Appendix 9

Technical Reports

(Please Note: This Appendix is being provided only in Electronic Version – CD provided in Binders)

Appendix 9a

Waste Dump and Infrastructure Plant Geotechnical – Supplemental (2015) Geotechnical Program (Golder, April 2016)

April 2016

WASTE DUMP/INFRASTRUCTURE GEOTECHNICAL REPORT

Grassy Mountain Project Waste Dump and Infrastructure - Supplemental (2015) Geotechnical Program

Submitted to:
Riversdale Resources Limited

REPORT

Report Number: 1406422

Distribution:

Two copies - Riversdale Resources Limited
One copy - Golder Associates Ltd.

Golder Associates

Executive Summary

Riversdale Resources Limited (Riversdale) commissioned Golder Associates Ltd. (Golder) to provide geotechnical engineering, hydrogeological and hydrological services related to the Grassy Mountain Project Feasibility Study. The Grassy Mountain Property is located in the Crowsnest Pass region of southwest Alberta, about 150 km south of Calgary. The Grassy Mountain surface mine area is about 6.5 km north of the town of Blairmore, Alberta. The mining conditions are expected to be similar to those in the nearby Elk Valley mines (to the west in British Columbia) which are developed using truck and shovel open pit methods.

This report presents the 2015 supplemental geotechnical investigation at the proposed waste dumps (South and North Dumps), plant site infrastructure and sediment and surge pond locations to support the Feasibility Study. The supplemental investigation was necessary following revisions to the mine and surface water management plans following the completion of Golder's 2014 field geotechnical program.

The drilling and test pit program was completed in two parts, between July 20 and 30, 2015 and November 3 and 7, 2015. Thirty-five (35) boreholes and 13 test pits were completed, though several were completed with a hand auger due to restricted access. Also several locations targeted by the investigation were not completed as permission for access could not be obtained. A geotechnical investigation will be required at these sites to support final design. The texture of the overburden is diverse, ranging from silty clay to sandy silt to sand and gravel. Index testing was completed on select samples collected during the field program.

The preliminary stability analyses on three cross sections of the waste dumps were updated to reflect the conditions encountered from the 2015 program. All sections achieve the minimum design factor of safety (FoS).

The encountered subsurface conditions across the plant site were variable with bedrock ranging from at surface to greater than 15.4 m below ground surface (bgs). Based on the geotechnical investigation, shallow or raft foundations on bedrock may be suitable for the following plant site infrastructure elements: coal handling and processing plant, ROM coal sizing station, and mine infrastructure area. Other plant site infrastructure sites, including the surge bin/conveyor system, blending bed and product stockpile pad, encountered bedrock at greater depth and unsuitable soil layers (clay and/or coal); therefore shallow foundations are likely not suitable for these structures. Other potential construction risks include inferred cobbles/boulders, variability in bedrock depth resulting in encountering bedrock shallower or deeper than expected, the possibility of additional undiscovered coal and high plasticity clay layers.

Preliminary plant site design parameters and recommendations, suitable for feasibility stage, are provided for general earthwork construction – cut and fill, backfill materials and compaction, fill settlement and winter earthwork, frost protection, lateral pressures on buried structures, Mechanically Stabilized Earth (MSE) walls, slab on grade floors and guidelines for machine foundations.

The Grassy Mountain Project includes four proposed sediment ponds and four proposed surge ponds. Stability analysis has been conducted for end of construction (undrained), long-term (drained), rapid drawdown and seismic conditions. The minimum design FoS has been achieved for most loading cases considered. For cases where the minimum design FoS was not achieved, design options have been provided that will achieve the required FoS, to be confirmed during detailed design. For the dams that are classified as Significant to High consequence, additional investigation of the subgrade soils is required to support final design.

Study Limitations

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Table of Contents

1.0 INTRODUCTION 1

1.1 Project Description 1

1.2 Previous Work 1

1.3 Scope of Work 1

2.0 SITE INVESTIGATION 2

2.1 Drilling (SPT) and Sampling Program 2

2.2 Test Pit and Sampling Program 5

2.3 Laboratory Testing Program 7

3.0 SUBSURFACE CONDITIONS 7

3.1 General 7

3.2 North External Dump 7

3.3 South External Dump 8

3.4 Plant Site 9

3.4.1 South Waste Dump Toe 10

3.4.2 Plant Site Sediment Pond 10

3.4.3 Product Stockpile 11

3.4.4 Blending Bed 12

3.4.5 Coal Handling and Processing Plant 12

3.4.6 ROM Coal Stockpile / Coal Sizing Station 12

3.4.7 Surge Bins / Conveyor System 12

3.4.8 Mine Infrastructure Area 13

3.5 Raw Water Pond 13

3.6 North West Surge Pond 14

3.7 West Sediment Pond 14

3.8 South West Surge Pond 15

3.9 North East Sediment Pond 15

3.10 East Sediment Pond 16

3.11 South East Surge Pond 16

4.0 WASTE ROCK DUMPS – ANALYSIS AND RECOMMENDATIONS 17
4.1 Design Criteria / Dump Stability Rating 17
4.2 Stability Analysis 17
4.3 Run Out Analysis 23
4.4 Ground Improvement/Construction Recommendations 23
5.0 PLANT SITE INFRASTRUCTURE – RECOMMENDATIONS 24
5.1 Historic Underground Workings 24
5.2 Foundation Alternatives 24
5.3 Deep Foundations 25
5.3.1 Pile Type Alternatives 25
5.3.2 Driven Pile Preliminary Design Values 27
5.3.3 Construction Considerations for Driven Piles 28
5.3.4 Drilled Cast-in-Place Concrete Pile Preliminary Design Values 28
5.3.5 Resistance of Laterally Loaded Piles 30
5.3.6 Pile Groups 31
5.3.6.1 Axial Capacity 31
5.3.6.2 Lateral Capacity 31
5.3.7 Uplift Resistance of Pile Foundations 31
5.3.8 Uplift Forces due to Adfreeze 31
5.4 Raft/Mat Slab 32
5.5 Shallow Foundations 33
5.6 Temporary Excavations 34
5.7 Suitability of Excavated Soils as Fill 35
5.8 Backfill and Fill Materials and Compaction 35
5.9 Fill Settlement 36
5.10 Permanent Cut and Fill Slopes 36
5.11 Winter Earthwork Construction 37
5.12 Frost Protection 37
5.13 Lateral Protection on Buried Structures 38
5.14 Mechanically Stabilized Earth (MSE) Walls 39
5.14.1 Resistance Factors 40

5.14.2 Typical Soil Parameters 40
5.14.3 Foundation Subgrade Preparation 40
5.14.4 Drainage 41
5.14.5 Bearing Capacity 41
5.15 Slab on Grade Floors 41
5.16 Guidelines for Machine Foundations 42
6.0 SEDIMENT AND SURGE PONDS – ANALYSIS AND RECOMMENDATIONS 43
6.1 Dam Classification and Design Criteria 43
6.1.1 Design Criteria 43
6.1.2 Consequence Classification 43
6.1.3 Factor of Safety 44
6.1.4 Seismic Design Criteria 44
6.2 General Dam Design Elements 44
6.2.1 Typical Dam Section 44
6.2.2 Filter Design 48
6.3 Stability Analysis 48
6.3.1 Approach 48
6.3.2 Material Properties 49
6.3.3 Plant Site Sediment Pond 50
6.3.4 West Sediment Pond 50
6.3.5 East Sediment Pond 52
6.3.6 North East Sediment Pond 54
6.3.7 North West Surge Pond 57
6.3.8 South West Surge Pond 60
6.3.9 Raw Water Pond 62
6.3.10 South East Surge Pond 64
6.4 Site Preparation and Construction Recommendations 66
7.0 GEOTECHNICAL INVESTIGATION RECOMMENDATIONS 66
8.0 CLOSURE 67

TABLES

Table 1: As-Built Borehole Coordinates and Drill Depth 3
Table 2: Point Load Test Results 4
Table 3: As-Built Test Pit Coordinates and Excavation Depth 5
Table 4: Uniaxial Compressive Strength Test Results 7
Table 5: Minimum Design FOS(1) - Waste Dump 17
Table 6: Material Parameters for Stability Analysis 18
Table 7: Summary of Slope Stability Analysis Results – Overall (Deep Seated) Stability 19
Table 8: Organic and Potentially Soft Cohesive Soil within the Waste Dump Subsurface 23
Table 9: Advantages and Disadvantages of Pile Types 26
Table 10: Recommended Ultimate Limit State (ULS) Pile Design Parameters for Driven Piles 27
Table 11: Recommended ULS Pile Design Parameters for CIP Concrete Piles 29
Table 12: Soil Parameters for Estimating Lateral Pile Capacity 30
Table 13: Reduction Factors for the Modulus of Subgrade Reaction 31
Table 14: Moduli of Subgrade Reaction for Raft Design 32
Table 15: Preliminary Bearing Capacity for Shallow Foundations 33
Table 16: Estimated Settlement versus Compaction Level 36
Table 17: Lateral Earth Pressure Parameters 39
Table 18: Limit States Design – Resistance Factors for MSE Walls 40
Table 19: Preliminary Soil Parameters for MSE Wall Design 40
Table 20: Preliminary Dam Consequence Classifications(1) 43
Table 21: CDA Earthquake Design Ground Motions 44
Table 22: Granular Filter Design Criteria(1) 48
Table 23: Summary of Material Properties 50
Table 24: Slope Stability Analysis Results – West Sediment Pond 50
Table 25: Slope Stability Analysis Results – East Sediment Pond 52
Table 26: Slope Stability Analysis Results – North East Sediment Pond 54
Table 27: Slope Stability Analysis Results - North East Sediment Pond, with Shear Key 54
Table 28: Slope Stability Analysis Results – North West Surge Pond 57
Table 29: Slope Stability Analysis Results - North West Surge Pond, Removal of Soft Subgrade Soils 57
Table 30: Slope Stability Analysis Results – South West Surge Pond 60
Table 31: Slope Stability Analysis Results – Raw Water Pond 62
Table 32: Slope Stability Analysis Results – South East Surge Pond 64

FIGURES

Figure 1: Site Plan 6
Figure 2: Stability Section A 20
Figure 3: Stability Section B 21
Figure 4: Stability Section C 22
Figure 5: Section – Typical Sediment Pond Dam 46
Figure 6: Section - Typical Surge Pond Dam 47
Figure 7: Stability Section West Sediment Pond 51
Figure 8: Stability Section East Sediment Pond 53
Figure 9: Stability Section North East Sediment Pond 55
Figure 10: Stability Section North East Sediment Pond – Shear Key 56
Figure 11: Stability Section North West Surge Pond 58
Figure 12: Stability Section North West Surge Pond – Removal of Soft Subgrade Soils 59
Figure 13: Stability Section South West Surge Pond 61
Figure 14: Stability Section Raw Water Pond 63
Figure 15: Stability Section South East Surge Pond 65

APPENDICES

APPENDIX A
Golder's Soil Classification System

APPENDIX B
Borehole Records

APPENDIX C
Test Pit Records

APPENDIX D
Laboratory Testing Results

1.0 INTRODUCTION

1.1 Project Description

The Grassy Mountain Property is located in the Crowsnest Pass region of southwest Alberta, about 150 km south of Calgary. The Grassy Mountain surface mine area is about 6.5 km north of the town of Blairmore, Alberta. Historic underground and surface mines exist in the Grassy Mountain area as well as in the adjacent properties. The coal deposit at Grassy Mountain is similar to that at other mountain coal mines in Western Canada. Topography is to moderate to steep, with the attitude of the coal varying from moderate to steeply dipping. The mining conditions are expected to be similar to those in the nearby Elk Valley mines (to the west in British Columbia) which are developed using truck and shovel open pit methods.

1.2 Previous Work

In 2014, Golder conducted a geotechnical investigation for the waste dumps (South and North Dumps) and plant site infrastructure (Golder, 2015a). There are two external (i.e. not in-pit backfill) waste rock dumps: North Dump and South Dump. Dump stability rating and preliminary slope stability analysis were performed for the external dumps. Preliminary plant site design parameters and recommendations were provided for deep and shallow foundations, general earthwork construction – cut and fill, backfill materials and compaction, fill settlement and winter earthwork, frost protection, lateral pressures on buried structures, Mechanically Stabilized Earth (MSE) walls, slab on grade floors and guidelines for machine foundations.

Revisions to the mine plan and further assessment of risk due to historical underground workings occurred after completion of the 2014 investigation. This resulted in changes to the locations of the waste dumps and plant site infrastructure and further geotechnical investigation was recommended at the new proposed waste dump, plant site infrastructure and sedimentation pond locations.

1.3 Scope of Work

Riversdale Resources Limited (Riversdale) commissioned Golder to perform a supplemental geotechnical program to support the Feasibility Study based on the waste dump, plant site and pond layouts shown on Figure 1 and as generally recommended in Golder (2015a). The investigation is preliminary, in support of the Feasibility Study, and it is understood that there will be a final investigation to support detailed design. This report presents the results of the supplemental program.

The scope of work included the following:

- Assessment of the subsurface conditions at the revised dump location, plant site layout and at the sedimentation pond locations.
- Revision of the North Dump and South Dump preliminary slope stability analyses as necessary.
- Revision of the preliminary plant site geotechnical design parameters and recommendations as necessary.
- Completion of preliminary stability analyses for the sediment and surge pond dams.

2.0 SITE INVESTIGATION

2.1 Drilling (SPT) and Sampling Program

A track mounted auger drill rig operated by Val's Drilling was contracted by Riversdale between July 14 and 30, 2015 and again between November 3 and 6, 2015. The drilling in the plant site and waste dump area was completed in two parts, between July 20 and 30, 2015 and November 3 and 7, 2015.

Forty (40) borehole locations were recommended by Golder with input by Sedgman and HMM (Golder, 2015b). In addition, two borehole locations for piezometers at the plant site were recommended by Millenium EMS Solutions Ltd. (MEMS). A total of 35 boreholes were advanced; seven boreholes could not be advanced as permission for access could not be obtained.

The locations for the boreholes were staked by Riversdale. Due to access restrictions, several of the boreholes could only be completed using a 50 mm diameter hand auger.

The target depth of the boreholes varied from 6 m bgs (below ground surface) to 25 m bgs or until refusal. Other than the hand auger holes, boreholes were advanced using 102 mm (4 inch) or 152 mm (6 inch) solid stem augers or 254 mm (10 inch) hollow stem augers. Solid stem was initially attempted however if the borehole was unstable and prone to collapse, the drillers switched to hollow stem and occasionally drilled with the 102 mm solid stem augers inside the hollow stem augers. Boreholes without standpipes were backfilled with cuttings and bentonite upon completion of drilling.

Standard Penetration Tests (SPT) were conducted during drilling to quantify subgrade compactness/stiffness and to collect split spoon samples. SPTs and split spoon samples were collected every 1.5 m. The field engineer also obtained samples from the auger flight if no sample could be retrieved or to collect supplemental samples to better define ground conditions.

Soil samples were visually classified on site using Golder's Soil Classification System (Appendix A). Samples retrieved from the split spoon were measured for recovery length and then immediately bagged and labeled. A total of 227 samples were collected and delivered to the Golder's Calgary geotechnical laboratory for further evaluation and testing as discussed in Section 2.3.

Four boreholes (PZ15-01a and b and PZ15-02a and b) had piezometers installed by MEMS. The boreholes were advanced with solid stem augers until bedrock and then advanced with HQ coring. Installation details are provided in the borehole records (Appendix B).

BH15-15 and BH15-18 to BH15-20 were excavated by shovel to depths between 0.15 m and 0.3 m bgs before striking bedrock or probable bedrock. BH15-03 (HA) and BH15-40 (HA) were advanced by hand auger to depths between 0.17 m and 0.2 m bgs before striking probable bedrock or boulders.

The depth of the boreholes ranged from 0.3 m to 18.6 m bgs (excluding hand excavated locations).

Table 1 provides the location, drilling depth, borehole type of all the borehole sites. Figure 1 presents the site plan with all the borehole sites. The GPS coordinates of the boreholes were measured using a hand-held GPS unit.

Table 1: As-Built Borehole Coordinates and Drill Depth

Borehole Number	Northing[1] (m)	Easting[1] (m)	Hole Depth (m bgs)	Bedrock Depth (m bgs)	Groundwater Depth[2] (m bgs)	Borehole Type	Location
BH15-01	5508267	684485	11.1	10.8	-	SPT	NW Surge Pond
BH15-02	5508219	684433	9.3	7.9	-	SPT	NW Surge Pond
BH15-03 (HA)	5507425	684668	0.2	0.2	-	Hand Auger	West Sed. Pond
BH15-04	5507320	684689	4.8	0.8	-	SPT	West Sed. Pond
BH15-05	5504844	685020	4.6	4.1	-[3]	SPT	SW Surge Pond
BH15-06	5504753	685006	3.1	2.0	-	SPT	SW Surge Pond
BH15-07	5504831	685722	8.5	8.5*	-	SPT	South Dump
BH15-08	5504669	683215	4.0	4.0*	0.8	SPT	South Dump
BH15-09	5504224	686010	10.7	-	8.0	SPT	South Dump
BH15-10	5503838	685581	10.7	10.7*	3.3	SPT	Plant Site
BH15-11	5503630	685604	4.6	1.6	-	SPT	Plant Site
BH15-12	5504058	685322	0.3	0.3	-	Auger	Plant Site
BH15-13	5503989	685231	4.7	-	-	SPT	Plant Site
BH15-14	5503963	685321	3.1	1.8	-	SPT	Plant Site
BH15-15	5504243	685125	0.2	0.2	-	Shovel	Plant Site
BH15-16	5504021	685122	15.4	-	-	SPT	Plant Site
BH15-17	5504044	685011	0.4	0.3	-	SPT	Plant Site
BH15-18	5504043	684983	0.3	0.3*	-	Shovel	Plant Site
BH15-19	5504436	685371	0.2	0.2	-	Shovel	Plant Site
BH15-20	5504511	685416	0.2	0.2	-	Shovel	Plant Site
BH15-21	5503243	685056	7.0	-	1.3	SPT	Plant Site
BH15-22	5503754	684990	9.6	-	8.1	SPT	Plant Site
BH15-23	5503660	684939	11.1	-	9.0	SPT	Plant Site
BH15-24	5503975	685015	0.8	0.8	-	SPT	Plant Site
BH15-25	5503770	685293	12.2	12.2*	6.8	SPT	Plant Site
BH15-26	5503596	685040	9.3	8.5	-	SPT	Plant Site
BH15-28	5504386	685060	2.6	2.0	-	SPT	Plant Site
BH15-29	5510554	687355	5.0	2.1	-	SPT	-
BH15-30	5510663	687396	11.1	9.1	-	SPT	-
BH15-31	5508280	687724	11.1	-	1.5**	SPT	NE Sed. Pond
BH15-32	5508452	687715	11.1	-	6.1**	SPT	NE Sed. Pond
BH15-40 (HA)[4]	5508256	684483	0.2	0.2	-	Hand	North Dump
PZ15-01a	5503690	684792	13.7	7.6	-	SPT and Coring with Piezometer	Plant Site
PZ15-01b	5503690	684792	6.9	N/A	-	Piezometer	Plant Site
PZ15-02a	5503690	684792	18.6	3.3*	-	Auger and Coring with Piezometer	Plant Site
PZ15-02b	5503690	684792	9.1	N/A	0.8	Piezometer	Plant Site

[1] All coordinates are UTM NAD 83 ZONE 11

[2] Depth to water was measured at end of drilling and may not represent actual groundwater level

[3] "-" indicates that bedrock or groundwater was not encountered

[4] Advanced and logged by Riversdale staff and reviewed by the Golder field staff

* Indicates inferred bedrock based on drilling conditions

** Indicates seepage

The texture of the overburden ranged from firm to very stiff silty clay to compact to very dense sand and gravel. The overburden also contained occasional cobbles and boulders which often made drilling difficult. Twenty-six (26) boreholes encountered sandstone/siltstone bedrock or probable bedrock in a depth range of 0.2 m to 12.2 m bgs. Ten boreholes encountered groundwater at a depth range of 0.8 m to 9.0 m bgs. Borehole records are provided in Appendix B.

Bedrock was logged and photographed at site. The bedrock ranged from highly weathered to fresh sandstone to mudstone. The core boxes remain at the Grassy Mountain site and select core samples were brought to Golder's Calgary geotechnical laboratory for further evaluation and testing (Section 2.3).

Point load strength index testing was carried out in the field on select rock cores. The test results are provided in Table 2 and on the borehole records (Appendix B).

Table 2: Point Load Test Results

Borehole	Sample	Depth (m bgs)	Facies	Load Configuration	$I_{s(50)}$ (MPa) *
PZ15-01	PLT1	7.9	Siltstone	Axial	0.2
	PLT2	8.1	Siltstone	Diametral	0.6
	PLT3	8.8	Siltstone/Mudstone	Axial	1.4
	PLT4	8.8	Siltstone/Mudstone	Diametral	2.7
	PLT5	9.4	Siltstone/Mudstone	Diametral	0.6
	PLT6	9.8	Siltstone/Mudstone	Diametral	1.0
	PLT7	11.3	Siltstone	Axial	1.1
	PLT8	11.3	Siltstone	Diametral	5.6
	PLT9	12.2	Siltstone/Mudstone	Axial	0.1
	PLT10	13.1	Siltstone/Mudstone	Diametral	0.3
PZ15-02	PLT1	6.1	Siltstone/Sandstone	Axial	0.5
	PLT2	6.1	Siltstone/Sandstone	Diametral	1.2
	PLT3	9.0	Siltstone/Sandstone	Diametral	2.7
	PLT4	9.0	Siltstone/Sandstone	Axial	2.9
	PLT5	12.2	Siltstone/Sandstone	Axial	6.7
	PLT6	12.2	Siltstone/Sandstone	Diametral	5.9
	PLT7	14.0	Siltstone	Axial	1.3
	PLT8	14.0	Siltstone	Diametral	2.9
	PLT9	18.0	Siltstone/Sandstone	Axial	0.8
	PLT10	18.3	Siltstone/Sandstone	Diametral	3.8
	PLT11	18.3	Siltstone/Sandstone	Axial	2.0

* Point load strength index testing applies to medium strength rock (compressive strength over 15 MPa) and can be very inaccurate for weak rocks. The low results that indicate weak rock are included to provide the complete data set. Point load strength is an index test and should not be used for design or analytical purposes.

2.2 Test Pit and Sampling Program

Between November 5 and 7, 2015, ten test pits were excavated by a private contractor using a track mounted John Deere 160C excavator. The test pit locations were staked in the field by Riversdale. Test pit locations were adjusted in the field by Golder field staff or, where equipment access was restricted, advanced using a 50 mm diameter hand auger. The hand auger holes were advanced and logged by Riversdale staff and checked by the Golder field engineer.

Fifteen (15) test pit locations were recommended by Golder based on the plant site layout and mine plan (Golder, 2015b). Two of the recommended test pits could not be excavated as permission for access could not be obtained.

The target depth for test pits was between 3.0 m and 7.0 m bgs. Test pits were excavated to between 4.7 m and 5.3 m bgs (not including the hand auger holes). TP15-01 (HA), TP15-14 (HA) and TP15-15 (HA) were advanced by hand auger to depths between 0.37 m and 0.5 m bgs before hitting refusal on either bedrock or a boulder.

Soil samples were retrieved from each major lithological unit from the spoil pile created by the excavator. Samples were visually classified on site using Golder's Soil Classification System (Appendix A). A total of 19 samples were submitted to the Golder's Calgary geotechnical laboratory for evaluation and testing as discussed in Section 2.3.

Table 3 provides the location and excavation depth of the test pit sites. Figure 1 presents the site plan with all of the test pit locations. The GPS coordinates of the boreholes were measured using a hand-held GPS unit.

Table 3: As-Built Test Pit Coordinates and Excavation Depth

Test Pit Number	Northing[1] (m)	Easting[1] (m)	Depth (m bgs)	Bedrock Depth (m bgs)	Groundwater Depth[2] (m bgs)	Test Pit Type	Location
TP15-01 (HA)[4]	5508256	684483	0.5	0.5	-[3]	Hand Auger	North Dump
TP15-01a	5509309	684716	4.7	-	-	Excavator	North Dump
TP15-02	5509670	685585	5.0	-	-	Excavator	North Dump
TP15-04	5509110	684624	5.3	-	-	Excavator	North Dump
TP15-05	5508686	684612	4.7	-	-	Excavator	North Dump
TP15-06	5508645	685531	5.0	-	-	Excavator	North Dump
TP15-07	5508405	684624	5.0	-	-	Excavator	North Dump
TP15-08	5508303	684488	5.0	-	-	Excavator	NW Surge Pond
TP15-09	5505343	686257	5.0	-	-	Excavator	South Dump
TP15-10	5505018	686109	5.1	-	-	Excavator	South Dump
TP15-11	5504323	685892	5.0	-	-	Excavator	South Dump
TP15-14 (HA)[4]	5503226	686722	0.4	0.4	-	Hand Auger	South Dump
TP15-15 (HA)[4]	5508292	684544	0.4	0.4	-	Hand Auger	South Dump

[1] All coordinates are UTM NAD 83 ZONE 11

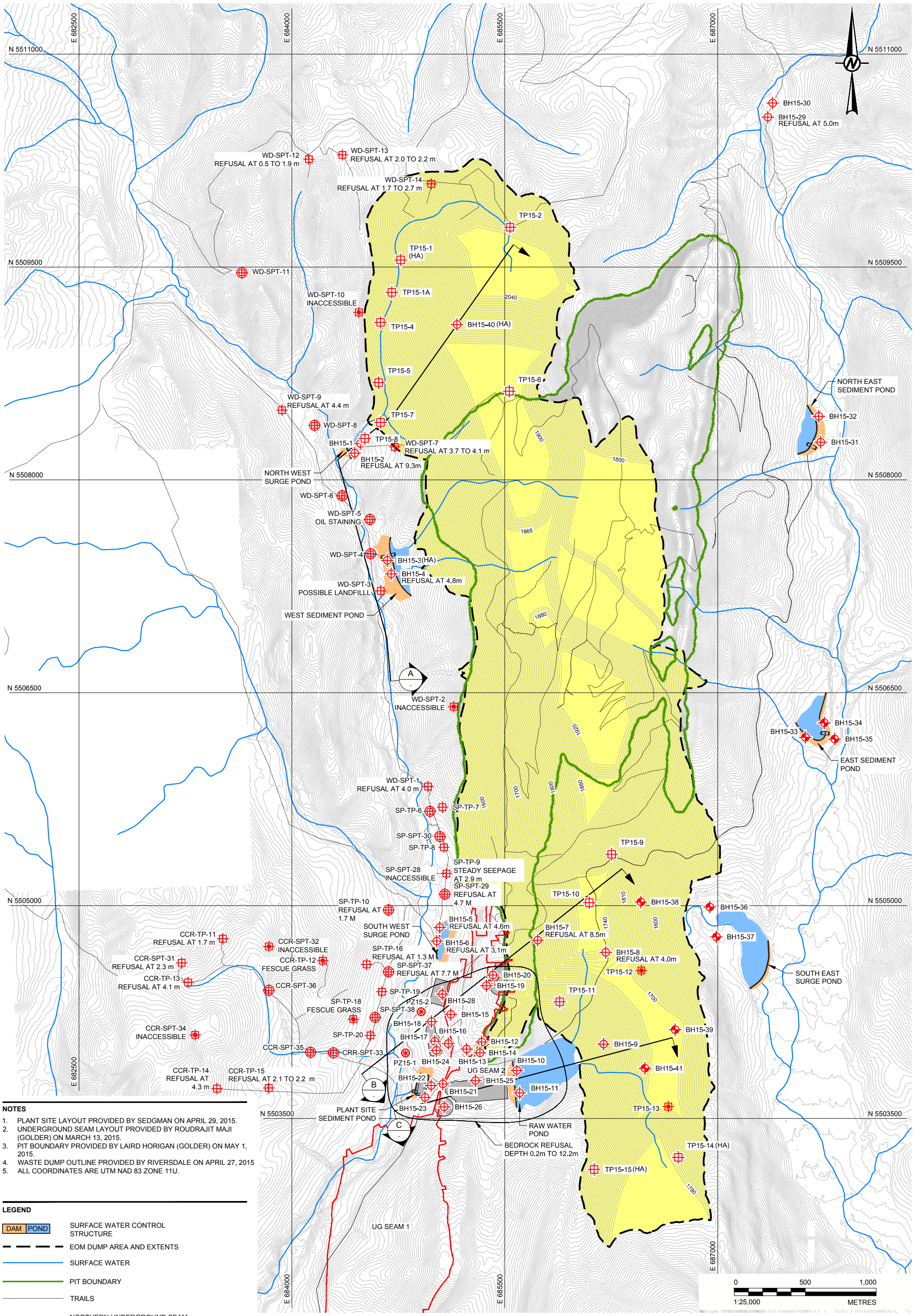
[2] Depth to water was measured at end of excavation and may not represent actual groundwater level

[3] "-" indicates that bedrock or groundwater was not encountered

[4] Advanced and logged by Riversdale staff and reviewed by the Golder field staff

The texture of the overburden ranged from silty clay to sand and gravel with occasional cobbles and boulders. Probable bedrock or boulders were encountered at three locations at depths between 0.37 m and 0.5 m bgs. None of the test pits encountered groundwater or seepage. Test pit records are provided in Appendix C.

Path: \\golder.gds\calgary\EDCAD\2014\1406422\PRODUCTION\FIGURES\ | File Name: 1406422FG030.dwg



NOTES

1. PLANT SITE LAYOUT PROVIDED BY SEDGMAN ON APRIL 29, 2015.
2. UNDERGROUND SEAM LAYOUT PROVIDED BY ROUDRAJIT MAJI (GOLDER) ON MARCH 13, 2015.
3. PIT BOUNDARY PROVIDED BY LAIRD HORIGAN (GOLDER) ON MAY 1, 2015.
4. WASTE DUMP OUTLINE PROVIDED BY RIVERSDALE ON APRIL 27, 2015
5. ALL COORDINATES ARE UTM NAD 83 ZONE 11U.

LEGEND

- DAM | POND — SURFACE WATER CONTROL STRUCTURE
- EOM DUMP AREA AND EXTENTS
- SURFACE WATER
- PIT BOUNDARY
- TRAILS
- NORTHERN UNDERGROUND SEAM
- PIEZOMETER
- SPT BOREHOLE
- TEST PIT
- TEST PIT NOT COMPLETED
- BOREHOLE NOT COMPLETED
- (HA) — HAND AUGER (IF NO OTHER OPTION)

CLIENT
RIVERSDALE RESOURCES LIMITED
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CONSULTANT
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YYYY-MM-DD	2016-01-08
PREPARED	TF
DESIGN	RA/KM
REVIEW	RA
APPROVED	AH/ASK

PROJECT
GRASSY MOUNTAIN COAL PROJECT

TITLE
SITE PLAN SUPPLEMENTAL (2015) GEOTECHNICAL INVESTIGATION WASTE DUMP AND INFRASTRUCTURE

PROJECT No.	CONTROL	Rev.	FIGURE
1406422		A	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25 mm
0

2.3 Laboratory Testing Program

Samples were delivered to Golder's Calgary geotechnical laboratory. Testing was completed on select overburden and bedrock samples collected during the test pit and drilling programs. Laboratory testing included Atterberg limits, water content, particle size analysis and unconfined compressive strength (UCS) testing on bedrock core. The laboratory test results are provided on the test pit and borehole records (Appendix C and B) and individually in Appendix D. The UCS test results are provided in Table 4.

Table 4: Uniaxial Compressive Strength Test Results

Borehole	Core No.	Depth (m bgs)	Facies	Peak Load (MPa)
PZ15-01	RC9	11.0	Siltstone	7.6
PZ15-01	RC13	12.8	Siltstone/Mudstone	1.0
PZ15-02	RC9	8.5	Siltstone/Sandstone	9.4
PZ15-02	RC23	17.1	Siltstone/Sandstone	42.3

3.0 SUBSURFACE CONDITIONS

3.1 General

The Grassy Mountain Project is located within an area subject to glacial ice sheet movement in which a U-shaped valley was formed and moraines were deposited.

The bedrock in this region is dominated by the Mist Mountain Formation of the Kootenay Group, which was deposited within a broad coastal plain environment on the western margin of the Fernie Sea during the Columbian Orogeny. This formation consists of thick-bedded fine to course-grained, cherty sandstone inter-bedded with dark grey shale, siltstone and coal (Hamilton et al., 1999).

The Mist Mountain Formation is overlain unconformably by thick-bedded to massive conglomerate of the Cadomin Formation at the base of the Blairmore Group.

Quaternary moraine tills of uneven thickness forming hummocky terrain are common in the Grassy Mountain area along with minor fluvial deposits ranging from coarse stream alluvium to fine sediments of fine sand, silt and clay composition (Shetsen, 1987). Colluvium reflecting the underlying bedrock is also common in the Grassy Mountain area (Bayrock et. al., 1975).

3.2 North External Dump

Six test pits (TP15-01A, TP15-02, TP15-04 to 07) and two hand auger holes (TP15-01 (HA) and BH15-40 (HA)) were advanced within the footprint of the North Dump (Figure 1) during the 2015 geotechnical program. Two test pits (WD-SPT-07 and 14) were advanced within the footprint of the North Dump in the 2014 geotechnical program. The subsurface conditions are inferred from the test pits and hand auger holes. Subsurface conditions will vary between and beyond the investigation locations. The conditions at the toe of the north external dump are described in Section 3.6.

A simplified stratigraphy is shown on the analytical sections in Section 4.2 (Figure 2) and described in more detail below:

Topsoil - Organic Silt to Silty Sand Trace Organics: A surficial layer between 0.02 m and 0.6 m thick of dark brown to dark grey to black organic silt to sandy organic silt to silty sand, trace organics was encountered at ground surface at all investigation locations. Hand auger hole BH15-40 (HA) terminates in this layer after encountering bedrock at 0.2 m bgs. No laboratory testing was conducted on this material.

Silty Sand to Gravelly Sand: Silty sand to gravelly silty sand to gravelly sand was encountered underlying the organic silt in all investigation locations except TP15-07 and BH15-40 (HA). The brown non-cohesive deposit contains cobbles and boulders and is moist becoming wet below 2.9 m to 4.5 m bgs. The natural water content measured in samples described as wet are between 14% and 17%. The layer had a loose to compact consistency. TP15-01 (HA) terminated in this layer after encountering bedrock or a boulder at 0.5 m bgs. TP15-01 (HA), 02, 05 and 06 terminate in this layer after penetrating 4.1 m to 4.8 m and reaching target excavation depth. The thickness of this layer varies between 0.4 m and greater than 4.8 m.

Sandy Clayey Silt: Grey to brown sandy clayey silt, trace to some gravel was encountered in TP15-07 under the organic silt at 0.15 m bgs and in TP15-04 under the silty sand at 1.6 m bgs. The layer thickness ranged from 0.85 m to 3.3 m. Natural water content of 19% was measured in a sample from this deposit. The sandy clayey silt had a firm consistency. Cobbles/boulders were encountered in TP15-07.

Silty Clay to Sandy Silty Clay: Grey silty clay, some sand, trace gravel to sandy silty clay was encountered below the sandy clayey silt at 1.0 m to 4.9 m bgs in TP15-07 and TP15-04. Both test pits reached target excavation depth in this layer and terminated. Natural water content of 11% was measured in a sample from this deposit. The silty clay to sandy silty clay had a stiff consistency. Cobbles/boulders were encountered in TP15-07 in this layer.

Bedrock: Inferred bedrock and/or cobbles/boulders were encountered at 0.2 m to 0.4 m bgs in hand auger holes (TP15-01 (HA) and BH15-40 (HA)). Bedrock was encountered at 0.7 m bgs and 3.7 m bgs in the 2014 test pits and the excavators were able to excavate up to an additional 2.0 m into the weak sandstone/siltstone bedrock prior to refusal. The 2015 test pits did not encounter bedrock. Based on the investigation, bedrock is shallower from the centre to north east edge of the North External Dump.

Groundwater: Groundwater and/or seepage was not encountered.

3.3 South External Dump

Three test pits (TP15-09 to 11), two hand auger holes (TP15-14 (HA) and 15 (HA)) and three boreholes (BH15-07 to 09) were advanced within the footprint of the South Dump (Figure 1) in the 2015 geotechnical program. The subsurface conditions are inferred from the test pits, hand auger holes and boreholes. Subsurface conditions will vary between and beyond the investigation locations.

The simplified stratigraphy is shown on the analytical sections in Section 4.2 (Figure 3 and Figure 4) and described in more detail below:

Fill: Coal waste/soil fill was encountered at ground surface in BH15-07. The fill layer is 7.8 m thick and is described as dry, containing inferred cobbles/boulders. SPT values indicate a loose to dense relative density, with density increasing with depth. Laboratory testing was not conducted on samples of this material.

Organic Silt to Clayey Organic Silt: A surficial 0.1 m to 0.6 m thick layer of black to brown organic clayey silt to organic silt was encountered at all locations except BH15-07 and BH15-09. Laboratory testing was not conducted on samples of this material. Hand auger hole TP15-14 (HA) terminated in this layer due to possible bedrock/boulders at 0.4 m bgs.

Sandy Clayey Gravel to Sandy Silt: A deposit of non-cohesive sandy clayey gravel to gravelly clayey sand to sand and gravel to gravelly silty sand to sandy silt colluvium was encountered in all boreholes, test pits and hand auger hole TP15-15 (HA). The deposit was encountered at ground surface or underlying either the organic silt to clayey organic silt at 0.05 m to 0.6 m bgs, except for BH15-07, where it is encountered below fill at 7.8 m bgs. The deposit is brown to grey, contains cobbles and inferred cobbles/boulders at multiple depths and SPT values indicate a compact to very dense relative density, generally increasing with depth. The natural water content varies between 5% and 20%, generally increasing with depth. The deposit is 0.4 m to 10.4 m thick. TP15-15 (HA) terminated in this layer due to possible bedrock/boulders at 0.4 m bgs. Only TP15-11 does not terminate in this material. All other boreholes and test pits terminated in this deposit either due to refusal (inferred bedrock) at 4.0 m to 10.7 m bgs or target excavation depth.

Silty Clay: Silty clay, some sand, containing boulders/cobbles was only encountered in TP15-11 (west side of South Dump – Figure 1). The dark grey silty clay layer has low plasticity and a firm to stiff consistency. The natural water content on a single sample was 10%. TP15-11 terminates in the silty clay after penetrating it for 3.5 m from 1.5 m bgs.

Bedrock: Bedrock was inferred at 0.4 m bgs in hand auger holes (TP15-14 (HA) and 15 (HA)) and bedrock was inferred at 4.0 m and 8.5 m bgs in boreholes (BH15-07 and 08). BH15-09 terminated due to refusal in very dense soil conditions at 10.7 m bgs and bedrock was not inferred at that location.

Groundwater: Groundwater was measured at 0.8 m bgs during drilling in BH15-08. Groundwater or seepage was not encountered at other investigation locations. The water levels in the open boreholes did not stabilize. Water levels are expected to fluctuate seasonally in response to changes in precipitation and snow melt.

3.4 Plant Site

Twenty-two (22) boreholes (BH15-10 to 26, 28, PZ15-01a,b and 02a,b) were advanced around the plant site in the 2015 geotechnical investigation. The subsurface conditions for the plant site infrastructure are inferred from the boreholes. Subsurface conditions will vary between and beyond the investigation locations.

Standpipe piezometers PZ15-01a,b and 02a,b were installed for environmental monitoring by MEMS and are not associated with specific plant site infrastructure subsurface conditions. Groundwater was measured at 7.6 m and 1.7 m bgs respectively in readings by Golder shortly after installation. The water levels in the piezometers had not stabilized and were not monitored by Golder following installation.

In general, the main deposit encountered in the subsurface is non-cohesive gravelly clayey sand to sandy clayey gravel. The depth to bedrock is variable, ranging from 0.2 m bgs to greater than 15 m bgs. Groundwater was typically not encountered during drilling or excavation. However, groundwater was encountered in three locations at around 2 m bgs.

The conditions at the plant site are variable and therefore are described for specific plant site infrastructure elements in the following sections.

- Section 3.4.1 South Waste Dump Toe (BH15-12, 13 and 14)
- Section 3.4.2 Plant Site Sediment Pond (BH15-22 and 23)
- Section 3.4.3 Product Stockpile (BH15-21 and 25)
- Section 3.4.4 Blending Bed (BH15-26)

- Section 3.4.5 Coal Handling and Processing Plant (BH15-17, 18 and 24)
- Section 3.4.6 ROM Coal Stockpile / Coal Sizing Station (BH15-19 and 20)
- Section 3.4.7 Surge Bins / Conveyor System (BH15-15 and 16)
- Section 3.4.8 Mine Infrastructure Area (BH15-28)

3.4.1 South Waste Dump Toe

Three boreholes (BH15-12, 13 and 14) were advanced in the plant site between the ROM Coal Stockpile, Product Stockpile and Coal Handling and Processing Plant near the toe of the proposed South External Dump. The interpreted stratigraphy is described below:

Clayey Sand (Fill) to Clayey Sand: Native and fill clayey sand was encountered as a surficial layer over shallow bedrock in BH15-12 and 14. The clayey sand layer varies between 0.3 m and 1.8 m thick. SPT values at the interface between clayey sand and bedrock suggest a hard consistency. Natural water content measured from samples varies from 5% to 6%. An Atterberg limits test measured a liquid limit of 28 and plastic limit of 16.

Clayey Gravel and Sand to Gravelly Clayey Sand: Non-cohesive clayey gravel and sand to gravelly clayey sand was encountered in BH15-13 at ground surface to borehole termination at 4.7 m bgs. A coal layer was encountered in this deposit. SPT values indicate a loose relative density above the coal layer and a very dense relative density below the coal layer. Natural water content of 6% was measured from samples from this layer.

Gravelly Silty Coal: Gravelly silty coal was encountered in the clayey gravel and sand to gravelly clayey sand at 2.0 m bgs in BH15-13. The gravelly silty coal is non-cohesive and 1.2 m thick. Laboratory testing was not conducted on samples from this layer.

Bedrock: Bedrock was encountered at 0.3 m bgs and 1.8 m bgs in BH15-12 and 14. BH15-14 was advanced 1.3 m through grey-brown bedrock. Bedrock was not encountered in BH15-13, and the borehole terminated due to refusal at 4.7 m bgs.

Groundwater: Groundwater was not encountered.

3.4.2 Plant Site Sediment Pond

Two boreholes (BH15-22 and 23) were advanced at the plant site sediment pond site. The interpreted stratigraphy is described below:

Gravelly Silty Sand and Coal: Gravelly silty sand and coal was encountered at ground surface in BH15-22. The layer is 3.5 m thick and SPT values indicate a very loose to loose relative density. Laboratory testing was not conducted on samples from this layer.

Sandy Silty Clay to Silty Clay: Sandy silty clay to silty clay of medium plasticity containing some fine to coarse gravel was encountered underlying the gravelly silty sand and coal layer in BH15-22 at 3.5 m bgs. The silty clay deposit is 5.0 m thick and SPT values indicate a firm to very stiff consistency, generally increasing with depth. Natural water content measured from samples from this layer range from 15% to 17%, decreasing with depth. The Atterberg limits test measured liquid limits of 34 to 41 and plastic limit of 17.

Gravelly Clayey Sand to Sandy Clayey Gravel: Gravelly clayey sand to sandy clayey gravel was encountered in both boreholes BH15-22 and 23. This deposit was encountered underlying the silty clay deposit at 8.5 m bgs in BH15-22. BH15-22 terminated in this deposit due to refusal at 9.6 m bgs. This deposit was encountered from ground surface in BH15-23. BH15-23 terminated in this deposit at 11.1 m bgs due to difficulty advancing due to potential hole deviation. Inferred cobbles and boulders are present in this deposit at various depths. SPT values indicate a compact to very dense relative density. Natural water content measured from samples from this deposit range from 7% to 14%. An Atterberg limits test on the fines fraction measured a liquid limit of 31 and a plastic limit of 15.

Bedrock: Bedrock was not encountered in the boreholes.

Groundwater: Groundwater was measured at 8.1 m bgs and 9.0 m bgs during drilling. The water levels in the open boreholes had not stabilized. Water levels are expected to fluctuate seasonally in response to changes in precipitation and snow melt.

3.4.3 Product Stockpile

Two boreholes (BH15-21 and 25) were advanced at the stockpile site. The interpreted stratigraphy is described below:

Gravelly Silty Sand: A layer of gravelly silty sand containing coal 1.2 m thick was encountered at ground surface in BH15-21. Samples of this layer were not collected.

Clayey Sand to Gravelly Clayey Sand: Clayey sand to gravelly clayey sand underlies the gravelly silty sand in BH15-21 at 1.2 m bgs. The deposit is 3.4 m thick and SPT values indicate a stiff consistency. Natural water content measured from samples from this layer range from 15% to 19%.

Clayey Gravel and Sand to Gravelly Clayey Sand: Clayey gravel and sand to gravelly clayey sand was encountered in both BH15-21 and BH15-25. The deposit was encountered at ground surface extending 9.6 m bgs in BH15-25. In BH15-21 the deposit was encountered at 4.6 m bgs and terminated by refusal at 7.0 m bgs. Auger grinding and inferred cobbles/boulders were observed at multiple depths in the deposit. SPT values indicate a compact to dense relative density, generally increasing with depth. Natural water content measured from samples from this layer range from 11% to 13%.

Clay Interlayer: A high plasticity clay interlayer 0.5 m thick was encountered in BH15-25 at 4.7 m bgs in the gravelly clayey sand deposit. A sample of the clay interlayer had a measured natural water content of 19%, liquid limit of 62 and a plastic limit of 21.

Gravelly Silty Clay: A gravelly silty clay layer of low plasticity was encountered at 9.6 m bgs underlying the gravelly clay and sand in BH15-25. The gravelly silty clay layer is 2.6 m thick and SPT values indicate a hard consistency. The natural water content measured from a sample from this layer is 15%. An Atterberg limits test measured a liquid limit of 27 and a plastic limit of 17.

Bedrock: Possible sandstone bedrock was encountered at 12.2 m bgs in BH15-25. A split spoon sample was advanced 25 mm into the possible bedrock. Bedrock was not encountered in BH15-21.

