.075mm - 0.425mm	22
Fines	< 0.075mm	23

Canadian Soil Survey Committee (CSSC)

Size Class	Size Range	Wt. (%)
Cobbles	> 3"	0
Gravel	2mm - 3"	29
Sand	0.05mm - 2mm	50
Silt	0.002mm - 0.05mm	16
Clay	< 0.002mm	5

Texture Sandy loam

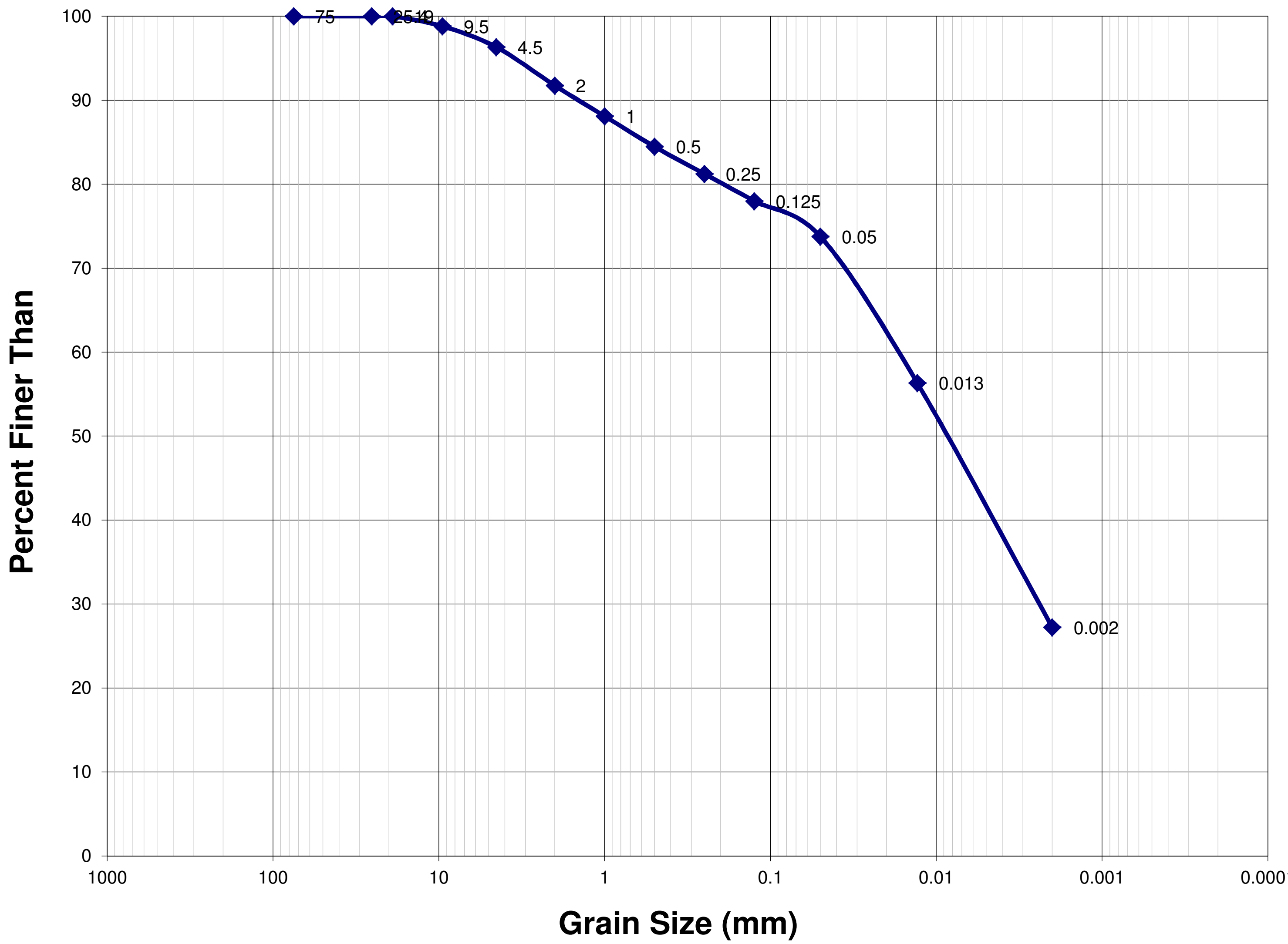
Method Reference: Can. Soc. Soil Sci. (1993) Method 47.2

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

819-58th Street, Saskatoon, SK S7K 6X5

Client Name: CH2M HILL, INC
Project: CHM400-CHM200-VA
Sample ID: CH13-303-BH003_SON
Lab ID: L1347043-15

Particle Size Distribution Curve



Summary of Results

Unified Soil Classification System (USCS)

Size Class	Size Range	Wt. (%)
Cobbles	> 3"	0
Gravel	4.75mm - 3"	4
Coarse Sand	2.0mm - 4.75mm	5
Medium Sand	0.425mm - 2.0mm	7
Fine Sand	0.075mm - 0.425mm	9
Fines	< 0.075mm	75

Canadian Soil Survey Committee (CSSC)

Size Class	Size Range	Wt. (%)
Cobbles	> 3"	0
Gravel	2mm - 3"	8
Sand	0.05mm - 2mm	18
Silt	0.002mm - 0.05mm	47
Clay	< 0.002mm	27

Texture Silty clay loam

Method Reference: Can. Soc. Soil Sci. (1993) Method 47.2

Tint 7.0, 13Aug13 13:40 L1347043

CH2MHILL **CHAIN OF CUSTODY RECORD** 8/10/2013 10:09:21 AM

Project Name Faro
Location Faro Mine Complex - Faro YK
Project Number 472645.18.VG.DF
Project Manager Jaco Esterhuizen
Sample Manager Charles Shewen

Task Order 303.1/2
Project CONSTRUCT NEW VCD 2013
Turnaround Time 10 Days
Shipping Date: 8/10/2013
COC Number: ALS08111301

L1347043-COFC

	Sample	DATE	TIME	Matrix	(ASTM 2216) Moisture	(ASTM D1140) Percent Fines Determination	(ASTM D422) Gradation	(ASTM D4318) Atterberg limits	Number of Containers	COMMENTS
	Container:				4oz jar	1 Gallon Ziploc	1 Gallon Ziploc	1 Gallon Ziploc		
	Preservatives:				4'C	4'C	4'C	4'C		
	Filtered:				NA	NA	NA	NA		
	Holding Time:				14	NA	NA	NA		
1	CH13-303-BH003_SOa	8/5/2013	10:46	Soil	X				1	
2	CH13-303-BH003_SOb	8/5/2013	11:17	Soil	X		X	X	3	
3	CH13-303-BH003_SOc	8/5/2013	11:35	Soil	X				1	
4	CH13-303-BH003_SOd	8/5/2013	11:59	Soil	X			X	2	
5	CH13-303-BH003_SOe	8/5/2013	12:15	Soil	X			X	2	
6	CH13-303-BH003_SOf	8/5/2013	12:55	Soil	X		X	X	3	
7	CH13-303-BH003_SOg	8/5/2013	13:43	Soil	X		X		2	
8	CH13-303-BH003_SOh	8/5/2013	14:18	Soil		X			1	
9	CH13-303-BH003_SOi	8/5/2013	15:00	Soil	X		X	X	3	
10	CH13-303-BH003_SOj	8/5/2013	16:04	Soil	X				1	
11	CH13-303-BH903_SOg	8/5/2013	13:53	Soil	X		X		2	
12	CH13-303-BH003_SOk	8/6/2013	9:23	Soil				X	1	
13	CH13-303-BH003_SOl	8/6/2013	10:02	Soil	X				1	
14	CH13-303-BH003_SOm	8/6/2013	11:01	Soil	X			X	2	

	Signatures		Date/Time
Approved by			
Sampled by			
Relinquished by	[signature]		8/11/13 2013
Received by			
Relinquished by	[signature]	5.7°C	12-Aug13
Received by	[signature]	7.0°C	10:15

Shipping Details
Method of Shipment: FedEx
On Ice: yes / no
Airbill No:
Lab Name: ALS Vancouver
Lab Phone: (604) 253-4188

ATTN:
Sample Custody and Amber Springer

Special Instructions:
Tar18 PO:604564 Metals Table1 Perform Lab Dup/MS on samples

Report Copy to
Bernice Kidd
(530) 229-3203

71347043

CH2MHILL — **CHAIN OF CUSTODY RECORD** — 8/10/2013 10:09:22 AM — Page 2 OF 2

Project Name Faro
Location Faro Mine Complex - Faro YK
Project Number 472645.18.VG.DF
Project Manager Jaco Esterhuizen
Sample Manager Charles Shewen

Task Order 303.1/2
Project CONSTRUCT NEW VCD 2013
Turnaround Time 10 Days
Shipping Date: 8/10/2013
COC Number: ALS08111301

L1347043-COFC

				(ASTM 2216) Moisture	(ASTM D1140) Percent Fines Determination	(ASTM D422) Gradation	(ASTM D4318) Atterberg limits	Number of Containers	COMMENTS
Container:				4oz jar	1 Gallon Ziploc	1 Gallon Ziploc	1 Gallon Ziploc		
Preservatives:				4'C	4'C	4'C	4'C		
Filtered:				NA	NA	NA	NA		
Holding Time:				14	NA	NA	NA		
	DATE	TIME	Matrix						
15 CH13-303-BH003_SOn	8/6/2013	14:06	Soil	X		X	X	3	
TOTAL NUMBER OF CONTAINERS								28	

	Signatures	Date/Time
Approved by		
Sampled by	[signature]	8/11/13 1200
Relinquished by		
Received by		
Relinquished by	[signature] 5.7°C	12-Aug-13
Received by	7.0°C	10:15

Shipping Details
Method of Shipment: FedEx
On Ice: yes / no
Airbill No:
Lab Name: ALS Vancouver
Lab Phone: (604) 253-4188

ATTN:
Sample Custody
and
Amber Springer

Special Instructions:
Tar18 PO:604564 Metals Table1 Perform Lab Dup/MS on samples

Report Copy to
Bernice Kidd
(530) 229-3203

Golder Associates Ltd. - Burnaby Laboratory
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C8

Unconfined Compressive Strength of Intact Rock Core Specimens

Reference: ASTM D7012-10 Method C

Project No.: 13-1417-0047/4000
Project: BSI ACCESS ROAD GRANITIC OUTCROP 2013
Client: CH2M HILL
Location: FARO MINE COMPLEX -FARO YK
Lab ID 194

Failure Mode
(1) Diagonal shear plane(s)
(2) Vertical fracture(s)
(3) Vertical splitting
(4) Shear along foliation / discontinuity
(5) Conical
(6) Spalling
(7) Other
Note: (deg) measured from core axis

No.	TAR 18 Borehole #	Sample #	Depth (m)	Dia (mm)	Ht (mm)	A (cm^2)	V (cm^3)	Mass (g)	Wet Density (kg/m^3)	W (%)	Dry Density (kg/m^3)	Maximum Load (kN)	Stress σ (MPa)	Rock Type	Failure Mode Type	Failure Mode (deg)
1	CH13-311	BH017_RKd	N/A	44.77	95.25	15.74	149.94	398.50	2658	0.06	2656	210.70	133.8	Not Provided	2	N/A
2	CH13-311	BH017_RKe	N/A	44.75	93.66	15.73	147.31	391.10	2655	0.05	2654	160.70	102.2	Not Provided	2	N/A
3	CH13-311	SS013_RKa	N/A	45.23	94.31	16.07	151.53	402.90	2659	0.15	2655	194.50	121.1	Not Provided	2/1	26
4	CH13-311	SS015_RKa	N/A	45.71	90.43	16.41	148.40	395.10	2662	0.10	2660	187.90	114.5	Not Provided	2	N/A
5	CH13-311	SS016_RKa	N/A	45.69	95.69	16.40	156.89	415.10	2646	0.27	2639	110.10	67.2	Not Provided	4	23
6	CH13-311	SS017_RKa	N/A	45.24	94.57	16.07	152.02	401.30	2640	0.10	2637	132.40	82.4	Not Provided	4	15
7	CH13-311	SS018_RKa	N/A	45.67	92.07	16.38	150.82	415.40	2754	0.03	2754	272.50	166.3	Not Provided	2	N/A

G. Patton	October 10, 2013	L.Perrey	October 15,2013
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates

Golder Associates Ltd. - Burnaby Lab
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C6

Unconfined Compressive Strength of Intact Rock Core Specimens

Reference
ASTM D7012-10 Method C

Project No.:	13-1417-0047/4000	**TAR 18 - Borehole:**	**CH13-311**
Project:	BSI ACCESS ROAD GRANITIC OUTCROP 2013	**Sample Number:**	BH017_RKd
Location:	FARO MINE COMPLEX -FARO YK	**Depth (m):**	N/A
Client:	CH2M HILL	**Lab ID No:**	194

Testing Results		Sample Measurements	
Max Load (kN)	**210.70**	Diameter (mm)	44.77
		Height (mm)	95.25
Stress σ (MPa)	**133.8**	Area (cm^2)	15.74
		Volume (cm^3)	149.94
Pace Rate (kN/s)	1.25	Mass (g)	398.50
		Moisture Content (%)	0.06
Lithology	Not Provided	Wet Density (kg/m^3)	2657.66
		Dry Density (kg/m^3)	2656.15

Failure Mode		Notes
		- Water content as received
Type:	**2**	**Mode:**
		(1) Diagonal shear plane(s)
Degrees:*	**N/A**	(2) Vertical fracture(s)
		(3) Vertical splitting
		(4) Shear along foliation /discontinuity
		(5) Conical
* Degrees measured with respect to core axis.		(6) Spalling
		(7) Other

Comments

** The test data given herein pertain to the sample provided only. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.*

BEFORE TEST

AFTER TEST

G. Patton	October 10, 2013	L.Perrey	October 15,2013
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates

Golder Associates Ltd. - Burnaby Lab
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C6

Unconfined Compressive Strength of Intact Rock Core Specimens

Reference
ASTM D7012-10 Method C

Project No.:	13-1417-0047/4000	**TAR 18 - Borehole:**	**CH13-311**
Project:	BSI ACCESS ROAD GRANITIC OUTCROP 2013	**Sample Number:**	BH017_RKe
Location:	FARO MINE COMPLEX -FARO YK	**Depth (m):**	N/A
Client:	CH2M HILL	**Lab ID No:**	194

Testing Results		Sample Measurements	
Max Load (kN)	**160.70**	Diameter (mm)	44.75
		Height (mm)	93.66
Stress σ (MPa)	**102.2**	Area (cm^2)	15.73
		Volume (cm^3)	147.31
Pace Rate (kN/s)	1.25	Mass (g)	391.10
		Moisture Content (%)	0.05
Lithology	Not Provided	Wet Density (kg/m^3)	2654.96
		Dry Density (kg/m^3)	2653.60

Failure Mode		Notes
		- Water content as received
Type:	**2**	**Mode:**
		(1) Diagonal shear plane(s)
Degrees:*	**N/A**	(2) Vertical fracture(s)
		(3) Vertical splitting
		(4) Shear along foliation /discontinuity
		(5) Conical
* Degrees measured with respect to core axis.		(6) Spalling
		(7) Other

Comments

** The test data given herein pertain to the sample provided only. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.*

BEFORE TEST

AFTER TEST

G. Patton	October 10, 2013	L.Perrey	October 15,2013
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates

Golder Associates Ltd. - Burnaby Lab
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C6

Unconfined Compressive Strength of Intact Rock Core Specimens

Reference
ASTM D7012-10 Method C

Project No.:	13-1417-0047/4000	**TAR 18 - Borehole:**	**CH13-311**
Project:	BSI ACCESS ROAD GRANITIC OUTCROP 2013	**Sample Number:**	SS013_RKa
Location:	FARO MINE COMPLEX -FARO YK	**Depth (m):**	N/A
Client:	CH2M HILL	**Lab ID No:**	194

Testing Results		Sample Measurements	
Max Load (kN)	**194.50**	Diameter (mm)	45.23
		Height (mm)	94.31
Stress σ (MPa)	**121.1**	Area (cm^2)	16.07
		Volume (cm^3)	151.53
Pace Rate (kN/s)	1.25	Mass (g)	402.90
		Moisture Content (%)	0.15
Lithology	Not Provided	Wet Density (kg/m^3)	2658.87
		Dry Density (kg/m^3)	2654.89

Failure Mode		Notes
		- Water content as received
Type:	**2/1**	**Mode:**
		(1) Diagonal shear plane(s)
Degrees:*	**26**	(2) Vertical fracture(s)
		(3) Vertical splitting
		(4) Shear along foliation /discontinuity
		(5) Conical
* Degrees measured with respect to core axis.		(6) Spalling
		(7) Other

Comments

** The test data given herein pertain to the sample provided only. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.*

BEFORE TEST

AFTER TEST

G. Patton	October 10, 2013	L.Perrey	October 15,2013
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates

Golder Associates Ltd. - Burnaby Lab
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C6

Unconfined Compressive Strength of Intact Rock Core Specimens

Reference
ASTM D7012-10 Method C

Project No.:	13-1417-0047/4000	**TAR 18 - Borehole:**	**CH13-311**
Project:	BSI ACCESS ROAD GRANITIC OUTCROP 2013	**Sample Number:**	SS015_RKa
Location:	FARO MINE COMPLEX -FARO YK	**Depth (m):**	N/A
Client:	CH2M HILL	**Lab ID No:**	194

Testing Results		Sample Measurements	
Max Load (kN)	**187.90**	Diameter (mm)	45.71
		Height (mm)	90.43
Stress σ (MPa)	**114.5**	Area (cm^2)	16.41
		Volume (cm^3)	148.40
Pace Rate (kN/s)	1.25	Mass (g)	395.10
		Moisture Content (%)	0.10
Lithology	Not Provided	Wet Density (kg/m^3)	2662.45
		Dry Density (kg/m^3)	2659.71

BEFORE TEST

Failure Mode

Type: **2**

Degrees:* **N/A**

* Degrees measured with respect to core axis.

Notes

- Water content as received

Mode:
(1) Diagonal shear plane(s)
(2) Vertical fracture(s)
(3) Vertical splitting
(4) Shear along foliation /discontinuity
(5) Conical
(6) Spalling
(7) Other

AFTER TEST

Comments

** The test data given herein pertain to the sample provided only. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.*

G. Patton	October 10, 2013	L.Perrey	October 15,2013
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates

Golder Associates Ltd. - Burnaby Lab
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C6

Unconfined Compressive Strength of Intact Rock Core Specimens

Reference: ASTM D7012-10 Method C

Project No.:	13-1417-0047/4000	**TAR 18 - Borehole:**	**CH13-311**
Project:	BSI ACCESS ROAD GRANITIC OUTCROP 2013	**Sample Number:**	SS016_RKa
Location:	FARO MINE COMPLEX -FARO YK	**Depth (m):**	N/A
Client:	CH2M HILL	**Lab ID No:**	194

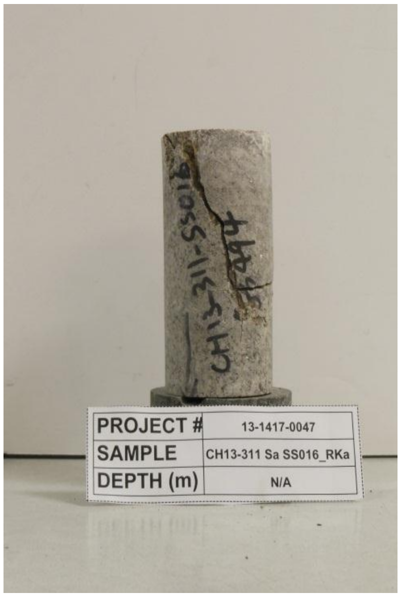
Testing Results		Sample Measurements	
Max Load (kN)	**110.10**	Diameter (mm)	45.69
		Height (mm)	95.69
Stress σ (MPa)	**67.2**	Area (cm^2)	16.40
		Volume (cm^3)	156.89
Pace Rate (kN/s)	1.25	Mass (g)	415.10
		Moisture Content (%)	0.27
Lithology	Not Provided	Wet Density (kg/m^3)	2645.78
		Dry Density (kg/m^3)	2638.76

Failure Mode		Notes
		- Water content as received
Type:	**4**	**Mode:**
		(1) Diagonal shear plane(s)
Degrees:*	**23**	(2) Vertical fracture(s)
		(3) Vertical splitting
		(4) Shear along foliation /discontinuity
		(5) Conical
* Degrees measured with respect to core axis.		(6) Spalling
		(7) Other

Comments

** The test data given herein pertain to the sample provided only. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.*

BEFORE TEST



AFTER TEST

G. Patton	October 10, 2013	L.Perrey	October 15,2013
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates

Golder Associates Ltd. - Burnaby Lab
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C6

Unconfined Compressive Strength of Intact Rock Core Specimens

Reference
ASTM D7012-10 Method C

Project No.:	13-1417-0047/4000	**TAR 18 - Borehole:**	**CH13-311**
Project:	BSI ACCESS ROAD GRANITIC OUTCROP 2013	**Sample Number:**	SS017_RKa
Location:	FARO MINE COMPLEX -FARO YK	**Depth (m):**	N/A
Client:	CH2M HILL	**Lab ID No:**	194

Testing Results		Sample Measurements	
Max Load (kN)	**132.40**	Diameter (mm)	45.24
		Height (mm)	94.57
Stress σ (MPa)	**82.4**	Area (cm^2)	16.07
		Volume (cm^3)	152.02
Pace Rate (kN/s)	1.25	Mass (g)	401.30
		Moisture Content (%)	0.10
Lithology	Not Provided	Wet Density (kg/m^3)	2639.86
		Dry Density (kg/m^3)	2637.22

Failure Mode		Notes
		- Water content as received
Type:	**4**	**Mode:**
		(1) Diagonal shear plane(s)
Degrees:*	**15**	(2) Vertical fracture(s)
		(3) Vertical splitting
		(4) Shear along foliation /discontinuity
		(5) Conical
* Degrees measured with respect to core axis.		(6) Spalling
		(7) Other

Comments

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AFTER TEST

G. Patton	October 10, 2013	L.Perrey	October 15,2013
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Burnaby, B.C. Canada V5C 6C6

Unconfined Compressive Strength of Intact Rock Core Specimens

Reference
ASTM D7012-10 Method C

Project No.:	13-1417-0047/4000	**TAR 18 - Borehole:**	**CH13-311**
Project:	BSI ACCESS ROAD GRANITIC OUTCROP 2013	**Sample Number:**	SS018_RKa
Location:	FARO MINE COMPLEX -FARO YK	**Depth (m):**	N/A
Client:	CH2M HILL	**Lab ID No:**	194

Testing Results		Sample Measurements	
Max Load (kN)	**272.50**	Diameter (mm)	45.67
		Height (mm)	92.07
Stress σ (MPa)	**166.3**	Area (cm^2)	16.38
		Volume (cm^3)	150.82
Pace Rate (kN/s)	1.25	Mass (g)	415.40
		Moisture Content (%)	0.03
Lithology	Not Provided	Wet Density (kg/m^3)	2754.21
		Dry Density (kg/m^3)	2753.51

Failure Mode		Notes
		- Water content as received
Type:	**2**	**Mode:**
		(1) Diagonal shear plane(s)
Degrees:*	**N/A**	(2) Vertical fracture(s)
		(3) Vertical splitting
		(4) Shear along foliation /discontinuity
		(5) Conical
* Degrees measured with respect to core axis.		(6) Spalling
		(7) Other

Comments

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BEFORE TEST

AFTER TEST

G. Patton	October 10, 2013	L.Perrey	October 15,2013
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates Ltd. - Burnaby Laboratory
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C8

Unconfined Compressive Strength of Intact Rock Core Specimens

Reference
ASTM D7012-10 Method C

Project No.: 13-1417-0047/4000
Project: BSI GRUM DUMP ROCK QUARRY 2013
Client: CH2M HILL
Location: FARO MINE COMPLEX -FARO YK
Lab ID 194

Failure Mode
(1) Diagonal shear plane(s)
(2) Vertical fracture(s)
(3) Vertical splitting
(4) Shear along foliation / discontinuity
(5) Conical
(6) Spalling
(7) Other
Note: (deg) measured from core axis

No.	TAR 18 Borehole #	Sample #	Depth (m)	Dia (mm)	Ht (mm)	A (cm^2)	V (cm^3)	Mass (g)	Wet Density (kg/m^3)	W (%)	Dry Density (kg/m^3)	Maximum Load (kN)	Stress σ (MPa)	Rock Type	Failure Mode Type	Failure Mode (deg)
1	CH13-311	SS001_RKa	N/A	45.54	96.62	16.29	157.38	473.40	3008	0.02	3007	215.60	132.4	Not Provided	2/1	11
2	CH13-311	SS019_RKa	N/A	45.85	94.31	16.51	155.71	465.00	2986	0.04	2985	223.30	135.2	Not Provided	2/1	16
3	CH13-311	SS026_RKa	N/A	45.82	91.96	16.49	151.63	410.00	2704	0.30	2696	143.50	87.0	Not Provided	2/6	N/A

G. Patton	October 10, 2013	L.Perrey	October 15,2013
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates

Golder Associates Ltd. - Burnaby Lab
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C6

Unconfined Compressive Strength of Intact Rock Core Specimens

Reference
ASTM D7012-10 Method C

Project No.:	13-1417-0047/4000	**TAR 18 - Borehole:**	**CH13-311**
Project:	BSI GRUM DUMP ROCK QUARRY 2013	**Sample Number:**	SS001_RKa
Location:	FARO MINE COMPLEX -FARO YK	**Depth (m):**	N/A
Client:	CH2M HILL	**Lab ID No:**	194

Testing Results		Sample Measurements	
Max Load (kN)	**215.60**	Diameter (mm)	45.54
		Height (mm)	96.62
Stress σ (MPa)	**132.4**	Area (cm^2)	16.29
		Volume (cm^3)	157.38
Pace Rate (kN/s)	1.25	Mass (g)	473.40
		Moisture Content (%)	0.02
Lithology	Not Provided	Wet Density (kg/m^3)	3008.05
		Dry Density (kg/m^3)	3007.42

Failure Mode		Notes
Type:	**2/1**	- Water content as received **Mode:** (1) Diagonal shear plane(s)
Degrees:*	**11**	(2) Vertical fracture(s) (3) Vertical splitting (4) Shear along foliation /discontinuity (5) Conical
* Degrees measured with respect to core axis.		(6) Spalling (7) Other

Comments

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BEFORE TEST

AFTER TEST

G. Patton	October 10, 2013	L.Perrey	October 15,2013
TESTED BY	DATE	CHECKED BY	DATE

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Burnaby, B.C. Canada V5C 6C6

Unconfined Compressive Strength of Intact Rock Core Specimens

Reference
ASTM D7012-10 Method C

Project No.:	13-1417-0047/4000	**TAR 18 - Borehole:**	**CH13-311**
Project:	BSI GRUM DUMP ROCK QUARRY 2013	**Sample Number:**	SS019_RKa
Location:	FARO MINE COMPLEX -FARO YK	**Depth (m):**	N/A
Client:	CH2M HILL	**Lab ID No:**	194

Testing Results		Sample Measurements	
Max Load (kN)	**223.30**	Diameter (mm)	45.85
		Height (mm)	94.31
Stress σ (MPa)	**135.2**	Area (cm^2)	16.51
		Volume (cm^3)	155.71
Pace Rate (kN/s)	1.25	Mass (g)	465.00
		Moisture Content (%)	0.04
Lithology	Not Provided	Wet Density (kg/m^3)	2986.25
		Dry Density (kg/m^3)	2984.97

Failure Mode		Notes
		- Water content as received
Type:	**2/1**	**Mode:**
		(1) Diagonal shear plane(s)
Degrees:*	**16**	(2) Vertical fracture(s)
		(3) Vertical splitting
		(4) Shear along foliation /discontinuity
		(5) Conical
* Degrees measured with respect to core axis.		(6) Spalling
		(7) Other

Comments

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G. Patton	October 10, 2013	L.Perrey	October 15,2013
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Burnaby, B.C. Canada V5C 6C6

Unconfined Compressive Strength of Intact Rock Core Specimens

Reference
ASTM D7012-10 Method C

Project No.:	13-1417-0047/4000	**TAR 18 - Borehole:**	**CH13-311**
Project:	BSI GRUM DUMP ROCK QUARRY 2013	**Sample Number:**	SS026_RKa
Location:	FARO MINE COMPLEX -FARO YK	**Depth (m):**	N/A
Client:	CH2M HILL	**Lab ID No:**	194

Testing Results		Sample Measurements	
Max Load (kN)	**143.50**	Diameter (mm)	45.82
		Height (mm)	91.96
Stress σ (MPa)	**87.0**	Area (cm^2)	16.49
		Volume (cm^3)	151.63
Pace Rate (kN/s)	1.25	Mass (g)	410.00
		Moisture Content (%)	0.30
Lithology	Not Provided	Wet Density (kg/m^3)	2703.86
		Dry Density (kg/m^3)	2695.73

Failure Mode		Notes
		- Water content as received
Type:	**2/6**	**Mode:**
		(1) Diagonal shear plane(s)
Degrees:*	**N/A**	(2) Vertical fracture(s)
		(3) Vertical splitting
		(4) Shear along foliation /discontinuity
		(5) Conical
* Degrees measured with respect to core axis.		(6) Spalling
		(7) Other

Comments

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BEFORE TEST

AFTER TEST

G. Patton	October 10, 2013	L.Perrey	October 15,2013
TESTED BY	DATE	CHECKED BY	DATE

EVALUATION OF DURABILITY OF ROCK FOR EROSION CONTROL UNDER FREEZING AND THAWING CONDITIONS

ASTM D 5312

CH2M Hill
1100 – 1st Street SE
Calgary, Alberta T2G 1B1

February 24, 2014
Project Number: 13-1417-0047.3000

ATTENTION: Mr. Mark Cichy

PROJECT: BSI Access Road Granitic Outcrop 2013

Sample:	CH13-311-SS016_RKa, Sample Date: 9-Jul-2013
Source:	BSI Access Road Granitic Outcrop, Tar #18, Faro Mine Complex, Yukon

Objective and Method:

The objective of this testing program was to conduct a test of the durability of rock proposed for use as erosion control in an environment where it is understood that it would be exposed to freezing and thawing and wetting and drying. The sample consisted of several boulder-sized rock chunks with an average diameter of 0.5 meters. The boulders were understood to have been sampled from a site proposed for quarry production of rip rap material; the sampling site was identified as "BSI Access Road Granitic Outcrop". The boulders were obtained by others.

The test program consisted solely of conducting the method described in ASTM D 5312. This report constitutes the final results of the test; all previously issued draft reports are hereby superseded. This report comprises a testing service only. Interpretation may be provided upon request.

In order to extract slab specimens from the boulder-size samples, a combination of wide diameter (6"/152 mm) rock coring and rock saw cutting was utilized. Some slab samples were circular in shape, while others were rectangular. Average dimensions of the slab specimens generally conformed to the requirements outlined in ASTM D 5240 and ASTM D 5121 (Preparation of Rock Slabs for Durability Testing). The rock slab specimens utilized in the test were generally 65 mm thick and not less than 125 mm on a side.

The test was designed such that the samples would be subjected to 55 cycles of freezing and thawing. In the absence of specific instruction from the client and provision of relevant climate data, the number of total cycles was determined by comparing the approximate geographic location to the "Isoline Map of Freeze-Thaw Severity Index," Figure 1 from ASTM D 5312.

The freezing portion of each cycle consisted of storing the samples in a freezer at -18°C for a minimum of 16 hours. This was followed by a minimum of 8 hours of thawing in an oven at 32°C. The condition of each sample was evaluated every five cycles through macroscopic and microscopic examination using a binocular microscope with magnifications up to 50x, enabling observations of pre-existing cracks and newly developed deterioration. Inspections included photographs and descriptive logs.

Prior to and at the end of the test, each sample is weighed and the percent loss by mass calculated for the individual specimens.

A selection of boulders from sample CH13-311-SS016_RKa was chosen for the tests; these were identified as 1, 4, 5, 6, and 7. Additional durability testing, consisting of ASTM D 5240 (Testing of Rock Slabs to Evaluate Soundness of Riprap by Use of Magnesium Sulfate) and ASTM D 5313 (Evaluation of Durability of Rock for

Erosion Control Under Wetting and Drying Conditions) are being conducted on the same boulders. To compare the results from each test method, three slab specimens were extracted from each of the selected boulders and the same boulder identification designation was used for the three slabs.

Quantitative Analysis:

Percent Loss

Sample ID	Boulder #	Slab ID	Original Mass (g)	Final Mass (g)	Measured Loss (%)
CH13-311-SS016_RKa	1	**16B1**	3311.4	3311.2	**0.01%**
	4	**16B4**	2670.1	2670.1	**0%**
	5	**16B5**	3504.8	3503.6	**0.03%**
	6	**16B6**	2421.7	2421.6	**0%**
	7	**16B7**	2970.3	2970.1	**0.01%**
				Final Average Loss (%)	**0.01%**

Qualitative Analysis:

Summary of Initial Condition

Petrographic examination was undertaken on a crushed composite of select chunks of rock from the CH13-311-SS016-RKa sample batch; generally, the rock consisted of gneissic granodiorite. Thin section analysis was conducted on one rock particle; chemical analyses, such as whole-rock analysis by X-Ray Fluorescence, were not conducted. Each rock slab was extracted from a specimen with slight to significant variations in compositional, textural and structural qualities. Parameters that varied included:

Composition

- Proportion of mafic and felsic minerals
- Presence or near absence of metallic minerals
- Distribution of oxidation product
- Amount of muscovite
- Presence/absence of iron oxide coating on fracture surfaces

Textural

- Gneissic texture which was slightly to moderately well-developed
- Spacing of gneissic bands
- Fine to medium mineral grain size
- Presence of veins

Structure

- Presence/absence of fractures
- Fracture width
- Number of fractures and fracture spacing
- Orientation and pattern of fractures
- Presence of weathering and oxidation around fractures

Observations of Individual Specimens

Slab ID	Observations		
	Initial @ 0 cycles	**Interim @ 40 cycles**	**Final @ 55 cycles**
16B1	- The slab was rectangular in shape with approximate dimensions of 132 mm wide by 139 mm long - The sample consisted of slightly gneissic granodiorite with a texture that was medium grained - Some portions of the slab were stained medium orange by oxidation while others were fresh and generally white-black in colour; the oxidized portions appeared to be slightly more weathered - Metallic mineral grains were not discernible; however, in thin section the dominant metallic mineral was hematite - Some very short gneissic bands had slightly higher absorption - One-third of the specimen was oxidized and stained orange; it had slightly high absorption compared to the fresh portions of the slab - There were no apparent fractures observed on the inspection surface	- No significant amount of material was dislodged from the slab - The absorptive gneissic bands did not develop into fractures; generally, the absorption characteristics remained unchanged between the beginning of the test and the interim observations, indicating that no widening occurred - There was no pitting or dislodgement of mineral grain fragments or flakes - Overall, this specimen did not exhibit any significant formation of fractures or loss of material	- Compared to the condition at the 40 cycle interim inspection, no material loss or propagation/formation of fractures was observed

16B4	- The slab was circular in shape with an approximate diameter of 142 mm - The sample consisted of slightly to moderately gneissic granodiorite with a texture that was medium grained - Metallic mineral grains were not discernible; however, in thin section the dominant metallic mineral was hematite - Some short gneissic bands were moderately well-developed and in several cases, they absorbed water; fractures were not detectable at 50x magnification in these bands and mica minerals were well bonded - Some bands and regions of the slab were lighter coloured and consisted of a greater proportion of felsic minerals and minor amounts of mafic minerals; the felsic bands ranged from 5 to 10 mm wide and were not parallel to the preferred orientation of mineral grains that defined the gneissic texture - There were some short, discontinuous, slightly absorptive fractures within the lighter coloured portion of the slab - One large fracture (#1) had irregular shape and extended nearly halfway across the slab and intersected the slab surface at a low angle; the fracture surface was slightly weathered and coated with a small amount of oxidation product - Some mineral fragments along Fracture #1 detached during preparation of the slab due to being thin and weathered; the result was that the fracture had a pitted appearance and appeared wider than its measured width of 0.3 mm - A second fracture (#2) was perpendicular to the slab surface and extended through to the opposite side of the slab; it was approximately 0.8 mm wide and was only very slightly oxidized - Oxidation staining was not prevalent across the specimen; however, localized blebs and patches of iron oxide were observed around some ferromagnesian and metallic minerals	- The absorptive gneissic bands did not develop into fractures; generally, the absorption characteristics remained unchanged between the beginning of the test and the interim observations, indicating that no widening of fractures occurred - The short fractures in the lighter coloured portion of the slab did not widen or grow in length and mineral grains did not detach - Fracture #1 did not widen or exhibit spalling or scaling along the fracture surface - Some small mineral fragments and flakes of biotite were dislodged along Fracture #2; they were poorly adhered to the slab prior to testing - Due to some material loss along the fracture path, Fracture #2 had a slightly wider appearance; additionally it was very slightly more absorptive indicating that it may have widened slightly - Overall, this specimen exhibited a slight loss of material along pre-existing fractures which had poorly attached mineral grains prior to testing. Some fractures may have widened very slightly.	- Compared to the condition at the 40 cycle interim inspection, no material loss or propagation/formation of fractures was observed - The fracture surfaces along the pre-existing fractures consisted of material that was well-bonded and strongly adhered, despite being somewhat weathered and oxidized; it could not be plucked or pried off without considerable effort using a steel tool

16B5	- The slab was rectangular in shape with approximate dimensions of 142 mm wide by 146 mm long - The sample consisted of granodioritewith a moderately gneissic texture and a mineral grain size that was fine to medium grained - Generally, the entire slab was stained orange by oxidation and was slightly weathered; lesser portions of the slab were stained dark orange and were slightly more absorptive - Metallic mineral grains were not discernible; however, in thin section the dominant metallic mineral was hematite - Some bands and regions of the slab were lighter coloured and consisted of a greater proportion of felsic minerals and minor amounts of mafic minerals; the felsic bands ranged from 3 to 6 mm wide and were not parallel to the preferred orientation of mineral grains that defined the gneissic texture - Some short fractures (#1 and #2) were observed on an edge of the specimen that was significantly weathered ; these extended 7 to 9 mm into the slab; the fractures were absorptive, they appeared to have weathered surfaces coated in iron oxide - Fractures #1 and #2 were parallel to gneissic banding and the slab edge - One fracture (#3) originated from the edge and extended 22 mm into the slab; it was tightly closed, moderately absorptive and the portion near the slab edge was slightly oxidized - A few gneissic bands which had higher concentration of mica minerals were absorptive; they were associated with very thin, discontinuous fractures	- The absorptive gneissic bands did not develop into significant fractures; generally, the absorption characteristics remained unchanged between the beginning and the test and the interim observations indicating that no widening occurred - A few small mineral fragments were dislodged from pre-existing Fracture #1 and #2 near the weathered edge of the slab - None of the pre-existing fractures exhibited widening or lengthening - Some short fractures became absorptive in the light coloured portion of the slab; they may have been pre-existing and were widened slightly; they ranged from 2 to 6 mm and generally occurred around mineral grain boundaries - Overall, this specimen exhibited minimal formation of fractures and loss of material	- Compared to the condition at the 40 cycle interim inspection, no material loss or propagation/formation of fractures was observed

16B6	- The slab was circular in shape with an approximate diameter of 141 mm - The sample consisted of slightly gneissic granodiorite with a mineral grain size that was fine to medium grained - Most of the slab was stained orange by oxidation and was slightly weathered; some portions of the slab were stained dark orange and a few small zones were fresh and not oxidized - Metallic mineral grains were not discernible; however, in thin section the dominant metallic mineral was hematite - One large fracture (#1) extended across the slab, intersecting a thin portion along the slab edge; it was open less than 0.2 mm, was slightly oxidized and was absorptive - Fracture #1 was perpendicular to the slab surface and had a shape that was generally planar but with a rough surface - A second fracture (#2) was nearly parallel to Fracture #1 and intersected a large portion of the slab; it was planar to irregular in shape and the fracture surface was weathered and oxidized - Fracture #2 consisted of several very thin (<0.05 mm) and braided fractures which were slightly weathered and stained with iron oxide; it was absorptive and the largest opening was about 0.5 mm - Fracture #1 or #2 were nearly parallel to the orientation of oxidation staining; neither were aligned with gneissic texture - Some fractures (#3) existed that were nearly parallel to gneissic texture; they were short, discontinuous and were less absorptive compared to Fractures #1 and #2 - A few gneissic bands that were moderately well-developed, were absorptive	- Fracture #2 is slightly flexible and absorptive and may have widened slightly; it lost some mineral fragments and flakes of oxidation product which had been coating the fracture surface - Some mineral fragments were dislodged where Fracture #1 intercepted the slab edge - Fracture #3 did not widened or become more absorptive - Overall, while this specimen did not exhibit significant loss of material, a pre-existing fracture that was well-developed widened slightly. This fracture did not appear particularly strong prior to testing or at the interim observations and could be susceptible to fracturing due to impact	- Compared to the condition at the 40 cycle interim inspection, no material loss or propagation/formation of fractures was observed - The thin portion of the slab intersected by Fracture #1 could not be dislodged by force, despite being weathered, oxidized and open - Upon detailed inspection it was detected that some pre-existing fractures had weathered, oxidized and fractured material along the fracture surface that could be plucked out with a steel tool. It is believed this material was weakly adhered prior to testing and did not become weak as a result of freeze-thaw stresses

16B7	- The slab was circular in shape with an approximate diameter of 148 mm - The sample consisted of granodiorite of moderately gneissic texture with a mineral grain size that was fine to medium grained - Generally, the entire slab was stained light orange by oxidation - Metallic mineral grains were not discernible; however, in thin section the dominant metallic mineral was hematite - There were many open and absorptive fractures in the slab specimen - The majority of fractures were moderately absorptive and exhibited signs of fracture surfaces that were slightly weathered, oxidized and coated in oxidation production; most fractures were tightly closed with an opening less than 4 mm - Many fractures include branches at nearly perpendicular angles; often the fractures originated and terminated at the edge of the slab but in some cases they gradually ended within the slab - Approximately half of all fractures extended through the full depth of the slab or out to the edge rather than gradually ending within the slab - One large fracture (#1) extended across the full width and depth of the slab and was very absorptive; it had width that ranged from 0.2 to 3 mm and although it had nearly planar orientation, the fracture surface was irregular and rough - Mineral fragments along the path of Fracture #1 had detached during preparation of the slab; the result was that the fracture had a pitted, wide and weathered appearance - The surfaces of Fracture #1 were significantly weathered and coated with oxidation product; mineral fragments near the fracture surfaces were only moderately well-attached - The edge of the slab was not sharp due to dislodgement of minerals grains during preparation of the slab; this may indicate a moderate to poor mineral bond strength overall	- For the majority of pre-existing fractures that were mostly closed, there was no significant increase in absorption or widening of the fractures - In some cases, but not all, thin flakes of oxidation product were dislodged from pre-existing fractures, but only to a very shallow depth (<0.5 mm) into the slab - One fracture which was mostly closed exhibited significant pitting and dislodgment of mineral grains along its path to a depth of about 1.5 mm. As well, there were some mineral fragment pop-outs in the area around this fracture - Fracture #1 lost the most significant amount of material along its plane due to mineral fragments being thin, weathered and poorly adhered; material loss did not extend more than 1.5 mm into the slab surface - Fracture #1 may have widened; however it was difficult to confirm as it was already very absorptive prior to testing - Some portions of Fracture #1 display thinly fractured material extruding from the fracture by less than ~0.2 mm - Overall, this specimen exhibited some pitting and detachment of material along and around pre-existing fractures; generally, the material was thin and only moderately to poorly attached to the slab specimen. Some widening of open, pre-existing fractures may have occurred. Due to the high frequency of fractures, including several that were open and weathered, the slab could be susceptible to fracturing due to impact	- Compared to the condition at the 40 cycle interim inspection, no material loss or propagation/formation of fractures was observed - Some mineral fragments along Fracture#1 were extruded above the slab surface by about 1 to 2 mm - Upon detailed inspection it was detected that the majority of pre-existing fractures had weathered, oxidized and fractured material along the fracture surface that could be plucked out with a steel tool. It is believed this material was weakly adhered prior to testing and did not become weak as a result of freeze-thaw stresses

Summary of Deterioration

The majority of specimens did not appear to have significant material loss. For those that exhibited any loss of material, the loss consisted only of small flakes and fragments that were thin and weakly attached to pre-existing fractures, noted prior to testing. The majority of pre-existing fractures did not enlarge and new fractures did not form as a result of the freezing and thawing action. Some pre-existing fractures that were open prior to testing may have widened very slightly. The following observations regarding sample conditions were made:

Loss of Material

- Dislodgement of thin portions of the slab specimen that were intersected by pre-existing fractures and were moderately to poorly adhered prior to testing
- Pitting and dislodgement of material occurred along pre-existing fracture paths where fractures were: i) braided and/or intersecting with other fractures, ii) open and with shallow angle relative to slab surface, iii) significantly weathered and oxidized
- Slight extrusion of rock material from braided and/or layered fractures
- Slabs with abundant pre-existing fractures and significant weathering and oxidation experienced slightly higher amounts of material loss

Formation and/or propagation of fractures

- Several pre-existing fractures widened slightly. Typically, the fractures that widened were open greater than ~0.5 mm and the fracture surfaces were weathered and coated with iron oxide. Prior to testing, the fractures were moderately strong; that is, material adjacent to the fracture would be expected to dislodge from the slab if they were impacted with moderate force. After testing and widening of the fractures, there was not a notable decrease in strength.
- Fractures which were associated with gneissic texture did not widen, propagate or exhibit material loss

Overall Summary

The data given in this report pertain to the samples provided, and may not be applicable to material from other locations or trial periods.

The observations for material loss and fracture formation, as well as the visual and measured estimate of mass loss were comparable between the 40 cycle interim inspection and the 55 cycle final inspection. This indicates that the specimens did not undergo significant additional deterioration after 55 cycles, compared to 40 cycles.

The specimens had an average measured loss of 0.01%. The samples were generally similar to each other with regard to their resistance to the stresses generated by freezing and thawing action. Material loss appeared to be caused by dislodging of material that was only moderately well adhered to pre-existing fracture surfaces prior to testing and generally consisted of the removal of small flakes, fragments and mineral grains. Specimens with more pre-existing fractures and more significant weathering and oxidation had an overall mineral bond strength that ranged from good to moderate and typically experienced higher loss.

Formation of new fractures, widening, and lengthening of pre-existing fractures was observed in very minor amounts in the tested rock slabs and was typically associated with fractures which were open, weathered, oxidized and coated. Some of the pre-existing fractures were interpreted to be of moderate strength and could be susceptible to fracturing if impacted with moderate force.