Groundwater: Groundwater was measured at 1.3 m bgs and 6.8 m bgs in BH15-21 and BH15-25 respectively during drilling. The water levels in the open boreholes had not stabilized. Water levels are expected to fluctuate seasonally in response to changes in precipitation and snow melt.

3.4.4 Blending Bed

One borehole (BH15-26) was advanced at the site of the Blending Bed. The interpreted stratigraphy is described below:

Clayey Gravel and Sand to Gravelly Clayey Sand: BH15-26 encountered this deposit from ground surface and advanced 8.5 m through this deposit and a coal layer before encountering bedrock. Cobbles and boulders were inferred in this deposit at various depths. SPT values indicate a loose to compact relative density above the coal layer. SPT values indicate a very dense relative density below the coal layer. Natural water content measured from samples from this layer range from 4% to 12%, generally decreasing with depth.

Coal: A layer of coal 1.1 m thick was encountered in the gravelly clayey sand deposit in BH15-26 at 4.1 m bgs. Laboratory testing was not conducted on the sample from this layer.

Bedrock: Bedrock was encountered at 8.5 m bgs in BH15-26. BH15-26 was advanced 0.7 m into the grey sandstone bedrock.

Groundwater: Groundwater was not encountered.

3.4.5 Coal Handling and Processing Plant

Three boreholes (BH15-17, 18 and 24) were advanced at the coal handling and processing plant site. The interpreted stratigraphy is described below:

Clayey Sand to Silty Clay and Sand to Gravelly Clayey Sand: A surficial layer of soil was encountered at ground surface overlying shallow bedrock. A 0.3 m thick layer of cohesive clayey sand to silty clay and sand was encountered along the northern part of the coal handling and processing plant site (BH15-17 and 28). Non-cohesive 0.8 m thick gravelly clayey sand was encountered on the south edge of the coal handling and processing plant site (BH15-24). The SPT value indicates a compact relative density in the surficial non-cohesive deposit. Natural water contents measured in samples of the surficial soil range from 7% to 10%.

Bedrock: Bedrock was encountered at 0.3 m bgs and 0.8 m bgs. BH15-17 was advanced 0.1 m through the grey sandstone bedrock.

Groundwater: Groundwater was not encountered.

3.4.6 ROM Coal Stockpile / Coal Sizing Station

Two boreholes (BH15-19 and 20) were advanced by hand excavation around the ROM Coal Stockpile site. The interpreted stratigraphy is described below:

Sandy Silty Clay: A surficial 0.2 m thick layer of sandy silty clay containing trace to some gravel and rootlets was encountered at ground surface. Natural water content measured in samples of this deposit range from 7% to 10%.

Bedrock: Bedrock was encountered at 0.2 m bgs.

Groundwater: Groundwater was not encountered.

3.4.7 Surge Bins / Conveyor System

Two boreholes (BH15-15 and BH15-16) were advanced around the surge bin site area and along the conveyor system that will carry raw coal to the coal handling and processing plant. The interpreted stratigraphy is described below:

Gravelly Clayey Sand to Sandy Clayey Gravel: Gravelly clayey sand to sandy clayey gravel was encountered in both BH15-15 and BH15-16. BH15-15 was hand excavated and terminated after encountering bedrock at 0.2 m bgs. BH15-16 was advanced 15.4 m through the sand and gravel and was terminated due to refusal at target depth. Inferred cobbles and boulders were encountered at multiple depths in BH15-16. SPT values in BH15-16 indicate loose to compact relative density above the coal layer and compact to dense relative density below the coal layer. Natural water content measured in samples of this deposit range from 4% to 10%.

Coal: A 0.8 m thick coal layer was encountered in BH15-16 in the gravelly clayey sand to sandy clayey gravel deposit at 6.4 m bgs. Samples were not collected from this layer.

Bedrock: Bedrock was encountered at 0.2 m bgs in BH15-15. Bedrock was not encountered in BH15-16.

Groundwater: Groundwater was not encountered.

3.4.8 Mine Infrastructure Area

One borehole (BH15-28) was advanced in the mine infrastructure area. The interpreted stratigraphy is described below:

Silty Clay and Sand: A 2.0 m thick layer of cohesive silty clay and sand, trace gravel was encountered at ground surface. The SPT value suggests a hard consistency. The natural water content measured from a sample is 6%.

Bedrock: Bedrock was encountered at 2.0 m bgs. BH15-28 was advanced 0.6 m into grey sandstone bedrock.

Groundwater: Groundwater was not encountered.

3.5 Raw Water Pond

Two boreholes (BH15-10 and 15-11) were advanced at the raw water pond site. The subsurface conditions are inferred from the boreholes and will vary between and beyond the investigation locations. The simplified interpreted stratigraphy is shown on the analytical sections in Section 6.3.9 (Figure 14) and is described in more detail below:

Organic Silty Sand to Gravelly Silty Sand: A 0.8 m to 1.6 m thick organic silt sand to gravelly silt sand was encountered at ground surface. The relative density of the layer was observed to be very loose. Laboratory testing was not conducted on samples from this layer.

Clayey Gravel and Sand to Clayey Sand: A clayey gravel and sand to clayey sand layer was encountered at 0.8 m bgs in BH15-10 underlying the organic silt sand. Cobbles and boulders were inferred at multiple depths and some coal was encountered at 6.6 m bgs. The SPT values indicate loose to very dense relative density, increasing with depth. BH15-10 terminates at 10.8 m bgs after refusal (inferred bedrock). The natural water content of the deposit varies between 11% and 13%.

Bedrock: Bedrock was inferred at 1.6 m and 10 m bgs (BH15-11 and 10, respectively). BH15-11 was advanced another 1.4 m into the grey sandstone until 3.0 m bgs. The bedrock was encountered at 4.1 m and 2.0 m bgs. A natural water content of 4% was measured in a sample from the bedrock.

Groundwater: Groundwater was measured at 3.3 m bgs in BH15-10 and was not encountered in BH15-11. The water levels in the open boreholes had not stabilized. Water levels are expected to fluctuate seasonally in response to changes in precipitation and snow melt.

3.6 North West Surge Pond

Two boreholes (BH15-01 and 02) and test pit TP15-08 were advanced at the north west (NW) surge pond site. The subsurface conditions are inferred from the test pits and boreholes and will vary between and beyond the investigation locations. The simplified interpreted stratigraphy is shown on the analytical sections in Section 6.3.7 (Figure 11) and is described in more detail below:

Organic Silt: A surficial layer of dark brown sandy organic silt to dark grey organic silt with thickness of 0.02 m to 0.2 m was encountered at ground surface at all investigation locations. Laboratory testing was not conducted on samples from this layer.

Sand and Gravel to Silty Sand: A sand and gravel to silty sand layer with thickness 1.8 m to 2.7 m was encountered on upstream (east) side of the NW surge pond, underlying the surficial organic silt in TP15-08 and BH15-01. The deposit is brown and SPT values indicate a loose relative density. Cobbles and boulders were encountered in this layer in TP15-08. Laboratory testing was not conducted on samples from this layer.

Clayey Silt to Silty Clay: The clayey silt to silty clay deposit contains some sand and trace to some gravel, along with observed and inferred cobbles/boulders at multiple depths at all investigation locations. The silt/clay deposit was encountered between 2.0 m and 2.7 m bgs below the sand and gravel to silty sand and at 0.02 m bgs below the organic silt in BH15-02 (furthest west). The deposit is brown, becoming grey below 3.7 m bgs in TP15-08 and BH15-02 and SPT values indicate firm to very stiff consistency, increasing in stiffness with depth. Natural water content varies from 7% to 18%, generally decreasing with depth. The Atterberg limits test measured liquid limits of 30 to 33 and plastic limits of 15 to 16. The layer is between 6.8 m and 7.2 m thick in the boreholes. TP15-08 terminates (reached target depth) in the cohesive deposit at 5.0 m bgs (thickness extending at least 3.0 m). BH15-02 encountered bedrock below the cohesive deposit at 7.9 m bgs.

Gravelly Sand Interlayer: A brown gravelly sand 0.4 m thick interlayer was encountered in TP15-08 in the cohesive clayey silt to silty clay deposit. The natural water content of a sample of this material is 13%.

Lower Silty Sand: A non-cohesive silty sand with some gravel was encountered underlying the clayey silt to silty clay deposit in BH15-01 at 9.5 m bgs. The layer is 1.3 m thick and SPT values indicate very dense relative density. No laboratory testing was conducted on samples from this layer. The silty sand overlies highly weathered sandstone bedrock at 10.8 m bgs.

Bedrock: Bedrock was encountered in BH15-01 and BH15-02 at 10.8 m and 7.9 m bgs respectively. The boreholes were advanced 0.3 m and 1.4 m respectively through highly weathered, very weak, grey sandstone bedrock until reaching target depth. A natural water content of 5% was measured in a sample from the bedrock.

Groundwater: Groundwater and/or seepage was not encountered.

3.7 West Sediment Pond

One hand auger hole and one borehole (BH15-03 (HA) and 04, respectively) were advanced at the west sediment pond site. The subsurface conditions are inferred from the hand auger hole and borehole and will vary between and beyond the investigation locations. The simplified interpreted stratigraphy is shown on the analytical sections in Section 6.3.4 (Figure 7) and described in more detail below:

Silty Sand: A 0.2 m to 0.3 m surficial layer of brown silty sand containing organic soil and rootlets was encountered in both holes. BH15-03 terminated upon encountering bedrock at 0.2 m bgs. Silty sand with some gravel containing cobbles was encountered at 0.3 m bgs with a thickness of 0.5 m in BH15-04. Laboratory testing was not conducted on samples from this layer.

Bedrock: Bedrock or a boulder was encountered at 0.2 m bgs in BH15-03. Bedrock was encountered at 0.8 m bgs in BH15-04. BH15-04 was advanced through highly weathered, extremely weak, brown sandstone for another 4.0 m before terminating by refusal. A natural water content of 5% was measured in a sample from the bedrock.

Groundwater: Groundwater and/or seepage was not encountered.

3.8 South West Surge Pond

Two boreholes (BH15-05 and 06) were advanced at the south west (SW) surge pond site. The subsurface conditions are inferred from the test pits and boreholes and will vary between and beyond the investigation locations. The simplified interpreted stratigraphy is shown on the analytical sections in Section 6.3.8 (Figure 13) and described in more detail below:

Clayey Sand and Gravel: A 2.0 m to 4.1 m thick deposit of non-cohesive clayey sand and gravel containing inferred cobbles and boulders at multiple depths was encountered at ground surface at both investigation locations. The SPT values indicate compact to dense relative density, increasing in density with depth. The natural water content of the deposit varies between 6% and 26%, generally decreasing with depth.

Bedrock: Bedrock was encountered at 4.1 m and 2.0 m bgs. The boreholes were advanced through grey sandstone until 4.6 m and 3.1 m bgs.

Groundwater: Groundwater and/or seepage was not encountered.

3.9 North East Sediment Pond

Two boreholes (BH15-31 and 32) were advanced at the north east (NE) sediment pond site. The subsurface conditions are inferred from the boreholes and will vary between and beyond the investigation locations. The simplified interpreted stratigraphy is shown on the analytical sections in Section 6.3.6 (Figure 9) and described in more detail below:

Organic Silt: A surficial layer of dark brown organic silt with thickness of 0.02 m to 0.46 m was encountered at ground surface.

Gravelly Sand to Sand and Gravel: Underlying the organic silt, gravelly sand to sand and gravel extend to 2.1 m bgs with thickness between 1.6 m and 2.1 m. Possible boulders/cobbles were encountered in this deposit in BH15-31. The deposit is brown and SPT values indicate loose to compact relative density. Natural water content varied from 11% to 21%.

Silty Clay to Sandy Silty Clay: A silty clay to sandy silty deposit was encountered at 2.1 m bgs. The deposit is grey and SPT values suggest a firm to stiff consistency. BH15-32 terminated in stiff silty clay at target borehole depth (11.1 m bgs). Natural water content in the deposit varies from 13% to 25%. An Atterberg limits test measured liquid limit of 37 and plastic limit of 16.

Silty Sand to Silt Interlayer: A 3.6 m thick interlayer of non-cohesive silty sand to silt was encountered in BH15-32 at 3.1 m bgs. The grey interlayer SPT values indicate a very loose to loose relative density. Natural water content in the interlayer varies from 17% to 25%, generally increasing with depth.

Lower Gravelly Sand: BH15-31 terminates in grey gravelly sand deposit at the target borehole depth (11.1 m bgs). The gravelly sand underlies the silty clay deposit at 9.1 m bgs. SPT values indicate a compact relative density. Natural water content varies from 16% to 28%, decreasing with depth.

Bedrock: Bedrock was not encountered.

Groundwater: Seepage into BH15-31 was observed at 1.5 m bgs. Other groundwater or seepage was not encountered. The water levels in the open boreholes had not stabilized. Water levels are expected to fluctuate seasonally in response to changes in precipitation and snow melt.

3.10 East Sediment Pond

Golder was unable to excavate test pits at the east sediment pond site as permission for access could not be obtained. The East Sediment pond is located approximately 2 km south of the NE sediment pond. Ground conditions have been inferred from the conditions encountered at the NE sediment pond site as they are located along the same watercourse. In the absence of a site investigation, assumed simplified ground conditions are:

1) 2.0 m loose to compact sand and gravel

2) 9.0 m firm to stiff clayey silt over deep bedrock

3) Groundwater table at 2 m bgs

The inferred stratigraphy is shown on the analytical sections in Section 6.3.5 (Figure 8).

A detailed geotechnical investigation will be required at the site of the East Sediment Pond to support final design.

3.11 South East Surge Pond

Golder was unable to excavate test pits at the planned investigation locations at the south east (SE) surge pond site as permission for access could not be obtained. Adjacent borehole and test pit locations intended to investigate the eastern portion of the South External Dump were also inaccessible. Therefore, ground conditions have been inferred from the South West Surge Pond and Raw Water Pond on west side of the South External Dump based on similar site elevations. In the absence of a site investigation, the assumed simplified ground conditions are:

1) Approximately 5.0 m thickness of compact to dense gravelly sandy clay

2) Weathered, weak sandstone/siltstone bedrock

3) Groundwater table at about 2 m bgs

The inferred stratigraphy is shown on the analytical sections in Section 6.3.10 (Figure 15).

A detailed geotechnical investigation will be required at the site of the South East Surge Pond to support final design.

4.0 WASTE ROCK DUMPS – ANALYSIS AND RECOMMENDATIONS

4.1 Design Criteria / Dump Stability Rating

The North and South External Waste Dumps were previously assessed by Golder (2015a) using the British Columbia Mined Rock and Overburden Investigation and Design Manual, Interim Guidelines, 1991. The Guidelines provide guidance for the level of effort and design criteria based on the Dump Stability Class. The North and South External Waste Dumps were found to have a Class III Moderate dump stability rating.

The Guidelines provide minimum design factors of safety for stability based on confidence in the understanding of the site conditions and material parameters and the consequences of failure. Table 5 shows the "Case A" minimum design values for factor of safety (FOS).

Table 5: Minimum Design FOS[(1)] - Waste Dump

Stability Condition	Case A - Minimum Design Values for FOS
Stability of Dump Surface	
Short Term (During Construction)	1.0
Long Term (Reclamation – abandonment)	1.2
Overall Stability (Deep Seated Stability)	
Short Term (During Construction)	1.3 – 1.5
Long Term Static (Reclamation – abandonment)	1.5
Long Term Pseudo-Static (Reclamation – abandonment)	1.1

(1) A range of suggested minimum design values are given to reflect different levels of confidence in understanding site conditions, material parameters, consequences of instability, and other factors.

The North and South Dumps meet the requirements of Case A for the following reasons:

- Reasonable assumptions have been made for material parameters based on field investigation, observation and index testing, however undisturbed sampling and laboratory testing to confirm material parameters is recommended to support detail design.
- Potential failure of the South Dump towards the plant site, should a lengthy run out result, would have severe consequence.

4.2 Stability Analysis

With the completion of the 2015 geotechnical investigation, the stability analysis for the waste rock dumps (Golder 2015a) was redone to incorporate the site specific stratigraphic information now available.

Stability analysis was performed on three cross sections, A, B and C (Figures 2, 3 and 4). These cross sections were selected for analysis by inspection, to be critical sections, based on dump height and foundation slopes. The overall slope angle of the spoil face of the dumps is 23°, which results in a factor of safety of 1.78, greater than the suggested minimum design value in Table 5.

Stability analysis of the North and South Dumps were performed using the limit equilibrium software SLOPE/W (Version 17.7). The Morgenstern-Price method was selected for the analysis along with the Mohr-Coulomb failure criterion to identify potential failure surfaces and the associated factors of safety.

For the seismic stability analysis, (pseudo-static cases), the 1 in 475 year design earthquake event was selected. A peak ground acceleration (PGA) of 0.056 g is associated with the 1 in 475 year event for the Grassy Mountain area (based on coordinates 49.69 North 114.4 West from 2010 National Building Code Seismic Hazard Calculation).

To model earthquake conditions, the pseudo-static method of analysis was used, which applies a horizontal force to the failure mass proportional to the design horizontal acceleration. To account for the non-rigid response of the foundation soils and waste rock, the horizontal seismic loading that was considered in the analysis was one-half the peak ground acceleration. The foundation soils material strengths were reduced to 80% of the peak strength (Hynes-Griffin and Franklin, 1984) to account for potential strain softening due to pore pressure generation during shaking.

Assumptions made for feasibility stage stability analysis of the North and South Dumps are:

- The South Dump foundation soil is generally a compact non-cohesive soil, as described in Section 3.3. At Section B, shallow bedrock (<2 m bgs) was encountered downslope of the dump toe and depth of bedrock (thickness of foundation soils) was at least 8.5 m under the dump. At Section C bedrock was encountered between 8.5 m and 12.2 m bgs. The depth to bedrock was assumed to be 12 m for both Sections B and C in the slope stability analysis.
- The North Dump foundation soil is generally a firm to very stiff low to intermediate plastic cohesive soil, as described in Sections 3.2 and 3.6. The depth to bedrock was found to be up to 10.8 m bgs, just downslope of the dump toe along Section A. The depth to bedrock was assumed to be 11 m for Section A in the slope stability analysis. The undrained strength of the shallow cohesive soil, estimated undrained strength is 40 kPa and higher, is insufficient to support a significant height of fill. These materials will need to be removed (stripped) prior to dump construction, potentially a shear key constructed at the dump toe, or the dump will need to be constructed in a manner that allows the soil to behave in a drained manner, such as the application of bottom up construction, preloading to improve the undrained strength, restricted dumping rates, supported by monitoring and application of the Observational Method or ground improvements techniques that would enhance drainage.
- The material parameters used in the analysis were inferred from field observation and testing and index laboratory testing. The assumed material parameters are presented in Table 6.
- Organic and deleterious materials are assumed to be removed prior to dumping waste rock. As described above where weak cohesive soils are not removed the dump design of construction methods must allow the soil to behave in a drained manner or enable strength gain to occur sufficient to achieve the minimum required factors of safety.

Table 6: Material Parameters for Stability Analysis

Material	Unit Weight (kN/m³)	Friction Angle (°)	Cohesion (kPa)
Waste Rock	20	37	0
Foundation Soils (Cohesive) – Long-term drained strength	19	30	0
Foundation Soils (Cohesive) – Long-term drained strength (Pseudo-static)	19	25	0
Foundation Soils (Non-cohesive)	19	27	0
Foundation Soils (Non-cohesive) – (Pseudo-Static)	19	22	0
Bedrock	Intact Rock Strength		

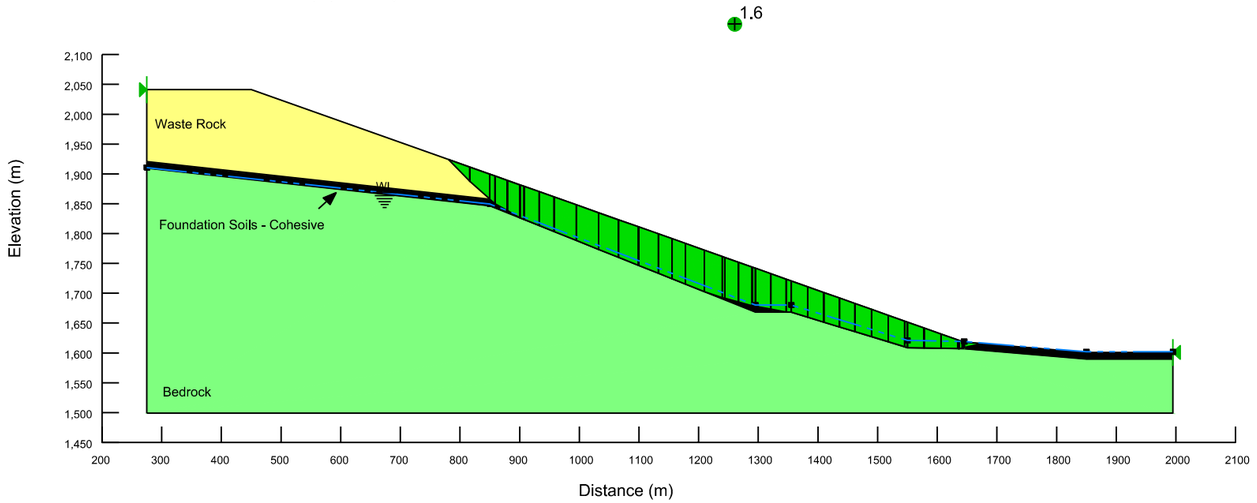
- Bedrock joints were assumed to be oriented in a favourable manner, thus failure surfaces were limited to within the foundation soils.
- Where groundwater elevation information was not available it was assumed to be at existing ground level underneath the toe and slopes of the dumps. Further upslope the groundwater elevation is assumed to be approximately coincident with bedrock elevation.

The results of the stability analysis are presented in Table 7 with a comparison of the calculated factors of safety and the design factors of safety for long term overall stability.

Table 7: Summary of Slope Stability Analysis Results – Overall (Deep Seated) Stability

Section	Factor of Safety (long-term)	Minimum Design Factor of Safety (per Table 5)	Factor of Safety (Pseudo-Static)	Minimum Pseudo-Static Factor of Safety (per Table 5)
North Dump Section A	1.6	1.5	1.2	1.1 – 1.3
South Dump Section B	1.7		1.6	
South Dump Section C	1.7		1.4	

Name: Waste Rock Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 37 °
Name: Foundation Soils - Cohesive Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 °
Name: Bedrock Model: Bedrock (Impenetrable)



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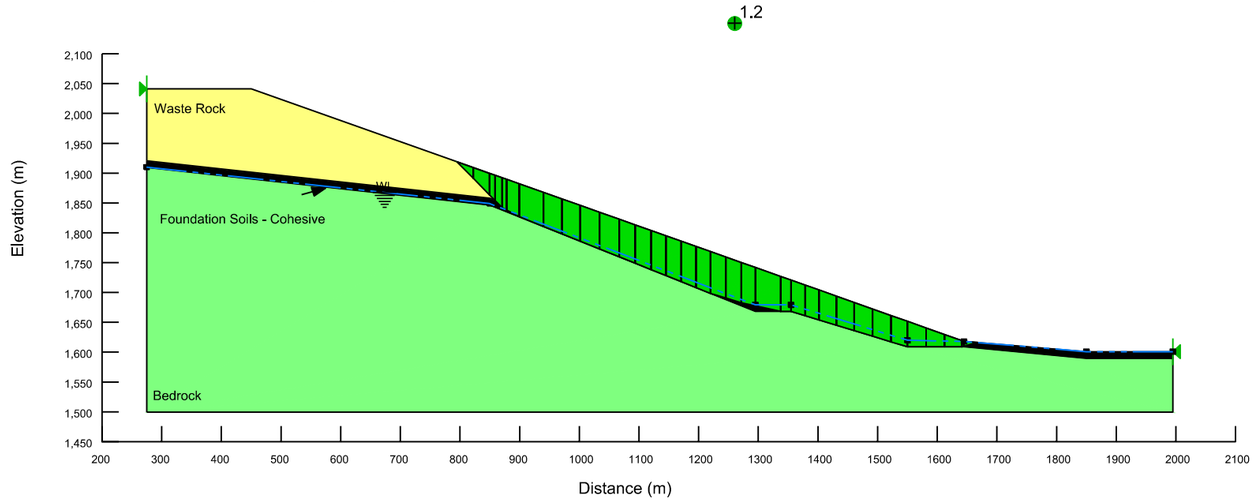
Name: Waste Rock Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 37 °
Name: Foundation Soils - Cohesive Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 25 °
Name: Bedrock Model: Bedrock (Impenetrable)



SCALE 1:10000 / VERT. SCALE 1:10 — A - STABILITY SECTION - SEISMIC

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CLIENT
RIVERSDALE RESOURCES LIMITED
BENGA MINING LIMITED

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-01-08
PREPARED	TF
DESIGN	CC
REVIEW	RA
APPROVED	AH

PROJECT
GRASSY MOUNTAIN COAL PROJECT

TITLE
STABILITY SECTION A

PROJECT No.	CONTROL	Rev.	FIGURE
1406422		A	2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
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0

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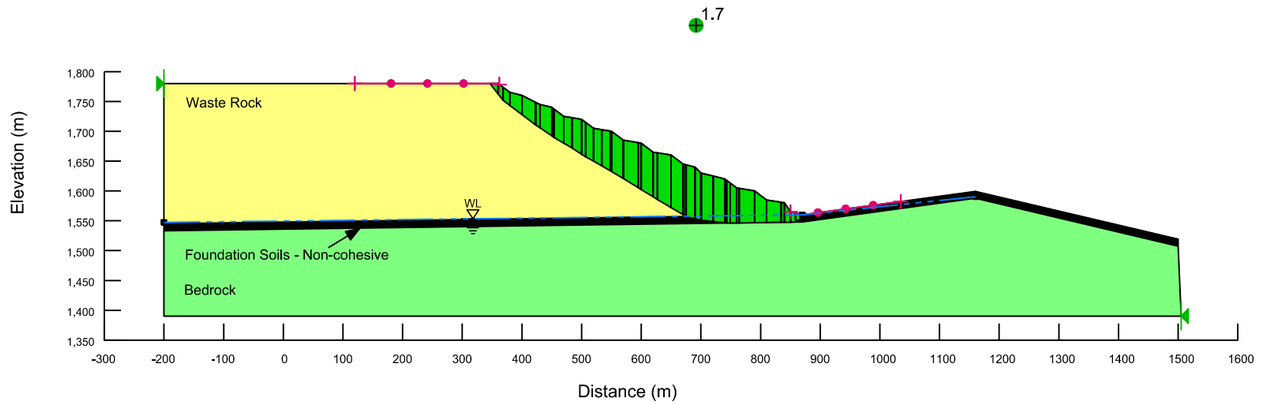
Name: Waste Rock Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 37 °
Name: Foundation Soils - Non-cohesive Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 27 °
Name: Bedrock Model: Bedrock (Impenetrable)



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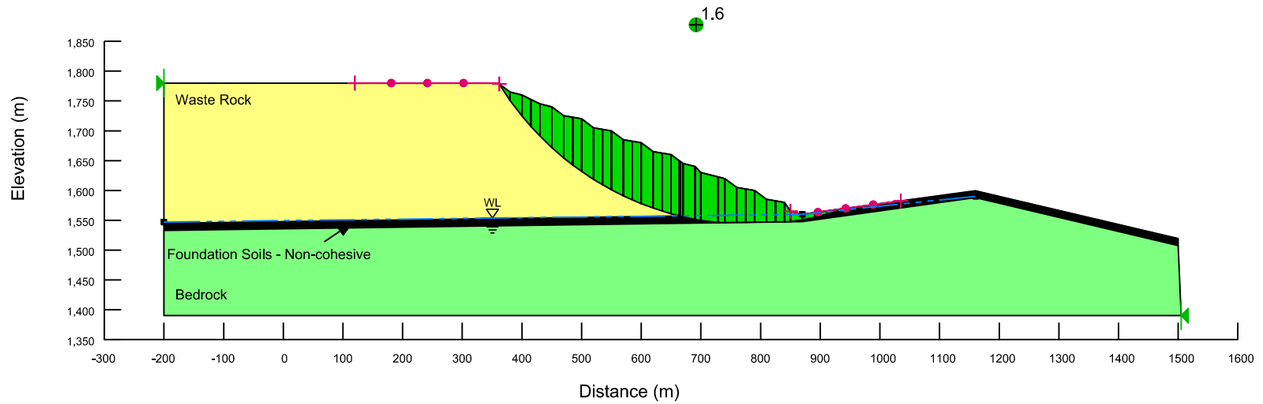
Name: Foundation Soils - Non-cohesive Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 22 °
Name: Bedrock Model: Bedrock (Impenetrable)



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PREPARED	TF
DESIGN	CC
REVIEW	RA
APPROVED	AH

PROJECT
GRASSY MOUNTAIN COAL PROJECT

TITLE
STABILITY SECTION B

PROJECT No.	CONTROL	Rev.	FIGURE
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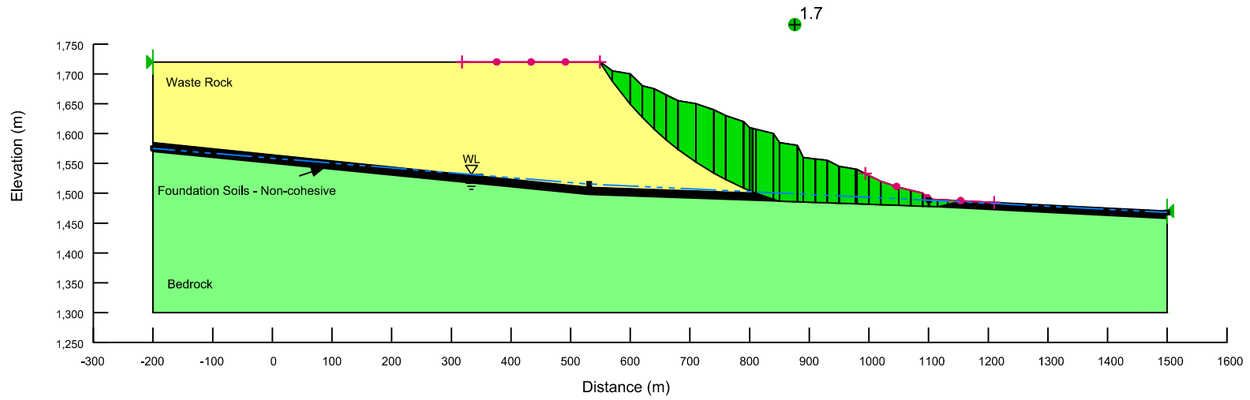
0

Name: Waste Rock Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 37 °
Name: Foundation Soils - Non-cohesive Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 27 °
Name: Bedrock Model: Bedrock (Impenetrable)



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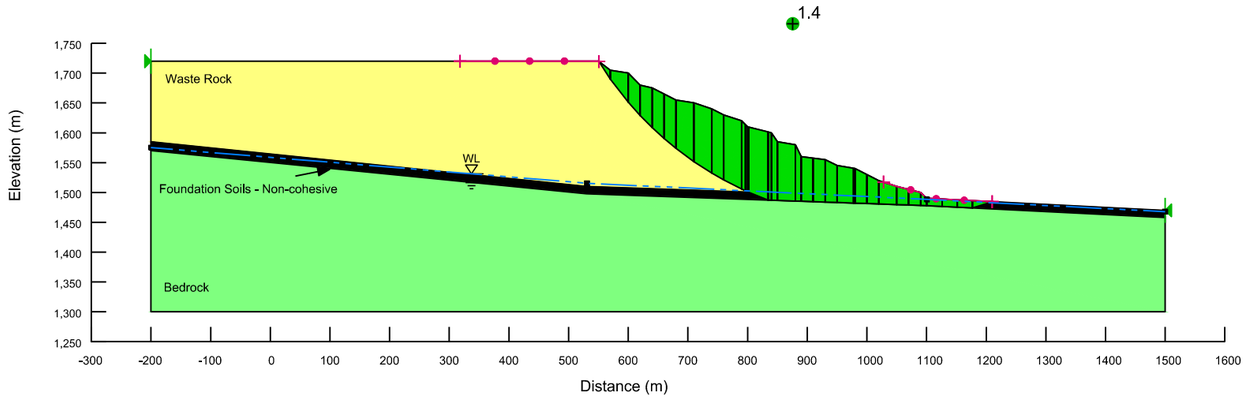
Name: Foundation Soils - Non-cohesive Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 22 °
Name: Bedrock Model: Bedrock (Impenetrable)



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PROJECT
GRASSY MOUNTAIN COAL PROJECT

TITLE
STABILITY SECTION C

PROJECT No.	CONTROL	Rev.	FIGURE
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25 mm
0

4.3 Run Out Analysis

Golder (2015a) previously analyzed run out from the waste dump sections to provide an estimate of the distance that waste rock can travel from the toe of the waste dump. The North Waste Dump (Section A) has the potential for significant run out under the reasonable worst case scenario if the flow becomes entrained in Blairmore Creek. Significant run out is not anticipated from the South Waste Dump (Sections B and C) due to the shallow foundation slope.

4.4 Ground Improvement/Construction Recommendations

An important part of dump construction is preparation of the foundation and drainage improvements that may be required, as discussed below:

- Strip 'A' and 'B' horizon topsoil and organic materials from the dump footprints and stockpile per site salvage/reclamation plan. The depths of organic materials identified by the geotechnical program are in Table 8.
- The foundation preparation for the dump must be inspected by a geotechnical engineer to confirm removal of soft soil deposits and exposure of competent, granular, till-like soils or bedrock. Weak, organic, or fine-grained soils should be stripped to underlying competent granular or till-like soils or bedrock for a minimum width of 50 m under the toe of the dump foundations, to reduce the likelihood of failure through soft foundation soils. This is especially important in the vicinity of the plant.
- The final site investigation and construction subgrade inspection may identify deeper deposits of soft soils in narrow V-channels (generally less than 10 m width). The soft soils are to be excavated and backfilled with select waste rock.

The presence of cohesive fine-grained and other deleterious materials at depth under and near the dump toe have been summarized from the borehole and test pit records and are in Table 8. Based on the investigation, the cohesive fine-grained and deleterious materials in the South Dump are assumed to be non-continuous except along the South Dump toe north of the South West Surge Pond. Surficial weak and organic soils (top 0.7 m bgs) have not been included.

Table 8: Organic and Potentially Soft Cohesive Soil within the Waste Dump Subsurface

Location	Borehole/Test Pit	Material Type	Depth (m)
North Dump	TP15-04	(OL/ML/CL/CI) organic silt to clayey silt to silty clay	0.0 - >5.3
	TP15-07[(1)]	(OL/ML/CL/CI) organic silt to clayey silt to silty clay	0.0 - >5.0
	TP15-08[(1)]	(CL) silty clay	2.0 - >5.0
	BH15-01[(1)]	(CI) silty clay	2.7 - 9.5
	BH15-02[(1)]	(ML/CL/CI) clayey silt to silty clay	0.0 - 7.9
	WD-SPT-7	(OL/ML) sandy silt to organic silt	0.0 - 2.2
South Dump	BH15-07	(FILL) coal to silty coal fill	0.0 - 7.7
	BH15-10	(CL) silty clay	8.8 - 9.1
	BH15-13	(COAL) gravelly silty coal	2.0 - 3.2
	BH15-14	(SC) clayey sand	0.0 - 1.8
	TP15-11	(OL/CL) organic silt to silty clay	0 - >5.0
	SP-TP-7[(2)]	(SC) clayey sand	1.7 - 2.4
	SP-TP-9[(2)]	(CI) clay	2.9 - >3.4
	SP-SPT-29[(2)]	(OL/CL/ML) organic silt to silty clay to clayey sand	0.0 - >4.7
	SP-SPT-30[(2)]	(OL/SC/CL/ML) organic silt to clayey sand/silt to silty clay	0.0 - >9.1

[(1)] Located along Section A – passing through North West Surge Pond.

[(2)] Located along stream channel north of South West Surge Pond.

5.0 PLANT SITE INFRASTRUCTURE – RECOMMENDATIONS

This section provides updated preliminary level plant site infrastructure foundation recommendations based on the subsurface conditions encountered in the 2015 geotechnical investigation.

5.1 Historic Underground Workings

Underground workings within the Grassy Mountain area were in production between around 1909 and 1968. Room and pillar mining is common within the underground workings. The risk to plant infrastructure is described in Golder (2015a). The northern portion of the underground workings is relatively close to the current proposed plant site location (Figure 1). The plant site infrastructure should not be located over these historic workings unless the workings are filled to provide structural support. Boreholes in the plant site area did not encounter any signs of underground workings. However, special consideration in design and construction/monitoring is required should evidence of underground workings be encountered underneath plant site infrastructure in the future.

5.2 Foundation Alternatives

Selection of foundation type will depend on foundation loads, and assessment of construction and performance risk and cost estimates. Golder has provided preliminary foundation recommendations for both shallow and deep foundations. The 2015 geotechnical investigation included boreholes at the site of the following site infrastructure elements requiring foundations, based on the site plan layout provided by Sedgman on April 29, 2015:

- Mine infrastructure area (e.g. office, garage) (BH15-28)
- Coal handling and processing plant (CHPP) (BH15-17, 18 and 24)
- ROM stockpile pad (e.g. bins / sizing station) (BH15-19 and 20)
- Surge bins/conveyor system to CHPP (BH15-15 and 16)
- Blending bed (BH15-26)
- Product stockpile pad (e.g. transfer towers, reclaim feeder stations) (BH15-21 and 25)

Boreholes were also advanced in the general vicinity for ponds and stockpiles.

Based on the field geotechnical investigation the subsurface conditions are variable across the plant site. The bedrock was encountered at depths ranging from 0.2 m bgs to greater than 15.4 m bgs. Groundwater was encountered between 1.3 m bgs and 9.0 m bgs. Where boreholes encountered shallow bedrock (less than 2 m bgs), groundwater was not encountered. For preliminary design a shallow (1.5 m bgs) perched groundwater table should be assumed.

Shallow foundations are generally suitable for: i) light to moderate loads and/or non-settlement sensitive structures; ii) sites with shallow bedrock (<6 m bgs); iii) sites with competent native soils near ground surface.

Deep (pile) foundations are generally suitable for: i) heavy loads and/or settlement sensitive structures; ii) sites with deep bedrock (>6 m bgs); iii) sites with thick overburden fill and/or weak/organic soils.

Shallow foundations can potentially be founded directly on bedrock (boreholes encountered bedrock at less than 2 m bgs) at the following sites (based on plant site layout provided by Sedgman on April 29, 2015):

- Coal handling and processing plant, 0.3 m to 0.8 m bgs (BH15-17, 18 and 24)
- ROM coal stockpile / coal sizing station, 0.2 m to 0.3 m bgs (BH15-19 and 20)
- Surge bins / conveyor system, 0.2 m bgs (BH15-15)
- Mine infrastructure area, 2.0 m bgs (BH15-28)

Several sites are unsuitable for shallow foundations due to deep bedrock or coal and high plasticity clay layers:

- Surge bins / conveyor system, bedrock >15.4 m bgs and 1 m thick coal layer at 6.4 m bgs (BH15-16)
- Blending bed, bedrock at 8.5 m bgs and 1 m thick coal layer at 4.4 m bgs (BH15-26)
- Product stockpile pad, bedrock >7 m to 12.2 m bgs and 0.5 m thick high plasticity clay layer was encountered in BH15-25 at 4.7 m bgs (BH15-21 and 25)

Potential foundation construction risks include:

- Auger grinding (i.e. inferred cobbles/boulders) was encountered at various depths below ground surface in boreholes BH15-16, 21, 22, 23, 25 and 26. Cobbles and boulders can result in abrupt pile refusal and/or pile tip damage before reaching minimum embedment depth.
- The variability in depth to bedrock means there is the possibility of encountering shallower or deeper bedrock than expected. Shallow bedrock can result in ineffective piles.
- Presence of shallow coal and high plasticity clay layers indicates the possibility of additional undiscovered coal and/or high plasticity clay layers.
- Possibility of undiscovered underground workings.

5.3 Deep Foundations

5.3.1 Pile Type Alternatives

Based on the current investigation at the plant site locations, the depth to bedrock in some areas of the plant site are expected to be deep (>6 m bgs). Furthermore, the subsurface soils may be unsuitable for shallow foundations, as coal and clay layers have been encountered in the first 7 m bgs. Where these conditions are encountered, deep foundations are recommended.

Selection of pile type will depend on foundation loads, an assessment of construction and performance risk and cost estimates. Some of the advantages and disadvantages of different pile types are presented in Table 9.

Table 9: Advantages and Disadvantages of Pile Types

Pile Type	Advantages	Disadvantages
Driven Steel Piles – Open Steel Pipe	■ Generally higher load capacity. ■ When driven to practical refusal in bedrock, not highly susceptible to downdrag or settlement. ■ Less susceptible to significant damage during driving and more resistant to over-stressing due to drag loads. ■ Capacity can be evaluated at time of installation using PDA. ■ Minimal drilling (possible pre-drilling) and sleeves not required. No spoil.	■ Cobbles and boulders can result in abrupt pile refusal and/or pile tip damage before reaching minimum embedment depth. ■ Shallow bedrock (generally less than 6 m bgs) can result in too shallow refusal and an ineffective pile to resist lateral and uplift loads.
Driven Steel Piles – H-Pile	■ Generally higher load capacity. ■ Lower risk of damage than open steel pipe when driven into dense soil, coarse gravel and soft rock. ■ When driven to practical refusal in bedrock, not highly susceptible to downdrag or settlement. ■ Less susceptible to significant damage during driving and more resistant to over-stressing due to drag loads. ■ Capacity can be evaluated at time of installation using PDA. ■ Minimal drilling (possible pre-drilling) and sleeves not required. No spoil.	■ Cobbles and boulders can result in abrupt pile refusal and/or pile tip damage before reaching minimum embedment depth. ■ Shallow bedrock (generally less than 6 m bgs) can result in too shallow refusal and an ineffective pile to resist lateral and uplift loads. ■ H-piles are more susceptible to bending and may not be suitable when small tolerances for lateral displacement of pile during driving are required.
Driven Pre-cast Pre-stressed Concrete Piles	■ When driven to practical refusal in bedrock, not highly susceptible to downdrag or settlement. ■ Minimal drilling (possible pre-drilling) and sleeves not required. No spoil. ■ Capacity can be evaluated at time of installation using PDA.	■ Generally lower single pile load capacity Shallow bedrock (generally less than 6 m bgs) can result in too shallow refusal and an ineffective pile to resist lateral and uplift loads. ■ More susceptible than steel to damage during installation. ■ Cobbles and boulders can result in abrupt pile refusal and/or pile tip/head damage before reaching minimum embedment depth. ■ Very hard to splice.
Drilled Shafts (rock socket cast-in-place concrete piles)	■ Allows visual observation of soil/rock conditions. ■ Can be sized to provide significant lateral load capacity (in vertical configuration). ■ Applicable to wide variety of subsurface conditions, including soils with cobbles/boulders.	■ Deep piles may require casing to prevent sloughing. ■ Installed capacity cannot readily be confirmed at time of installation. ■ Expensive and installation is slow.

5.3.2 Driven Pile Preliminary Design Values

Table 10 presents the recommended skin friction and end bearing values for the design of driven piles (open pipe, H-pile, pre-cast concrete) for use in preliminary design. The resistance has been estimated based on current conventional engineering practice, as described in CFEM (2006) by accounting for the ultimate values of frictional resistance along the shaft, in terms of the effective vertical stress and relevant β and N_t values or undrained strength and adhesion coefficient (α). The groundwater table is assumed to be 1.5 m bgs.

The design values are presented for the major soil types and bedrock found in the plant site infrastructure area where bedrock was encountered at depths greater than 7 m below ground surface. Surficial soils, the high plasticity clay interlayer found in BH15-25 and coal layers are not included.

Table 10: Recommended Ultimate Limit State (ULS) Pile Design Parameters for Driven Piles

Material	Depth below Existing Ground Surface (m)*	Unfactored ULS Skin Friction q_s (kPa)	Unfactored ULS End Bearing[(1)] q_t (kPa)
Stiff sandy clay[(2)]	<4	20-40	-
Loose to compact clayey gravel and sand	<4	20-40	-
Compact to dense clayey gravel and sand	4 – >10	90	2,000
Weak sandstone/siltstone bedrock	>12	90	10,000

(1) Pile diameter <1.0 m

(2) Only encountered in BH15-22 (plant site sediment pond) and BH15-25 (stockpile pad)

The values provided are the unfactored ULS skin friction and end bearing capacities. A geotechnical resistance factor (ϕ) of 0.4 should be applied for axial compression loading based on static parameters. For uplift (skin friction only) the geotechnical resistance factor (ϕ) at ULS is 0.3. Alternatively if a steel pile is driven to refusal the capacity will be governed by the structural capacity of the pile, which can be determined from the pile section and the maximum allowable stress of $0.3f_y$, where f_y is the yield strength of steel.

Piles can be driven onto or into rock. However the exact area of contact with rock, the depth of penetration into the rock, and the quality of the rock is largely unknown. Consequently the determination of capacity cannot be made with certainty. Therefore the capacity should be confirmed on the basis of driving observations, local experience and test loading. Pile refusal in bedrock will typically occur within less than 5 m depending on pile type and driving equipment.

Dynamic testing (i.e. PDA testing) may be carried out to aid in the evaluation of pile axial resistances achieved in the field, hammer performance, installation criteria, and pile bearing certification. If PDA testing is performed a geotechnical resistance factor of 0.5 can be applied to axial compression.

For the design of single piles, serviceability limit states (SLS) is not considered relevant. The anticipated settlement of individual piles is less than 25 mm. The design of pile groups may be governed by SLS conditions and further analysis will be required for pile groups.

For determination of geotechnical axial capacity of the piles, it is recommended that the skin friction is not included in the upper 3 m below final grade due to the potential disturbance effects associated with frost, desiccation and construction. Further, depending on the thickness of site fills, downdrag loads should be assessed and may need to be considered in the pile design.

5.3.3 Construction Considerations for Driven Piles

- The proposed hammer, piling rig and methodology should be approved in advance of construction and the refusal criterion should be confirmed for the actual hammer and design load. This can be achieved by performing a wave equation analysis using commercially available software such as GRLWEAP.
- The refusal criterion to achieve the required capacity should be confirmed with PDA testing.
- For piles driven in the winter, increased driving resistance should be expected in the upper frozen layer, which may warrant pre-drilling through the frozen layer.
- Pile driving should be stopped immediately if abrupt high resistance to penetration is encountered. In such cases, the driving record and depth of penetration should be carefully examined to determine if the pile has adequate bearing capacity. If the depth of penetration is inadequate, the need for additional piles should be evaluated.
- After each pile is driven to its required refusal or depth an elevation should be taken of the pile top or of a suitable mark on the side of the pile. This elevation should be checked periodically to measure potential heave caused by driving of the adjacent piles or any uplift forces. Piles that have heaved must be re-driven to at least their previous final elevation and final set.
- Where piles are designed to gain support by shaft friction, it is essential that the walls including driving shoes are free from protrusions that could cause voids or disturbances of the adjacent soil during driving.
- The use of driving shoes will be required to improve drivability of the piles and to reduce likelihood of damage to the pile tips if PDA testing reveals that the pile tips are yielding.
- Full-time inspection by qualified geotechnical personnel during driving is recommended to maintain pile driving records. Information to be recorded should include pile dimensions, hammer type, rated energy, ram weight, anvil weight, cushion parameters, number of blows for each 0.3 m penetration and final set. It is recommended that each pile be reviewed by the geotechnical engineer responsible for the design to assess that the required load capacity is achieved.

Strict control of pile location and orientation should be exercised to obtain accurate pile installation.

5.3.4 Drilled Cast-in-Place Concrete Pile Preliminary Design Values

For preliminary design purposes Table 11 below presents the recommended skin friction and end bearing values for the design of cast-in-place (CIP) concrete piles. Drilled CIP concrete piles may be designed to resist static axial compressive loads on the basis of skin friction and end bearing parameters at Ultimate Limit State (ULS) as described in CFEM (2006) by accounting for the ultimate values of frictional resistance along the shaft, in terms of the effective vertical stress and relevant β and N_t values or undrained strength and adhesion coefficient (α).

The design values are presented for the major soil types and bedrock found in the plant site infrastructure area where bedrock was encountered at depths greater than 7 m below ground surface. Surficial soils, the high plasticity clay interlayer found in BH15-25 and coal layers were not considered.

Table 11: Recommended ULS Pile Design Parameters for CIP Concrete Piles

Material	Depth below Existing Ground Surface (m)*	Unfactored ULS Skin Friction q_s (kPa)	Unfactored ULS End Bearing[(1)] q_t (kPa)
Stiff clayey sand[(2)]	<4	20-30	-
Loose to compact clayey gravel and sand	<4	20-30	-
Compact to dense clayey gravel and sand	4 – >10	40-50	2,000
Weak sandstone/siltstone bedrock - weathered[(3)]	>12	90	10,000

(1) Pile diameter < 1.0 m

(2) Only encountered in BH15-22 (plant site sediment pond) and BH15-25 (stockpile pad)

(3) If both toe and shaft resistance are to be used to estimate socket capacity, the ratio of the load must be estimated per CFEM (2006)

The values provided are the unfactored ULS skin friction and end bearing capacities. A geotechnical resistance factor (ϕ) of 0.4 should be applied for axial compression loading based on static parameters. For uplift (skin friction only) the geotechnical resistance factor (ϕ) at ULS is 0.3.

Dynamic testing (i.e. PDA testing) may be carried out to aid in the evaluation of pile axial resistances achieved in the field, hammer performance, installation criteria, and pile bearing certification. If PDA testing is performed a geotechnical resistance factor of 0.5 can be applied to axial compression.

For the design of single piles, serviceability limit states (SLS) is not considered relevant. The anticipated settlement of individual piles is less than 25 mm. The design of pile groups may be governed by SLS conditions and further analysis will be required if the pile configuration will result in group action.

For determination of geotechnical axial capacity of the piles, it is recommended that the skin friction is not included in the upper 3 m below final grade due to the potential disturbance effects associated with frost, desiccation and construction. Further, depending on the thickness of site fills, downdrag loads should be assessed and may need to be considered in the pile design.

It is recommended that the sides and base of piles be free of water and loose or remolded material prior to placing concrete. Inspection by qualified personnel during pile installation is required to ensure that the recommended design values are obtained. The inspection must also include assurance that the as-built pile installation is in accordance with the pile designs as approved by the geotechnical and structural engineers.

5.3.5 Resistance of Laterally Loaded Piles

The design of piles subject to lateral loads should take into account such factors as the relative rigidity of the pile to the surrounding soil, the fixity condition at the head of the pile, the structural capacity of the pile to withstand bending moments, the soil resistance that can be mobilized, the tolerable deflection at the head of the pile and pile group effects. The lateral resistance and deflections of piles are usually mobilized within the upper 4 to 6 m of the pile below the pile cap. Therefore it is important that any gaps that may develop during pile installation between the ground and pile be filled to provide good contact between the ground and pile. If not, the lateral resistance of a vertical pile will be reduced significantly.

The soil parameters required for estimating lateral capacity of piles in clay are generally modulus of subgrade reaction – horizontal (k), undrained shear strength (C_u), unit weight (γ), and soil strain parameter (E_{50}). In sand the parameters used for estimating lateral capacity of piles are k and γ. The soil parameters recommended for estimating lateral response of piles are given in Table 12.

Table 12: Soil Parameters for Estimating Lateral Pile Capacity

Material Type	Depth below Existing Ground Surface (m)	Cu (kPa)	γ (kN/m^3)	Coefficient of Horizontal Subgrade Reaction k_s (MPa/m)	E_{50} (%)
Stiff clayey sand[(1)]	<4	50	19	5	0.7
Loose to compact clayey gravel and sand	<4	-	20	5	-
Compact to dense clayey gravel and sand	4 – >10	-	22	20	-
Weak sandstone/siltstone bedrock - weathered	>12	300	25	30	0.4

[(1)] Only encountered in BH15-22 (plant site sediment pond) and BH15-25 (stockpile pad)

The lateral resistance of piles for this project is calculated based on the information from the drilling program. The pile also needs to be checked for structural considerations such as excessive bending stresses in the pile material that could lead to structural distress. In addition, SLS conditions would need to be considered as per the structural design specifications.

For Limit States Design, a resistance factor of 0.5 should be applied to the ultimate lateral pile capacity to calculate the factored capacity.

The coefficient of horizontal subgrade reaction when applied over a specific area provides a spring constant that is commonly used to model load-deformation response of a pile subjected to lateral load. The lateral ground movement is given by the spring constant, which is bounded (limited) by a maximum lateral capacity (load) where there is no further increase in resistance with increasing lateral movement. This limiting value (ultimate lateral load capacity) corresponds to full mobilization of the passive resistance of the ground. A lateral ground movement on the order of 50 to 80 mm may be needed to fully mobilize passive resistance of the ground.

5.3.6 Pile Groups

5.3.6.1 Axial Capacity

Piles spaced at greater than 2.5 pile diameters (centre-to-centre) can be assumed for design purposes to act as single piles, with no group interaction effects with regards to axial capacity. For piles spaced at less than 2.5 diameters, the ultimate pile geotechnical axial capacity should be reduced by a group reduction factor. For design, these group factors may be approximated as:

- 1.0 for piles at a spacing of 2.5 diameters or more
- 0.85 for piles at a spacing of 1.25 to 2.5 diameters

Group reduction factors for other pile spacings may be interpolated from the values above.

5.3.6.2 Lateral Capacity

Group interaction effects should be considered when the piles in the direction of the applied loading are spaced at less than 8 pile diameters. To account for the group interaction effects, a subgrade modulus reduction factor should be applied to the subgrade modulus values given in Table 12. Table 13 presents the recommended subgrade modulus reduction factors to be used.

Table 13: Reduction Factors for the Modulus of Subgrade Reaction

Pile Spacing	Subgrade Reduction Factor
>8d	1.00
6d	0.70
4d	0.40
<3d	0.25

These reduction factors should be applied to all piles within the group, with the exception of the lead (first) piles, where no reduction factor is required.

5.3.7 Uplift Resistance of Pile Foundations

The design uplift resistance of a single, straight-shafted pile may be calculated using only the shaft resistance and the weight of the pile itself, and applying a resistance factor of 0.3 as per NBCC 2010.

The ultimate uplift resistance of a pile group may be taken as the lesser of: i) the sum of the individual pile uplift resistance or, ii) the weight of the block of soil and concrete within the pile group, with no contribution from the soil shear strength along the assumed vertical uplift failure plane. A resistance factor of 0.3 should be applied to the ultimate group capacity to obtain the factored ultimate uplift resistance at ULS of the group.

5.3.8 Uplift Forces due to Adfreeze

An adfreeze stress of 65 kPa to 100 kPa for concrete and steel, respectively along the pile shafts is recommended within the zone that would be subject to frost heave, which should be assumed to extend to depths of 2.5 m bgs for unheated structures and 2.0 m bgs for heated structures. Resistance to frost jacking on the piles will be provided by the sustained vertical loads on the pile, the weight of the pile, and the skin friction developed on the portion of the pile shaft embedded within the bedrock. The pile embedment should be sufficient to resist uplift due to frost action. Where frost-jacking and transient uplift loads (such as wind loads) occur simultaneously, these two loads need not be considered together and the larger of the two should be used.

5.4 Raft/Mat Slab

For significant loaded structures raft/mat slabs may be the most appropriate foundation design option. The slabs should be designed using appropriate moduli of subgrade reaction for the subgrade soils or bedrock. The appropriate moduli of subgrade reaction will depend on the subgrade support characteristics. Typical values of moduli of subgrade reaction for various soil/bedrock types at this site are provided in Table 14.

Table 14: Moduli of Subgrade Reaction for Raft Design

General Soil/Rock Type	Modulus of Subgrade Reaction (kN/m^3)
Stiff low plasticity clayey sand/sandy silty clay	20,000
Hard low plasticity clayey sand/sandy silty clay	35,000
Loose to compact clayey gravel and sand	20,000
Compact to dense clayey gravel and sand	45,000
Engineered fill (well-graded granular)	25,000
Weak sandstone/siltstone bedrock – weathered	50,000

The above parameters assume assumes native or imported granular fill is compacted to at least 95% of Standard Proctor Maximum Dry Density (SPMDD).

The design load on rafts is generally less than the allowable bearing capacity; therefore, the design of rafts is governed by settlement considerations rather than bearing capacity. To keep settlements within the tolerances, the bearing pressures under rafts on compact to dense sand should be less than 100 kPa.

Based on the investigation a raft foundation could potentially be used at the coal handling and processing plant, mine infrastructure area and ROM pad. Depending on the specific location and nature of the infrastructure it may be possible to found directly on the weak sandstone/siltstone bedrock.

Other parts of the plant site area where the presence of coal layers and high plasticity clay layers were found are unsuitable for raft/mat slab foundations. Although these layers may be removed by over-excavation, the presence of these layers indicates the possibility of additional undiscovered unsuitable layers in the overburden.

A resistance factor of 0.25 should be used on ultimate bearing capacity values for limit states design of machine block foundations. The intent is to limit the total static service load applied to 50% of the working load capacity of the foundation unit. Any over-excavation under the foundation blocks/mats should be backfilled with lean concrete to avoid formation of voids due to dynamic loads. To improve the dynamic response of foundation, the backfill around the foundations blocks should be lean mix concrete and not granular fill as the fill materials tend to consolidate over time under dynamic loads and increase the risk of excessive dynamic foundation response. A minimum thickness of approximately 1 m is recommended for raft or mat foundations subject to dynamic loads.

The subgrade under raft/mat slab on soil should be prepared by removing all topsoil, soil containing organics and soft/loose soil. All soft/loose spots should be over-excavated, backfilled with compacted structural fill. The raft/mat slab should be placed on unfrozen soil. The subgrade under raft/mat slab on bedrock should be prepared by removing all loose rock debris, coal seams, and other deleterious material so that the foundation is placed on a competent bedrock surface and the surface is reasonably level.

The foundation should be poured immediately following excavation to the bearing surface to prevent degradation from construction traffic and weather conditions. Prolonged exposure of foundation excavations should be avoided. The raft/mat slab bearing surfaces should be protected from rain, snow, freezing temperatures, excessive drying and the ingress of free water before, during and after footing construction. A lean concrete mud slab, approximately 300 mm thick, is recommended on the finished grade below the raft/mat slab to reduce disturbance of the exposed subgrade and/or to protect the bearing surface if raft construction is delayed. Soils beneath raft/mat slab should be protected from seasonal frost during and after construction by providing either adequate soil cover or insulation.

A shallow groundwater table perched on the bedrock should be assumed. The uplift pressure on raft and hydrostatic pressure on the buried walls can be neglected if the groundwater table is lowered below the base of the raft/mat slab.

5.5 Shallow Foundations

Shallow foundations comprising strip/spread footings, or blocks could be a suitable foundation alternative for light to moderate loads and non-settlement sensitive structures. Footings may also be used to support facilities such as small pumps, equipment or pump boxes that are housed within the heated buildings. The disadvantage of such foundations is the requirement to provide sufficient soil cover or insulation to resist frost heave forces.

Preliminary estimates of unfactored ultimate limit state (ULS) bearing capacity for soils and rock found at the plant site are provided in Table 15.

Table 15: Preliminary Bearing Capacity for Shallow Foundations

Soil Type	Unfactored ULS Bearing Capacity (kPa)
Stiff low plastic sandy silty clay	200
Hard low plastic sandy silty clay	350
Loose to compact clayey gravel and sand	200
Compact to dense clayey gravel and sand	450
Engineered fill (well-graded granular)	400
Weak sandstone/siltstone bedrock – weathered	1,000

The above parameters assume assumes native or imported granular fill is compacted to at least 95% of Standard Proctor Maximum Dry Density (SPMDD).

A resistance factor of 0.5 should be used on ultimate values to obtain the factored bearing capacities. The resistance factor is in accordance with the Canadian Foundation Engineering Manual (CFEM 2006).

Depending on the specific location and nature of the infrastructure it may be possible to found directly on the weak sandstone/siltstone bedrock. However the borehole records should be reviewed carefully in the plant site area to identify locations where the presence of coal layers and high plasticity clay layers in the subgrade make shallow foundations unsuitable. Although these layers may be removed by over-excavation, the presence of these layers indicates the possibility of additional undiscovered unsuitable layers in the overburden.

Detail design will require a site specific geotechnical investigation and design recommendations. The Serviceability Limit State (SLS) bearing capacity should be determined at final design based on allowable total and differential settlements, typically 25 mm and 15 mm respectively.

The bearing capacity is based on the following assumptions:

- Base of the footings is placed on structural fill compacted to at least 100% of the Standard Proctor Maximum Dry Density (SPMDD).
- A minimum soil cover of 2.5 m is maintained above the base of the footing on either side.
- The minimum and maximum footing widths are 0.6 m and 2.5 m.

The above bearing capacities are valid only if base of the footings is placed on compact/firm native soil or compacted structural fill. Any soft, loose, or unsuitable soil encountered at the footing base elevation is to be over-excavated and backfilled with compacted structural fill. Design and construction of shallow foundations should be in accordance with good practice and should meet the requirements of relevant building code. All foundation excavations and bearing surface should be inspected by a qualified geotechnical engineer prior to forming and pouring concrete to ensure that recommendations in this report have been followed.

Footing excavations should be carried down into the designated bearing stratum. Any loose/soft or unsuitable soil encountered at the bearing level should be over-excavated and backfilled with compacted structural fill or lean-mix concrete under the directions of a qualified geotechnical engineer. Where a foundation pad is to be placed above stripped natural ground surface such over-excavation should be backfilled to subgrade elevation utilizing either compacted structural fill or lean-mix concrete.

Foundation excavations and bearing surfaces should be protected from rain, snow, freezing temperatures, excessive drying and the ingress of free water before, during and after footing construction. Prolonged exposure of foundation excavations should be avoided. A mud slab should be poured to protect the bearing surface if foundation construction is delayed. Foundations should be placed on unfrozen soil. Soils beneath foundations should be protected from seasonal frost during and after construction by providing either adequate soil cover or insulation.

A shallow groundwater table perched on the bedrock should be assumed. The effect of groundwater (e.g. soil self-weight, uplift pressure) must be considered in design if the groundwater table is at or above the length of the footing width below the footing founding level.

5.6 Temporary Excavations

The composition and consistency of the soils encountered at the site are such that conventional hydraulic excavators should be able to excavate these materials to a depth of several metres. The top surface of bedrock is generally weathered and can likely be excavated at least an additional metre before a ripper is required. A ripper may be required to excavate seasonally frozen soils.

All excavations shall be in accordance with the provisions in the Alberta Occupation Health and Safety Regulations. The excavations walls should be sloped or adequately shored. The appropriate side slopes will depend on the soil type, drainage method, controlling groundwater infiltration into the excavation and the time the trench is left open. A slope of 1 horizontal to 1 vertical (1H:1V) is the steepest recommended slope for temporary excavations up to 1.5 m deep. Slopes of 2H:1V are the steepest recommended for temporary excavation up to 6 m deep in sand and clay. A geotechnical engineer should be consulted for excavations deeper than 6 m or if groundwater is encountered. Localized instability (seepage/sloughing/flowing soil) in trench/excavation walls may occur. In these cases, side slopes would need to be made flatter, under the direction of a qualified geotechnical engineer.

The stability of cut slopes will deteriorate with time. Therefore, temporary side slopes should be monitored for any signs of deterioration especially after periods of rain. If there are any signs of movement the side slopes should be unloaded by benching the upper portion of the crest of the slope to relieve overburden pressure. The temporary cut slopes should also be protected against surface runoff and heavy rainfall. Small earth falls from the side slopes are a potential source of danger to workers and must be guarded against.

The groundwater table is variable across most of the site. It should be assumed that a shallow groundwater table is perched on the bedrock across most of the site. Specific local groundwater conditions should be determined for excavations. Dewatering can be accomplished by installation of sumps and pumps or individual large diameter wells depending on the rate of infiltration of the soil. Also the surface drainage should be directed away from the crest of excavations.

Temporary surcharge loads, such as construction materials, equipment, or excavated soil (spoil piles), should not be allowed within a distance equal to the depth of the excavation from the unsupported excavated face. Vehicles delivering materials should be kept back from excavation faces by at least 3.0 m.

5.7 Suitability of Excavated Soils as Fill

The overburden soils at the site are predominately non-cohesive well-graded clayey gravel and sand (or sandy clayey gravel, gravelly clayey sand) or cohesive clayey sand/silty clay and sand of low plasticity. These soil types are suitable as general engineered fill from a geotechnical perspective. The suitability of the soil must be further evaluated and subject to review and confirmation by a geotechnical engineer during construction.

Prior to backfilling operations, the Standard Proctor Maximum Dry Density (SPMDD) of the excavated soils and of potential borrow sources should be determined for quality control during compaction and backfill operations. Water content condition may be required, depending on the natural water content relative to the optimum water content for compaction purposes. Removal of oversize material, which has been inferred in the non-cohesive clayey gravel and sand, will be required. Other deleterious materials such as organics or debris must also be removed.

Clean granular (structural) fill may be required for certain applications (e.g. as a leveling course for slab-on-grade floors). Clean sands or gravels for use in these applications have not been identified at the site.

5.8 Backfill and Fill Materials and Compaction

A minimum compaction of 95% of the SPMDD is recommended for all fill and backfill, except as noted below.

Within roadway areas, areas subject to heavy traffic, or where excavation settlement would be detrimental, the top 1 m of the backfill should be compacted to 98% of the SPMDD. The compacted thickness of each backfill lift should not exceed 200 mm. Thicker lifts may be used if allowed by the geotechnical engineer and if the specified compaction can be achieved using thicker lifts.

Backfill adjacent to and above footings, basement walls, grade beams and pile caps, or parking lot pavement sections and base courses should comprise general engineered fill materials. To reduce seepage into the subsoil the upper 300 mm of fill adjacent to the exterior footings, foundation walls, grade beams, and pile caps should comprise compacted inorganic low plastic clay. General engineered fill materials should comprise clean, well-graded granular soils or inorganic low plastic clay soils. General engineered fills should be compacted to a minimum of 98% of the SPMDD unless otherwise specified. Granular soils used for general engineered fills should consist of relatively clean, well graded mixture of sand and gravel (maximum size 75 mm). Low plasticity clays used for general engineered fills should be compacted at or slightly above the Standard optimum water content.

Backfill placed under structural elements of buildings such as foundations, columns, mats/rafts, etc., should comprise structural fill materials comprising clean, well-graded inorganic granular soils (sand and gravel). Such fill should be placed in compacted lifts not exceeding 150 mm and compacted to not less than 100% of SPMDD at a water content at or slightly above the standard optimum water content.

Backfill should not be placed against a foundation structure, basement walls or retaining walls until the structure has sufficient strength to withstand the earth pressures resulting from placement and compaction. During compaction, careful observation of the foundation wall for deflection should be carried out continuously. Where deflections are apparent, the compaction effort should be reduced accordingly. To reduce potential compaction induced stresses, only hand held compaction equipment should be used in the compaction of fill within 0.5 m of retaining walls or basement walls.

Backfill materials should not be placed in a frozen state or placed on a frozen subgrade. All lumps of materials should be broken down during placement. The size of the largest particles in any backfill material should not exceed half the lift thickness.

Bonding should be provided between backfill lifts if the previous lift has become desiccated. For fine-grained materials the previous lift should be scarified to the base of the desiccated layer, properly water-conditioned and re-compacted and bonded thoroughly to the succeeding lift.

5.9 Fill Settlement

The expected settlement of the fill depends on the type of fill material, degree of compaction and uniformity of compaction. The fill settlement can be reduced by using strict placement and compaction specifications. Uniform placement and compaction techniques are necessary to ensure uniform settlement behaviour and reduce differential settlements. The consequences of lower than recommended compaction standards include increased settlement of the fill under its own weight. The estimated settlement of cohesive and granular (cohesionless) materials as a function of compaction level is provided in Table 16.

Table 16: Estimated Settlement versus Compaction Level

Compaction Level (% of SPMDD)	Fill Settlement (% of Fill Thickness)	
	Cohesive Soils	Cohesionless Soils
100	0.5	<0.5
98	1.0	0.5
95	1.5	1.0
90	4.0	3.0
<90	>4.0	>3.0

5.10 Permanent Cut and Fill Slopes

Permanent cut and fill slopes in sand or clay above the groundwater table should be between 3H:1V to 4H:1V or flatter depending on soil and groundwater conditions. With subgrade investigation, subgrade preparation and designed fill slopes, permanent slopes of 2.5H:1V may be reasonable. Below the groundwater table, slopes of 5H:1V to 7H:1V (or flatter) are likely to be required.

All permanent slopes should have some form of erosion protection installed to minimize the potential for scour and erosion of the slope face, which may lead to slope failures. Erosion protection may include: covering with organics and seeding with a native seed mixture, and/or covering with erosion mats.

5.11 Winter Earthwork Construction

Earthworks should be avoided in winter if possible. In certain situations where winter earthwork is unavoidable cold weather construction procedures should be strictly followed. The fill should be hauled, placed and compacted in an unfrozen state. Compaction of backfill material to the required standards can generally be achieved if the air temperature is above -5°C; however more compaction effort is required to achieve the required density than when temperatures are above freezing. Compaction is increasingly difficult at temperatures from -5°C to -10°C and should be prohibited at temperatures below -10°C.

Cold weather compaction requires attention to fill quality, particularly water content, and placement and compaction practices. The water content of the backfill material is difficult to adjust when temperatures are below freezing; therefore, a material that may be suitable during summer may not be suitable during winter. If the required density cannot be achieved, the choice is either to suspend the fill placement and compaction until favourable conditions prevail, implement procedures such as heating and hoarding and re-compact the material that does not meet the compaction requirements, or use dry, non-cohesive, non-frost-susceptible material for backfill.

The time available for placement and compaction of soil before it freezes depends on many factors including soil type, lift thickness, time for loading, unloading and hauling, air temperature, wind speed, etc. Common fill placement and compaction should be possible provided the borrow soil is placed and compacted quickly (i.e. within half an hour). The lifts should not be allowed to freeze prior to placement of the next lift. At the end of each day a loose layer of soil should be placed over the development area and borrow areas. Prior to the start of compaction the following day the cover lift should be removed and wasted or stockpiled separately. After completion of the fill placement and compaction it is acceptable to allow the soil to freeze provided that all frost is allowed to thaw from the subgrade prior to continued fill placement the following spring.

Within borrow areas the surficial layer of frozen soil should be removed. The frozen soils and soils with water contents higher than the optimum should either be wasted or stockpiled separately for later use in summer after thawing and proper water conditioning. The fill materials should not be placed on frozen subgrade. The frozen subgrade should be stripped of frozen soils. The frozen soils should either be wasted or stockpiled separately for later use after thawing and proper water conditioning. A higher waste factor (approximately 40%) should be assumed for these conditions.

Contractors with cold weather experience should be selected for winter construction.

5.12 Frost Protection

The seasonal frost penetration depth was estimated following the procedure in the Canadian Foundation Engineering Manual (CFEM, 2006). A mean freezing index of approximately 750 C-days was used for this purpose. A general prediction for frost depth across the plant site is 2.5 m, assuming no snow cover and organic soil at surface. Greater frost depths are likely at higher elevations.

The frost depths can be reduced in heated buildings. Frost depth is not considered to be an issue for interior foundations of heated buildings. Frost depth can be reduced to approximately 2.0 m for perimeter foundations of heated buildings without insulation. Perimeter insulation should be provided if the base of the perimeter footings in heated buildings is placed at a depth of less than 2.0 m (minimum soil cover of 2.0 m).

Pipelines, foundations and other infrastructure elements below the finished grade should be protected from frost heave either by burial below the seasonal frost zone or by shallow burial accompanied with insulation and/or heat tracing.

The minimum burial depth of un-insulated utility lines, water pipelines and foundations should be greater than the 2.5 m predicted frost depth. If burial depth is less than 2.5 m, insulation should be used to reduce the frost penetration.

For shallow foundations the insulation should have a total buried width of 2.5 m. The buried width is the sum of the vertical portion along the foundation element and the horizontal projection. A minimum buried depth of 0.6 m is recommended for insulation.

Compacted general engineered granular fill should be placed above the insulation. The finished surface should be capped with a 300 mm thick compacted clay layer and should have a minimum grade of 1% to reduce ponding and infiltration of water.

Frost adfreeze/uplift pressures due to adfreeze on below grade structures may be in the order of 65 kPa, to be determined during final design. For this reason, unheated and un-insulated shallow foundation bases should be founded below the frost zone. An acceptable frost bond breaker should also be applied to the wall surface in this unheated application down to the base of the wall face.

5.13 Lateral Protection on Buried Structures

Buried structures should be designed to resist lateral earth pressure in the at rest condition. The stability of buried structures against overturning and sliding should be checked by the structural engineers. Lateral earth pressure on the buried walls can be calculated using the following equation.

$$P_o = K_o(\gamma_b H+q)$$

Where:

P_o = Lateral earth pressure at rest (kPa)

K_o = Coefficient of earth pressure at rest

γ_b = Unit weight of backfill soil (kN/m^3)

H = Depth below final grade (m)

q = Any surcharge pressure at ground level (kPa)

Lateral hydrostatic pressure needs to be included for design of buried structures exposed to hydrostatic pressure. The hydrostatic pressure (P_w, kPa) on the structures exposed to water can be calculated using the following equation.

$$P_w = \gamma_w H_{wmax}$$

Alternatively, free draining backfill can be used together with a weeping tile system to lower the groundwater table below the base of the structure, in which case hydrostatic pressure on the structure can be neglected. A weeping tile system should be installed at or slightly below the base of the footing. The weeping tile system should consist of a perforated pipe wrapped in a geotextile fabric surrounded by a 150 mm thick layer of free-draining granular material with a gradation similar to that of concrete sand. Alternatively, the weeping tile pipe may be surrounded by coarse drainage rock wrapped in a medium weight non-woven geotextile. The weeping tile should drain towards a sump pump. Gravity drainage is preferred but may not be possible depending on actual site drainage conditions. The free draining backfill should comprise well graded granular material with less than 5% fines (i.e. passing 0.075 mm).

The parameters required for calculation of the lateral earth pressure are summarized in Table 17.

Table 17: Lateral Earth Pressure Parameters

Backfill Type	γ (kN/m^3)	ϕ' (degrees)	K_a	K_p	K_o
Native - gravelly sandy silt	17	30	0.33	3.00	0.50
Native – low plastic sandy silty clay	17	26	0.39	2.56	0.56
Native - clayey sand and gravel (engineered fill)	21	32	0.31	3.25	0.47
Imported – clean sand/gravel (structural fill)	22	34	0.28	3.54	0.44

The above parameters assume native or imported granular fill compacted to approximately 95% of Standard Proctor Maximum Dry Density (SPMDD) and horizontal ground behind the buried wall. If the ground surface slopes away from the wall, design pressure should be re-evaluated. The above parameters are based on the assumption that adequate drainage will be provided behind the buried structures so that hydrostatic pressure is not developed.

Backfill around buried walls should not commence before the concrete walls have reached a minimum two-thirds of their 28 day strength and floor framing and intake chamber floor slab are in place. Only hand operated compaction should be employed within 600 mm of the concrete basement walls. Caution should be used during compaction of backfill to reduce lateral loads caused by the compaction. To avoid differential lateral pressures against walls during construction the backfill should be brought up evenly around the walls. It is preferable to place a clay cap with a minimum thickness of 600 mm at ground surface to reduce infiltration of surface water.

5.14 Mechanically Stabilized Earth (MSE) Walls

The following sections provide general geotechnical recommendations to support design and construction of Mechanically Stabilized Earth (MSE) walls. Due to the variability in depth to bedrock in the plant site area, typical soil parameters have been provided in Section 5.14.2 for all major soil types found in the general plant site area. The location and the required height of MSE walls have not yet been finalized and a site investigation may be required to support final design.

Based on the preliminary plant site layout as provided by Sedgman on April 29, 2015, it has been assumed the MSE wall for the crusher is located by boreholes BH15-19 and 20. These boreholes have shallow depth (<0.3 m) to bedrock.

5.14.1 Resistance Factors

Resistance factors must be incorporated in foundation design. The resistance factors in Table 18 are per AASHTO (2012).

Table 18: Limit States Design – Resistance Factors for MSE Walls

Shallow Foundation	Resistance Factor
Bearing Capacity	0.65
Sliding Resistance	1.00

The above resistance factors generally apply to the long term condition, thus applying the drained parameters of the soil. In certain cases a lower factor of safety may be applied for the short term condition, thus applying the undrained parameters.

5.14.2 Typical Soil Parameters

Soil parameters provided in Table 19 are appropriate for feasibility stage design for MSE walls.

Table 19: Preliminary Soil Parameters for MSE Wall Design

Soil Type	γ (kN/m^3)	ϕ' (degrees)
Low plastic sandy silty clay	19	30
Loose to compact clayey gravel and sand	20	30
Compact to dense clayey gravel and sand	22	33
Engineered Fill (Well Graded Granular) – MSE Reinforced Zone	22	34
Weak Sandstone/Siltstone Bedrock - Weathered	25	34

The soil parameters for retained soil are based on the assumption that the fill material will be compacted to at least 95% of the SPMDD.

5.14.3 Foundation Subgrade Preparation

Typically an un-reinforced concrete footing/levelling pad (150 mm thick by 300 mm wide) is placed on prepared bearing surface to receive the MSE wall panels. Typically a 600 mm burial depth is required by the wall supplier for the levelling pad below finished grade. The bearing surface for the reinforced zone will be either undisturbed native soil or general engineered fill compacted to 98% of the SPMDD. Any soft/loose, frozen or otherwise unsuitable soils encountered at the exposed bearing surface should be over-excavated and backfilled with general engineered fill compacted to 98% of the SPMDD.

The general engineered fill should comprise granular soils or low to medium plasticity clay/clay till. Locally excavated soil can be used as general engineered fill provided these soils do not contain deleterious material such as organics, roots, debris, etc. The general engineered fill should not contain high plasticity clays.

The reinforced zone should not be placed on frozen subgrade or in freezing conditions. The exposed subgrade should be inspected by a qualified geotechnical engineer prior to pouring footing concrete to confirm that the footing subgrade is prepared in accordance with recommendations provided in this report. The zone of over-excavation (if required) below the reinforced zone should extend laterally beyond the wall footprint a distance equal to the depth of over-excavation below the bearing elevation.

The reinforced zone behind the panels should be backfilled with free draining granular materials meeting the wall designer's specifications.

5.14.4 Drainage

The reinforced zone behind the MSE walls must be properly drained to prevent development of hydrostatic pressure behind the walls. As a minimum a drain (weeping tile) should be provided behind the MSE wall at the foundation pad or at the base of sub-cut.

5.14.5 Bearing Capacity

To meet the bearing capacity requirements and to limit settlement of the MSE wall the reinforced zone should be placed on acceptable bearing stratum. In areas of high fills or weak subgrades over-excavation to an acceptable bearing stratum and placement of general engineered fill compacted to 98% of the Standard Proctor Maximum Density (SPMDD) may be required.

For bearing capacity values refer to Section 5.5. Appropriate resistance factors should be applied on ultimate bearing capacity and ultimate sliding resistance to obtain factored bearing capacity and factored sliding resistance.

For relatively high MSE walls ground improvement may be required to achieve the required bearing capacity and to satisfy global stability requirements. Ground improvements may include sub-cutting and basal reinforcement.

5.15 Slab on Grade Floors

Slab-on-grade construction is considered feasible for lightly loaded structures provided certain precautions are undertaken. All topsoil, soil containing organics, and any loose/soft soils should be removed to expose the native soil. The exposed surface should be proof-rolled. Any soft or loose soil pockets should be over-excavated and replaced with general engineered fill. The general engineered fill should be compacted to at least 98% of the Standard Proctor Maximum Dry Density (SPMDD) unless otherwise specified. If seasonally frozen ground is present at the time of slab construction, it should be over-excavated and replaced with general engineered fill. The exposed subgrade should be protected from rain, snow, drying, seasonal frost, and ingress of water. The subgrade should not be allowed to freeze during or after construction.

The final grade should be restored by placing general engineered fill. A levelling course of suitably crushed gravel should be provided directly under the slab. To limit potential stress concentrations, the levelling course should not contain very coarse material. The levelling course may comprise 200 mm thick compacted layer of 20 mm minus crush. The levelling course should be compacted to 100% of the SPMDD.

If the floor slab loading is expected to exceed 10 kPa, or if the floor slab is to support vibrating equipment or if the floor slab traffic is expected to be high, a geotechnical engineer should evaluate the recommendations for slab-on-grade construction.

The slab-on-grade floors should contain an adequate number of construction joints to ensure controlled cracking of the slab concrete. The slab-on-grade floors should be adequately reinforced to reduce the possibility of uncontrolled slab cracking.

The slab-on-grade floor, and walls and columns supported on foundation system (piles) should be structurally independent from each other. Non-load bearing walls placed directly on slab-on-grade floors should also be structurally independent from walls and columns supported on foundation system.

Some relative movement between floor slabs-on-grade and adjacent walls or foundations and differential movements within the slab should be anticipated. Generally, if the recommendations outlined in this report are followed, these movements should be acceptably small. It is possible however that some cracking of the slab or distortion of any internal partition walls supported by the slab may occur. Such damage may be visible particularly if a brittle surface finishing, such as ceramic tiles, is adopted. Mechanical equipment placed on floor slabs should be designed to permit some re-levelling in case of differential settlement. Piping and electrical conduit connections should also permit some flexibility to remove any distress. The risk of such damage should be weighed against the additional cost associated with alternative slab support systems, such as structurally supported slabs.

5.16 Guidelines for Machine Foundations

Certain guidelines have been found to be useful for design of machine foundations subject to dynamic forces, pending determination of the actual operating characteristics of the machinery and a detailed dynamic analysis. In many cases, where experience with similar equipment or similar soil types exists, no further design refinement may be necessary.

These guidelines have been compiled from the Canadian Foundation Engineering Manual (CFEM, 2006). The guidelines may be used for the trial sizing of foundation blocks and pile caps. Foundation blocks and pile caps are referred to as the block below.

- Generally, the base of the block should be above the water level.
- The mass of the block should be 2 to 3 times the mass of the supported centrifugal machine, and 3 to 5 times the mass of the supported reciprocating machine if shallow foundations are used. If piles are used, the mass of the block should be 1.5 to 2 times the mass of the supported centrifugal machine and 2.5 to 4 times the mass of the supported reciprocating machine.
- The top of the block should be 0.3 m above the elevation of the finished floor.
- The thickness of the block should be the greatest of 0.6 m, the anchorage length of the anchor bolts and 1/5 the least footing dimension.
- The width of the block should be 1 to 1.5 times the vertical distance from the base to the machine centreline to increase damping in the rocking mode.
- The length of the block is estimated from the mass requirements and estimated thickness and width of the foundation. The length should be increased by 0.3 m for maintenance purposes.
- The length and width of the block are adjusted so that the centre of gravity of the machine plus equipment lies within 5% of the block dimension in each direction, from the block centre of gravity.
- It is desirable to increase the embedded depth of the block to increase the damping and provide lateral restraint as well.

- If resonance is predicted from a dynamic analysis, mass of the block should be changed to change its natural frequency.

The following guidelines may be used for the trial configuration of the pile group.

- The number and size of piles should be such that the average static load per pile ≤½ the pile design load.
- The piles should be arranged so that the centroid of the pile group coincides with the centre of gravity of the combined structure and machine.
- If battered piles are used, the batter should be away from the pile cap and should be symmetrical.
- Piles should be properly anchored to the pile cap for adequate rigidity.

6.0 SEDIMENT AND SURGE PONDS – ANALYSIS AND RECOMMENDATIONS

6.1 Dam Classification and Design Criteria

6.1.1 Design Criteria

The design criteria have been selected from, and comply with the following guidelines:

- Canadian Dam Association: *Dam Safety Guidelines* (2013)
- Canadian Dam Association: *Technical Bulletin –Application of Dam Safety Guidelines to Mining Dams* (2014)
- Canadian Dam Association: *Technical Bulletin – Geotechnical Considerations for Dam Safety* (2007)

The following sections outline the design criteria for the Grassy Mountain pond dams.

6.1.2 Consequence Classification

The Canadian Dam Association Dam Safety Guidelines (CDA 2013) outlines a dam classification system based on the potential consequence of failure.

Four sediment ponds and four surge ponds are planned for the Grassy Mountain operations. The preliminary consequence classifications and key pond parameters of the ponds are presented in Table 20.

Table 20: Preliminary Dam Consequence Classifications[(1)]

Pond Name	Overall Classification	Dam Type	Max. Dam Height (m)	Water Storage Volume (m^3)
West Sediment	Significant	Cross-Valley	20.5	109,000
East Sediment	Very High	Side-hill	11.5	125,000
North East Sediment	Very High	Side-hill	17.5	115,000
North West Surge	Significant	Cross-Valley	12.5	35,000
South West Surge	Low	Side-hill	10.0	34,000
Raw Water	High	Cross-Valley	23.0	1,200,000
South East Surge	Very High	Cross-Valley	9.2	280,360
Plant Site Sediment	Low	-	8.5	20,000

(1) Golder (2015c). Feasibility Study of the Grassy Mountain Coal Project for Benga Mining Limited.

6.1.3 Factor of Safety

The target design minimum factors of safety (FoS) for the dams are shown below (from CDA 2013).

- FS = 1.3 for end of construction (short-term undrained conditions)
- FS = 1.5 for long-term, steady-state seepage conditions (drained conditions)
- FS = 1.2 to 1.3 for rapid drawdown
- FS = 1.0 for seismic loading conditions

6.1.4 Seismic Design Criteria

The annual exceedence probability for an earthquake design ground motion (EDGM) corresponding to various CDA dam consequence classifications is provided in Table 21 along with the mean peak ground acceleration (PGA) based on the data provided by the National Building Code of Canada (NBCC) (based on coordinates 49.69 North 114.4 West). The EDGM for a very high consequence dam was extrapolated using a graphical method (NBCC 2015) from provided data for the Grassy Mountain site. These PGA values are used as the EDGM for the Grassy Mountain dams depending on the consequence classification (Section 6.1.2).

Table 21: CDA Earthquake Design Ground Motions

Dam Class	Annual Exceedance Probability Earthquake Design Ground Motion (EDGM)	Peak Ground Acceleration (PGA) (g)
Low	1/500	0.056
Significant	1/1,000	0.080
High	1/2,475	0.120
Very High	1/5,000	0.170
Extreme	1/10,000	N/A

6.2 General Dam Design Elements

6.2.1 Typical Dam Section

Figure 5 and Figure 6 shows the typical dam sections for the feasibility level design stage. All the surge pond and sediment pond dams have the same geometry:

- Downstream slope = 3H:1V
- Upstream slope = 2.5H:1V

The typical dam sections protect against erosion with:

- 0.7 m thick rip-rap armouring on upstream slope
- Minimum 4.0 m wide, 0.4 m thick gravel wearing course on dam crest

Both the surge and sediment ponds include a 1 m thick toe drain from the dam centreline to downstream toe to control foundation uplift pressure and phreatic surface in the dam.

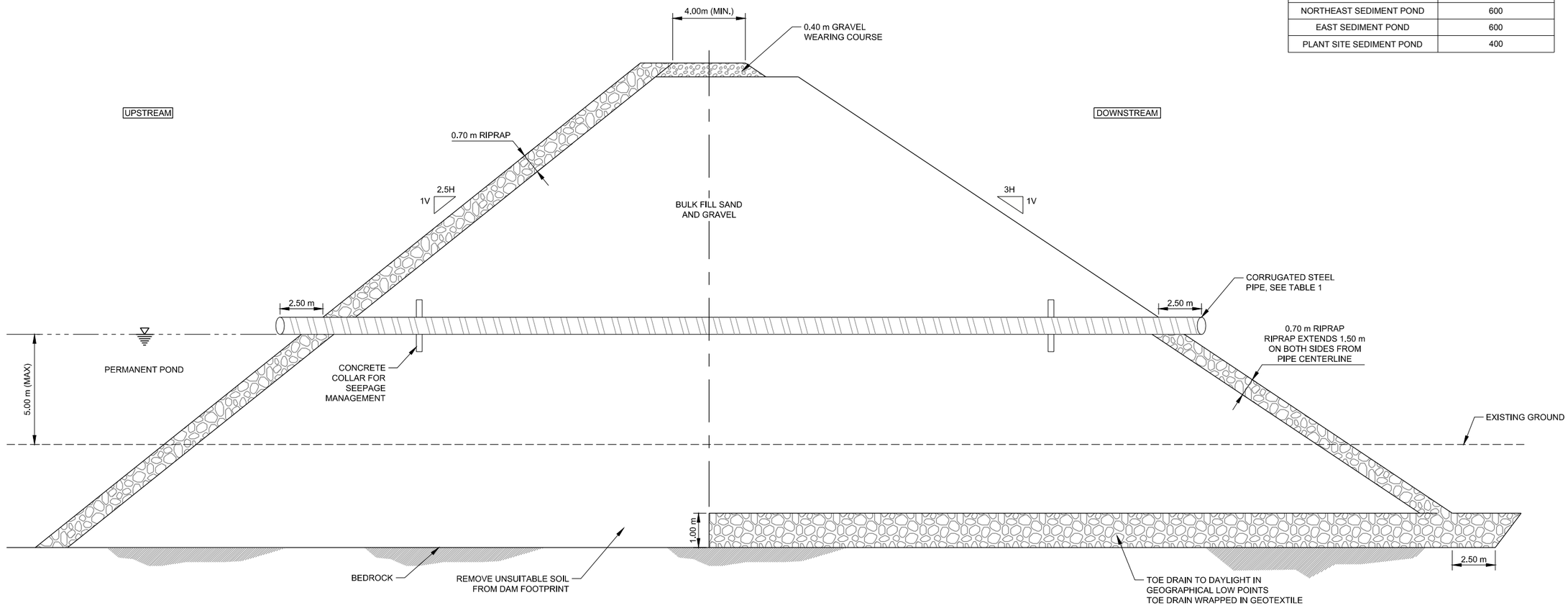
Internal design elements specific to the surge ponds include:

- 1.0 m thick sand and gravel frost protection layer on dam crest
- 4.0 m thick clay blanket to limit seepage from the pond into the dam
- 2.5 m thick layer of filter sand downstream of clay blanket

The stability analysis uses the typical geometry, a 5 m wide crest and the internal toe drain. Other dam design elements (e.g. clay blanket) are not included in the stability analysis at this stage.

The sediment ponds are currently designed to discharge through pipes embedded through the embankment. This element is not included in the stability analysis model.

TABLE 1	
SEDIMENT POND	CSP PIPE DIAMETER (mm)
WEST SEDIMENT POND	500
NORTHEAST SEDIMENT POND	600
EAST SEDIMENT POND	600
PLANT SITE SEDIMENT POND	400



SCALE 1:250 A SECTION - TYPICAL SEDIMENT POND DAM

REFERENCE

FIGURE APPEARS IN APPENDIX 10B, FEASIBILITY STUDY OF THE GRASSY MOUNTAIN COAL PROJECT FOR BENGA MINING LTD., GOLDER, OCTOBER 2015.