Prepared, tested and reported by:

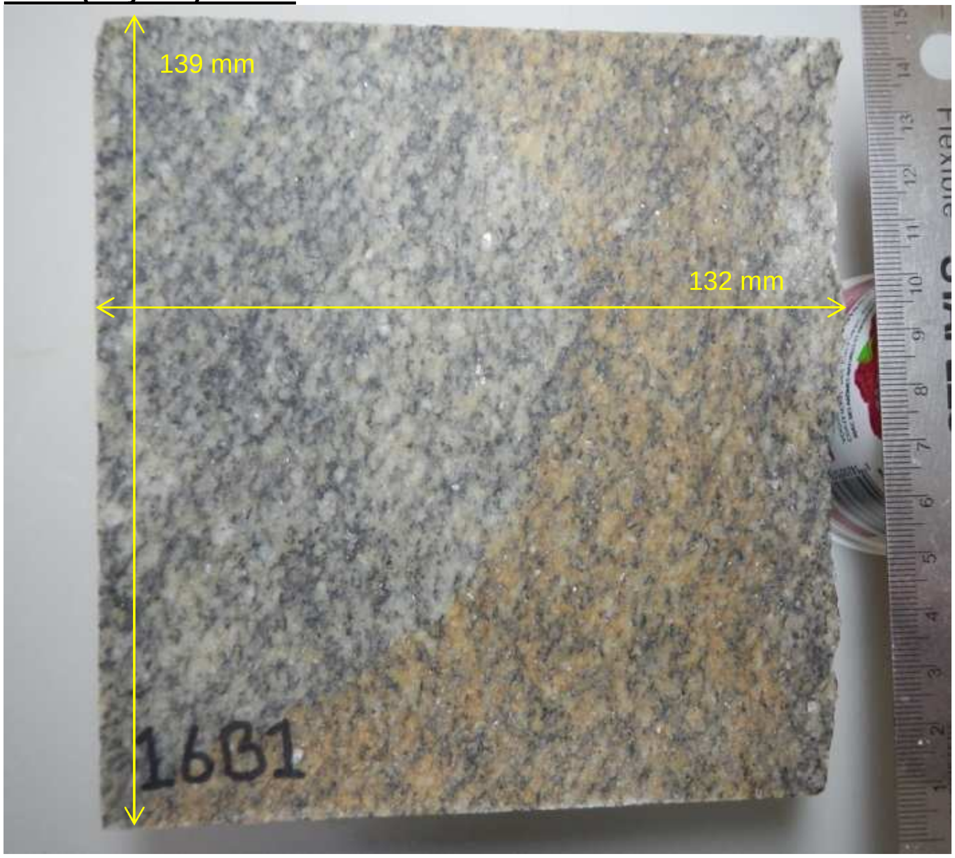
B. Hudson, P. Geo.

Reviewed by:

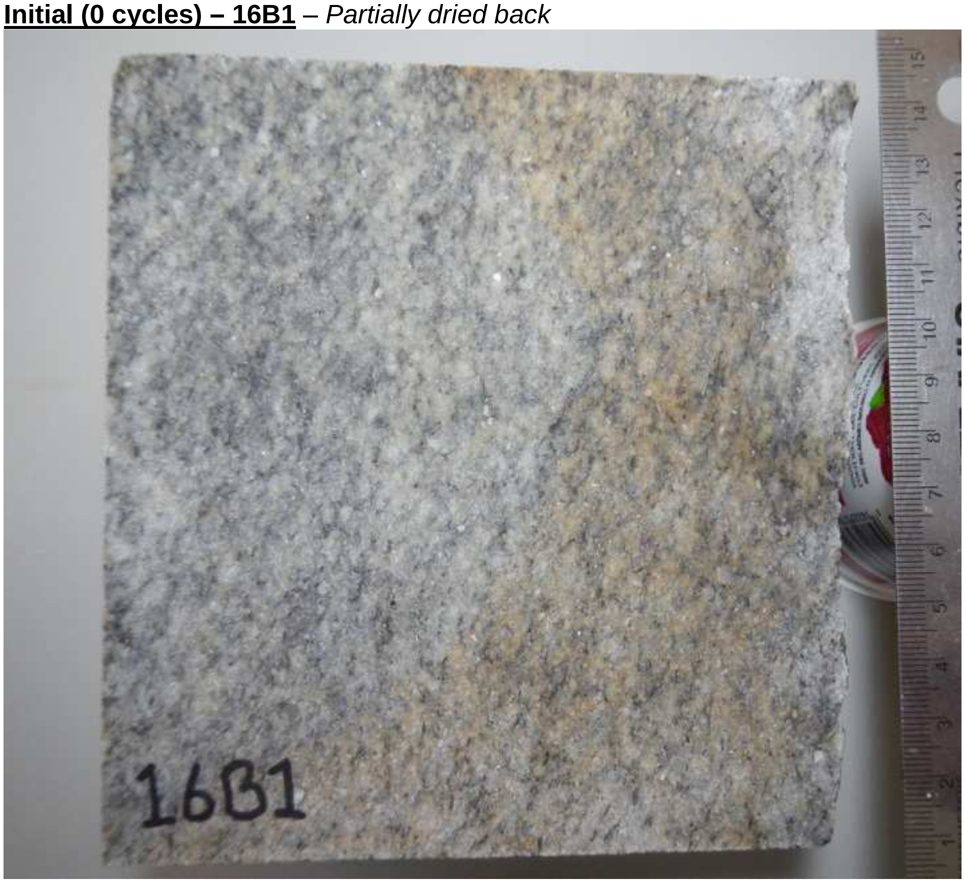
F. Shrimer, P. Geo.

PHOTOGRAPHS

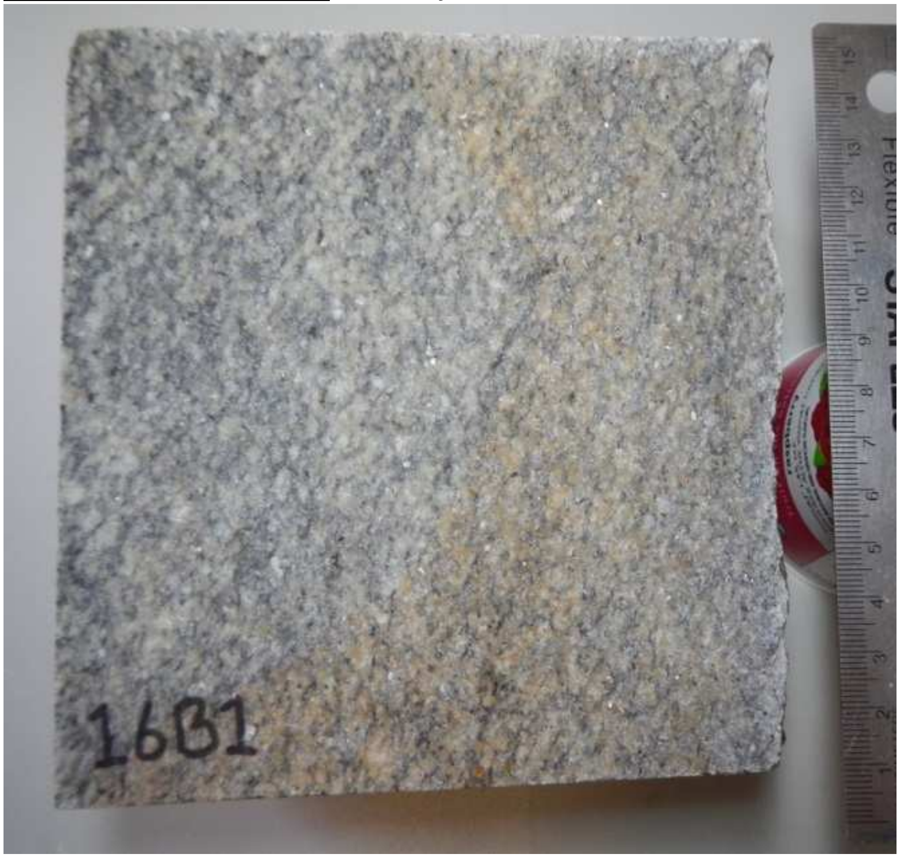
Initial (0 cycles) – 16B1 – *Wetted*



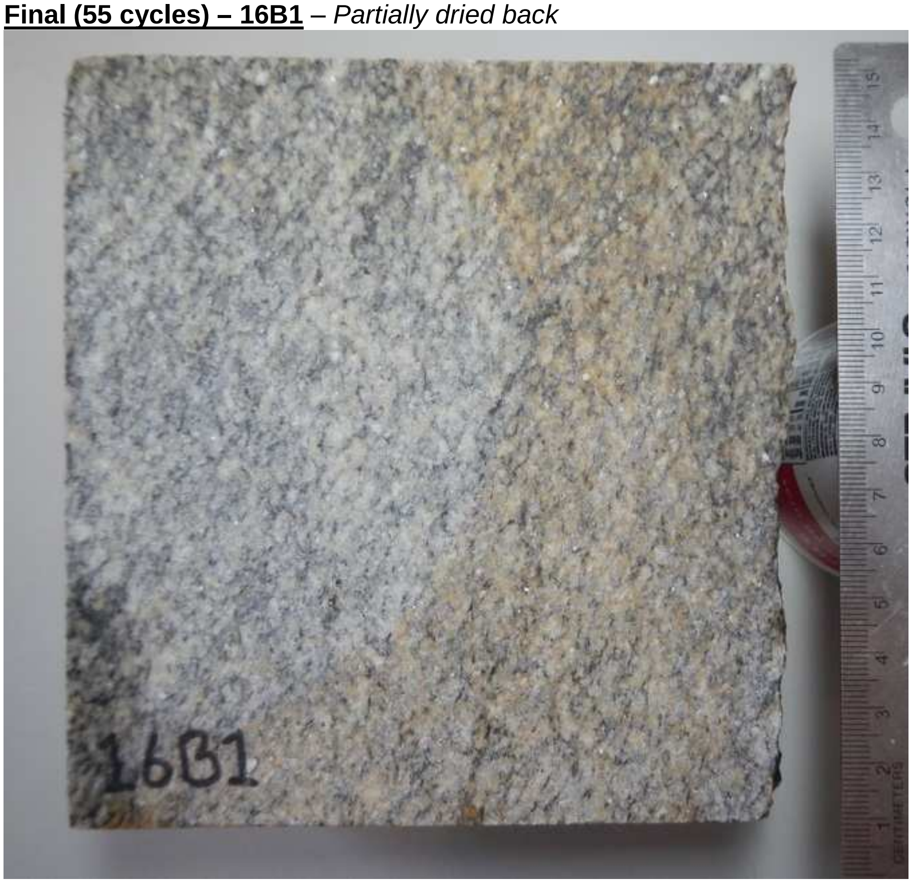
Initial (0 cycles) – 16B1 – *Partially dried back*



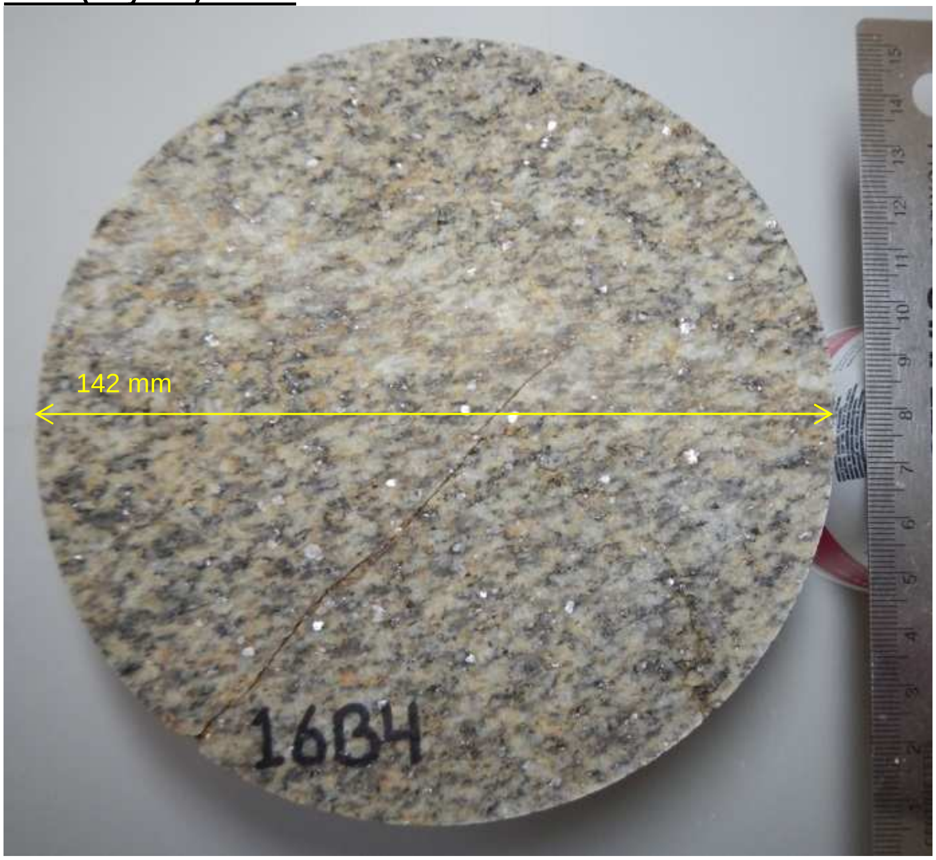
Interim (40 cycles) – 16B1 – *Partially dried back*



Final (55 cycles) – 16B1 – *Partially dried back*



Initial (0 cycles) – 16B4 – *Wetted*



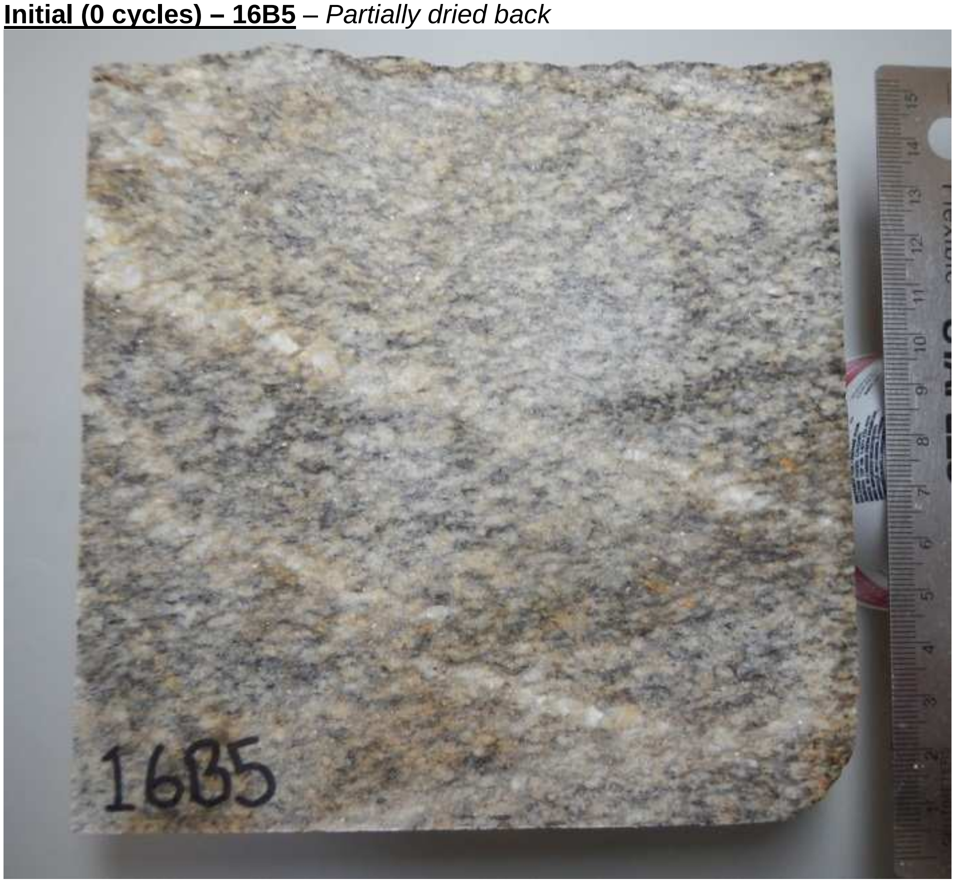
Initial (0 cycles) – 16B4 – *Partially dried back*

Interim (40 cycles) – 16B4 – *Partially dried back*

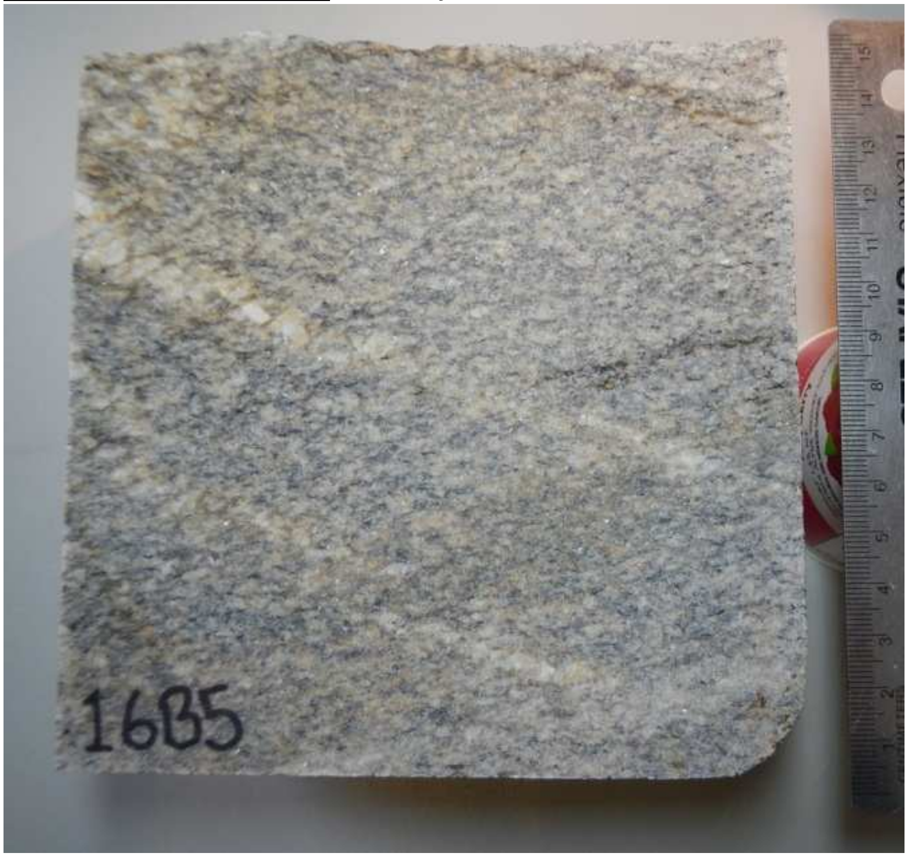
Final (55 cycles) – 16B4 – *Partially dried back*

Initial (0 cycles) – 16B5 – *Wetted*

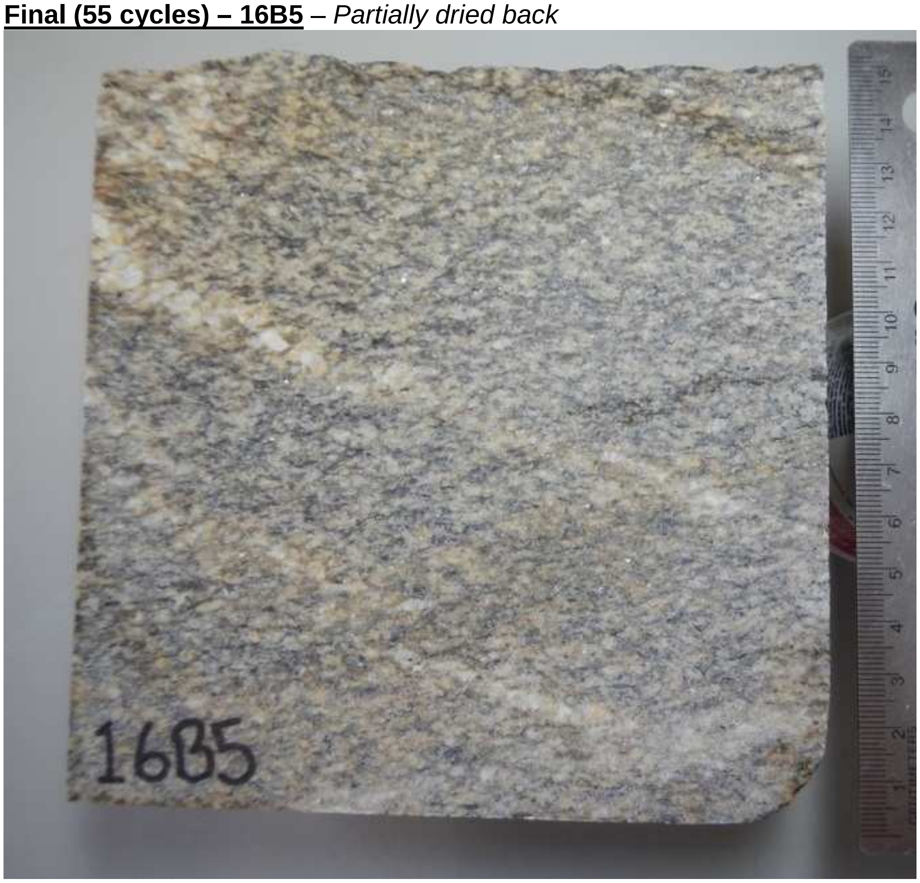
Initial (0 cycles) – 16B5 – *Partially dried back*



<u>Interim (40 cycles) – 16B5</u> – *Partially dried back*



<u>Final (55 cycles) – 16B5</u> – *Partially dried back*



<u>Initial (0 cycles) – 16B6</u> – *Wetted*

<u>Initial (0 cycles) – 16B6</u> – *Partially dried back*

<u>Interim (40 cycles) – 16B6</u> – *Partially dried back*

<u>Final (55 cycles) – 16B6</u> – *Partially dried back*

<u>Initial (0 cycles) – 16B7</u> – *Wetted*

<u>Initial (0 cycles) – 16B7</u> – *Partially dried back*

Interim (40 cycles) – 16B7 – *Partially dried back*

Final (55 cycles) – 16B7 – *Partially dried back*

-End of Photographs-

EVALUATION OF DURABILITY OF ROCK FOR EROSION CONTROL UNDER FREEZING AND THAWING CONDITIONS
ASTM D 5312

CH2M Hill
1100 – 1st Street SE
Calgary, Alberta, T2G 1B1

February 24, 2014
Project Number: 13-1417-0047-3000

ATTENTION: Mr. Mark Cichy

PROJECT: BSI Access Road Granitic Outcrop 2013

Sample:	**CH13-311-SS017_RKa, Sample Date: 9-Jul-2013**
Source:	**BSI Access Road Granitic Outcrop, Tar #18, Faro Mine Complex, Yukon**

Objective and Method:

The objective of this testing program was to evaluate the durability of rock proposed for use as erosion control in an environment where it is understood that it would be exposed to freezing and thawing and wetting and drying. The sample consisted of boulder-sized rock chunks with an average diameter of 0.5 meters. The boulders were understood to have been sampled from a site proposed for quarry production of rip rap material; the sampling site was identified as BSI Access Road Granitic Outcrop. The boulders were obtained by others in a sampling program.

The test program consisted solely of conducting the method described in ASTM D 5312. This report constitutes the final results of the test; all previously issued draft reports are hereby superseded. This report comprises a testing service only. Interpretation may be provided upon request.

In order to extract slab specimens from the boulder-size samples, a combination of wide diameter (6"/152 mm) rock coring and rock saw cutting was utilized. Some slab samples were circular in shape, while others were rectangular. Average dimensions of the slab specimens generally conformed to the requirements outlined in ASTM D 5240 and ASTM D 5121 (Preparation of Rock Slabs for Durability Testing). The rock slab specimens utilized in the test were generally 65 mm thick and not less than 125 mm on a side.

The test was designed such that the samples would be subjected to 55 cycles of freezing and thawing. In absence of specific instruction from the client and provision of relevant climate data, the number of total cycles was determined by comparing the approximate geographic location to the "Isoline Map of Freeze-Thaw Severity Index," Figure 1 from ASTM D 5312.

The freezing portion of each cycle consisted of storing the samples in a freezer at -18°C for a minimum of 16 hours. This was followed by a minimum of 8 hours of thawing in an oven at 32°C. The condition of each sample was evaluated every five cycles through macroscopic and microscopic examination using a binocular microscope with magnifications up to 50x, enabling observations of pre-existing cracks and newly developed deterioration. Inspections included photographs and descriptive logs.

Prior to and at the end of the test, each sample was weighed and the percent loss by mass calculated for the individual specimens.

A selection of boulders from sample CH13-311-SS017_RKa were identified as 1, 2, 3, 4, and 5 and were selected for testing. Additional durability testing, consisting of ASTM D 5240 (Testing of Rock Slabs to Evaluate Soundness of Riprap by Use of Magnesium Sulphate) and ASTM D 5313 (Evaluation of Durability of Rock for

Erosion Control Under Wetting and Drying Conditions) are being conducted on the same boulders. To compare the results from each test method, three slab specimens were extracted from each of the selected boulders and the same boulder identification designation was used for the three slabs.

Quantitative Analysis:

Percent Loss

Sample ID	Boulder #	Slab ID	Original Mass (g)	Final Mass (g)	Measured Loss (%)
CH13-311-SS017_RKa	1	**17B1**	2942.2	2942.1	**0%**
	2	**17B2**	2687.9	2687.7	**0.01%**
	3	**17B3**	2692.5	2692.5	**0%**
	4	**17B4**	3036.0	3035.4	**0.02%**
	5	**17B5**	3493.5	3491.7	**0.05%**
				Final Average Loss (%)	**0.02%**

Qualitative Analysis:

Summary of Initial Condition

Petrographic examination was undertaken on a crushed composite of select chunks of rock from the CH13-311-SS017-RKa sample batch; generally, the specimen rock type consisted of gneissic granodiorite. Thin section analysis was conducted on one rock particle; chemical analyses, such as whole-rock analysis by X-Ray Fluorescence, were not conducted. Each rock slab was extracted from a specimen with slight to significant variations in compositional, textural and structural qualities. Parameters that varied included:

Composition

- Proportion of mafic and felsic minerals
- Presence or near absence of metallic minerals
- Distribution of oxidation
- Mineral composition in veins

Textural

- Gneissic texture, which was slightly to moderately well-developed
- Fine/medium/coarse mineral grain size
- Presence of veins and their mode of occurrence

Structure

- Presence/absence of fractures
- Fracture width
- Number of fractures and fracture spacing
- Orientation and pattern of fractures
- Presence of weathering and oxidation around fractures

Observations of Individual Specimens

Slab ID	Observations		
	Initial @ 0 cycles	**Interim @ 40 cycles**	**Final @ 55 cycles**
17B1	- The slab was circular in shape with an approximate diameter of 148 mm - The sample consisted of slightly gneissic granodiorite with a mineral grain size that was fine to medium grained - Metallic mineral grains were not discernible; however, in thin section the dominant metallic minerals were rutile grains and hematite with trace amounts of very fine sulphide mineral grains - Slight oxidation staining was prevalent across the specimen, consisting of light yellow blotches throughout - Gneissic bands were short and not well-developed; they were not absorptive - One fracture (#1) extended from the edge of the slab towards the centre; the fracture transitioned from tightly closed and slightly absorptive near the edge and disappeared towards the center - Fracture #1 had slightly lighter and yellow coloured rock along the path of the fracture indicating that it was slightly weathered and stained	- No significant amount of material was dislodged from the slab - A few small mineral fragments were dislodged from pre-existing Fracture #1; these mineral fragments were weathered prior to testing - Fracture #1 was slightly more absorptive at the interim observation compared to the beginning of the test; it may have widened very slightly - Overall, this specimen did not exhibit any significant formation of fractures or loss of material	- Compared to the condition at the 40 cycle interim inspection, no material loss or propagation/formation of fractures was observed

17B2	- The slab was circular in shape with an approximate diameter of 148 mm - The sample consisted of moderately gneissic granodiorite with a mineral grain size that was fine grained - Metallic mineral grains were not discernible; however, in thin section the dominant metallic minerals were rutile grains and hematite with trace amounts of very fine sulphide mineral grains - Oxidation staining was not prevalent across the specimen; however, localized blebs and patches of dark orange iron oxide were observed around some ferromagnesian and other metallic minerals - Gneissic bands were moderately well-developed but were not absorptive - One fracture (#1) extended from the edge of the slab in a direction that was generally towards the centre; the fracture transitioned from tightly closed near the edge and disappeared towards the center - The absorption characteristics of Fracture #1 ranged from slightly to not absorptive - There were some short fractures (#2 and #3) which extended from the same edge of the slab where Fracture #1 originated and in a parallel direction; they were on the order of 2 to 8 mm long and were associated with some dark orange stained minerals	- The absorptive gneissic bands did not develop into fractures; generally, the absorption characteristics remained unchanged between the beginning of the test and the interim observations, indicating that no widening occurred - There was no loss of material along Fracture #2; mineral fragments along the path of the fracture were intact and well-adhered - New dark orange oxidation blebs formed in a few locations; this may be an indication of freshly exposed unoxidized metallic minerals being present in this specimen - Fracture #2 and #3 increased in length by about 1 to 2 mm further into the slab - Overall, this specimen did not exhibit any significant loss of material. Some very short fractures near the edge of the slab lengthened a very slight amount.	- Compared to the condition at the 40 cycle interim inspection, no material loss or propagation/formation of fractures was observed - Absorptive gneissic bands did not increase in length and they did not become more absorptive, more so than was observed at the interim inspection

17B3	- The slab was circular in shape with an approximate diameter of 143 mm - The sample consisted of slightly to moderately gneissic granodiorite with a mineral grain size that was fine to medium grained - Slight oxidation staining was prevalent across the specimen, consisting of light yellow and light orange blebs throughout - Metallic mineral grains were not discernible; however, in thin section the dominant metallic minerals were rutile grains and hematite with trace amounts of very fine sulphide mineral grains - One fracture (#1) extended a moderate distance into the slab and was roughly parallel to gneissic texture; it was approximately 55 mm long and was tightly closed with a width of less than 0.2 mm - Fracture #1 was slightly absorptive and coated with some oxidation product; it had undulating shape and was branched/braided to form an undulating and lens-shaped fracture pattern - A second fracture (#2) was very tightly closed, slightly absorptive and biotite mineral grains along the fracture were slightly oxidized - There were many slightly absorptive strands that appeared to be associated with gneissic texture but could not be discerned as fractures at 50x magnification; their extent was difficult to determine and were estimated based on absorption characteristics	- A few small mineral fragments were dislodged from pre-existing Fracture #2; they were slightly weathered and oxidized prior to testing - Fracture #2 did not appear to widen or extend - Despite consisting of multiple, branched, closely-spaced fractures, Fracture #1 did not exhibit material loss or growth of the fracture - The absorptive strands associated with gneissic texture appeared to be slightly more absorptive and greater in length; they may have widened and extended very slightly but they remained tightly closed and difficult to discern even under 50x magnification - Overall, there was a slight amount of material loss along pre-existing fractures and possibly slight growth of fractures along absorptive gneissic bands	- Compared to the condition at the 40 cycle interim inspection, no material loss or propagation/formation of fractures was observed

17B4	- The slab was rectangular in shape with approximate dimensions of 149 mm wide by 119 mm long - The sample consisted of strongly gneissic granodiorite with a mineral grain size that was fine grained - Metallic mineral grains were not discernible; however, in thin section the dominant metallic minerals were rutile grains and hematite with trace amounts of very fine sulphide mineral grains - Oxidation staining was not prevalent across the specimen; it was localized to very thin fractures throughout the specimen and to some zones along the edge of the slab - A vein (#1) in-filled with dark green/grey mineral extended across the specimen with consistent direction but irregular shape; a 6 mm zone to either side of the vein was weathered and had an opaque white colour - Vein #1 was about 1 mm thick, had a layered and braided pattern, and was not fractured or absorptive - One additional vein (#2) followed the same general orientation as Vein #1; however, the vein was thin by comparison (~0.5 mm) and the weathered zone was less well pronounced - There was a prevalence of short to medium length (10 to 50 mm), discontinuous and oxidized fractures that were roughly parallel with the gneissic bands; they ranged from moderately absorptive to not absorptive and in some cases were coated/infilled with a small amount of oxidation product	- The prevalent, thin oxidized fractures associated with the gneissic bands did not widen or lose material; generally, the absorption characteristics remained unchanged between the beginning of the test and the interim observations - Vein #1 and #2 were completely unaffected - Overall, this specimen did not exhibit formation of fractures or loss of material	- Compared to the condition at the 40 cycle interim inspection, no material loss or propagation/formation of fractures was observed - Absorptive gneissic bands did not increase in length and they did not become more absorptive

17B5	- The slab was rectangular in shape with an approximate dimension of 165 mm wide by 141 mm long - The sample consisted of very slightly gneissic granodiorite with a mineral grain size that was medium to coarse grained - This specimen had a noticeably different mineral composition and texture compared to specimens 17B1, 17B2, 17B3 and 17B4; 17B5 had less mafic minerals and a coarse mineral grain size - Mineral grain boundaries were distinct and had a weathered appearance; alteration of feldspar minerals was prevalent - Oxidation consisted of localized yellow blebs that appeared to be associated with feldspar minerals as much as with ferromagnesian minerals - It is not known whether fine metallic mineral grains were present; thin section analysis was not conducted on this rock type - Muscovite was abundant throughout and was coarse-grained - Localized stringlets and short bands of mica (biotite and muscovite) were observed; they were undulating and not continuous and were only slightly absorptive - The length of these micaceous stringlets/bands ranged from 2 to about 10 mm; however, it was observed that if the slab had been cut at a different orientation, the length of the bands would have been greater (on the order of 80 mm) - One fracture (#1) extended from the edge to the center of the slab, transitioning from open/absorptive to closed/ not absorptive; it was 2 mm at its widest and an average of 0.5 mm wide overall - Where Fracture #1 met the edge of the slab some chunks of the slab edge had detached; additionally, some mineral fragments had pitted and dislodged along the path of the fracture giving it a wide appearance - Fracture #1 terminated (or originated) at a dark orange oxidized bleb in the center of the specimen; the fracture did not extend through the full depth of the slab and was slightly weathered - A second fracture (#2) was located within the slab and appeared to be associated with a stringlet of mica minerals; it was moderately absorptive	- Fragments dislodged along Fracture #1; they had moderate to poor bond strength prior to testing - The length of Fracture #1 increased in length by approximately 8 mm; the extended portion was only slightly absorptive and was tightly closed - The rate of absorption for Fracture #1 appears to have increased, indicating potential future widening - A few mineral fragments dislodged along Fracture #2 - The absorptive stringlets and bands of mica did not develop into fractures, or lose material - Some thin portions along the slab edge that were not well adhered prior to testing may have broken off during testing - Overall, this specimen had some extension of pre-existing fractures and slight loss of material. Mineral grains appeared to be weathered in this specimen and intergranular bond strength was moderate	- Compared to the condition at the 40 cycle interim inspection, no material loss or propagation/formation of fractures was observed - Material along the outside edge (rind) of the slab and on fracture surfaces of some pre-existing fractures had weathered, oxidized and fractured material that could be pried and plucked off with a steel tool. This material was weakly adhered prior to testing and did not become weak as a result of freeze-thaw stresses

Summary of Deterioration

The majority of specimens did not appear to have significant material loss. For those that exhibited any loss of material the loss consisted of only small fragments that were thin and/or poorly attached to pre-existing fractures, noted prior to testing. The majority of pre-existing fractures did not propagate and new fractures did not form as a result of the freezing and thawing action. Some pre-existing fractures that were open prior to testing and absorptive gneissic bands may have widened and lengthened very slightly; however, this only occurred for select specimens and with certain conditions. The following observations regarding sample conditions were made:

Loss of Material

- Dislodgement of thin portions of the slab specimen that were intersected by pre-existing fractures and were moderately to poorly adhered prior to testing
- Pitting and dislodgement of material along pre-existing fracture paths where fractures were: i) weathered and oxidized, ii) braided and/or intersecting with other fractures, iii) located within moderately strong rock
- Rock types that were weathered, coarse grained and with moderate intergranular bond strength had a greater amount of material loss along pre-existing fractures

Formation and/or propagation of fractures

- Several pre-existing fractures widened and extended in length slightly. Typically, the fractures that widened were open greater than ~0.5 mm and the fracture surfaces were weathered and oxidized prior to testing.
- The fractures that extended in length were similarly open, weathered and oxidized. One specimen exhibited 1 to 2 mm extension in fine grained, generally competent rock. Another specimen, which was coarse grained and with only moderately intergranular bond strength, had one fracture extend by 8 mm.
- Some microscopic fractures which appeared to be associated with gneissic texture may have widened very slightly.
- Some specimens had an abundance of very fine fractures that were oxidized and absorptive; however, they were unaffected by the stresses imposed by freezing and thawing

Overall Summary

The data given in this report pertain to the samples provided, and may not be applicable to material from other locations or trial periods.

The observations for material loss and fracture formation, as well as the visual and measured estimate of mass loss were comparable between the 40 cycle interim inspection and the 55 cycle final inspection. This indicates that the specimens did not undergo significant additional deterioration after 55 cycles, compared to 40 cycles.

The specimens had an average measured loss of 0.02%. Only specimen 17B5, which consisted of a rock type inconsistent with the other 4 specimens, had an outlying result; this suggests that the majority of samples were similar in regards to their resistance to the stresses imposed by freezing and thawing action. Material loss appeared to be caused by dislodgment of material which was only moderately well adhered to pre-existing fracture surfaces prior to testing and generally consisted of small fragments and mineral grains.

Formation of new fractures, widening, and lengthening of pre-existing fractures was observed in very minor amounts in the tested rock slabs and was typically associated with fractures which were open, weathered, oxidized and coated. Similar to the trend which was observed with material loss, specimen 17B5 had inconsistently more significant fracture propagation compared with the other 4 specimens; this is likely due to the rock being coarse grained, slightly weathered and having moderate intergranular bond strength.

Prepared, tested and reported by:

B. Hudson, P. Geo.

Reviewed by:

F. Shrimer., P. Geo.

PHOTOGRAPHS

Initial (0 cycles) – 17B1 – *Wetted*

Initial (0 cycles) – 17B1 – *Partially dried back*

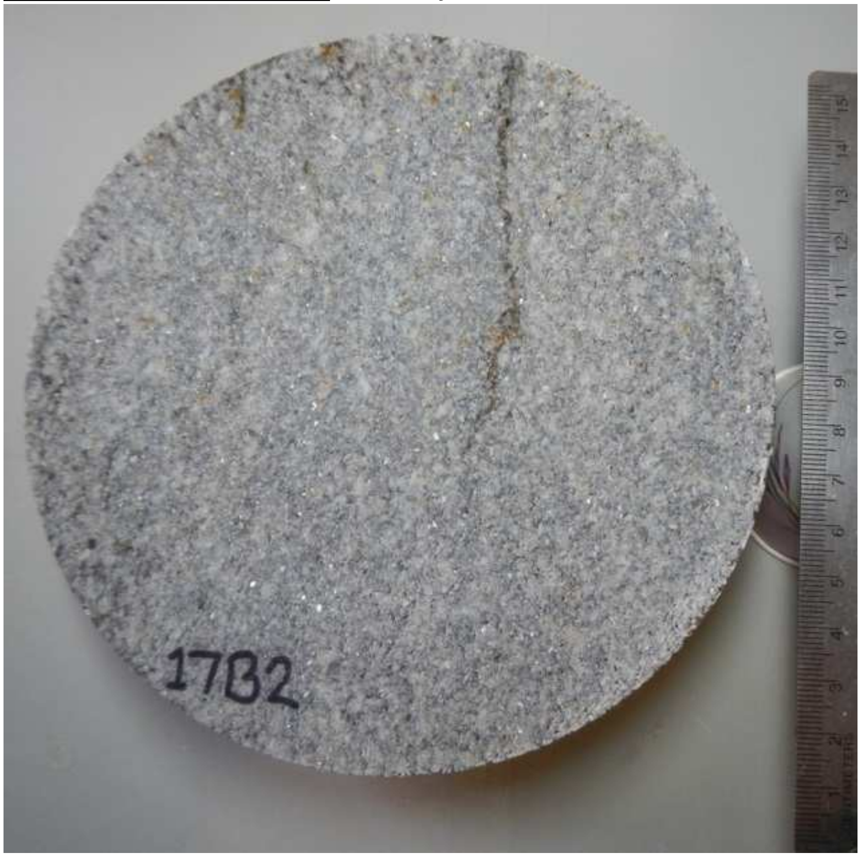
Interim (40 cycles) – 17B1 – *Partially dried back*

Final (55 cycles) – 17B1 – *Partially dried back*

Initial (0 cycles) – 17B2 – *Wetted*

Initial (0 cycles) – 17B2 – *Partially dried back*

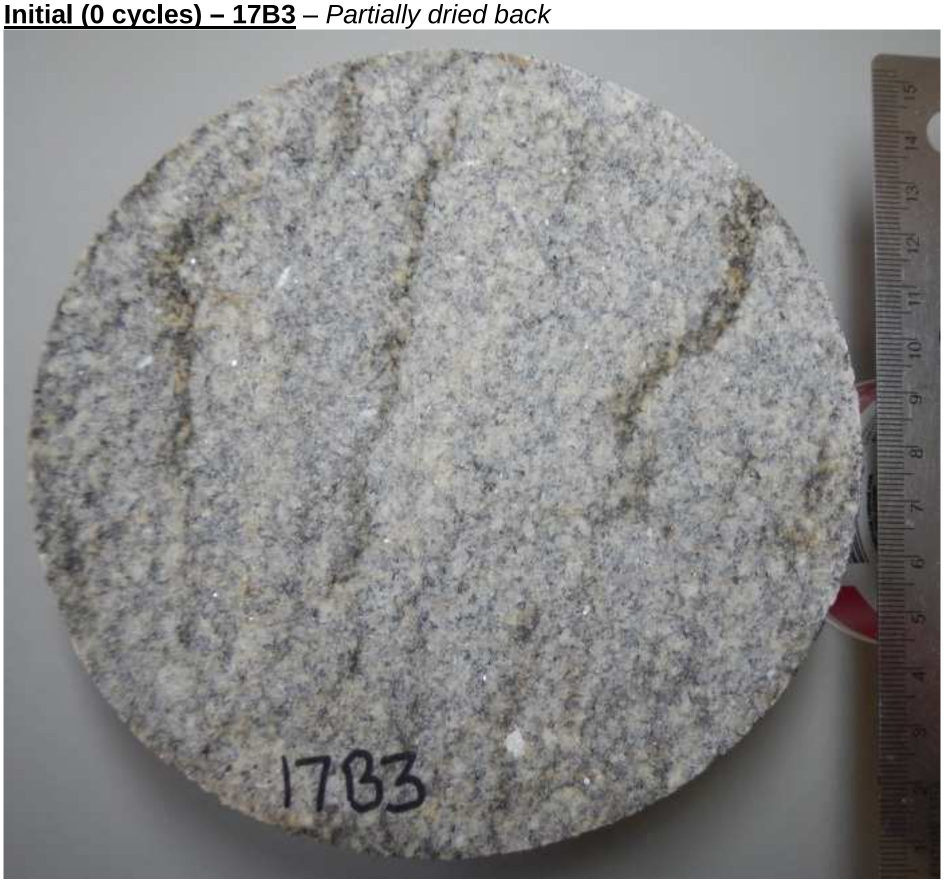
Interim (40 cycles) – 17B2 – *Partially dried back*



Final (55 cycles) – 17B2 – *Partially dried back*

Initial (0 cycles) – 17B3 – *Wetted*

Initial (0 cycles) – 17B3 – *Partially dried back*



Interim (40 cycles) – 17B3 – *Partially dried back*

Final (55 cycles) – 17B3 – *Partially dried back*

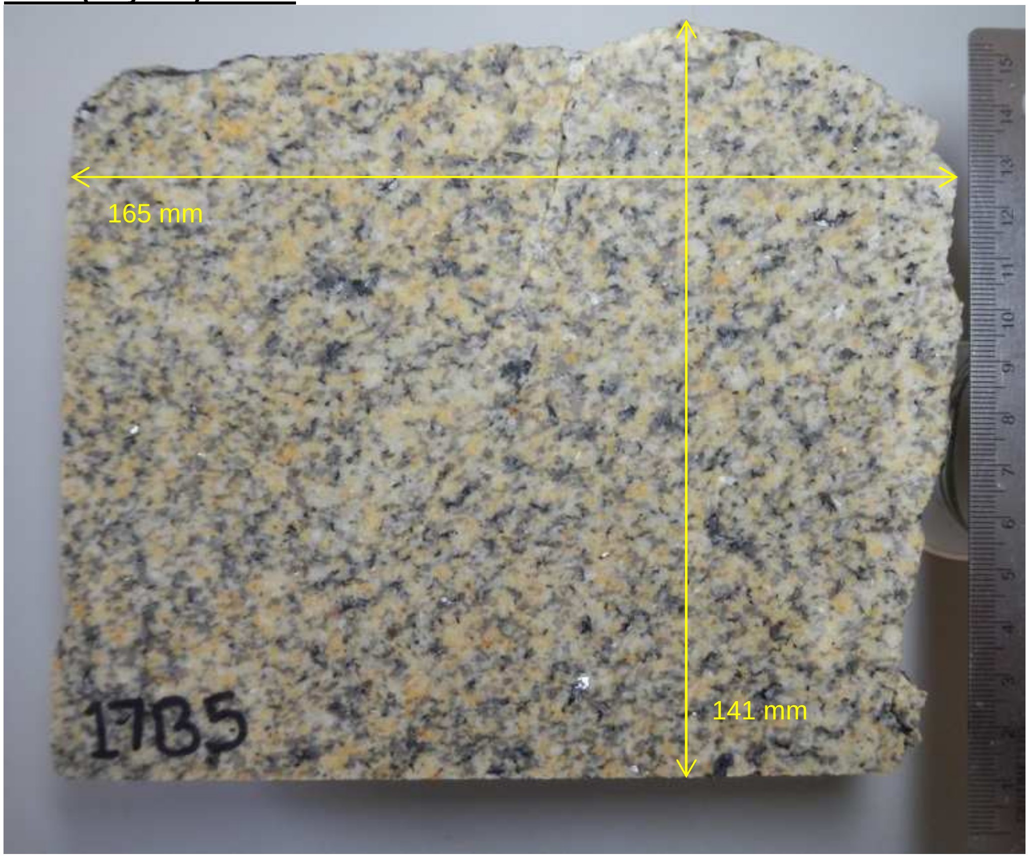
Initial (0 cycles) – 17B4 – *Wetted*

Initial (0 cycles) – 17B4 – *Partially dried back*

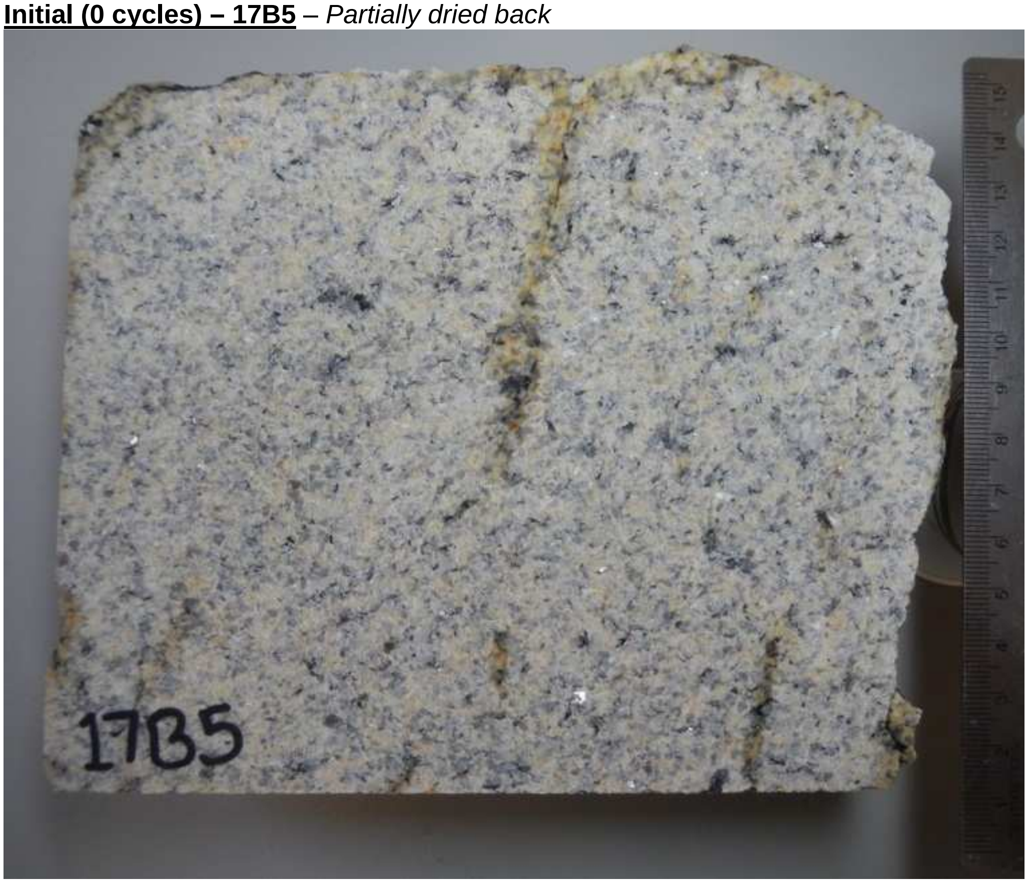
Interim (40 cycles) – 17B4 – *Partially dried back*

Final (55 cycles) – 17B4 – *Partially dried back*

Initial (0 cycles) – 17B5 – *Wetted*

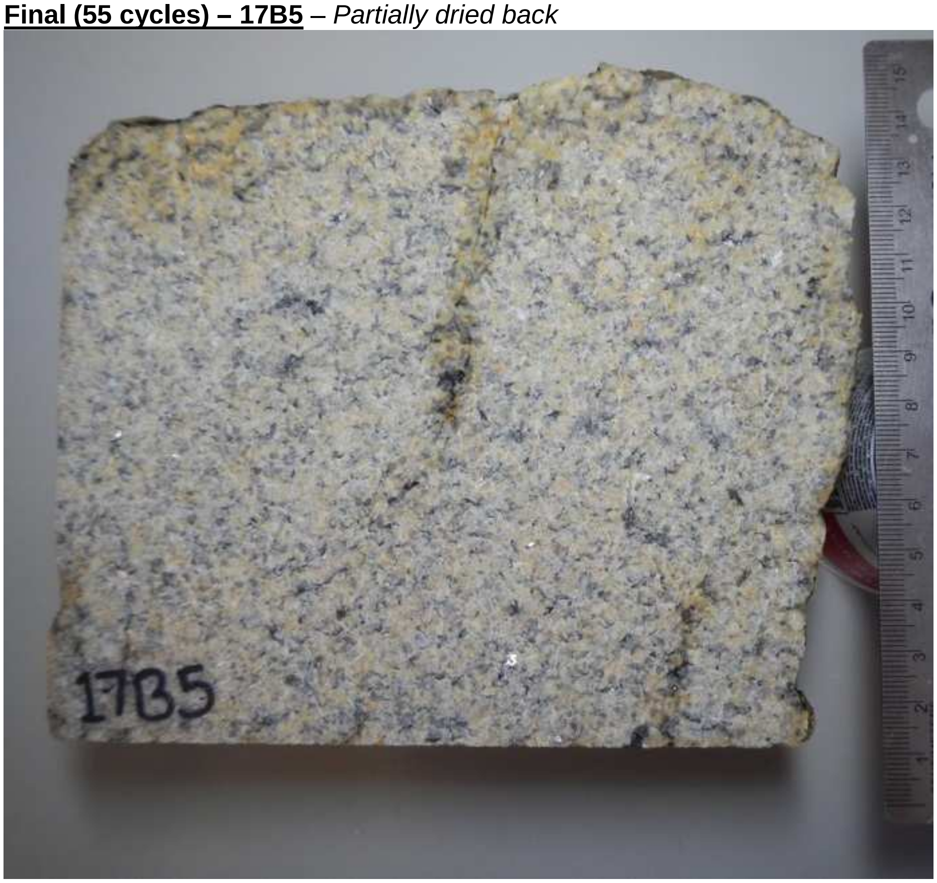


Initial (0 cycles) – 17B5 – *Partially dried back*



Interim (40 cycles) – 17B5 – *Partially dried back*

Final (55 cycles) – 17B5 – *Partially dried back*



-End of Photographs-

SPECIFIC GRAVITY AND ABSORPTION OF ROCK FOR EROSION CONTROL

ASTM D6473

October 18, 2013
Project Number: 13-1417-0047-3000

CH2M Hill
1100 – 1st Street SE
Calgary, Alberta
T2G 1B1

ATTENTION: Mr. Mark Cichy

PROJECT: BSI Access Road Granitic Outcrop 2013

Sample:	**CH13-311-SS013_Rka**
Source:	**Access Road Granitic Outcrop, Tar #18, Faro Mine Complex, Yukon**

Date sampled: July 9, 2013
Date tested: October 15, 2013

Sampled by: Client
Tested by: DC/VN

Rock #	Mass (grams)	Relative Density (g/cm^3) (Dry Basis)	Relative Density (g/cm^3) (SSD Basis)	Relative Density (g/cm^3) (Apparent)	Absorption (%)
1	1948.2	2.595	2.610	2.635	0.58
2	2171.3	2.644	2.656	2.675	0.44
3	5555.0	2.606	2.624	2.655	0.70
4	4537.5	2.589	2.609	2.642	0.78
5	8581.1	2.638	2.652	2.674	0.51
AVERAGE		**2.614**	**2.630**	**2.656**	**0.60**

Reported by: S. John, AScT

Reviewed by: ______________________
L. Hu, M. Sc. E., P.Eng.