0 5 10
1:250 METRES
2x VERT. EXAGGERATION

CLIENT
RIVERSDALE RESOURCES LIMITED
BENGA MINING LIMITED

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-01-08
PREPARED	TF
DESIGN	CC
REVIEW	RA
APPROVED	AH

PROJECT
GRASSY MOUNTAIN COAL PROJECT

TITLE
SECTION - TYPICAL SEDIMENT POND DAM

PROJECT No.	CONTROL	Rev.	FIGURE
1406422		A	5

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25 mm
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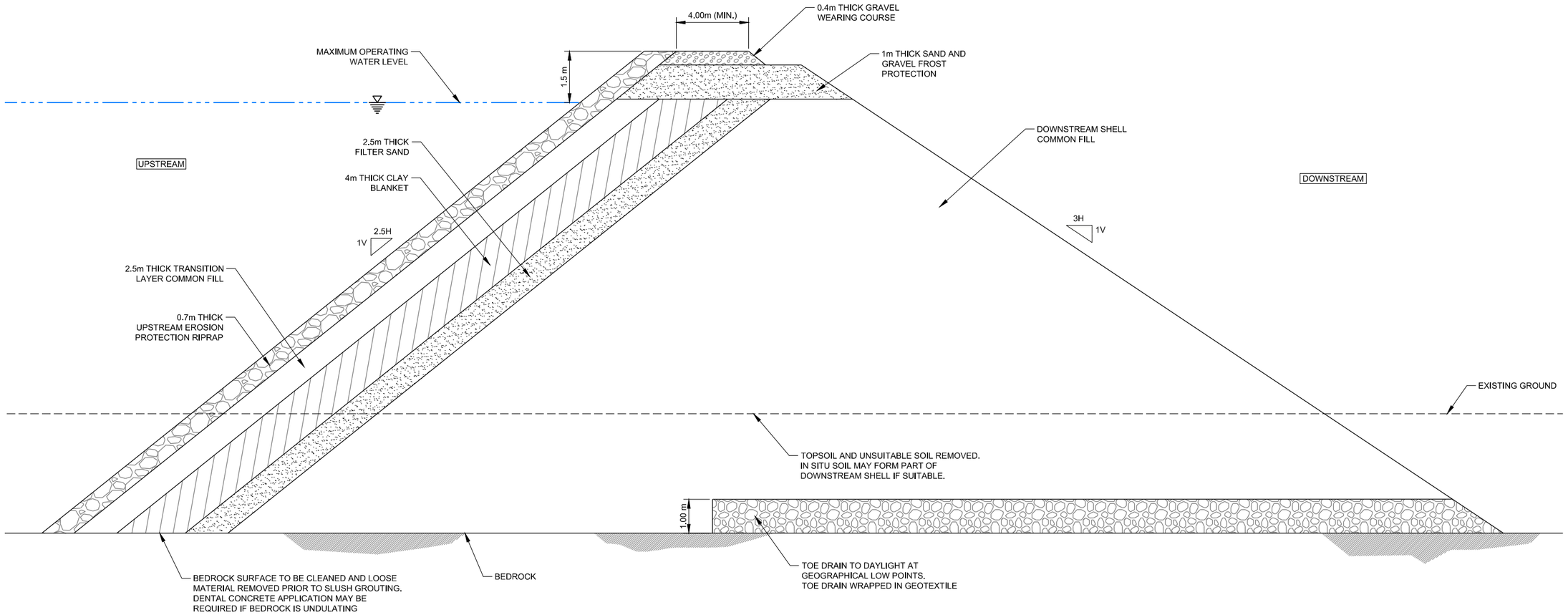

SCALE 1:250 B SECTION - TYPICAL SURGE POND DAM

REFERENCE

FIGURE APPEARS IN APPENDIX 10B, FEASIBILITY STUDY OF THE GRASSY MOUNTAIN COAL PROJECT FOR BENGA MINING LTD., GOLDER, OCTOBER 2015.

0 5 10
1:250 METRES
2x VERT. EXAGGERATION

CLIENT
RIVERSDALE RESOURCES LIMITED
BENGA MINING LIMITED

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-01-08
PREPARED	TF
DESIGN	CC
REVIEW	RA
APPROVED	AH

PROJECT
GRASSY MOUNTAIN COAL PROJECT

TITLE
SECTION - TYPICAL SURGE POND DAM

PROJECT No.	CONTROL	Rev.	FIGURE
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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25 mm
0

6.2.2 Filter Design

The Canadian Dam Association (2013) recommends having well-designed granular filters to prevent internal erosion and piping failure. Internal erosion occurs when the fine particles from one material migrate into adjacent materials. Internal erosion can also occur within a single material (i.e. suffusion) if it is internally unstable.

The dam fill (compacted well-graded clayey gravel and sand), clay blanket and filter sand need to be designed to be 'filter compatible'. This section describes the design methods which should be used to design filter gradation limits and then confirm filter compatibility between the multiple earth materials in the dam.

CDA (2007) refers to the filter design criteria developed by Sherard et al. (1984a, 1984b and 1989) (Table 22) and the internal stability criteria suggested by Kenney and Lau (1985). These criteria should be used in conjunction with procedures developed by the U.S. Army Corps of Engineers (USACE, 2004).

Table 22: Granular Filter Design Criteria[(1)]

Base Soil	Filter Criteria
Fine silts, clays (85-100% fines)	$D_{15\ (filter)} \leq 9 \times d_{85\ (base)}$ (Not smaller than 0.2 mm)
Sandy silts, clays (40-85% fines)	$D_{15\ (filter)} \leq 0.7$ mm
Sands and gravels (0-15% fines)	$D_{15\ (filter)} \leq 4 \times d_{85\ (base)}$
Clayey/silty sands (15-40% fines)	Between : $D_{15\ (filter)} \leq 4 \times d_{85\ (base)}$, and $D_{15\ (filter)} \leq 0.7$ mm

(1) Adapted from Sherard et al. (1984a, 1984b and 1989) by CDA (2013)

In addition, fill materials should be placed in a manner to avoid segregation. Segregated materials may not provide adequate filtration and may be susceptible to suffusion.

6.3 Stability Analysis

6.3.1 Approach

Each pond dam was analyzed for global stability through the section at maximum dam height. The soil and bedrock stratigraphy through that section were inferred based on available information from the geotechnical investigations. The description of the stratigraphy for each pond site is presented in Section 3.0.

The slope stability analysis was carried out using the software SLOPE/W (Version 7.20) GEOSTUDIO 2007. The factor of safety (FoS) was calculated based on Morgenstern-Price limit equilibrium approach. The following cases were assessed:

- Static short-term (construction) condition
- Static long-term condition
- Rapid drawdown condition
- Pseudo-static (seismic) condition

Construction conditions evaluate the stability immediately after construction, where the dam has been constructed to full height and excess porewater pressure is present in the foundation and dam fill. Undrained conditions have been considered for the foundation where appropriate (cohesive soils in subsurface). A porewater pressure coefficient r_u = 0.3 has been applied to the common fill (compacted well-graded clayey gravel and sand), where r_u is defined as the ratio of the porewater pressure to the overburden pressure.

The long-term case evaluates stability under static conditions where excess porewater pressure in the dam and foundation are fully dissipated. The long-term case has been modelled by defining a piezometric line drawn from the operating pond level to the granular toe drain. The detail design phase of the dams should include 2-D steady state finite element seepage analysis to model the phreatic surface in the dam and the design internal drainage elements.

The rapid drawdown case evaluates stability of the upstream slope when the water level has dropped rapidly (i.e. during rapid drawdown of the reservoir). The rapid drawdown condition is assumed to be a relatively unlikely event for the sediment ponds, but a more common occurrence for the surge ponds and the raw water pond. The rapid drawdown case has been modelled by defining a piezometric line at ground surface upstream of the dam and rising inside the dam to slightly below operating pond level to the granular toe drain. The rapid drawdown cases assume an undrained response in the foundation soils.

To model earthquake conditions, the pseudo-static method of analysis was used, which applies a horizontal force to the failure mass proportional to the design horizontal acceleration. To account for the non-rigid response of the foundation soils and waste rock, the horizontal seismic loading that was considered in the analysis was one-half the peak ground acceleration. The foundation soils material strengths were reduced to 80% of the peak strength (Hynes-Griffin and Franklin, 1984) to account for potential strain softening due to pore pressure generation during shaking.

6.3.2 Material Properties

The material properties used for the slope stability assessment are presented in Table 23. The material properties are based on the site investigation, field testing, index laboratory testing, engineering judgement and experience in similar soils. These materials encompass the soil materials used for slope stability analysis of the pond dams. Not all materials were encountered at every pond site.

Table 23: Summary of Material Properties

Material	Unit Weight (kN/m^3)	Undrained Shear Strength (kPa)	Drained Parameters			
			Effective Friction Angle (degrees)		Effective Cohesion (kPa)	
			Static	*Pseudo-Static*	*Static*	*Pseudo-Static*
Fill	21	-	32	27	0	0
Granular Toe Drain	22	-	34	28	0	0
Clayey gravel & sand - loose to compact	20	-	30	25	0	0
Clayey gravel & sand - compact to dense	22	-	33	27	0	0
Silty Clay - firm to stiff	19	50	30	25	0	0
Silty Clay - very stiff to hard	19	120	30	25	0	0
Silty sand to silt – very loose to loose	17	-	27	22	0	0
Sandstone/Siltstone Bedrock	Impenetrable					

6.3.3 Plant Site Sediment Pond

The plant site sediment pond design capacity is 20,000 m^3. The pond does not meet the definition of a dam as outlined in the CDA Dam Safety Guidelines (2013). Furthermore, the pond will be constructed primarily cutting into existing ground instead of building an embankment. For these reasons, a stability analysis of the plant site sediment pond was not conducted for the feasibility level design.

6.3.4 West Sediment Pond

The West Sediment Pond site subsurface conditions are described in Section 3.7. The interpreted subsurface conditions and analysis is shown in Figure 7.

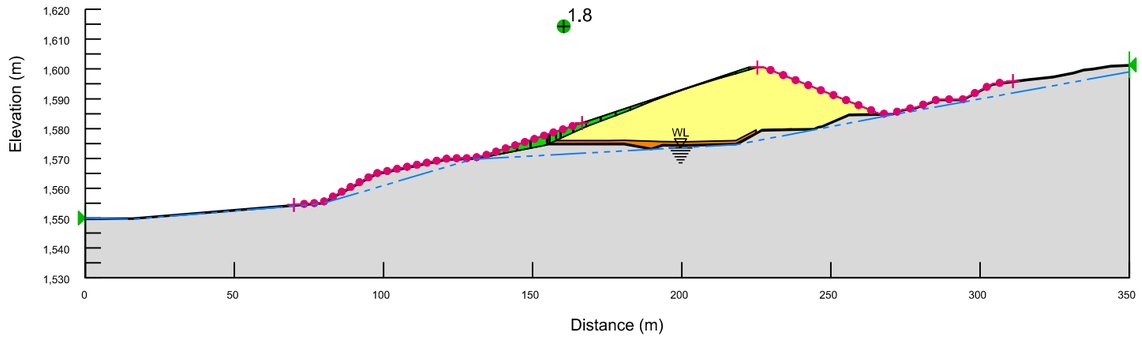
Table 24 presents a summary of the stability analysis results for construction, long-term and pseudo-static conditions.

Table 24: Slope Stability Analysis Results – West Sediment Pond

Condition	Failure Mode	FoS	Minimum Target FoS
Construction (Undrained)	Embankment	1.8	1.3
Long-term (Drained)	Foundation	1.7	1.5
Rapid drawdown	Foundation	1.3	1.2 to 1.3
Seismic	Foundation	1.1	1.0

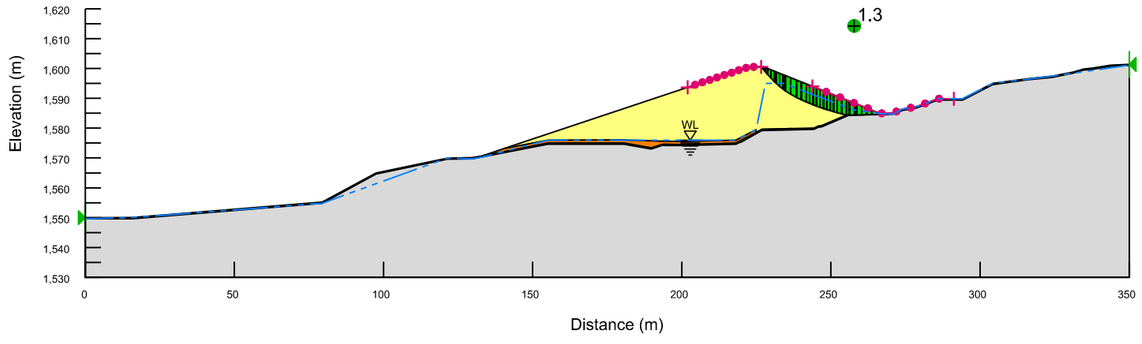
The minimum FoS per CDA (2013) Guidelines is achieved for all cases.

Name: Fill Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 32 ° Piezometric Line: 1 Ru: 0.3 Include in PWP: No
Name: Toe Drain Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 34 ° Piezometric Line: 1 Include in PWP: No
Name: Silty Sand (Loose) Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1 Include in PWP: No
Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1 Include in PWP: No



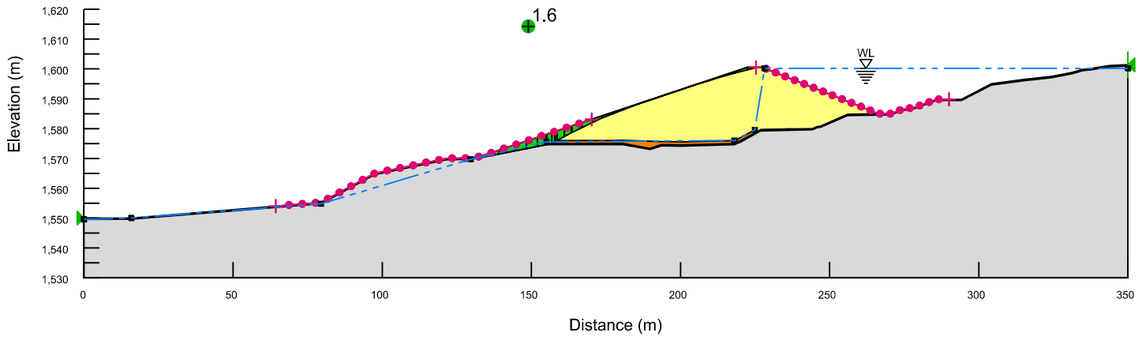
SCALE 1:2000 D - STABILITY SECTION - CONSTRUCTION - UNDRAINED

Name: Fill Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 32 ° Piezometric Line: 1
Name: Toe Drain Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 34 ° Piezometric Line: 1
Name: Silty Sand (Loose) Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1
Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1



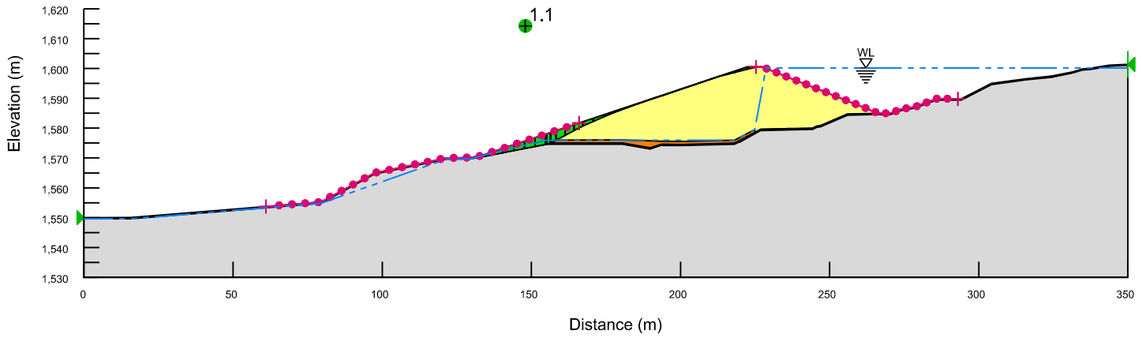
SCALE 1:2000 D - STABILITY SECTION - RAPID DRAWDOWN

Name: Fill Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 32 ° Piezometric Line: 1
Name: Toe Drain Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 34 ° Piezometric Line: 1
Name: Silty Sand (Loose) Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1
Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1



SCALE 1:2000 D - STABILITY SECTION - LONG TERM - DRAINED

Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Fill - Seismic Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1
Name: Toe Drain - Seismic Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 28 ° Piezometric Line: 1
Name: Silty Sand (Loose) - Seismic Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 22 ° Piezometric Line: 1
Horz Seismic Load: 0.04



SCALE 1:2000 D - STABILITY SECTION - LONG TERM - SEISMIC

LEGEND

- FILL
- GRANULAR TOE DRAIN
- CLAYEY GRAVEL AND SAND TO SAND AND GRAVEL (LOOSE TO COMPACT)
- CLAYEY GRAVEL AND SAND (COMPACT TO DENSE)
- SILTY CLAY (FIRM TO STIFF)
- SILTY CLAY (VERY STIFF TO HARD)
- SILTY SAND TO SILT (VERY LOOSE TO LOOSE)
- SANDSTONE/SILTSTONE BEDROCK

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DESIGN	CC
REVIEW	RA
APPROVED	AH

PROJECT
GRASSY MOUNTAIN COAL PROJECT

TITLE
STABILITY SECTION WEST SEDIMENT POND

PROJECT No.	CONTROL	Rev.	FIGURE
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25 mm

6.3.5 East Sediment Pond

The East Sediment Pond site subsurface conditions are unknown as no ground investigation has taken place at or near the east sediment pond site. The assumed subsurface conditions are described in Section 3.10. It is noted that there is a relatively steep natural hill just downstream of the dam that should be included in future assessments of slope stability. The interpreted subsurface conditions and analysis is shown in Figure 8.

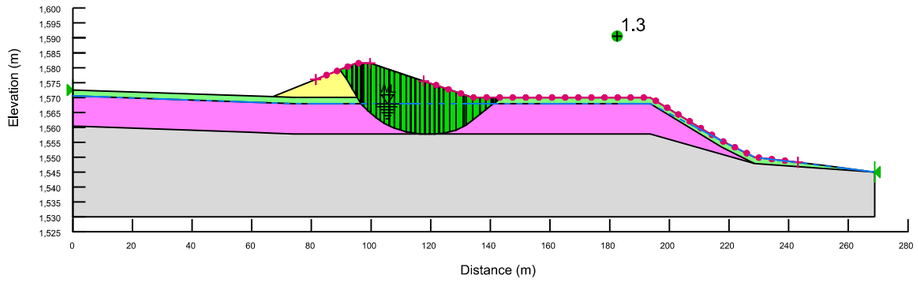
Table 25 presents a summary of the stability analysis results for construction, long-term and pseudo-static conditions.

Table 25: Slope Stability Analysis Results – East Sediment Pond

Condition	Failure Mode	FoS	Minimum Target FoS
Construction (Undrained)	Foundation	1.3	1.3
Long-term (Drained)	Foundation	1.7	1.5
Rapid drawdown	Foundation	1.2	1.2 to 1.3
Seismic	Foundation	1.1	1.0

Though the minimum FoS per CDA (2013) Guidelines is achieved for all cases, a geotechnical investigation is required at the east sediment pond site and the slope stability analysis must be updated during the next design phase.

Name: Fill Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 32 ° Piezometric Line: 1 Ru: 0.3 Include in PWP: Yes
Name: Toe Drain Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 34 ° Piezometric Line: 1 Include in PWP: No
Name: Non-Cohesive (loose to compact) Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Piezometric Line: 1 Ru: 0 Include in PWP: No
Name: Cohesive (firm to stiff) - undrained Model: Undrained (Phi=0) Unit Weight: 19 kN/m³ Cohesion: 50 kPa Piezometric Line: 1 Include in PWP: No
Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1 Include in PWP: No



SCALE 1:2000 E - STABILITY SECTION - CONSTRUCTION - UNDRAINED

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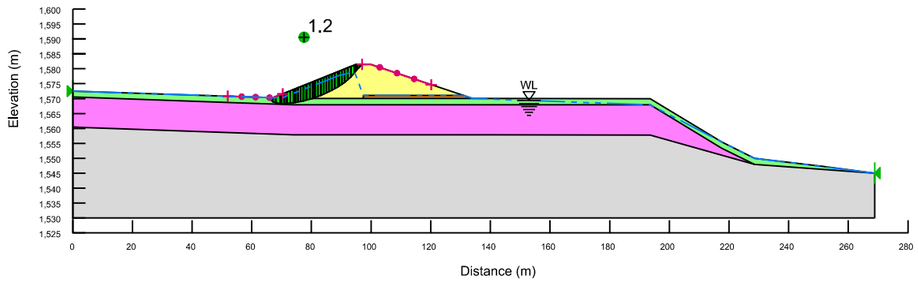
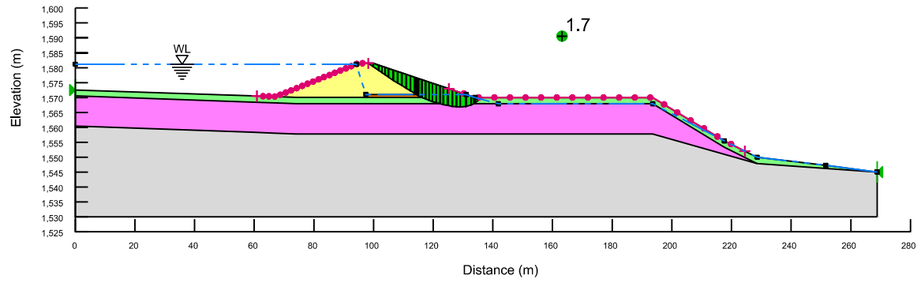
Name: Toe Drain Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 34 ° Piezometric Line: 1
Name: Non-Cohesive (loose to compact) Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Piezometric Line: 1
Name: Cohesive (firm to stiff) - undrained Model: Undrained (Phi=0) Unit Weight: 19 kN/m³ Cohesion: 50 kPa Piezometric Line: 1
Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1



SCALE 1:2000 E - STABILITY SECTION - RAPID DRAWDOWN

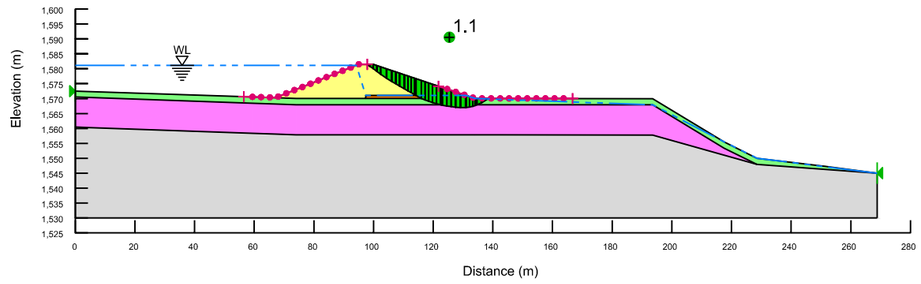
Name: Fill Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 32 ° Piezometric Line: 1
Name: Toe Drain Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 34 ° Piezometric Line: 1
Name: Non-Cohesive (loose to compact) Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Piezometric Line: 1
Name: Cohesive (firm to stiff) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Piezometric Line: 1
Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1



SCALE 1:2000 E - STABILITY SECTION - LONG TERM - DRAINED

Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Fill - Seismic Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1
Name: Toe Drain - Seismic Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 28 ° Piezometric Line: 1
Name: Non-Cohesive (loose to compact) - seismic Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 25 ° Piezometric Line: 1
Name: Cohesive (firm to stiff) - seismic Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 25 ° Piezometric Line: 1

Horz Seismic Load: 0.085



SCALE 1:2000 E - STABILITY SECTION - LONG TERM - SEISMIC

LEGEND

- FILL
- GRANULAR TOE DRAIN
- NON-COHESIVE (LOOSE TO COMPACT)
- NON-COHESIVE (COMPACT TO DENSE)
- COHESIVE (FIRM TO STIFF)
- COHESIVE (VERY STIFF TO HARD)
- SILTY SAND TO SILT (VERY LOOSE TO LOOSE)
- SANDSTONE/SILTSTONE BEDROCK

0 50 100
1:2,000 METRES

CLIENT
RIVERSDALE RESOURCES LIMITED
BENGA MINING LIMITED

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-01-08
PREPARED	TF
DESIGN	CC
REVIEW	RA
APPROVED	AH

PROJECT
GRASSY MOUNTAIN COAL PROJECT

TITLE
STABILITY SECTION EAST SEDIMENT POND

PROJECT No.	CONTROL	Rev.	FIGURE
1406422		A	8

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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25 mm

6.3.6 North East Sediment Pond

The North East Sediment Pond site subsurface conditions are described in Section 3.9. The interpreted subsurface conditions and analysis is shown in Figure 9.

Table 26 presents a summary of the stability analysis results for construction, long-term and pseudo-static conditions.

Table 26: Slope Stability Analysis Results – North East Sediment Pond

Condition	Failure Mode	FoS	Minimum Target FoS
Construction (Undrained)	Foundation	0.8	1.3
Long-term (Drained)	Foundation	1.6	1.5
Rapid drawdown	Foundation	1.1	1.2 to 1.3
Seismic	Foundation	1.0	1.0

The FoS for the construction (undrained) and rapid drawdown conditions do not meet the minimum target FoS per CDA (2013). However, the rapid drawdown condition is assumed to be an uncommon occurrence for the North East Sediment Pond.

Potential design solutions to increase the FoS include:

- Excavation of shallow cohesive soils.
- Staged construction, supported by with monitoring of embankment and foundation performance during construction.
- Foundation improvement, such as a shear key or caissons.
- Buttressing or flattening the downstream slope.

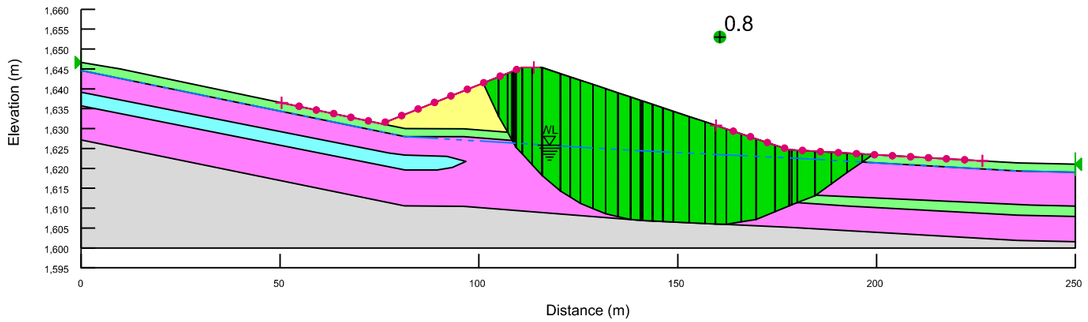
As an example, Table 27 summarizes the results of the slope stability analysis if the dam foundation is reinforced with a shear key installed through the overburden soil to the bedrock below the dam. Figure 10 shows the subsurface conditions and analysis.

Table 27: Slope Stability Analysis Results - North East Sediment Pond, with Shear Key

Condition	Failure Mode	FoS	Minimum Target FoS
Construction (Undrained)	Foundation	1.3	1.3
Long-term (Drained)	Foundation	1.6	1.5
Rapid drawdown	Foundation	1.1	1.2 to 1.3
Seismic	Foundation	1.0	1.0

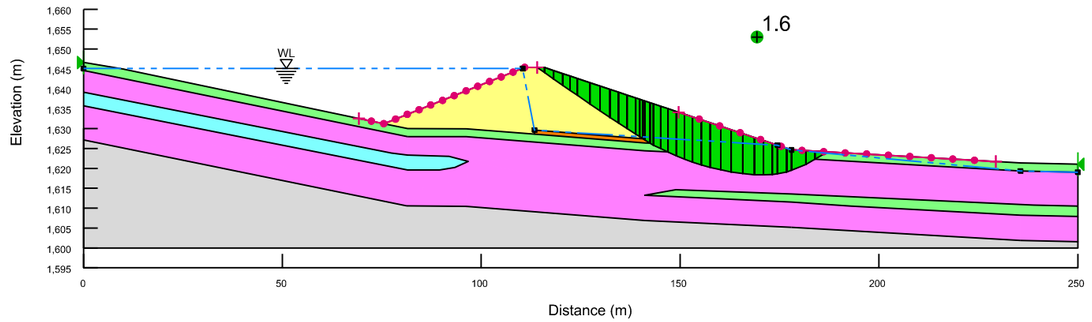
Selection and design of the most appropriate design solution will be undertaken during detailed design.

Name: Fill Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 32 ° Piezometric Line: 1 Ru: 0.3 Include in PWP: Yes
Name: Toe Drain Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 34 ° Piezometric Line: 1 Include in PWP: No
Name: Gravel and Sand (loose to compact) Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Piezometric Line: 1 Include in PWP: No
Name: Silty Clay (firm to stiff) - undrained Model: Undrained (Phi=0) Unit Weight: 19 kN/m³ Cohesion: 50 kPa Piezometric Line: 1 Include in PWP: No
Name: Silty Sand (v loose to loose) Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1 Include in PWP: No
Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1 Include in PWP: No



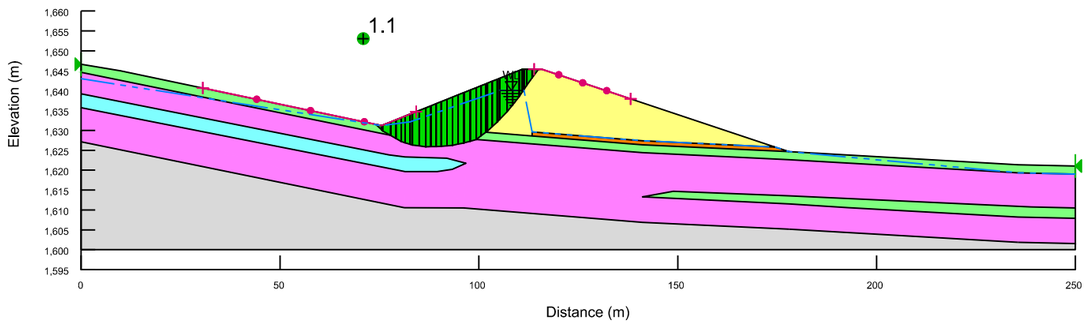
SCALE 1:1500 F - STABILITY SECTION - CONSTRUCTION - UNDRAINED

Name: Fill Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 32 ° Piezometric Line: 1
Name: Toe Drain Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 34 ° Piezometric Line: 1
Name: Gravel and Sand (loose to compact) Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Piezometric Line: 1
Name: Silty Clay (firm to stiff) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Piezometric Line: 1
Name: Silty Sand (v loose to loose) Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1
Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1



SCALE 1:1500 F - STABILITY SECTION - LONG TERM - DRAINED

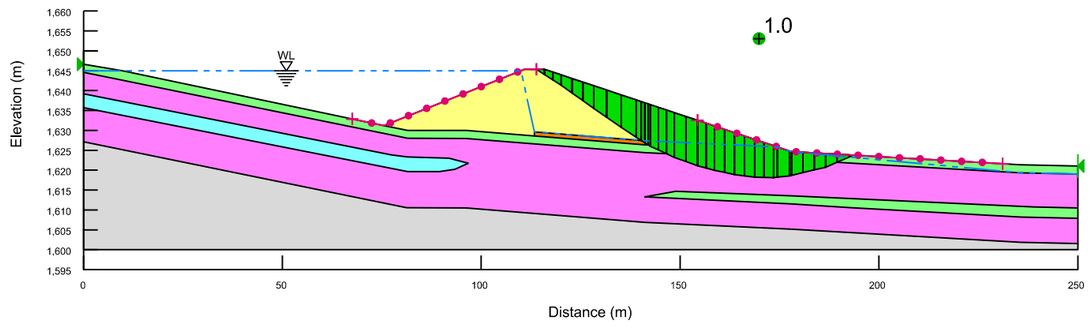
Name: Fill Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 32 ° Piezometric Line: 1
Name: Toe Drain Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 34 ° Piezometric Line: 1
Name: Gravel and Sand (loose to compact) Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Piezometric Line: 1
Name: Silty Clay (firm to stiff) - undrained Model: Undrained (Phi=0) Unit Weight: 19 kN/m³ Cohesion: 50 kPa Piezometric Line: 1
Name: Silty Sand (v loose to loose) Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1
Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1



SCALE 1:1500 F - STABILITY SECTION - RAPID DRAWDOWN

Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Fill - seismic Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1
Name: Toe Drain - seismic Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 28 ° Piezometric Line: 1
Name: Gravel and Sand (loose to compact) - seismic Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 25 ° Piezometric Line: 1
Name: Silty Clay (firm to stiff) - seismic Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 25 ° Piezometric Line: 1
Name: Silty Sand (v loose to loose) - seismic Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 22 ° Piezometric Line: 1

Horz Seismic Load: 0.085



SCALE 1:1500 F - STABILITY SECTION - LONG TERM - SEISMIC

LEGEND

- FILL
- GRANULAR TOE DRAIN
- CLAYEY GRAVEL AND SAND TO SAND AND GRAVEL (LOOSE TO COMPACT)
- CLAYEY GRAVEL AND SAND (COMPACT TO DENSE)
- SILTY CLAY (FIRM TO STIFF)
- SILTY CLAY (VERY STIFF TO HARD)
- SILTY SAND TO SILT (VERY LOOSE TO LOOSE)
- SANDSTONE/SILTSTONE BEDROCK

0 25 50
1:1,500 METRES

CLIENT
RIVERSDALE RESOURCES LIMITED
BENGA MINING LIMITED

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-01-08
PREPARED	TF
DESIGN	CC
REVIEW	RA
APPROVED	AH

PROJECT
GRASSY MOUNTAIN COAL PROJECT

TITLE
STABILITY SECTION NORTH EAST SEDIMENT POND

PROJECT No.	CONTROL	Rev.	FIGURE
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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25 mm
0

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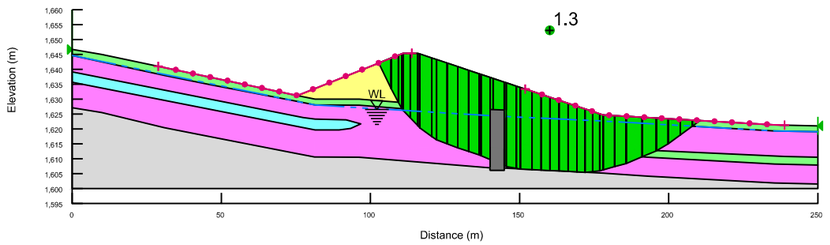
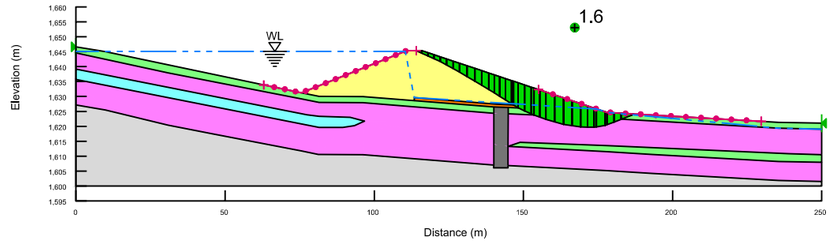
Name: Fill Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 32 ° Piezometric Line: 1 Ru: 0.3 Include in PWP: Yes
Name: Toe Drain Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 34 ° Piezometric Line: 1 Include in PWP: No
Name: Gravel and Sand (loose to compact) Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Piezometric Line: 1 Include in PWP: No
Name: Silty Clay (firm to stiff) - undrained Model: Undrained (Phi=0) Unit Weight: 19 kN/m³ Cohesion: 50 kPa Piezometric Line: 1 Include in PWP: No
Name: Silty Sand (v loose to loose) Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1 Include in PWP: No
Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1 Include in PWP: No
Name: Shear Key Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 350 kPa Phi: 50 ° Piezometric Line: 1 Include in PWP: No



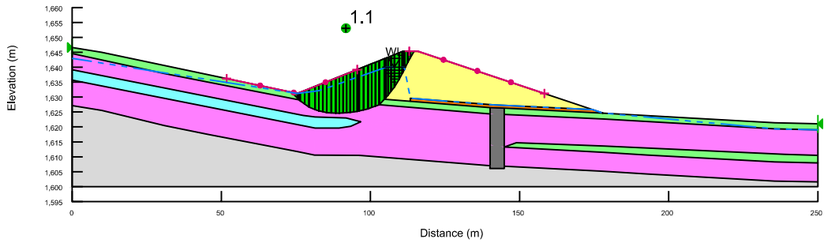
SCALE 1:2000 G - STABILITY SECTION - CONSTRUCTION - UNDRAINED

Name: Fill Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 32 ° Piezometric Line: 1
Name: Toe Drain Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 34 ° Piezometric Line: 1
Name: Gravel and Sand (loose to compact) Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Piezometric Line: 1
Name: Silty Clay (firm to stiff) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Piezometric Line: 1
Name: Silty Sand (v loose to loose) Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1
Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Shear Key Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 350 kPa Phi: 50 ° Piezometric Line: 1



SCALE 1:2000 G - STABILITY SECTION - LONG TERM - DRAINED

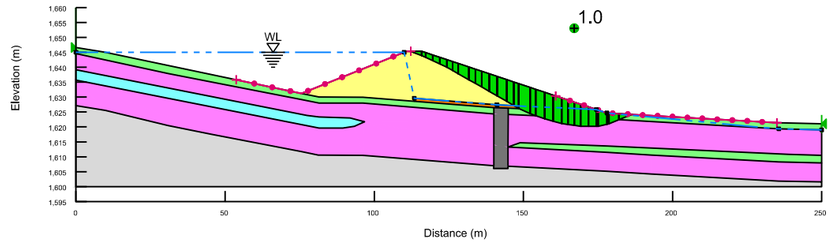
Name: Fill Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 32 ° Piezometric Line: 1
Name: Toe Drain Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 34 ° Piezometric Line: 1
Name: Gravel and Sand (loose to compact) Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Piezometric Line: 1
Name: Silty Clay (firm to stiff) - undrained Model: Undrained (Phi=0) Unit Weight: 19 kN/m³ Cohesion: 50 kPa Piezometric Line: 1
Name: Silty Sand (v loose to loose) Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1
Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Shear Key Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 350 kPa Phi: 50 ° Piezometric Line: 1



SCALE 1:2000 G - STABILITY SECTION - RAPID DRAWDOWN

Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Fill - seismic Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1
Name: Toe Drain - seismic Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 28 ° Piezometric Line: 1
Name: Gravel and Sand (loose to compact) - seismic Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 25 ° Piezometric Line: 1
Name: Silty Clay (firm to stiff) - seismic Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 25 ° Piezometric Line: 1
Name: Silty Sand (v loose to loose) - seismic Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 22 ° Piezometric Line: 1
Name: Shear Key - seismic Model: Mohr-Coulomb Unit Weight: 24 kN/m³ Cohesion: 280 kPa Phi: 44 ° Piezometric Line: 1

Horz Seismic Load: 0.085



SCALE 1:2000 G - STABILITY SECTION - LONG TERM - SEISMIC

LEGEND

- FILL
- GRANULAR TOE DRAIN
- CLAYEY GRAVEL AND SAND TO SAND AND GRAVEL (LOOSE TO COMPACT)
- CLAYEY GRAVEL AND SAND (COMPACT TO DENSE)
- SILTY CLAY (FIRM TO STIFF)
- SILTY CLAY (VERY STIFF TO HARD)
- SILTY SAND TO SILT (VERY LOOSE TO LOOSE)
- SANDSTONE/SILTSTONE BEDROCK
- SHEAR KEY

0 50 100
1:2,000 METRES

CLIENT
RIVERSDALE RESOURCES LIMITED
BENGA MINING LIMITED

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-01-22
PREPARED	TF
DESIGN	CC
REVIEW	RA
APPROVED	AH

PROJECT
GRASSY MOUNTAIN COAL PROJECT

TITLE
STABILITY SECTION NORTH EAST SEDIMENT POND SHEAR KEY

PROJECT No.	CONTROL	Rev.	FIGURE
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25 mm
0

6.3.7 North West Surge Pond

The North West Surge Pond site subsurface conditions are described in Section 3.6. The interpreted subsurface conditions and analysis is shown in Figure 11.

Table 28 presents a summary of the stability analysis results for construction, long-term and pseudo-static conditions.

Table 28: Slope Stability Analysis Results – North West Surge Pond

Condition	Failure Mode	FoS	Minimum Target FoS
Construction (Undrained)	Foundation	1.0	1.3
Long-term (Drained)	Foundation	1.7	1.5
Rapid drawdown	Foundation	1.4	1.2 to 1.3
Seismic	Foundation	1.2	1.0

The FoS for the end of construction stability (undrained conditions) of the dam does not meet minimum target per CDA (2013) without excavation of the surficial firm to stiff clay.

Table 29 presents a summary of the stability analysis results when the surficial firm to stiff clay is removed from the footprint of the dam (~5 m of excavation). Figure 12 shows the subsurface conditions and analysis if the surficial firm to stiff clay is excavated.

Table 29: Slope Stability Analysis Results - North West Surge Pond, Removal of Soft Subgrade Soils

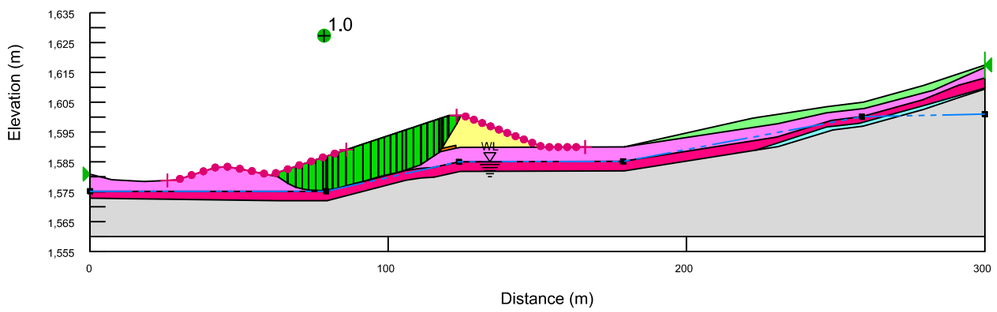
Condition	Failure Mode	FoS	Minimum Target FoS
Construction (Undrained)	Foundation	1.8	1.3
Long-term (Drained)	Foundation	1.8	1.5
Rapid drawdown	Embankment	1.2	1.2 to 1.3
Seismic	Foundation	1.3	1.0

Other potential design solutions to increase the FoS include:

- Staged construction, supported by with monitoring of embankment and foundation performance during construction.
- Buttressing or flattening downstream slope.

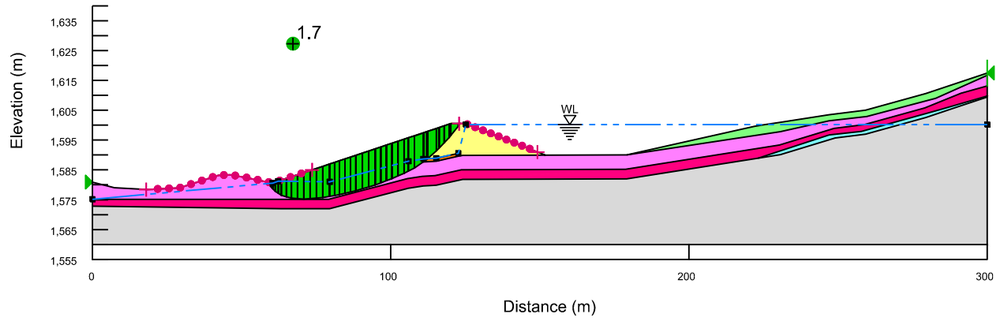
Selection and design of the most appropriate solution will be undertaken during detailed design.

Name: Fill Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 32 ° Piezometric Line: 1 Ru: 0.3 Include in PWP: Yes
Name: Toe Drain Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 34 ° Piezometric Line: 1 Include in PWP: No
Name: Sand and Gravel (loose to compact) Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Piezometric Line: 1 Include in PWP: No
Name: Silty Clay (firm to stiff) - undrained Model: Undrained (Phi=0) Unit Weight: 19 kN/m³ Cohesion: 50 kPa Piezometric Line: 1 Include in PWP: No
Name: Silty Clay (v stiff to hard) - undrained Model: Undrained (Phi=0) Unit Weight: 19 kN/m³ Cohesion: 120 kPa Piezometric Line: 1 Include in PWP: No
Name: Silty Sand - Loose Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1 Include in PWP: No
Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1 Include in PWP: No



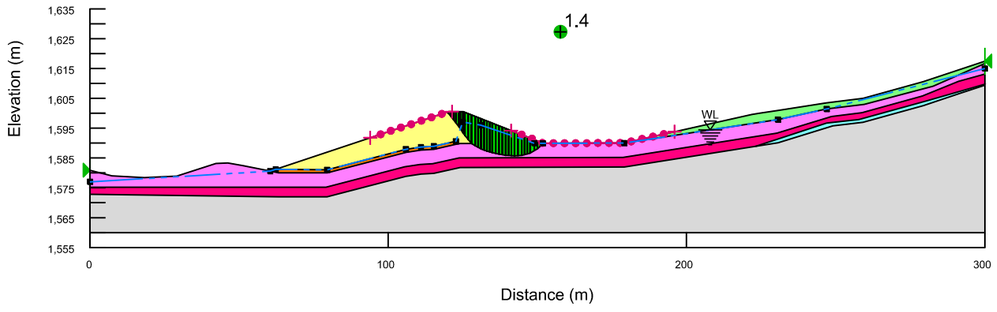
SCALE 1:2000 H - STABILITY SECTION - CONSTRUCTION - UNDRAINED

Name: Fill Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 32 ° Piezometric Line: 1
Name: Toe Drain Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 34 ° Piezometric Line: 1
Name: Sand and Gravel (loose to compact) Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Piezometric Line: 1
Name: Silty Clay (firm to stiff) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Piezometric Line: 1
Name: Silty Clay (v stiff to hard) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Piezometric Line: 1
Name: Silty Sand - Loose Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1
Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1



SCALE 1:2000 H - STABILITY SECTION - LONG TERM - DRAINED

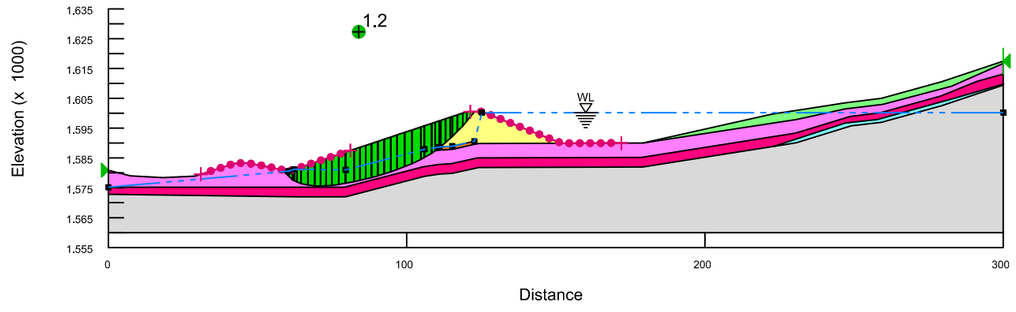
Name: Fill Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 32 ° Piezometric Line: 1
Name: Toe Drain Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 34 ° Piezometric Line: 1
Name: Sand and Gravel (loose to compact) Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Piezometric Line: 1
Name: Silty Clay (firm to stiff) - undrained Model: Undrained (Phi=0) Unit Weight: 19 kN/m³ Cohesion: 50 kPa Piezometric Line: 1
Name: Silty Clay (v stiff to hard) - undrained Model: Undrained (Phi=0) Unit Weight: 19 kN/m³ Cohesion: 120 kPa Piezometric Line: 1
Name: Silty Sand - Loose Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1
Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1



SCALE 1:2000 H - STABILITY SECTION - RAPID DRAWDOWN

Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Fill - seismic Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1
Name: Toe Drain - seismic Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 28 ° Piezometric Line: 1
Name: Sand and Gravel (loose to compact) - seismic Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 25 ° Piezometric Line: 1
Name: Silty Clay (firm to stiff) - seismic Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 25 ° Piezometric Line: 1
Name: Silty Clay (v stiff to hard) - seismic Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 25 ° Piezometric Line: 1
Name: Silty Sand - Loose - seismic Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 22 ° Piezometric Line: 1

Horz Seismic Load: 0.04



SCALE 1:2000 H - STABILITY SECTION - LONG TERM - SEISMIC

LEGEND

- FILL
- GRANULAR TOE DRAIN
- CLAYEY GRAVEL AND SAND TO SAND AND GRAVEL (LOOSE TO COMPACT)
- CLAYEY GRAVEL AND SAND (COMPACT TO DENSE)
- SILTY CLAY (FIRM TO STIFF)
- SILTY CLAY (VERY STIFF TO HARD)
- SILTY SAND TO SILT (VERY LOOSE TO LOOSE)
- SANDSTONE/SILTSTONE BEDROCK

0 50 100
1:2,000 METRES

CLIENT
RIVERSDALE RESOURCES LIMITED
BENGA MINING LIMITED

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-01-08
PREPARED	TF
DESIGN	CC
REVIEW	RA
APPROVED	AH

PROJECT
GRASSY MOUNTAIN COAL PROJECT

TITLE
STABILITY SECTION NORTH WEST SURGE POND

PROJECT No.	CONTROL	Rev.	FIGURE
1406422		A	11

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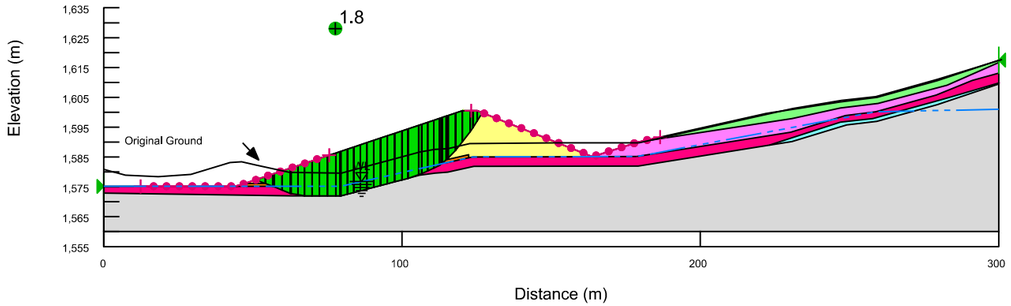
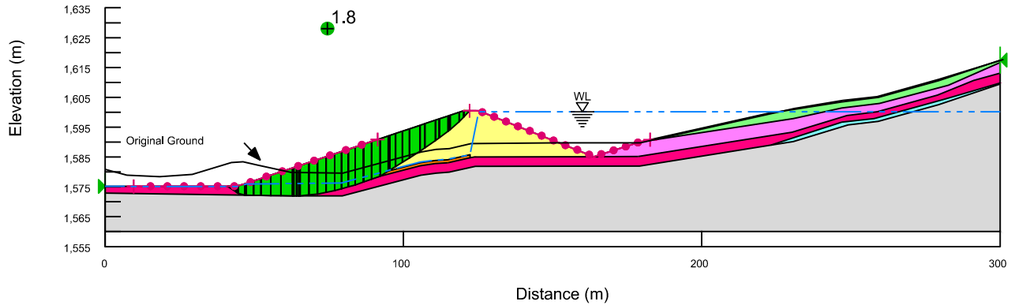
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25 mm
0

Name: Fill Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 32 ° Piezometric Line: 1 Ru: 0.3 Include in PWP: Yes
Name: Toe Drain Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 34 ° Piezometric Line: 1 Include in PWP: No
Name: Sand and Gravel (loose to compact) Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Piezometric Line: 1 Include in PWP: No
Name: Silty Clay (firm to stiff) - undrained Model: Undrained (Phi=0) Unit Weight: 19 kN/m³ Cohesion: 50 kPa Piezometric Line: 1 Include in PWP: No
Name: Silty Clay (v stiff to hard) - undrained Model: Undrained (Phi=0) Unit Weight: 19 kN/m³ Cohesion: 120 kPa Piezometric Line: 1 Include in PWP: No
Name: Silty Sand - Loose Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1 Include in PWP: No
Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1 Include in PWP: No



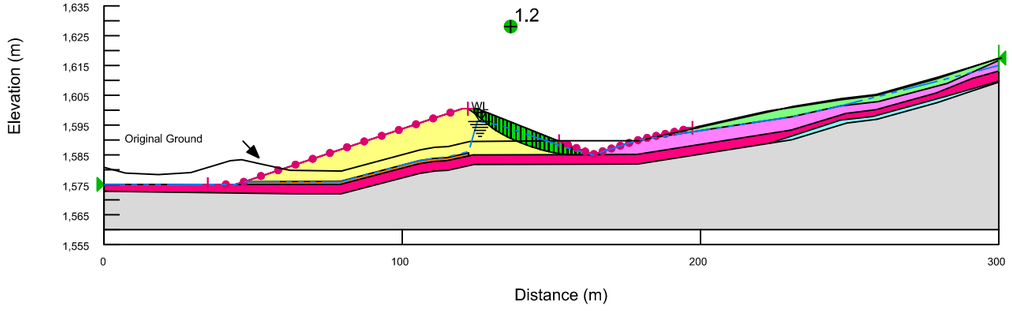
SCALE 1:2000 — STABILITY SECTION - CONSTRUCTION - UNDRAINED

Name: Fill Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 32 ° Piezometric Line: 1
Name: Toe Drain Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 34 ° Piezometric Line: 1
Name: Sand and Gravel (loose to compact) Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Piezometric Line: 1
Name: Silty Clay (firm to stiff) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Piezometric Line: 1
Name: Silty Clay (v stiff to hard) Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 30 ° Piezometric Line: 1
Name: Silty Sand - Loose Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1
Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1



SCALE 1:2000 — STABILITY SECTION - LONG TERM - DRAINED

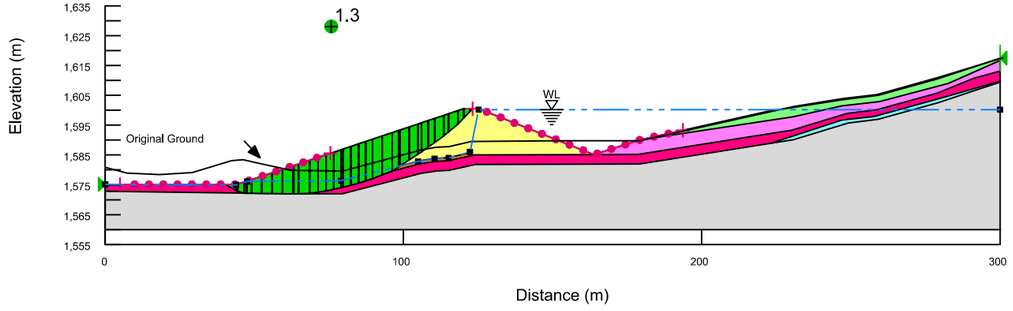
Name: Fill Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 32 ° Piezometric Line: 1
Name: Toe Drain Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 34 ° Piezometric Line: 1
Name: Sand and Gravel (loose to compact) Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Piezometric Line: 1
Name: Silty Clay (firm to stiff) - undrained Model: Undrained (Phi=0) Unit Weight: 19 kN/m³ Cohesion: 50 kPa Piezometric Line: 1
Name: Silty Clay (v stiff to hard) - undrained Model: Undrained (Phi=0) Unit Weight: 19 kN/m³ Cohesion: 120 kPa Piezometric Line: 1
Name: Silty Sand - Loose Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1
Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1



SCALE 1:2000 — STABILITY SECTION - RAPID DRAWDOWN

Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Fill - seismic Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1
Name: Toe Drain - seismic Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 28 ° Piezometric Line: 1
Name: Sand and Gravel (loose to compact) - seismic Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 25 ° Piezometric Line: 1
Name: Silty Clay (firm to stiff) - seismic Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 25 ° Piezometric Line: 1
Name: Silty Clay (v stiff to hard) - seismic Model: Mohr-Coulomb Unit Weight: 19 kN/m³ Cohesion: 0 kPa Phi: 25 ° Piezometric Line: 1
Name: Silty Sand - Loose - seismic Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 22 ° Piezometric Line: 1

Horz Seismic Load: 0.04



SCALE 1:2000 — STABILITY SECTION - LONG TERM - SEISMIC

LEGEND

- FILL
- GRANULAR TOE DRAIN
- CLAYEY GRAVEL AND SAND TO SAND AND GRAVEL (LOOSE TO COMPACT)
- CLAYEY GRAVEL AND SAND (COMPACT TO DENSE)
- SILTY CLAY (FIRM TO STIFF)
- SILTY CLAY (VERY STIFF TO HARD)
- SILTY SAND TO SILT (VERY LOOSE TO LOOSE)
- SANDSTONE/SILTSTONE BEDROCK

0 50 100
1:2,000 METRES

CLIENT
RIVERSDALE RESOURCES LIMITED
BENGA MINING LIMITED

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-01-22
PREPARED	TF
DESIGN	CC
REVIEW	RA
APPROVED	AH

PROJECT
GRASSY MOUNTAIN COAL PROJECT

TITLE
STABILITY SECTION NORTH WEST SURGE POND REMOVAL OF SOFT SUBGRADE SOILS

PROJECT No.	CONTROL	Rev.	FIGURE
1406422		A	12

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25 mm
0

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6.3.8 South West Surge Pond

The South West Surge Pond site subsurface conditions are described in Section 3.8. The interpreted subsurface conditions and analysis is shown in Figure 13.

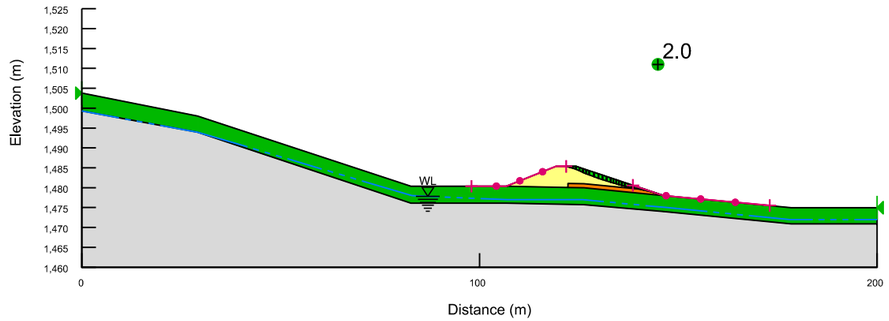
Table 30 presents a summary of the stability analysis results for construction, long-term and pseudo-static conditions.

Table 30: Slope Stability Analysis Results – South West Surge Pond

Condition	Failure Mode	FoS	Minimum Target FoS
Construction (Undrained)	Embankment	2.0	1.3
Long-term (Drained)	Foundation	1.6	1.5
Rapid drawdown	Foundation	1.3	1.2 to 1.3
Seismic	Foundation	1.2	1.0

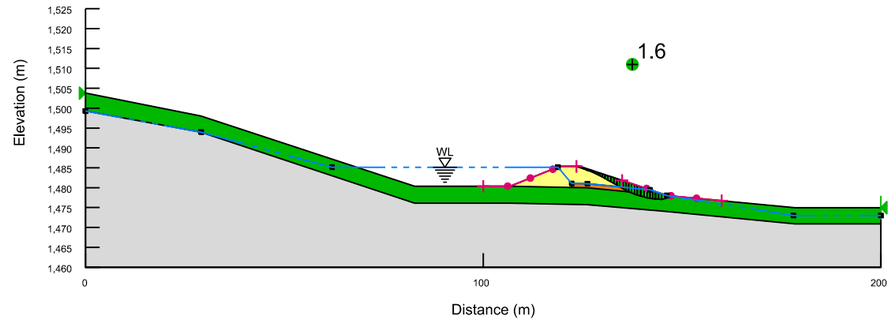
The minimum FoS per CDA (2013) Guidelines is achieved for all cases.

Name: Fill Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 32 ° Piezometric Line: 1 Ru: 0.3 Include in PWP: Yes
Name: Toe drain Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 34 ° Piezometric Line: 1 Include in PWP: No
Name: Clayey Gravel and Sand (compact to dense) Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 33 ° Piezometric Line: 1 Include in PWP: No
Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1 Include in PWP: No



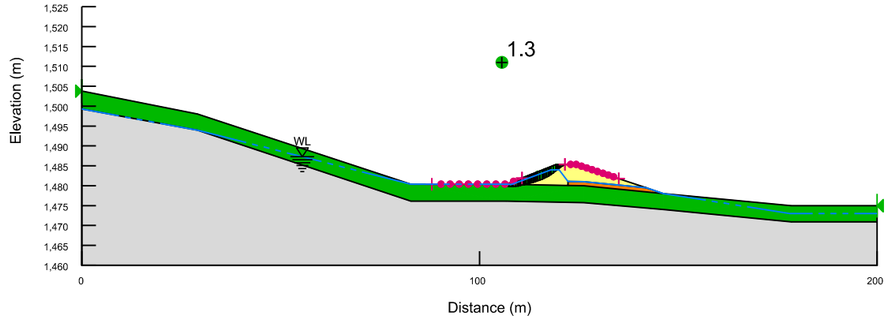
SCALE 1:1500 J - STABILITY SECTION - CONSTRUCTION - UNDRAINED

Name: Fill Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 32 ° Piezometric Line: 1
Name: Toe drain Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 34 ° Piezometric Line: 1
Name: Clayey Gravel and Sand (compact to dense) Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 33 ° Piezometric Line: 1
Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1



SCALE 1:1500 J - STABILITY SECTION - LONG TERM - DRAINED

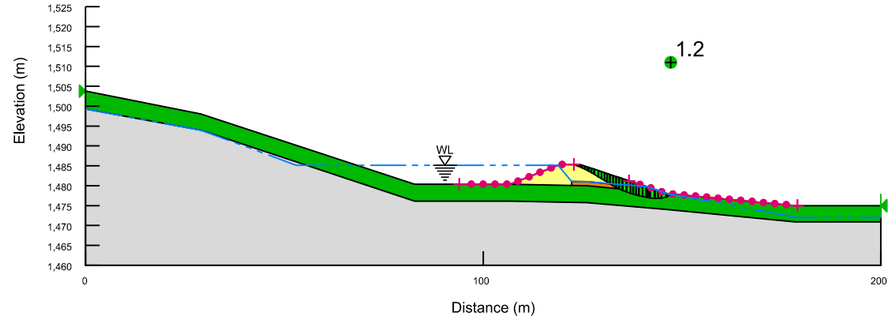
Name: Fill Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 32 ° Piezometric Line: 1
Name: Toe drain Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 34 ° Piezometric Line: 1
Name: Clayey Gravel and Sand (compact to dense) Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 33 ° Piezometric Line: 1
Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1



SCALE 1:1500 J - STABILITY SECTION - RAPID DRAWDOWN

Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Fill - Seismic Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1
Name: Toe Drain - Seismic Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 28 ° Piezometric Line: 1
Name: Clayey gravel and sand (compact to dense) - seismic Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1

Horz Seismic Load: 0.028



SCALE 1:1500 J - STABILITY SECTION - LONG TERM - SEISMIC

LEGEND

- FILL
- GRANULAR TOE DRAIN
- CLAYEY GRAVEL AND SAND TO SAND AND GRAVEL (LOOSE TO COMPACT)
- CLAYEY GRAVEL AND SAND (COMPACT TO DENSE)
- SILTY CLAY (FIRM TO STIFF)
- SILTY CLAY (VERY STIFF TO HARD)
- SILTY SAND TO SILT (VERY LOOSE TO LOOSE)
- SANDSTONE/SILTSTONE BEDROCK

0 25 50
1:1,500 METRES

CLIENT
RIVERSDALE RESOURCES LIMITED
BENGA MINING LIMITED

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-01-08
PREPARED	TF
DESIGN	CC
REVIEW	RA
APPROVED	AH

PROJECT
GRASSY MOUNTAIN COAL PROJECT

TITLE
STABILITY SECTION SOUTH WEST SURGE POND

PROJECT No.	CONTROL	Rev.	FIGURE
1406422		A	13

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25 mm
0

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6.3.9 Raw Water Pond

The Raw Water Pond site subsurface conditions are described in Section 3.5. The interpreted subsurface conditions and analysis is shown in Figure 14.

Table 31 presents a summary of the stability analysis results for construction, long-term and pseudo-static conditions.

Table 31: Slope Stability Analysis Results – Raw Water Pond

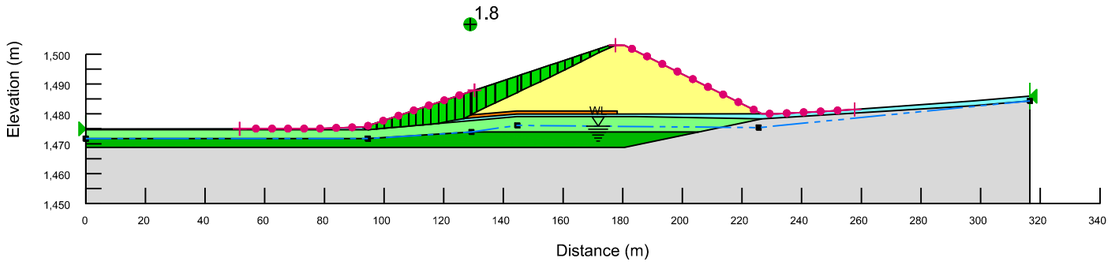
Condition	Failure Mode	FoS	Minimum Target FoS
Construction (Undrained)	Embankment	1.8	1.3
Long-term (Drained)	Foundation	1.6	1.5
Rapid drawdown	Foundation	1.0	1.2 to 1.3
Seismic	Foundation	1.1	1.0

The FoS for the rapid drawdown condition of the dam does not meet CDA minimum target (CDA, 2013). The Raw Water Pond is used as a storage pond to supply the plant site with water for process. Therefore, drawdown will occur relatively frequently. This analysis assumes complete drawdown without enough time to allow for significant drainage of the dam fill. The detailed design of the Raw Water Pond should consider the rate and extent of drawdown as well as the hydraulic conductivity of the dam fill, and assess the requirements to improve the stability of the upstream face during rapid drawdown.

Potential design solutions to increase the FoS for the rapid drawdown condition include:

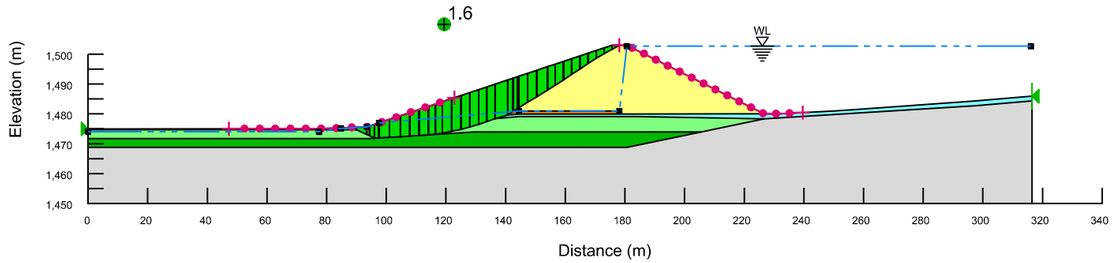
- Limiting rate of drawdown.
- Flattening upstream slope.

Name: Fill Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 32 ° Piezometric Line: 1 Ru: 0.3 Include in PWP: Yes
Name: Toe Drain Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 34 ° Piezometric Line: 1 Include in PWP: No
Name: Silty Sand Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1 Include in PWP: No
Name: Clayey Gravel and Sand (loose to compact) Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Piezometric Line: 1 Include in PWP: No
Name: Clayey Gravel and Sand (dense) Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 33 ° Piezometric Line: 1 Include in PWP: No
Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1 Include in PWP: No



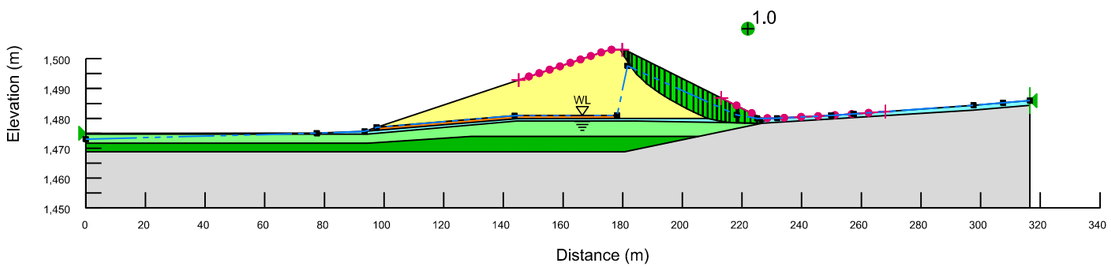
SCALE 1:2000 K - STABILITY SECTION - CONSTRUCTION - UNDRAINED

Name: Fill Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 32 ° Piezometric Line: 1
Name: Toe Drain Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 34 ° Piezometric Line: 1
Name: Silty Sand Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1
Name: Clayey Gravel and Sand (loose to compact) Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Piezometric Line: 1
Name: Clayey Gravel and Sand (dense) Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 33 ° Piezometric Line: 1
Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1



SCALE 1:2000 K - STABILITY SECTION - LONG TERM - DRAINED

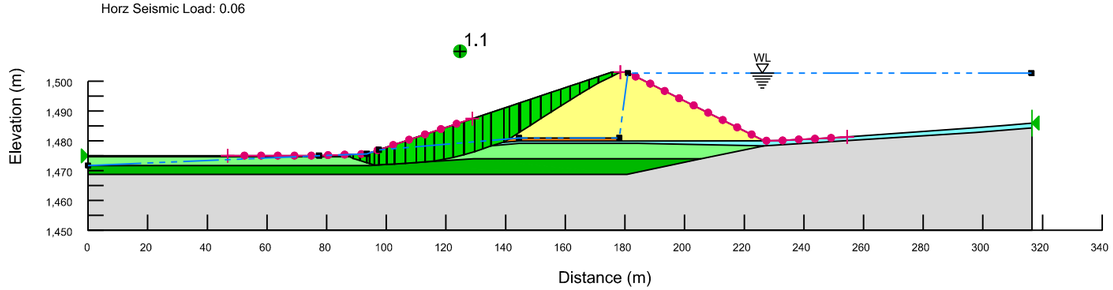
Name: Fill Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 32 ° Piezometric Line: 1
Name: Toe Drain Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 34 ° Piezometric Line: 1
Name: Silty Sand Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1
Name: Clayey Gravel and Sand (loose to compact) Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 30 ° Piezometric Line: 1
Name: Clayey Gravel and Sand (dense) Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 33 ° Piezometric Line: 1
Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1



SCALE 1:2000 K - STABILITY SECTION - RAPID DRAWDOWN

Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Fill - Seismic Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1
Name: Toe Drain - seismic Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 28 ° Piezometric Line: 1
Name: Silty Sand - seismic Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion: 0 kPa Phi: 22 ° Piezometric Line: 1
Name: Clayey Gravel and Sand (loose to compact) - seismic Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion: 0 kPa Phi: 25 ° Piezometric Line: 1
Name: Clayey Gravel and Sand (dense) - seismic Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1

Horz Seismic Load: 0.06



SCALE 1:2000 K - STABILITY SECTION - LONG TERM - SEISMIC

LEGEND

- FILL
- GRANULAR TOE DRAIN
- CLAYEY GRAVEL AND SAND TO SAND AND GRAVEL (LOOSE TO COMPACT)
- CLAYEY GRAVEL AND SAND (COMPACT TO DENSE)
- SILTY CLAY (FIRM TO STIFF)
- SILTY CLAY (VERY STIFF TO HARD)
- SILTY SAND TO SILT (VERY LOOSE TO LOOSE)
- SANDSTONE/SILTSTONE BEDROCK

0 50 100
1:2,000 METRES

CLIENT
RIVERSDALE RESOURCES LIMITED
BENGA MINING LIMITED

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-01-08
PREPARED	TF
DESIGN	CC
REVIEW	RA
APPROVED	AH

PROJECT
GRASSY MOUNTAIN COAL PROJECT

TITLE
STABILITY SECTION RAW WATER POND

PROJECT No.	CONTROL	Rev.	FIGURE
1406422		A	14

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IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
25 mm
0

6.3.10 South East Surge Pond

The South East Surge Pond site subsurface conditions are unknown as no ground investigation has taken place at or near the site. The assumed subsurface conditions are described in Section 3.11. The interpreted subsurface conditions and analysis is shown in Figure 15.

Table 32 presents a summary of the stability analysis results for construction, long-term and pseudo-static conditions.

Table 32: Slope Stability Analysis Results – South East Surge Pond

Condition	Failure Mode	FoS	Minimum Target FoS
Construction (Undrained)	Embankment	1.9	1.3
Long-term (Drained)	Foundation	1.8	1.5
Rapid drawdown	Foundation	1.1	1.2 to 1.3
Seismic	Foundation	1.1	1.0

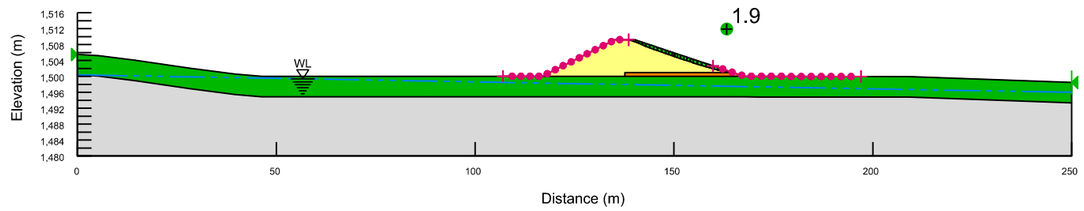
Though the minimum FoS per CDA (2013) Guidelines is achieved for all cases a geotechnical investigation is required at the South East Surge Pond site and the slope stability analysis must be updated during the next design phase.

The FoS for the rapid drawdown condition of the dam does not meet the minimum target per CDA (2013). The South East Surge Pond is used to divert water away from creeks on the east side of the active mine area. This analysis assumes complete drawdown without enough time to allow for significant drainage of the dam fill. At this stage of design it is assumed drawdown will occur relatively frequently. The detailed design should consider the rate and extent of drawdown as well as test the hydraulic conductivity of the dam fill, and assess the requirements to improve the stability of the upstream face during rapid drawdown.

Potential design solutions to increase the FoS for the rapid drawdown condition include:

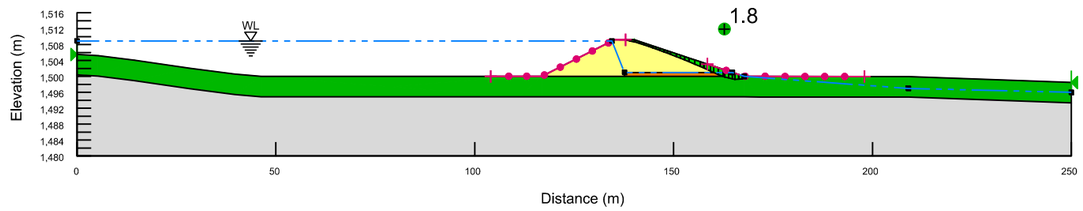
- Limiting rate of drawdown.
- Flattening the upstream slope.

Name: Fill Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 32 ° Piezometric Line: 1 Ru: 0,3 Include in PWP: Yes
Name: Toe Drain Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 34 ° Piezometric Line: 1 Include in PWP: No
Name: Non-Cohesive (compact to dense) Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 33 ° Piezometric Line: 1 Include in PWP: No
Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1 Include in PWP: No



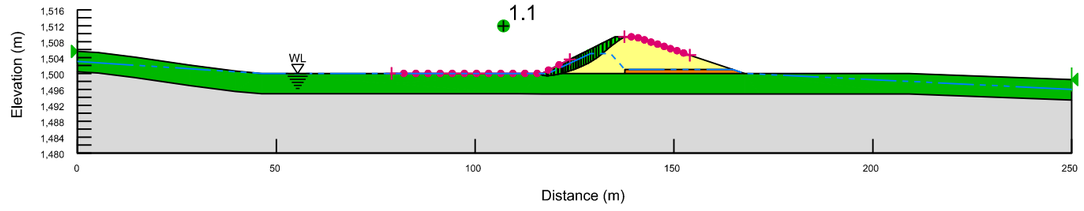
SCALE 1:1500 L - STABILITY SECTION - CONSTRUCTION - UNDRAINED

Name: Fill Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 32 ° Piezometric Line: 1
Name: Toe Drain Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 34 ° Piezometric Line: 1
Name: Non-Cohesive (compact to dense) Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 33 ° Piezometric Line: 1
Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1



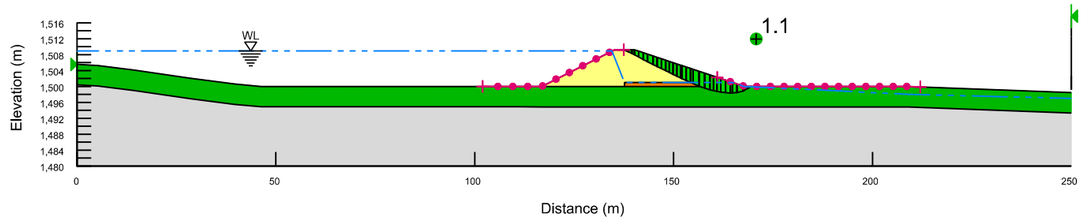
SCALE 1:1500 L - STABILITY SECTION - LONG TERM - DRAINED

Name: Fill Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 32 ° Piezometric Line: 1
Name: Toe Drain Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 34 ° Piezometric Line: 1
Name: Non-Cohesive (compact to dense) Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 33 ° Piezometric Line: 1
Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1



SCALE 1:1500 L - STABILITY SECTION - RAPID DRAWDOWN

Name: Sandstone/Siltstone Bedrock Model: Bedrock (Impenetrable) Piezometric Line: 1
Name: Fill - Seismic Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1
Name: Toe Drain - Seismic Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 28 ° Piezometric Line: 1
Name: Non-Cohesive (compact to dense) - Seismic Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion: 0 kPa Phi: 27 ° Piezometric Line: 1
Horz Seismic Load: 0.085



SCALE 1:1500 L - STABILITY SECTION - LONG TERM - SEISMIC

LEGEND

- FILL
- GRANULAR TOE DRAIN
- NON-COHESIVE (LOOSE TO COMPACT)
- NON-COHESIVE (COMPACT TO DENSE)
- COHESIVE (FIRM TO STIFF)
- COHESIVE (VERY STIFF TO HARD)
- SILTY SAND TO SILT (VERY LOOSE TO LOOSE)
- SANDSTONE/SILTSTONE BEDROCK

0 25 50
1:1,500 METRES

CLIENT
RIVERSDALE RESOURCES LIMITED
BENGA MINING LIMITED

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-01-08
PREPARED	TF
DESIGN	CC
REVIEW	RA
APPROVED	AH

PROJECT
GRASSY MOUNTAIN COAL PROJECT

TITLE
STABILITY SECTION SOUTH EAST SURGE POND

PROJECT No.	CONTROL	Rev.	FIGURE
1406422		A	15

Path: \\golder.gds\calgary\EDCAD\2014\1406422\PRODUCTION\FIGURES\ | File Name: 1406422FG042.dwg

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25 mm
0

6.4 Site Preparation and Construction Recommendations

An important part of dam construction is preparation of the foundation and drainage improvements that may be required, as discussed below:

- Strip 'A' and 'B' horizon topsoil and organics from the dam footprints and stockpile per site salvage/reclamation plan.
- Weak, organic, or fine-grained soils must be stripped to underlying competent granular or till-like soils or bedrock, to reduce the likelihood of failure through soft foundation soils. Alternately, fine-grained cohesive soils may be preloaded to achieve long-term drained strength behaviour.
- Preliminary slope stability analysis indicates the undrained response in the foundation where fine-grained cohesive soils were encountered will result in FoS which does not meet the target minimum FoS. This may be remediated by stripping fine-grained cohesive soils from the foundation or constructing the dam in stages with porewater pressure monitoring to confirm dissipation of excess porewater pressures.
- Preliminary slope stability analysis indicates the rapid drawdown condition may result in shallow slope failures or shallow failures through the foundation. Potential solutions to address the low factor of safety rapid drawdown condition include:
  - Limiting rate of drawdown.
  - Flattening upstream slope.
- The foundation preparation for the dam should be inspected by a geotechnical engineer to confirm removal of soft soil deposits and exposure of competent, granular, till-like soils or bedrock.

7.0 GEOTECHNICAL INVESTIGATION RECOMMENDATIONS

The following recommendations are made for investigations to support detailed design:

- Perform investigations of the plant site when the location of all facilities is final. Drilling to include bedrock coring and strength testing of rock cores to support deep foundation design in bedrock, where necessary. Where bedrock is encountered drilling is to be minimum 6 m into bedrock or to approximate depth of bottom of foundation, whichever is deeper.
- Perform additional geotechnical investigation, sampling and testing at Significant to Very High consequence classification dams to obtain undisturbed samples of cohesive materials for advanced testing (e.g. consolidated undrained triaxial) to evaluate shear strength properties. Deep boreholes will be required at some dam sites to determine stratigraphy and depth to bedrock and laboratory testing on core samples to evaluate rock strength. The investigations must provide information to inform the approach for addressing the cohesive materials identified in the foundation of the North East Sediment Pond and the North West Surge Pond.
- Perform geotechnical investigations for the East Sediment Pond, South East Surge Pond and the South Waste Rock Dump.

- Identify suitable borrow sources for engineered fill and structural fill/sand filter/granular toe drain material. These borrow sources should be characterized for moisture content, gradation, moisture-density relationships and hydraulic conductivity.

8.0 CLOSURE

We trust that this report provides the information that you require at this time. Please do not hesitate to contact the undersigned if you have any questions or need clarification. Golder appreciates the opportunity to be of service on this project.

Report Signature Page

GOLDER ASSOCIATES LTD.

APEGA PERMIT TO PRACTICE #05122

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April 13/16

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CC/AH/RCA/sb

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APPENDIX A

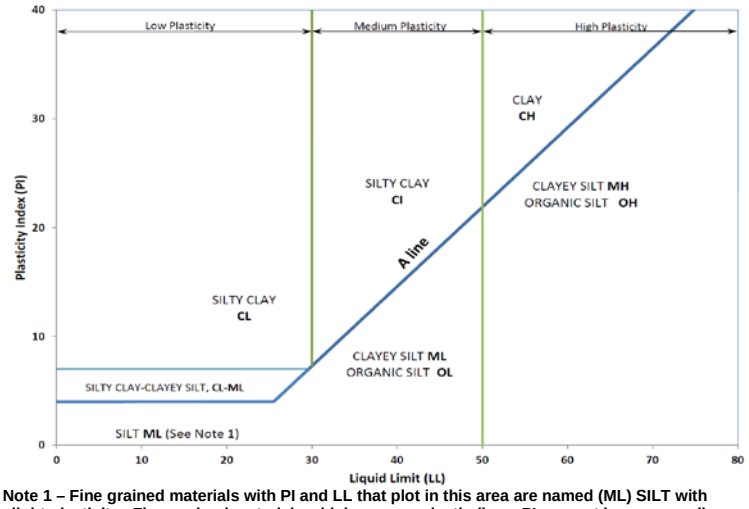
Golder's Soil Classification System

METHOD OF SOIL CLASSIFICATION

The Golder Associates Ltd. Soil Classification System is based on the Unified Soil Classification System (USCS)

Organic or Inorganic	Soil Group	Type of Soil		Gradation or Plasticity	$Cu = \frac{D_{60}}{D_{10}}$	$Cc = \frac{(D_{30})^2}{D_{10} x D_{60}}$	Organic Content	USCS Group Symbol	Group Name
INORGANIC (Organic Content ≤30% by mass)	COARSE-GRAINED SOILS (>50% by mass is larger than 0.075 mm)	GRAVELS (>50% by mass of coarse fraction is larger than 4.75 mm)	Gravels with ≤12% fines (by mass)	Poorly Graded	<4	≤1 or ≥3	≤30%	GP	GRAVEL
				Well Graded	≥4	1 to 3		GW	GRAVEL
			Gravels with >12% fines (by mass)	Below A Line	n/a			GM	SILTY GRAVEL
				Above A Line	n/a			GC	CLAYEY GRAVEL
		SANDS (≥50% by mass of coarse fraction is smaller than 4.75 mm)	Sands with ≤12% fines (by mass)	Poorly Graded	<6	≤1 or ≥3		SP	SAND
				Well Graded	≥6	1 to 3		SW	SAND
			Sands with >12% fines (by mass)	Below A Line	n/a			SM	SILTY SAND
				Above A Line	n/a			SC	CLAYEY SAND

Organic or Inorganic	Soil Group	Type of Soil		Laboratory Tests	Field Indicators					Organic Content	USCS Group Symbol	Primary Name
					Dilatancy	Dry Strength	Shine Test	Thread Diameter	Toughness (of 3 mm thread)			
INORGANIC (Organic Content ≤30% by mass)	FINE-GRAINED SOILS (≥50% by mass is smaller than 0.075 mm)	SILTS (Non-Plastic or PI and LL plot below A-Line on Plasticity Chart below)		Liquid Limit <50	Rapid	None	None	>6 mm	N/A (can't roll 3 mm thread)	<5%	ML	SILT
					Slow	None to Low	Dull	3mm to 6 mm	None to low	<5%	ML	CLAYEY SILT
					Slow to very slow	Low to medium	Dull to slight	3mm to 6 mm	Low	5% to 30%	OL	ORGANIC SILT
				Liquid Limit ≥50	Slow to very slow	Low to medium	Slight	3mm to 6 mm	Low to medium	<5%	MH	CLAYEY SILT
					None	Medium to high	Dull to slight	1 mm to 3 mm	Medium to high	5% to 30%	OH	ORGANIC SILT
		CLAYS (PI and LL plot above A-Line on Plasticity Chart below)		Liquid Limit <30	None	Low to medium	Slight to shiny	~ 3 mm	Low to medium	0% to 30% **(see Note 2)**	CL	SILTY CLAY
				Liquid Limit 30 to 50	None	Medium to high	Slight to shiny	1 mm to 3 mm	Medium		CI	SILTY CLAY
				Liquid Limit ≥50	None	High	Shiny	<1 mm	High		CH	CLAY
HIGHLY ORGANIC SOILS (Organic Content >30% by mass)		Peat and mineral soil mixtures								30% to 75%	PT	SILTY PEAT, SANDY PEAT
		Predominantly peat, may contain some mineral soil, fibrous or amorphous peat								75% to 100%		PEAT



Note 1 – Fine grained materials with PI and LL that plot in this area are named (ML) SILT with slight plasticity. Fine-grained materials which are non-plastic (i.e. a PL cannot be measured) are named SILT.
Note 2 – For soils with <5% organic content, include the descriptor "trace organics" for soils with between 5% and 30% organic content include the prefix "organic" before the Primary name.

Dual Symbol — A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC and CL-ML.
For non-cohesive soils, the dual symbols must be used when the soil has between 5% and 12% fines (i.e. to identify transitional material between "clean" and "dirty" sand or gravel.
For cohesive soils, the dual symbol must be used when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart (see Plasticity Chart at left).

Borderline Symbol — A borderline symbol is two symbols separated by a slash, for example, CL/CI, GM/SM, CL/ML.
A borderline symbol should be used to indicate that the soil has been identified as having properties that are on the transition between similar materials. In addition, a borderline symbol may be used to ~~or~~ indicate~~s~~ a range of similar soil types within a stratum.

ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES AND TEST PITS

PARTICLE SIZES OF CONSTITUENTS

Soil Constituent	Particle Size Description	Millimetres	Inches (US Std. Sieve Size)
BOULDERS	Not Applicable	>300	>12
COBBLES	Not Applicable	75 to 300	3 to 12
GRAVEL	Coarse Fine	19 to 75 4.75 to 19	0.75 to 3 (4) to 0.75
SAND	Coarse Medium Fine	2.00 to 4.75 0.425 to 2.00 0.075 to 0.425	(10) to (4) (40) to (10) (200) to (40)
SILT/CLAY	Classified by plasticity	<0.075	< (200)

MODIFIERS FOR SECONDARY AND MINOR CONSTITUENTS

Percentage by Mass	Modifier
>35	Use 'and' to combine major constituents (*i.e.,* SAND and GRAVEL, SAND and CLAY)
> 12 to 35	Primary soil name prefixed with "gravelly, sandy, SILTY, CLAYEY" as applicable
> 5 to 12	some
≤ 5	trace

PENETRATION RESISTANCE

Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split-spoon sampler for a distance of 300 mm (12 in.).

Cone Penetration Test (CPT)

An electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm^2 pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance (q_t), porewater pressure (u) and sleeve frictions are recorded electronically at 25 mm penetration intervals.

Dynamic Cone Penetration Resistance (DCPT); N_d:

The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

PH: Sampler advanced by hydraulic pressure
PM: Sampler advanced by manual pressure
WH: Sampler advanced by static weight of hammer
WR: Sampler advanced by weight of sampler and rod

SAMPLES

AS	Auger sample
BS	Block sample
CS	Chunk sample
DO or DP	Seamless open ended, driven or pushed tube sampler – note size
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
SS	Split spoon sampler – note size
ST	Slotted tube
TO	Thin-walled, open – note size
TP	Thin-walled, piston – note size
WS	Wash sample

SOIL TESTS

w	water content
PL , w_p	plastic limit
LL , w_L	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test[1]
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement[1]
D_R	relative density (specific gravity, Gs)
DS	direct shear test
GS	specific gravity
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
SO_4	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V (FV)	field vane (LV-laboratory vane test)
γ	unit weight

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

NON-COHESIVE (COHESIONLESS) SOILS

Compactness[2]

Term	SPT 'N' (blows/0.3m)[1]
Very Loose	0 - 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	>50

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects.
2. Definition of compactness descriptions based on SPT 'N' ranges from Terzaghi and Peck (1967) and correspond to typical average N_{60} values.

Field Moisture Condition

Term	Description
Dry	Soil flows freely through fingers.
Moist	Soils are darker than in the dry condition and may feel cool.
Wet	As moist, but with free water forming on hands when handled.

COHESIVE SOILS

Consistency

Term	Undrained Shear Strength (kPa)	SPT 'N'[1] (blows/0.3m)
Very Soft	<12	0 to 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	>200	>30

1. SPT 'N' in accordance with ASTM D1586, uncorrected for overburden pressure effects; approximate only.

Water Content

Term	Description
w < PL	Material is estimated to be drier than the Plastic Limit.
w ~ PL	Material is estimated to be close to the Plastic Limit.
w > PL	Material is estimated to be wetter than the Plastic Limit.