Notice: The test data given herein pertain to the sample provided, and may not be applicable to material from other production zones/periods. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

SPECIFIC GRAVITY AND ABSORPTION OF ROCK FOR EROSION CONTROL

ASTM D6473

October 18, 2013
Project Number: 13-1417-0047-3000

CH2M Hill
1100 – 1st Street SE
Calgary, Alberta
T2G 1B1

ATTENTION: Mr. Mark Cichy

PROJECT: BSI Access Road Granitic Outcrop 2013

Sample:	**CH13-311-SS016_Rka**
Source:	**Access Road Granitic Outcrop, Tar #18, Faro Mine Complex, Yukon**

Date sampled: July 9, 2013 **Sampled by:** Client
Date tested: October 15, 2013 **Tested by:** DC/VN

Rock #	Mass (grams)	Relative Density (g/cm^3) (Dry Basis)	Relative Density (g/cm^3) (SSD Basis)	Relative Density (g/cm^3) (Apparent)	Absorption (%)
1	4106.5	2.570	2.597	2.640	1.02
2	4754.7	2.608	2.624	2.650	0.60
3	2222.0	2.618	2.631	2.653	0.51
4	2196.0	2.582	2.599	2.627	0.66
5	2564.0	2.576	2.599	2.637	0.89
AVERAGE		**2.591**	**2.610**	**2.641**	**0.74**

Reported by: S. John, AScT

Reviewed by: ____________________
L. Hu, M. Sc. E., P.Eng.

The Voice Of Independent Canadian Laboratories
La voix des laboratoires indépendants canadiens

Notice: The test data given herein pertain to the sample provided, and may not be applicable to material from other production zones/periods. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

SPECIFIC GRAVITY AND ABSORPTION OF ROCK FOR EROSION CONTROL

ASTM D6473

October 18, 2013
Project Number: 13-1417-0047-3000

CH2M Hill
1100 – 1st Street SE
Calgary, Alberta
T2G 1B1

ATTENTION: Mr. Mark Cichy

PROJECT: BSI Access Road Granitic Outcrop 2013

Sample:	**CH13-311-SS017_Rka**
Source:	**Access Road Granitic Outcrop, Tar #18, Faro Mine Complex, Yukon**

Date sampled: July 9, 2013 **Sampled by:** Client
Date tested: October 15, 2013 **Tested by:** DC/VN

Rock #	Mass (grams)	Relative Density (g/cm^3) (Dry Basis)	Relative Density (g/cm^3) (SSD Basis)	Relative Density (g/cm^3) (Apparent)	Absorption (%)
1	906.1	2.622	2.636	2.658	0.52
2	1205.5	2.575	2.604	2.651	1.11
3	2432.0	2.912	2.923	2.944	0.38
4	3283.8	2.606	2.625	2.656	0.73
5	4202.4	2.611	2.626	2.650	0.56
AVERAGE		**2.665**	**2.683**	**2.712**	**0.66**

Reported by: S. John, AScT

Reviewed by: ______________________
L. Hu, M. Sc. E., P.Eng.

Notice: The test data given herein pertain to the sample provided, and may not be applicable to material from other production zones/periods. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

SPECIFIC GRAVITY AND ABSORPTION OF ROCK FOR EROSION CONTROL

ASTM D6473

October 18, 2013
Project Number: 13-1417-0047-3000

CH2M Hill
1100 – 1st Street SE
Calgary, Alberta
T2G 1B1

ATTENTION: Mr. Mark Cichy

PROJECT: BSI Access Road Granitic Outcrop 2013

Sample:	**CH13-311-SS018_Rka**
Source:	**Access Road Granitic Outcrop, Tar #18, Faro Mine Complex, Yukon**

Date sampled: July 9, 2013 **Sampled by:** Client
Date tested: October 15, 2013 **Tested by:** DC/VN

Rock #	Mass (grams)	Relative Density (g/cm^3) (Dry Basis)	Relative Density (g/cm^3) (SSD Basis)	Relative Density (g/cm^3) (Apparent)	Absorption (%)
1	1740.0	2.639	2.647	2.661	0.32
2	3058.1	2.641	2.648	2.661	0.29
3	2016.9	2.614	2.629	2.653	0.57
4	3961.8	2.627	2.636	2.650	0.34
5	2567.5	2.557	2.591	2.646	1.31
AVERAGE		**2.615**	**2.630**	**2.654**	**0.57**

Reported by: S. John, AScT

Reviewed by: ______________________
L. Hu, M. Sc. E., P.Eng.

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Golder Associates

SPECIFIC GRAVITY AND ABSORPTION OF ROCK FOR EROSION CONTROL

ASTM D6473

October 18, 2013
Project Number: 13-1417-0047-3000

CH2M Hill
1100 – 1st Street SE
Calgary, Alberta
T2G 1B1

ATTENTION: Mr. Mark Cichy

PROJECT: BSI Access Road Granitic Outcrop 2013

Sample:	**CH13-311-SS015_Rka**
Source:	**Access Road Granitic Outcrop, Tar #18, Faro Mine Complex, Yukon**

Date sampled: July 10, 2013 **Sampled by:** Client
Date tested: October 15, 2013 **Tested by:** DC/VN

Rock #	Mass (grams)	Relative Density (g/cm^3) (Dry Basis)	Relative Density (g/cm^3) (SSD Basis)	Relative Density (g/cm^3) (Apparent)	Absorption (%)
1	2829.0	2.618	2.629	2.647	0.42
2	1681.4	2.592	2.607	2.630	0.56
3	1320.3	2.605	2.621	2.647	0.62
4	1293.2	2.595	2.610	2.635	0.58
5	1442.5	2.603	2.619	2.645	0.60
6	1985.1	2.616	2.626	2.644	0.40
AVERAGE		**2.605**	**2.619**	**2.641**	**0.53**

Reported by: S. John, AScT

Reviewed by: ______________________
L. Hu, M. Sc. E., P.Eng.

Notice: The test data given herein pertain to the sample provided, and may not be applicable to material from other production zones/periods. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

GOLDER ASSOCIATES LTD., 300 - 3811 North Fraser Way, Burnaby, BC, Canada V5J 5J2 Tel: 604-412-6899 Fax: 604-412-6816

SPECIFIC GRAVITY AND ABSORPTION OF ROCK FOR EROSION CONTROL

ASTM D6473

October 18, 2013
Project Number: 13-1417-0047-3000

CH2M Hill
1100 – 1st Street SE
Calgary, Alberta
T2G 1B1

ATTENTION: Mr. Mark Cichy

PROJECT: BSI Access Road Granitic Outcrop 2013

Sample:	**CH13-311-BH017_RKd**
Source:	**Access Road Granitic Outcrop, Tar #18, Faro Mine Complex, Yukon**

Date sampled: August 7, 2013
Date tested: October 15, 2013

Sampled by: Client
Tested by: DC/VN

Rock #	Mass (grams)	Relative Density (g/cm^3) (Dry Basis)	Relative Density (g/cm^3) (SSD Basis)	Relative Density (g/cm^3) (Apparent)	Absorption (%)
1	555.4	2.644	2.652	2.666	0.31
2	564.1	2.644	2.652	2.665	0.30
3	552.9	2.612	2.625	2.647	0.51
4	422.1	2.621	2.636	2.662	0.60
5	370.3	2.630	2.643	2.666	0.52
AVERAGE		**2.630**	**2.642**	**2.661**	**0.45**

Reported by: S. John, AScT

Reviewed by: ____________________
L. Hu, M. Sc. E., P.Eng.

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SPECIFIC GRAVITY AND ABSORPTION OF ROCK FOR EROSION CONTROL

ASTM D6473

October 18, 2013
Project Number: 13-1417-0047-3000

CH2M Hill
1100 – 1st Street SE
Calgary, Alberta
T2G 1B1

ATTENTION: Mr. Mark Cichy

PROJECT: BSI Access Road Granitic Outcrop 2013

Sample:	**CH13-311-BH017_RKe**
Source:	**Access Road Granitic Outcrop, Tar #18, Faro Mine Complex, Yukon**

Date sampled: August 7, 2013 **Sampled by:** Client
Date tested: October 15, 2013 **Tested by:** DC/VN

Rock #	Mass (grams)	Relative Density (g/cm^3) (Dry Basis)	Relative Density (g/cm^3) (SSD Basis)	Relative Density (g/cm^3) (Apparent)	Absorption (%)
1	1136.7	2.657	2.664	2.675	0.25
2	1156.8	2.645	2.655	2.672	0.37
3	868.7	2.655	2.662	2.674	0.27
4	389.6	2.648	2.659	2.679	0.44
AVERAGE		**2.651**	**2.660**	**2.675**	**0.33**

Reported by: S. John, AScT

Reviewed by: ______________________
L. Hu, M. Sc. E., P.Eng.

TESTING OF ROCK SLABS TO EVALUATE SOUNDNESS OF RIPRAP BY USE OF SODIUM SULPHATE OR MAGNESIUM SULPHATE
ASTM D 5240

CH2M Hill
1100 – 1st Street SE
Calgary, Alberta, T2G 1B1

November 27, 2013
Project Number: 13-1417-0047-3000

ATTENTION: Mr. Mark Cichy

PROJECT: BSI Access Road Granitic Outcrop 2013

Sample:	CH13-311-SS016_RKa, Sample Date: 9-Jul-2013
Source:	BSI Access Road Granitic Outcrop, Tar #18, Faro Mine Complex, Yukon

Objective and Method:

The objective of this testing program was to evaluate the durability of rock proposed for use as erosion control in an environment where it would be exposed to freezing and thawing and wetting and drying. The sample that was provided consisted of boulder-sized rock chunks with an average diameter of 0.5 meters. The boulders were understood to have been sampled from a proposed quarry site for production of rip rap material; the sampling site was identified as BSI Access Road Granitic Outcrop. The boulders were obtained by others in a sampling program.

The test program consisted of the method described in ASTM D 5240; the results of this test are summarized in this report. This report comprises a testing service only. Interpretation may be provided upon request.

In order to extract slab specimens from the boulder-size samples, a combination of wide diameter (6"/ 152 mm) rock coring and rock saw cutting was utilized. Some slab samples were circular in shape, while others were rectangular. Average dimensions of the slab specimens generally conformed to the requirements outlined in ASTM D 5240 and ASTM D 5121 (Preparation of Rock Slabs for Durability Testing). The rock slab specimens utilized in the test were generally 65 mm thick and not less than 125 mm on a side.

The test was conducted such that the specimens were subjected to 5 cycles of soaking and drying; this is the number of cycles specified in ASTM D 5240 and is the same number of cycles utilized in ASTM C 88 (Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate). The soaking portion of each cycle consisted of storing the specimens in a solution of magnesium sulphate for a minimum of 16 hours. This was followed by a minimum of 8 hours of drying in an oven at 110 °C.

For this test, magnesium sulphate was utilized, as opposed to sodium sulphate because magnesium sulphate is routinely used in Golder's laboratory for the ASTM C 88 test and was readily available when testing was started, while sodium sulphate would have had to be ordered, possibly contributing to a delay in initiation of the test. ASTM C 88 Section 3.2 states that "the test is usually more severe when magnesium sulphate is used…;" thus, it may be interpreted that the percent loss and deterioration when using magnesium sulphate may be exaggerated slightly compared to when using sodium sulphate.

The condition of each slab specimen was evaluated before and after the 5 cycles through macroscopic and microscopic examination using a binocular microscope with magnifications up to 50x. Observations were made

of material dislodgement, pre-existing cracks and newly developed deterioration. At each inspection, a photo and inspection log was generated for each specimen.

Prior to and at the end of the test procedure, each slab was weighed and the percent loss by mass was calculated for the individual specimens.

A batch of boulders from sample CH13-311-SS016_RKa were provided from which the boulders identified as 1, 4, 5, 6, and 7 were selected for testing. Additional durability testing, consisting of ASTM D 5312 (Evaluation of Durability of Rock for Erosion Control Under Freezing and Thawing Conditions) and ASTM D 5313 (Evaluation of Durability of Rock for Erosion Control Under Wetting and Drying Conditions) are being conducted on the same boulders. To compare the results from each test method, three slab specimens were extracted from each of the selected boulders and the same boulder identification # was shared between the three slabs.

<u>Quantitative Analysis</u>:

<u>Percent Loss</u>

Sample ID	Boulder #	Slab ID	Original Mass (g)	Final Mass (g)	Loss (%)
CH13-311-SS016_RKa	1	**16A1**	3203.5	3203.5	***0.00***
	4	**16A4**	3033.6	3033.6	***0.00***
	5	**16A5**	3398.1	3398.1	***0.00***
	6	**16A6**	2353.6	2352.9	***0.03***
	7	**16A7**	3646.3	3630.9	***0.42***
				Final Average Loss (%)	**<u>0.09</u>**

<u>Qualitative Analysis:</u>

<u>Summary of Initial Condition</u>

Petrographic examination was undertaken on a crushed composite of select chunks of rock from the CH13-311-SS016-RKa sample batch; generally, the specimen rock type consisted of gneissic granodiorite. Thin section analysis was conducted on one piece of rock; chemical analyses, such as whole-rock analysis by X-Ray Fluorescence, were not conducted. Each rock slab was extracted from a specimen with slight to significant variations in compositional, textural and structural qualities. Parameters that varied included:

Composition
- Proportion of mafic and felsic minerals
- Presence or near absence of metallic minerals
- Distribution of oxidation product
- Amount of muscovite
- Presence/absence of iron oxide coating on fracture surfaces

Textural
- Gneissic texture which was slightly to moderately well-developed
- Spacing of gneissic bands
- Fine to medium mineral grain size

- Presence of veins

Structure

- Presence/absence of fractures
- Fracture width
- Number of fractures and fracture spacing
- Orientation and pattern of fractures
- Presence of weathering and oxidation around fractures

Observations of Individual Specimens

Slab ID	Observations	
	Initial @ 0 cycles	**Final @ 5 cycles**
16A1	- The slab was rectangular in shape with an approximate dimension of 140 mm wide by 147 mm long - The sample consisted of slightly gneissic granodiorite with a mineral grain size that was medium grained - Some portions of the slab were stained medium orange by oxidation while others were fresh and generally white-black in colour; the oxidized portions appeared to be slightly more weathered - Muscovite was moderately abundant and some patches of coarsely crystalline hornblende were observed on some fresh fracture surfaces and very rarely throughout the slab - Metallic mineral grains were not discernible; however, in thin section the dominant metallic mineral was hematite - Gneissic bands were not well-developed and were not absorptive - One edge of the specimen that was significantly weathered had some short fractures extending 10 to 18 mm into the slab; the fractures were highly absorptive, they appeared to have weathered surfaces coated in iron oxide, and they were not oriented parallel to gneissic banding - A small corner of the slab had several short and intersecting fractures that were all weathered; this was interpreted to be a portion of weathered rind from the original boulder sample	- No significant amount of material was dislodged from the slab - All short fractures along the edge of the slab absorbed magnesium sulphate solution; however, they did not widen and no material was dislodged from them - Overall, this specimen did not exhibit any significant formation of fractures or loss of material. One edge of the slab was weathered and contained some short fractures.

16A4	- The slab was rectangular in shape with approximate dimensions of 145 mm wide by 128 mm long - The sample consisted of slightly to moderately gneissic granodiorite with a mineral grain size that was fine to medium grained - Some bands and regions of the slab were lighter coloured and consisted of a greater proportion of felsic minerals and minor amounts of mafic minerals; the felsic bands ranged from 28 to 50 mm wide and were not parallel to the preferred orientation of mineral grains that defined the gneissic texture - Muscovite was present in lesser amounts - Metallic mineral grains were not discernible; however, in thin section the dominant metallic mineral was hematite - Some short gneissic bands were moderately well-developed and in several cases, they absorbed water; fractures were not detectable at 50x magnification in these bands - Oxidation staining was not prevalent across the specimen; however, localized blebs and patches of iron oxide were observed around some ferromagnesian and metallic minerals	- The absorptive gneissic bands did not develop into fractures; generally, the absorption characteristics remained unchanged between the beginning and end of the test, indicating that no widening of fractures occurred - Some concentrated bands of mica appeared to have lost very slight amounts of material at the slab surface, indicating that the magnesium sulphate penetrated into these bands and causing heave of the material - Overall, this specimen did not exhibit any significant formation of fractures or loss of material; however, magnesium sulphate was able to penetrate into concentrated gneissic bands of mica
16A5	- The slab was rectangular in shape with an approximate dimension of 143 mm wide by 134 mm long - The sample consisted of moderately gneissic granodiorite with a mineral grain size that was fine to medium grained - Large portions of the slab were stained light to dark orange by oxidation while others were fresh and generally white-black in colour; the oxidized portions appeared to be slightly more weathered - Muscovite was present in lesser amounts - Metallic mineral grains were not discernible; however, in thin section the dominant metallic mineral was hematite - One fracture (#1) extended through a large portion of the slab and was tightly closed with a width of less than 0.1 mm; some mineral fragments had dislodged along the fracture leaving a pitted appearance in some portions - Fracture #1 was slightly weathered and the fracture surfaces had a light coating of iron oxide; it was not oriented parallel to gneissic banding - A second fracture (#2) extended through a large portion of the slab and intersected Fracture #1; it was tightly closed with a width of less than 0.1 mm and while appearing to be slightly weathered, it did not have oxidized surfaces - The fracture pattern of Fracture #2 was layered and braided but mineral grains were generally well attached; its orientation was not parallel to banding - Some short gneissic bands were moderately well-developed and in several cases, they were absorptive and were associated with very thin, discontinuous fractures	- The absorptive gneissic bands did not develop into fractures; generally, the absorption characteristics remained unchanged between the beginning and end of the test indicating that no widening occurred - A few small mineral fragments were dislodged from pre-existing Fracture #1 in the portion that was already pitted; magnesium sulphate appeared to have readily penetrated some portions of the fracture - Fracture #1 did not widen or lengthen - Fracture #2 was generally unaffected besides a few small mineral fragments that were dislodged along the fracture path - Overall, this specimen did not exhibit any significant formation of fractures or loss of material

16A6	- The slab was circular in shape with an approximate diameter of 153 mm - The sample consisted of slightly gneissic granodiorite with a mineral grain size that was medium grained - Generally, the entire slab was stained light orange by oxidation - Muscovite was abundant throughout the sample and had random orientation of mineral grains - Metallic mineral grains were not discernible; however, in thin section the dominant metallic mineral was hematite - One significant fracture was located near the edge of the slab; it intersected an 11 mm wide portion of the slab - The fracture ranged in width from 0.2 to 1 mm and extended through the entire depth of the slab; the fracture had a layered and braided fracture pattern and was highly absorptive - Many segments of the fracture had a pitted appearance and the surfaces appeared weathered and were coated in iron oxide - A few gneissic bands that were moderately well-developed, were absorptive and were associated with very thin and discontinuous fractures	- The pre-existing fracture near the edge of the slab widened slightly; the thin, 11 mm portion that was intersected did not appear to be well attached after testing - Some mineral fragments were dislodged along the fracture that widened - Magnesium sulphate staining was prevalent on the fracture and water readily absorbed - Overall, while this specimen did not exhibit significant loss of material, a pre-existing fracture that was well-developed widened slightly and the portion of slab which it intersected became only moderately well attached to the slab
16A7	- The slab was square in shape with an approximate dimension of 140 mm wide by 140 mm long - The sample consisted of moderately gneissic granodiorite with a mineral grain size that was fine to medium grained - Muscovite was present in lesser amounts - Metallic mineral grains were not discernible; however, in thin section the dominant metallic mineral was hematite - One large fracture (#1) extended across the slab and intersected the slab surface at a low angle; the fracture surface was significantly weathered and coated with iron oxide - Mineral fragments along Fracture #1 detached during preparation of the slab due to being thin and weathered; the result was that the fracture had a pitted and wide appearance despite being generally less than 0.3 mm wide overall - Fracture #1 was intersected by a second fracture (#2) which was almost perpendicular to the slab surface - Fracture #2 was well-developed, approximately 0.2 mm wide and moderately to highly absorptive; however, it was not continuous through the slab and tapered into non-fractured rock in some locations - A third fracture (#3) had a similar low angle to the slab surface as Fracture #1; however it was not weathered, oxidized or pitted - Oxidation staining was not prevalent across the specimen; however, localized blebs and patches of iron oxide were observed around some ferromagnesian and metallic minerals	- A few small mineral fragments were dislodged from all pre-existing fractures - Fracture #1 lost the most significant amount of material along its fracture path due to mineral fragments being thin, weathered and poorly adhered; material loss did not extend more than 1.2 mm into the slab surface - Fracture #1 may have widened slightly for the portion that was intersected by Fracture #2 and was underlying a very thin portion of the slab - Fracture #2 and #3 did not widen or exhibit significant loss of material along their fracture path; they were susceptible to magnesium sulphate penetration as was evident by staining - A thin portion along the edge of the slab detached; it was not attached to the inspection surface - The thin portion of slab that detached was a wedge shaped piece which ranged in thickness from 0.2 to 5.5 mm and was originally poorly bound to the slab by a weathered fracture - Overall, this specimen exhibited some detachment of material that was thin and only moderately to poorly attached to the slab specimen; additionally, a fracture which intersected a thin portion of the slab was observed to have widened

Summary of Deterioration

The majority of specimens did not appear to lose any material and those that did, lost only small fragments that were thin and poorly attached to the slab prior to testing. The majority of pre-existing fractures did not propagate and new fractures did not form as a result of subjecting the material to cycles of drying and soaking with magnesium sulphate solution. Some pre-existing fractures that intersected thin portions of the slab were observed to have widened. The following observations regarding sample conditions were made:

Loss of Material

- dislodgement of thin portions of the slab specimen that were intersected by pre-existing fractures and were moderately to poorly adhered prior to testing
- pitting and dislodgement of material along pre-existing fracture paths where fractures were: i) braided and/or intersecting with other fractures, ii) open and with shallow angle relative to slab surface, iii) significantly weathered and oxidized

Formation and/or propagation of fractures

- Several pre-existing fractures widened slightly. Typically, the fractures that widened intersected thin and/or wedge-shaped portions along the slab edge and slab surface and the fracture surfaces were weathered and coated in iron oxide. Prior to testing, the fractures were moderately strong at best; that is, adjacent material would be expected to dislodge from the slab if they were impacted with moderate force. After testing and widening of the fractures they were of moderate to poor strength and it is likely they could be broken from the slab with slight force.
- Pre-existing fractures that intersected the slab at high angles through the interior of the slab surface were not observed to have widened or deteriorated in strength. Additionally, fractures that were not weathered and oxidized appeared to be more resistant to widening.

Overall Summary:

The data given in this report pertain to the samples provided, and is not applicable to material from other locations or trial periods.

At the end of five cycles of drying and soaking in magnesium sulphate solution, upon completion of the test, the specimens had an average measured loss of 0.09% by mass, with a high value of 0.42% and a low of 0.00%. This suggests that the specimens ranged somewhat in regards to their resistance to the stresses imposed by soundness testing using magnesium sulphate solution. Some specimens had weathered and oxidized fractures that intersected thin portions of the slab along the perimeter and surface of the slabs while others did not; this appeared to be the cause of the range in measured loss as those aforementioned fractures were associated with material that dislodged.

Most specimens did not exhibit formation of new fractures, widening, or lengthening of pre-existing fractures. Widening did occur in fractures that were significantly weathered, oxidized and were intersecting thin portions of the slab; these fractures were judged to be of moderate strength prior to testing and of moderate to poor strength after testing.

Prepared, tested and reported by:

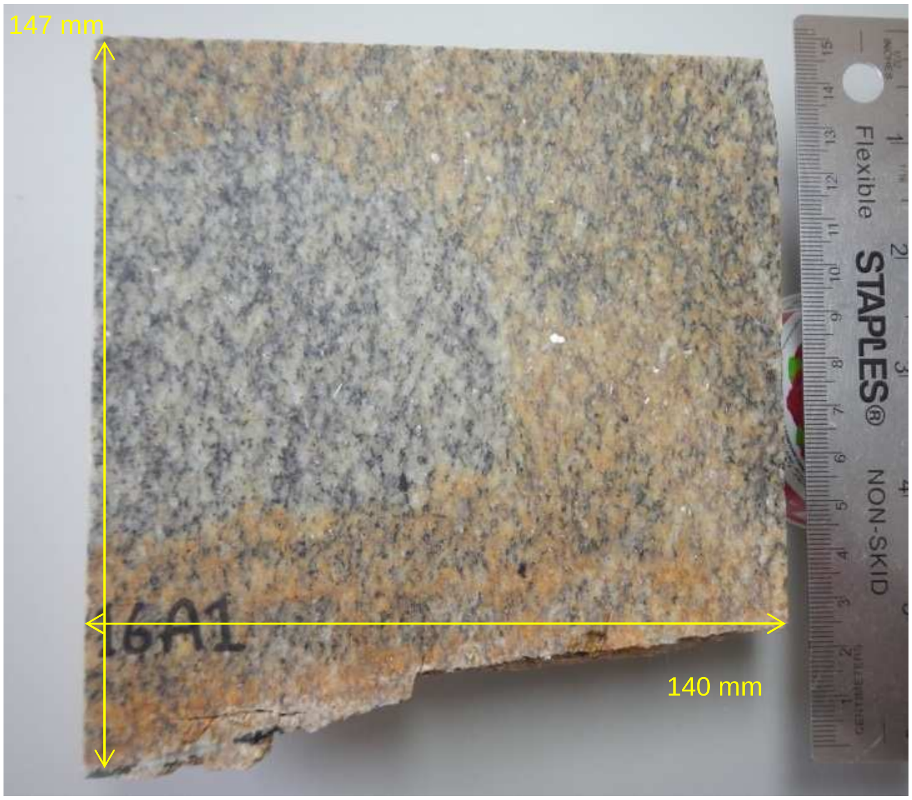
B. Hudson, B. Sc., GIT

Reviewed by:

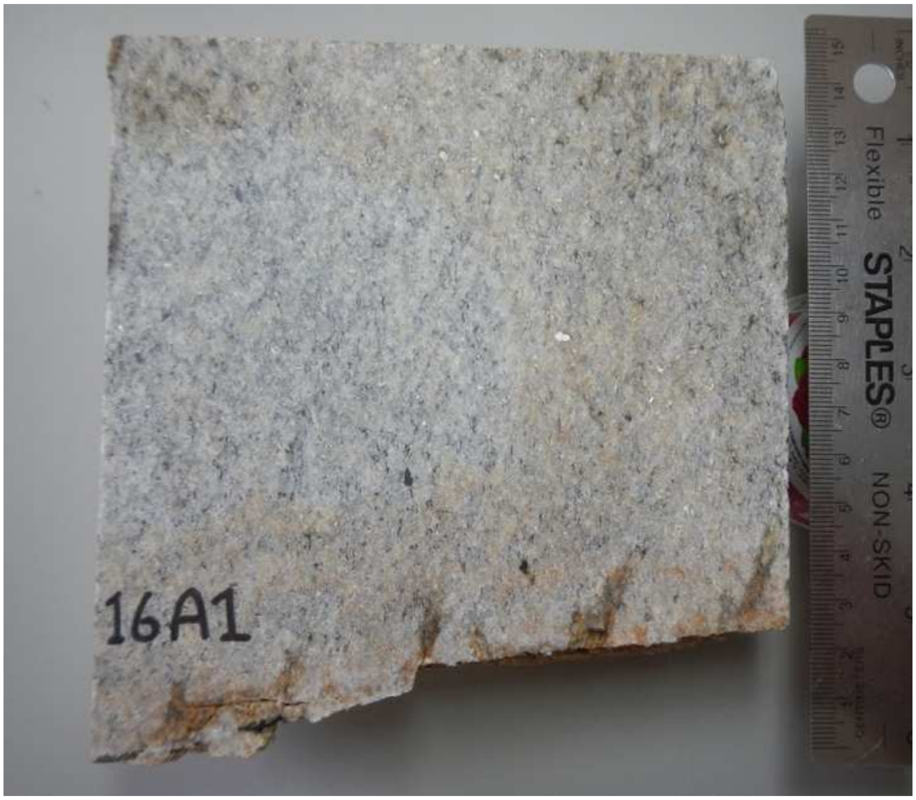
A. Briggs, M. Sc., P. Geo.

PHOTOGRAPHS

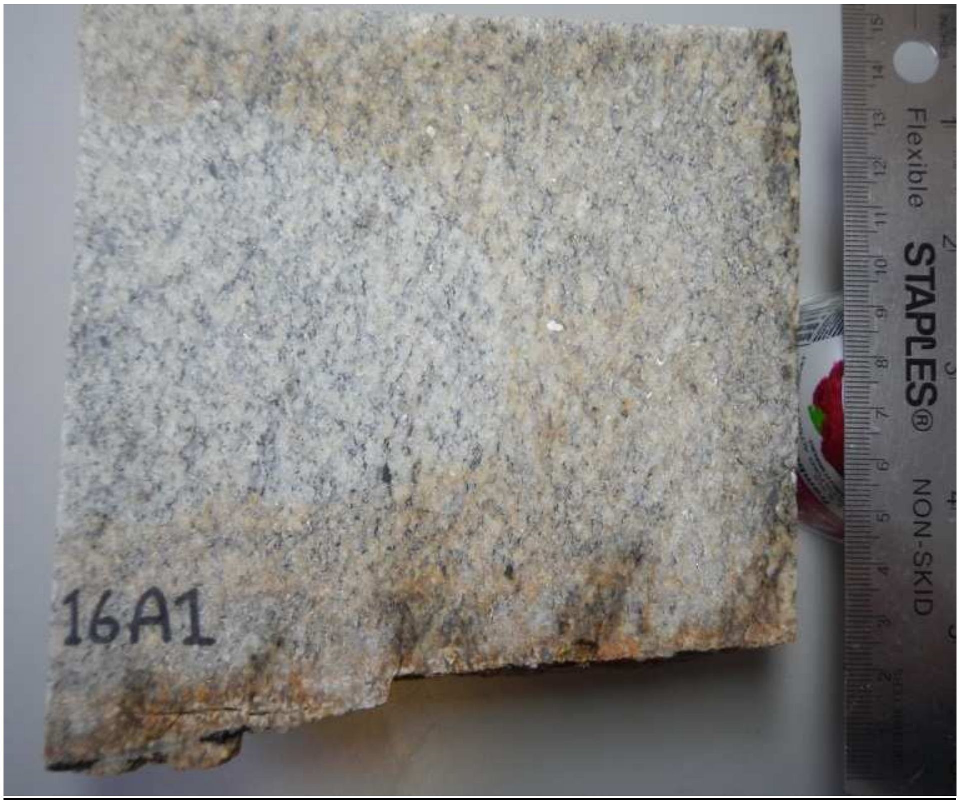
Initial (0 cycles) – 16A1 – *Wetted*



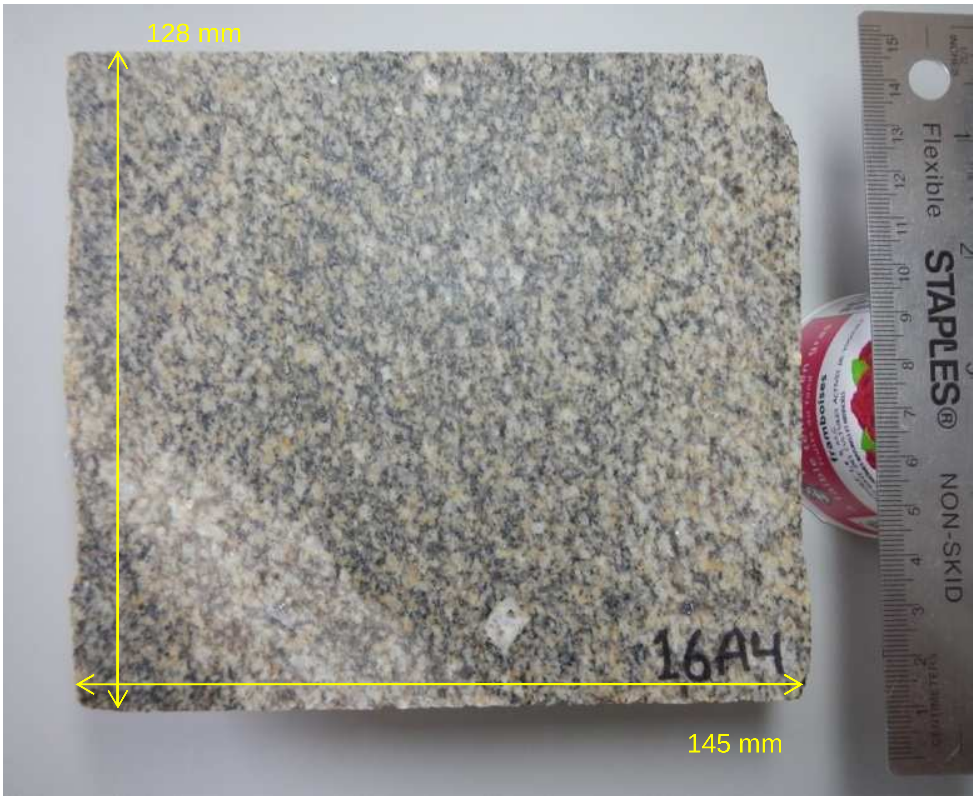
Initial (0 cycles) – 16A1 – *Partially dried back*



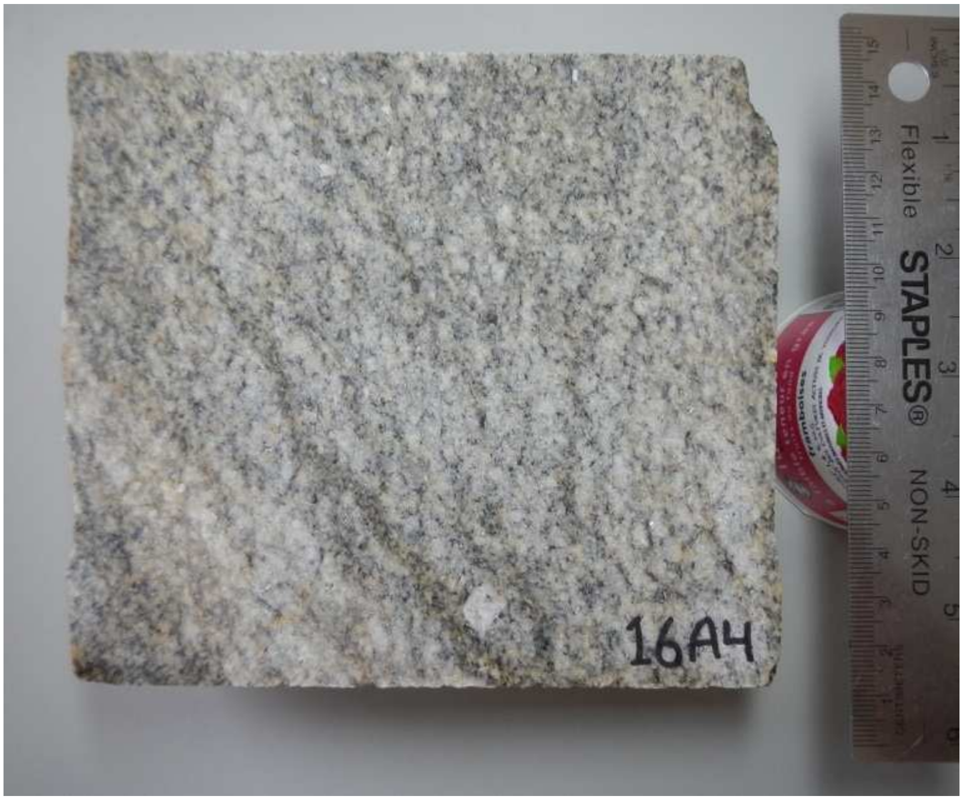
Final (20 cycles) – 16A1 – *Partially dried back*



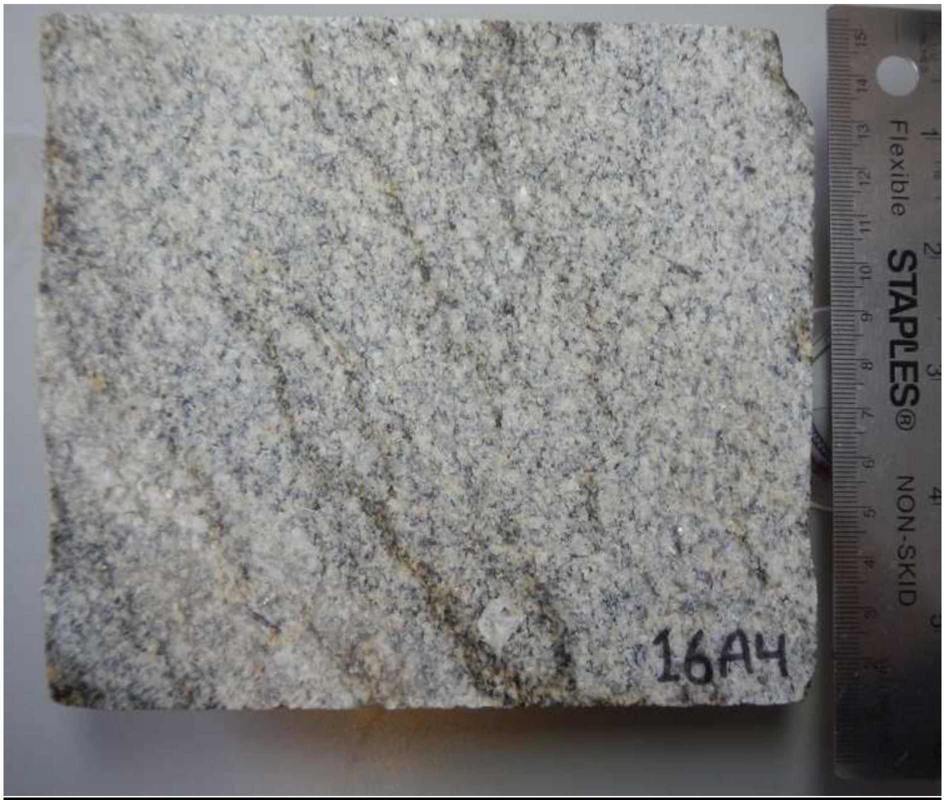
Initial (0 cycles) – 16A4 – *Wetted*



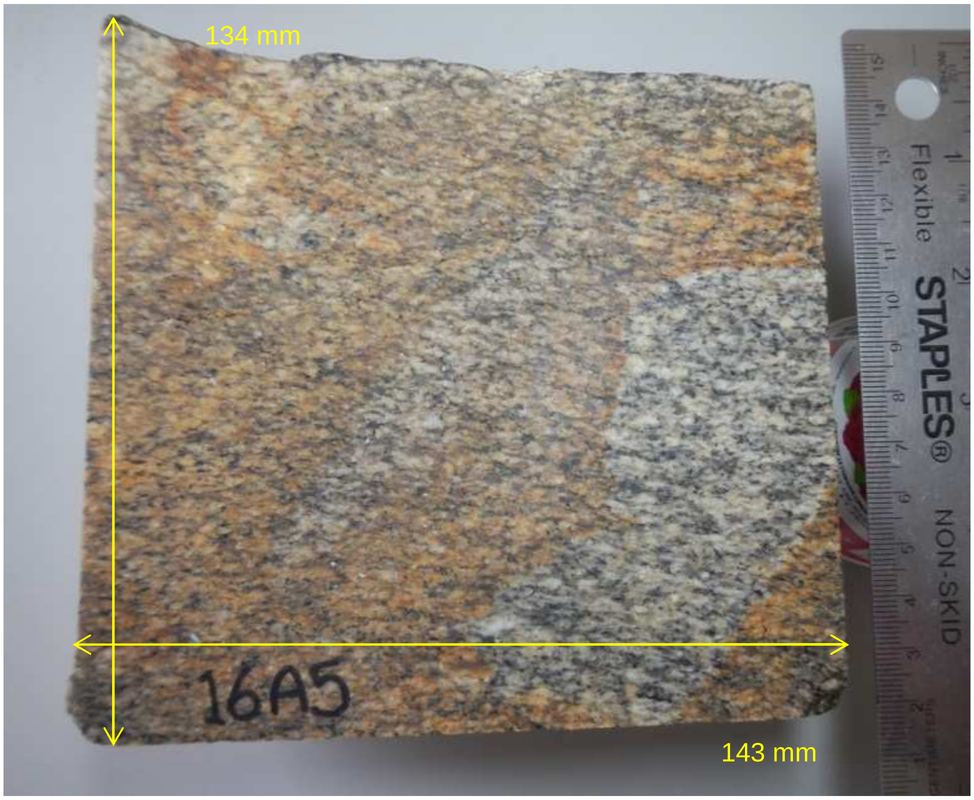
Initial (0 cycles) – 16A4 – *Partially dried back*



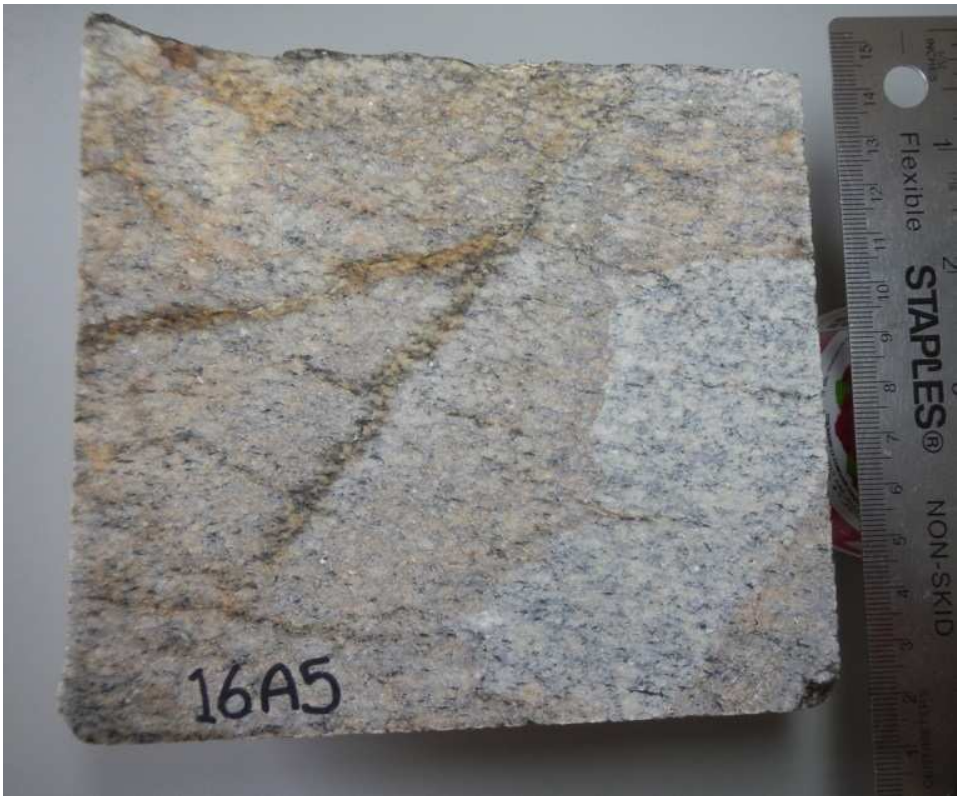
Final (20 cycles) – 16A4 – *Partially dried back*