LIST OF SYMBOLS

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

I. GENERAL

π	3.1416
ln x	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time

II. STRESS AND STRAIN

γ	shear strain
Δ	change in, e.g. in stress: $\Delta\sigma$
ε	linear strain
ε_v	volumetric strain
η	coefficient of viscosity
υ	Poisson's ratio
σ	total stress
σ'	effective stress ($\sigma' = \sigma - u$)
σ'_{vo}	initial effective overburden stress
σ_1, σ_2, σ_3	principal stress (major, intermediate, minor)
σ_{oct}	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
τ	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

III. SOIL PROPERTIES

(a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight)*
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
γ'	unit weight of submerged soil ($\gamma' = \gamma - \gamma_w$)
D_R	relative density (specific gravity) of solid particles ($D_R = \rho_s / \rho_w$) (formerly G_s)
e	void ratio
n	porosity
S	degree of saturation

* Density symbol is ρ. Unit weight symbol is γ where $\gamma = \rho g$ (i.e. mass density multiplied by acceleration due to gravity)

(a) Index Properties (continued)

w	water content
w_l or LL	liquid limit
w_p or PL	plastic limit
I_p or PI	plasticity index = $(w_l - w_p)$
w_s	shrinkage limit
I_L	liquidity index = $(w - w_p) / I_p$
I_C	consistency index = $(w_l - w) / I_p$
e_{max}	void ratio in loosest state
e_{min}	void ratio in densest state
I_D	density index = $(e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

(b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

(c) Consolidation (one-dimensional)

C_c	compression index (normally consolidated range)
C_r	recompression index (over-consolidated range)
C_s	swelling index
C_α	secondary compression index
m_v	coefficient of volume change
c_v	coefficient of consolidation (vertical direction)
c_h	coefficient of consolidation (horizontal direction)
T_v	time factor (vertical direction)
U	degree of consolidation
σ'_p	pre-consolidation stress
OCR	over-consolidation ratio = σ'_p / σ'_{vo}

(d) Shear Strength

τ_p, τ_r	peak and residual shear strength
ϕ'	effective angle of internal friction
δ	angle of interface friction
μ	coefficient of friction = tan δ
c′	effective cohesion
c_u, s_u	undrained shear strength ($\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
p′	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 - \sigma_3)/2$ or $(\sigma'_1 - \sigma'_3)/2$
q_u	compressive strength $(\sigma_1 - \sigma_3)$
S_t	sensitivity

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

2 shear strength = (compressive strength)/2

APPENDIX B

Borehole Records

DATA ENTRY: MD

PROJECT No.: 1406422

LOCATION: See Location Plan

N: 5508267 E: 684485

RECORD OF BOREHOLE: BH15-01

BORING DATE: November 05, 2015

Riversdale Resources Limited

SHEET 1 OF 2

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	B-37 Mobile Rig, Solid Stem Augers, Val's Drilling Ltd.	(OL) sandy ORGANIC SILT, trace rootlets, dark brown, moist.		0.03							
		(SP-GP) SAND and GRAVEL, fine grained sand, poorly graded sand and gravel, sub-angular gravel, some fines; brown; non-cohesive, moist, loose.			1	AS					
1											
					2	SS	8				
2											
					3	AS					
		(Cl) SILTY CLAY, medium plasticity, trace to some gravel; brown; cohesive, w~PL to w<PL, firm to very stiff.		2.74							
3					4	SS	6				
4					5	AS					
					6	SS	6				
5											
					7	AS					
6		--- Becoming very stiff, w<PL at 6.1 m									
					8	SS	16				
7					9	AS					
		CONTINUED NEXT PAGE									

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: HM

CHECKED: RA

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_WASTEDUMP _BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

PROJECT No.: 1406422

RECORD OF BOREHOLE: BH15-01

SHEET 2 OF 2

LOCATION: See Location Plan

BORING DATE: November 05, 2015

DATUM: UTM Zone 11 (Nad 83)

N: 5508267 E: 684485

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
8	B-37 Mobile Rig, Solid Stem Augers, Val's Drilling Ltd.	(Cl) SILTY CLAY, medium plasticity, trace to some gravel; brown; cohesive, w~PL to w<PL, firm to very stiff. *(continued)* --- Auger grinding due to possible boulders and cobbles at 7.9 m.			10	SS	23				
9		--- Becoming hard at 9.1 m.			11	AS					
10		(SM) SILTY SAND, some gravel, fine grained sand; non-cohesive, moist, very dense.		9.47	12A	SS	43				
11		(BEDROCK) Highly weathered, grey; very weak, SANDSTONE.		10.79	12B						
		End of BOREHOLE. NOTES: Borehole terminated at 11.1 m. No seepage observed during drilling. Backfilled with cuttings.		11.13	13	AS					
12					14	SS	71				
13											
14											
15											

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: HM

CHECKED: RA

DATA ENTRY: MD

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_WASTEDUMP _BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: MD

PROJECT No.: 1406422

LOCATION: See Location Plan

N: 5508219 E: 684433

RECORD OF BOREHOLE: BH15-02

BORING DATE: November 05, 2015

Riversdale Resources Limited

SHEET 1 OF 2

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	B-37 Mobile Rig, Solid Stem Augers, Val's Drilling Ltd.	(OL) ORGANIC SILT, trace rootlets, trace organics.		0.02							
		(ML) CLAYEY SILT, some sand, trace gravel; brown; cohesive, firm to stiff.			1	AS					
1											
					2	SS	4				
2											
					3	AS					
3		--- Becoming stiff at 3.0 m			4	SS	10				
		--- Becoming grey at 3.7 m.			5	AS					
4											
		--- Boulder inferred from 4.7 m to 5.5 m			6	SS	17				
5											
		(CL-CI) SILTY CLAY, low to medium plasticity, trace gravel, some sand; grey; cohesive, w<PL, very stiff.		5.49	7	AS					
6											
					8	SS	18				
7											
					9	AS					
		CONTINUED NEXT PAGE									

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: HM

CHECKED: RA

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_WASTEDUMP _BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: MD

PROJECT No.: 1406422

RECORD OF BOREHOLE: BH15-02

SHEET 2 OF 2

LOCATION: See Location Plan

BORING DATE: November 05, 2015

DATUM: UTM Zone 11 (Nad 83)

N: 5508219 E: 684433

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp ○W WI) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
8	B-37 Mobile Rig, Solid Stem Augers, Val's Drilling Ltd.	(CL-CI) SILTY CLAY, low to medium plasticity, trace gravel, some sand; grey; cohesive, w<PL, very stiff. *(continued)*			10	SS	26		○		
		(BEDROCK) Highly weathered, light grey; very weak, SANDSTONE.		7.92							
9					11	AS					
					12	SS	38				
		End of BOREHOLE.		9.30							
		NOTES: Borehole terminated at 9.3 m. Backfilled with cuttings.									
10											
11											
12											
13											
14											
15											

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: HM

CHECKED: RA

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_WASTEDUMP _BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: MD

PROJECT No.: 1406422

RECORD OF HAND AUGER: BH15-03 (HA)

SHEET 1 OF 1

LOCATION: See Location Plan

N: 5507425 E: 684668

EXCAVATION DATE: November 06, 2015

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface											
0	Ø 50 mm Hand Auger Golder Staff	(SM) SILTY SAND, trace organics, trace rootlets.		0.00	1	HA							
		End of HAND AUGER.		0.17									
1		NOTES: Hand auger hole could not be advanced due to presence of bedrock. Exposed bedrock observed on the surface around the vicinity of the hand auger hole.											
2													
3													
4													
5													
6													
7													

TESTPIT - EXP ADD LAB TESTING 1406422_BENGA - RIVERSDALE_WASTEDUMP_TESTPITS_20160111.GPJ CALGARY.GDT 01/11/16

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: HM

CHECKED: RA

DATA ENTRY: MD

PROJECT No.: 1406422

RECORD OF BOREHOLE: BH15-04

SHEET 1 OF 1

LOCATION: See Location Plan

BORING DATE: November 06, 2015

DATUM: UTM Zone 11 (Nad 83)

N: 5507320 E: 684689

Riversdale Resources Limited

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	B-37 Mobile Rig, Solid Stem Augers, Val's Drilling Ltd.	(SM) SILTY SAND, trace organics, trace rootlets.		0.00							
		(SM) SILTY SAND, with cobbles, fine grained sand, some gravel; brown; non-cohesive, moist.		0.30							
1		(BEDROCK) Highly weathered, brown; extremely weak, SANDSTONE.		0.76	1	AS					
2					2	SS	34		○		
					3	AS					
3											
					4	SS	14				
4					5	AS					
					6	SS	50 for 100 mm				
5		End of BOREHOLE. NOTES: Borehole terminated due to auger refusal at 4.8 m. No groundwater observed during drilling. Backfilled with cuttings.		4.83							
6											
7											

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: HM

CHECKED: RA

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_WASTEDUMP _BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: JZ

PROJECT No.: 1406422

LOCATION: See Location Plan

N: 5504844 E: 685020

RECORD OF BOREHOLE: BH15-05

BORING DATE: July 25, 2015

Riversdale Resources Limited

SHEET 1 OF 1

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface											
0	Mobile Rig, 152 mm Solid Stem Augers, Val's Drilling Ltd.	(GC/SC) CLAYEY GRAVEL and SAND, fine to coarse angular gravel; brown; non-cohesive, compact becoming dense --- Auger grinding near ground surface, possible cobbles/boulders		0.00	1	AS							
1													
2	Mobile Rig, 254 mm Hollow Stem Augers, Val's Drilling Ltd.	--- Redrilled with hollow stem augers to 1.5 mbgs due to hole deviation caused by solid stem pulling up angular cobbles. --- Auger grinding below 1.5 mbgs to end of hole, possible cobbles/boulders			1	SS	22				○	SS1/SS2 Combined Gravel=40% Sand=37% Fines=23%	
3		--- Higher plasticity fines layer at 3.5 mbgs			2	SS	41				○	SS1/SS2 Combined Gravel=40% Sand=37% Fines=23%	
4		Grey SANDSTONE (BEDROCK)		4.11									
		End of BOREHOLE.		4.57									
5		NOTES: 1. No groundwater observed during drilling. 2. Backfilled with cuttings and bentonite.											
6													
7													

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: JZ

PROJECT No.: 1406422

LOCATION: See Location Plan

N: 5504753 E: 685006

RECORD OF BOREHOLE: BH15-06

BORING DATE: July 25, 2015

Riversdale Resources Limited

SHEET 1 OF 1

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	Mobile Rig, 254 mm Hollow Stem Augers, Val's Drilling Ltd.	(SC/GC) CLAYEY SAND and GRAVEL, fine to coarse sand, fine to coarse angular gravel; brown; non-cohesive, moist, dense -- Auger grinding near ground surface, due to gravel and possible cobbles/boulders		0.00							
1					1	SS	45		○	Gravel=37% Sand=42% Fines=21%	
2	Mobile Rig, 102 mm Solid Stem Augers, Val's Drilling Ltd.	Grey SANDSTONE (BEDROCK) --- Auger grinding		1.98							
3		End of BOREHOLE.		3.05							
4		NOTES: 1. No groundwater observed during drilling. 2. Backfilled with cuttings and bentonite.									
5											
6											
7											

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

DATA ENTRY: JZ

PROJECT No.: 1406422

LOCATION: See Location Plan

N: 5504831 E: 685722

RECORD OF BOREHOLE: BH15-07

BORING DATE: July 24, 2015

Riversdale Resources Limited

SHEET 1 OF 2

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp — W — Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	Mobile Rig, 254 mm Hollow Stem Augers, Val's Drilling Ltd.	[FILL] - COAL, fine to coarse, some fine to coarse angular gravel; black; non-cohesive, dry, loose -- Auger grinding near ground surface		0.00							
1					1	SS	10				
2											
3		--- Possible cobbles/boulder at 2.9 mbgs									
	Mobile Rig, 102 mm Solid Stem Augers, Val's Drilling Ltd.	[FILL] - SILTY COAL, fine, some fine to coarse angular gravel, some sand; brown to black with oxidation staining; non-cohesive, dry, compact becoming dense		3.05	2	SS	11				
4					1	AS					
					3	SS	13				
5											
6		--- becomes dense below 6.1 mbgs			4	SS	33				
7		--- Auger grinding due to cobbles/boulders at 6.6 mbgs. Dry grey sand (possible sandstone boulder) between 6.6 mbgs and 6.9 mbgs. --- becomes sandy gravelly SILTY COAL below 6.9 mbgs									
		CONTINUED NEXT PAGE									

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

DATA ENTRY: JZ

PROJECT No.: 1406422

RECORD OF BOREHOLE: BH15-07

SHEET 2 OF 2

LOCATION: See Location Plan

BORING DATE: July 24, 2015

DATUM: UTM Zone 11 (Nad 83)

N: 5504831 E: 685722

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
8	Val's Drilling Ltd.	(GC) sandy CLAYEY GRAVEL, fine to coarse angular gravel; brown; non-cohesive, very dense		7.77	5A				○		
					5B	SS	72		○	Gravel=50% Sand=33% Fines=17%	
		--- Auger refusal at at 8.2 mbgs ---Spoon contains coarse, broken angular gravel under layer of likely sloughed soil			6	SS	50 for 100 mm		○ ⊢—⊣	Gravel=10% Sand=31% Fines=59%	
				8.48							
9		--- Possible BEDROCK End of BOREHOLE.									
10		NOTES: 1. No groundwater observed during drilling. 2. Backfilled with cuttings and bentonite. 3. Inferred bedrock at 8.5 mbgs, auger and spoon refusal.									
11											
12											
13											
14											
15											

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: JZ

PROJECT No.: 1406422

LOCATION: See Location Plan

N: 5504669 E: 683215

RECORD OF BOREHOLE: BH15-08

BORING DATE: July 20, 2015

Riversdale Resources Limited

SHEET 1 OF 1

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	Mobile Rig, 152 mm Solid Stem Augers, Val's Drilling Ltd.	[TOPSOIL] - (OH) Clayey ORGANIC SILT; black; cohesive, w<PL		0.00							
1		(SC) gravelly CLAYEY SAND, fine to coarse angular gravel; brown; non-cohesive, compact		0.61	1	SS	12			SS1/SS2 Combined Gravel=32% Sand=35% Fines=33%	20/07/2015 ▽
2											
3					2	SS	15			SS1/SS2 Combined Gravel=32% Sand=35% Fines=33%	
4		--- Grey SANDSTONE (Possible BEDROCK)		3.99	3	SS	50 for 25 mm				
		End of BOREHOLE.									
5		NOTES: 1. Groundwater measured at 0.8 mbgs during drilling. 2. Backfilled with cuttings and bentonite. 3. Inferred bedrock at 4.0 mbgs, auger and spoon refusal.									
6											
7											

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: JZ

PROJECT No.: 1406422

LOCATION: See Location Plan

N: 5504224 E: 686010

RECORD OF BOREHOLE: BH15-09

BORING DATE: July 21, 2015

Riversdale Resources Limited

SHEET 1 OF 2

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp — W — Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface											
0	Mobile Rig, 152 mm Solid Stem Augers, Val's Drilling Ltd.	(SM) SILTY SAND, some fine sub-rounded gravel; brown; non-cohesive, dry		0.00									
		(SC) gravelly CLAYEY SAND, fine to coarse sub-rounded gravel; brown to grey; non-cohesive, loose becoming very dense		0.30									
1		--- Auger grinding at 1.2 mbgs			1	SS	7					SS1/SS2 Combined Gravel=29% Sand=32% Fines=39%	
2													
3		--- becomes dense to very dense below 3.0 mbgs			2	SS	64					SS1/SS2 Combined Gravel=29% Sand=32% Fines=39%	
4		--- Auger grinding at 4.3 mbgs			3	SS	43						
5													
6		--- Auger grinding and jamming at 5.8 mbgs			4	SS	45					SS4/SS5 Combined Gravel=21% Sand=43% Fines=36%	
7													
		CONTINUED NEXT PAGE											

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: JZ

PROJECT No.: 1406422

RECORD OF BOREHOLE: BH15-09

SHEET 2 OF 2

LOCATION: See Location Plan

BORING DATE: July 21, 2015

DATUM: UTM Zone 11 (Nad 83)

N: 5504224 E: 686010

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
8	Mobile Rig, 152 mm Solid Stem Augers Val's Drilling Ltd.	(SC) gravelly CLAYEY SAND, fine to coarse sub-rounded gravel; brown to grey; non-cohesive, loose becoming very dense *(continued)* --- sand pockets at 7.6 mbgs			5	SS	50 for 100 mm		○	SS4/SS5 Combined Gravel=21% Sand=43% Fines=36%	21/07/2015 ▽
9					1	AS					
10					6	SS	50 for 75 mm		○	SS6/SS7 Combined Gravel=24% Sand=51% Fines=25%	
					7	SS	50 for 50 mm		○	SS6/SS7 Combined Gravel=24% Sand=51% Fines=25%	
11		End of BOREHOLE. NOTES: 1. Groundwater measured at 8.0 mbgs during drilling. 2. Backfilled with cuttings and bentonite.		10.72							
12											
13											
14											
15											

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

DATA ENTRY: JZ

PROJECT No.: 1406422

LOCATION: See Location Plan

N: 5503838 E: 685581

RECORD OF BOREHOLE: BH15-10

BORING DATE: July 21, 2015

Riversdale Resources Limited

SHEET 1 OF 2

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp ○ W WI) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	Mobile Rig, 152 mm Solid Stem Augers, Val's Drilling Ltd.	(SM) ORGANIC SILTY SAND, some fine rounded to sub-rounded gravel; black to brown; non-cohesive, dry, very loose		0.00							
1		(GC/SC) CLAYEY GRAVEL and SAND, fine to coarse angular to sub-rounded gravel; grey to brown; non-cohesive, loose becoming dense		0.76							
2					1	SS	8		○	SS1/SS2 Combined Gravel=40% Sand=36% Fines=24%	
3		--- becomes compact below 3.0 mbgs			2	SS	16		○	SS1/SS2 Combined Gravel=40% Sand=36% Fines=24%	21/07/2015 ▽
4		--- becomes brown to black below 4.6 mbgs			3	SS	18				
5		--- becomes (GC) sandy CLAYEY GRAVEL below 5.0 mbgs			1	AS			○	Gravel=35% Sand=32% Fines=34%	
6	Mobile Rig, 102 mm Solid Stem Augers, Val's Drilling Ltd.	--- Redrilled with hollow stem augers to 6.1 mbgs due to hole sloughing to 1.2 mbgs. --- Auger grinding, becomes grey to black and dense below 6.1 mbgs --- contains some coal below 6.6 mbgs			4	SS	32				
7		*CONTINUED NEXT PAGE*									

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

DATA ENTRY: JZ

PROJECT No.: 1406422

RECORD OF BOREHOLE: BH15-10

SHEET 2 OF 2

LOCATION: See Location Plan

BORING DATE: July 21, 2015

DATUM: UTM Zone 11 (Nad 83)

N: 5503838 E: 685581

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp ○ W WI) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
				7.62	5	SS	50 for 125 mm				
8	Mobile Rig, 102 mm Solid Stem Augers, Val's Drilling Ltd.	(SC) CLAYEY SAND, fine to coarse sand, plastic fines, trace gravel; black to grey, contains some coal; non-cohesive, very dense									
9		--- SILTY CLAY from 8.8 mbgs to 9.1 mbgs			6	SS	50 for 125 mm		○	Gravel=3% Sand=62% Fines=35%	
10		--- Auger grinding below 9.6 mbgs									
		--- Possible COAL seam or SHALE/SANDSTONE/SILTSTONE BEDROCK		10.74	7	SS	50 for 75 mm				
11		End of BOREHOLE.									
12		NOTES: 1. Groundwater measured at 3.3 mbgs during drilling. 2. Backfilled with cuttings and bentonite. 3. Hole sloughed to 1.2 mbgs at 6.1 mbgs. Redrilled with 254 mm hollow stem augers, hole continued with 102 mm solid stem augers inside 254 mm hollow stem augers. 4. Inferred bedrock or coal seam at 10.7 mbgs, spoon refusal.									
13											
14											
15											

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: JZ

PROJECT No.: 1406422

LOCATION: See Location Plan

N: 5503630 E: 685604

RECORD OF BOREHOLE: BH15-11

BORING DATE: July 25, 2015

Riversdale Resources Limited

SHEET 1 OF 1

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp W Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface											
0	Mobile Rig, 152 mm Solid Stem Augers, Val's Drilling Ltd.	(SM) gravelly SILTY SAND, fine to coarse sand, coarse angular and sub-rounded gravel, some plastic fines; brown; non-cohesive, moist		0.00									
1					1	SS	50 for 100 mm			○			
2		Grey SANDSTONE (BEDROCK)		1.63									
3					2	SS	49						
4		--- Auger grinding at 3.9 mbgs											
		End of BOREHOLE.		4.57									
5		NOTES: 1. No groundwater observed during drilling. 2. Backfilled with cuttings and bentonite.											
6													
7													

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: JZ

PROJECT No.: 1406422

LOCATION: See Location Plan

N: 5504058 E: 685322

RECORD OF BOREHOLE: BH15-12

BORING DATE: July 25, 2015

Riversdale Resources Limited

SHEET 1 OF 1

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	Mobile Rig, 152 mm Solid Stem Augers Val's Drilling Ltd.	FILL - (SC) CLAYEY SAND, some gravel; grey, contains some coal; non-cohesive		0.00	1	AS			○		
		--- BEDROCK End of BOREHOLE. NOTES: 1. No groundwater observed during drilling. 2. Backfilled with cuttings and bentonite.		0.30							
1											
2											
3											
4											
5											
6											
7											

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: JZ

PROJECT No.: 1406422

LOCATION: See Location Plan

N: 5503989 E: 685231

RECORD OF BOREHOLE: BH15-13

BORING DATE: July 24, 2015

Riversdale Resources Limited

SHEET 1 OF 1

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface											
0	Mobile Rig, 152 mm Solid Stem Augers, Val's Drilling Ltd.	(GC/SC) CLAYEY GRAVEL and SAND, fine to coarse angular gravel, fine to coarse sand; black, contains some coal; non-cohesive, dry to moist, loose		0.00									
1					1	SS	8			○		Gravel=42% Sand=41% Fines=17%	
2		gravelly silty COAL, fine to coarse angular gravel, some fine sand		1.98									
3					2A	SS	50 for 75 mm						
		(SC) gravelly CLAYEY SAND; brown; non-cohesive, dry, very dense		3.16	2B								
4					3	SS	50 for 125 mm			○		Gravel=17% Sand=55% Fines=28%	
		End of BOREHOLE.		4.70									
5		NOTES: 1. No groundwater observed during drilling. 2. Backfilled with cuttings and bentonite.											
6													
7													

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: JZ

PROJECT No.: 1406422

LOCATION: See Location Plan

N: 5503963 E: 685321

RECORD OF BOREHOLE: BH15-14

BORING DATE: July 25, 2015

Riversdale Resources Limited

SHEET 1 OF 1

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface											
0	Mobile Rig, 152 mm Solid Stem Augers, Val's Drilling Ltd.	(SC) CLAYEY SAND, fine to coarse sand, plastic fines, some fine to coarse angular gravel; grey to brown; cohesive, w<PL, hard		0.00	1	SS	50 for 100 mm				○ — W —	Gravel=12% Sand=45% Fines-43%	
1													
2		Greyish light brown BEDROCK		1.83									
3		End of BOREHOLE.		3.05									
4		NOTES: 1. No groundwater observed during drilling. 2. Backfilled with cuttings and bentonite.											
5													
6													
7													

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

DATA ENTRY: JZ

PROJECT No.: 1406422

LOCATION: See Location Plan

N: 5504243 E: 685125

RECORD OF BOREHOLE: BH15-15

BORING DATE: July 25, 2015

Riversdale Resources Limited

SHEET 1 OF 1

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp — W — Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	SHOVEL (Val's Drilling Ltd)	Ground Surface									
		(SC) gravelly CLAYEY SAND, fine to coarse sand, fine to coarse angular gravel; brown, contains rootlets; non-cohesive, moist		0.00							
		--- BEDROCK		0.15							
		End of BOREHOLE.									
		NOTES: 1. No groundwater observed during drilling. 2. Backfilled with cuttings.									
1											
2											
3											
4											
5											
6											
7											

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: JZ

PROJECT No.: 1406422

LOCATION: See Location Plan

N: 5504021 E: 685122

RECORD OF BOREHOLE: BH15-16

BORING DATE: July 24, 2015

Riversdale Resources Limited

SHEET 1 OF 3

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● rem V. ⊕ U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	Mobile Rig, 102 mm Solid Stem Augers, Val's Drilling Ltd.	(GC) sandy CLAYEY GRAVEL, fine to coarse angular gravel, medium to coarse sand; dark brown; non-cohesive, moist		0.00							
1		--- Auger grinding near ground surface, possible cobbles/boulder									
		(SC) gravelly CLAYEY SAND, fine to coarse sand, fine to coarse angular gravel; dark brown; non-cohesive, loose to compact		1.52	1	SS	13				
2		--- Auger grinding at 2.1 mbgs --- Transitioning to light grey between 2.0 mbgs and 3.0 mbgs									
3		--- Contains some coal below 3.0 mbgs			2	SS	8		○	SS2/SS3 Combined Gravel=30% Sand=51% Fines=19%	
4											
					3	SS	15		○	SS2/SS3 Combined Gravel=30% Sand=51% Fines=19%	
5		--- Auger grinding at 5.2 mbgs									
6											
					4	SS	10		○		
		COAL, fine, trace angular gravel; black; non-cohesive, dry to moist		6.40							
7											
		CONTINUED NEXT PAGE									

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

DATA ENTRY: JZ

PROJECT No.: 1406422

RECORD OF BOREHOLE: BH15-16

SHEET 2 OF 3

LOCATION: See Location Plan

BORING DATE: July 24, 2015

DATUM: UTM Zone 11 (Nad 83)

N: 5504021 E: 685122

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
8	Mobile Rig, 102 mm Solid Stem Augers, Val's Drilling Ltd.	(SC) gravelly CLAYEY SAND, fine to coarse sand, fine to coarse angular gravel; light brown, contains some coal; non-cohesive, compact becoming dense --- 0.2 m layer of fine coal at 7.8 mbgs		7.62	5	SS	15			○		SS5/SS6 Combined Gravel=23% Sand=49% Fines=28%	
9		--- Becoming grey to brown below 9.1 mbgs			6	SS	15			○		SS5/SS6 Combined Gravel=23% Sand=49% Fines=28%	
10													
11					7	SS	12			○		SS7/SS8 Combined Gravel=30% Sand=41% Fines=29%	
12													
13					8	SS	13			○		SS7/SS8 Combined Gravel=30% Sand=41% Fines=29%	
14		--- Becoming grey to black below 12.6 mbgs --- Becoming dense below 13.7 mbgs			9	SS	49						
15		--- Auger grinding due to gravel and possible cobbles/boulders from 14.2 mbgs to 15.2 mbgs											
		CONTINUED NEXT PAGE											

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: JZ

PROJECT No.: 1406422

RECORD OF BOREHOLE: BH15-16

SHEET 3 OF 3

LOCATION: See Location Plan

BORING DATE: July 24, 2015

DATUM: UTM Zone 11 (Nad 83)

N: 5504021 E: 685122

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
15					10	SS	50 for 50 mm				○		
		End of BOREHOLE.		15.44									
		NOTES: 1. No groundwater observed during drilling. 2. Backfilled with cuttings and bentonite.											
16													
17													
18													
19													
20													
21													
22													

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: JZ

PROJECT No.: 1406422

LOCATION: See Location Plan

N: 5504044 E: 685011

RECORD OF BOREHOLE: BH15-17

BORING DATE: July 23, 2015

Riversdale Resources Limited

SHEET 1 OF 1

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	Mobile Rig, 152 mm Solid Stem Augers Vafs Drilling Ltd.	(SC) CLAYEY SAND, fine to medium sand, some gravel to gravelly; contains rootlets; non-cohesive		0.00	1	SS	66/ for 280 mm		○		
		Grey SANDSTONE (BEDROCK)		0.30							
		End of BOREHOLE.		0.43							
1		NOTES: 1. No groundwater observed during drilling. 2. Backfilled with cuttings and bentonite.									
2											
3											
4											
5											
6											
7											

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: JZ

PROJECT No.: 1406422

RECORD OF BOREHOLE: BH15-18

SHEET 1 OF 1

LOCATION: See Location Plan

BORING DATE: July 23, 2015

DATUM: UTM Zone 11 (Nad 83)

N: 5504043 E: 684983

Riversdale Resources Limited

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface											
0	SHOVEL Val's Drilling Ltd	(Cl) SILTY CLAY and SAND, fine to medium sand, some gravel; grey, contains rootlets; cohesive, w<PL		0.00	1	GRAB					○		
		--- Possible BEDROCK End of BOREHOLE. NOTES: 1. No groundwater observed during excavation. 2. Backfilled with cuttings.		0.30									
1													
2													
3													
4													
5													
6													
7													

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: JZ

PROJECT No.: 1406422

RECORD OF BOREHOLE: BH15-19

SHEET 1 OF 1

LOCATION: See Location Plan

BORING DATE: July 25, 2015

DATUM: UTM Zone 11 (Nad 83)

N: 5504436 E: 685371

Riversdale Resources Limited

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface									
	SHOVEL Vat's Drilling Ltd	(CL) sandy SILTY CLAY, low plasticity, trace gravel; brown, contains rootlets; cohesive, w<PL		0.00	1	GRAB			○		
		--- BEDROCK		0.15							
		End of BOREHOLE.									
		NOTES: 1. No groundwater observed during excavation. 2. Backfilled with cuttings.									
1											
2											
3											
4											
5											
6											
7											

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: JZ

PROJECT No.: 1406422

RECORD OF BOREHOLE: BH15-20

SHEET 1 OF 1

LOCATION: See Location Plan

BORING DATE: July 25, 2015

DATUM: UTM Zone 11 (Nad 83)

N: 5504511 E: 685416

Riversdale Resources Limited

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	SHOVEL Vat's Drilling Ltd	Ground Surface									
		(CL) sandy SILTY CLAY, low plasticity, some gravel; black to brown, contains rootlets; cohesive, w<PL		0.00	1	GRAB			○		
		--- BEDROCK		0.15							
		End of BOREHOLE.									
		NOTES: 1. No groundwater observed during excavation. 2. Backfilled with cuttings.									
1											
2											
3											
4											
5											
6											
7											

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

DATA ENTRY: JZ

PROJECT No.: 1406422

LOCATION: See Location Plan

N: 5503243 E: 685056

RECORD OF BOREHOLE: BH15-21

BORING DATE: July 23, 2015

Riversdale Resources Limited

SHEET 1 OF 2

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● rem V. ⊕ U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	Mobile Rig, 152 mm Solid Stem Augers, Val's Drilling Ltd.	(SM) gravelly SILTY SAND, fine angular gravel; brown to black, contains coal; non-cohesive, dry		0.00							
1		(SC) CLAYEY SAND, fine to coarse sand, plastic fines, some fine angular gravel; brown; cohesive, stiff --- Auger grinding between 1.2 mbgs and 1.5 mbgs		1.22	1	SS	11			Gravel=8% Sand=43% Fines=49%	23/07/2015 ▽
2		--- Auger grinding, possible cobbles/boulders between 1.5 mbgs and 3.0 mbgs			2	SS	9				
3		(SC) gravelly CLAYEY SAND, fine to coarse sand, fine angular gravel, plastic fines; brown; cohesive		3.51	1	AS				Gravel=24% Sand=35% Fines=42%	
4		(GC/SC) CLAYEY GRAVEL and SAND, fine to coarse angular gravel, fine to coarse sand, plastic fines; grey; non-cohesive, dense		4.57	3	SS	35				
5		--- Augers grinding, very little recovery, possible cobbles/boulders at 5.2 mbgs and 5.8 mbgs									
6					4	SS	41			Gravel=38% Sand=38% Fines=24%	
7		--- Augers grinding, no recovery below 6.6 mbgs									
		--- Auger refusal at 7.0 mbgs			5	SS	50 for 25 mm				
		End of BOREHOLE.		7.04							
		NOTES: 1. Groundwater measured at 1.3									
		CONTINUED NEXT PAGE									

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: JZ

PROJECT No.: 1406422

RECORD OF BOREHOLE: BH15-21

SHEET 2 OF 2

LOCATION: See Location Plan

BORING DATE: July 23, 2015

DATUM: UTM Zone 11 (Nad 83)

N: 5503243 E: 685056

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: STRATA PLOT	SOIL PROFILE: ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		mbgs during drilling. 2. Backfilled with cuttings and bentonite.									
8											
9											
10											
11											
12											
13											
14											
15											

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: JZ

PROJECT No.: 1406422

LOCATION: See Location Plan

N: 5503754 E: 684990

RECORD OF BOREHOLE: BH15-22

BORING DATE: July 23, 2015

Riversdale Resources Limited

SHEET 1 OF 2

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface											
0	Mobile Rig, 152 mm Solid Stem Augers, Val's Drilling Ltd.	(SM) gravelly SILTY SAND and COAL, fine sand, fine angular gravel; black to brown; non-cohesive, dry, very loose to loose		0.00									
1					1	SS	6						
2													
3					2	SS	3						
4		(Cl) sandy SILTY CLAY, medium plasticity, some fine to coarse angular to sub-rounded gravel; brown and grey; cohesive, firm becoming very stiff		3.51									
5					3	SS	5				○		
		--- becomes (Cl) SILTY CLAY, some sand, some gravel											
6					4	SS	9				○—|		
7													
		CONTINUED NEXT PAGE											

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

DATA ENTRY: JZ

PROJECT No.: 1406422

RECORD OF BOREHOLE: BH15-22

SHEET 2 OF 2

LOCATION: See Location Plan

BORING DATE: July 23, 2015

DATUM: UTM Zone 11 (Nad 83)

N: 5503754 E: 684990

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
8	Mobile Rig, 152 mm Solid Stem Augers, Val's Drilling Ltd.	(Cl) sandy SILTY CLAY, medium plasticity, some fine to coarse angular to sub-rounded gravel; brown and grey; cohesive, firm becoming very stiff *(continued)* --- trace fine angular gravel below 7.6 mbgs			5	SS	17		W		23/07/2015 ▽
9		(SC) gravelly CLAYEY SAND, fine angular gravel; grey; non-cohesive, w<PL, very dense --- Auger grinding between 8.5 mbgs and 8.8 mbgs, possible cobbles/boulders		8.53	6	SS	50 for 25 mm		W		
10		--- Auger refusal at 9.6 mbgs End of BOREHOLE. NOTES: 1. Groundwater measured at 8.1 mbgs during drilling. 2. Backfilled with cuttings and bentonite.		9.60							
11											
12											
13											
14											
15											

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: JZ

PROJECT No.: 1406422

LOCATION: See Location Plan

N: 5503660 E: 684939

RECORD OF BOREHOLE: BH15-23

BORING DATE: July 22, 2015

Riversdale Resources Limited

SHEET 1 OF 2

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	Mobile Rig, 152 mm Solid Stem Augers, Val's Drilling Ltd.	(GC) sandy CLAYEY GRAVEL, fine to coarse sub-rounded gravel, fine to coarse sand, plastic fines; brown; non-cohesive, dry to moist, compact becoming very dense		0.00							
1					1	SS	25				
2											
3					2	SS	22		○	SS2/SS3 Combined Gravel=50% Sand=24% Fines=26%	
4		--- Auger grinding between 3.5 mbgs and 7.6 mbgs due to gravel and possible cobbles/boulders									
5					3	SS	27		○	SS2/SS3 Combined Gravel=50% Sand=24% Fines=26%	
6		--- Becomes very dense below 6.1 mbgs									
					4	SS	65				
7											
		CONTINUED NEXT PAGE									

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

DATA ENTRY: JZ

PROJECT No.: 1406422

RECORD OF BOREHOLE: BH15-23

SHEET 2 OF 2

LOCATION: See Location Plan

BORING DATE: July 22, 2015

DATUM: UTM Zone 11 (Nad 83)

N: 5503660 E: 684939

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
8	Mobile Rig, 152 mm Solid Stem Augers, Val's Drilling Ltd.	(SC) gravelly CLAYEY SAND, fine angular gravel, plastic fines; brown; non-cohesive, dense becoming very dense		7.62	5	SS	45				
9											22/07/2015 ▽
10		--- Auger grinding below 9.6 mbgs, possible cobbles/boulders, auger teeth broken off			6	SS	60			Gravel=28% Sand=37% Fines=35%	
11					7	SS	58				
12		End of BOREHOLE.		11.13							
13		NOTES: 1. Groundwater measured at 9.0 mbgs during drilling. 2. Backfilled with cuttings and bentonite. 3. Borehole terminated due to possible hole deviation.									
14											
15											

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: JZ

PROJECT No.: 1406422

LOCATION: See Location Plan

N: 5503975 E: 685015

RECORD OF BOREHOLE: BH15-24

BORING DATE: July 23, 2015

Riversdale Resources Limited

SHEET 1 OF 1

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m; SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s; WATER CONTENT PERCENT (Wp, W, Wl)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	152 mm Solid Stem Augers Val's Drilling Ltd.	(SC) gravelly CLAYEY SAND; black to brown, contains rootlets; non-cohesive, dry to moist		0.00	1	SS	17				
1	Mobile Rig,	--- SANDSTONE (BEDROCK) End of BOREHOLE. NOTES: 1. No groundwater observed during drilling. 2. Backfilled with cuttings and bentonite.		0.76							
2											
3											
4											
5											
6											
7											

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: JZ

PROJECT No.: 1406422

LOCATION: See Location Plan

N: 5503770 E: 685293

RECORD OF BOREHOLE: BH15-25

BORING DATE: July 22, 2015

Riversdale Resources Limited

SHEET 1 OF 2

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp W Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface											
0	Mobile Rig, 152 mm Solid Stem Augers, Val's Drilling Ltd.	(SC) gravelly CLAYEY SAND, fine to coarse sand, fine and coarse angular and sub-rounded gravel; brown; non-cohesive, dry to moist, dense to compact		0.00									
1		--- Auger grinding from surface to 1.5 mbgs			1	SS	31			○			
2													
3					2	SS	17						
4													
5		(CH) CLAY, trace angular and sub-rounded gravel; grey; cohesive, stiff		4.72	3	SS	15			○			
					4	AS				○——62			
6		(SC) gravelly CLAYEY SAND, fine to coarse sand, fine to coarse angular to sub-rounded gravel; brown; non-cohesive, compact becoming dense		5.18									
					4	SS	14			○			22/07/2015 ▽
7		*CONTINUED NEXT PAGE*											

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: JZ

PROJECT No.: 1406422

RECORD OF BOREHOLE: BH15-25

SHEET 2 OF 2

LOCATION: See Location Plan

BORING DATE: July 22, 2015

DATUM: UTM Zone 11 (Nad 83)

N: 5503770 E: 685293

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
8	Mobile Rig, 152 mm Solid Stem Augers, Val's Drilling Ltd.	(SC) gravelly CLAYEY SAND, fine to coarse sand, fine to coarse angular to sub-rounded gravel; brown; non-cohesive, compact becoming dense *(continued)* --- moist to wet between 7.6 mbgs and 9.6 mbgs			5	SS	18			Gravel=17% Sand=55% Fines=29%	
9					6	SS	36				
10		(CL) gravelly SILTY CLAY, some sand; brown to grey; cohesive, hard		9.60							
11					7	SS	50 for 137 mm			Gravel=16% Sand=12% Fines=73%	
12					8	SS	50 for 25 mm				
		Possible SANDSTONE (BEDROCK) End of BOREHOLE.		12.22							
13		NOTES: 1. Groundwater measured at 6.8 mbgs during drilling. 2. Backfilled with cuttings and bentonite. 3. Inferred bedrock at 12.2 mbgs, spoon refusal.									
14											
15											

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

DATA ENTRY: JZ

PROJECT No.: 1406422

LOCATION: See Location Plan

N: 5503596 E: 685040

RECORD OF BOREHOLE: BH15-26

BORING DATE: July 22, 2015

Riversdale Resources Limited

SHEET 1 OF 2

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	Mobile Rig, 152 mm Solid Stem Augers, Val's Drilling Ltd.	(SC) gravelly CLAYEY SAND, fine to coarse angular to sub-rounded gravel; brown, contains organic matter to 0.3 mbgs; non-cohesive, dry to moist, loose becoming compact		0.00							
1		--- Auger grinding near ground surface			1	SS	7				
2											
3		--- becomes compact below 3.0 mbgs			2	SS	29			Gravel=30% Sand=44% Fines=26%	
4		COAL, fine; black; non-cohesive, dry, very dense		4.11	3	SS	50 for 125 mm				
5		(SC) gravelly CLAYEY SAND, fine angular to sub-rounded gravel; brown, contains some fine coal to 6.6 mbgs; non-cohesive, very dense		5.18							
6					4	SS	50 for 125 mm			Gravel=20% Sand=35% Fines=45%	
7		--- Auger grinding, slow progress between 6.1 mbgs and 8.5 mbgs									
		CONTINUED NEXT PAGE									

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

PROJECT No.: 1406422

RECORD OF BOREHOLE: BH15-26

SHEET 2 OF 2

LOCATION: See Location Plan

BORING DATE: July 22, 2015

DATUM: UTM Zone 11 (Nad 83)

N: 5503596 E: 685040

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
8	Mobile Rig, 152 mm Solid Stem Augers, Val's Drilling Ltd.	(SC) gravelly CLAYEY SAND, fine angular to sub-rounded gravel; brown, contains some fine coal to 6.6 mbgs; non-cohesive, very dense *(continued)*			5	SS	50 for 100 mm						
9		--- Auger refusal between 8.5 mbgs and 9.1 mbgs Grey SANDSTONE (BEDROCK)		8.53	6	SS	50 for 100 mm			○			
		End of BOREHOLE.		9.25									
10		NOTES: 1. No groundwater observed during drilling. 2. Backfilled with cuttings and bentonite.											
11													
12													
13													
14													
15													

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

DATA ENTRY: JZ

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: JZ

PROJECT No.: 1406422

LOCATION: See Location Plan

N: 5504386 E: 685060

RECORD OF BOREHOLE: BH15-28

BORING DATE: July 25, 2015

Riversdale Resources Limited

SHEET 1 OF 1

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	Mobile Rig, 152 mm Solid Stem Augers, Val's Drilling Ltd.	(Cl) SILTY CLAY and SAND, fine to coarse sand, plastic fines, trace fine angular gravel; brown; cohesive, w<PL, hard		0.00	1	SS	50 for 50 mm		○	Gravel=0% Sand=50% Fines=50%	
1											
2		Grey SANDSTONE (BEDROCK) --- Auger grinding below 2.0 mbgs		1.98							
		End of BOREHOLE.		2.59							
3		NOTES: 1. No groundwater observed during drilling. 2. Backfilled with cuttings and bentonite.									
4											
5											
6											
7											

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

DATA ENTRY: MD

PROJECT No.: 1406422

LOCATION: See Location Plan

N: 5510554 E: 687355

RECORD OF BOREHOLE: BH15-29

BORING DATE: 03 and 04 November, 2015

Riversdale Resources Limited

SHEET 1 OF 1

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp ○ W I WI) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	B-37 Mobile Rig, Solid Stem Augers, Val's Drilling Ltd.	(SP-GP) GRAVELLY SAND to SAND and GRAVEL, trace to some fines, trace rootlets/organics up to 0.6 m; dark brown; non-cohesive, moist, very dense.		0.00							
1					1	AS					
2					2	SS	69		○		
3		(BEDROCK) Highly weathered, grey; very weak, SANDSTONE.		2.13	3	AS					
4					4	SS	31		○		
5					5	AS					
					6	SS	33				
5		End of BOREHOLE.		5.03							
6		NOTES: Borehole redrilled with hollow stem from 0 to 3.1 m on November 4, 2015 before advancing with 102 mm diameter solid stem from 3.1 m to 5.0 m. Borehole terminated at 5.0 m. Backfilled with cuttings.									
7											

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_WASTEDUMP _BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: HM

CHECKED: RA

DATA ENTRY: MD

PROJECT No.: 1406422

LOCATION: See Location Plan

N: 5510663 E: 687396

RECORD OF BOREHOLE: BH15-30

BORING DATE: November 04, 2015

Riversdale Resources Limited

SHEET 1 OF 2

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	B-37 Mobile Rig, Solid Stem Augers, Val's Drilling Ltd.	(SP-GP) SAND and GRAVEL, trace fines; brown; non-cohesive, moist, loose.		0.00	1	AS					
1											
2					2	SS	7		W		
		(SM) SILTY SAND, some gravel, some fines, trace organics; brown; non-cohesive, wet, very loose to compact.		2.13	3	AS					
3					4	SS	3		W		
					5	AS					
4		--- Becoming compact at 4.6 m.			6	SS	20		W		
5					7	AS					
6		--- Groundwater seepage observed at 6.1 m.			8	SS	16		W	Gravel=10% Sand=44% Fines=46%	
		(ML) sandy CLAYEY SILT, trace gravel; grey; moist, stiff.		6.50							
7					9	AS					
		CONTINUED NEXT PAGE									

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_WASTEDUMP _BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: HM

CHECKED: RA

PROJECT No.: 1406422

RECORD OF BOREHOLE: BH15-30

SHEET 2 OF 2

LOCATION: See Location Plan

BORING DATE: November 04, 2015

DATUM: UTM Zone 11 (Nad 83)

N: 5510663 E: 687396

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		(ML) sandy CLAYEY SILT, trace gravel; grey; moist, stiff. *(continued)*			10	SS	11				○		
8		(SP) GRAVELLY SAND, trace to some fines; dark grey; non-cohesive, wet, compact.		7.92	11	AS							
9	B-37 Mobile Rig, Solid Stem Augers, Val's Drilling Ltd.	(BEDROCK) Highly weathered, grey; very weak, SANDSTONE.		9.14	12	SS	17				○		
10					13	AS							
11					14	SS	60 for 200 mm						
		End of BOREHOLE. NOTES: Borehole terminated at 11.1 m. Backfilled with cuttings.		11.07									
12													
13													
14													
15													

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: HM

CHECKED: RA

DATA ENTRY: MD

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_WASTEDUMP _BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: MD

PROJECT No.: 1406422

LOCATION: See Location Plan

N: 5508280 E: 687724

RECORD OF BOREHOLE: BH15-31

BORING DATE: November 03, 2015

Riversdale Resources Limited

SHEET 1 OF 2

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	B-37 Mobile Rig, Solid Stem Augers, Val's Drilling Ltd.	(OL) ORGANIC SILT, some sand, grass, trace rootlets; loose.		0.00							
		(SP) gravelly SAND, with boulders/cobbles, fine grained sand; brown; non-cohesive, wet, loose.		0.46	1	AS					
1		--- possible boulder, becoming wet at 1.2 m.									
		--- water seepage at 1.5 m.			2	SS	5		○		
2		(Cl) SILTY CLAY, trace gravel, medium plasticity; dark grey to grey; cohesive, w~PL to w>PL, stiff.		2.13	3	AS					
3					4	SS	9		○		
4					5	AS					
					6	SS	8		○		
5					7	AS					
6					8	SS	9		○		
7					9	AS					
		CONTINUED NEXT PAGE									

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_WASTEDUMP _BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: HM

CHECKED: RA

PROJECT No.: 1406422

RECORD OF BOREHOLE: BH15-31

SHEET 2 OF 2

LOCATION: See Location Plan

BORING DATE: November 03, 2015

DATUM: UTM Zone 11 (Nad 83)

N: 5508280 E: 687724

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
8	B-37 Mobile Rig, Solid Stem Augers, Val's Drilling Ltd.	(Cl) SILTY CLAY, trace gravel, medium plasticity; dark grey to grey; cohesive, w~PL to w>PL, stiff. *(continued)*			10	SS	9				Wp, W, Wl		
9					11	AS							
10		(SP) GRAVELLY SAND, some fines; grey; non-cohesive, wet, compact.		9.14	12	SS	17						
11					13	AS							
					14	SS	18						
12		End of BOREHOLE. NOTES: Borehole terminated at 11.1 m. Seepage observed at 1.5 m at the end of drilling. Backfilled with cuttings and bentonite at the top.		11.13									
13													
14													
15													

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: HM

CHECKED: RA

DATA ENTRY: MD

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_WASTEDUMP _BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: MD

PROJECT No.: 1406422

LOCATION: See Location Plan

N: 5508452 E: 687715

RECORD OF BOREHOLE: BH15-32

BORING DATE: November 03, 2015

Riversdale Resources Limited

SHEET 1 OF 2

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp — W — Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface											
0	B-37 Mobile Rig, Solid Stem Augers, Val's Drilling Ltd.	(OL) ORGANIC SILT, trace rootlets; dark brown; moist, loose.		0.02									
		(SP-GP) SAND and GRAVEL, fine grained, poorly graded, trace fines, trace organics/rootlets up to 0.9 m; brown; non-cohesive, moist, compact.			1	AS							
1													
					2	SS	12			○			
2					3A	AS							
		(CL) sandy SILTY CLAY, trace gravel, low plasticity; grey; cohesive, moist, firm.		2.13	3B	AS							
3		(SM) SILTY SAND, fine grained, trace to some fines, trace gravel; grey; non-cohesive, loose.		3.05	4	SS	5			○			
					5	AS							
4		(ML) SILT, some sand; grey; non-cohesive, wet, very loose to loose.		4.27									
					6	SS	2				○		
5					7	AS							
6		--- water seepage at 6.1 m.			8	SS	5				○		
		(CI) SILTY CLAY, medium plasticity, trace gravel; grey; cohesive, w~PL, firm to stiff.		6.71									
7					9	AS							
		CONTINUED NEXT PAGE											

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_WASTEDUMP _BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: HM

CHECKED: RA

DATA ENTRY: MD

PROJECT No.: 1406422

RECORD OF BOREHOLE: BH15-32

SHEET 2 OF 2

LOCATION: See Location Plan

BORING DATE: November 03, 2015

DATUM: UTM Zone 11 (Nad 83)

N: 5508452 E: 687715

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
8	B-37 Mobile Rig, Solid Stem Augers, Val's Drilling Ltd.	(Cl) SILTY CLAY, medium plasticity, trace gravel; grey; cohesive, w~PL, firm to stiff. *(continued)*			10	SS	8		W		
9					11	AS					
10					12	SS	6		W		
11					13	AS					
					14	SS	9		W		
		End of BOREHOLE. NOTES: Borehole terminated at 36.5 m. Backfilled with cuttings.		11.13							
12											
13											
14											
15											

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: HM

CHECKED: RA

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_WASTEDUMP _BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: MD

PROJECT No.: 1406422

RECORD OF HAND AUGER: BH15-40 (HA)

SHEET 1 OF 1

LOCATION: See Location Plan

N: 5509094 E: 685163

EXCAVATION DATE: November 07, 2015

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface											
0	Ø 50 mm Hand Auger Riversdale Staff	(OL) ORGANIC SILT, trace rootlets; black; loose.		0.00	1	HA							
		End of HAND AUGER.		0.20									
		NOTES: Terminated at 0.2 m. Hand auger hole could not be advanced due to presence of boulders/bedrock.											
1													
2													
3													
4													
5													
6													
7													

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: DL/HM

CHECKED: RA

TESTPIT - EXP ADD LAB TESTING 1406422_BENGA - RIVERSDALE_WASTEDUMP_TESTPITS_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: JZ

PROJECT No.: 1406422

LOCATION: See Location Plan

N: 5503690 E: 684792

RECORD OF BOREHOLE: PZ15-01a

BORING DATE: 28-29 July, 2015

Riversdale Resources Limited

SHEET 1 OF 1

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp ⊖ W WI) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	Mobile Rig, 154 mm Solid Stem Augers, Val's Drilling Ltd.	(SM) gravelly SILTY SAND, fine to medium sand, fine angular and coarse sub-rounded gravel; light brown; non-cohesive, dry		0.00							Cuttings
1		Possibly rafted BEDROCK		0.76							
2											
3		--- Weak zone between 3.0 mbgs and 4.6 mbgs --- Auger bringing up clay coated angular coarse sand cuttings (very weak weathered bedrock) below 3.0 mbgs									28/07/2015 ▽
4											Bentonite
5		(GC) CLAYEY GRAVEL, sub-rounded; dark brown; non-cohesive, moist --- Auger grinding at 4.6 mbgs		4.57							
6		(Cl/CH) gravelly sandy SILTY CLAY, high plasticity, fine to medium sand, fine gravel; brown; w>PL		5.33							
		End of BOREHOLE.		6.10							
7		NOTES: 1. Switched to core drilling at 6.1 mbgs.									

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

DATA ENTRY: JZ

PROJECT No.: 1406422

RECORD OF BOREHOLE: PZ15-01a

SHEET 1 OF 2

LOCATION: See Location Plan
N: 5503690 E: 684792

DRILLING DATE: 28-29 July, 2015
DRILL RIG: Mobile Rig
DRILLING CONTRACTOR: Val's Drilling Ltd.

DATUM: UTM Zone 11 (Nad 83)

INCLINATION: -90° AZIMUTH: 0°

FR-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE
C-CONCH.FRACT. J-JOINT R-ROUGH U-UNDULATING MB-MECH. BREAK
SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING
VN-VEIN K-SLICKENSIDED PL-PLANAR C-CURVED CH-CHLORITIZED

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	PENETRATION RATE (m/hr)	FLUSH	COLOUR % RETURN	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 1.5m	DISCONTINUITY DATA DIP w.r.t. CORE AXIS 0, 30, 60, 90	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	ROCK STRENGTH INDEX	WEATHERING INDEX	COMMENTS/SAMPLE No
		Continued from Record of BOREHOLE.															
7	Mobile Rig Val's Drilling Ltd.	(GP) GRAVEL, coarse, sub-rounded; coated in brown clay; non-cohesive --- Losing circulation water between 6.1 mbgs and 7.6 mbgs		6.10	1												Bentonite
8		Slightly weathered (W2), grey, very weak to weak (R1-R2) SILTSTONE		7.62	2				100		33			0.1 m broken core at 7.9 mbgs Fractured at 40°, 50° and 60°, 1 to 4 cm reddish infilling and staining on joints	R1-R2	W2	PLT1 $Is_{(50)}$=0.2 MPa PLT2 $Is_{(50)}$=0.6 MPa
9		Fresh to moderately weathered (W1-W3), grey, extremely weak to strong (R0-R4) SILTSTONE/MUDSTONE		8.69	3				100		66			Fractured at 0°, 50°, 60° and 80°, very rough and irregular Joints at 50°, smooth	R3-R4 R2-R3	W1 W1	PLT3 $Is_{(50)}$=1.4 MPa PLT4 $Is_{(50)}$=2.7 MPa PLT5 $Is_{(50)}$=0.6 MPa PLT6 $Is_{(50)}$=1.0 MPa
10		--- Becomes greenish grey to purple												Irregular fractures	R0	W3	Sand
11		Slightly weathered (W1), greenish grey, weak to very strong (R2-R5) SILTSTONE		10.82	4				100		59			Fractures at 50°, smooth, some staining	R2-R5	W2	RC9 q_u=7.7 MPa PLT7 $Is_{(50)}$=1.1 MPa PLT8 $Is_{(50)}$=5.6 MPa
12		Slightly to moderately weathered (W2-W3), grey to purple, extremely weak to weak (R0-R2) SILTSTONE/MUDSTONE		11.89											R0	W3	Slotted Section/ Sand
13					5				100		56			Most fractures at 50°, smooth, irregular, some staining	R0-R2	W2	PLT9 $Is_{(50)}$=0.1 MPa RC12 q_u=1.0 MPa PLT10 $Is_{(50)}$=0.3 MPa
		CONTINUED NEXT PAGE															

DRILLHOLE - NO GRAPHICS FOR RECOVERY 1416422_BENGA - RIVERSDALE_ROCK CORE DRILLING - 20160111.GPJ CALGARY.GDT 01/11/16

DEPTH SCALE
1 : 37.5

Golder Associates

LOGGED: AK
CHECKED: RA

DATA ENTRY: JZ

PROJECT No.: 1406422

RECORD OF BOREHOLE: PZ15-01a

SHEET 2 OF 2

LOCATION: See Location Plan
N: 5503690 E: 684792

DRILLING DATE: 28-29 July, 2015
DRILL RIG: Mobile Rig
DRILLING CONTRACTOR: Val's Drilling Ltd.

DATUM: UTM Zone 11 (Nad 83)

INCLINATION: -90° AZIMUTH: 0°

FR-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE
C-CONCH.FRACT. J-JOINT R-ROUGH U-UNDULATING MB-MECH. BREAK
SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING
VN-VEIN K-SLICKENSIDED PL-PLANAR C-CURVED CH-CHLORITIZED

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	PENETRATION RATE (m/hr)	COLOUR % RETURN / FLUSH	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 1.5m	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS (0, 30, 60, 90)	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	ROCK STRENGTH INDEX	WEATH-ERING INDEX	COMMENTS/SAMPLE No
					5			100		56				R0-R2	W2	
		End of DRILLHOLE.		13.72												
14		NOTES: 1. Groundwater measured at 3.0 mbgs at completion of drilling. 2. Standpipe installed by Millenium EMS Solutions Ltd. at completion of drilling 3. Standpipe installed at shallower depth in adjacent borehole PZ15-01b.														
15																
16																
17																
18																
19																
20																
21																

DRILLHOLE - NO GRAPHICS FOR RECOVERY 1416422_BENGA - RIVERSDALE_ROCK CORE DRILLING - 20160111.GPJ CALGARY.GDT 01/11/16

DEPTH SCALE
1 : 37.5

Golder Associates

LOGGED: AK
CHECKED: RA

DATA ENTRY: CC

PROJECT No.: 1406422

LOCATION: See Location Plan

N: 5503690 E: 684792

RECORD OF BOREHOLE: PZ15-01b

BORING DATE: July 29, 2015

Riversdale Resources Limited

SHEET 1 OF 1

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	Mobile Rig, 102 mm Solid Stem Auger Val's Drilling	Borehole drilled for piezometer installation. Not logged.		0.00							Cuttings
1											29/07/2015 ▽
2											Bentonite
3											
4											Sand
5											Slotted Section/ Sand
6											
7		End of BOREHOLE. NOTES: 1. See PZ15-01a for stratigraphy. 2. Piezometer installed by Millenium EMS Solutions Ltd. 3. Borehole located within 2 m of PZ15-01a.		6.86							

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

DATA ENTRY: JZ

PROJECT No.: 1406422

RECORD OF BOREHOLE: PZ15-02a

SHEET 1 OF 1

LOCATION: See Location Plan

BORING DATE: July 27, 2015

DATUM: UTM Zone 11 (Nad 83)

N: 5504244 E: 684914

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									Stick-up=/0.91 m
0	Mobile Rig, 154 mm Solid Stem Augers, Val's Drilling Ltd.	(SC) gravelly CLAYEY SAND, fine to coarse sand, fine angular to sub-rounded gravel; brown; non-cohesive, dry		0.00							Cuttings
1					1	SS	50 for 50 mm		○	Gravel=14% Sand=44% Fines=42%	
2		Grey SANDSTONE (BEDROCK) --- Auger grinding		1.68							Bentonite
3											
		End of BOREHOLE.		3.35							
4		NOTES: 1. Switched to core drilling at 3.35 mbgs.									
5											
6											
7											

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

DATA ENTRY: JZ

PROJECT No.: 1406422

RECORD OF BOREHOLE: PZ15-02a

SHEET 1 OF 3

LOCATION: See Location Plan

DRILLING DATE: 27-28 July, 2015

DATUM: UTM Zone 11 (Nad 83)

DRILL RIG: Mobile Rig

INCLINATION: -90° AZIMUTH: 0°

DRILLING CONTRACTOR: Val's Drilling Ltd.

FR-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE
C-CONCH.FRACT. J-JOINT R-ROUGH U-UNDULATING MB-MECH. BREAK
SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING
VN-VEIN K-SLICKENSIDED PL-PLANAR C-CURVED CH-CHLORITIZED

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	PENETRATION RATE (m/hr)	COLOUR % RETURN / FLUSH	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 1.5m	DISCONTINUITY DATA DIP w.r.t. CORE AXIS 0, 30, 60, 90	DISCONTINUITY DATA TYPE AND SURFACE DESCRIPTION	ROCK STRENGTH INDEX	WEATH-ERING INDEX	COMMENTS/SAMPLE No
		Continued from Record of BOREHOLE.														
		Moderately weathered (W3), grey, weak (R2) SANDSTONE		3.35	1			50		0			Heavily fractured at 30° and 70°, rough, some clay infilling, staining on fractures	R2	W3	27/07/2015 ▽
4																28/07/2015 ▽
		Fresh to highly weathered (W1-W4), grey, fine grained, extremely weak to very strong (R0-R5) SILTSTONE/SANDSTONE		4.57									Clay seam sharp contact at 90°	R0	W4	
5					2			80		66			Fractures at 50°, some fractures with clay coating, staining on fractures, rough, irregular	R2-R3	W2	PLT1 $Is_{(50)}$=0.5 MPa PLT2 $Is_{(50)}$=1.2 MPa
6		--- Becoming green and purple														
7	Mobile Rig Val's Drilling Ltd.				3			80		26				R0-R1	W3-W4	Bentonite
8					4			80		39			Fractures at 60° and 80°, very rough	R2-R4	W3	RC9 q_u=9.4 MPa
9																PLT3 $Is_{(50)}$=2.7 MPa PLT4 $Is_{(50)}$=2.9 MPa
		--- Becoming grey														
10					5			80		36			Fractures at 10° and 60°, alteration 1cm from fracture, rough to very rough, irregular	R3	W2	
		CONTINUED NEXT PAGE														

DEPTH SCALE
1 : 37.5

Golder Associates

LOGGED: AK
CHECKED: RA

DRILLHOLE - NO GRAPHICS FOR RECOVERY 1416422_BENGA - RIVERSDALE_ROCK CORE DRILLING - 20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: JZ

PROJECT No.: 1406422

RECORD OF BOREHOLE: PZ15-02a

LOCATION: See Location Plan

DRILLING DATE: 27-28 July, 2015

DRILL RIG: Mobile Rig

DRILLING CONTRACTOR: Val's Drilling Ltd.

DATUM: UTM Zone 11 (Nad 83)

INCLINATION: -90° AZIMUTH: 0°

FR-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE
C-CONCH.FRACT. J-JOINT R-ROUGH U-UNDULATING MB-MECH. BREAK
SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING
VN-VEIN K-SLICKENSIDED PL-PLANAR C-CURVED CH-CHLORITIZED

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	PENETRATION RATE (m/hr)	COLOUR % RETURN / FLUSH	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 1.5m	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS (0, 30, 60, 90)	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	ROCK STRENGTH INDEX	WEATHERING INDEX	COMMENTS/SAMPLE No
11	Mobile Rig Val's Drilling Ltd.	Fresh to highly weathered (W1-W4), grey, fine grained, extremely weak to very strong (R0-R5) SILTSTONE/SANDSTONE *(continued)*			5			80		36				R3	W2	
12					6			80		63				R4-R5	W1	Bentonite PLT5 $Is_{(50)}$=6.7 MPa PLT6 $Is_{(50)}$=5.9 MPa
13		Fresh to slightly weathered (W1-W2), grey, weak to strong (R2-R4) SILTSTONE		12.50	7			80		34			Thinly bedded at 60° Irregular fractures	R3 R2-R3	W1 W1	
14		--- Poor circulation water recovery between 12.5 mbgs and 17.1 mbgs			8			80		34			Fractures at 40°, 60° and 80°, stained, 2-4 mm calcite veins on 80° fractures Bedding, staining on fractures	R3-R4 R3	W1-W2 W2	Sand PLT7 $Is_{(50)}$=1.3 MPa PLT8 $Is_{(50)}$=2.9 MPa
15																
16		Fresh to slightly weathered (W1-W2), purple to grey, fine grained, weak to strong (R2-R4) SILTSTONE/SANDSTONE		15.54	9			100		66			Fractures at 10° and 60°, fine bedding at 60°, no staining, rough	R3	W1	
17																Slotted Section/ Sand RC23 q_u=42.3 MPa
18					10			100		63			Many fractures at 0°, 50° and 90°, irregular, smooth and rough Irregular fractures, rough	R2 R3-R4	W2 W1-W2	PLT9 $Is_{(50)}$=0.8 MPa PLT10 $Is_{(50)}$=3.8 MPa PLT11 $Is_{(50)}$=2.0 MPa

CONTINUED NEXT PAGE

DEPTH SCALE
1 : 37.5

Golder Associates

LOGGED: AK
CHECKED: RA

DRILLHOLE - NO GRAPHICS FOR RECOVERY 1416422_BENGA - RIVERSDALE_ROCK CORE DRILLING - 20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: JZ

PROJECT No.: 1406422

RECORD OF BOREHOLE: PZ15-02a

SHEET 3 OF 3

LOCATION: See Location Plan

DRILLING DATE: 27-28 July, 2015

DATUM: UTM Zone 11 (Nad 83)

DRILL RIG: Mobile Rig

INCLINATION: -90° AZIMUTH: 0°

DRILLING CONTRACTOR: Val's Drilling Ltd.

FR-FRACTURE F-FAULT SM-SMOOTH FL-FLEXURED BC-BROKEN CORE
C-CONCH.FRACT. J-JOINT R-ROUGH U-UNDULATING MB-MECH. BREAK
SH-SHEAR P-POLISHED ST-STEPPED W-WAVY B-BEDDING
VN-VEIN K-SLICKENSIDED PL-PLANAR C-CURVED CH-CHLORITIZED

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	PENETRATION RATE (m/hr)	COLOUR % RETURN / FLUSH	RECOVERY TOTAL CORE %	RECOVERY SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 1.5m	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS (0, 30, 60, 90)	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	ROCK STRENGTH INDEX	WEATH-ERING INDEX	COMMENTS/SAMPLE No
					10			100		63				R3-R4	W1-W2	Slotted Section/ Sand
		End of DRILLHOLE.		18.59												

NOTES:
1. Groundwater measured at 3.5 mbgs at completion of drilling.
2. Groundwater measured at 4.42 mbgs after standpipe installation July 28, 2015.
3. Standpipe installed by Millenium EMS Solutions Ltd. at completion of drilling
4. Standpipe installed at shallower depth in adjacent borehole PZ15-02b.

19
20
21
22
23
24
25

DRILLHOLE - NO GRAPHICS FOR RECOVERY 1416422_BENGA - RIVERSDALE_ROCK CORE DRILLING - 20160111.GPJ CALGARY.GDT 01/11/16

DEPTH SCALE
1 : 37.5

Golder Associates

LOGGED: AK
CHECKED: RA

DATA ENTRY: CC

PROJECT No.: 1406422

LOCATION: See Location Plan

N: 5504244 E: 684914

RECORD OF BOREHOLE: PZ15-02b

BORING DATE: July 28, 2015

Riversdale Resources Limited

SHEET 1 OF 2

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									Stick-up=/0.81 m
0	Mobile Rig, 154 mm Solid Stem Auger Val's Drilling	Borehole drilled for piezometer installation. Not logged.		0.00							Cuttings
1											
2											
3											Bentonite
4											
5											
6											Sand
7											Slotted Section/ Sand
		CONTINUED NEXT PAGE									

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

DATA ENTRY: CC

PROJECT No.: 1406422

RECORD OF BOREHOLE: PZ15-02b

SHEET 2 OF 2

LOCATION: See Location Plan

BORING DATE: July 28, 2015

DATUM: UTM Zone 11 (Nad 83)

N: 5504244 E: 684914

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
8	Mobile Rig, 154 mm Solid Stem Auger, Val's Drilling	Borehole drilled for piezometer installation. Not logged. *(continued)*									Slotted Section/ Sand 28/07/2015 ▽
9		End of BOREHOLE.		9.14							
10		NOTES: 1. See PZ15-02a for stratigraphy. 2. Standpipe installed by Millenium EMS Solutions Ltd. 3. Groundwater measured at 9.0 mbgs after standpipe installation July 28, 2015. 4. Borehole located within 2 m of PZ15-02a.									
11											
12											
13											
14											
15											

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: AK

CHECKED: RA

BOREHOLE - EXPANDED ADD. LAB TESTING 1406422_BENGA - RIVERSDALE_BOREHOLE_20160111.GPJ CALGARY.GDT 01/11/16

APPENDIX C

Test Pit Records

DATA ENTRY: MD

PROJECT No.: 1406422

RECORD OF HAND AUGER: TP15-01 (HA)

SHEET 1 OF 1

LOCATION: See Location Plan

N: 5509548 E: 684744

EXCAVATION DATE: November 07, 2015

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface											
	Ø 50 mm Hand Auger Riversdale Staff	(OL) ORGANIC SILT, trace topsoil/rootlets.		0.00									
		(SM) SILTY SAND, some gravel with cobbles/boulders.		0.10	1	HA							
		End of HAND AUGER.		0.50									
1		NOTES: Hand auger hole could not be advanced due to presence of boulders/bedrock.											
2													
3													
4													
5													
6													
7													

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: DL/HM

CHECKED: RA

TESTPIT - EXP ADD LAB TESTING 1406422_BENGA - RIVERSDALE_WASTEDUMP_TESTPITS_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: MD

PROJECT No.: 1406422

RECORD OF TEST PIT: TP15-01A

SHEET 1 OF 1

LOCATION: See Location Plan

N: 5509322 E: 684704

EXCAVATION DATE: November 05, 2015

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	John Deere 160C / Diggers Bobcat Service Ltd.	(SM) SILTY SAND, trace organics, grass, trace rootlets.		0.02							
		(SM) gravelly SILTY SAND, fine grained sand, with cobbles and boulders; brown; non-cohesive, moist to wet.									
1											
2											
3					1	GS			○		
		--- Becoming wet at 3.6 m.									
4											
		End of TEST PIT.		4.70							
5		NOTES: Test pit terminated at 4.7 mbgs. Backfilled in layers with excavated soils.									
6											
7											

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: DL/HM

CHECKED: RA

TESTPIT - EXP ADD LAB TESTING 1406422_BENGA - RIVERSDALE_WASTEDUMP_TESTPITS_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: MD

PROJECT No.: 1406422

RECORD OF TEST PIT: TP15-02

SHEET 1 OF 1

LOCATION: See Location Plan

N: 5509670 E: 685585

EXCAVATION DATE: November 06, 2015

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface											
0	John Deere 160C Diggers Bobcat Service Ltd.	(SM) SILTY SAND, trace organics, some gravel, with cobbles, trace roots; brown.		0.00									
		(SM) gravelly SILTY SAND,fine grained sand, with cobbles and boulders up to 0.6 m; brown; non-cohesive, moist to wet, compact.		0.20									
1					1	GS						Gravel=16% Sand=62% Fines=22%	
2													
3		--- very weak, black SANDSTONE boulders at 3.0 to 3.8 m.			2	GS							
4		--- becoming wet at 4.5 m											
5		End of TEST PIT.		5.00									
		NOTES: Test pit terminated at 5.0 mbgs. Backfilled in layers.											
6													
7													

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: HM

CHECKED: RA

TESTPIT - EXP ADD LAB TESTING 1406422_BENGA - RIVERSDALE_WASTEDUMP_TESTPITS_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: MD

PROJECT No.: 1406422

RECORD OF TEST PIT: TP15-04

SHEET 1 OF 1

LOCATION: See Location Plan

N: 5509110 E: 684624

EXCAVATION DATE: November 04, 2015

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. + Q - ●, rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface											
0	John Deere 160C Diggers Bobcat Service Ltd.	(OL) ORGANIC SILT, trace rootlets, loose.		0.00									
		(SM) SILTY SAND, trace gravel, cobbles/boulders up to 0.6 m; brown; non-cohesive, loose to compact.		0.20									
1													
2		(ML) sandy clayey SILT, low plasticity, trace gravel; brown; cohesive, moist to wet, firm.		1.60									
3													
		--- Becoming wet at 3.7 m			1	GS					W		
4													
5		(CL) sandy SILTY CLAY, low plasticity; olive grey; cohesive, stiff.		4.90	2	GS							
		End of TEST PIT.		5.30									
		NOTES: Test pit terminated at 5.3 mbgs. Backfilled in layers.											
6													
7													

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: DL/HM

CHECKED: RA

TESTPIT - EXP ADD LAB TESTING 1406422_BENGA - RIVERSDALE_WASTEDUMP_TESTPITS_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: MD

PROJECT No.: 1406422

RECORD OF TEST PIT: TP15-05

SHEET 1 OF 1

LOCATION: See Location Plan

N: 5508686 E: 684612

EXCAVATION DATE: November 05, 2015

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	John Deere 160C Diggers Bobcat Service Ltd.	(OL) sandy ORGANIC SILT, trace rootlets, trace organics, some cobbles; dark grey; loose.		0.00							
		--- Topsoil at 0.5~0.6 m									
		(SM) gravelly SAND, trace fines; brown; non-cohesive, moist.		0.60							
1											
2											
					1	GS			○		
		--- some fines, becoming wet at 2.9 m									
3											
4		--- coarse-grained sand.									
					2	GS					
		End of TEST PIT.		4.70							
5		NOTES: Test pit terminated at 4.7 mbgs. Backfilled in layers.									
6											
7											

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: DL/HM

CHECKED: RA

TESTPIT - EXP ADD LAB TESTING 1406422_BENGA - RIVERSDALE_WASTEDUMP_TESTPITS_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: MD

PROJECT No.: 1406422

RECORD OF TEST PIT: TP15-06

SHEET 1 OF 1

LOCATION: See Location Plan

N: 5508645 E: 685531

EXCAVATION DATE: November 05, 2015

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface											
0		(OL) ORGANIC SILT, trace rootlets; dark grey; loose.		0.00									
		(SP) gravelly SAND, trace fines, with boulders/cobbles up to 0.4 m size; brown; non-cohesive, moist, loose to compact.		0.20									
1													
2													
3		--- Becoming wet at 3.5 m			1	GS					○		
4													
5		End of TEST PIT.		5.00									
6		NOTES: Test pit terminated at 5.0 mbgs. Backfilled in layers.											
7													

John Deere 160C
Diggers Bobcat Service Ltd.

DEPTH SCALE
1 : 37.5

Golder Associates

LOGGED: HM

CHECKED: RA

TESTPIT - EXP ADD LAB TESTING 1406422_BENGA - RIVERSDALE_WASTEDUMP_TESTPITS_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: MD

PROJECT No.: 1406422

RECORD OF TEST PIT: TP15-07

SHEET 1 OF 1

LOCATION: See Location Plan

N: 5508405 E: 684624

EXCAVATION DATE: November 05, 2015

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	John Deere 160C Diggers Bobcat Service Ltd.	(OL) ORGANIC SILT, trace rootlets; loose.		0.00							
		(ML) sandy clayey SILT, some gravel, with boulders, cobbles; olive grey; low plasticity, moist.		0.15							
1		(Cl-CL) SILTY CLAY, low to medium plasticity, some sand, trace gravel, with boulders, cobbles; olive grey; cohesive, moist.		1.00							
2											
3		--- Becoming wet, sandy at 3.3 m			1	GS					
4											
5		End of TEST PIT.		5.00							
		NOTES: Test pit terminated at 5.0 mbgs. Backfilled in layers.									
6											
7											

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: DL/HM

CHECKED: RA

TESTPIT - EXP ADD LAB TESTING 1406422_BENGA - RIVERSDALE_WASTEDUMP_TESTPITS_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: MD

PROJECT No.: 1406422

RECORD OF TEST PIT: TP15-08

SHEET 1 OF 1

LOCATION: See Location Plan

N: 5508303 E: 684488

EXCAVATION DATE: November 05, 2015

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface									
0	John Deere 160C Diggers Bobcat Service Ltd.	(OL) ORGANIC SILT, some fine-grained sand, trace roots; dark grey; moist, soft.		0.00							
		(SM) SILTY SAND, some gravel, with cobbles/boulders; brown; compact to dense.		0.20							
1		(SP-GP) SAND and GRAVEL, fine grained sand, sub-rounded gravel, poorly graded, with cobbles/boulders; brown; non-cohesive, moist.		1.00							
2		(CL) SILTY CLAY, some sand, trace gravel, with cobbles and boulders; brown; cohesive, moist, stiff.		2.00							
		--- less cobbly from 2.6 m			1	GS					
3		(SP) gravelly SAND, trace fines; brown; wet, dense.		3.30	2	GS			○		
		(CL) SILTY CLAY, some sand, some cobbles, trace gravel; grey; cohesive, moist.		3.70							
4											
5		End of TEST PIT.		5.00							
		NOTES: Test pit terminated at 5.0 mbgs. Backfilled in layers.									
6											
7											

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: DL/HM

CHECKED: RA

TESTPIT - EXP ADD LAB TESTING 1406422_BENGA - RIVERSDALE_WASTEDUMP_TESTPITS_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: MD

PROJECT No.: 1406422

RECORD OF TEST PIT: TP15-09

SHEET 1 OF 1

LOCATION: See Location Plan

N: 5505343 E: 686257

EXCAVATION DATE: November 07, 2015

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface						SHEAR STRENGTH Cu, kPa: nat V. + Q - ●; rem V. ⊕ U - ○ (20 40 60 80)	WATER CONTENT PERCENT: Wp — W — Wl (10 20 30 40)		
0		(OL) ORGANIC SILT, trace roots, vegetation/grass.		0.00							
		(SM) SILTY SAND, some gravel to gravelly, occasional cobbles/ boulders up to 0.6 m; grey to brown.		0.20							
1											
		--- some fines at 1.8 m to 2.0 m									
2	John Deere 160C Diggers Bobcat Service Ltd.										
3					1	GS					
4		--- becoming brown at 4.5 m			2	GS					
5		End of TEST PIT.		5.00							
		NOTES: Test pit terminated at 5.0 mbgs. Backfilled in layers. No seepage observed.									
6											
7											

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: HM

CHECKED: RA

TESTPIT - EXP ADD LAB TESTING 1406422_BENGA - RIVERSDALE_WASTEDUMP_TESTPITS_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: MD

PROJECT No.: 1406422

RECORD OF TEST PIT: TP15-10

SHEET 1 OF 1

LOCATION: See Location Plan

N: 5505018 E: 686109

EXCAVATION DATE: November 07, 2015

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface											
0	John Deere 160C Diggers Bobcat Service Ltd.	(OL) ORGANIC SILT, grass, trace rootlets.		0.00									
		(SM) SILTY SAND, some gravel, occasional cobbles; brown; moist, loose to compact.		0.15									
1													
2		(SP-GP) SAND and GRAVEL, trace cobbles, some fines; dark grey; moist to wet, compact to dense.		2.00									
3													
4		--- some fines, wet at 4.0 m.			1	GS					○		
5													
		End of TEST PIT.		5.10									
6		NOTES: Test pit terminated at 5.1 mbgs. Backfilled in layers. No seepage observed.											
7													

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: HM

CHECKED: RA

TESTPIT - EXP ADD LAB TESTING 1406422_BENGA - RIVERSDALE_WASTEDUMP_TESTPITS_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: MD

PROJECT No.: 1406422

RECORD OF TEST PIT: TP15-11

SHEET 1 OF 1

LOCATION: See Location Plan

N: 5504323 E: 685892

EXCAVATION DATE: November 07, 2015

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface											
0	John Deere 160C Diggers Bobcat Service Ltd.	(OL) ORGANIC SILT, trace topsoil, trace rootlets, grass, loose.		0.00									
		(ML) SANDY SILT, trace gravel; brown; non-cohesive, loose to compact.		0.20									
1													
		(CL) SILTY CLAY, low plasticity, some gravel, occasional boulders/cobbles; brown; cohesive, firm to stiff.		1.50									
2													
3													
					1	GS							
4		-- becoming dark grey; stiff at 4.0 m.											
					2	GS							
5		End of TEST PIT.		5.00									
		NOTES: Test pit terminated at 5.0 mbgs. Backfilled in layers.											
6													
7													

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: HM

CHECKED: RA

TESTPIT - EXP ADD LAB TESTING 1406422_BENGA - RIVERSDALE_WASTEDUMP_TESTPITS_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: MD

PROJECT No.: 1406422

RECORD OF HAND AUGER: TP15-14 (HA)

SHEET 1 OF 1

LOCATION: See Location Plan

N: 5503226 E: 686722

EXCAVATION DATE: November 07, 2015

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface											
	Ø 50 mm Hand Auger Riverstale Staff	(OL) ORGANIC SILT, trace topsoil, rootlets.		0.00	1	HA							
		End of HAND AUGER.		0.37									
1		NOTES: Terminated at 0.37 m. Hand auger hole could not be advanced due to presence of boulders/bedrock.											
2													
3													
4													
5													
6													
7													

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: DL/HM

CHECKED: RA

TESTPIT - EXP ADD LAB TESTING 1406422_BENGA - RIVERSDALE_WASTEDUMP_TESTPITS_20160111.GPJ CALGARY.GDT 01/11/16

DATA ENTRY: MD

PROJECT No.: 1406422

RECORD OF HAND AUGER: TP15-15 (HA)

SHEET 1 OF 1

LOCATION: See Location Plan

N: 5508292 E: 684544

EXCAVATION DATE: November 07, 2015

DATUM: UTM Zone 11 (Nad 83)

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp — W — Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface											
	Ø 50 mm Hand Auger Riversdale Staff	(OL) ORGANIC SILT, trace rootlets; brown.		0.05	1	HA							
		(SM) SILTY SAND, trace clay, some gravel; brown; loose.											
		End of HAND AUGER.		0.43									
1		NOTES: Terminated at 0.43 m. Hand auger hole could not be advanced due to presence of boulders/bedrock.											
2													
3													
4													
5													
6													
7													

TESTPIT - EXP ADD LAB TESTING 1406422_BENGA - RIVERSDALE_WASTEDUMP_TESTPITS_20160111.GPJ CALGARY.GDT 01/11/16

DEPTH SCALE

1 : 37.5

Golder Associates

LOGGED: DL/HM

CHECKED: RA

APPENDIX D

Laboratory Testing Results

Golder Associates

General Lab Testing Summary

Project No.: 1406422
Short Title: Benga/FeasibilityStudy/AB
Tested By: DS

Phase: -
Sched: B580
Date: 13-Aug-15

Sample Identification					Laboratory Test Results					
Borehole No.	Sample No.	Depth (m) from	Depth (m) to	Lab No.	Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	SPMDD (kg/m^3)	Optimum w (%)
BH15-05	AS1	0.00	1.52	B580-01						
	SS1	1.52	1.98	B580-02	25.8					
	SS2	3.05	3.51	B580-03	20.3					
BH15-06	SS1	1.52	1.98	B580-04	6.2					
BH15-07	SS1	1.52	1.98	B580-05						
	SS2	3.05	3.51	B580-06						
	AS1	3.51	4.57	B580-07						
	SS3	4.57	5.03	B580-08						
	SS4	6.10	6.55	B580-09						
	SS5A	7.62	7.77	B580-10	7.3					
	SS5B	7.77	8.08	B580-11	4.7					
	SS6	8.23	8.48	B580-12	5.3	29	16	13		
BH15-08	SS1	1.52	1.98	B580-13	12.6					
	SS2	3.05	3.51	B580-14	9.6					
	SS3	3.96	3.99	B580-15	12.6					
BH15-09	SS1	1.52	1.98	B580-16	12.4					
	SS2	3.05	3.51	B580-17	7.6					
	SS3	4.57	5.03	B580-18	11.5					
	SS4	6.10	6.55	B580-19	12.3					
	SS5	7.62	7.87	B580-20	17.1					
	AS1	7.87	9.14	B580-21						
	SS6	9.14	9.37	B580-22	19.5					
	SS7	10.67	10.72	B580-23	19.0					
BH15-10	SS1	1.52	1.98	B580-24	10.6					
	SS2	3.05	3.51	B580-25	13.2					
	SS3	4.57	5.03	B580-26						
	AS1	5.03	6.10	B580-27	12.9					
	SS4	6.10	6.55	B580-28						
	SS5	7.62	7.90	B580-29						
	SS6	9.14	9.27	B580-30	12.9					
	SS7	10.67	10.74	B580-31						

Reviewed By: _____

Golder Associates

General Lab Testing Summary

Project No.: 1406422
Short Title: Benga/FeasibilityStudy/AB
Tested By: DS

Phase: -
Sched: B580
Date: 13-Aug-15

Sample Identification					Laboratory Test Results					
Borehole No.	Sample No.	Depth (m)		Lab No.	Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	SPMDD (kg/m^3)	Optimum w (%)
		from	to							
BH15-11	SS1	1.52	1.63	B580-32	4.2					
	SS2	3.05	3.51	B580-33						
BH15-12	AS1	0.00	0.30	B580-34	5.5					
BH15-13	SS1	1.52	1.98	B580-35	6.4					
	SS2A	3.05	3.20	B580-36						
	SS2B	3.20	3.28	B580-37						
	SS3	4.57	4.70	B580-38	6.3					
BH15-14	SS1	1.52	1.92	B580-39	4.7	28	16	12		
BH15-16	SS1	1.52	1.98	B580-40						
	SS2	3.05	3.51	B580-41	4.4					
	SS3	4.57	5.03	B580-42	6.1					
	SS4	6.10	6.55	B580-43	10.1					
	SS5	7.62	8.08	B580-44	6.2					
	SS6	9.14	9.60	B580-45	7.1					
	SS7	10.67	11.13	B580-46	4.3					
	SS8	12.19	12.65	B580-47	10.1					
	SS9	13.72	14.17	B580-48						
	SS10	15.24	15.44	B580-49	6.8					
BH15-17	SS1	0.00	0.43	B580-50	6.9					
BH15-18	AS1	0.00	0.30	B580-51	9.5					
BH15-19	AS1	0.00	0.15	B580-52	9.8					
BH15-20	AS1	0.00	0.15	B580-53	6.9					
BH15-21	SS1	1.52	1.98	B580-54	19.1					
	SS2	3.05	3.51	B580-55						
	AS1	3.51	4.57	B580-56	15.1					
	SS3	4.57	5.03	B580-57						
	SS4	6.10	6.55	B580-58	10.7					
	SS5	7.01	7.04	B580-59						

Reviewed By: _____

Golder Associates

General Lab Testing Summary

Project No.: 1406422
Short Title: Benga/FeasibilityStudy/AB
Tested By: DS

Phase: -
Sched: B580
Date: 13-Aug-15

Sample Identification					Laboratory Test Results					
Borehole No.	Sample No.	Depth (m)		Lab No.	Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	SPMDD (kg/m^3)	Optimum w (%)
		from	to							
BH15-22	SS1	1.52	1.98	B580-60						
	SS2	3.05	3.51	B580-61						
	SS3	4.57	5.03	B580-62	16.8					
	SS4	6.10	6.55	B580-63	16.1	34	17	17		
	SS5	7.62	8.08	B580-64	14.8	41	17	24		
	SS6	8.84	9.02	B580-65	14.2					
BH15-23	SS1	1.52	1.98	B580-66						
	SS2	3.05	3.51	B580-67	6.5					
	SS3	4.57	5.03	B580-68	8.5					
	SS4	6.10	6.55	B580-69						
	SS5	7.62	8.08	B580-70	10.3					
	SS6	9.14	9.60	B580-71	8.5	31	15	16		
	SS7	10.67	11.13	B580-72	10.0					
BH15-24	SS1	0.00	0.46	B580-73	8.3					
BH15-25	SS1	1.52	1.98	B580-74	5.9					
	SS2	3.05	3.51	B580-75						
	SS3	4.57	5.03	B580-76	6.9					
	AS1	5.03	6.10	B580-77	18.5	62	21	41		
	SS4	6.10	6.55	B580-78	11.0					
	SS5	7.62	8.08	B580-79	13.3					
	SS6	9.14	9.60	B580-80	12.5					
	SS7	10.67	10.81	B580-81	15.1	27	17	10		
	SS8	12.19	12.22	B580-82	14.4					
BH15-26	SS1	1.52	1.98	B580-83	11.8					
	SS2	3.05	3.51	B580-84	9.1					
	SS3A	4.57	4.63	B580-85						
	SS3B	4.63	4.72	B580-86						
	SS4	6.10	6.38	B580-87	8.1					
	SS5	7.62	7.72	B580-88						
	SS6	9.14	9.24	B580-89	3.9					
BH15-28	SS1	1.52	1.57	B580-90	5.9					
P215-02	SS1	1.52	1.73	B580-91	8.5					

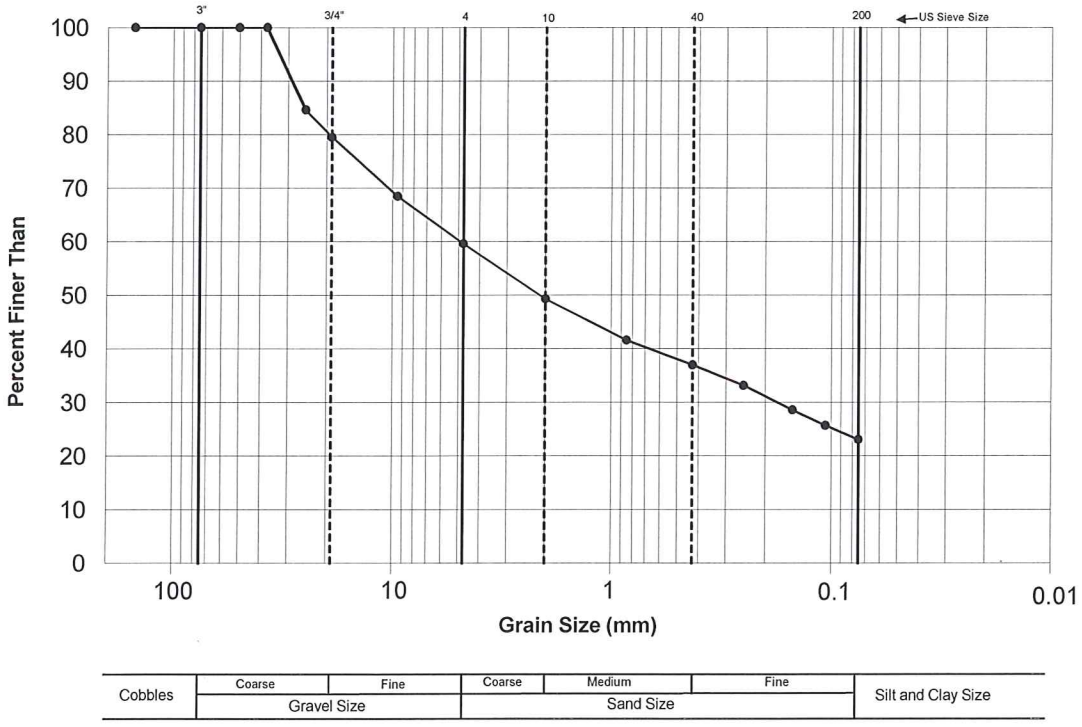
Reviewed By: _____

Particle Size Distribution of Soils using Sieve Analysis

(ASTM D6913-04)

Project No.:	1406422	Phase:	-		Date:	13-Aug-15
Short Title:	Benga/FeasibilityStudy/AB					
Sub Sampled By:	DS	Washed By:	DS		Sieved By:	CL
Field Tag No.:	-	Location:	-		BH or TP No.:	BH15-05
Lab No.:	B580-02 & 03	Northing:	-	m	Sample No.:	SS1 & SS2
Sampled By:	AK	Easting:	-	m	Depth From:	1.52 m
Sample Date:	25-Jul-15	Elevation:	-	m	Depth To:	3.51 m

Test Method:	A	Drying Method:	Oven	
Composite Sieve:	Yes	if Yes, Split on:	4.75	mm
Material Exluded from Sieve:	No	Describe:		
Prior Testing on Sample:	No	Describe:		



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25	85
19	80
9.5	69
4.75	60
2	49
0.85	42
0.425	37
0.25	33
0.15	29
0.106	26
0.075	23

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
23.1	0	40	37	23	4.9	0.2	N/A	N/A	N/A

Sample Description: (GC) CLAYEY GRAVEL and fine to coarse SAND, fine to coarse sub-angular gravel; brown; cohesive, w<PL

USCS Classification: GC

Remarks:

The testing services reported herein have been performed in accordance with the indicated recognized standard, or in accordance with local industry practice. This report is for the sole use of the designated client. This report constitutes a testing service only and does not represent any results interpretation or opinion regarding specification compliance or material suitability. Engineering interpretation can be provided by Golder Associates Ltd. upon request.

Bay 8, 820 - 28 St. NE
Calgary, AB T2A 6K1

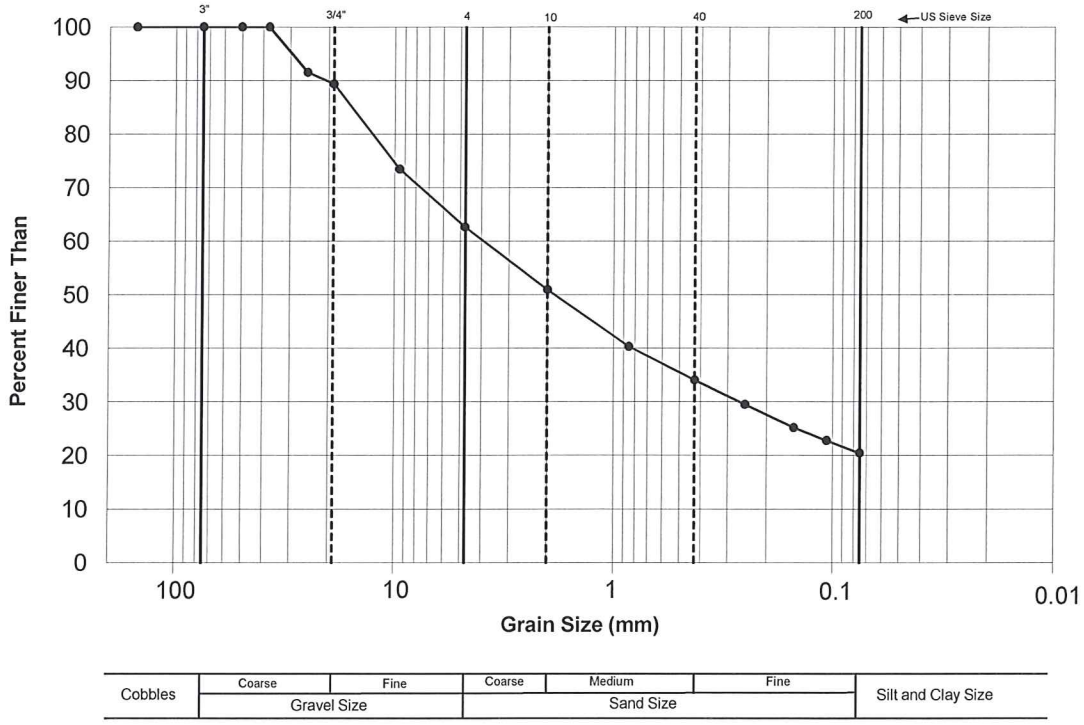
Reviewed by: _____

Particle Size Distribution of Soils using Sieve Analysis

(ASTM D6913-04)

Project No.:	1406422	Phase:	-		Date:	13-Aug-15
Short Title:	Benga/FeasibilityStudy/AB					
Sub Sampled By:	DS	Washed By:	-		Sieved By:	CL
Field Tag No.:	-	Location:	-		BH or TP No.:	BH15-06
Lab No.:	B580-04	Northing:	-	m	Sample No.:	SS1
Sampled By:	AK	Easting:	-	m	Depth From:	1.52 m
Sample Date:	25-Jul-15	Elevation:	-	m	Depth To:	1.98 m

Test Method:	A	Drying Method:	Oven	
Composite Sieve:	Yes	if Yes, Split on:	4.75	mm
Material Exluded from Sieve:	No	Describe:		
Prior Testing on Sample:	No	Describe:		



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25	92
19	89
9.5	73
4.75	63
2	51
0.85	40
0.425	34
0.25	30
0.15	25
0.106	23
0.075	20

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
6.2	0	37	42	20	4.1	0.3	N/A	N/A	N/A

Sample Description: (SC) gravelly CLAYEY SAND and GRAVEL, fine to coarse sand, fine to coarse gravel; brown; cohesive, w<PL

USCS Classification: SC

Remarks:

The testing services reported herein have been performed in accordance with the indicated recognized standard, or in accordance with local industry practice. This report is for the sole use of the designated client. This report constitutes a testing service only and does not represent any results interpretation or opinion regarding specification compliance or material suitability. Engineering interpretation can be provided by Golder Associates Ltd. upon request.