Initial (0 cycles) – 16A5 – *Wetted*

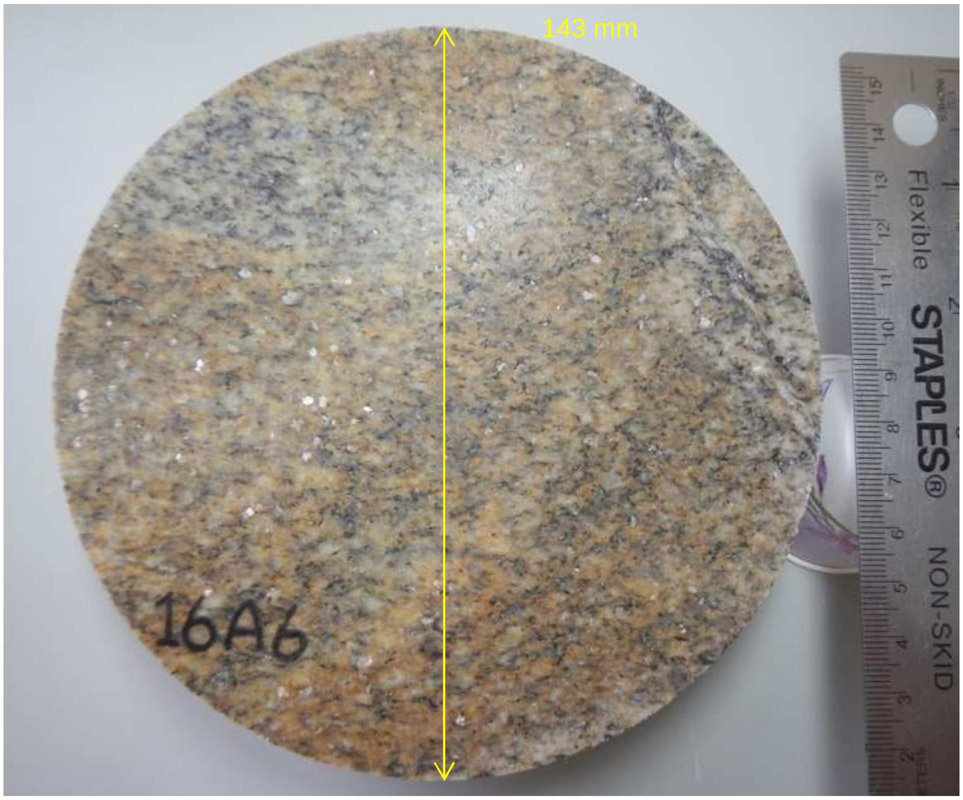


Initial (0 cycles) – 16A5 – *Partially dried back*



Final (20 cycles) – 16A5 – *Partially dried back*

Initial (0 cycles) – 16A6 – *Wetted*

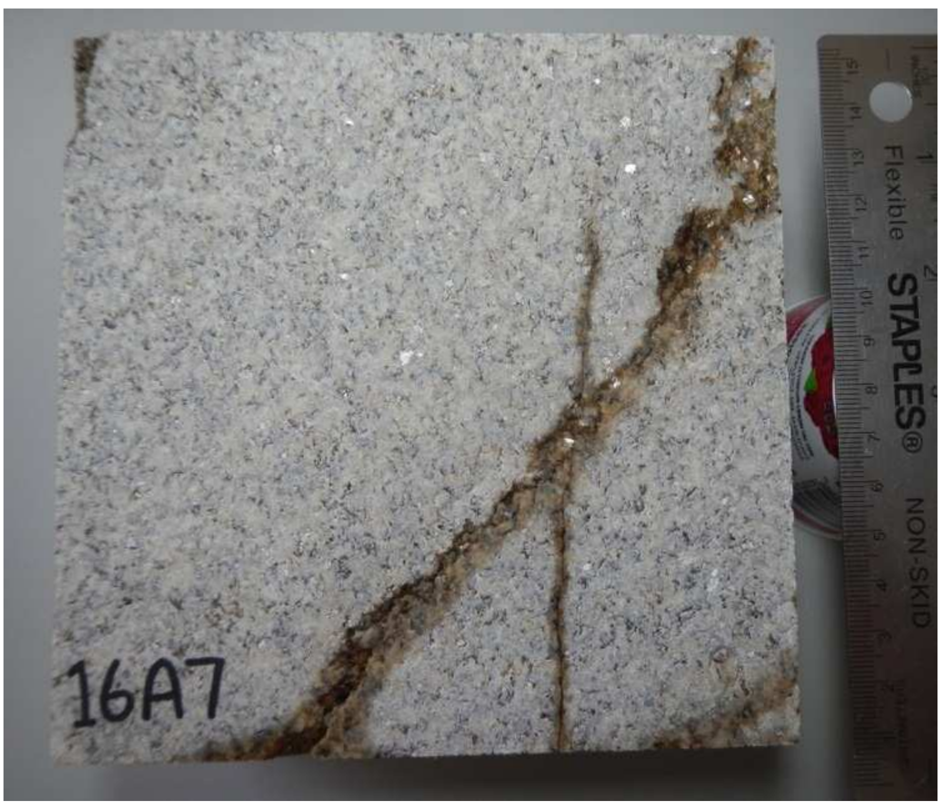


Initial (0 cycles) – 16A6 – *Partially dried back*

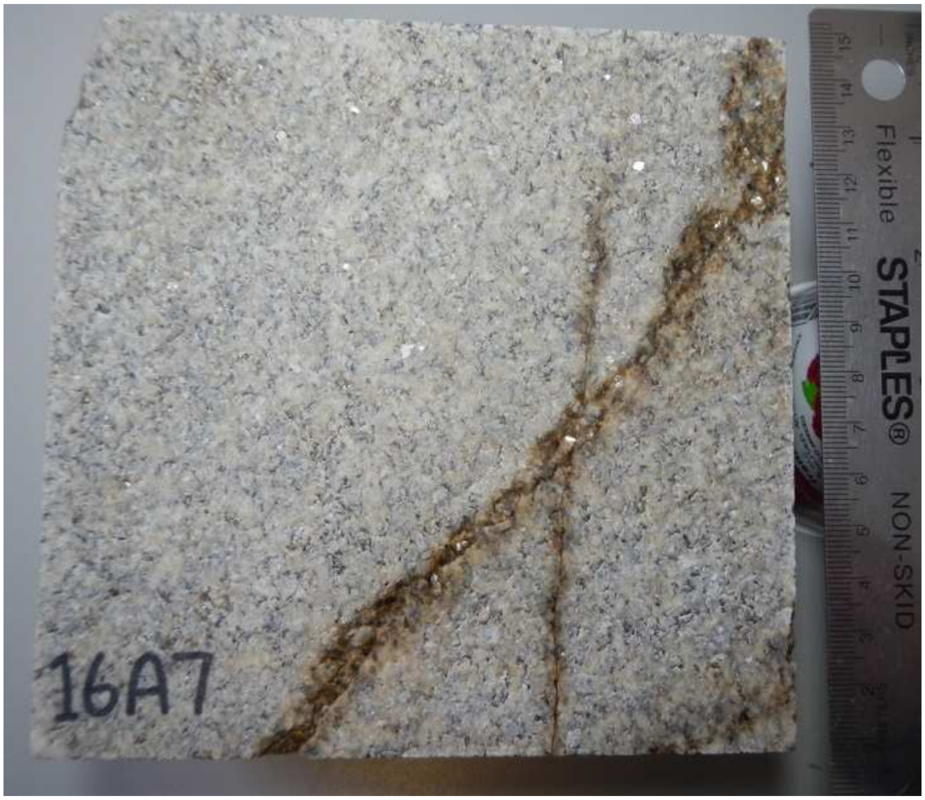
Final (20 cycles) – 16A6 – *Partially dried back*

Initial (0 cycles) – 16A7 – *Wetted*

Initial (0 cycles) – 16A7 – *Partially dried back*



Final (20 cycles) – 16A7 – *Partially dried back*



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TESTING OF ROCK SLABS TO EVALUATE SOUNDNESS OF RIPRAP BY USE OF SODIUM SULPHATE OR MAGNESIUM SULPHATE

ASTM D 5240

CH2M Hill
1100 – 1st Street SE
Calgary, Alberta, T2G 1B1

November 27, 2013
Project Number: 13-1417-0047-3000

ATTENTION: Mr. Mark Cichy

PROJECT: BSI Access Road Granitic Outcrop 2013

Sample:	CH13-311-SS017_RKa, Sample Date: 9-Jul-2013
Source:	BSI Access Road Granitic Outcrop, Tar #18, Faro Mine Complex, Yukon

Objective and Method:

The objective of this testing program was to evaluate the durability of rock proposed for use as erosion control in an environment where it would be exposed to freezing and thawing and wetting and drying. The sample that was provided consisted of boulder-sized rock chunks with an average diameter of 0.5 meters. The boulders were understood to have been sampled from a proposed quarry site for production of rip rap material; the sampling site was identified as BSI Access Road Granitic Outcrop. The boulders were obtained by others in a sampling program.

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The test was conducted such that the specimens were subjected to 5 cycles of soaking and drying; this is the number of cycles specified in ASTM D 5240 and is the same number of cycles utilized in ASTM C 88 (Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate). The soaking portion of each cycle consisted of storing the specimens in a solution of magnesium sulphate for a minimum of 16 hours. This was followed by a minimum of 8 hours of drying in an oven at 110 °C.

For this test, magnesium sulphate was utilized as opposed to sodium sulphate because magnesium sulphate is routinely used in Golder's laboratory for the ASTM C 88 test and was readily available when testing was started, while sodium sulphate would have had to be ordered, possibly contributing to a delay in initiation of the test. ASTM C 88 Section 3.2 states that "the test is usually more severe when magnesium sulphate is used…;" thus, it may be interpreted that the percent loss and deterioration when using magnesium sulphate may be exaggerated slightly compared to when using sodium sulphate.

The condition of each slab specimen was evaluated before and after the 5 cycles through macroscopic and microscopic examination using a binocular microscope with magnifications up to 50x. Observations were made

of material dislodgement, pre-existing cracks and newly developed deterioration. At each inspection, a photo and inspection log was generated for each specimen.

Prior to and at the end of the test procedure, each sample was weighed and the percent loss by mass was calculated for the individual specimens.

A batch of boulders from sample CH13-311-SS017_RKa were provided from which the boulders identified as 1, 2, 3, 4, and 5 were selected for testing. Additional durability testing, consisting of ASTM D 5312 (Evaluation of Durability of Rock for Erosion Control Under Freezing and Thawing Conditions) and ASTM D 5313 (Evaluation of Durability of Rock for Erosion Control Under Wetting and Drying Conditions) are being conducted on the same boulders. To compare the results from each test method, three slab specimens were extracted from each of the selected boulders and the same boulder identification # was shared between the three slabs.

Quantitative Analysis:

Percent Loss

Sample ID	Boulder #	Slab ID	Original Mass (g)	Final Mass (g)	Loss (%)
CH13-311-SS017_RKa	1	**17A1**	2944.5	2944.5	***0.00***
	2	**17A2**	3317.5	3317.2	***0.01***
	3	**17A3**	3258.9	3258.9	***0.00***
	4	**17A4**	3013.3	3013.3	***0.00***
	5	**17A5**	3661.3	3661.3	***0.00***
				Final Average Loss (%)	0.00

Qualitative Analysis:

Summary of Initial Condition

Petrographic examination was undertaken on a crushed composite of select chunks of rock from the CH13-311-SS017-RKa sample batch; generally, the specimen rock type consisted of gneissic granodiorite. Thin section analysis was conducted on one piece of rock; chemical analyses, such as whole-rock analysis by X-Ray Fluorescence, were not conducted. Each rock slab was extracted from a specimen with slight to significant variation in compositional, textural and structural qualities. Parameters that varied included:

Composition
- Proportion of mafic and felsic minerals
- Presence or near absence of metallic minerals
- Distribution of oxidation
- Mineral composition in veins

Textural
- Gneissic texture, which was slightly to moderately well-developed
- Fine/medium/coarse mineral grain size
- Presence of veins

Structure
- Presence/absence of fractures
- Fracture width
- Number of fractures and fracture spacing
- Orientation and pattern of fractures
- Presence of weathering and oxidation around fractures

Observations of Individual Specimens

Slab ID	Observations	
	Initial @ 0 cycles	**Final @ 5 cycles**
17A1	- The slab was circular in shape with an approximate diameter of 148 mm - The sample consisted of slightly gneissic granodiorite with a mineral grain size that was fine to medium grained - Metallic mineral grains were not discernible; however, in thin section the dominant metallic minerals were rutile grains and hematite with trace amounts of very fine sulphide mineral grains - Oxidation staining was not prevalent across the specimen; however, light yellow oxidation blebs were observed around some ferromagnesian minerals - Gneissic bands were not well-developed and were not absorptive - One significant fracture extended from the edge of the slab into its centre; the fracture was discontinuous and tapered into non-fracture rock for some segments - The fracture ranged in width from 0.2 to 1 mm and extended through the entire depth; it was moderately absorptive - Mineral grains along the fracture were weathered and of moderate strength; a very slight amount of pitting was evident along the fracture	- No significant amount of material was dislodged from the slab - A few small mineral fragments were dislodged from the pre-existing fracture; the mineral fragments were of moderate strength prior to testing - Magnesium sulphate staining was prevalent through the fracture - The fracture did not appear to have widened or lengthened - Overall, this specimen did not exhibit any significant formation of fractures or loss of material

17A2	- The slab was square in shape with an approximate dimension of 142 mm wide by 142 mm long - The sample consisted of moderately gneissic granodiorite with a mineral grain size that was fine grained - Metallic mineral grains were not discernible; however, in thin section the dominant metallic minerals were rutile grains and hematite with trace amounts of very fine sulphide mineral grains - Oxidation staining was not prevalent across the specimen; however, localized blebs and patches of iron oxide were observed around some ferromagnesian and metallic minerals, and around some pre-existing fractures - One edge of the specimen was weathered and had some short fractures extending approximately 3 mm into the slab in a direction parallel to gneissic banding; the fractures were moderately absorptive - One fracture (#1) was located near the edge of the slab and was tightly closed with a width of less than 0.2 mm; the fracture pattern was layered and braided and it was moderately absorptive - Fracture #1 was slightly weathered; it had an orientation that was roughly parallel to banding; however, it was irregularly shaped - A second fracture (#2) was also roughly parallel to banding; it was very tightly closed and had a width of less than 0.1 mm - A very slight amount of weathering was observed along Fracture #2 and it was moderately absorptive - Some short gneissic bands were moderately well-developed and in several cases, they were absorptive and were associated with very thin, discontinuous fractures	- The short fractures associated with the gneissic bands did not widen or lose material; generally, the absorption characteristics remained unchanged between the beginning and end of the test - A few small mineral fragments were dislodged from pre-existing Fracture #1 from the portion that was layered, braided and weathered - Fracture #1 did not widen or lengthen; after testing it exhibited dark orange oxidation staining - Fracture #2 was unaffected - Some dark orange oxidation blebs formed in a few locations where fine grained metallic minerals may have been present - Overall, this specimen did not exhibit any significant formation of fractures or loss of material
17A3	- The slab was rectangular in shape with an approximate dimension of 140 mm wide by 130 mm long - The sample consisted of moderately gneissic granodiorite with a mineral grain size that was fine to medium grained; some gneissic bands were undulating while others were generally straight and planar - Large portions of the slab were stained light to dark orange by oxidation while others were fresh and generally white-black in colour; the oxidized portions appeared to be slightly more weathered - Muscovite was present in moderate amounts - Metallic mineral grains were not discernible; however, in thin section the dominant metallic minerals were rutile grains and hematite with trace amounts of very fine sulphide mineral grains - One fracture (#1) extended through a large portion of the slab and was tightly closed with a width of less than 0.1 mm; some portions of the fracture were parallel to gneissic banding while some were irregularly shaped - Fracture #1 had black staining in a buffering zone 2 mm to either side of the fracture - A second fracture (#2) also roughly followed the orientation of banding; it was tightly closed with a width of less than 0.1 mm and appeared to be slightly weathered and oxidized - There were some short, discontinuous and oxidized fractures that were parallel with the gneissic bands with biotite concentrated into thin layers; they ranged from moderately absorptive to not absorptive	- The short fractures associated with the gneissic bands did not widen or lose material; generally, the absorption characteristics remained unchanged between the beginning and end of the test - Very slight amounts of material were dislodged from gneissic bands, indicating that the magnesium sulphate was able to penetrate into these bands and heave material to some degree - Fracture #1 was unchanged and it did not appear the magnesium sulphate significantly penetrated this fracture - A few small mineral fragments were dislodged from pre-existing Fracture #2; magnesium sulphate appeared to have soaked into this fracture - No fractures widened or extended in length - Overall, this specimen did not exhibit any significant formation of fractures or loss of material

17A4	- The slab was rectangular in shape with an approximate dimension of 149 mm wide by 135 mm long - The sample consisted of strongly gneissic granodiorite with a mineral grain size that was fine grained - Metallic mineral grains were not discernible; however, in thin section the dominant metallic minerals were rutile grains and hematite with trace amounts of very fine sulphide mineral grains - Oxidation staining was not prevalent across the specimen; it was localized to very thin fractures throughout the specimen - A vein (#1) in-filled with dark green/grey mineral extended across the specimen with consistent direction but irregular shape; a 4 mm zone to either side of the vein was weathered had an opaque white colour - A segment of Vein #1 was fractured and absorptive; however most of the vein was well attached - The fracture ranged in width from 0.2 to 1 mm and extended through the entire depth of the slab; the fracture had a layered and braided fracture pattern and was highly absorptive - Two additional veins (#2 and 3) followed the same general orientation as Vein #1; however, they were 0.3 mm wide at most and the weathered zone was less well pronounced - There was a prevalence of short to medium length (10 to 50 mm), discontinuous and oxidized fractures that were roughly parallel with the gneissic bands; they ranged from moderately absorptive to not absorptive	- The frequent oxidized fractures associated with the gneissic bands did not widen or lose material; generally, the absorption characteristics remained unchanged between the beginning and end of the test - The fracture in Vein #1 did not widen or lengthen - The smaller veins (#2 and 3) were unaffected - Overall, this specimen did not exhibit any significant formation of fractures or loss of material
17A5	- The slab was rectangular in shape with an approximate dimension of 164 mm wide by 145 mm long - The sample consisted of very slightly gneissic granodiorite with a mineral grain size that was medium to coarse grained - This specimen had a noticeably different mineral composition and texture compared to specimens 17A1, 17A2, 17A3 and 17A4; 17A5 had a lower abundance of mafic minerals and a coarse mineral grain size - Mineral grain boundaries were distinct and had a weathered appearance; alteration of feldspar minerals was prevalent - Oxidation consisted of localized yellow blebs that appeared to be associated with feldspar minerals as much as with ferromagnesian minerals - Fine metallic mineral grains may or may not have been present; thin section analysis was not available for this rock type - Muscovite was abundant throughout and was coarse-grained - Localized stringlets and short bands of biotite and muscovite were observed; however, they were undulating, not continuous and ranged in length from 5 to about 80 mm - Some of the bands and stringlets of mica were absorptive; fractures were not detectable at 50x magnification - A short fracture along the edge of the specimen was weathered and between 0.1 and 0.3 mm wide; mineral fragments along this fracture looked to be of moderate strength	- A few small mineral fragments were dislodged from the pre-existing fracture near the edge of the slab; however, the thin portion of slab between the fracture and the edge of the slab did not dislodge - The absorptive stringlets and bands of mica did not develop into fractures, or lose material - Overall, this specimen did not exhibit any significant formation of new fractures or loss of material. Mineral grains appeared to be weathered in this specimen and intergranular bond strength was moderate

Summary of Deterioration

None of the specimens appeared to lose any material and those that did lost only small fragments that were poorly attached to the slab edge prior to testing, generally amounting to less than 0.01% of the specimen mass. Fracture propagation was not observed and no new fractures formed as a result of subjecting the material to cycles of drying and soaking with magnesium sulphate solution. The following observations regarding sample conditions were made:

Loss of Material

- pitting and dislodgement of material along pre-existing fractures that were: i) braided and/or intersecting with other fractures, ii) significantly weathered and oxidized

Formation and/or propagation of fractures

- Pre-existing fractures were not observed to have widened and did not appear to have a decrease in strength after testing
- Some specimens had an abundance of very fine fractures that were oxidized and often associated with gneissic bands. They were absorptive; however, they were unaffected by the action of the magnesium sulphate solution.

Overall Summary:

The data given in this report pertain to the samples provided, and is not applicable to material from other locations or trial periods.

At the end of five cycles of drying and soaking in magnesium sulphate, and completion of the test, the specimens had an average measured loss of 0.00% by mass, with a high value of 0.01% and a low of 0.00%. This suggests that the specimens were generally similar to each other in regards to their resistance to the stresses imposed by soundness testing using magnesium sulphate solution. Material loss appeared to be caused by dislodging of material which was only moderately well adhered to the slab prior to testing and generally consisted of small fragments and mineral grains.

Formation of new fractures, widening, and lengthening of pre-existing fractures, was not observed in the tested rock slabs. One of the specimens consisted of a rock type with mineral grains that were altered, weathered and had moderate intergranular bond strength. They appeared susceptible to dislodgement if they were impacted with moderate force; however, they were unaffected by this test.

Prepared, tested and reported by:

B. Hudson, B. Sc., GIT

Reviewed by:

A. Briggs, M. Sc., P. Geo.

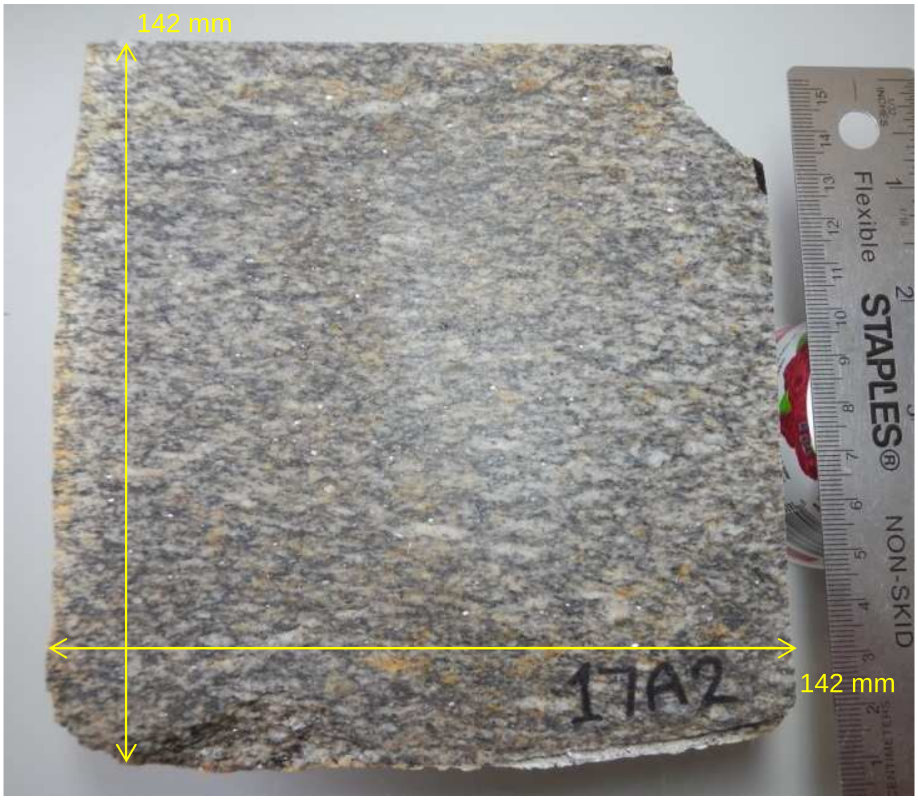
PHOTOGRAPHS

Initial (0 cycles) – 17A1 – *Wetted*

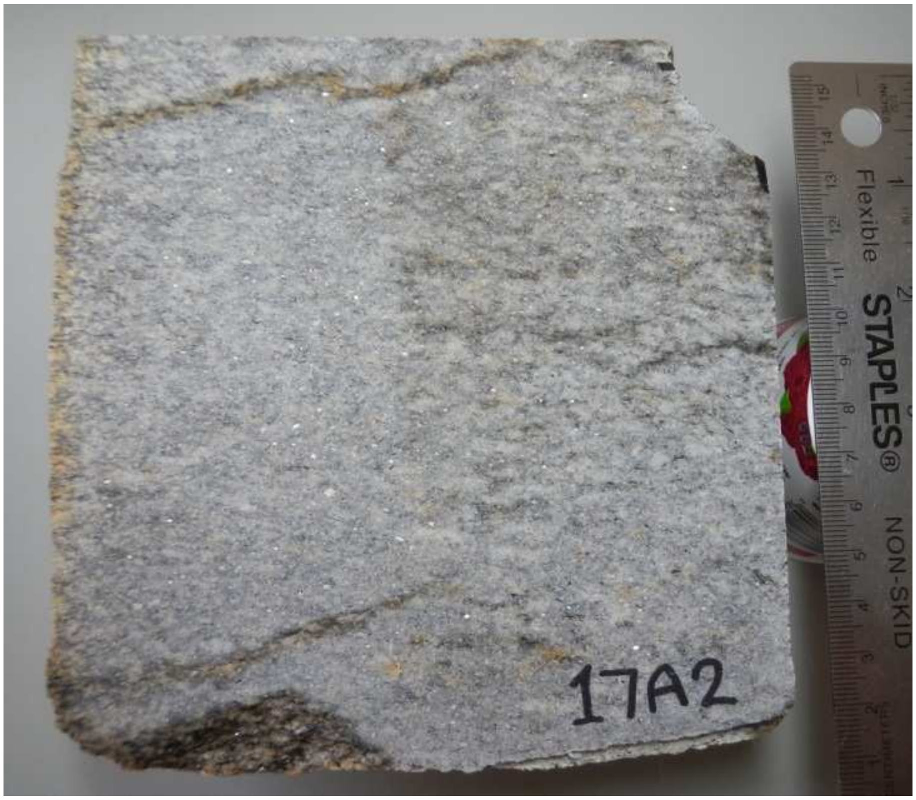
Initial (0 cycles) – 17A1 – *Partially dried back*

Final (20 cycles) – 17A1 – *Partially dried back*

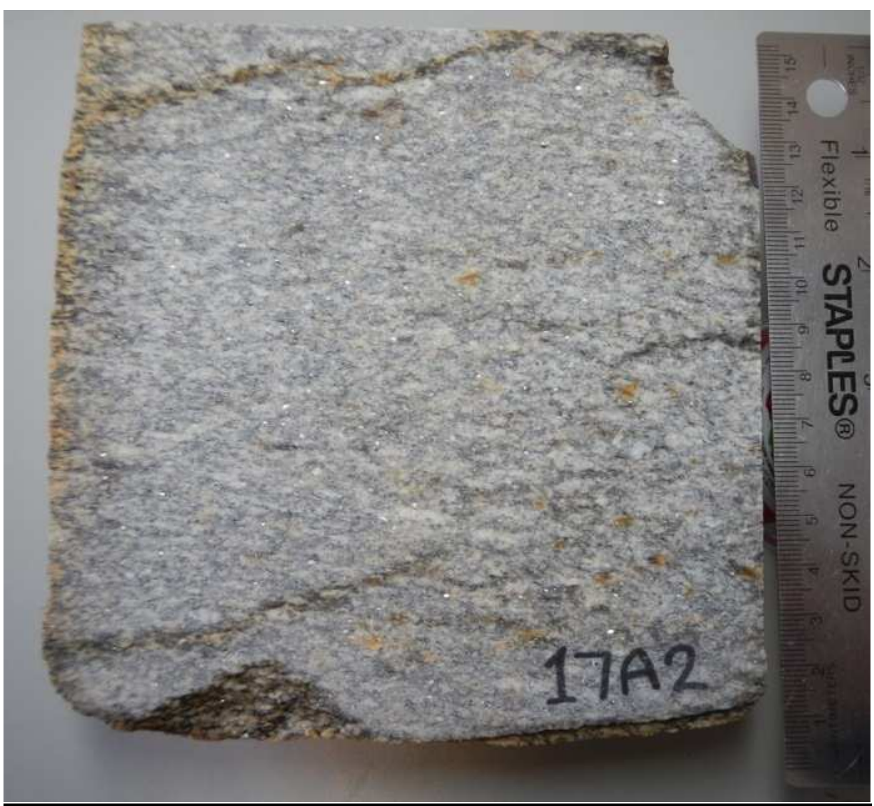
Initial (0 cycles) – 17A2 – *Wetted*



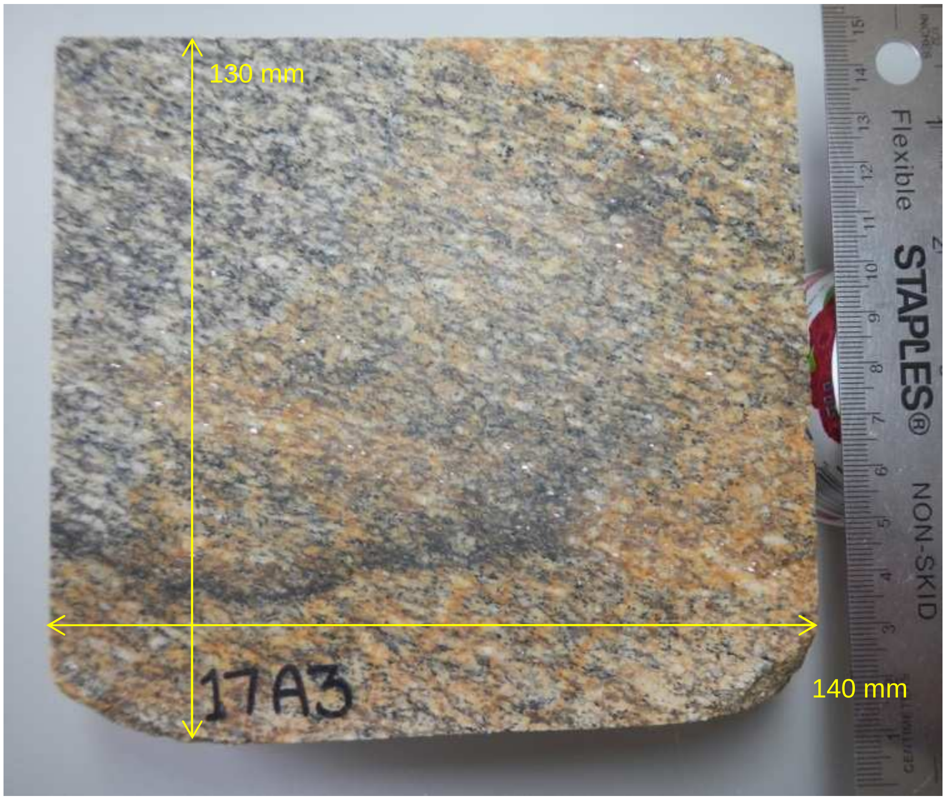
Initial (0 cycles) – 17A2 – *Partially dried back*



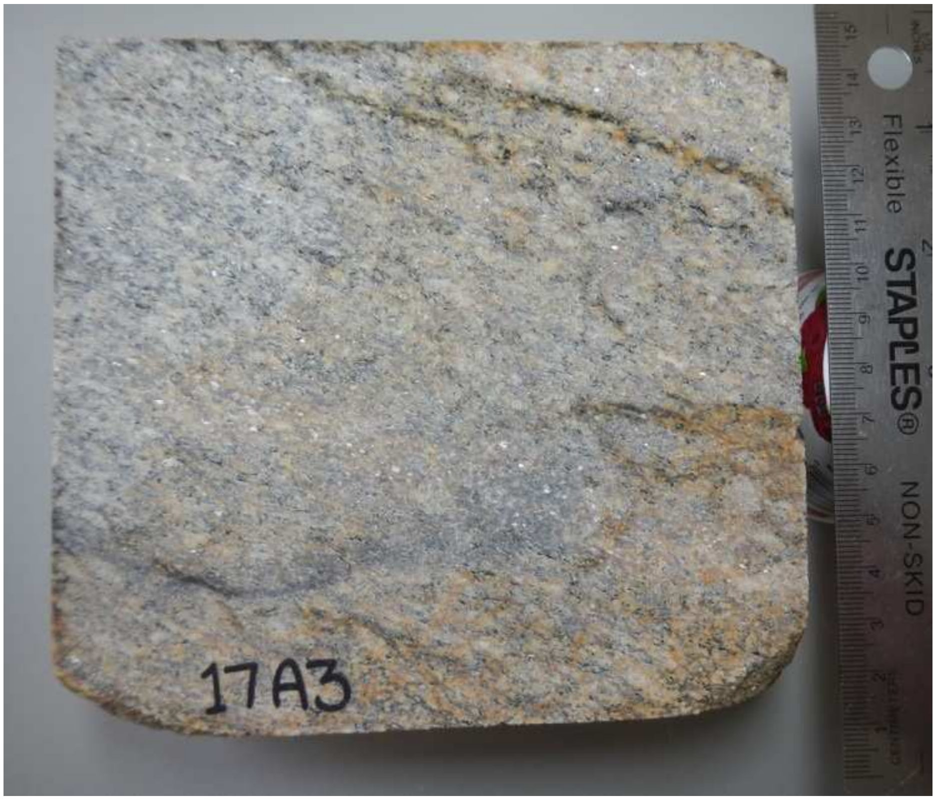
Final (20 cycles) – 17A2 – *Partially dried back*



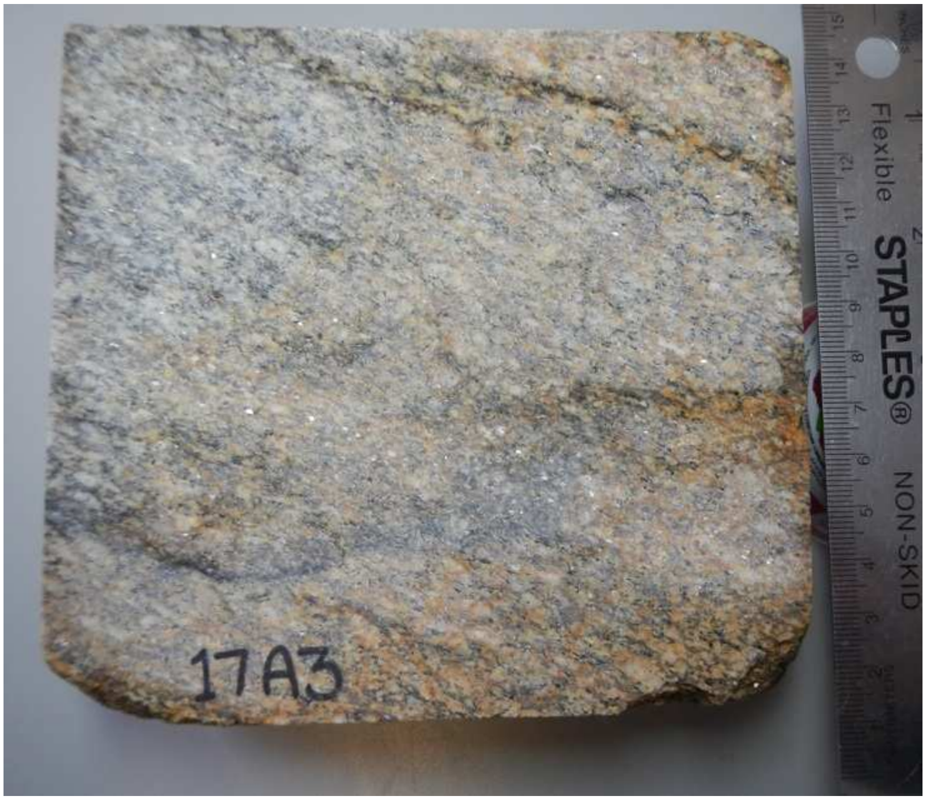
<u>Initial (0 cycles) – 17A3</u> – *Wetted*



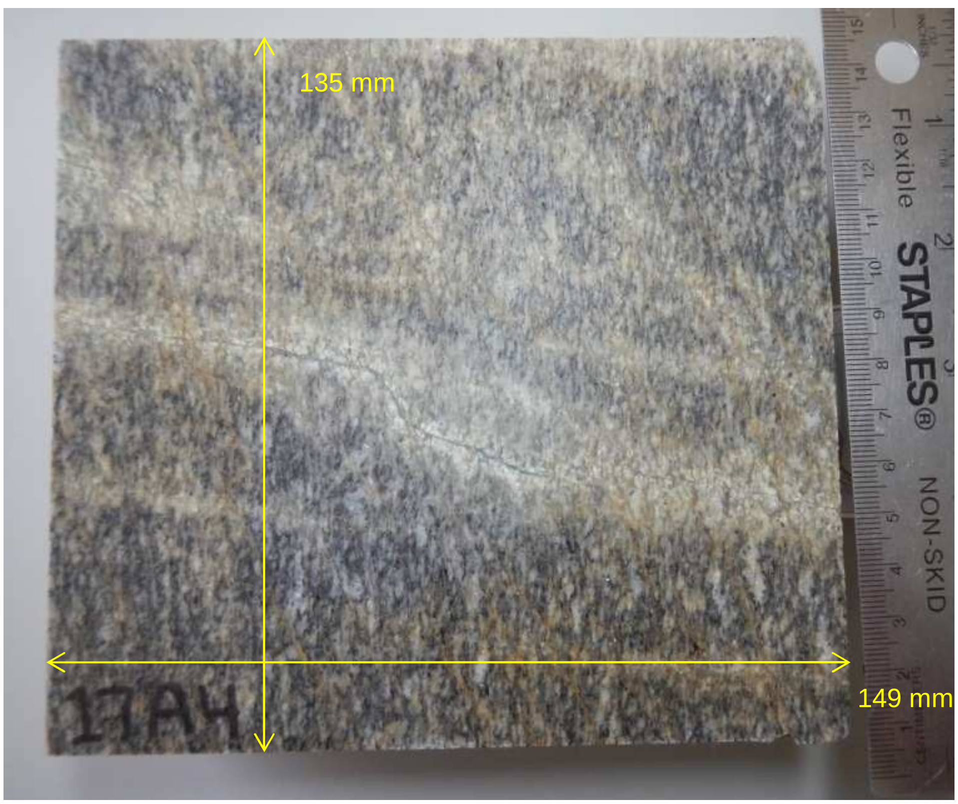
<u>Initial (0 cycles) – 17A3</u> – *Partially dried back*



Final (20 cycles) – 17A3 – *Partially dried back*



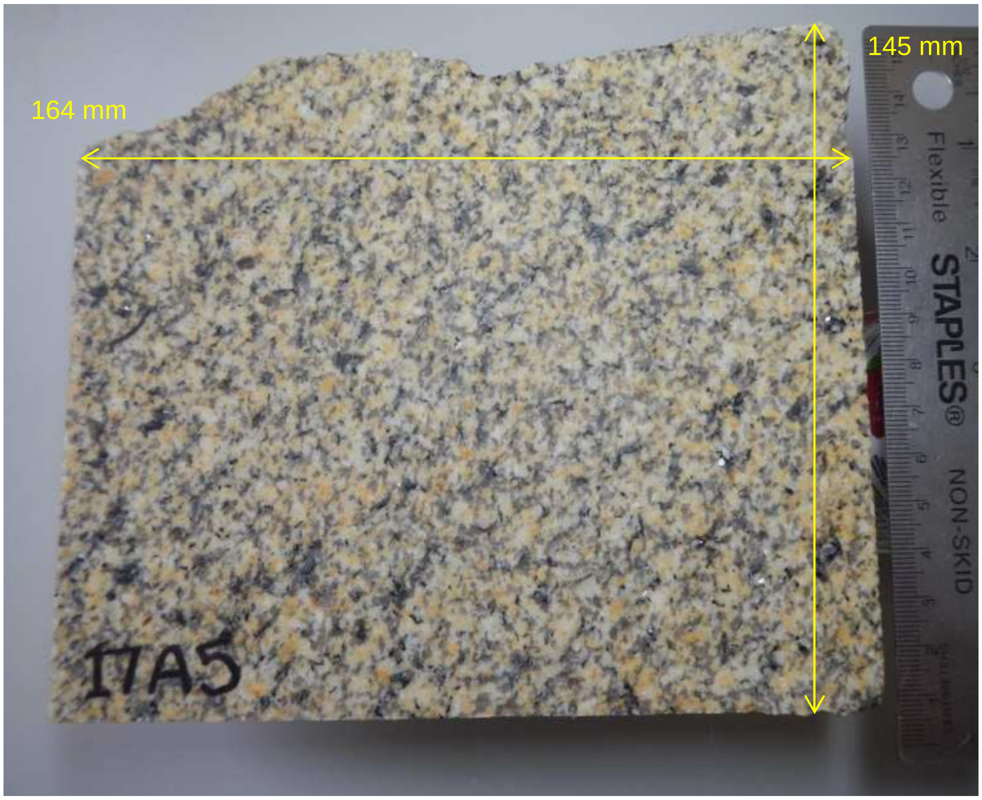
Initial (0 cycles) – 17A4 – *Wetted*



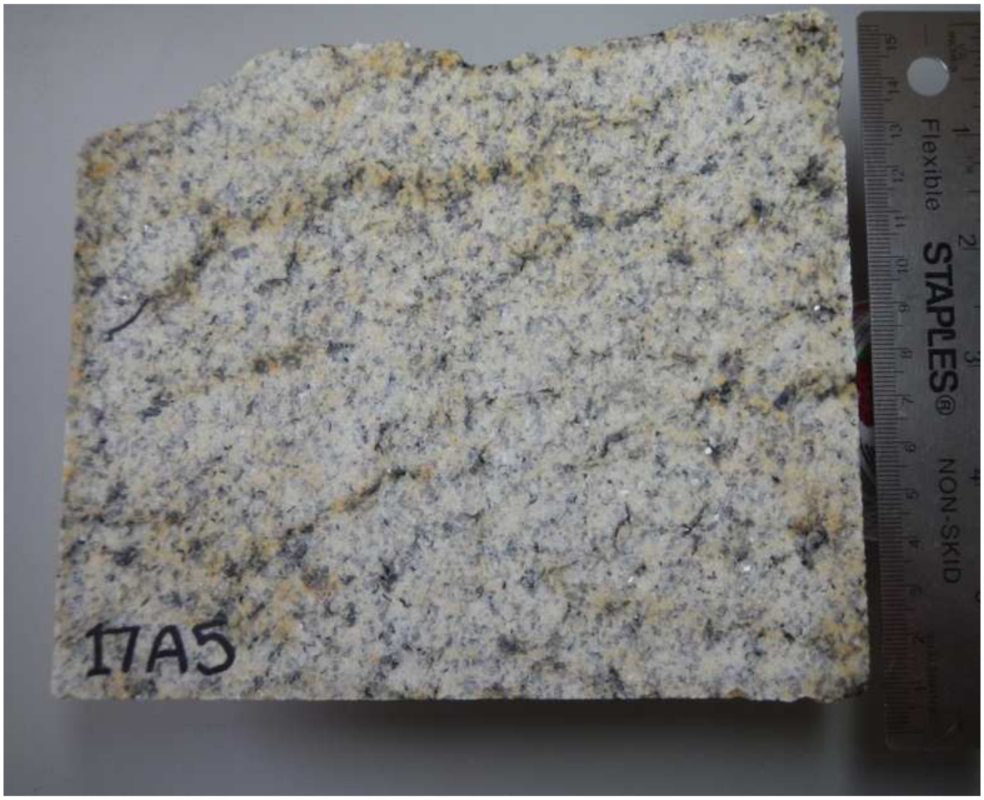
Initial (0 cycles) – 17A4 – *Partially dried back*

Final (20 cycles) – 17A4 – *Partially dried back*

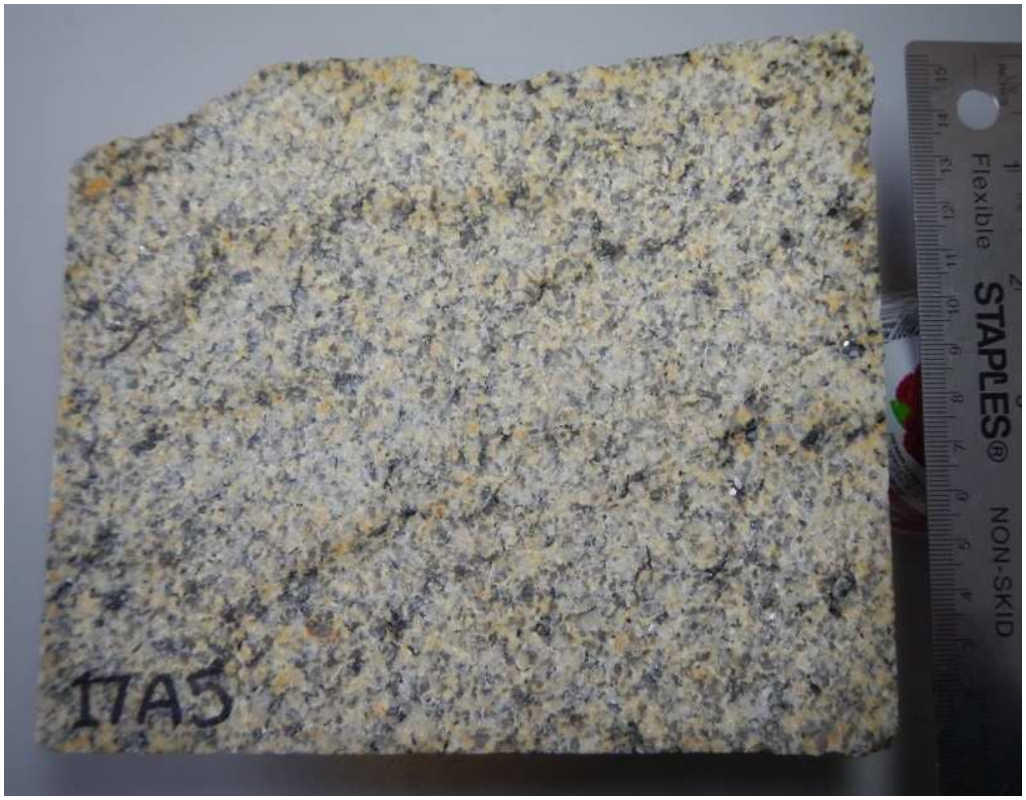
Initial (0 cycles) – 17A5 – *Wetted*



Initial (0 cycles) – 17A5 – *Partially dried back*



Final (20 cycles) – 17A5 – *Partially dried back*



-End of Photographs-

TESTING OF ROCK SLABS TO EVALUATE SOUNDNESS OF RIPRAP BY USE OF SODIUM SULPHATE OR MAGNESIUM SULPHATE

ASTM D 5240

CH2M Hill
1100 – 1st Street SE
Calgary, Alberta, T2G 1B1

November 27, 2013
Project Number: 13-1417-0047-3000

ATTENTION: Mr. Mark Cichy

PROJECT: BSI Grum Dump Rock Quarry 2013

Sample:	**CH13-311-SS001_RKa, Sample Date: 10-Jul-2013**
Source:	**BSI Grum Dump Rock Quarry, Tar #18, Faro Mine Complex, Yukon**

Objective and Method:

The objective of this testing program was to evaluate the durability of rock proposed for use as erosion control in an environment where it would be exposed to freezing and thawing and wetting and drying. The sample that was provided consisted of boulder-sized rock chunks with an average diameter of 0.5 meters. The boulders were understood to have been sampled from a proposed quarry site for production of rip rap material; the sampling site was identified as BSI Grum Dump Rock Quarry. The boulders were obtained by others in a sampling program.

The test program consisted of the method described in ASTM D 5240; the results of this test are summarized in this report. This report comprises a testing service only. Interpretation may be provided upon request.

In order to extract slab specimens from the boulder-size samples, a combination of wide diameter (6"/ 152 mm) rock coring and rock saw cutting was utilized. Some slab samples were circular in shape, while others were rectangular. Average dimensions of the slab specimens generally conformed to the requirements outlined in ASTM D 5240 and ASTM D 5121 (Preparation of Rock Slabs for Durability Testing). The rock slab specimens utilized in the test were generally 65 mm thick and not less than 125 mm on a side.

The test was conducted such that the specimens were subjected to 5 cycles of soaking and drying; this is the number of cycles specified in ASTM D 5240 and is the same number of cycles utilized in ASTM C 88 (Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate). The soaking portion of each cycle consisted of storing the specimens in a solution of magnesium sulphate for a minimum of 16 hours. This was followed by a minimum of 8 hours of drying in an oven at 110 °C.

For this test, magnesium sulphate was utilized as opposed to sodium sulphate because magnesium sulphate is routinely used in Golder's laboratory for the ASTM C 88 test and was readily available when testing was started, while sodium sulphate would have had to be ordered, possibly contributing to a delay in initiation of the test. ASTM C 88 Section 3.2 states that "the test is usually more severe when magnesium sulphate is used…;" thus, it may be interpreted that the percent loss and deterioration when using magnesium sulphate may be exaggerated slightly compared to when using sodium sulphate.

The condition of each slab specimen was evaluated before and after the 5 cycles through macroscopic and microscopic examination using a binocular microscope with magnifications up to 50x. Observations were made

of material dislodgement, pre-existing cracks and newly developed deterioration. At each inspection, a photo and inspection log was generated for each specimen.

Prior to and at the end of the test procedure, each slab was weighed and the percent loss by mass was calculated for the individual specimens.

A batch of boulders from sample CH13-311-SS001_RKa were provided from which the boulders identified as 1, 2, 3, 4, and 5 were selected for testing. Additional durability testing, consisting of ASTM D 5312 (Evaluation of Durability of Rock for Erosion Control Under Freezing and Thawing Conditions) and ASTM D 5313 (Evaluation of Durability of Rock for Erosion Control Under Wetting and Drying Conditions) are being conducted on the same boulders. To compare the results from each test method, three slab specimens were extracted from each of the selected boulders and the same boulder identification # was shared between the three slabs.

Quantitative Analysis:

Percent Loss

Sample ID	Boulder #	Slab ID	Original Mass (g)	Final Mass (g)	Loss (%)
CH13-311-SS001_RKa	1	**01A1**	4023.1	4022.0	***0.03***
	2	**01A2**	3117.6	3116.9	***0.02***
	3	**01A3**	2983.1	2981.5	***0.05***
	4	**01A4**	2984.6	2983.5	***0.04***
	5	**01A5**	3013.9	3012.9	***0.03***
				Final Average Loss (%)	**0.03**

Qualitative Analysis:

Summary of Initial Condition

Petrographic examination was undertaken on a crushed composite of select chunks of rock from the CH13-311-SS001-RKa sample batch; generally, the specimen rock type consisted of metamorphosed gabbro. Thin sections analysis was conducted on one piece of rock; chemical analyses, such as whole-rock analysis by X-Ray Fluorescence, were not conducted. Each rock slab was extracted from a specimen with slight to significant variations in compositional, textural and structural qualities. Parameters that varied included:

Composition
- Proportion of mafic and felsic minerals
- Amount of metallic minerals (chalcopyrite, etc.)
- Degree of alteration to protolith minerals
- Amount of secondary alteration minerals (chlorite, etc.)
- Presence of veins in-filled with calcite

Textural
- Average mineral grain size
- Distribution of veins
- Presence and size of relict protolith minerals

Structure

- Presence/absence of fractures
- Number of fractures and fracture spacing
- Orientation and pattern of fractures
- Presence of thin calcite in fractures

Observations of Individual Specimens

Slab ID	**Observations**	
	Initial @ 0 cycles	**Final @ 5 cycles**
01A1	- The slab was rectangular in shape with an approximate dimension of 159 mm wide by 151 mm long - The sample consisted of light green meta-gabbro with a mineral grain size that was medium to coarse grained; felsic minerals were slightly more abundant than mafic minerals - Secondary alteration was prevalent and chlorite was abundant - Fine metallic mineral grains, which included pyrite and chalcopyrite, were in moderate abundance and observed in concentrated zones, patches and stringlets - A thick calcite vein extended across the entire slab and had a width ranging from 0.5 to 2.5 mm; it had a braided and layered texture and the calcite was opaque and slightly weathered - A very thin fracture travelled the length of the thick calcite vein along its boundary and parallel to the layering of the calcite; it ranged from not absorptive to moderately absorptive - A region of the slab, approximately 47 mm in diameter, was composed of higher proportions of soft minerals (chlorite, muscovite, biotite, calcite); this region of the slab was more absorptive, particularly around the boundaries - Some thin calcite veins were present throughout the slab; they ranged from 0.1 to 0.5 mm in width and were not absorptive - There were some dark green veins and stringlets throughout; generally, they were less than 0.2 mm in width and were not absorptive	- A few small fragments of calcite appear to have dislodged along pre-existing fractures - The fracture associated with the thick calcite vein did not widened or extend; magnesium sulphate staining indicates that solution only penetrated about 5 mm into the fracture from the slab surface - Some thin flakes of calcite along the edge of the slab had detached - Overall, this specimen did not exhibit any significant formation of fractures or loss of material. A fracture associated with a thick calcite vein did not widen; however it did not appear particularly strong and could be susceptible to fracturing if the slab were struck or dropped

01A2	- The slab was circular in shape with an approximate diameter of 142 mm - The sample consisted of medium green meta-gabbro with a mineral grain size that was medium to coarse grained; mafic and felsic minerals were in nearly equal proportions - Secondary alteration was prevalent and chlorite was abundant - Fine metallic mineral grains were observed; however, they were in low abundance - Two parallel calcite veins extended across the entire slab and had widths ranging from 1 to 2 mm; the calcite was crystalline and translucent and there was no fracture or absorptive zone associated with them - There were several thin veins throughout the slab that contained variable proportions of chlorite, calcite and other secondary minerals; generally, they had random orientation - Two thin veins were moderately absorptive and were lighter coloured due to slight weathering; they were associated with very thin (< 0.2 mm) and closed fractures that extended through the slab	- No significant amount of material was dislodged from the slab - The two thin veins that were absorptive and associated with very thin fractures did not widen or extend; it was observed that magnesium sulphate staining penetrated into the fractures - Overall, this specimen did not exhibit any significant formation of fractures or loss of material
01A3	- The slab was circular in shape with an approximate diameter of 143 mm - The sample consisted of medium green meta-gabbro with a mineral grain size that was fine to medium grained; mafic and felsic minerals were in nearly equal proportions - Secondary alteration was prevalent and chlorite was abundant - Fine metallic mineral grains were observed; however, they were in low abundance - There was one fracture that was moderately absorptive and was thinly coated with calcite; it followed a consistent direction but was irregularly shaped - The fracture partially extended through the slab and was thin with a width less than approximately 0.1 mm - The calcite coating the fracture surface was opaque and appeared to be slightly weathered	- No significant amount of material was dislodged from the slab - A few small fragments of calcite appear to have dislodged along a pre-existing fracture; the fracture did not widen or lengthen - Overall, this specimen did not exhibit any significant formation of fractures or loss of material
01A4	- The slab was circular in shape with an approximate diameter of 143 mm - The sample consisted of medium to dark green meta-gabbro with a mineral grain size that was medium to coarse grained; mafic minerals were slightly more abundant than felsic minerals - Secondary alteration was prevalent and chlorite was abundant - Fine metallic mineral grains were observed along some veins; however, they were in low abundance - There were several open and highly absorptive fractures in the slab specimen - One fracture (#1) extended through and across the middle of the slab and was thinly coated with calcite; it ranged in width from 0.1 to 0.4 mm and followed a consistent direction - A second fracture (#2) was near the edge of the slab and was general less than 0.2 mm in width; it was thinly coated with calcite, had a consistent orientation, and was irregularly shaped - The calcite coating the fracture surfaces was opaque and appeared to be slightly weathered	- No significant amount of material was dislodged from the slab - Fracture #1 and fracture #2 did not appear to have widened or extended; however, a few small fragments of calcite appear to have dislodged along the fractures - Magnesium sulphate was observed to have readily penetrated into the majority of fractures - Overall, this specimen did not exhibit any significant formation of fractures or loss of material. The fractures that were pre-existing did not widen; however they do not appear particularly strong and could be susceptible to fracturing if the slab were struck or dropped

01A5	- The slab was circular in shape with an approximate diameter of 142 mm - The sample consisted of dark green meta-gabbro with a mineral grain size that was fine grained; mafic minerals were more abundant than felsic minerals - Secondary alteration was prevalent and chlorite was abundant - Fine metallic mineral grains were observed along some veins; however, they were in low abundance - There was one fracture that was moderately absorptive and was thinly coated with calcite; it ranged in width from 0.2 to less than 0.1 mm - The fracture extended through the slab and had a short fracture that branched out with a width less than 0.1 mm; the short fracture was only slightly absorptive - The calcite coating the fracture surfaces was opaque and appeared to be slightly weathered - A calcite vein intersected a thin, 4 mm wide portion of the slab near its edge; it was approximately 0.8 mm wide and was not absorptive	- No significant amount of material was dislodged from the slab - A few small fragments of calcite appear to have dislodged along a pre-existing fracture; in some locations this left a pitted appearance - A few select grains of metallic minerals were oxidized and stained dark orange - Magnesium sulphate was observed to have readily penetrated into the majority of fractures - The calcite vein which intersected the thin 4 mm portion of the slab was completely unaffected - Overall, this specimen did not exhibit any significant formation of fractures or loss of material

Summary of Deterioration

Many of the specimens did not appear to lose any material and those that did lost only small flakes and fragments that were thin and poorly attached to the slab edge prior to testing. Fracture propagation was not observed and no new fractures formed as a result of subjecting the material to cycles of drying and soaking with magnesium sulphate solution. The following observations regarding sample conditions were made:

Loss of Material

- dislodgement of thin calcite flakes around the rind of the some slabs
- pitting and dislodgement of material along pre-existing fracture paths where fractures were: i) closely spaced, ii) braided and/or intersecting with other fractures, iii) open and with shallow angle relative to slab surface, iv) coated or in/filled with calcite

Formation and/or propagation of fractures

- Pre-existing fractures were not observed to have widened or lengthened; however, several of the pre-existing fractures appeared to be of moderate strength and susceptible to fracturing if the material were impacted with moderate force

Overall Summary:

The data given in this report pertain to the samples provided, and is not applicable to material from other locations or trial periods.

At the end of five cycles of drying and soaking in magnesium sulphate solution, and completion of the test, the specimens had an average measured loss of 0.03% by mass, with a high value of 0.05% and a low of 0.02%. This suggests that the specimens were generally similar to each other in regards to their resistance to the stresses imposed by soundness testing using magnesium sulphate solution. Material loss appeared to be caused by dislodging of material which was only moderately well adhered to the slab prior to testing and generally consisted of small fragments and mineral grains.

Formation of new fractures, widening, and lengthening of pre-existing fractures, was not observed in the tested rock slabs. Several of the pre-existing fractures were interpreted to be of moderate strength and could be susceptible to fracturing if impacted with moderate force. Many of the moderate strength fractures were coated with calcite and slightly weathered.

Prepared, tested and reported by:

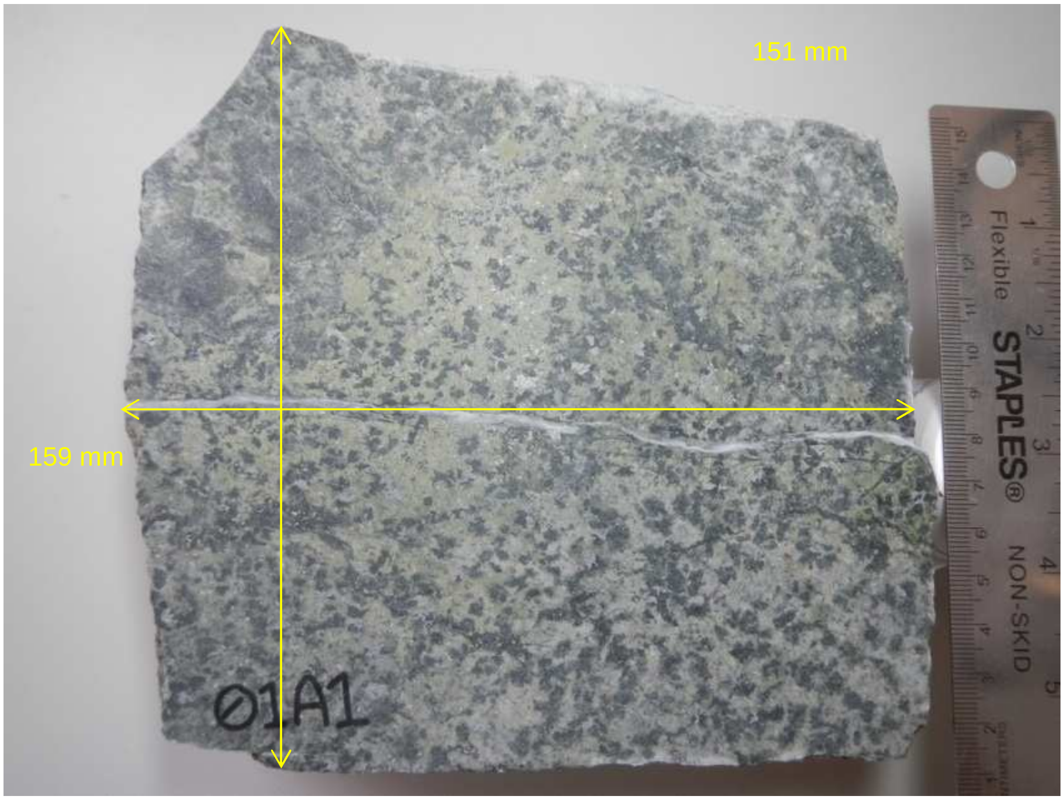
B. Hudson, B. Sc., GIT

Reviewed by:

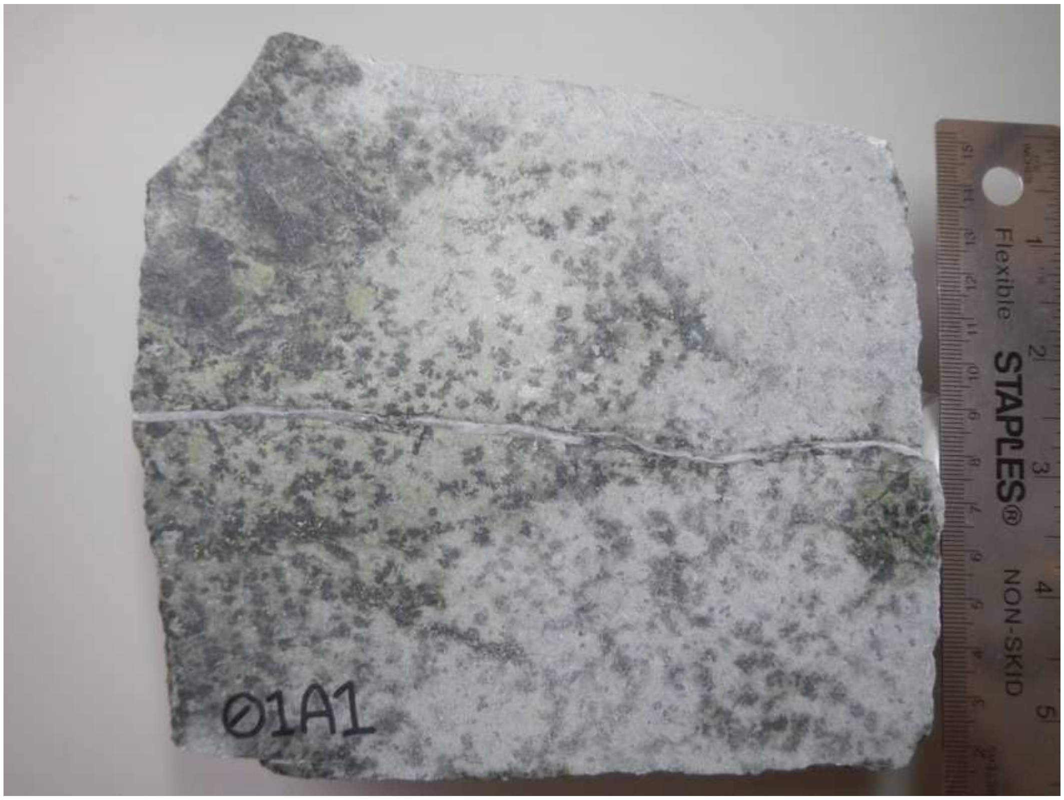
A. Briggs, M. Sc., P. Geo.

PHOTOGRAPHS

Initial (0 cycles) – 01A1 – *Wetted*

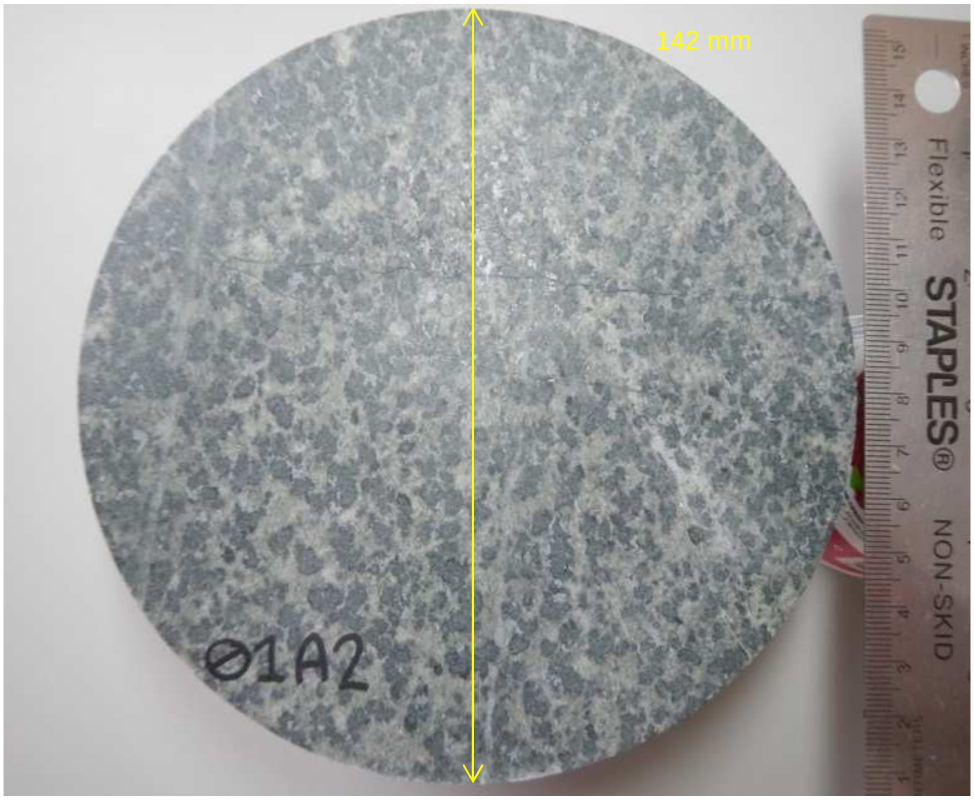


Initial (0 cycles) – 01A1 – *Partially dried back*

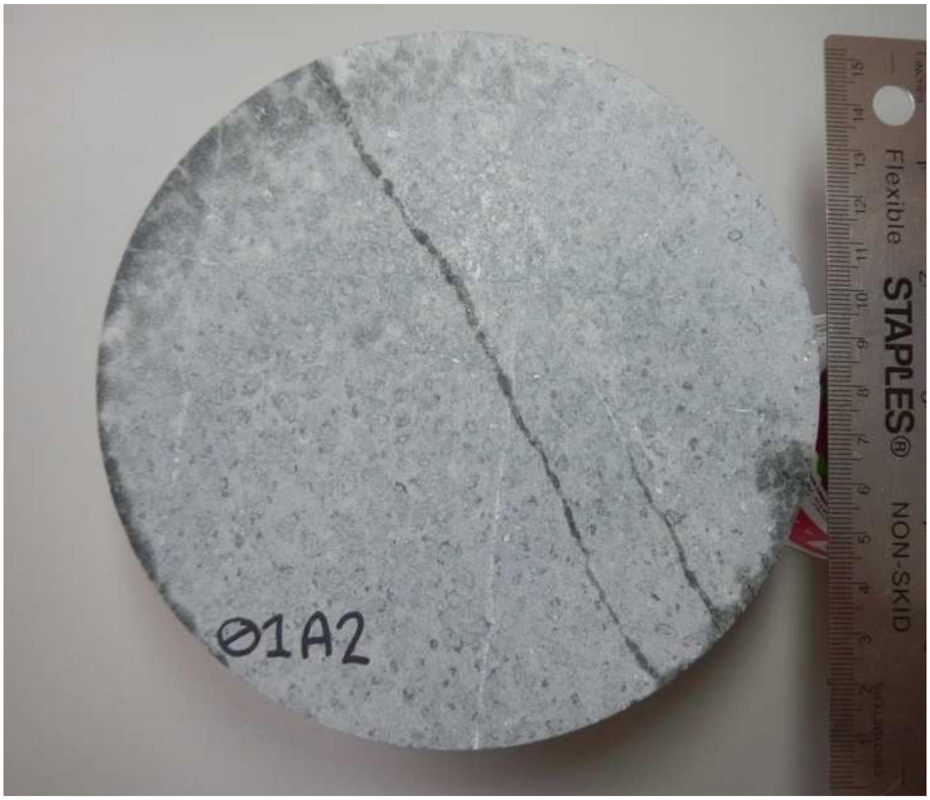


Final (20 cycles) – 01A1 – *Partially dried back*

Initial (0 cycles) – 01A2 – *Wetted*

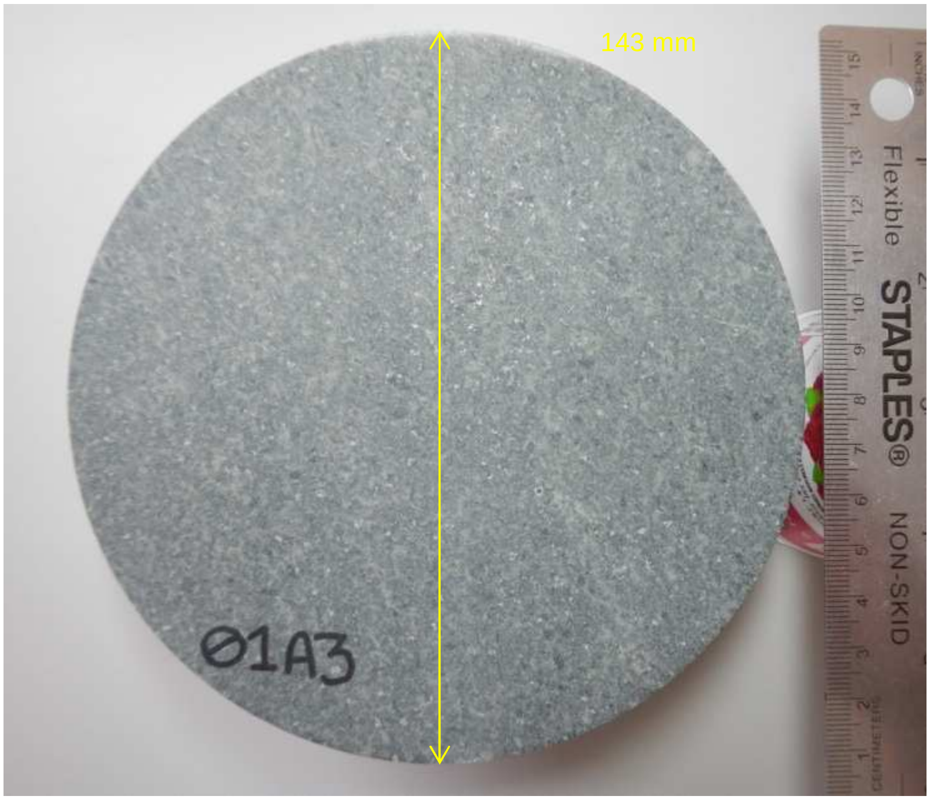


Initial (0 cycles) – 01A2 – *Partially dried back*



Final (20 cycles) – 01A2 – *Partially dried back*

<u>Initial (0 cycles) – 01A3</u> – *Wetted*

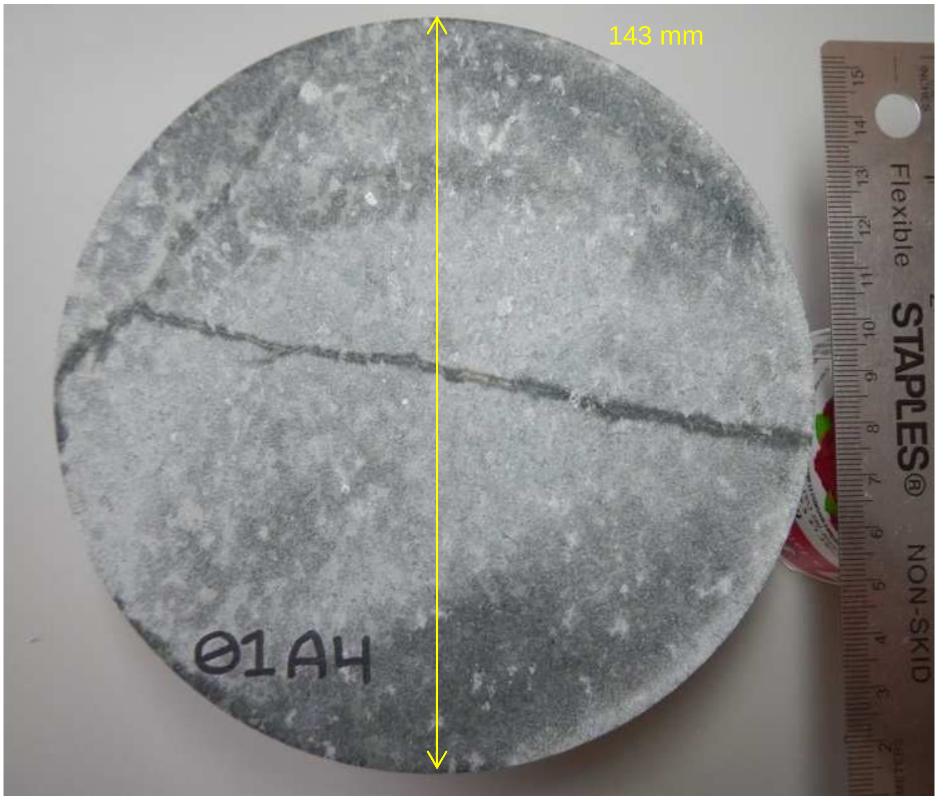


<u>Initial (0 cycles) – 01A3</u> – *Partially dried back*

Final (20 cycles) – 01A3 – *Partially dried back*

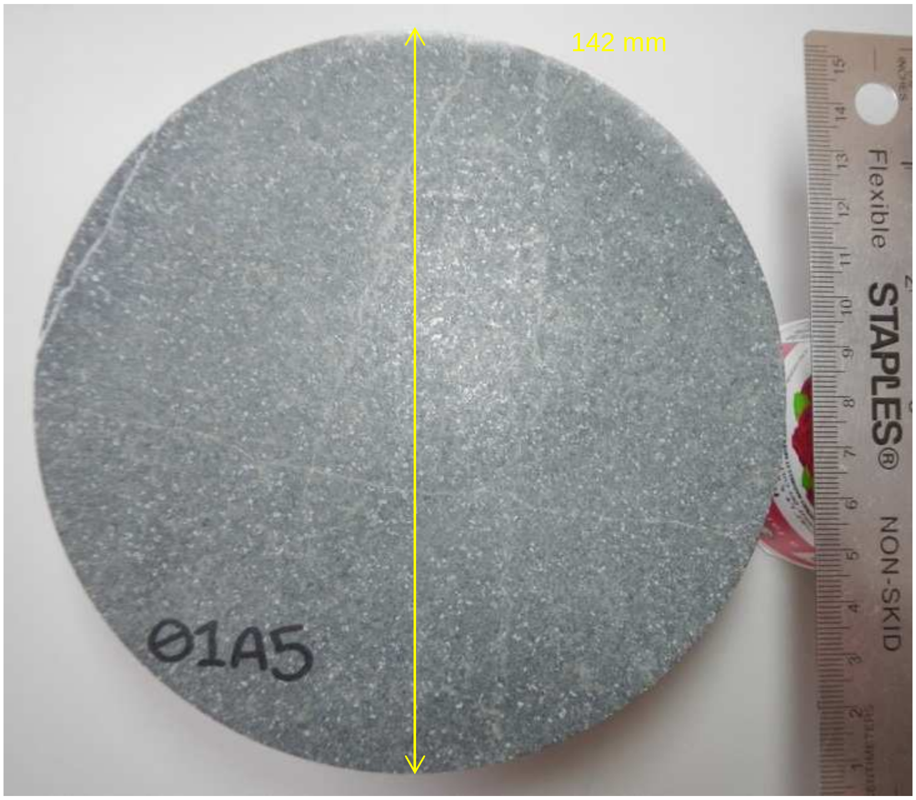
Initial (0 cycles) – 01A4 – *Wetted*

Initial (0 cycles) – 01A4 – *Partially dried back*

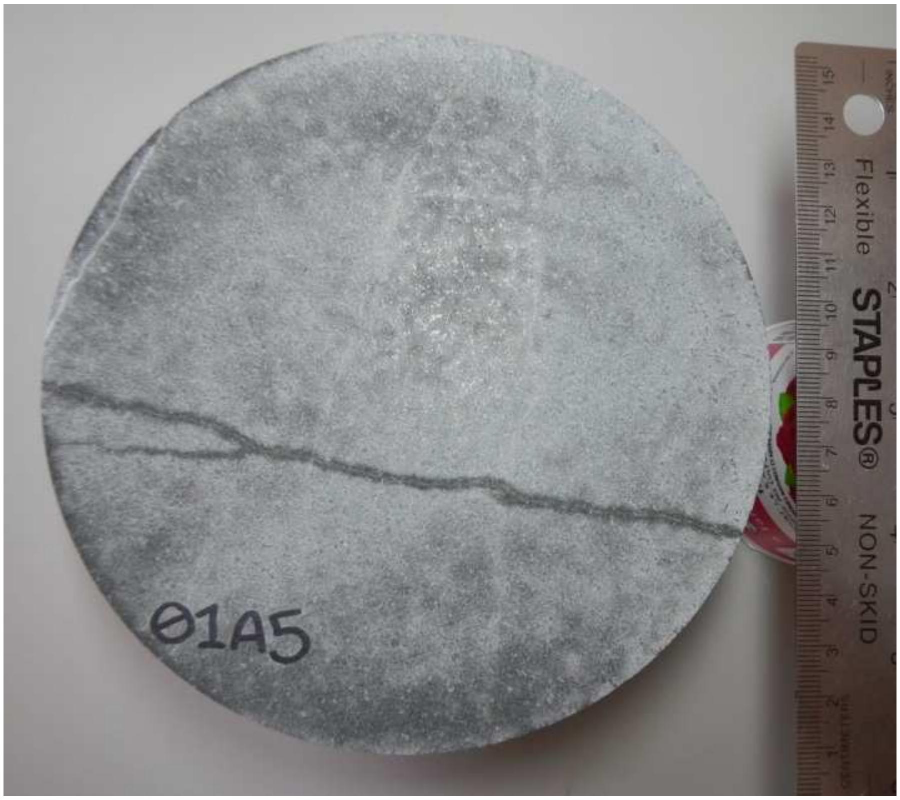


Final (20 cycles) – 01A4 – *Partially dried back*

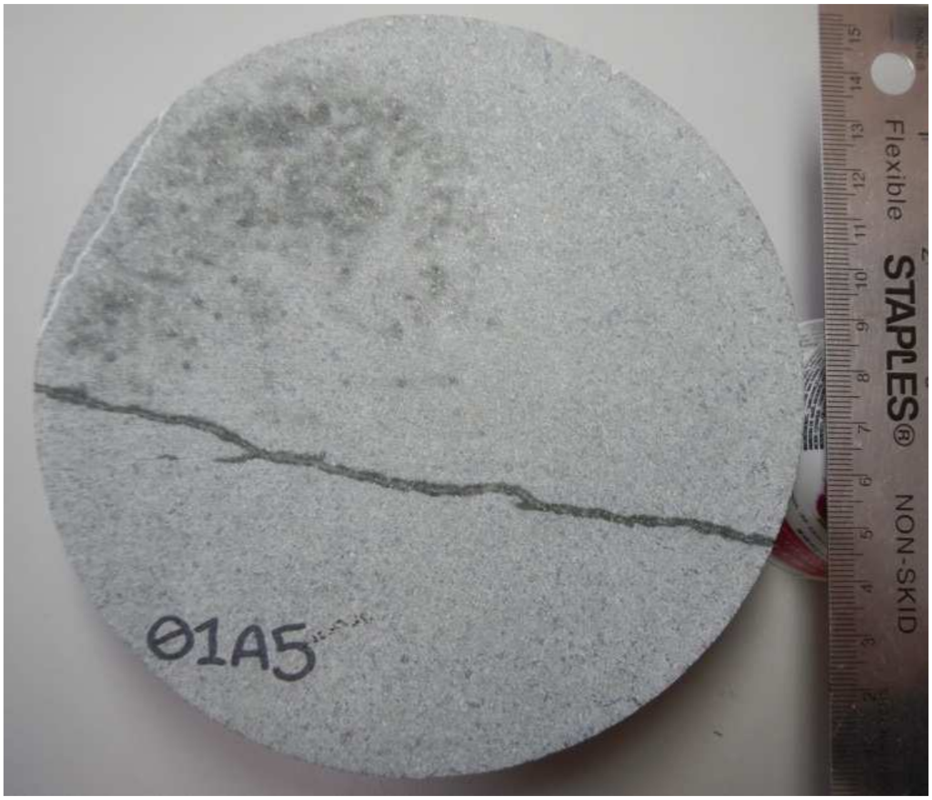
Initial (0 cycles) – 01A5 – *Wetted*



Initial (0 cycles) – 01A5 – *Partially dried back*



Final (20 cycles) – 01A5 – *Partially dried back*



-End of Photographs-

EVALUATION OF DURABILITY OF ROCK FOR EROSION CONTROL UNDER FREEZING AND THAWING CONDITIONS

ASTM D 5312

CH2M Hill
1100 – 1st Street SE
Calgary, Alberta, T2G 1B1

February 24, 2014
Project Number: 13-1417-0047-3000

ATTENTION: Mr. Mark Cichy

PROJECT: BSI Grum Dump Rock Quarry 2013

Sample:	**CH13-311-SS001_RKa, Sample Date: 10-Jul-2013**
Source:	**BSI Grum Dump Rock Quarry, Tar #18, Faro Mine Complex, Yukon**

Objective and Method:

The objective of this testing program was to conduct a test of the durability of rock proposed for use as erosion control in an environment where it is understood that it would be exposed to freezing and thawing and wetting and drying. The sample consisted of several boulder-sized rock chunks with an average diameter of 0.5 meters. The boulders were understood to have been sampled from a site proposed for quarry production of rip rap material; the sampling site was identified as BSI Grum Dump Rock Quarry. The boulders were obtained by others.

The test program consisted solely of conducting the method described in ASTM D 5312. This report constitutes the final results of the test; all previously issued draft reports are hereby superseded. This report comprises a testing service only. Interpretation may be provided upon request.

In order to extract slab specimens from the boulder-size samples, a combination of wide diameter (6"/152 mm) rock coring and rock saw cutting was utilized. Some slab samples were circular in shape, while others were rectangular. Average dimensions of the slab specimens generally conformed to the requirements outlined in ASTM D 5240 and ASTM D 5121 (Preparation of Rock Slabs for Durability Testing). The rock slab specimens utilized in the test were generally 65 mm thick and not less than 125 mm on a side.

The test was designed such that the samples would be subjected to 55 cycles of freezing and thawing. In absence of specific instruction from the client and provision of relevant climate data, the number of total cycles was determined by comparing the approximate geographic location to the "Isoline Map of Freeze-Thaw Severity Index," Figure 1 from ASTM D 5312.

The freezing portion of each cycle consisted of storing the samples in a freezer at -18°C for a minimum of 16 hours. This was followed by a minimum of 8 hours of thawing in an oven at 32°C. The condition of each sample was evaluated every five cycles through macroscopic and microscopic examination using a binocular microscope with magnifications up to 50x, enabling observations of pre-existing cracks and newly developed deterioration. Inspections included photographs and descriptive logs.

Prior to and at the end of the test, each sample is weighed and the percent loss by mass calculated for the individual specimens.

A selection of boulders from sample CH13-311-SS001_RKa was chosen for the tests; these were identified as 1, 2, 3, 4, and 5. Additional durability testing, consisting of ASTM D 5240 (Testing of Rock Slabs to Evaluate Soundness of Riprap by Use of Magnesium Sulfate) and ASTM D 5313 (Evaluation of Durability of Rock for Erosion Control Under Wetting and Drying Conditions) are being conducted on the same boulders. To compare the results from each test method, three slab specimens were extracted from each of the selected boulders and the same boulder identification designation was used for the three slabs.

Quantitative Analysis:

Percent Loss

Sample ID	Boulder #	Slab ID	Original Mass (g)	Final Mass (g)	Measured Loss (%)
CH13-311-SS001_RKa	1	**01B1**	3008.2	3007.9	**0.01%**
	2	**01B2**	3065.5	3065.5	**0%**
	3	**01B3**	2997.4	2997.1	**0.01%**
	4	**01B4**	2983.7	2983.6	**0%**
	5	**01B5**	2742.7	2742.6	**0%**
				Final Average Loss (%)	**0.01%**

Qualitative Analysis:

Summary of Initial Condition

Petrographic examination was undertaken on a crushed composite of select chunks of rock from the CH13-311-SS001-RKa sample batch; generally, the rock consisted of metamorphosed gabbro. Thin section analysis was conducted on one rock particle; chemical analyses, such as whole-rock analysis by X-Ray Fluorescence, were not conducted. Each rock slab was extracted from a specimen with slight to significant variations in compositional, textural and structural qualities. Parameters that varied included:

Composition
- Proportion of mafic and felsic minerals
- Amount of metallic minerals (chalcopyrite, etc.)
- Degree of alteration to protolith minerals
- Amount of secondary alteration minerals (chlorite, etc.)
- Presence of veins in-filled with calcite

Textural
- Average mineral grain size
- Distribution of veins
- Presence and size of relict protolith minerals

Structure
- Presence/absence of fractures
- Number of fractures and fracture spacing
- Orientation and pattern of fractures
- Presence of thin calcite in fractures
- Degree of weathering in fracture

-

Observations of Individual Specimens

Slab ID	Observations		
	Initial @ 0 cycles	**Interim @ 40 cycles**	**Final @ 55 cycles**
01B1	- The slab was circular in shape with an approximate diameter of 142 mm - The sample consisted of light green meta-gabbro with a mineral grain size that was medium to coarse grained; felsic minerals were slightly more abundant than mafic minerals - Secondary alteration was prevalent and chlorite was abundant - Fine metallic mineral grains, which included pyrite and chalcopyrite, were of low to moderate abundance and observed in concentrated zones, patches and stringlets - A thin calcite vein extended across the entire slab in with sub-planar shape and had a width ranging from 0.02 to 0.1 mm; the calcite was intermediate between translucent and opaque - Approximately half of this calcite vein was strongly bond to the rock and was only slightly absorptive while the other half was discontinuously attached, had developed into a fracture, and was highly absorptive - The fracture associated with this calcite vein was 0.3 to 1 mm in width and fragments of calcite had dislodged from the fracture imparting an open appearance; it was moderately to highly absorptive and extended through to the other side of the slab - This fracture abruptly progressed in a perpendicular direction at the point where the vein became well adhered to the rock; essentially, the fracture sectioned off a one-quarter pie slice of the circular slab (and the vein sectioned off one-half) - There were some fractures on the side of the slab opposite the inspection surface that were connect to thin, closed, moderately absorptive fissures on the inspection surface; they were irregularly shaped and often discontinuous and stepped	- A few small fragments of calcite appear to have dislodged along pre-existing fractures - The fracture associated with the calcite vein widened very slightly and a few small fragments of calcite appear to have detached and dislodged - Overall, this specimen did not exhibit any significant propagation or formation of fractures, or loss of material. A fracture associated with a calcite vein widened very slightly; however, prior to testing, this fracture did not appear particularly strong and could be susceptible to fracturing if the slab were struck or dropped	- Compared to the condition at the 40 cycle interim inspection, no material loss or propagation/formation of fractures was observed - Upon detailed inspection, it was detected that pre-existing fractures contained very finely fractured material to a depth of less than 0.2 mm along the fracture surface; this material was absorptive, soft and could be gouged out with a steel tool. It is believed this weaker material was associated with weathering of the pre-existing fractures prior to testing and did not form as a result of freeze-thaw stresses.

01B2	- The slab was circular in shape with an approximate diameter of 142 mm - The sample consisted of medium green meta-gabbro with a mineral grain size that was medium to coarse grained; mafic and felsic minerals were in nearly equal proportions - Secondary alteration was prevalent and chlorite was abundant - Fine metallic mineral grains were observed; however, they were in low abundance - Calcite veins were present throughout the specimen and ranged in width from 0.5 to 3 mm; the calcite was intermediate between being translucent and opaque and the majority of veins were not absorptive or associated with fractures - The calcite veins were sub-planar in shape and they were often discontinuous and stepped - One of the calcite veins was absorptive but did not appear to be an open fracture (width less than ~0.2 mm) and calcite infill was continuously attached to the surrounding rock - There were some dark green veins and stringlets throughout; generally, they were less than 0.8 mm in width and were not absorptive	- No significant amount of material was dislodged from the slab; pre-existing fractures and calcite veins did not heave or exude material - Calcite veins that were absorptive and associated with very thin fractures did not widen or extend - Overall, this specimen did not exhibit any significant formation of fractures or loss of material	- Compared to the condition at the 40 cycle interim inspection, no material loss or propagation/formation of fractures was observed
01B3	- The slab was circular in shape with an approximate diameter of 142 mm - The sample consisted of medium green meta-gabbro with a mineral grain size that was fine to medium grained; mafic and felsic minerals were in nearly equal proportions - Secondary alteration was prevalent and chlorite was abundant - Fine metallic mineral grains were observed; however, they were in low abundance - There was one calcite vein of irregular shape and occurring in discontinuous segments; it was not absorptive and was thinly in-filled with calcite - The calcite infilling the veins was opaque and appeared to be slightly weathered	- No significant amount of material was dislodged from the slab; surface pitting did not occur and veins were entirely intact - Overall, this specimen did not exhibit any significant formation of fractures or loss of material	- Compared to the condition at the 40 cycle interim inspection, no material loss or propagation/formation of fractures was observed

01B4	- The slab was circular in shape with an approximate diameter of 142 mm - The sample consisted of medium to dark green meta-gabbro with a mineral grain size that was medium to coarse grained; mafic minerals were slightly more abundant than felsic minerals - Mineral composition was not uniformly distributed across the slab specimen; in some cases, there were concentrated, light green patches that contained dominantly felsic minerals - Secondary alteration was prevalent and chlorite was abundant - Fine metallic mineral grains were observed along some veins and were in low to moderate abundance overall - There were several open and absorptive fractures in the slab specimen - One fracture (#1) extended through and across the middle of the slab and was thinly coated with calcite; it ranged in width from 0.05 to 0.2 mm and was sub-planar in shape - Fracture #1 consisted of several very thin (<0.05 mm) and braided fractures which were slightly weathered and stained with iron oxide; metallic minerals, including chalcopyrite, were present within these fractures - A second fracture (#2) was near the edge of the slab and ranged in width from 0.02 to 1 mm; it was thinly in-filled with calcite that discontinuously coated the fracture and was detached from the fracture surface in several places - Fracture #2 tapered from an open fracture that was moderately absorptive to a thin (0.5 to 1 mm) calcite vein that was only slightly absorptive; the open fracture and closed vein component was irregularly shaped and branched into multiple veins towards the centre of the specimen - A third fracture (#3) had irregular shape and was thinly coated (<0.2mm) with calcite; it was not open and was only slightly absorptive	- No significant amount of material was dislodged from the slab - Fracture #1 did not appear to have widened or extended; extrusion and dislodgement of material along the fracture path was not observed - Fracture # 2 did not appear to have extended; a few thin flakes of calcite were dislodged from within the open fracture given it a slightly wider appearance - Overall, this specimen did not exhibit any significant formation of fractures or loss of material. There was a slight loss of material from pre-existing fractures that were thinly coated with poorly adhered calcite. Some pre-existing fractures did not appear particularly strong prior to or after the testing and could be susceptible to fracturing if the slab were struck or dropped	- A few thin flakes of calcite and sulphide mineral grains were dislodged to a very shallow depth (<0.2 mm) along Fracture #1 - Besides a very minor amount of material loss, the specimen did not exhibit significant change (propagation/formation of fractures) compared to its condition at the 40 cycle interim inspection

01B5	- The slab was circular in shape with an approximate diameter of 142 mm - The sample consisted of dark green meta-gabbro with a mineral grain size that was fine grained; mafic minerals were more abundant than felsic minerals - Secondary alteration was prevalent and chlorite was abundant - Fine metallic mineral grains were observed along some veins; however, they were in low abundance - There was one fracture that was divided into two-thirds moderately absorptive and very slightly open and one-third slightly absorptive and tightly closed - The fracture was discontinuously coated/in-filled with calcite (<0.5 mm thick) and it was sub-planar in shape - There was one calcite vein that had undulating shape; it was not absorptive and the calcite was generally translucent - The main portion of the aforementioned calcite vein was 1 to 3 mm thick; there was a short, discontinuous branch from the thick portion that was <0.5 mm thick and contained abundant iron sulphide minerals	- No significant amount of material was dislodged from the slab - A few small fragments of rock mass and calcite appear to have dislodged along the most open portion (~0.5 mm) portion of the one pre-existing fracture - At a location where the pre-existing fracture was stepped, a short 1.5 mm forked extension formed at one end - A few select grains of metallic minerals were oxidized resulting in localized dark orange blebs on the slab surface - Overall, fracture propagation and material loss was minimal for this specimen.	- Compared to the condition at the 40 cycle interim inspection, no material loss or propagation/formation of fractures was observed - Upon detailed inspection it was noted that pre-existing fractures contained very finely fractured material to a depth of less than 0.2 mm along the fracture surface; this material was absorptive, soft and could be gouged out with a steel tool. It is believed this weaker material was associated with weathering of the pre-existing fractures prior to testing and did not form as a result of freeze-thaw stresses.

Summary of Deterioration

Many of the specimens did not appear to have lost any material. For those that exhibited any loss of material, the loss consisted of only small flakes and fragments that were thin and weakly attached to pre-existing fractures, noted prior to testing. Fracture propagation was observed in only very slight amounts and no new fractures formed as a result of the freezing and thawing action. The following observations regarding sample conditions were made:

Loss of Material

- Dislodgement of thin calcite flakes along pre-existing fracture paths where fractures were open and containing discontinuously coatings and infill of calcite
- Extrusion of rock material and calcite infill from braided and/or layered fractures with pre-existing evidence of weathering

Formation and/or propagation of fractures

- Pre-existing fractures were observed to have widened only very slightly for select specimens. One fracture developed a short (1 to 2 mm), forked extension and offset and nearly intersected another pre-existing fracture
- The pre-existing fractures that widened slightly were in-filled with calcite that was discontinuously coating and poorly adhered to the fracture surface
- Although fracture propagation was minimal, several of the pre-existing fractures appeared to be of moderate strength and susceptible to fracturing if the material were impacted with moderate force

Overall Summary

The data given in this report pertain to the samples provided, and may not be applicable to material from other locations or trial periods.

The observations for material loss and fracture formation, as well as the visual and measured estimate of mass loss were comparable between the 40 cycle interim inspection and the 55 cycle final inspection. This indicates that the specimens did not undergo significant additional deterioration after 55 cycles, compared to 40 cycles.

The specimens had an average measured loss of 0.01% by mass. The samples were generally similar to each other with regard to their resistance to the stresses generated by freezing and thawing action. Material loss appeared to be caused by dislodging of material that was only moderately well adhered to pre-existing fracture surfaces prior to testing and generally consisted of the removal of small flakes, fragments and mineral grains.

Formation of new fractures, widening, and lengthening of pre-existing fractures was observed in very minor amounts in the tested rock slabs. Several of the pre-existing fractures were interpreted to be of moderate strength and could be susceptible to fracturing if impacted with moderate force. Many of the moderate strength fractures were coated with calcite and were open prior to testing.

Prepared, tested and reported by:

B. Hudson, P. Geo.

Reviewed by:

F. Shrimer, P. Geo.

PHOTOGRAPHS

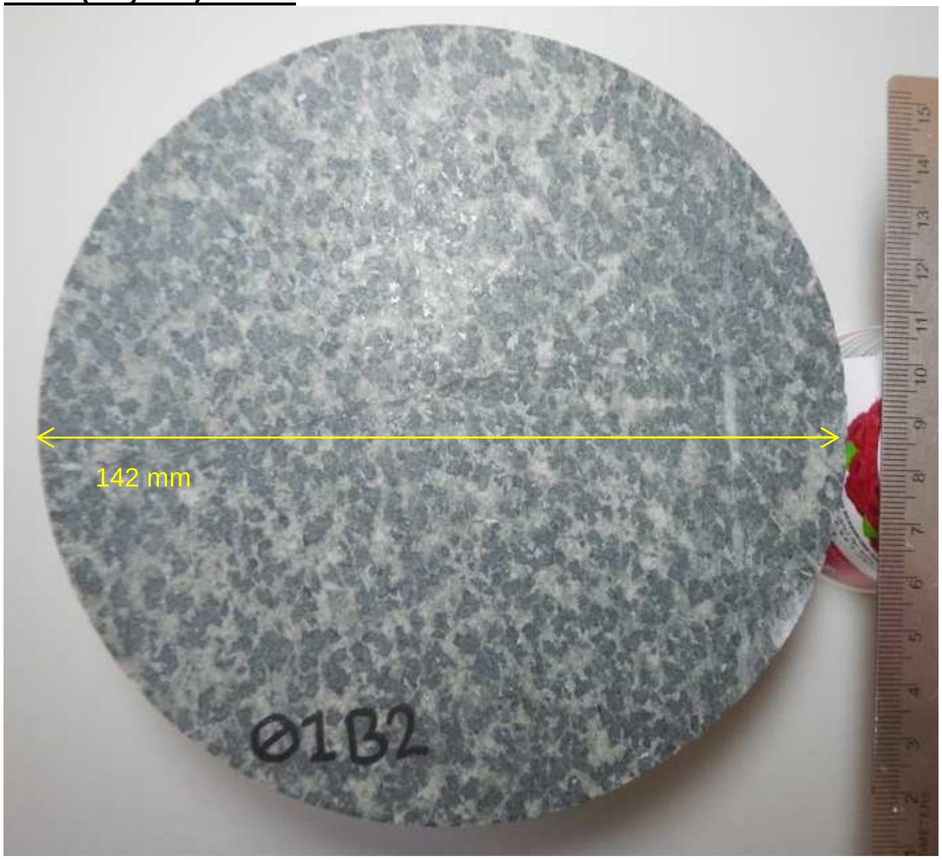
Initial (0 cycles) – 01B1 – *Wetted*

Initial (0 cycles) – 01B1 – *Partially dried back*

Interim (40 cycles) – 01B1 – *Partially dried back*

Final (55 cycles) – 01B1 – *Partially dried back*

Initial (0 cycles) – 01B2 – *Wetted*



Initial (0 cycles) – 01B2 – *Partially dried back*

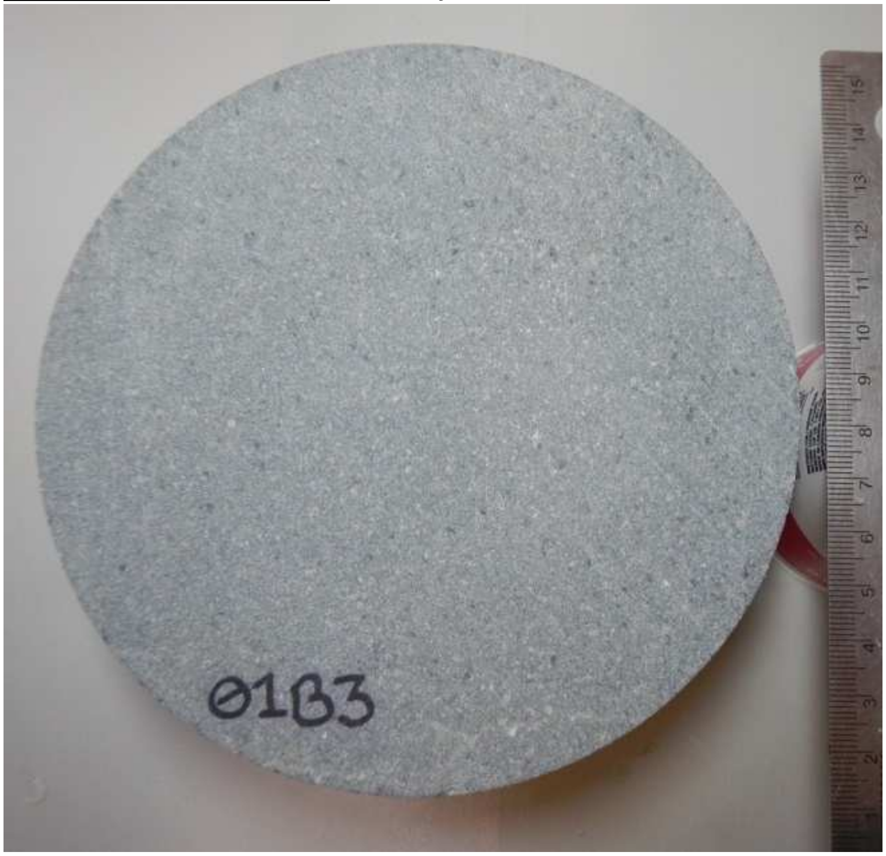
Interim (40 cycles) – 01B2 – *Partially dried back*

Final (55 cycles) – 01B2 – *Partially dried back*

Initial (0 cycles) – 01B3 – *Wetted*

Initial (0 cycles) – 01B3 – *Partially dried back*

Interim (40 cycles) – 01B3 – *Partially dried back*



Final (55 cycles) – 01B3 – *Partially dried back*

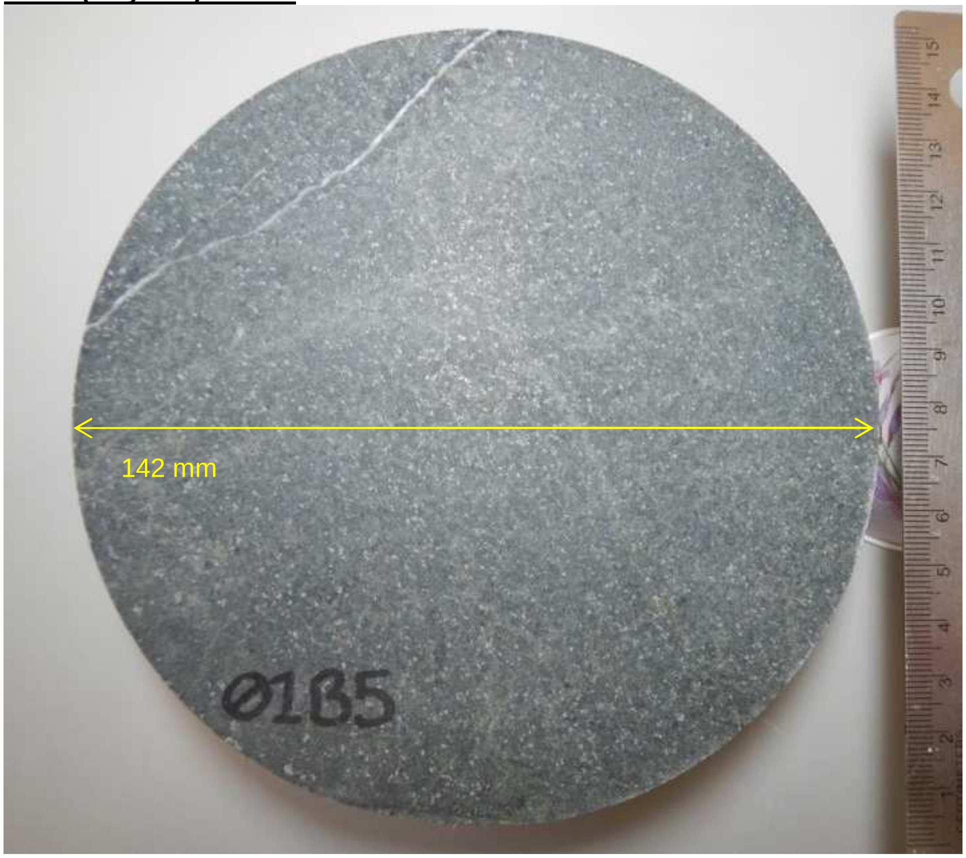
Initial (0 cycles) – 01B4 – *Wetted*

Initial (0 cycles) – 01B4 – *Partially dried back*

Interim (40 cycles) – 01B4 – *Partially dried back*

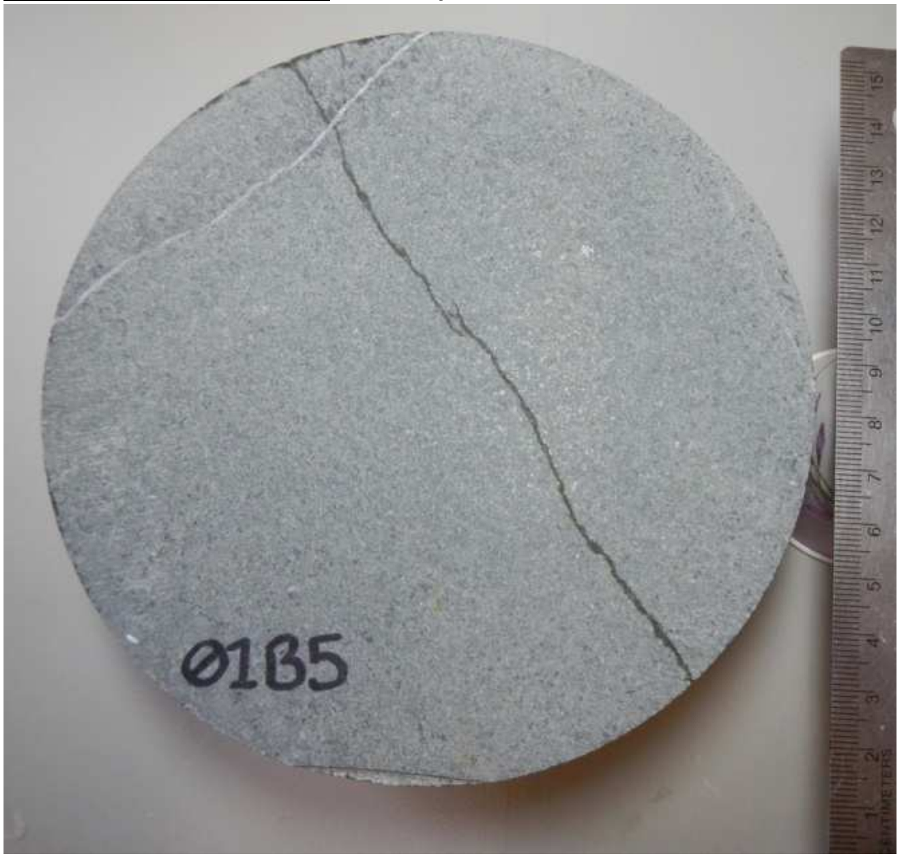
Final (55 cycles) – 01B4 – *Partially dried back*

<u>Initial (0 cycles) – 01B5</u> – *Wetted*



<u>Initial (0 cycles) – 01B5</u> – *Partially dried back*

Interim (40 cycles) – 01B5 – *Partially dried back*



Final (55 cycles) – 01B5 – *Partially dried back*

-End of Photographs-

SPECIFIC GRAVITY AND ABSORPTION OF ROCK FOR EROSION CONTROL

ASTM D6473

October 18, 2013
Project Number: 13-1417-0047-3000

CH2M Hill
1100 – 1st Street SE
Calgary, Alberta
T2G 1B1

ATTENTION: Mr. Mark Cichy

PROJECT: BSI Grum Dump Rock Quarry 2013

Sample:	**CH13-311-SS001_Rka**
Source:	**Grum Dump Rock Quarry, Tar #18, Faro Mine Complex, Yukon**

Date sampled: July 10, 2013 **Sampled by:** Client
Date tested: October 15, 2013 **Tested by:** DC/VN

Rock #	Mass (grams)	Relative Density (g/cm^3) (Dry Basis)	Relative Density (g/cm^3) (SSD Basis)	Relative Density (g/cm^3) (Apparent)	Absorption (%)
1	1902.0	2.717	2.728	2.748	0.41
2	2378.3	2.670	2.681	2.699	0.41
3	3259.4	2.951	2.958	2.973	0.25
4	3326.4	2.976	2.980	2.986	0.11
5	2646.1	2.869	2.875	2.886	0.20
AVERAGE		**2.837**	**2.844**	**2.858**	**0.28**

Reported by: S. John, AScT

Reviewed by: ______________________
L. Hu, M. Sc. E., P.Eng.

Notice: The test data given herein pertain to the sample provided, and may not be applicable to material from other production zones/periods. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

SPECIFIC GRAVITY AND ABSORPTION OF ROCK FOR EROSION CONTROL
ASTM D6473

October 18, 2013
Project Number: 13-1417-0047-3000

CH2M Hill
1100 – 1st Street SE
Calgary, Alberta
T2G 1B1

ATTENTION: Mr. Mark Cichy

PROJECT: BSI Grum Dump Rock Quarry 2013

Sample:	**CH13-311-SS019_Rka**
Source:	**Grum Dump Rock Quarry, Tar #18, Faro Mine Complex, Yukon**

Date sampled: July 10, 2013 **Sampled by:** Client
Date tested: October 15, 2013 **Tested by:** DC/VN

Rock #	Mass (grams)	Relative Density (g/cm^3) (Dry Basis)	Relative Density (g/cm^3) (SSD Basis)	Relative Density (g/cm^3) (Apparent)	Absorption (%)
1	4609.3	2.897	2.916	2.955	0.68
2	4040.3	2.860	2.882	2.924	0.77
3	4336.8	2.913	2.928	2.957	0.51
4	4899.0	2.919	2.954	3.024	1.20
AVERAGE		**2.897**	**2.920**	**2.965**	**0.79**

Reported by: S. John, AScT

Reviewed by: ______________________
L. Hu, M. Sc. E., P.Eng.

Notice: The test data given herein pertain to the sample provided, and may not be applicable to material from other production zones/periods. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

GOLDER ASSOCIATES LTD., 300 - 3811 North Fraser Way, Burnaby, BC, Canada V5J 5J2 Tel: 604-412-6899 Fax: 604-412-6816

SPECIFIC GRAVITY AND ABSORPTION OF ROCK FOR EROSION CONTROL

ASTM D6473

October 18, 2013
Project Number: 13-1417-0047-3000

CH2M Hill
1100 – 1st Street SE
Calgary, Alberta
T2G 1B1

ATTENTION: Mr. Mark Cichy

PROJECT: BSI Grum Dump Rock Quarry 2013

Sample:	**CH13-311-SS021_Rka**
Source:	**Grum Dump Rock Quarry, Tar #18, Faro Mine Complex, Yukon**

Date sampled: July 12, 2013 **Sampled by:** Client
Date tested: October 15, 2013 **Tested by:** DC/VN

Rock #	Mass (grams)	Relative Density (g/cm^3) (Dry Basis)	Relative Density (g/cm^3) (SSD Basis)	Relative Density (g/cm^3) (Apparent)	Absorption (%)
1	2141.6	2.972	2.991	3.028	0.62
2	2864.7	2.990	3.006	3.038	0.53
3	2497.7	3.008	3.016	3.031	0.25
4	2668.3	3.019	3.025	3.036	0.18
5	2179.9	3.003	3.010	3.024	0.23
AVERAGE		**2.999**	**3.009**	**3.032**	**0.36**

Reported by: S. John, AScT

Reviewed by: ______________________
L. Hu, M. Sc. E., P.Eng.

Notice: The test data given herein pertain to the sample provided, and may not be applicable to material from other production zones/periods. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

SPECIFIC GRAVITY AND ABSORPTION OF ROCK FOR EROSION CONTROL

ASTM D6473

October 18, 2013
Project Number: 13-1417-0047-3000

CH2M Hill
1100 – 1st Street SE
Calgary, Alberta
T2G 1B1

ATTENTION: Mr. Mark Cichy

PROJECT: BSI Grum Dump Rock Quarry 2013

Sample:	**CH13-311-SS022_Rka**
Source:	**Grum Dump Rock Quarry, Tar #18, Faro Mine Complex, Yukon**

Date sampled: July 12, 2013 **Sampled by:** Client
Date tested: October 15, 2013 **Tested by:** DC/VN

Rock #	Mass (grams)	Relative Density (g/cm^3) (Dry Basis)	Relative Density (g/cm^3) (SSD Basis)	Relative Density (g/cm^3) (Apparent)	Absorption (%)
1	1525.2	3.027	3.033	3.047	0.22
2	1377.7	2.953	2.969	2.999	0.51
3	1500.8	3.003	3.015	3.039	0.39
4	3021.2	2.900	2.910	2.930	0.35
5	2843.1	2.907	2.915	2.929	0.25
AVERAGE		**2.958**	**2.968**	**2.989**	**0.34**

Reported by: S. John, AScT

Reviewed by: ______________________
L. Hu, M. Sc. E., P.Eng.

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SPECIFIC GRAVITY AND ABSORPTION OF ROCK FOR EROSION CONTROL

ASTM D6473

October 18, 2013
Project Number: 13-1417-0047-3000

CH2M Hill
1100 – 1st Street SE
Calgary, Alberta
T2G 1B1

ATTENTION: Mr. Mark Cichy

PROJECT: BSI Grum Dump Rock Quarry 2013

Sample:	**CH13-311-SS026_Rka**
Source:	**Grum Dump Rock Quarry, Tar #18, Faro Mine Complex, Yukon**

Date sampled: July 15, 2013 **Sampled by:** Client
Date tested: October 15, 2013 **Tested by:** DC/VN

Rock #	Mass (grams)	Relative Density (g/cm^3) (Dry Basis)	Relative Density (g/cm^3) (SSD Basis)	Relative Density (g/cm^3) (Apparent)	Absorption (%)
1	946.2	2.677	2.697	2.732	0.76
2	2926.2	2.562	2.598	2.658	1.41
3	2834.0	2.622	2.643	2.678	0.79
4	3479.8	2.922	2.942	2.980	0.66
5	4105.0	2.679	2.698	2.730	0.70
AVERAGE		**2.693**	**2.716**	**2.756**	**0.87**

Reported by: S. John, AScT

Reviewed by: ______________________
L. Hu, M. Sc. E., P.Eng.

ASTM INTERNATIONAL ORGANIZATIONAL MEMBER

CCIL The Voice Of Independent Canadian Laboratories La voix des laboratoires indépendants canadiens

Notice: The test data given herein pertain to the sample provided, and may not be applicable to material from other production zones/periods. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

PETROGRAPHIC EXAMINATION OF COARSE AGGREGATE
ASTM C 295/CSA A23.2-15A

CH2M Hill
1100 – 1st Street SE
Calgary, Alberta, T2G 1B1

November 19, 2013
Project Number: 13-1417-0047-3000

ATTENTION: Mr. Mark Cichy

PROJECT: BSI Grum Dump Rock Quarry 2013

Sample:	**CH13-311-SS001_RKa, 10-Jul-2013 –19 x 9.5 mm, Laboratory Crushed Composite**
Source:	**BSI Grum Dump Rock Quarry, Tar #18, Faro Mine Complex, Yukon**

	PETROGRAPHIC DESCRIPTION/ PHYSICAL QUALITY	**PERCENT BY COUNT (mm)**		
		19 x 12.5	**12.5 x 9.5**	**TOTAL**
GOOD	**Meta-gabbro 1** - medium grained, white and dark green, strong	17.3	20.5	**18.3**
GOOD	**Meta-gabbro 2** - medium grained, light green and dark green, strong	1.7	5.0	**2.8**
GOOD	**Meta-gabbro 3** - medium grained, dark green, strong	30.5	23.0	**28.0**
GOOD	**Meta-gabbro 4** - fine grained, dark coloured, strong	14.9	13.7	**14.5**
GOOD	**Veined meta-gabbro 1, 3 and 4** – crystalline calcite veins 1 to 15 mm thick, strong	10.5	9.9	**10.3**
GOOD	**Oxidized meta-gabbro 1, 3 and 4** - orange oxidation staining on at least one surface, strong	11.5	9.0	**10.7**
GOOD	**Oxidized and veined meta-gabbro 1, 3 and 4** - orange oxidation staining on at least one surface, oxidation product in veins, strong	6.5	9.6	**7.5**
GOOD	*Subtotal*	**92.9**	**90.7**	**92.1**
FAIR	**Meta-gabbro 1** - brittle, pre-existing fractures	0.0	0.9	**0.3**
FAIR	**Meta-gabbro 3** - brittle, moderate strength	1.0	1.2	**1.1**
FAIR	**Meta-gabbro 4** - brittle, moderate strength, medium hard	0.7	1.3	**0.9**
FAIR	**Veined meta-gabbro** - brittle veins, moderate strength'	1.7	1.9	**1.8**
FAIR	**Oxidized meta-gabbro** - weathered, moderate strength, oxidized pre-existing fractures	1.7	1.2	**1.5**
FAIR	**Oxidized and veined meta-gabbro** - moderate strength and brittle veins	2.0	2.8	**2.3**
FAIR	*Subtotal*	**7.1**	**9.3**	**7.9**
	TOTALS	**100.0**	**100.0**	**100.0**

Note: 1. The PN is not related to potential for Alkali-Aggregate Reaction. AAR must be separately assessed.

PETROGRAPHER: [signature]
B. Hudson, B. Sc., GIT

Notice: The test data given herein pertain to the sample provided, and may not be applicable to material from other locations/depths. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

BSI Grum Dump Rock Quarry 2013, CH13-311-SS001-RKa, Laboratory Crushed Composite

General

The sample consisted entirely of crushed material, which was generated by crushing rock chunks in a laboratory crusher. The rock chunks consisted of cobble- and boulder-sized pieces, each of which were labelled as CH13-311-SS001-RKa; identification of each individual chunks was not provided. The rock chunks that were crushed were selected with the goal of capturing the range of rock types observed across entire set of all chunks. The proportions of individual rock type categories presented here may not be representative of the proportions existing at the outcrop from which they were collected.

The material was crushed to pass 19 mm, then split and sieved into its constituent sieve size fractions in preparation for the petrographic examination. The size fractions that were examined consisted of the 19 x 12.5 mm and 12.5 x 9.5 mm portions, material that was finer than 9.5 mm was not examined. The sample was lightly washed to remove surficial crusher dust.

Particle shape was entirely angular with a morphology which was mostly cubic with some flat and/or elongated pieces. Almost all of the particles had rough, fresh fracture surfaces on all sides and sharp edges. Some particles had one surface which was smooth and rounded; these represent the original outer core surface of the rock core.

Lithologic Composition

Identification of rock types and minerals was done using a stereomicroscope with magnifications from 8x to about 50x, supplemented by basic geologic diagnostic methods. Rock type classification was based on visual estimates of mineral proportions in hand sample and in thin section; further refinement of the classification, if needed, could be achieved with whole-rock geochemistry. A cursory review of a thin section was conducted on only one of the rock types in this sample; additional examination on all rock types could be conducted to provide more accurate identification of minerals.

The sample was composed entirely of metamorphosed gabbro with some veined and oxidized varieties. The mineral grain size of the meta-gabbro ranged from nearly aphanitic to 4 mm. The mineral composition was difficult to discern due to the rock being severely metamorphosed; however, plagioclase feldspar, chlorite, epidote and altered mafic minerals made up a significant portion of the sample. Although severely altered and replaced by other minerals, large grains of clinopyroxene, amphibole and olivine were discernible in thin section. Crystalline calcite was localized to veins and generally not observed throughout the rock. Metallic minerals were observed and ranged from fresh to oxidized; they included pyrite, chalcopyrite, ilmenite and rutile. Pyrite and chalcopyrite were observed in hand specimen together with calcite veins, as well as on their own in thin (~1 mm wide) veins and stringlets.

Rock type categories and sub-categories were defined on the basis of grain size, presence/absence of veining, and degree of weathering and oxidation; these are presented in the table above and summarized below.

Almost 19% of the sample consisted of Meta-gabbro 1 which was medium grained and white and dark green. The lighter colour of this category of meta-gabbro compared to subsequent varieties indicates a higher proportion of plagioclase feldspar.

Meta-gabbro 2 was very similar to Meta-gabbro 1; however it was light green as opposed to white and may indicate chlorite and epidote alteration of the feldspar. The sample contained a small portion of Meta-gabbro 2; almost 4% of the total.

Meta-gabbro 3 was the dominant rock type and made up about 29% of the sample; it was medium grained and dark green in colour with a higher proportion of mafic minerals and feldspar.

Approximately 15% of the sample consisted of Meta-gabbro 4 which was also dark green but was fine grained and nearly aphantic in texture.

All categories of meta-gabbro included varieties that were veined; these made up 12% of the sample. The veins were composed of crystalline calcite and ranged in thickness from 1 to 15 mm. Some of the veins were brittle and were often found on the outside surface of particles because the rock would have preferentially fractured along them during crushing, as they constituted planes of weakness.

Some of the meta-gabbro from each category was oxidized, together comprising about 22% of the sample. Orange staining from iron oxidation was prevalent on particle surfaces and in fractures. Many veined particles contained thin fracture surfaces in-filled with oxidation product.

Generally, most particles were dense, hard, and of good strength. Medium grained Meta-gabbro 1, 2 and 3 contained only very small proportions of particles that were brittle or of moderate strength. The fine grained Meta-gabbro 4 had a slightly higher proportion of moderate strength particles and some that were only medium hard; this could be a function of higher chlorite content in this rock type.

Some of the calcite in the veined varieties of meta-gabbro was brittle or soft. As a result, the veined meta-gabbro had a higher proportion of moderate strength particles compared to the varieties that were not veined. Particles that were oxidized also had greater proportions of moderate strength particles compared to fresh particles of the same rock type.

Some particles in all categories had pre-existing fractures that were coated with a black, soft mineral. The composition of the mineral could not be determined but it is recommended that further investigation be undertaken to confirm that it is not a clay mineral that could cause deleterious expansion.

Physical-Mechanical Quality

In addition to the geologic classification of the aggregate, the sample was also examined for characteristics relevant to engineering uses. Aspects such as porosity, strength, tenacity, presence or absence of vugs, voids, fissures, cracks, coatings, particle shape and impurities in the particles were considered in the assignment of individual particles into various quality classifications.

Consistent with the CSA A23.2-15A method, the relative proportions of material classified as being of "Good" and "Fair" physical-mechanical quality were determined, as presented in the table above. In this sample, material that was classified as "Good" represented particles that were dense, hard, and strong and were resistant to fracturing when struck with a geologic hammer. "Fair" particles had a tendency to fracture and split when struck and were typically weathered, oxidized, porous and/or consisted of particles with poor mineral bond strength.

The amount of particles belonging to the "Fair" category was 8%, with the remaining 92% belonging to the "Good" category. Based on these proportions of "Good" and "Fair" quality material, the crushed composite aggregate sample generated in the lab from CH13-311-SS016-RKa rock chunks would be considered to be suitable for use in a variety of applications, subject to compliance with applicable specification requirements and the recommendations given herein.

The sample that was examined consisted of particles that were reduced in size from larger rock chunks. It is possible some features in the larger rock chunks were not captured by this examination; this could include weak fractures that were destroyed during crushing and widely spaced fractures that are not well represented by particles smaller than 19 mm. These features could have potentially deleterious effects on the overall physical-mechanical suitability for some applications such as rip-rap/armourstone and should be assessed separately. Durability testing is underway; such features will be described and discussed in the context of the individual testing procedures, which will be reported under separate cover upon completion.

Alkali-Aggregate Reaction Potential

The Petrographic Examination indicates that the sample was composed of meta-gabbro. Quartz was not identified in abundance; however, as the rock type is metamorphic it is possible that small amounts of very fine grained quartz could be present and could contribute under certain circumstances to a deleterious expansive reaction in concrete termed *"Alkali-Aggregate Reaction"* (AAR). Strained quartz, which is most likely for a metamorphic rock, is associated with a higher likelihood of AAR.

In order to evaluate this potential, the sample should be tested using a suitable method, such as the method given in CSA A23.2-25A, if the material is considered for use as concrete aggregate.

Summary

The CH13-311-SS001-RKa crushed composite sample consisted entirely of laboratory crushed rock material composed of meta-gabbro with weathered, oxidized and veined varieties.

On the basis of the Petrographic Examination, the material is judged to be of suitable quality for use in a variety of applications; however, acceptance of the material for any use should be based upon assessment with relevant specification requirements and review of all applicable durability testing results, including those given in the current version of ASTM and CSA A23.2-1.

Reviewed by:

B. Hudson, B. Sc., GIT

A. Briggs, P. Geo.

PETROGRAPHIC EXAMINATION OF COARSE AGGREGATE

ASTM C 295

CH2M Hill
1100 – 1st Street SE
Calgary, Alberta, T2G 1B1

November 18, 2013
Project Number: 13-1417-0047-3000

ATTENTION: Mr. Mark Cichy

PROJECT: BSI Access Road Granitic Outcrop 2013

Sample:	**CH13-311-SS016_RKa, 9-Jul-2013 –19 x 9.5 mm, Laboratory Crushed Composite**
Source:	**BSI Access Road Granitic Outcrop, Tar #18, Faro Mine Complex, Yukon**

	PETROGRAPHIC DESCRIPTION/ PHYSICAL QUALITY	PERCENT BY COUNT (mm)		
		19 x 12.5	12.5 x 9.5	TOTAL
GOOD	**Granodiorite 1** - medium grained, moderately rough surface texture, dense, hard strong	23.1	15.9	**20.7**
GOOD	**Granodiorite 2** - fine grained, smooth to moderately rough surface texture, dense, hard, strong	11.5	6.2	**9.7**
GOOD	**Granodiorite 3** – cream coloured, low mafic content, medium grained, moderately rough surface texture, dense, hard, strong	14.3	17.3	**15.3**
GOOD	**Oxidized granodiorite 1 and 2** - mostly medium grained, orange oxidation staining/tint, some weathered portions, oxidation product throughout, strong.	25.5	39.9	**30.2**
GOOD	**Oxidized granodiorite 3** – low mafic content, medium grained, orange oxidation staining/tint, some weathered portions, zones with oxidation product, strong.	9.4	5.1	**8.0**
GOOD	**Coated granodiorite** - at least one particle surface thinly coated with silty product and/or concentrated band of biotite, strong.	2.4	1.1	**2.0**
GOOD	*Subtotal*	**86.2**	**85.5**	**85.9**
FAIR	**Granodiorite 1** - moderate strength, brittle, pre-existing discontinuities	2.7	2.6	**2.7**
FAIR	**Granodiorite 3** - moderate strength, brittle	0.9	2.6	**1.4**
FAIR	**Oxidized Granodiorite 1 and 2** - weathered, moderate strength, brittle	3.9	5.4	**4.4**
FAIR	**Oxidized Granodiorite 3** – weathered, moderate strength, brittle	1.2	1.1	**1.2**
FAIR	**Coated Granodiorite** - at least one particle surface with thick band of biotite, particle surfaces coated with silty product, moderate strength	1.8	2.0	**1.9**
FAIR	**Weathered Granodiorite** - weathered, moderate mineral bond strength, oxidized, porous, moderate strength	3.3	0.8	**2.5**
FAIR	*Subtotal*	**13.8**	**14.5**	**14.1**
	TOTALS	**100.0**	**100.0**	**100.0**

Note: 1. The PN is not related to potential for Alkali-Aggregate Reaction. AAR must be separately assessed.

PETROGRAPHER: ____________________
B. Hudson, B. Sc., GIT

Notice: The test data given herein pertain to the sample provided, and may not be applicable to material from other locations/depths. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.

BSI Access Road Granitic Outcrop, CH13-311-SS016-RKa, Laboratory Crushed Composite

General

The sample consisted entirely of crushed material, which was generated by crushing rock chunks in a laboratory crusher. The rock chunks consisted of cobble- and boulder-sized pieces, each of which were labelled as CH13-311-SS016-RKa; identification of each individual chunks was not provided. The rock chunks that were crushed were selected with the goal of capturing the range of rock types observed across entire set of all chunks. The proportions of individual rock type categories presented here may not be representative of the proportions existing at the outcrop from which they were selected.

The material was crushed to pass 19 mm, then split and sieved into its constituent sieve size fractions in preparation for the petrographic examination. The size fractions that were examined consisted of the 19 x 12.5 mm and 12.5 x 9.5 mm portions, material that was finer than 9.5 mm was not examined. The sample was lightly washed to remove surficial crusher dust.

Particle shape was entirely angular with a morphology which was mostly cubic with some flat and/or elongated pieces. Almost all of the particles had rough, fresh fracture surfaces on all sides and sharp edges. Some particles had one surface which was smooth and rounded; these represent the original outer core surface of the rock core.

Lithologic Composition

Identification of rock types and minerals was done using a stereomicroscope with magnifications from 8x to about 50x, supplemented by basic geologic diagnostic methods. Rock type classification was based on visual estimates of mineral proportions in hand sample and one thin section; further refinement of the classification, if needed, could be achieved with whole-rock geochemistry. A cursory review of a thin section was conducted on only one of the rock types in this sample; additional examination on all rock types could be conducted to provide more accurate identification of minerals.

The sample was composed entirely of the crystalline igneous rock granodiorite with some weathered and oxidized varieties. Generally, the mineral grain size ranged from 0.5 to 2 mm and the mineral composition consisted of plagioclase and quartz with lesser amounts of alkali feldspar, biotite, muscovite, sericite and hematite. The granodiorite in this sample was slightly altered; this was indicated by myrmekitic texture in quartz grains and sericite intergrowths in some feldspar grains. Thin discontinuities (~0.01 to 0.06 mm wide) were observed in low abundance and they were often lined with fine to very fine grained muscovite and biotite; it is uncertain whether they are veins that developed into fractures or fractures that developed vein-like mineral deposits. A few grains of hematite were observed. A slight gneissic texture was observed in some particles; however, it was not well-developed in the particles finer than 19 mm and was more readily identifiable in the larger rock chunks.

Rock type categories and sub-categories were defined on the basis of grain size, texture, and degree of weathering and oxidation; these are presented in the table above and summarized below.

Almost one-quarter of the sample consisted of Granodiorite 1 which was fresh, medium grained, and had moderately rough surface texture. Mineral grain boundaries were discernible and ferromagnesian minerals such as biotite were not significantly oxidized. Granodiorite 2, which made up almost 10% of the sample, was fine grained and had a smooth surface texture. The particles of Granodiorite 2 were harder than those belonging to the Granodiorite 1 category, possibly due to a higher proportion of quartz or presence of recrystallized quartz.

Making up almost 17% of the sample was Granodiorite 3, a medium grained variety of granodiorite that was cream-coloured due to very low proportions of biotite. Some particles appeared to be slightly altered; however, a thin section was not available for this rock type, so alteration minerals could not be identified.

Large portions of the granodiorite from each category were significantly oxidized, together comprising about 45% of the sample. Orange staining from iron oxidation was prevalent throughout many particles and oxidation product was often concentrated around ferromagnesian minerals such as biotite. Inclusions of fine grained iron oxide were also observed in some feldspar in thin section. Many of the oxidized granodiorite particles contained one or more surfaces that were weathered.

Granodiorite particles that were significantly weathered were separately classified and made up almost 3% of the sample. "Weathered granodiorite" contained mineral grains that were less translucent and more opaque white; the mineral bond strength was moderate for most particles. Some particle surfaces were smooth and slightly porous. The particles grouped into this category are believed to represent the outside rind of the larger rock chunks that were crushed; they were all of moderate strength.

A few particles of granodiorite were identified that had thick bands of biotite attached to a particle surface. Additionally, some particles were coated in brown silty product, possibly associated with a fracture zone or originating from the outside rind of the rock chunk. These particles were separately classified as "Coated Granodiorite" and accounted for almost 4% of the sample. Nearly half of the particles in this category were of moderate strength.

Generally, most particles were dense, hard, and of good strength. Fine grained Granodiorite 2 was hard and strong, while medium grained Granodiorite 1 included some brittle and moderate strength particles. Particles composed of Granodiorite 2 and 3 that were oxidized had greater proportions of moderate strength particles compared to fresh particles of the same rock type. The "coated" particles with thick bands of biotite were of moderate strength due to fissile bands of mica. Some particles that were entirely coated in silty material were weathered and of moderate strength.

Physical-Mechanical Quality

In addition to the geologic classification of the aggregate, the sample was also examined for characteristics relevant to engineering uses. Aspects such as porosity, strength, tenacity, presence or absence of vugs, voids, fissures, cracks, coatings, particle shape and impurities in the particles were considered in the assignment of individual particles into various quality classifications.

Consistent with the CSA A23.2-15A method, the relative proportions of material classified as being of "Good" and "Fair" physical-mechanical quality were determined, as presented in the table above. In this sample, material that was classified as "Good" represented particles that were dense, hard, and strong and were resistant to fracturing when struck with a geologic hammer. "Fair" particles had a tendency to fracture and split when struck and were typically weathered, oxidized, porous and/or consisted of particles with poor mineral bond strength.

The amount of particles belonging to the "Fair" category was 15%, with the remaining 85% belonging to the "Good" category. Based on these proportions of "Good" and "Fair" quality material, the crushed composite aggregate sample generated in the lab from CH13-311-SS016-RKa rock chunks would be considered to be unsuitable for use in some applications, including some concrete exposure classes, railroad ballast and rock for erosion control.

The sample that was examined consisted of particles that were reduced in size from larger rock chunks. It is possible some features in the larger rock chunks were not captured by this examination; this could include weak fractures that were destroyed during crushing and widely spaced fractures that are not well represented by particles smaller than 19 mm. These features could have potentially deleterious effects on the overall physical-mechanical suitability for some applications such as rip-rap/armourstone and should be assessed separately. Durability testing is underway; such features will be described and discussed in the context of the individual testing procedures, which will be reported under separate cover upon completion.

Alkali-Aggregate Reaction Potential

The Petrographic Examination indicates that the sample was composed of granodiorite, a rock type that contains some quartz, which may contribute under certain circumstances to a deleterious expansive reaction in concrete termed *"Alkali-Aggregate Reaction"* (AAR). Strained quartz, which was observed in the thin section, is associated with a higher likelihood of AAR.

In order to evaluate this potential, the sample should be tested using a suitable method, such as the method given in CSA A23.2-25A, if the material is considered for use as concrete aggregate.

Summary

The CH13-311-SS016-RKa crushed composite sample consisted entirely of laboratory crushed rock material composed of granodiorite with weathered and oxidized varieties.

On the basis of the Petrographic Examination, the material is judged to be unsuitable for many aggregate uses, including some concrete, railroad ballast and erosion control applications. It could be considered suitable for use as general fill, provided that some attrition of the material could be tolerated, and if it complies with applicable specification requirements..

Reviewed by:

B. Hudson, B. Sc., GIT

A. Briggs, P. Geo.

PETROGRAPHIC EXAMINATION OF COARSE AGGREGATE

ASTM C 295

CH2M Hill
1100 – 1st Street SE
Calgary, Alberta, T2G 1B1

November 18, 2013
Project Number: 13-1417-0047-3000

ATTENTION: Mr. Mark Cichy

PROJECT: BSI Access Road Granitic Outcrop 2013

Sample:	**CH13-311-SS017_RKa, 9-Jul-2013 –19 x 9.5 mm, Laboratory Crushed Composite**
Source:	**BSI Access Road Granitic Outcrop, Tar #18, Faro Mine Complex, Yukon**

	PETROGRAPHIC DESCRIPTION/ PHYSICAL QUALITY	**PERCENT BY COUNT (mm)**		
		19 x 12.5	**12.5 x 9.5**	**TOTAL**
GOOD	**Granite** - medium to coarse grained, cream with yellow speckles, dense, hard, strong	6.0	9.1	**7.0**
	Granodiorite 1 - slightly gneissic, white with black speckles, fine to medium grained, dense, hard, strong	25.0	18.7	**22.9**
	Granodiorite 2 - moderately gneissic, white, with black speckles, some thin (<1 mm) bands of biotite, fine to medium grained, dense, hard, strong	15.4	18.1	**16.3**
	Granodiorite 3 – cream coloured, medium grained, dense, hard, strong	5.7	1.7	**4.4**
	Oxidized Granodiorite 1 and 2 - orange oxidation staining/tint, some weathered portions, oxidation product throughout, strong	22.6	18.1	**21.1**
	Oxidized Granodiorite 3 – creamed coloured, medium grained, orange oxidation staining/tint, some weathered portions, zones with oxidation product, strong	13.0	16.1	**14.0**
	Subtotal	**87.7**	**81.8**	**85.7**
FAIR	**Granite** - moderate strength	2.1	1.4	**1.9**
	Granodiorite 1 - moderate strength, brittle	2.4	4.0	**2.9**
	Granodiorite 2 - moderate strength, brittle, fissile	1.2	2.3	**1.6**
	Oxidized Granodiorite 1 and 2 - weathered, moderate strength, brittle	3.9	5.4	**4.4**
	Oxidized Granodiorite 3 - weathered, moderate strength	2.7	5.1	**3.5**
	Subtotal	**12.3**	**18.2**	**14.3**
TOTALS		**100.0**	**100.0**	**100.0**

Note: 1. The PN is not related to potential for Alkali-Aggregate Reaction. AAR must be separately assessed.

PETROGRAPHER: B. Hudson, B. Sc., GIT

BSI Access Road Granitic Outcrop, CH13-311-SS017-RKa, Laboratory Crushed Composite

General

The sample consisted entirely of crushed material, which was generated by crushing rock chunks in a laboratory crusher. The rock chunks consisted of cobble- and boulder-sized pieces, each of which were labelled as CH13-311-SS017-RKa; identification of each individual chunk was not provided. The rock chunks that were crushed were selected with the goal of capturing the range of rocks types observed across entire set of all chunks. The proportions of individual rock type categories presented here may not be representative of the proportions existing at the outcrop from which they were selected.

The material was crushed to pass 19 mm, then split and sieved into its constituent sieve size fractions in preparation for the petrographic examination. The size fractions that were examined consisted of the 19 x 12.5 mm and 12.5 x 9.5 mm portions, material that was finer than 9.5 mm was not examined. The sample was lightly washed to remove surficial crusher dust.

Particle shape was entirely angular with a morphology which was mostly cubic with some flat and/or elongated pieces. Almost all of the particles had rough, fresh fracture surfaces on all sides and sharp edges. Some particles had one surface which was smooth and rounded; these represent the original outer core surface of the rock core.

Lithologic Composition

Identification of rock types and minerals was done using a stereomicroscope with magnifications from 8x to about 50x, supplemented by basic geologic diagnostic methods. Rock type classification was based on visual estimates of mineral proportions in hand sample and in one thin section; further refinement of the classification, if needed, could be achieved with whole-rock-geochemistry. A cursory review of a thin section was conducted on only one of the rock types in this sample; additional examination on all rock types could be conducted to provide more accurate identification of minerals.

The sample was dominantly composed of slight to moderately gneissic varieties of the crystalline igneous rock granodiorite. It ranged from fine to medium grained and comprised varieties that were fresh as well as a significant portion that was weathered and oxidized. Generally, the mineral grain size ranged from 0.2 to 2 mm and the mineral composition consisted of plagioclase and quartz with lesser amounts of alkali feldspar, biotite, muscovite and sericite. Metal oxide minerals were rarely observed and ranged from fresh to oxidized; they consisted of cubic grains of pyrite and chalcopyrite, as well as ilmenite, hematite and possibly some rutile.

The granodiorite in this sample was altered and had a gneissic texture which ranged from being well defined with concentrated bands of biotite and muscovite, to only slightly recognizable with some parallel orientation of biotite grains. Alteration was also evident by partially recrystallized quartz, myrmekitic texture in feldspar grains, and sericite in some feldspar grains. Thin discontinuities (~0.01 to 0.06 mm) were observed in moderate abundance and they were often lined with fine to very fine grained muscovite and biotite; it is uncertain whether they are veins that developed into fractures or fractures that developed vein-like mineral deposits.

Rock type categories and sub-categories were defined on the basis of composition, the degree to which gneissic texture was developed and the degree of weathering and oxidation; these categories are presented in the table above and summarized below.

Approximately one-quarter of the sample consisted of Granodiorite 1 which was fresh, fine to medium grained and exhibited slightly gneissic texture. Flat/elongated mineral grains, such as the phyllosilicate mica minerals biotite and muscovite, had parallel alignment but were not concentrated in bands.

Particles belonging to the Granodiorite 2 group were moderately gneissic and mica minerals were often concentrated in thin bands (~1 mm) and stringlets. Granodiorite 2 made up almost 18% of the sample.

Making up about 4% of the sample was Granodiorite 3, a lighter coloured variety of granodiorite that did not have an obvious gneissic texture. Particles of Granodiorite 3 consisted of very low proportions of biotite and were cream in colour.

Large portions of the granodiorite from each category were significantly oxidized, together comprising about 43%. Orange staining from iron oxidation was prevalent throughout many particles and oxidation product was often concentrated around ferromagnesian minerals such as biotite. Inclusions of fine grained iron oxide were also observed in some feldspar in thin section.

A small portion of the sample consisted of medium to coarse grained granite that did not have a readily identifiable gneissic texture. This rock type was readily distinguished from the others in that it was lightly coloured with yellow speckling and had a larger mineral grain size compared to the granodiorites.

Generally, most particles were dense, hard, and of good strength. Particles composed of Granodiorite 1, 2 and 3 that were oxidized had greater proportions of moderate strength particles compared to fresh particles of the same rock type. The degree to which gneissic texture had developed did not appear to have an effect on the overall proportion of strong and moderate strength material, i.e., comparing Granodiorite 1 and 2. All of the Granodiorite 3 particles were strong, possibly due to the lack of concentrated bands of biotite that were susceptible to oxidizing, becoming weak, and propagating fractures. Some of the medium to coarse grained granite was of moderate strength; the mineral bond strength of this rock type ranged from good to moderate, possible due to weathering.

Physical-Mechanical Quality

In addition to the geologic classification of the aggregate, the sample was also examined for characteristics relevant to engineering uses. Aspects such as porosity, strength, tenacity, presence or absence of vugs, voids, fissures, cracks, coatings, particle shape and impurities in the particles were considered in the assignment of individual particles into various quality classifications.

Consistent with the CSA A23.2-15A method, the relative proportions of material classified as being of "Good" and "Fair" physical-mechanical quality were determined, as presented in the table above. In this sample, material that was classified as "Good" represented particles that were dense, hard, and strong and were resistant to fracturing when struck with a geologic hammer. "Fair" particles had a tendency to fracture and split when struck and were typically weathered, oxidized, porous and/or consisted of particles with poor mineral bond strength.

The amount of particles belonging to the "Fair" category was 14%, with the remaining 86% belonging to the "Good" category. Based on these proportions of Good and Fair quality material, the crushed composite aggregate sample generated in the lab from CH13-311-SS017-RKa rock chunks would be considered to be unsuitable for use in some applications, including some concrete exposure classes, railroad ballast and rock for erosion control.

The sample that was examined consisted of particles that were reduced in size from larger rock chunks. It is possible some features in the larger rock chunks were not captured by this examination; this could include weak fractures that were destroyed during crushing and widely spaced fractures that are not well represented by particles smaller than 19 mm. These features could have potentially deleterious effects on the overall physical-mechanical suitability for some applications such as rip-rap/armourstone and should be assessed separately. Durability testing is underway; such features will be described and discussed in the context of the individual testing procedures, which will be reported under separate cover upon completion.

Alkali-Aggregate Reaction Potential

The Petrographic Examination indicates that the sample was composed of granodiorite and granite, a rock type that contains some quartz, which may contribute under certain circumstances to a deleterious expansive reaction in concrete termed *"Alkali-Aggregate Reaction"* (AAR). Strained quartz, which was observed in the thin section, is associated with a higher likelihood of AAR.

In order to evaluate this potential, the sample should be tested using a suitable method, such as the method given in CSA A23.2-25A, if the material is considered for use as concrete aggregate.

Summary

The CH13-311-SS017-RKa crushed composite sample consisted entirely of laboratory crushed rock material composed of gneissic granodiorite with weathered and oxidized varieties and a small amount of granite.

On the basis of the Petrographic Examination, the material is judged to be unsuitable for many aggregate uses, including some concrete, railroad ballast and erosion control applications. It could be considered suitable for use as general fill, provided that some attrition of the material could be tolerated, and if it complies with applicable specification requirements...

Some potentially acid-generating minerals were identified in the sample; furthermore, potentially neutralizing minerals were not observed. Additional testing for potential for acid rock drainage is recommended.

Reviewed by:

B. Hudson, B. Sc., GIT

A. Briggs, P. Geo.

PETROGRAPHIC EXAMINATION OF COARSE AGGREGATE
ASTM C 295

CH2M Hill
1100 – 1st Street SE
Calgary, Alberta, T2G 1B1

November 15, 2013
Project Number: 13-1417-0047.3000

Attention: Mr. Mark Cichy

PROJECT: **BSI GRUM DUMP ROCK QUARRY 2013**

Sample:	**CH13-311-SS026_Rka**

Date sampled: September 2013 **Sampled by:** Client

	PETROGRAPHIC DESCRIPTION/ PHYSICAL QUALITY	**PERCENT BY SIEVE FRACTION (mm)**		
		12.5 mm	**9.5 mm**	**TOTAL**
GOOD	**Tonalite 1A –** Speckled black and white, strong, fresh.	28.3	35.0	**31.7**
	Tonalite 1B – As above, with yellow tint and occasional brown surfaces. Strong.	25.5	23.9	**24.7**
	Tonalite 2A – Altered, pinkish brown. . Strong.	14.4	14.8	**14.6**
	Tonalite 2B – altered pinkish brown, one particle surface stained brown. Strong.	3.4	0.4	**1.9**
	Subtotal	***71.6***	***74.1***	***72.9***
FAIR	**Tonalite 1A –** moderate strength	5.8	6.6	**6.2**
	Tonalite 1B – moderate strength	7.7	5.4	**6.5**
	Tonalite 2A – moderate strength	9.1	11.5	**10.3**
	Tonalite 2B - moderate strength	3.4	1.2	**2.3**
	Subtotal	***26.0***	***24.7***	***25.3***
POOR	**Tonalite 2A -** weak	2.4	0.8	**1.6**
	Tonalite 2B - weak	0.0	0.4	**0.2**
	Subtotal	***2.4***	***1.2***	***1.8***
TOTALS		**100.0**	**100.0**	**100.0**

PETROGRAPHER: ______________________
A. Briggs, M.Sc., P. Geo.

Sample CH13-311-SS026_Rka

General

The sample consisted entirely of crushed material, which was generated by crushing cobble-sized rock particles in a laboratory crusher. It was split and sieved into its constituent sieve size fractions in preparation for the petrographic examination.

Particle shape was angular with a morphology which was mostly cubic with some flat and/or elongated pieces. All of the particles had rough, fresh fracture surfaces on all sides and sharp edges.

Lithologic Composition

Identification of rock types and minerals was done using a stereomicroscope with magnifications from 8x to about 50x, supplemented by basic geologic diagnostic methods. One thin section was examined to aid in the identification of constituent minerals. Chemical analysis was not carried out.

The sample was composed entirely of tonalite. It had a grain size of 1 – 3 mm and was composed of quartz, plagioclase, amphibole, biotite and chlorite. Sericite alteration of the plagioclase was moderate to severe; in some feldspars, it had affected only the centre of the crystal.

The fresh rock was speckled black and white, but some particles that are thought to have originated from near or at the surface of the crushed larger chunks had a yellow tint and sometimes one particle face exhibited a yellow and brown crust. Another variety of the rock was pinkish brown in colour throughout. Some of these particles had one face that was brown and likely constituted a portion of the original cobble surface. The particles were classified into four subgroups to represent these different forms of the rock material.

The speckled black and white Tonalite 1A accounted for almost 38% of the sample; most of these particles were strong and fresh.

Tonalite 1B, which was a weathered variety of tonalite 1A, made up about 31% of the sample. Although most of these rock particles were strong, about 1/5 were of only medium strength.

About one quarter of the sample consisted of the pinkish brown Tonalite 2A. A significant portion of this rock type comprised particles that were of medium or low strength.

Particles composed of pinkish brown tonalite with a brown weathering rim were classified as tonalite 2B. These accounted for about 4% of the sample; more than half of these were weak or of medium strength.

Physical-Mechanical Quality

In addition to the geologic classification of the aggregate, the sample was also examined for characteristics relevant to engineering uses. Aspects such as porosity, strength, tenacity, presence or absence of vugs, voids, fissures, cracks, coatings, particle shape and impurities in the particles were considered in the assignment of individual particles into various quality classifications.

Consistent with the CSA A23.2-15A method, the relative proportions of material classified as being of "Good", "Fair" and "Poor" physical-mechanical quality were determined, as presented in the table above.

Based on the Petrographic examination of the sample CH13-311-SS026_Rka the material would be considered unsuitable for use in most aggregate applications, including some concrete, railroad ballast and rock for erosion control.

Alkali-Aggregate Reaction Potential

The Petrographic Examination indicates that the sample was composed of tonalite, a rock type that contains some quartz, which may contribute under certain circumstances to a deleterious expansive reaction in concrete termed *"Alkali-Aggregate Reaction"* (AAR).

Very fine grained and strained quartz has been found to be particularly susceptible to AAR. The thin section examination detected no to minimal strain in the quartz, which was medium grained. Therefore, the likelihood of AAR resulting from use of the material as concrete aggregate is low.

Summary

The crushed sample CH13-311-SS026_Rka was composed of tonalite and contained 72.9% "Good" quality material, 25.3% "Fair" and 1.8% "Poor" quality material.

On the basis of the Petrographic Examination, Sample CH13-311-SS026_Rka would be considered unsuitable for some aggregate uses, such as concrete, asphalt, and rip rap/armourstone. It could be considered suitable for use as general fill, provided that some attrition of the material could be tolerated, and if it complies with applicable specification requirements.

A. Briggs, M.Sc., P. Geo.

Reviewed by:

FOR: F. Shrimer, P.Geo.

Appendix F
Data Quality Evaluation Report

APPENDIX F

Borrow Source Investigation Access Road Granitic Outcrop, Borrow Source Investigation Grum Dump Rock Quarry, and Construct New VCD 2013 Soil Sampling Data Quality Evaluation

Soil samples were collected and analyzed during the 2013 Borrow Source Investigation (BSI) Access Road Granitic Outcrop, BSI Grum Dump Rock Quarry, and Construct New VCD sampling events in support of the Faro Mine Remediation Project. All analytical data were evaluated as described in the *Quality Assurance Project Plan, Faro Mine Remediation Project* (QAPP) (CH2M HILL, 2013). This Data Quality Evaluation report summarizes the results of the quality assurance and quality control (QA/QC) activities prescribed in the QAPP and provides a complete data usability assessment. The QAPP identifies the method-specific QC requirements for each analytical parameter and matrix and defines a plan to test that the correct sampling, analytical, and data reduction procedures are followed using audits and data validation.

This report is intended as a general data quality assessment designed to summarize data issues.

Analytical Data

Eleven rock, 2 rock field duplicates (FD), 29 native environmental soil samples, and 1 soil FD were collected from July 10 through August 9, 2013. Samples were analyzed by the ALS Laboratory Group (ALS) network of laboratories, with the majority of analyses performed by ALS Vancouver in Burnaby, British Columbia. The laboratory divided the samples into five sample delivery groups (SDG). Summaries of the samples collected are presented in Tables 1 and 2. Sixteen methods were used to analyze the environmental samples. Samples were collected and couriered to the ALS Whitehorse laboratory. Samples were then shipped by overnight carrier to the ALS Vancouver laboratory for analysis. Selected samples were analyzed for one or more of the following analytes/methods:

- Moisture by Method ASTM International (ASTM) 2216
- Percent sand fraction by Method ASTM D422-63
- Moisture at liquid limit and plasticity index by Method ASTM D4318
- Organic matter and Organic matter_LOI by Method CSSS 1978_P160
- Paste pH and pH by Method CSSS/APHA 4500H
- Mercury by Method E245.7
- Mercury in synthetic precipitation leaching procedure (SPLP) extract at pHs 3, 4, and 5 by Methods E245.7_SPLP3, E245.7_SPLP4, and E245.7_SPLP5
- Sulphur by Method ISO 15178:2000
- Neutralization potential by Method MOD-SOBEK-3.2.3
- Inorganic carbon and total inorganic carbon by Method SSSA P 455-456
- Metals by Method SW6010B
- Metals in SPLP extract at pHs 3, 4, and 5 by Methods SW6010B_SPLP3, SW6010B_SPLP4, and SW6010B_SPLP5

Each SDG was evaluated by CH2M HILL chemists for data quality. Analytical performance was initially assessed on an SDG basis or an analytical batch basis. Several SDGs may be associated with the same laboratory QC samples.

The association of laboratory QC samples and environmental samples from the same analytical batches is determined by the laboratory lot control number. Data were assessed using Level II validation as follows:

- Review of the data set narrative to identify issues that the laboratory reported in the data deliverable
- Check of sample integrity (sample collection, preservation, and holding times)
- Evaluation of basic QC measurements used to assess the accuracy, precision, and representativeness of data, including QC blanks, laboratory control sample, matrix spike, surrogate recovery when applicable, and FD or laboratory duplicate results
- Review of sample results, target compound lists, and detection limits to verify that project analytical requirements are met
- Initiation of corrective actions, as necessary, based on the data review findings
- Verification that hardcopy results match electronic deliverable results
- Qualification of the data using appropriate qualifier flags, as necessary, to reflect data usability limitations

Field samples were also reviewed to ascertain field compliance and data quality issues. This included a review of FDs. Adequate FDs were collected, as FDs are not required for the soil moisture determinations.

Data flags were assigned according to the QC acceptance limits defined in the QAPP (CH2M HILL, 2013a). The data validation flags for each SDG are summarized in each data quality validation report. These flags, and the reason for each flag, are recorded in the electronic validation database. Multiple flags can routinely be applied to a specific sample method/matrix/analyte combination, but there will be only one final flag. As discussed in this report, a final flag is applied to the data on the basis of the flags entered into the database and is the most conservative of the applied validation flags. The final flag also includes matrix and blank sample impacts.

Data flags can be separated into the following two categories to be used in estimating both contractor and analytical completeness:

- Flags caused by laboratory deviation from requirements in the QAPP
- Flags applied because of the nature of the sample matrix or method limitations

The database keeps track of the type of protocol violation, and contractual and analytical completeness during data validation.

The data flags are those listed in the QAPP and are defined as follows:

J — Analyte was present but the reported value may not be accurate or precise.

UJ — Analyte was not detected above the detection limit objective. However, the reported detection limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

R — Result has been rejected for use.

U — Analyte was analyzed for but not detected at the specified detection limit.

None — A database flag with no QC implications. A flag is not applied. This is a placeholder for calculating QC criteria issues that do not require flagging.

Exclude — A database flag with no QC implications. When multiple data points have been reported, such as dilutions or re-extractions, the data that best match QAPP requirements are presented to the data users and the remainders are marked with this flag.

= — A database flag with no QC implications. A place holder for data quality evaluation reporting purposes noting that the reported result is a detected concentration greater than the reporting limit.

Findings

The overall summaries of the data validation findings are contained in Tables 3 through 7 and summarized in the following method sections:

- **Table 3**: Overall Flagging Summary. Presents the number of occurrences for each data validation reason by method.
- **Table 4:** Holding Time Exceedances – Qualified Data. Presents the data qualified because of holding time criteria exceedances.
- **Table 5:** Blank Contamination – Qualified Data. Presents the data qualified because of blank contamination criteria exceedances.
- **Table 6:** Field Duplicate Precision – Qualified Data. Presents the results that are qualified because of FD precision exceedances.
- **Table 7**: Site Completeness by Analyte – Qualified Data. Presents the percent completeness by method, analyte and matrix.

Overall Flagging Summary

The frequency of field and laboratory QC samples and the associated control criteria are specified in the QAPP (CH2M HILL, 2013). These control criteria were used to evaluate the laboratory data. In the following method-specific discussions, only the criteria exceedances that impact data qualification are provided.

General Comments

Laboratory Qualifiers

The laboratory applied informational qualifiers to multiple results, to note analytical issues such as dilutions, blank contamination, matrix effects, limited sample volume, holding time, and reanalyses. These qualifiers were reviewed and where the informational qualifiers did not result in validation flags noting a QC exceedances, these qualifiers were replaced with concentration flags “U” or “=”. All instances of these laboratory qualifier replacements are recorded in Table 3 and are not further discussed.

Holding Time

Holding times were also exceeded for several samples. The laboratory completed a detailed analysis and corrective action report (see Attachment 1) to address these exceedances. Qualified data are detailed in the following sections.

Method ASTM 2216 (Moisture)

Holding Time

Table 4 lists the specific field samples and their associated holding time criteria exceedances. The 14-day holding time for soil samples was exceeded by 1 to 46 days for 6 samples. The associated results were flagged “J” or “UJ.”

Method CSSS/APHA 4500H (Paste pH, pH (1:2 soil:water))

Holding Time

Table 4 lists the specific field samples and their associated holding time criteria exceedances. The 28-day holding time for soil samples was exceeded by 1 to 80 days for 9 samples. The associated results were flagged “J.”

Method E245.7 (Mercury)

Holding Time

Table 4 lists the specific field samples and their associated holding time criteria exceedances. The 28-day holding time for soil samples was exceeded by 1 day for 2 samples. The associated results were flagged “UJ.”

Method SW6010B (Metals)

Blanks

Table 5 lists the specific field samples and their associated laboratory blank (LB) exceedances. Five soil sample detected concentrations were less than five times the LB concentration. The associated concentrations were flagged “U.”

Field Duplicates

Table 6 lists the specific field samples and their associated FD precision criteria exceedances. Two FD pairs had criteria exceedances. The associated detected concentrations were flagged “J.”

Method SW6010B_SPLP3 (Metals, Synthetic Precipitation Leach Procedure pH 3)

Blanks

Table 5 lists the specific field samples and their associated LB exceedances. Two soil extract samples detected concentrations were less than five times the LB concentration. The associated concentrations were flagged “U.”

Field Duplicates

Table 6 lists the specific field samples and their associated FD precision criteria exceedances. Two FD pairs had criteria exceedances. The associated detected concentrations were flagged “J.”

Method SW6010B_SPLP4 Metals, (Synthetic Precipitation Leach Procedure pH 4)

Blanks

Table 5 lists the specific field samples and their associated LB exceedances. Five soil extract samples detected concentrations were less than five times the LB concentration. The associated concentrations were flagged “U.”

Field Duplicates

Table 6 lists the specific field samples and their associated FD precision criteria exceedances. Two FD pairs had criteria exceedances. The associated detected concentrations were flagged “J.”

Method SW6010B_SPLP5 Metals, (Synthetic Precipitation Leach Procedure pH 5)

Blanks

Table 5 lists the specific field samples and their associated LB exceedances. Five soil extract sample detected concentrations were less than five times the LB concentration. The associated concentrations were flagged “U.”

Field Duplicates

Table 6 lists the specific field samples and their associated FD precision criteria exceedances. Two FD pairs had criteria exceedances. The associated detected concentrations were flagged “J.”

Overall Assessment

Completeness is calculated and reported for each method, matrix, and analyte combination as outlined in the QAPP (CH2M HILL, 2013a). The number of valid (not qualified with an “R” flag) results divided by the number of possible individual analyte results, expressed as a percentage, determines the completeness of the data set. A summary of the completeness percentages can be found in Table 7.

The QAPP completeness goal is 90 percent and the overall data completeness is 100 percent.

Out of 1,053 normal and FD data points, 51 detected results and 6 non-detected results (approximately 5.4 percent) were qualified as estimated concentrations because of QC exceedances and 17 detected results were qualified as non-detects because of LB contamination.

Evaluation of 100 percent of the chemical data was performed by using the QAPP as a guide for data quality evaluation.

Data Management

Faro Mine Remediation sampling activity logs and laboratory analytical data are maintained in a project database and/or in project files, where appropriate. Data were collected and stored in a manner consistent with the requirements of the QAPP (CH2M HILL, 2013a).

All raw data will be maintained on file in the laboratory, and will be available upon request. Complete documentation of sample preparation and analysis and associated QC information will be maintained in a manner that allows easy retrieval in the event that additional information is required. The following minimum documentation should be kept for each project:

- Original work order, chain-of-custody (COC) forms, and other pertinent documents received with the samples
- Records of communication between the laboratory, field personnel, and the client
- Corrective action reports
- Laboratory data reports
- Laboratory logbooks and all raw sample preparation and analytical data
- Electronic data and all pertinent standard operating procedures

Field records to be retained as a minimum will include correspondence, COC forms, field notes, field equipment performance records, maintenance logs, field procedures, corrective action reports, field personnel files, and project-related reports.

The receipt of electronic and pdf laboratory data was logged into the sample tracking program to determine completeness and contractor turnaround time compliance.

The laboratory uploaded electronic data to the Faro Mine Environmental Quality Information System (EQuIS) site. CH2M HILL chemists downloaded this data into the validation program. All data quality evaluation was done using a semi-automated data validation program that uses laboratory pdf report and electronic data simultaneously. All validation flags and discoveries were entered into the validation database and linked directly to each individual data point.

All data quality evaluation reports were generated from the validation database. Final validation flags were uploaded to the Faro Mine EQuIS site.

The data management system was designed to maintain the usability and integrity of the data through a series of procedures and QC checks that began at the field site and carried through to the generation of data for the user. These data included both the chemical data and field operation information. Both the chemical data and the field data were handled according to the guidelines established in the QAPP (CH2M HILL, 2013) and in the *Faro Mine Complex Data Management Plan* (CH2M HILL, 2013b).

The laboratory pdf reports are stored in the project files and project local area network hard drive areas in the CH2M HILL office in Redding, California and the Faro Mine SharePoint site. The original field data forms are stored on the Faro Mine Sharepoint site. Laboratories are required to archive the analytical data as outlined in the QAPP (CH2M HILL, 2013a).

Works Cited

CH2M HILL Canada Limited (CH2M HILL). 2013a. *Quality Assurance Project Plan, Faro Mine Remediation Project.* Draft. Prepared for Government of Canada as represented by Aboriginal Affairs and Northern Development Canada and the Government of Yukon. July 3.

CH2M HILL Canada Limited (CH2M HILL). 2013b. *Faro Mine Complex Data Management Plan.* Final. Prepared for Government of Canada as represented by Aboriginal Affairs and Northern Development Canada and the Government of Yukon. August 12.

Tables

TABLE 1

Sample Summary by COC - Data Summary

CoC Number	Sample Date	Matrix	Sample ID / QAQC Type	SDG	Laboratory
ALS07231301					
	10-Jul-13	SOIL	CH13-311-SS001_RKa / N	L1338738	ALS
			CH13-311-SS019_RKa / N	L1338738	ALS
	12-Jul-13		CH13-311-SS021_RKa / N	L1338738	ALS
			CH13-311-SS022_RKa / N	L1338738	ALS
	15-Jul-13		CH13-311-SS026_RKa / N	L1338738	ALS
ALS07231301R					
	10-Jul-13	SOIL	CH13-311-SS001_RKa / N	L1338738	ALS
			CH13-311-SS019_RKa / N	L1338738	ALS
	12-Jul-13		CH13-311-SS021_RKa / N	L1338738	ALS
			CH13-311-SS022_RKa / N	L1338738	ALS
	15-Jul-13		CH13-311-SS026_RKa / N	L1338738	ALS
ALS08041301					
	31-Jul-13	SOIL	CH13-303-BH001_SOa / N	L1342690	ALS
			CH13-303-BH001_SOb / N	L1342690	ALS
			CH13-303-BH001_SOc / N	L1342690	ALS
			CH13-303-BH001_SOd / N	L1342690	ALS
			CH13-303-BH001_SOe / N	L1342690	ALS
ALS08071301					
	02-Aug-13	SOIL	CH13-303-BH002_SOa / N	L1345512	ALS
			CH13-303-BH002_SOb / N	L1345512	ALS
			CH13-303-BH002_SOc / N	L1345512	ALS
			CH13-303-BH002_SOd / N	L1345512	ALS
	03-Aug-13		CH13-303-BH002_SOe / N	L1345512	ALS
			CH13-303-BH002_Sof / N	L1345512	ALS
			CH13-303-BH002_SOg / N	L1345512	ALS
			CH13-303-BH002_SOh / N	L1345512	ALS
			Ch13-303-BH002_SOi / N	L1345512	ALS
			CH13-303-BH002_SOj / N	L1345512	ALS
ALS08111301					
	05-Aug-13	SOIL	CH13-303-BH003_SOa / N	L1347043	ALS
			CH13-303-BH003_SOb / N	L1347043	ALS
			CH13-303-BH003_SOc / N	L1347043	ALS

TABLE 1

Sample Summary by COC - Data Summary

CoC Number	Sample Date	Matrix	Sample ID / QAQC Type	SDG	Laboratory
ALS08111301					
	05-Aug-13	SOIL	CH13-303-BH003_SOd / N	L1347043	ALS
			CH13-303-BH003_SOe / N	L1347043	ALS
			CH13-303-BH003_SOf / N	L1347043	ALS
			CH13-303-BH003_SOg / N	L1347043	ALS
			CH13-303-BH003_SOh / N	L1347043	ALS
			CH13-303-BH003_SOi / N	L1347043	ALS
			CH13-303-BH003_SOj / N	L1347043	ALS
	06-Aug-13		CH13-303-BH003_SOk / N	L1347043	ALS
			CH13-303-BH003_SOl / N	L1347043	ALS
			CH13-303-BH003_SOm / N	L1347043	ALS
			CH13-303-BH003_SOn / N	L1347043	ALS
	05-Aug-13		CH13-303-BH903_SOg / FD	L1347043	ALS
ALS08111303					
	09-Aug-13	SOIL	CH13-311-BH016_RKa / N	L1346114	ALS
			CH13-311-BH016_RKb / N	L1346114	ALS
			CH13-311-BH016_RKBMS / MS	L1346114	ALS
			CH13-311-BH016_RKc / N	L1346114	ALS
	07-Aug-13		CH13-311-BH017_RKa / N	L1346114	ALS
			CH13-311-BH017_RKAMS / MS	L1346114	ALS
	08-Aug-13		CH13-311-BH017_RKb / N	L1346114	ALS
			CH13-311-BH017_RKc / N	L1346114	ALS
	09-Aug-13		CH13-311-BH916_RKb / FD	L1346114	ALS
	08-Aug-13		CH13-311-BH917_RKc / FD	L1346114	ALS
ALS08111303R					
	09-Aug-13	SOIL	CH13-311-BH016_RKa / N	L1346114	ALS
			CH13-311-BH016_RKb / N	L1346114	ALS
			CH13-311-BH016_RKc / N	L1346114	ALS
	07-Aug-13		CH13-311-BH017_RKa / N	L1346114	ALS
	08-Aug-13		CH13-311-BH017_RKb / N	L1346114	ALS
			CH13-311-BH017_RKc / N	L1346114	ALS
	09-Aug-13		CH13-311-BH916_RKb / FD	L1346114	ALS
	08-Aug-13		CH13-311-BH917_RKc / FD	L1346114	ALS

TABLE 1

Sample Summary by COC - Data Summary

CoC Number	Sample Date	Matrix	Sample ID / QAQC Type	SDG	Laboratory

QAQC Type

N = normal environmental sample
FD = field duplicate
MS = matrix spike
SD = spike duplicate
TB = trip blank
EB = equipment blank
AB = ambient blank
FB = field blank

TABLE 2

Sample Chronology - Data Summary

Laboratory	SDG	Sample ID	Method	Sample Date	Receive Date	Extract Date	Analysis Date
ALS	L1338738	CH13-311-SS001_RKa	CSSS/APHA 4500H	7/10/2013	7/25/2013		8/8/2013
		CH13-311-SS001_RKa	CSSS/APHA 4500H	7/10/2013	7/25/2013		8/15/2013
		CH13-311-SS001_RKa	E245.7	7/10/2013	7/25/2013	8/7/2013	8/8/2013
		CH13-311-SS001_RKa	ISO 15178:2000	7/10/2013	7/25/2013	7/29/2013	7/29/2013
		CH13-311-SS001_RKa	MOD-SOBEK-3.2.3	7/10/2013	7/25/2013		8/28/2013
		CH13-311-SS001_RKa	SSSA P 455-456	7/10/2013	7/25/2013		7/30/2013
		CH13-311-SS001_RKa	SSSA P 455-456	7/10/2013	7/25/2013	7/30/2013	7/30/2013
		CH13-311-SS001_RKa	SW6010B	7/10/2013	7/25/2013	8/7/2013	8/7/2013
		CH13-311-SS019_RKa	CSSS/APHA 4500H	7/10/2013	7/25/2013		8/8/2013
		CH13-311-SS019_RKa	CSSS/APHA 4500H	7/10/2013	7/25/2013		8/15/2013
		CH13-311-SS019_RKa	E245.7	7/10/2013	7/25/2013	8/7/2013	8/8/2013
		CH13-311-SS019_RKa	ISO 15178:2000	7/10/2013	7/25/2013	7/29/2013	7/29/2013
		CH13-311-SS019_RKa	MOD-SOBEK-3.2.3	7/10/2013	7/25/2013		8/28/2013
		CH13-311-SS019_RKa	SSSA P 455-456	7/10/2013	7/25/2013		7/30/2013
		CH13-311-SS019_RKa	SSSA P 455-456	7/10/2013	7/25/2013	7/30/2013	7/30/2013
		CH13-311-SS019_RKa	SW6010B	7/10/2013	7/25/2013	8/7/2013	8/7/2013
		CH13-311-SS021_RKa	CSSS/APHA 4500H	7/12/2013	7/25/2013		8/8/2013
		CH13-311-SS021_RKa	CSSS/APHA 4500H	7/12/2013	7/25/2013		8/15/2013
		CH13-311-SS021_RKa	E245.7	7/12/2013	7/25/2013	8/7/2013	8/8/2013
		CH13-311-SS021_RKa	ISO 15178:2000	7/12/2013	7/25/2013	7/29/2013	7/29/2013
		CH13-311-SS021_RKa	MOD-SOBEK-3.2.3	7/12/2013	7/25/2013		8/28/2013
		CH13-311-SS021_RKa	SSSA P 455-456	7/12/2013	7/25/2013		7/30/2013
		CH13-311-SS021_RKa	SSSA P 455-456	7/12/2013	7/25/2013	7/30/2013	7/30/2013
		CH13-311-SS021_RKa	SW6010B	7/12/2013	7/25/2013	8/7/2013	8/7/2013
		CH13-311-SS022_RKa	CSSS/APHA 4500H	7/12/2013	7/25/2013		8/8/2013
		CH13-311-SS022_RKa	CSSS/APHA 4500H	7/12/2013	7/25/2013		8/15/2013
		CH13-311-SS022_RKa	E245.7	7/12/2013	7/25/2013	8/7/2013	8/8/2013
		CH13-311-SS022_RKa	ISO 15178:2000	7/12/2013	7/25/2013	7/29/2013	7/29/2013
		CH13-311-SS022_RKa	MOD-SOBEK-3.2.3	7/12/2013	7/25/2013		8/28/2013
		CH13-311-SS022_RKa	SSSA P 455-456	7/12/2013	7/25/2013		7/30/2013
		CH13-311-SS022_RKa	SSSA P 455-456	7/12/2013	7/25/2013	7/30/2013	7/30/2013
		CH13-311-SS022_RKa	SW6010B	7/12/2013	7/25/2013	8/7/2013	8/7/2013
		CH13-311-SS026_RKa	CSSS/APHA 4500H	7/15/2013	7/25/2013		8/8/2013
		CH13-311-SS026_RKa	CSSS/APHA 4500H	7/15/2013	7/25/2013		8/15/2013
		CH13-311-SS026_RKa	E245.7	7/15/2013	7/25/2013	8/7/2013	8/8/2013

TABLE 2

Sample Chronology - Data Summary

Laboratory	SDG	Sample ID	Method	Sample Date	Receive Date	Extract Date	Analysis Date
ALS	L1338738	CH13-311-SS026_RKa	ISO 15178:2000	7/15/2013	7/25/2013	7/29/2013	7/29/2013
		CH13-311-SS026_RKa	MOD-SOBEK-3.2.3	7/15/2013	7/25/2013		8/28/2013
		CH13-311-SS026_RKa	SSSA P 455-456	7/15/2013	7/25/2013		7/30/2013
		CH13-311-SS026_RKa	SSSA P 455-456	7/15/2013	7/25/2013	7/30/2013	7/30/2013
		CH13-311-SS026_RKa	SW6010B	7/15/2013	7/25/2013	8/7/2013	8/7/2013
	L1342690	CH13-303-BH001_SOa	ASTM 2216	7/31/2013	8/5/2013		8/13/2013
		CH13-303-BH001_SOb	ASTM 2216	7/31/2013	8/5/2013		8/13/2013
		CH13-303-BH001_SOb	CSSS 1978_P160	7/31/2013	8/5/2013	8/12/2013	8/13/2013
		CH13-303-BH001_SOc	ASTM 2216	7/31/2013	8/5/2013		8/13/2013
		CH13-303-BH001_SOc	ASTM D422-63	7/31/2013	8/5/2013	8/9/2013	8/9/2013
		CH13-303-BH001_SOd	ASTM 2216	7/31/2013	8/5/2013		8/13/2013
		CH13-303-BH001_SOe	ASTM 2216	7/31/2013	8/5/2013		8/13/2013
	L1345512	CH13-303-BH002_SOa	ASTM 2216	8/2/2013	8/9/2013		8/16/2013
		CH13-303-BH002_SOb	ASTM 2216	8/2/2013	8/9/2013		8/16/2013
		CH13-303-BH002_SOb	ASTM D422-63	8/2/2013	8/9/2013	8/13/2013	8/13/2013
		CH13-303-BH002_SOc	ASTM 2216	8/2/2013	8/9/2013		8/18/2013
		CH13-303-BH002_SOc	ASTM D4318	8/2/2013	8/9/2013	8/24/2013	8/24/2013
		CH13-303-BH002_SOd	ASTM 2216	8/2/2013	8/9/2013		8/16/2013
		CH13-303-BH002_SOd	ASTM D4318	8/2/2013	8/9/2013	8/16/2013	8/16/2013
		CH13-303-BH002_SOe	ASTM 2216	8/3/2013	8/9/2013	10/2/2013	10/2/2013
		CH13-303-BH002_SOe	ASTM D422-63	8/3/2013	8/9/2013	10/3/2013	10/3/2013
		CH13-303-BH002_SOe	ASTM D4318	8/3/2013	8/9/2013	10/3/2013	10/3/2013
		CH13-303-BH002_Sof	ASTM 2216	8/3/2013	8/9/2013		8/16/2013
		CH13-303-BH002_SOg	ASTM 2216	8/3/2013	8/9/2013		8/16/2013
		CH13-303-BH002_SOh	ASTM 2216	8/3/2013	8/9/2013		8/16/2013
		CH13-303-BH002_SOh	ASTM D4318	8/3/2013	8/9/2013	8/22/2013	8/22/2013
		Ch13-303-BH002_SOi	ASTM 2216	8/3/2013	8/9/2013		8/16/2013
		Ch13-303-BH002_SOi	ASTM D422-63	8/3/2013	8/9/2013	8/13/2013	8/13/2013
		CH13-303-BH002_SOj	ASTM 2216	8/3/2013	8/9/2013		8/16/2013
		CH13-303-BH002_SOj	ASTM D422-63	8/3/2013	8/9/2013	8/13/2013	8/13/2013
	L1346114	CH13-311-BH016_RKa	ASTM 2216	8/9/2013	8/12/2013		8/23/2013
		CH13-311-BH016_RKa	CSSS/APHA 4500H	8/9/2013	8/12/2013		8/28/2013
		CH13-311-BH016_RKa	CSSS/APHA 4500H	8/9/2013	8/12/2013		9/13/2013
		CH13-311-BH016_RKa	E245.7	8/9/2013	8/12/2013	8/23/2013	8/27/2013
		CH13-311-BH016_RKa	ISO 15178:2000	8/9/2013	8/12/2013	8/24/2013	8/24/2013

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Sample Chronology - Data Summary

Laboratory	SDG	Sample ID	Method	Sample Date	Receive Date	Extract Date	Analysis Date
ALS	L1346114	CH13-311-BH016_RKa	MOD-SOBEK-3.2.3	8/9/2013	8/12/2013		9/19/2013
		CH13-311-BH016_RKa	SSSA P 455-456	8/9/2013	8/12/2013		8/24/2013
		CH13-311-BH016_RKa	SSSA P 455-456	8/9/2013	8/12/2013	8/24/2013	8/24/2013
		CH13-311-BH016_RKa	SW6010B	8/9/2013	8/12/2013	8/23/2013	8/27/2013
		CH13-311-BH016_RKb	ASTM 2216	8/9/2013	8/12/2013		8/23/2013
		CH13-311-BH016_RKb	CSSS/APHA 4500H	8/9/2013	8/12/2013		8/28/2013
		CH13-311-BH016_RKb	E245.7	8/9/2013	8/12/2013	8/23/2013	8/27/2013
		CH13-311-BH016_RKb	E245.7_SPLP3	8/9/2013	8/12/2013	9/4/2013	9/5/2013
		CH13-311-BH016_RKb	E245.7_SPLP4	8/9/2013	8/12/2013	9/4/2013	9/5/2013
		CH13-311-BH016_RKb	E245.7_SPLP5	8/9/2013	8/12/2013	9/4/2013	9/5/2013
		CH13-311-BH016_RKb	ISO 15178:2000	8/9/2013	8/12/2013	8/24/2013	8/24/2013
		CH13-311-BH016_RKb	MOD-SOBEK-3.2.3	8/9/2013	8/12/2013		9/19/2013
		CH13-311-BH016_RKb	SSSA P 455-456	8/9/2013	8/12/2013		8/24/2013
		CH13-311-BH016_RKb	SSSA P 455-456	8/9/2013	8/12/2013	8/24/2013	8/24/2013
		CH13-311-BH016_RKb	SW6010B	8/9/2013	8/12/2013	8/23/2013	8/27/2013
		CH13-311-BH016_RKb	SW6010B_SPLP3	8/9/2013	8/12/2013	9/4/2013	9/5/2013
		CH13-311-BH016_RKb	SW6010B_SPLP3	8/9/2013	8/12/2013	9/4/2013	9/6/2013
		CH13-311-BH016_RKb	SW6010B_SPLP4	8/9/2013	8/12/2013	9/4/2013	9/13/2013
		CH13-311-BH016_RKb	SW6010B_SPLP4	8/9/2013	8/12/2013	9/4/2013	9/16/2013
		CH13-311-BH016_RKb	SW6010B_SPLP5	8/9/2013	8/12/2013	9/4/2013	9/13/2013
		CH13-311-BH016_RKb	SW6010B_SPLP5	8/9/2013	8/12/2013	9/4/2013	9/16/2013
		CH13-311-BH016_RKBMS	E245.7_SPLP3	8/9/2013		9/5/2013	9/5/2013
		CH13-311-BH016_RKBMS	E245.7_SPLP4	8/9/2013		9/5/2013	9/5/2013
		CH13-311-BH016_RKBMS	E245.7_SPLP5	8/9/2013		9/5/2013	9/5/2013
		CH13-311-BH016_RKBMS	SW6010B	8/9/2013		8/27/2013	8/23/2013
		CH13-311-BH016_RKBMS	SW6010B_SPLP3	8/9/2013		9/13/2013	9/5/2013
		CH13-311-BH016_RKBMS	SW6010B_SPLP3	8/9/2013		9/16/2013	9/5/2013
		CH13-311-BH016_RKBMS	SW6010B_SPLP4	8/9/2013		9/13/2013	9/5/2013
		CH13-311-BH016_RKBMS	SW6010B_SPLP4	8/9/2013		9/16/2013	9/5/2013
		CH13-311-BH016_RKBMS	SW6010B_SPLP5	8/9/2013		9/13/2013	9/5/2013
		CH13-311-BH016_RKBMS	SW6010B_SPLP5	8/9/2013		9/16/2013	9/5/2013
		CH13-311-BH016_RKc	ASTM 2216	8/9/2013	8/12/2013		8/23/2013
		CH13-311-BH016_RKc	CSSS/APHA 4500H	8/9/2013	8/12/2013		8/28/2013
		CH13-311-BH016_RKc	CSSS/APHA 4500H	8/9/2013	8/12/2013		9/13/2013
		CH13-311-BH016_RKc	E245.7	8/9/2013	8/12/2013	8/23/2013	8/27/2013

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Sample Chronology - Data Summary

Laboratory	SDG	Sample ID	Method	Sample Date	Receive Date	Extract Date	Analysis Date
ALS	L1346114	CH13-311-BH016_RKc	ISO 15178:2000	8/9/2013	8/12/2013	8/24/2013	8/24/2013
		CH13-311-BH016_RKc	MOD-SOBEK-3.2.3	8/9/2013	8/12/2013		9/19/2013
		CH13-311-BH016_RKc	SSSA P 455-456	8/9/2013	8/12/2013		8/24/2013
		CH13-311-BH016_RKc	SSSA P 455-456	8/9/2013	8/12/2013	8/24/2013	8/24/2013
		CH13-311-BH016_RKc	SW6010B	8/9/2013	8/12/2013	8/23/2013	8/27/2013
		CH13-311-BH017_RKa	ASTM 2216	8/7/2013	8/12/2013		8/23/2013
		CH13-311-BH017_RKa	CSSS/APHA 4500H	8/7/2013	8/12/2013		8/28/2013
		CH13-311-BH017_RKa	CSSS/APHA 4500H	8/7/2013	8/12/2013		9/13/2013
		CH13-311-BH017_RKa	E245.7	8/7/2013	8/12/2013	8/23/2013	8/27/2013
		CH13-311-BH017_RKa	E245.7_SPLP3	8/7/2013	8/12/2013	9/1/2013	9/3/2013
		CH13-311-BH017_RKa	E245.7_SPLP4	8/7/2013	8/12/2013	9/1/2013	9/3/2013
		CH13-311-BH017_RKa	E245.7_SPLP5	8/7/2013	8/12/2013	9/5/2013	9/5/2013
		CH13-311-BH017_RKa	ISO 15178:2000	8/7/2013	8/12/2013	8/24/2013	8/24/2013
		CH13-311-BH017_RKa	MOD-SOBEK-3.2.3	8/7/2013	8/12/2013		9/19/2013
		CH13-311-BH017_RKa	SSSA P 455-456	8/7/2013	8/12/2013		8/24/2013
		CH13-311-BH017_RKa	SSSA P 455-456	8/7/2013	8/12/2013	8/24/2013	8/24/2013
		CH13-311-BH017_RKa	SW6010B	8/7/2013	8/12/2013	8/23/2013	8/27/2013
		CH13-311-BH017_RKa	SW6010B_SPLP3	8/7/2013	8/12/2013	9/1/2013	9/3/2013
		CH13-311-BH017_RKa	SW6010B_SPLP3	8/7/2013	8/12/2013	9/1/2013	9/4/2013
		CH13-311-BH017_RKa	SW6010B_SPLP4	8/7/2013	8/12/2013	9/1/2013	9/3/2013
		CH13-311-BH017_RKa	SW6010B_SPLP4	8/7/2013	8/12/2013	9/1/2013	9/4/2013
		CH13-311-BH017_RKa	SW6010B_SPLP5	8/7/2013	8/12/2013	9/5/2013	9/5/2013
		CH13-311-BH017_RKa	SW6010B_SPLP5	8/7/2013	8/12/2013	9/5/2013	9/9/2013
		CH13-311-BH017_RKAMS	E245.7_SPLP3	8/7/2013		9/3/2013	8/31/2013
		CH13-311-BH017_RKAMS	E245.7_SPLP4	8/7/2013		9/3/2013	8/31/2013
		CH13-311-BH017_RKAMS	SW6010B_SPLP3	8/7/2013		9/3/2013	8/31/2013
		CH13-311-BH017_RKAMS	SW6010B_SPLP3	8/7/2013		9/4/2013	8/31/2013
		CH13-311-BH017_RKAMS	SW6010B_SPLP4	8/7/2013		9/3/2013	8/31/2013
		CH13-311-BH017_RKAMS	SW6010B_SPLP4	8/7/2013		9/4/2013	8/31/2013
		CH13-311-BH017_RKb	ASTM 2216	8/8/2013	8/12/2013		8/23/2013
		CH13-311-BH017_RKb	CSSS/APHA 4500H	8/8/2013	8/12/2013		8/28/2013
		CH13-311-BH017_RKb	CSSS/APHA 4500H	8/8/2013	8/12/2013		9/13/2013
		CH13-311-BH017_RKb	E245.7	8/8/2013	8/12/2013	8/23/2013	8/27/2013
		CH13-311-BH017_RKb	ISO 15178:2000	8/8/2013	8/12/2013	8/24/2013	8/24/2013
		CH13-311-BH017_RKb	MOD-SOBEK-3.2.3	8/8/2013	8/12/2013		9/19/2013

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Sample Chronology - Data Summary

Laboratory	SDG	Sample ID	Method	Sample Date	Receive Date	Extract Date	Analysis Date
ALS	L1346114	CH13-311-BH017_RKb	SSSA P 455-456	8/8/2013	8/12/2013		8/24/2013
		CH13-311-BH017_RKb	SSSA P 455-456	8/8/2013	8/12/2013	8/24/2013	8/24/2013
		CH13-311-BH017_RKb	SW6010B	8/8/2013	8/12/2013	8/23/2013	8/27/2013
		CH13-311-BH017_RKc	ASTM 2216	8/8/2013	8/12/2013		8/23/2013
		CH13-311-BH017_RKc	CSSS/APHA 4500H	8/8/2013	8/12/2013		8/28/2013
		CH13-311-BH017_RKc	E245.7	8/8/2013	8/12/2013	8/23/2013	8/27/2013
		CH13-311-BH017_RKc	E245.7_SPLP3	8/8/2013	8/12/2013	9/4/2013	9/5/2013
		CH13-311-BH017_RKc	E245.7_SPLP3	8/8/2013	8/12/2013	9/7/2013	9/12/2013
		CH13-311-BH017_RKc	E245.7_SPLP4	8/8/2013	8/12/2013	9/4/2013	9/5/2013
		CH13-311-BH017_RKc	E245.7_SPLP5	8/8/2013	8/12/2013	9/4/2013	9/5/2013
		CH13-311-BH017_RKc	ISO 15178:2000	8/8/2013	8/12/2013	8/24/2013	8/24/2013
		CH13-311-BH017_RKc	MOD-SOBEK-3.2.3	8/8/2013	8/12/2013		9/19/2013
		CH13-311-BH017_RKc	SSSA P 455-456	8/8/2013	8/12/2013		8/24/2013
		CH13-311-BH017_RKc	SSSA P 455-456	8/8/2013	8/12/2013	8/24/2013	8/24/2013
		CH13-311-BH017_RKc	SW6010B	8/8/2013	8/12/2013	8/23/2013	8/27/2013
		CH13-311-BH017_RKc	SW6010B_SPLP3	8/8/2013	8/12/2013	9/4/2013	9/6/2013
		CH13-311-BH017_RKc	SW6010B_SPLP3	8/8/2013	8/12/2013	9/7/2013	9/8/2013
		CH13-311-BH017_RKc	SW6010B_SPLP3	8/8/2013	8/12/2013	9/7/2013	9/10/2013
		CH13-311-BH017_RKc	SW6010B_SPLP4	8/8/2013	8/12/2013	9/4/2013	9/13/2013
		CH13-311-BH017_RKc	SW6010B_SPLP4	8/8/2013	8/12/2013	9/4/2013	9/16/2013
		CH13-311-BH017_RKc	SW6010B_SPLP5	8/8/2013	8/12/2013	9/4/2013	9/13/2013
		CH13-311-BH017_RKc	SW6010B_SPLP5	8/8/2013	8/12/2013	9/4/2013	9/16/2013
		CH13-311-BH916_RKb	ASTM 2216	8/9/2013	8/12/2013		8/23/2013
		CH13-311-BH916_RKb	CSSS/APHA 4500H	8/9/2013	8/12/2013		8/28/2013
		CH13-311-BH916_RKb	E245.7	8/9/2013	8/12/2013	8/23/2013	8/27/2013
		CH13-311-BH916_RKb	E245.7_SPLP3	8/9/2013	8/12/2013	9/4/2013	9/5/2013
		CH13-311-BH916_RKb	E245.7_SPLP4	8/9/2013	8/12/2013	9/4/2013	9/5/2013
		CH13-311-BH916_RKb	E245.7_SPLP5	8/9/2013	8/12/2013	9/4/2013	9/5/2013
		CH13-311-BH916_RKb	ISO 15178:2000	8/9/2013	8/12/2013	8/24/2013	8/24/2013
		CH13-311-BH916_RKb	MOD-SOBEK-3.2.3	8/9/2013	8/12/2013		9/19/2013
		CH13-311-BH916_RKb	SSSA P 455-456	8/9/2013	8/12/2013		8/24/2013
		CH13-311-BH916_RKb	SSSA P 455-456	8/9/2013	8/12/2013	8/24/2013	8/24/2013
		CH13-311-BH916_RKb	SW6010B	8/9/2013	8/12/2013	8/23/2013	8/27/2013
		CH13-311-BH916_RKb	SW6010B_SPLP3	8/9/2013	8/12/2013	9/4/2013	9/5/2013
		CH13-311-BH916_RKb	SW6010B_SPLP3	8/9/2013	8/12/2013	9/4/2013	9/6/2013

TABLE 2

Sample Chronology - Data Summary

Laboratory	SDG	Sample ID	Method	Sample Date	Receive Date	Extract Date	Analysis Date
ALS	L1346114	CH13-311-BH916_RKb	SW6010B_SPLP4	8/9/2013	8/12/2013	9/4/2013	9/13/2013
		CH13-311-BH916_RKb	SW6010B_SPLP4	8/9/2013	8/12/2013	9/4/2013	9/16/2013
		CH13-311-BH916_RKb	SW6010B_SPLP5	8/9/2013	8/12/2013	9/4/2013	9/13/2013
		CH13-311-BH916_RKb	SW6010B_SPLP5	8/9/2013	8/12/2013	9/4/2013	9/16/2013
		CH13-311-BH917_RKc	ASTM 2216	8/8/2013	8/12/2013		8/23/2013
		CH13-311-BH917_RKc	CSSS/APHA 4500H	8/8/2013	8/12/2013		8/28/2013
		CH13-311-BH917_RKc	E245.7	8/8/2013	8/12/2013	8/23/2013	8/27/2013
		CH13-311-BH917_RKc	E245.7_SPLP3	8/8/2013	8/12/2013	9/4/2013	9/5/2013
		CH13-311-BH917_RKc	E245.7_SPLP4	8/8/2013	8/12/2013	9/4/2013	9/5/2013
		CH13-311-BH917_RKc	E245.7_SPLP5	8/8/2013	8/12/2013	9/4/2013	9/5/2013
		CH13-311-BH917_RKc	ISO 15178:2000	8/8/2013	8/12/2013	8/24/2013	8/24/2013
		CH13-311-BH917_RKc	MOD-SOBEK-3.2.3	8/8/2013	8/12/2013		9/19/2013
		CH13-311-BH917_RKc	SSSA P 455-456	8/8/2013	8/12/2013		8/24/2013
		CH13-311-BH917_RKc	SSSA P 455-456	8/8/2013	8/12/2013	8/24/2013	8/24/2013
		CH13-311-BH917_RKc	SW6010B	8/8/2013	8/12/2013	8/23/2013	8/27/2013
		CH13-311-BH917_RKc	SW6010B_SPLP3	8/8/2013	8/12/2013	9/4/2013	9/5/2013
		CH13-311-BH917_RKc	SW6010B_SPLP3	8/8/2013	8/12/2013	9/4/2013	9/6/2013
		CH13-311-BH917_RKc	SW6010B_SPLP4	8/8/2013	8/12/2013	9/4/2013	9/13/2013
		CH13-311-BH917_RKc	SW6010B_SPLP4	8/8/2013	8/12/2013	9/4/2013	9/16/2013
		CH13-311-BH917_RKc	SW6010B_SPLP5	8/8/2013	8/12/2013	9/4/2013	9/13/2013
		CH13-311-BH917_RKc	SW6010B_SPLP5	8/8/2013	8/12/2013	9/4/2013	9/16/2013
	L1347043	CH13-303-BH003_SOa	ASTM 2216	8/5/2013	8/13/2013		8/19/2013
		CH13-303-BH003_SOb	ASTM 2216	8/5/2013	8/13/2013		8/19/2013
		CH13-303-BH003_SOb	ASTM D4318	8/5/2013	8/13/2013	8/22/2013	8/22/2013
		CH13-303-BH003_SOc	ASTM 2216	8/5/2013	8/13/2013		8/19/2013
		CH13-303-BH003_SOd	ASTM 2216	8/5/2013	8/13/2013		8/19/2013
		CH13-303-BH003_SOd	ASTM D4318	8/5/2013	8/13/2013	8/22/2013	8/22/2013
		CH13-303-BH003_SOe	ASTM 2216	8/5/2013	8/13/2013		8/19/2013
		CH13-303-BH003_SOe	ASTM D4318	8/5/2013	8/13/2013	8/22/2013	8/22/2013
		CH13-303-BH003_SOf	ASTM 2216	8/5/2013	8/13/2013		8/19/2013
		CH13-303-BH003_SOf	ASTM D4318	8/5/2013	8/13/2013	8/22/2013	8/22/2013
		CH13-303-BH003_SOg	ASTM 2216	8/5/2013	8/13/2013		8/19/2013
		CH13-303-BH003_SOh	ASTM D422-63	8/5/2013	8/13/2013	8/20/2013	8/20/2013
		CH13-303-BH003_SOi	ASTM 2216	8/5/2013	8/13/2013		8/19/2013
		CH13-303-BH003_SOi	ASTM D4318	8/5/2013	8/13/2013	8/22/2013	8/22/2013

TABLE 2

Sample Chronology - Data Summary

Laboratory	SDG	Sample ID	Method	Sample Date	Receive Date	Extract Date	Analysis Date
ALS	L1347043	CH13-303-BH003_SOj	ASTM 2216	8/5/2013	8/13/2013		8/19/2013
		CH13-303-BH003_SOk	ASTM D4318	8/6/2013	8/13/2013	8/22/2013	8/22/2013
		CH13-303-BH003_SOl	ASTM 2216	8/6/2013	8/13/2013		8/19/2013
		CH13-303-BH003_SOm	ASTM 2216	8/6/2013	8/13/2013		8/19/2013
		CH13-303-BH003_SOm	ASTM D4318	8/6/2013	8/13/2013	8/22/2013	8/22/2013
		CH13-303-BH003_SOn	ASTM 2216	8/6/2013	8/13/2013		8/19/2013
		CH13-303-BH003_SOn	ASTM D4318	8/6/2013	8/13/2013	8/22/2013	8/22/2013
		CH13-303-BH903_SOg	ASTM 2216	8/5/2013	8/13/2013		8/19/2013

TABLE 3

Overall Flagging Summary

Method	Matrix	Validation Reason	Qualifier*	Qualifier Type	Number of Affected Analytes
ASTM 2216	SOIL				
Category = HoldingTime		Holding time exceeded			
			UJ	Protocol	4
			J	Protocol	2
CSSS/APHA 4500H	SOIL				
Category = HoldingTime		Holding time exceeded			
			J	Protocol	11
E245.7	SOIL				
Category = HoldingTime		Holding time exceeded			
			UJ	Protocol	2
SW6010B	SOIL				
Category = Blank		Laboratory blank contamination greater than the RL			
			U	Protocol	5
Category = FieldDuplicate		Field duplicate exceeds RPD criteria			
			J	Other	12
SW6010B_SPLP3	SOIL				
Category = Blank		Laboratory blank contamination greater than the RL			
			U	Protocol	2
Category = FieldDuplicate		Field duplicate exceeds RPD criteria			
			J	Other	10
SW6010B_SPLP4	SOIL				
Category = Blank		Laboratory blank contamination greater than the RL			
			U	Protocol	5
Category = FieldDuplicate		Field duplicate exceeds RPD criteria			
			J	Other	8
SW6010B_SPLP5	SOIL				
Category = Blank		Laboratory blank contamination greater than the RL			

TABLE 3

Overall Flagging Summary

Method	Matrix	Validation Reason	Qualifier*	Qualifier Type	Number of Affected Analytes
			U	Protocol	5
Category = FieldDuplicate		Field duplicate exceeds RPD criteria			
			J	Other	12

* The most severe flag for each analyte becomes the final validation flag.

Qualifier Description:

J = Analyte was present but the reported value may not be accurate or precise.

U = This analyte was analyzed for but not detected at the specified detection limit.

UJ = The analyte was not detected above the detection limit objective. However, the reported detection limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

Qualifier Type:

Protocol = Flagging due to contractor/laboratory protocol violations.
Other = Flagging due to sample, matrix, or field issues not related to Quality Assurance Project Plan (QAPP) or Sampling and Analysis Plan (SAP) protocol.

TABLE 4
Holding Times - Qualified Data

Method	Matrix	Sample ID	Analyte	Holding Time	Result	Holding Time Qualifier	Final Flag*
ASTM 2216	SOIL	CH13-303-BH002_SOc					
			Moisture	16 Days	12.3 percent	J	J
ASTM 2216	SOIL	CH13-303-BH002_SOe					
			Moisture	60 Days	7.07 percent	J	J
ASTM 2216	SOIL	CH13-311-BH017_RKa					
			Moisture	16 Days	0.25 percent	UJ	UJ
ASTM 2216	SOIL	CH13-311-BH017_RKb					
			Moisture	15 Days	0.25 percent	UJ	UJ
ASTM 2216	SOIL	CH13-311-BH017_RKc					
			Moisture	15 Days	0.25 percent	UJ	UJ
ASTM 2216	SOIL	CH13-311-BH917_RKc					
			Moisture	15 Days	0.25 percent	UJ	UJ
CSSS/APHA 4500H	SOIL	CH13-311-BH016_RKa					
			Paste pH	35 Days	7.32 pH Units	J	J
CSSS/APHA 4500H	SOIL	CH13-311-BH016_RKc					
			Paste pH	35 Days	7.55 pH Units	J	J
CSSS/APHA 4500H	SOIL	CH13-311-BH017_RKa					
			Paste pH	37 Days	7.03 pH Units	J	J
CSSS/APHA 4500H	SOIL	CH13-311-BH017_RKb					
			Paste pH	36 Days	7.26 pH Units	J	J
CSSS/APHA 4500H	SOIL	CH13-311-SS001_RKa					
			Paste pH	36 Days	7.95 pH Units	J	J
			pH (1:2 soil:water)	29 Days	8.94 pH Units	J	J
CSSS/APHA 4500H	SOIL	CH13-311-SS019_RKa					
			Paste pH	36 Days	7.64 pH Units	J	J
			pH (1:2 soil:water)	29 Days	7.63 pH Units	J	J

TABLE 4
Holding Times - Qualified Data

Method	Matrix	Sample ID	Analyte	Holding Time	Result	Holding Time Qualifier	Final Flag*
CSSS/APHA 4500H	SOIL	CH13-311-SS021_RKa					
			Paste pH	34 Days	7.71 pH Units	J	J
CSSS/APHA 4500H	SOIL	CH13-311-SS022_RKa					
			Paste pH	34 Days	8.07 pH Units	J	J
CSSS/APHA 4500H	SOIL	CH13-311-SS026_RKa					
			Paste pH	31 Days	7.76 pH Units	J	J
E245.7	SOIL	CH13-311-SS001_RKa					
			Mercury	29 Days	0.005 mg/kg	UJ	UJ
E245.7	SOIL	CH13-311-SS019_RKa					
			Mercury	29 Days	0.005 mg/kg	UJ	UJ

* The most severe flag for each analyte becomes the final validation flag.

Qualifier Description:

J = Analyte was present but the reported value may not be accurate or precise.

UJ = The analyte was not detected above the detection limit objective. However, the reported detection limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.

Criteria:

HTa>UCL = Holding time exceeded

TABLE 5

Blank Contamination - Qualified Data

Method	Matrix	Analyte / Sample ID	Result	Blank Contamination Qualifier*	Criteria	Comments
SW6010B	SOIL	**Zinc**				
		CH13-311-SS001_RKa	52.9 mg/kg	U	LB>RL	blank target = 2.4mg/kg
		CH13-311-SS019_RKa	56.1 mg/kg	U	LB>RL	blank target = 2.4mg/kg
		CH13-311-SS021_RKa	46.4 mg/kg	U	LB>RL	blank target = 2.4mg/kg
		CH13-311-SS022_RKa	45.1 mg/kg	U	LB>RL	blank target = 2.4mg/kg
		CH13-311-SS026_RKa	41.2 mg/kg	U	LB>RL	blank target = 2.4mg/kg
SW6010B_SPLP3	SOIL	**Nickel, SPLP3**				
		CH13-311-BH016_RKb	0.00334 mg/l	U	LB>RL	blank target = 0.00069mg/l
		CH13-311-BH916_RKb	0.0032 mg/l	U	LB>RL	blank target = 0.00069mg/l
SW6010B_SPLP4	SOIL	**Manganese, SPLP4**				
		CH13-311-BH016_RKb	0.00416 mg/l	U	LB>RL	blank target = 0.00289mg/l
		CH13-311-BH017_RKc	0.00329 mg/l	U	LB>RL	blank target = 0.00289mg/l
		CH13-311-BH916_RKb	0.00601 mg/l	U	LB>RL	blank target = 0.00289mg/l
		CH13-311-BH917_RKc	0.00131 mg/l	U	LB>RL	blank target = 0.00289mg/l
SW6010B_SPLP4	SOIL	**Nickel, SPLP4**				
		CH13-311-BH916_RKb	0.00072 mg/l	U	LB>RL	blank target = 0.00069mg/l
SW6010B_SPLP5	SOIL	**Manganese, SPLP5**				
		CH13-311-BH016_RKb	0.00497 mg/l	U	LB>RL	blank target = 0.00289mg/l
		CH13-311-BH017_RKc	0.00238 mg/l	U	LB>RL	blank target = 0.00289mg/l
		CH13-311-BH916_RKb	0.00692 mg/l	U	LB>RL	blank target = 0.00289mg/l
		CH13-311-BH917_RKc	0.00515 mg/l	U	LB>RL	blank target = 0.00289mg/l
SW6010B_SPLP5	SOIL	**Nickel, SPLP5**				
		CH13-311-BH916_RKb	0.00066 mg/l	U	LB>RL	blank target = 0.00069mg/l

Blank target = concentration of field or laboratory blank.

* The most severe flag for each analyte becomes the final validation flag.

Qualifier Description:

U = This analyte was analyzed for but not detected at the specified detection limit.

Criteria:

LB>RL = Laboratory blank contamination greater than the RL

TABLE 6

Field Duplicate Precision - Qualified Data

Method	Matrix	Sample ID	Analyte	Result	Field Duplicate Qualifier*	Criteria
SW6010B	SOIL		**Antimony**			
		CH13-311-BH016_RKb		24.4 mg/kg	J	FD>RPD
		CH13-311-BH916_RKb		10.5 mg/kg	J	FD>RPD
SW6010B	SOIL		**Arsenic**			
		CH13-311-BH016_RKb		10.2 mg/kg	J	FD>RPD
		CH13-311-BH916_RKb		17.6 mg/kg	J	FD>RPD
SW6010B	SOIL		**Copper**			
		CH13-311-BH016_RKb		34.9 mg/kg	J	FD>RPD
		CH13-311-BH916_RKb		14.8 mg/kg	J	FD>RPD
SW6010B	SOIL		**Lead**			
		CH13-311-BH016_RKb		51.1 mg/kg	J	FD>RPD
		CH13-311-BH916_RKb		24.7 mg/kg	J	FD>RPD
SW6010B	SOIL		**Uranium**			
		CH13-311-BH017_RKc		3.18 mg/kg	J	FD>RPD
		CH13-311-BH917_RKc		7.33 mg/kg	J	FD>RPD
SW6010B	SOIL		**Zinc**			
		CH13-311-BH016_RKb		44.5 mg/kg	J	FD>RPD
		CH13-311-BH916_RKb		20.5 mg/kg	J	FD>RPD
SW6010B_SPLP3	SOIL		**Cadmium, SPLP3**			
		CH13-311-BH016_RKb		0.000136 mg/l	J	FD>RPD
		CH13-311-BH916_RKb		0.00037 mg/l	J	FD>RPD
SW6010B_SPLP3	SOIL		**Chromium, SPLP3**			
		CH13-311-BH016_RKb		0.00368 mg/l	J	FD>RPD
		CH13-311-BH916_RKb		0.00148 mg/l	J	FD>RPD
SW6010B_SPLP3	SOIL		**Copper, SPLP3**			
		CH13-311-BH016_RKb		0.00077 mg/l	J	FD>RPD
		CH13-311-BH916_RKb		0.00427 mg/l	J	FD>RPD
SW6010B_SPLP3	SOIL		**Uranium, SPLP3**			
		CH13-311-BH016_RKb		0.00186 mg/l	J	FD>RPD
		CH13-311-BH017_RKc		0.00116 mg/l	J	FD>RPD

TABLE 6

Field Duplicate Precision - Qualified Data

Method	Matrix	Sample ID	Analyte	Result	Field Duplicate Qualifier*	Criteria
		CH13-311-BH916_RKb		0.00062 mg/l	J	FD>RPD
		CH13-311-BH917_RKc		0.00202 mg/l	J	FD>RPD
SW6010B_SPLP4	SOIL		**Aluminum, SPLP4**			
		CH13-311-BH017_RKc		0.569 mg/l	J	FD>RPD
		CH13-311-BH917_RKc		0.335 mg/l	J	FD>RPD
SW6010B_SPLP4	SOIL		**Arsenic, SPLP4**			
		CH13-311-BH016_RKb		0.00068 mg/l	J	FD>RPD
		CH13-311-BH916_RKb		0.00162 mg/l	J	FD>RPD
SW6010B_SPLP4	SOIL		**Iron, SPLP4**			
		CH13-311-BH016_RKb		0.54 mg/l	J	FD>RPD
		CH13-311-BH916_RKb		1.06 mg/l	J	FD>RPD
SW6010B_SPLP4	SOIL		**Manganese, SPLP4**			
		CH13-311-BH017_RKc		0.00329 mg/l	J	FD>RPD
		CH13-311-BH917_RKc		0.00131 mg/l	J	FD>RPD
SW6010B_SPLP5	SOIL		**Aluminum, SPLP5**			
		CH13-311-BH017_RKc		0.556 mg/l	J	FD>RPD
		CH13-311-BH917_RKc		1.01 mg/l	J	FD>RPD
SW6010B_SPLP5	SOIL		**Arsenic, SPLP5**			
		CH13-311-BH016_RKb		0.00104 mg/l	J	FD>RPD
		CH13-311-BH916_RKb		0.00189 mg/l	J	FD>RPD
SW6010B_SPLP5	SOIL		**Iron, SPLP5**			
		CH13-311-BH016_RKb		0.571 mg/l	J	FD>RPD
		CH13-311-BH017_RKc		0.137 mg/l	J	FD>RPD
		CH13-311-BH916_RKb		1.08 mg/l	J	FD>RPD
		CH13-311-BH917_RKc		0.335 mg/l	J	FD>RPD
SW6010B_SPLP5	SOIL		**Lead, SPLP5**			
		CH13-311-BH017_RKc		0.00052 mg/l	J	FD>RPD
		CH13-311-BH917_RKc		0.00095 mg/l	J	FD>RPD
SW6010B_SPLP5	SOIL		**Manganese, SPLP5**			
		CH13-311-BH017_RKc		0.00238 mg/l	J	FD>RPD

TABLE 6

Field Duplicate Precision - Qualified Data

Method	Matrix	Sample ID	Analyte	Result	Field Duplicate Qualifier*	Criteria
		CH13-311-BH917_RKc		0.00515 mg/l	J	FD>RPD

* The most severe flag for each analyte becomes the final validation flag.

Qualifier Description:

J = Analyte was present but the reported value may not be accurate or precise.

Criteria:

FD>RPD = Field duplicate exceeds RPD criteria

TABLE 7

Site Completeness by Analyte - Qualified Data

Method	Analyte	Units	Number of Occurrences: Analyses	Detects	Non-detects	Blank Flags	J Flags	M Flags	Contractor R Flags	Total R Flags	Contractor Percent Completeness	Overall Percent Completeness
ASTM 2216	Moisture	PERCENT	36	30	6		6				100	100
ASTM D422-63	MUST PSA % > 75um	PERCENT	6	6							100	100
ASTM D4318	MOISTURE AT LIQUID LIMIT	PERCENT	12	12							100	100
ASTM D4318	PLASTICITY INDEX	PERCENT	12	12							100	100
CSSS 1978_P160	Organic Matter	PERCENT	1	1							100	100
CSSS 1978_P160	Organic Matter_LOI	PERCENT	1	1							100	100
CSSS/APHA 4500H	Paste pH	PH UNITS	9	9			9				100	100
CSSS/APHA 4500H	pH (1:2 soil:water)	PH UNITS	13	13			2				100	100
E245.7	Mercury	MG/KG	13	4	9		2				100	100
E245.7_SPLP3	Mercury, SPLP3	MG/L	5		5						100	100
E245.7_SPLP4	Mercury, SPLP4	MG/L	5		5						100	100
E245.7_SPLP5	Mercury, SPLP5	MG/L	5		5						100	100
ISO 15178:2000	Sulfur	MG/KG	13	5	8						100	100
MOD-SOBEK-3.2.3	Neutralization Potential (as CaCO3 Eq.)	T CACO3/1	13	13							100	100
SSSA P 455-456	Inorganic Carbon (as CACO3 Equivalent)	PERCENT	13	9	4						100	100
SSSA P 455-456	Total Inorganic Carbon	PERCENT	13	8	5						100	100
SW6010B	Aluminum	MG/KG	13	13							100	100
SW6010B	Antimony	MG/KG	13	7	6		2				100	100
SW6010B	Arsenic	MG/KG	13	13			2				100	100

TABLE 7

Site Completeness by Analyte - Qualified Data

			Number of Occurrences									
Method	Analyte	Units	Analyses	Detects	Non-detects	Blank Flags	J Flags	M Flags	Contractor R Flags	Total R Flags	Contractor Percent Completeness	Overall Percent Completeness
SW6010B	Barium	MG/KG	13	13							100	100
SW6010B	Beryllium	MG/KG	13	10	3						100	100
SW6010B	Bismuth	MG/KG	13	6	7						100	100
SW6010B	Boron	MG/KG	13		13						100	100
SW6010B	Cadmium	MG/KG	13	9	4						100	100
SW6010B	Calcium	MG/KG	13	13							100	100
SW6010B	Chromium	MG/KG	13	13							100	100
SW6010B	Cobalt	MG/KG	13	13							100	100
SW6010B	Copper	MG/KG	13	12	1		2				100	100
SW6010B	Iron	MG/KG	13	13							100	100
SW6010B	Lead	MG/KG	13	13			2				100	100
SW6010B	Lithium	MG/KG	13	10	3						100	100
SW6010B	Magnesium	MG/KG	13	13							100	100
SW6010B	Manganese	MG/KG	13	13							100	100
SW6010B	Molybdenum	MG/KG	13	5	8						100	100
SW6010B	Nickel	MG/KG	13	13							100	100
SW6010B	Phosphorus	MG/KG	13	13							100	100
SW6010B	Potassium	MG/KG	13	13							100	100
SW6010B	Selenium	MG/KG	13		13						100	100

Method	Analyte	Units	Number of Occurrences: Analyses	Detects	Non-detects	Blank Flags	J Flags	M Flags	Contractor R Flags	Total R Flags	Contractor Percent Completeness	Overall Percent Completeness
SW6010B	Silver	MG/KG	13	4	9						100	100
SW6010B	Sodium	MG/KG	13	7	6						100	100
SW6010B	Strontium	MG/KG	13	13							100	100
SW6010B	Thallium	MG/KG	13	8	5						100	100
SW6010B	Tin	MG/KG	13	3	10						100	100
SW6010B	Titanium	MG/KG	13	13							100	100
SW6010B	Uranium	MG/KG	13	12	1		2				100	100
SW6010B	Vanadium	MG/KG	13	13							100	100
SW6010B	Zinc	MG/KG	13	8	5		2				100	100
SW6010B_SPLP3	Aluminum, SPLP3	MG/L	5	5							100	100
SW6010B_SPLP3	Antimony, SPLP3	MG/L	5	5							100	100
SW6010B_SPLP3	Arsenic, SPLP3	MG/L	5	5							100	100
SW6010B_SPLP3	Barium, SPLP3	MG/L	5		5						100	100
SW6010B_SPLP3	Beryllium, SPLP3	MG/L	5	2	3						100	100
SW6010B_SPLP3	Bismuth, SPLP3	MG/L	5		5						100	100
SW6010B_SPLP3	Boron, SPLP3	MG/L	5		5						100	100
SW6010B_SPLP3	Cadmium, SPLP3	MG/L	5	2	3		2				100	100
SW6010B_SPLP3	Calcium, SPLP3	MG/L	5	5							100	100
SW6010B_SPLP3	Chromium, SPLP3	MG/L	5	2	3		2				100	100

TABLE 7

Site Completeness by Analyte - Qualified Data

Method	Analyte	Units	Analyses	Detects	Non-detects	Blank Flags	J Flags	M Flags	Contractor R Flags	Total R Flags	Contractor Percent Completeness	Overall Percent Completeness
			Number of Occurrences									
SW6010B_SPLP3	Cobalt, SPLP3	MG/L	5	2	3						100	100
SW6010B_SPLP3	Copper, SPLP3	MG/L	5	2	3		2				100	100
SW6010B_SPLP3	Iron, SPLP3	MG/L	5	2	3						100	100
SW6010B_SPLP3	Lead, SPLP3	MG/L	5	5							100	100
SW6010B_SPLP3	Lithium, SPLP3	MG/L	5	5							100	100
SW6010B_SPLP3	Magnesium, SPLP3	MG/L	5	5							100	100
SW6010B_SPLP3	Manganese, SPLP3	MG/L	5	5							100	100
SW6010B_SPLP3	Molybdenum, SPLP3	MG/L	5		5						100	100
SW6010B_SPLP3	Nickel, SPLP3	MG/L	5		5						100	100
SW6010B_SPLP3	Phosphorus, SPLP3	MG/L	5		5						100	100
SW6010B_SPLP3	Potassium, SPLP3	MG/L	5	5							100	100
SW6010B_SPLP3	Selenium, SPLP3	MG/L	5		5						100	100
SW6010B_SPLP3	Silicon, SPLP3	MG/L	5	5							100	100
SW6010B_SPLP3	Silver, SPLP3	MG/L	5		5						100	100
SW6010B_SPLP3	Sodium, SPLP3	MG/L	5	5							100	100
SW6010B_SPLP3	Strontium, SPLP3	MG/L	5	5							100	100
SW6010B_SPLP3	Thallium, SPLP3	MG/L	5	2	3						100	100
SW6010B_SPLP3	Tin, SPLP3	MG/L	5		5						100	100
SW6010B_SPLP3	Titanium, SPLP3	MG/L	5		5						100	100

TABLE 7
Site Completeness by Analyte - Qualified Data

Method	Analyte	Units	Number of Occurrences								Contractor Percent Completeness	Overall Percent Completeness
			Analyses	Detects	Non-detects	Blank Flags	J Flags	M Flags	Contractor R Flags	Total R Flags		
SW6010B_SPLP3	Uranium, SPLP3	MG/L	5	5			4				100	100
SW6010B_SPLP3	Vanadium, SPLP3	MG/L	5		5						100	100
SW6010B_SPLP3	Zinc, SPLP3	MG/L	5		5						100	100
SW6010B_SPLP4	Aluminum, SPLP4	MG/L	5	5			2				100	100
SW6010B_SPLP4	Antimony, SPLP4	MG/L	5	5							100	100
SW6010B_SPLP4	Arsenic, SPLP4	MG/L	5	5			2				100	100
SW6010B_SPLP4	Barium, SPLP4	MG/L	5		5						100	100
SW6010B_SPLP4	Beryllium, SPLP4	MG/L	5		5						100	100
SW6010B_SPLP4	Bismuth, SPLP4	MG/L	5		5						100	100
SW6010B_SPLP4	Boron, SPLP4	MG/L	5		5						100	100
SW6010B_SPLP4	Cadmium, SPLP4	MG/L	5	2	3						100	100
SW6010B_SPLP4	Calcium, SPLP4	MG/L	5	5							100	100
SW6010B_SPLP4	Chromium, SPLP4	MG/L	5	3	2						100	100
SW6010B_SPLP4	Cobalt, SPLP4	MG/L	5	3	2						100	100
SW6010B_SPLP4	Copper, SPLP4	MG/L	5	2	3						100	100
SW6010B_SPLP4	Iron, SPLP4	MG/L	5	5			2				100	100
SW6010B_SPLP4	Lead, SPLP4	MG/L	5	5							100	100
SW6010B_SPLP4	Lithium, SPLP4	MG/L	5	5							100	100
SW6010B_SPLP4	Magnesium, SPLP4	MG/L	5	5							100	100

TABLE 7

Site Completeness by Analyte - Qualified Data

			Number of Occurrences									
Method	**Analyte**	**Units**	**Analyses**	**Detects**	**Non-detects**	**Blank Flags**	**J Flags**	**M Flags**	**Contractor R Flags**	**Total R Flags**	**Contractor Percent Completeness**	**Overall Percent Completeness**
SW6010B_SPLP4	Manganese, SPLP4	MG/L	5	1	4						100	100
SW6010B_SPLP4	Molybdenum, SPLP4	MG/L	5	2	3						100	100
SW6010B_SPLP4	Nickel, SPLP4	MG/L	5		5						100	100
SW6010B_SPLP4	Phosphorus, SPLP4	MG/L	5		5						100	100
SW6010B_SPLP4	Potassium, SPLP4	MG/L	5	5							100	100
SW6010B_SPLP4	Selenium, SPLP4	MG/L	5		5						100	100
SW6010B_SPLP4	Silicon, SPLP4	MG/L	5	5							100	100
SW6010B_SPLP4	Silver, SPLP4	MG/L	5	2	3						100	100
SW6010B_SPLP4	Sodium, SPLP4	MG/L	5	5							100	100
SW6010B_SPLP4	Strontium, SPLP4	MG/L	5	5							100	100
SW6010B_SPLP4	Thallium, SPLP4	MG/L	5	3	2						100	100
SW6010B_SPLP4	Tin, SPLP4	MG/L	5		5						100	100
SW6010B_SPLP4	Titanium, SPLP4	MG/L	5	5							100	100
SW6010B_SPLP4	Uranium, SPLP4	MG/L	5	5							100	100
SW6010B_SPLP4	Vanadium, SPLP4	MG/L	5	4	1						100	100
SW6010B_SPLP4	Zinc, SPLP4	MG/L	5		5						100	100
SW6010B_SPLP5	Aluminum, SPLP5	MG/L	5	5			2				100	100
SW6010B_SPLP5	Antimony, SPLP5	MG/L	5	4	1						100	100
SW6010B_SPLP5	Arsenic, SPLP5	MG/L	5	5			2				100	100

TABLE 7
Site Completeness by Analyte - Qualified Data

Method	Analyte	Units	Number of Occurrences: Analyses	Detects	Non-detects	Blank Flags	J Flags	M Flags	Contractor R Flags	Total R Flags	Contractor Percent Completeness	Overall Percent Completeness
SW6010B_SPLP5	Barium, SPLP5	MG/L	5		5						100	100
SW6010B_SPLP5	Beryllium, SPLP5	MG/L	5		5						100	100
SW6010B_SPLP5	Bismuth, SPLP5	MG/L	5		5						100	100
SW6010B_SPLP5	Boron, SPLP5	MG/L	5		5						100	100
SW6010B_SPLP5	Cadmium, SPLP5	MG/L	5	1	4						100	100
SW6010B_SPLP5	Calcium, SPLP5	MG/L	5	5							100	100
SW6010B_SPLP5	Chromium, SPLP5	MG/L	5	2	3						100	100
SW6010B_SPLP5	Cobalt, SPLP5	MG/L	5	3	2						100	100
SW6010B_SPLP5	Copper, SPLP5	MG/L	5	2	3						100	100
SW6010B_SPLP5	Iron, SPLP5	MG/L	5	5			4				100	100
SW6010B_SPLP5	Lead, SPLP5	MG/L	5	5			2				100	100
SW6010B_SPLP5	Lithium, SPLP5	MG/L	5	5							100	100
SW6010B_SPLP5	Magnesium, SPLP5	MG/L	5	5							100	100
SW6010B_SPLP5	Manganese, SPLP5	MG/L	5	1	4						100	100
SW6010B_SPLP5	Molybdenum, SPLP5	MG/L	5	2	3						100	100
SW6010B_SPLP5	Nickel, SPLP5	MG/L	5		5						100	100
SW6010B_SPLP5	Phosphorus, SPLP5	MG/L	5		5						100	100
SW6010B_SPLP5	Potassium, SPLP5	MG/L	5	5							100	100
SW6010B_SPLP5	Selenium, SPLP5	MG/L	5		5						100	100

TABLE 7

Site Completeness by Analyte - Qualified Data

Method	Analyte	Units	Analyses	Detects	Non-detects	Blank Flags	J Flags	M Flags	Contractor R Flags	Total R Flags	Contractor Percent Completeness	Overall Percent Completeness
			Number of Occurrences									
SW6010B_SPLP5	Silicon, SPLP5	MG/L	5	5							100	100
SW6010B_SPLP5	Silver, SPLP5	MG/L	5	2	3						100	100
SW6010B_SPLP5	Sodium, SPLP5	MG/L	5	5							100	100
SW6010B_SPLP5	Strontium, SPLP5	MG/L	5	5							100	100
SW6010B_SPLP5	Thallium, SPLP5	MG/L	5	2	3						100	100
SW6010B_SPLP5	Tin, SPLP5	MG/L	5		5						100	100
SW6010B_SPLP5	Titanium, SPLP5	MG/L	5	5							100	100
SW6010B_SPLP5	Uranium, SPLP5	MG/L	5	4	1						100	100
SW6010B_SPLP5	Vanadium, SPLP5	MG/L	5	4	1						100	100
SW6010B_SPLP5	Zinc, SPLP5	MG/L	5		5						100	100

Attachment 1
Holding Time Corrective Action Report

December 11, 2013

CH2M Hill
2525 Airpark Drive
Redding, CA
96001

Attention: Travis Gouveia

Dear Mr. Gouveia,

RE: ALS Corrective Action Report (CAR) #10939 – Missed Holding Times for CH2M Hill Faro Mine Project IDs 472645.06.AD.01.04.13, 472645.18.VG.DF, 472645.15.CS.DM.01, and 472645.13.WT.AD.01

Between July 15 and September 9, ALS Whitehorse received several submissions from CH2M Hill for the above mentioned projects. Analyses for these submissions were performed by the ALS labs in Whitehorse and Vancouver, and some unexpected holding time (HT) exceedances were experienced for HTs set at three to twenty -eight days.

The affected tests and samples span a number of submissions and the root causes have been summarized below:

Insufficient Time: ALS does request a minimum of 24 hours lead time to perform any tests where holding times are about to expire. The samples/test requests listed below were received at ALS with insufficient time to meet prescribed holding time requirements. ALS recommends submitting samples/test requests to the lab with additional lead time to ensure the laboratory can meet HT requirements.

Work Order	Samples	Client ID	Analyte	Matrix	ALS HT	Root Cause
L1359691	1-3	CH13-311-TP022_SOA CH13-311-TP023_SOA CH13-311-TP021_SOA	Moisture	Soil	14 Days	Insufficient Time to Perform Testing.
L1332147	2	CH13-311-SS024_SOA	N-Tot-LECO		28 Days	

Contingent Login: For the CH2M Hill projects listed above, the selection of the appropriate Acidity method is contingent upon the iron concentrations of the samples. Thus, Iron testing must be performed before the initiation of the acidity testing and can directly affect the acidity testing timeline. The samples listed below experienced delays for iron testing which resulted in the Acidity HT failure. For future submissions, holding time requirements can be satisfied if iron analysis is performed on a rush basis or if both acidity methods are concurrently tested with iron.

<table>
<tr><th>Work Order</th><th>Samples</th><th>Client ID</th><th>Analyte</th><th>Matrix</th><th>ALS HT</th><th>Root Cause</th></tr>
<tr><td>L1355914</td><td>5-8, 11, 13, 17, 19, 20</td><td>P05-01-01_GW0813
P05-01-02_GW0813
P05-01-04_GW0813
P05-01-06_GW0813
CH12-204-MW001A_GW0813
CH12-204-MW901A_GW0813
P05-02_GW0813
P905-02_GW0813
P03-08-04_GW0813</td><td rowspan="2">Acidity</td><td rowspan="3">Water</td><td rowspan="3">14</td><td rowspan="3">Contingent Login: Acidity could not be run until iron concentration was known.</td></tr>
<tr><td>L1356637</td><td>2-6, 9, 10</td><td>P03-03-03_GW0813
P03-03-06_GW0813
P03-05-02_GW0813
P03-05-03_GW0813
P903-05-02_GW0813
X21A-96_GW0813
X21B-96_GW0813</td></tr>
<tr><td>L1356684</td><td>16-19, 23-28</td><td>P03-04-06_GW0813
P03-06-03_GW0813
P03-06-04_GW0813
P03-08-05_GW0813
P03-04-08_GW0813
P03-05-05_GW0813
P03-05-06_GW0813
P03-05-07_GW0813
P03-05-08_GW0813
P03-06-05_GW0813</td><td>Acidity - H2O2</td></tr>
</table>

Lab Error: For the holding time failures listed in the table below, ALS errors pertaining to logistics and sample reception were the direct causes. These errors, and their consequences, have been reviewed with all affected staff. ALS endeavors to prevent all future occurrences though improved awareness and training.

Work Order	Samples	Client ID	Analyte	Matrix	ALS HT	Root Cause
L1349069	1	CH13-204-MW011A_GW0813	PO4	Water	3	Lab Error - shipping delays.
L1346114	1-4	CH13-311-BH017_RKA CH13-311-BH017_RKB CH13-311-BH017_RKC CH13-311-BH917_RKC	Moisture	Soil	14	Lab Error - Sample Reception: Test missed at the login stage.

No Failure: Six parameters, in two separate instances, were analyzed by ALS within their prescribed HTs but were reported with HT qualification. In both instances, the analysis date was not correctly compared to the sampling date in determination of the holding time exceedance. Revised reports with holding time qualifications removed are available upon request.

Work Order	Samples	Client ID	Analyte	Matrix	ALS HT	Root Cause
L1346114	11,12	CH13-311-BH017_RKA PH5 CH13-311-BH017_RKC PH3	SPLP Hg	Soil	28	No Failure - Reporting Error: Reports can be revised upon request.
L1338656	1-4	CH13-311-BH011_SOA CH13-311-BH011_SOB CH13-311-BH011_SOC CH13-311-BH011_SOD	Moisture		14	

Non-Routine Procedure: For the samples listed in the table below, ALS received soil core tubes which required special handling before moisture testing could be initiated. Samples required Direct Shear Testing through the Golder Associates Laboratory before our testing could be initiated. As a result, holding times could not be met.

Work Order	Samples	Client ID	Analyte	Matrix	ALS HT	Root Cause
L1345512	3,5	CH13-303-BH002_SOC CH13-303-BH002_SOE	Moisture -VA, SK	Soil	14	Non-Routine Procedure Required Prior to Testing

CH2M Hill Quality Assurance Project Plan (QAPP) - Faro Mine: The holding times listed in the Faro Mine QAPP, and agreed to by ALS, were not met for certain parameters. In response, ALS will monitor due dates where QAPP HT < ALS HT, and will ensure the applied sample due date is prior to the QAPP HT expiration dates.

Work Order	Analyte	Matrix	ALS HT	QAPP HT	Root Cause
L1332147	Exchangeable Sodium	Soil	365	28	QAPP HT < ALS Recommended Holding Time: ALS testing prioritization did not account for CH2M Hill QAPP holding times.
L1338738	Paste pH pH 1:2 soil water				
L1346114	Paste pH				
L1351297	pH 1:2 soil water				
L1352327	Paste pH				
L1359691	Paste pH				

Re-testing and Quality Assurance: During the assembly of a final report, quality checks are performed as part of the ALS Quality Assurance program, which can lead to questions about non-conforming data points. The standard response is to confirm validity of the original results through re-testing. It is not uncommon for the re-test to be requested after HTs have expired and may even require the re-tested data to be entered into the report. The table below lists four affected work orders where HT failures occurred as a result of re-testing.

Work Order	Samples	Client ID	Analyte	Matrix	ALS HT	Root Cause
L1356684	28	P03-06-05_GW0813	Alkalinity	Water	14	Retested for Quality Assurance: Retested result replaced the original data point.
L1350226	1	E_204_13_003	TIC			
L1356637	3,9	P03-03-06_GW0813 X21A-96_GW0813	Alkalinity			
L1357022	7	P03-02-05_GW0813	Alkalinity			

Temporary Re-allocation of Testing: The Whitehorse laboratory offers testing for some short holding time parameters. The scope of testing performed by this lab can be affected on short notice. For the samples listed below, the short HT parameters were missed due to the inability of the Whitehorse lab to perform testing at the time of sample receipt. ALS will improve its notification system for temporary Whitehorse testing interruptions, and will inform CH2M Hill when additional lead time will be required to satisfy alternate testing arrangements.

Work Order	Samples	Client ID	Analytes	Matrix	ALS HT	Root Cause
L1347053	1, 2	CH13-204-MW009A_GW0813 CH13-204-MW909A_GW0813	NO2 NO3 PO4	Water	3	Temporary Re-allocation of Testing: Vancouver lab used as an alternate provider during brief Whitehorse outage.

Workload Management Issue: ALS Vancouver relies on a core group of staff which is expanded seasonally to match resource requirements. During the period these samples were received at ALS, workloads for some departments at ALS Vancouver were approaching unexpected record highs at a time when the resources required to accommodate these workloads had not yet been fully mobilized.

As a result, the workload management tools used to prioritize the workloads were not performing as designed due to the backlogged test volumes. Thus, work lists were manually re-sorted during peak workloads to ensure correct prioritization was occurring.

The laboratory is taking other measures to address this gap including the reorganization of our Canadian database and workload management tools, and increased resource management planning.

The table below summarizes the affected samples and tests:

Work Order	Samples	Client ID	Analyte	Matrix	ALS HT	Root Cause
L1335790	8	CH13-204-MW007_SOG	Moisture	Soil	14	Workload Management Issue
L1335880	1, 4-6	CH13-108-TP027_SOA CH13-108-TP025_SOA CH13-108-TP026_SOA CH13-108-TP027A_SOA				
L1335953	1	CH13-108-TP031_SOA				
L1336037	3,4	CH13-311-BH010_SOC CH13-311-BH010_SOD				
L1336054	1-4	CH13-311-BH013_SOA CH13-311-BH013_SOB CH13-311-BH013_SOC CH13-311-BH913_SOB				
L1338657	1	CH13-108-TP032_SOA				
L1338766	1-6	CH13-311-BH015_SOA CH13-311-BH015_SOB CH13-311-BH015_SOC CH13-311-BH015_SOD CH13-311-BH015_SOE CH13-311-BH915_SOC				
L1339332	4	CH13-311-BH012_SOD				
L1348930	1-10	CH13-311-TP006_SOA CH13-311-TP906_SOA CH13-311-TP002_SOA CH13-311-TP003_SOA CH13-311-TP004_SOA CH13-311-TP005_SOA CH13-311-TP902_SOA CH13-311-TP903_SOA CH13-311-TP904_SOA CH13-311-TP905_SOA				
L1353073	6-8	CH13-311-BH004_SOA CH13-311-BH005_SOA CH13-311-BH005_SOB				
L1355921	1,2	CH13-311-BH022_SOA CH13-311-BH022_SOB				
L1338738	1,2	CH13-311-SS001_RKA CH13-311-SS019_RKA	Hg	Soil	28	
L1351297	1-11	CH13-204-MW016E_SOA CH13-204-MW016E_SOB CH13-204-MW016E_SOC CH13-204-MW016E_SOD CH13-204-MW016E_SOE CH13-204-MW016E_SOF CH13-204-MW016E_SOG CH13-204-MW016E_SOH CH13-204-MW016E_SOI CH13-204-MW016E_SOJ CH13-204-MW016E_SOK				

We sincerely apologize for any problems and inconvenience that holding time issues may have caused CH2M Hill. We hope that this letter sufficiently explains how these issues occurred and addresses how ALS plans to ensure that they do not occur again in the future.

Please feel free to contact myself or Joyce Chow if you require any additional information.

Sincerely,

Jerry Holzbecher, B.Sc. Client Services Manager, Vancouver	Joyce Chow, B.Sc. Director, Western Canada

Appendix G
Rapid Geomorphic Assessment Data Sheets

CHANNEL-STABILITY RANKING SCHEME

River VCDC Site Identifier UPSTREAM REACH

Date 8/31/13 Time______ Crew CRIM Samples Taken NO

Pictures (circle) U/S D/S X-section Slope__________ Pattern: Meandering / Straight / Braided

1. Primary bed material

	Bedrock	Boulder/Cobble	Gravel	Sand	Silt Clay	
	0	(1)	2	3	4	1

2. Bed/bank protection

	Yes	No	(with)	1 bank protected	2 banks	
	0	(1)		2	3	1

3. Degree of incision (Relative elevation of "normal" low water; floodplain/terrace @ 100%)

	0-10%	11-25%	26-50%	51-75%	76-100%	
	(4)	~~(3)~~	2	1	0	~~3~~ 4

4. Degree of constriction (Relative decrease in top-bank width from up to downstream)

	0-10%	11-25%	26-50%	51-75%	76-100%	
	0	1	2	3	4	0

5. Stream bank erosion (Each bank)

	None	Fluvial	Mass wasting (failures)	
Left	0	1	2	1
Right	0	1	2	2

6. Stream bank instability (Percent of each bank failing)

	0-10%	11-25%	26-50%	51-75%	76-100%	
Left	0	0.5	1	1.5	2	0
Right	0	0.5	1	1.5	2	1

7. Established riparian woody-vegetative cover (Each bank)

	0-10%	11-25%	26-50%	51-75%	76-100%	
Left	2	1.5	1	0.5	0	0.5
Right	2	1.5	1	0.5	0	1

8. Occurrence of bank accretion (Percent of each bank with fluvial deposition)

	0-10%	11-25%	26-50%	51-75%	76-100%	
Left	2	1.5	1	0.5	0	2
Right	2	1.5	1	0.5	0	2

9. Stage of channel evolution

	I	II	III	IV	V	VI	
	0	1	2	4	3	1.5	4

Figure 1 – Channel stability ranking scheme used to conduct rapid geomorphic assessments (RGAs). The channel stability index is the sum of the values obtained for the nine criterion.

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CHANNEL-STABILITY RANKING SCHEME

River VCDC | Site Identifier DOWNSTREAM REACH

Date 8/31/13 Time PM Crew CRIM Samples Taken No

Pictures (circle) U/S D/S X-section Slope__________ Pattern: Meandering / Straight / Braided

1. Primary bed material

	Bedrock	Boulder/Cobble	Gravel	Sand	Silt Clay	
	0	(1)	2	3	4	1

2. Bed/bank protection

	Yes	No	(with)	1 bank protected	2 banks	
	0	(1)		2	3	1

3. Degree of incision (Relative elevation of "normal" low water; floodplain/terrace @ 100%)

	0-10%	11-25%	26-50%	51-75%	76-100%	
	4	(3)	2	1	0	3

4. Degree of constriction (Relative decrease in top-bank width from up to downstream)

	0-10%	11-25%	26-50%	51-75%	76-100%	
	(0)	1	2	3	4	0

5. Stream bank erosion (Each bank)

	None	Fluvial	Mass wasting (failures)	
Left	0	(1)	2	1
Right	0	(1)	2	1

6. Stream bank instability (Percent of each bank failing)

	0-10%	11-25%	26-50%	51-75%	76-100%	
Left	0	(0.5)	1	1.5	2	0.5
Right	0	(0.5)	1	1.5	2	0.5

7. Established riparian woody-vegetative cover (Each bank)

	0-10%	11-25%	26-50%	51-75%	76-100%	
Left	2	1.5	(1)	0.5	0	1
Right	2	1.5	(1)	0.5	0	1

8. Occurrence of bank accretion (Percent of each bank with fluvial deposition)

	0-10%	11-25%	26-50%	51-75%	76-100%	
Left	(2)	1.5	1	0.5	0	2
Right	(2)	1.5	1	0.5	0	2

9. Stage of channel evolution

	I	II	III	IV	V	VI	
	0	1	2	(4)	3	1.5	4

Figure 1 – Channel stability ranking scheme used to conduct rapid geomorphic assessments (RGAs). The channel stability index is the sum of the values obtained for the nine criterion.

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