Bay 8, 820 - 28 St. NE
Calgary, AB T2A 6K1

Reviewed by: _____

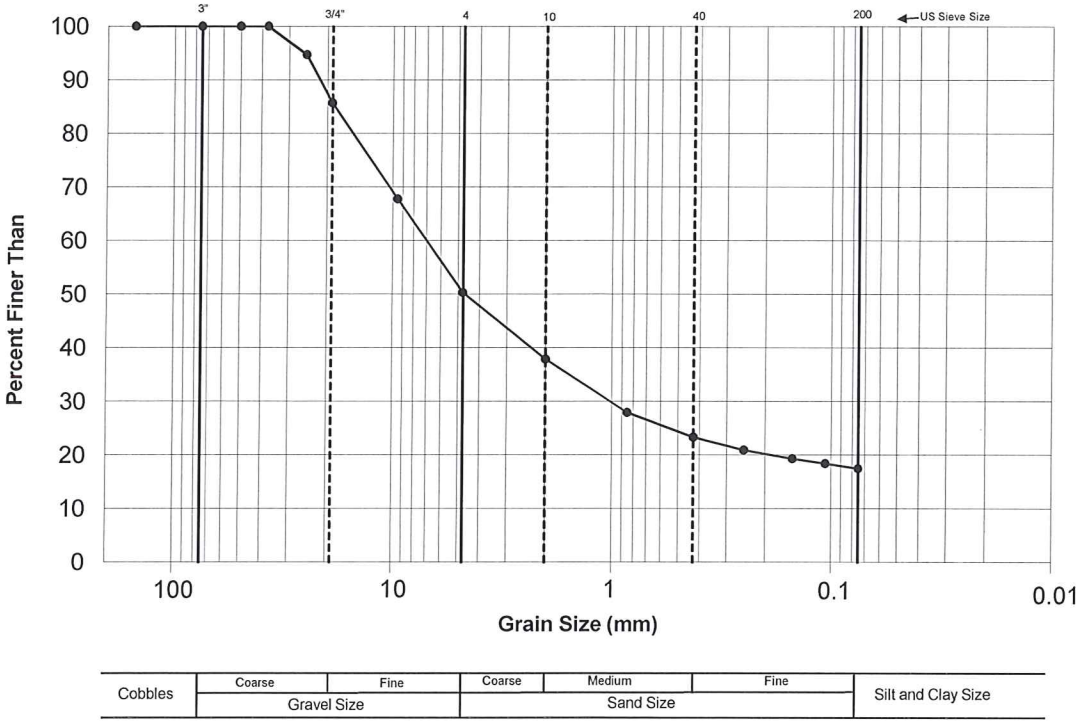
Golder Associates

Particle Size Distribution of Soils using Sieve Analysis

(ASTM D6913-04)

Project No.:	1406422	Phase:	-		Date:	13-Aug-15
Short Title:	Benga/FeasibilityStudy/AB					
Sub Sampled By:	DS	Washed By:	-		Sieved By:	CL
Field Tag No.:	-	Location:	-		BH or TP No.:	BH15-07
Lab No.:	B580-11	Northing:	-	m	Sample No.:	SS5B
Sampled By:	AK	Easting:	-	m	Depth From:	7.77 m
Sample Date:	24-Jul-15	Elevation:	-	m	Depth To:	8.08 m

Test Method:	A	Drying Method:	Oven	
Composite Sieve:	Yes	if Yes, Split on:	4.75	mm
Material Exluded from Sieve:	No	Describe:		
Prior Testing on Sample:	No	Describe:		



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25	95
19	86
9.5	68
4.75	50
2	38
0.85	28
0.425	23
0.25	21
0.15	19
0.106	18
0.075	17

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
4.7	0	50	33	17	7.4	1.1	N/A	N/A	N/A

Sample Description: (GC) sandy CLAYEY GRAVEL, fine to coarse angular gravel, medium to coarse sand, some fine sand; brown; cohesive, w<PL

USCS Classification: GC

Remarks:

The testing services reported herein have been performed in accordance with the indicated recognized standard, or in accordance with local industry practice. This report is for the sole use of the designated client. This report constitutes a testing service only and does not represent any results interpretation or opinion regarding specification compliance or material suitability. Engineering interpretation can be provided by Golder Associates Ltd. upon request.

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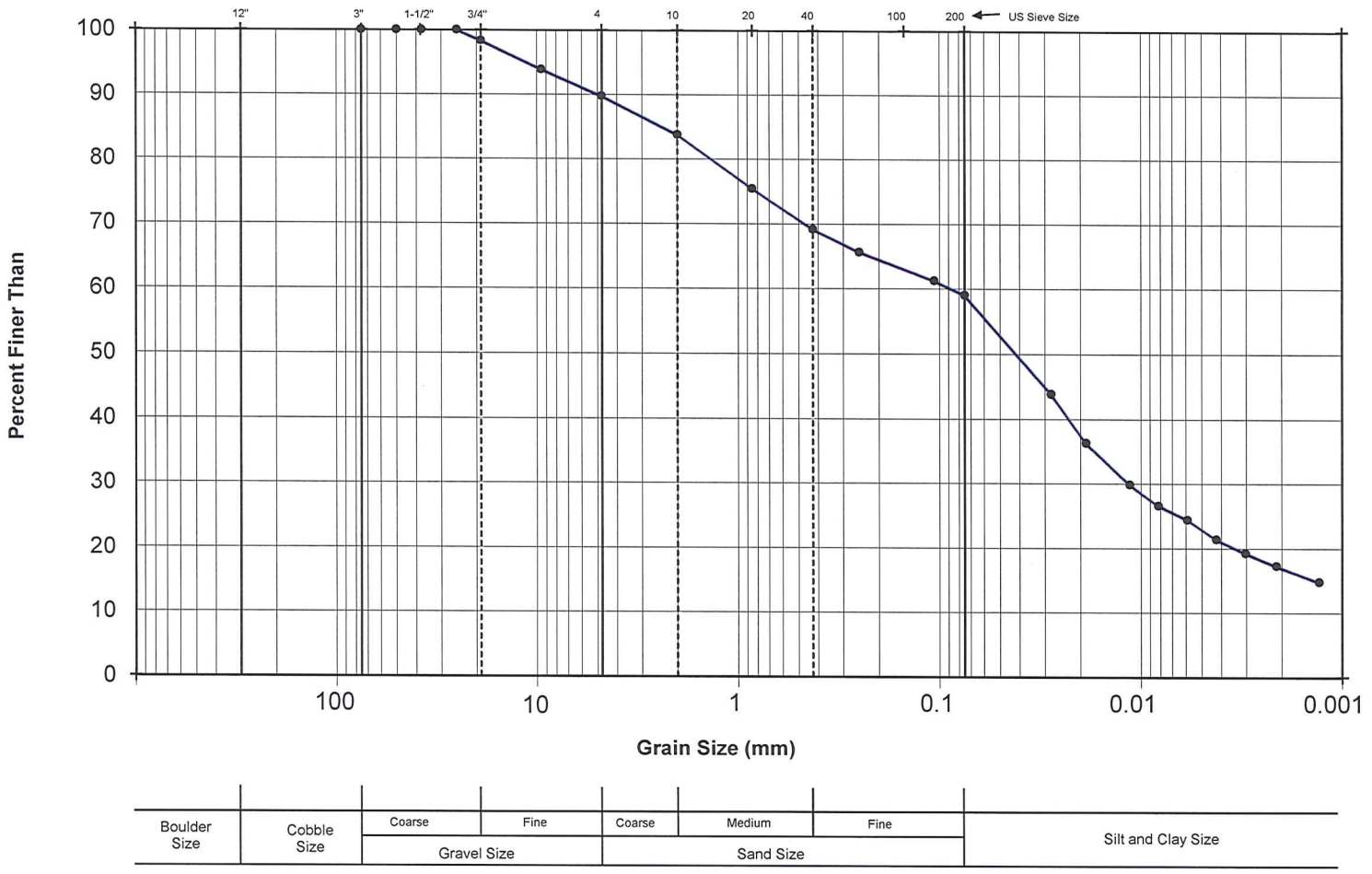
Calgary, AB T2A 6K1

Reviewed by: _____

Golder Associates

Particle Size Analysis of Soil
(ASTM D422)

Project No.:	1406422	Lab No.:	B580-12
Project Title:	Benga/FeasibilityStudy/AB		
Borehole:	BH15-07	Sample No.:	SS6
Depth:	8.23 - 8.48 m		
Date Tested:	13-Aug-15	By:	DS



Diameter of Sieve (mm)	Percent Passing (%)
75.0	100.0
50.0	100.0
37.5	100.0
25.0	100.0
19.0	98.3
9.5	93.9
4.75	89.8
2.0	83.8
0.850	75.5
0.425	69.2
0.250	65.7
0.106	61.3
0.075	59.1
0.028	43.9
0.019	36.4
0.011	29.9
0.008	26.7
0.006	24.5
0.004	21.5
0.003	19.3
0.002	17.3
0.001	14.8

Comments:

Reviewed:

Golder Associates

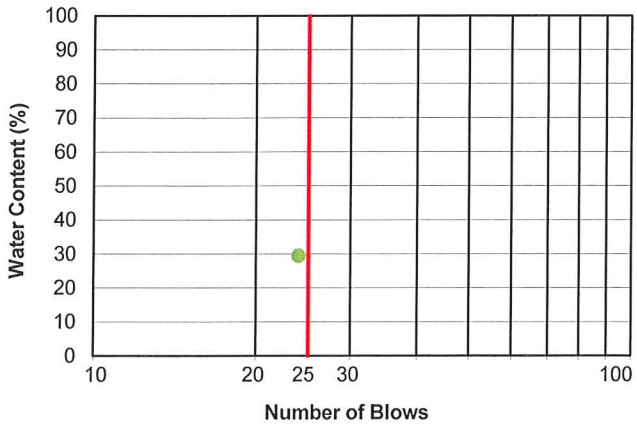
Atterberg Limits (ASTM D 4318)

Project No.:	1406422	Phase:	-
Short Title:	Benga/FeasibilityStudy/AB	Lab No.:	B580-12
Tested By:	DS	Date:	13-Aug-15

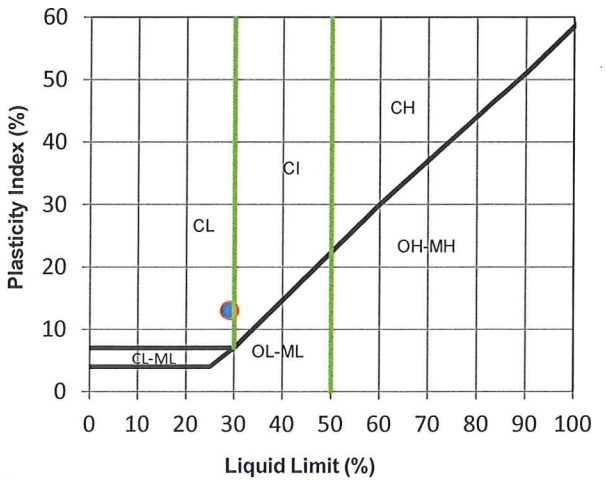
Borehole: BH15-07 Sample No.: SS6 Depth: 8.23-8.48 m

Liquid Limit Determination:			Natural Water Content:		
Number of Blows	24	24	As Received Water Content (%)		5.3%
Blow Correction Factor	1.00	1.00	**Plastic Limit Determination:**		
Mass of wet sample + tare (g)	42.80	37.02	Mass of wet sample + tare (g)	19.40	18.41
Mass of dry sample + tare (g)	39.71	33.75	Mass of dry sample + tare (g)	18.25	17.39
Mass of tare (g)	29.20	22.64	Mass of tare (g)	10.86	10.82
Weight of Water (g)	3.09	3.27	Weight of Water (g)	1.15	1.02
Weight of dry soil (g)	10.51	11.11	Weight of dry soil (g)	7.39	6.57
Water Content (%)	29.4	29.4	Water Content (%)	15.56	15.53
Liquid Limit	29.0	29.0	Average Water Content (%)		15.54

Liquid Limit Test



Plasticity chart for soil passing 425 µm sieve



Liquid Limit =	29	%
Plastic Limit =	16	%
Plasticity Index =	13	

Comments:

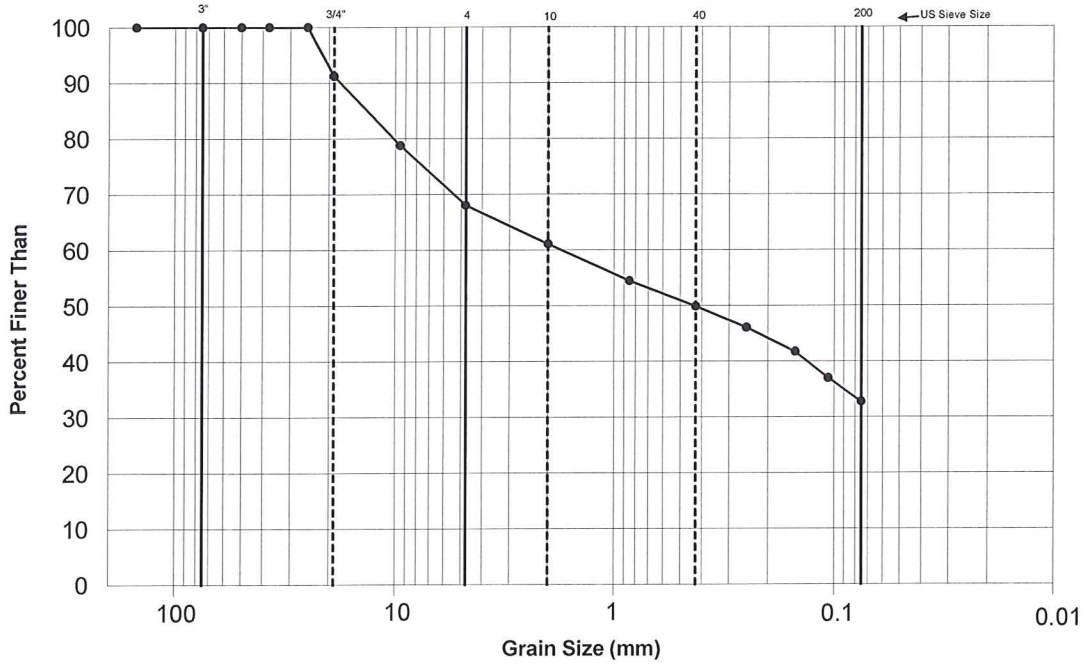
Reviewed:

Particle Size Distribution of Soils using Sieve Analysis

(ASTM D6913-04)

Project No.:	1406422	Phase:	-		Date:	13-Aug-15
Short Title:	Benga/FeasibilityStudy/AB					
Sub Sampled By:	DS	Washed By:	CG		Sieved By:	CL
Field Tag No.:	-	Location:	-		BH or TP No.:	BH15-08
Lab No.:	B580-13&14	Northing:	-	m	Sample No.:	SS1&SS2
Sampled By:	Alex Kaul	Easting:	-	m	Depth From:	1.52 m
Sample Date:	20-Jul-15	Elevation:	-	m	Depth To:	3.51 m

Test Method:	A	Drying Method:	Oven	
Composite Sieve:	Yes	if Yes, Split on:	4.75	mm
Material Exluded from Sieve:	No	Describe:		
Prior Testing on Sample:	No	Describe:		



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25	100
19	91
9.5	79
4.75	68
2	61
0.85	55
0.425	50
0.25	46
0.15	42
0.106	37
0.075	33

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
11.1	0	32	35	33	1.8	N/A	N/A	N/A	N/A

Sample Description: (SC) gravelly CLAYEY SAND, fine to coarse sand, fine sub-angular gravel, some coarse sub-angular gravel; dark brown; cohesive, w > PL

USCS Classification: SC

Remarks:

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Bay 8, 820 - 28 St. NE
Calgary, AB T2A 6K1

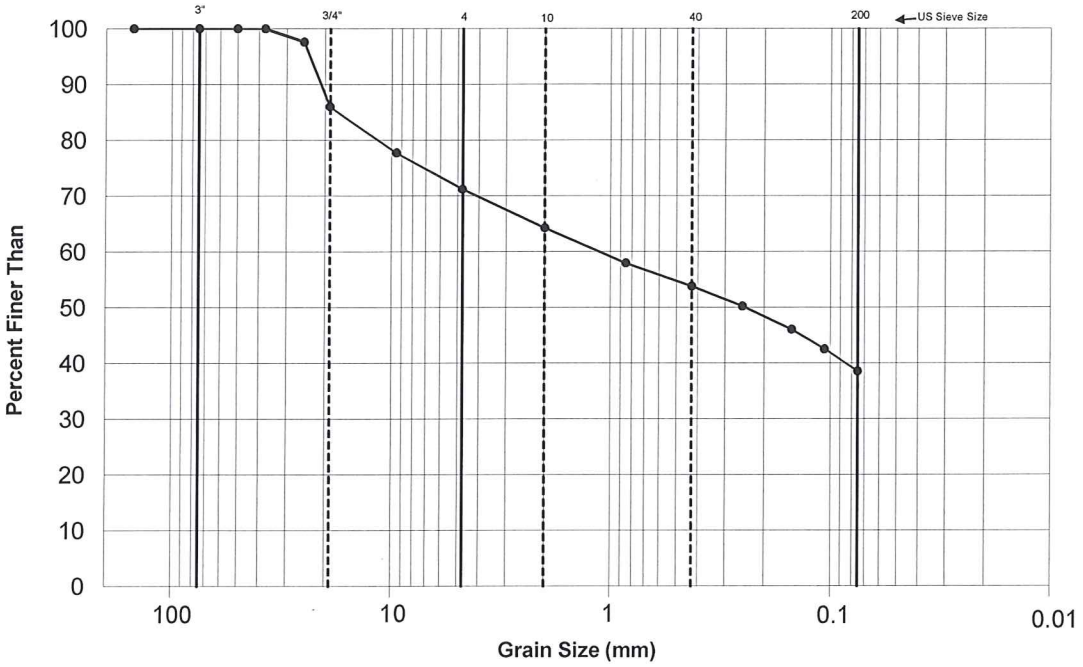
Reviewed by: _____

Particle Size Distribution of Soils using Sieve Analysis

(ASTM D6913-04)

Project No.:	1406422	Phase:	-		Date:	13-Aug-15
Short Title:	Benga/FeasibilityStudy/AB					
Sub Sampled By:	DS	Washed By:	CG		Sieved By:	CL
Field Tag No.:	-	Location:	-		BH or TP No.:	BH15-09
Lab No.:	B580-16&17	Northing:	-	m	Sample No.:	SS1&SS2
Sampled By:	Alex Kaul	Easting:	-	m	Depth From:	1.52 m
Sample Date:	21-Jul-15	Elevation:	-	m	Depth To:	3.51 m

Test Method:	A	Drying Method:	Oven	
Composite Sieve:	Yes	if Yes, Split on:	4.75	mm
Material Exluded from Sieve:	No	Describe:		
Prior Testing on Sample:	No	Describe:		



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25	98
19	86
9.5	78
4.75	71
2	64
0.85	58
0.425	54
0.25	50
0.15	46
0.106	43
0.075	39

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
10.0	0	29	33	39	1.2	N/A	N/A	N/A	N/A

Sample Description: (SC) gravelly CLAYEY SAND, fine to coarse sub-angular gravel, fine to mediun sand, some coarse sand; dark brown; cohesive, w ≈ PL

USCS Classification: SC

Remarks:

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Bay 8, 820 - 28 St. NE
Calgary, AB T2A 6K1

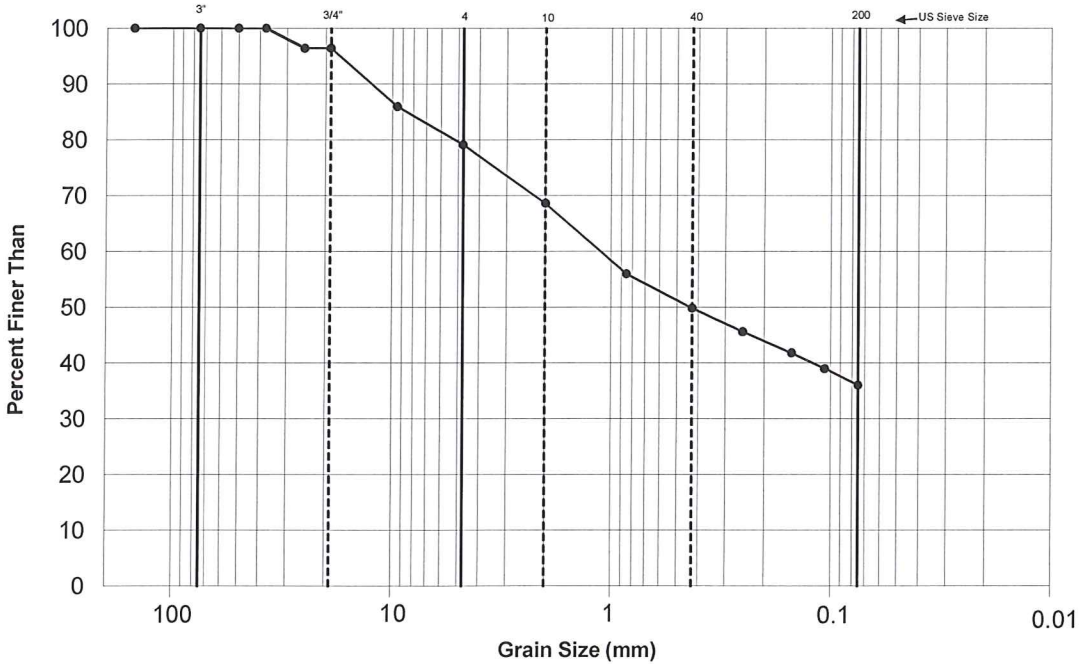
Reviewed by: _____

Particle Size Distribution of Soils using Sieve Analysis

(ASTM D6913-04)

Project No.:	1406422	Phase:	-		Date:	13-Aug-15
Short Title:	Benga/FeasibilityStudy/AB					
Sub Sampled By:	DS	Washed By:	CG		Sieved By:	CL
Field Tag No.:	-	Location:	-		BH or TP No.:	BH15-09
Lab No.:	B580-19&20	Northing:	-	m	Sample No.:	SS4&SS5
Sampled By:	Alex Kaul	Easting:	-	m	Depth From:	6.10 m
Sample Date:	21-Jul-15	Elevation:	-	m	Depth To:	7.87 m

Test Method:	A	Drying Method:	Oven	
Composite Sieve:	Yes	if Yes, Split on:	4.75	mm
Material Exluded from Sieve:	No	Describe:		
Prior Testing on Sample:	No	Describe:		



Cobbles	Gravel Size		Sand Size			Silt and Clay Size
	Coarse	Fine	Coarse	Medium	Fine	

Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25	96
19	96
9.5	86
4.75	79
2	69
0.85	56
0.425	50
0.25	46
0.15	42
0.106	39
0.075	36

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
14.7	0	21	43	36	1.2	N/A	N/A	N/A	N/A

Sample Description: (SC) gravelly CLAYEY SAND, fine to medium sand, some fine, fine sub-angular gravel; dark brown; cohesive, w > PL

USCS Classification: SC

Remarks:

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Bay 8, 820 - 28 St. NE
Calgary, AB T2A 6K1

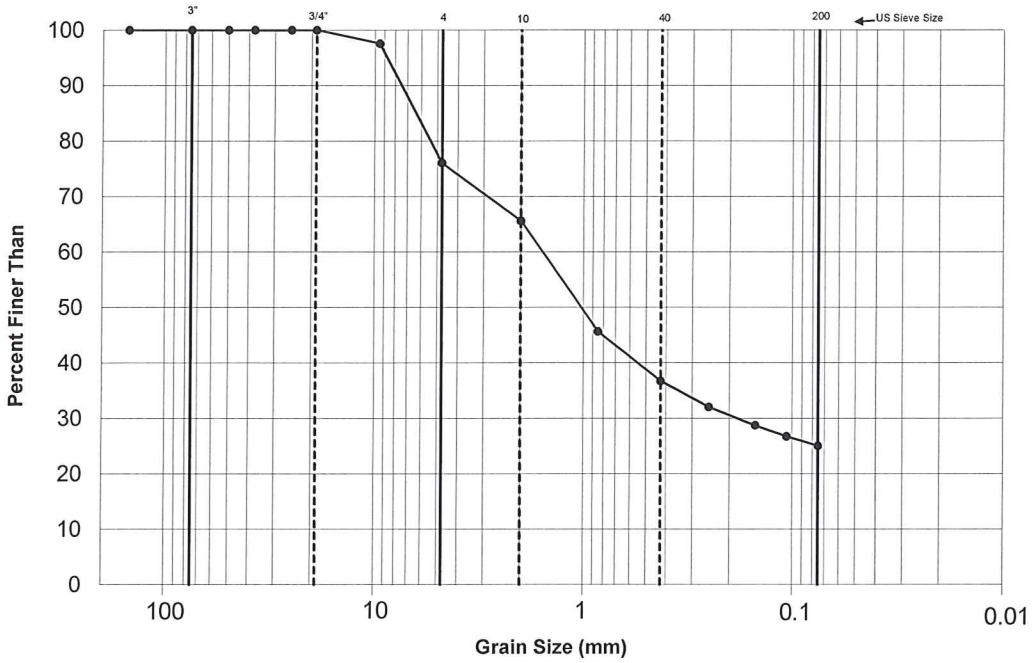
Reviewed by: _____

Particle Size Distribution of Soils using Sieve Analysis

(ASTM D6913-04)

Project No.:	1406422	Phase:	-		Date:	13-Aug-15
Short Title:	Benga/FeasibilityStudy/AB					
Sub Sampled By:	DS	Washed By:	CG		Sieved By:	CL
Field Tag No.:	-	Location:	-		BH or TP No.:	BH15-09
Lab No.:	B580-22&23	Northing:	-	m	Sample No.:	SS6&SS7
Sampled By:	Alex Kaul	Easting:	-	m	Depth From:	9.14 m
Sample Date:	21-Jul-15	Elevation:	-	m	Depth To:	10.72 m

Test Method:	A	Drying Method:	Oven	
Composite Sieve:	Yes	if Yes, Split on:	4.75	mm
Material Exluded from Sieve:	No	Describe:		
Prior Testing on Sample:	No	Describe:		



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25	100
19	100
9.5	98
4.75	76
2	66
0.85	46
0.425	37
0.25	32
0.15	29
0.106	27
0.075	25

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
19.2	0	24	51	25	1.7	0.2	N/A	N/A	N/A

Sample Description: (SC) gravelly CLAYEY SAND, fine to coarse sand, fine sub-angular gravel; brown; cohesive, w > PL

USCS Classification: SC

Remarks:

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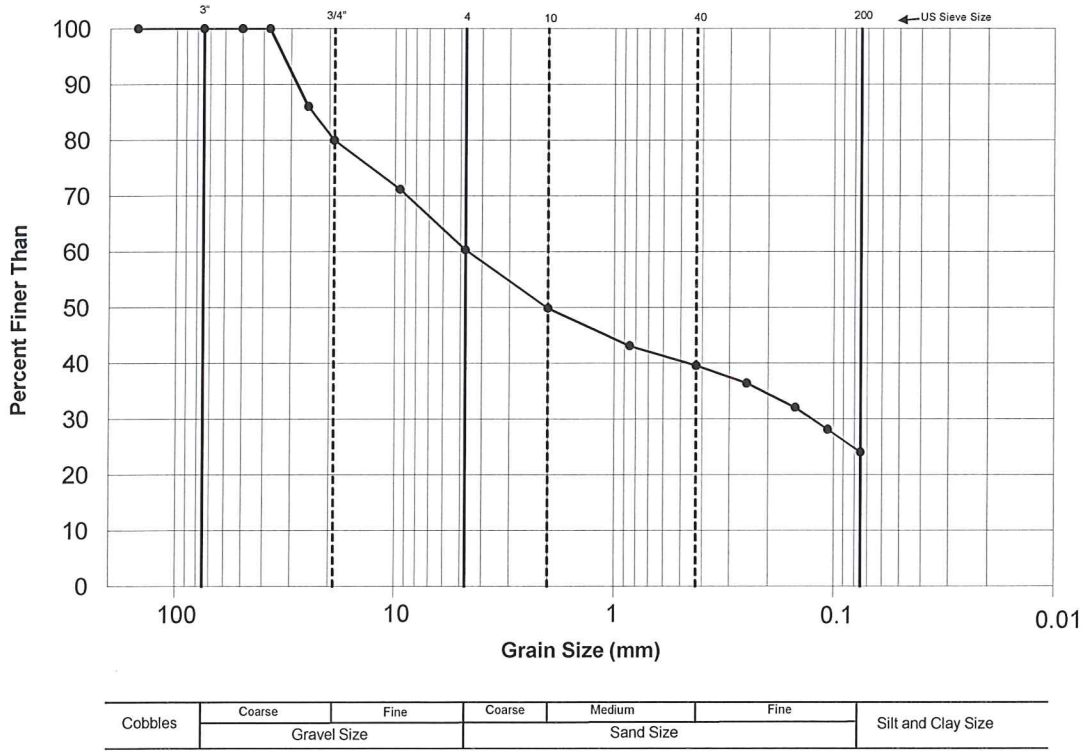
Bay 8, 820 - 28 St. NE
Calgary, AB T2A 6K1

Reviewed by: _____

Particle Size Distribution of Soils using Sieve Analysis

(ASTM D6913-04)

Project No.:	1406422		Phase:	-		Date:	13-Aug-15
Short Title:	Benga/FeasibilityStudy/AB						
Sub Sampled By:	DS		Washed By:	CG		Sieved By:	CL
Field Tag No.:	-		Location:	-		BH or TP No.:	BH15-10
Lab No.:	B580-24&25		Northing:	-	m	Sample No.:	SS1&SS2
Sampled By:	Alex Kaul		Easting:	-	m	Depth From:	1.52 m
Sample Date:	21-Jul-15		Elevation:	-	m	Depth To:	3.51 m
Test Method:		A	Drying Method:	Oven			
Composite Sieve:		Yes	if Yes, Split on:	4.75	mm		
Material Exluded from Sieve:		No	Describe:				
Prior Testing on Sample:		No	Describe:				



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25	86
19	80
9.5	71
4.75	60
2	50
0.85	43
0.425	40
0.25	36
0.15	32
0.106	28
0.075	24

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
11.9	0	40	36	24	4.7	0.1	N/A	N/A	N/A

Sample Description: (GC) fine to coarse CLAYEY GRAVEL and fine to coarse SAND; brown; cohesive, w>PL

USCS Classification: SC

Remarks:

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Bay 8, 820 - 28 St. NE
Calgary, AB T2A 6K1

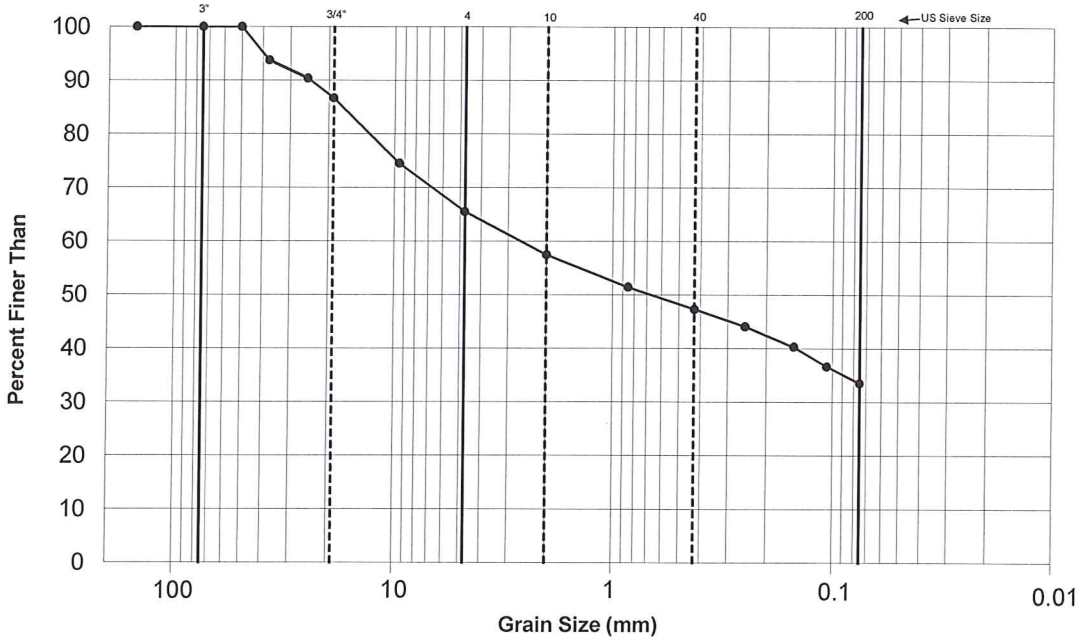
Reviewed by: _____

Particle Size Distribution of Soils using Sieve Analysis

(ASTM D6913-04)

Project No.:	1406422	Phase:	-		Date:	13-Aug-15
Short Title:	Benga/FeasibilityStudy/AB					
Sub Sampled By:	DS	Washed By:	-		Sieved By:	CL
Field Tag No.:	-	Location:	-		BH or TP No.:	BH15-10
Lab No.:	B580-27	Northing:	-	m	Sample No.:	AS1
Sampled By:	AK	Easting:	-	m	Depth From:	5.03 m
Sample Date:	21-Jul-15	Elevation:	-	m	Depth To:	6.1 m

Test Method:	A	Drying Method:	Oven	
Composite Sieve:	Yes	if Yes, Split on:	4.75	mm
Material Exluded from Sieve:	No	Describe:		
Prior Testing on Sample:	No	Describe:		



Cobbles	Gravel Size		Sand Size			Silt and Clay Size
	Coarse	Fine	Coarse	Medium	Fine	

Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	94
25	90
19	87
9.5	74
4.75	65
2	58
0.85	51
0.425	47
0.25	44
0.15	40
0.106	37
0.075	34

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
12.9	0	35	32	34	2.9	N/A	N/A	N/A	N/A

Sample Description: (GC) sandy CLAYEY GRAVEL, fine to coarse sub-angular gravel, some fine sand, some medium to course sand; brown; cohesive, w>PL

USCS Classification: GC

Remarks:

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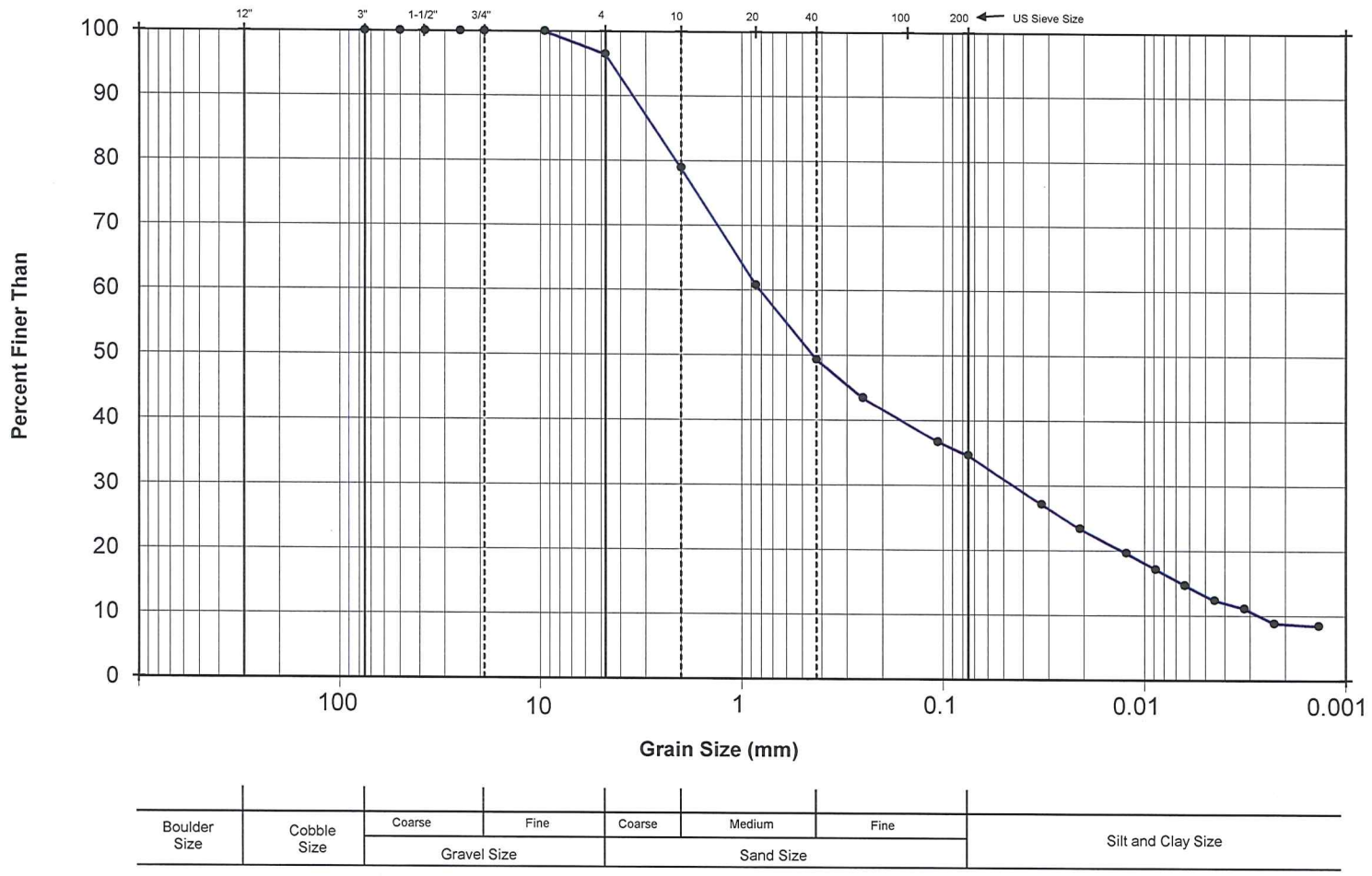
Calgary, AB T2A 6K1

Reviewed by: _____

Golder Associates

Particle Size Analysis of Soil
(ASTM D422)

Project No.:	1406422	Lab No.:	B580-30
Project Title:	Benga/FeasibilityStudy/AB		
Borehole:	BH15-10	Sample No.:	SS6
Depth:	9.14 - 9.27 m		
Date Tested:	13-Aug-15	By:	DS



Diameter of Sieve (mm)	Percent Passing (%)
75.0	100.0
50.0	100.0
37.5	100.0
25.0	100.0
19.0	100.0
9.5	100.0
4.75	96.5
2.0	79.0
0.850	60.8
0.425	49.4
0.250	43.5
0.106	36.8
0.075	34.7
0.032	27.2
0.021	23.4
0.012	19.7
0.009	17.2
0.006	14.7
0.004	12.4
0.003	11.2
0.002	8.8
0.001	8.5

Comments:

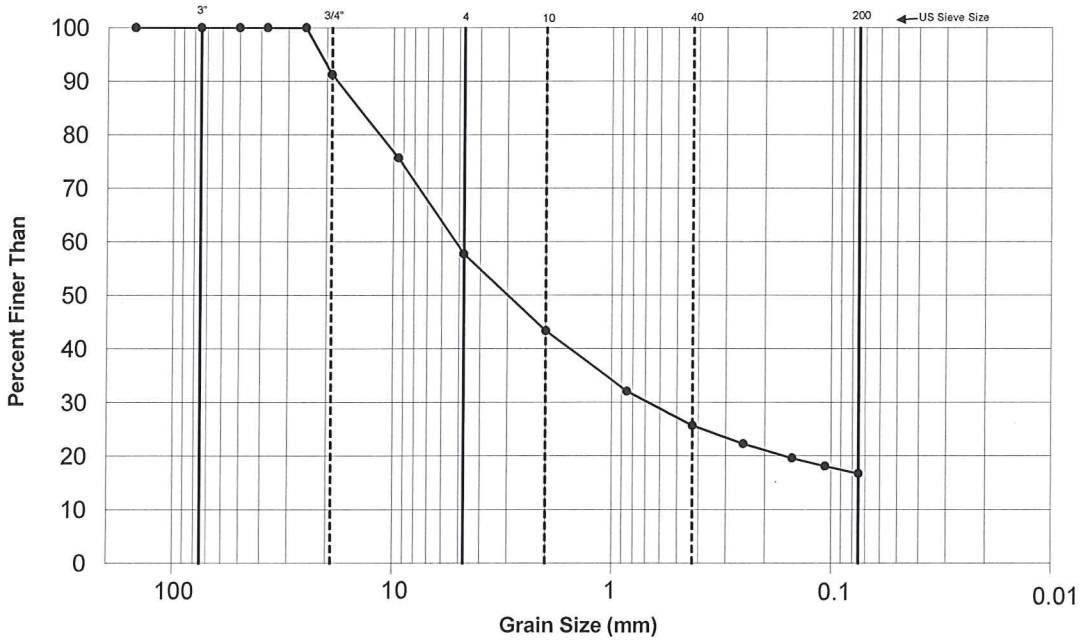
Reviewed:

Particle Size Distribution of Soils using Sieve Analysis

(ASTM D6913-04)

Project No.:	1406422	Phase:	-		Date:	13-Aug-15
Short Title:	Benga/FeasibilityStudy/AB					
Sub Sampled By:	DS	Washed By:	-		Sieved By:	CL
Field Tag No.:	-	Location:	-		BH or TP No.:	BH15-13
Lab No.:	B580-35	Northing:	-	m	Sample No.:	SS1
Sampled By:	AK	Easting:	-	m	Depth From:	1.52 m
Sample Date:	24-Jul-15	Elevation:	-	m	Depth To:	1.98 m

Test Method:	A	Drying Method:	Oven	
Composite Sieve:	Yes	if Yes, Split on:	4.75	mm
Material Exluded from Sieve:	No	Describe:		
Prior Testing on Sample:	No	Describe:		



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25	100
19	91
9.5	76
4.75	58
2	43
0.85	32
0.425	26
0.25	22
0.15	20
0.106	18
0.075	17

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
6.4	0	42	41	17	5.3	0.7	N/A	N/A	N/A

Sample Description: (GC) CLAYEY GRAVEL and SAND, fine angular gravel, some coarse gravel, medium to coarse sand, some fine sand; black; cohesive, w<PL

USCS Classification: GC

Remarks:

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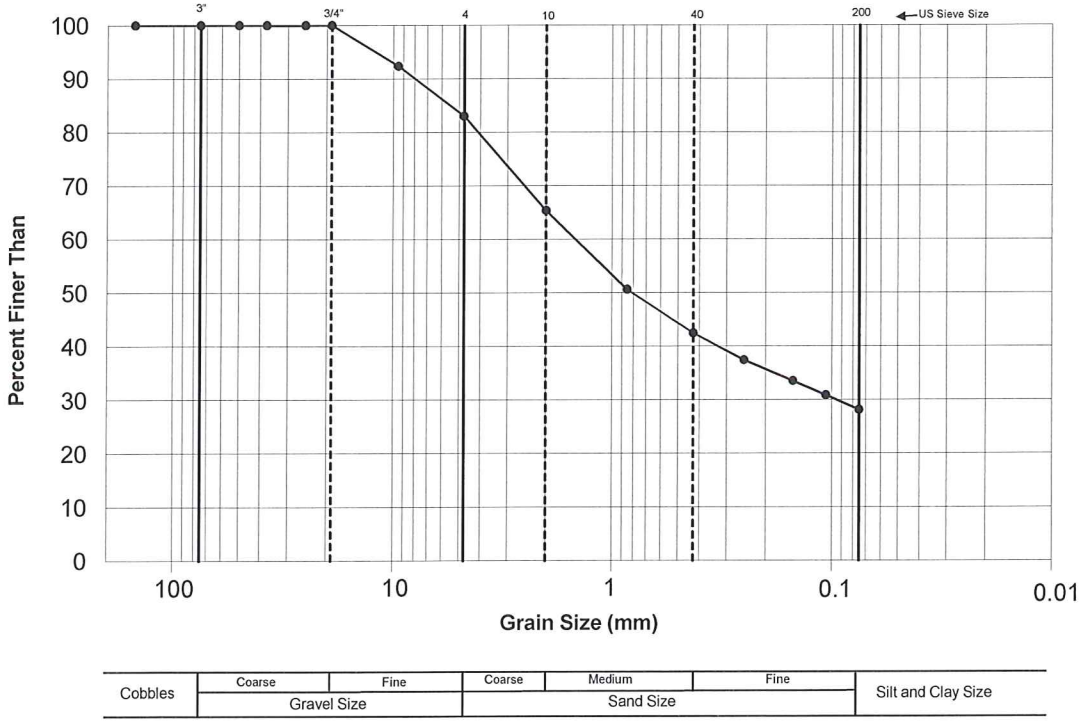
Bay 8, 820 - 28 St. NE
Calgary, AB T2A 6K1

Reviewed by: _____

Particle Size Distribution of Soils using Sieve Analysis

(ASTM D6913-04)

Project No.:	1406422		Phase:	-		Date:	13-Aug-15
Short Title:	Benga/FeasibilityStudy/AB						
Sub Sampled By:	DS		Washed By:	CG		Sieved By:	-
Field Tag No.:	-		Location:	-		BH or TP No.:	BH15-13
Lab No.:	B580-38		Northing:	-	m	Sample No.:	SS3
Sampled By:	AK		Easting:	-	m	Depth From:	4.57 m
Sample Date:	24-Jul-15		Elevation:	-	m	Depth To:	4.7 m
Test Method:		A	Drying Method:	Oven			
Composite Sieve:		Yes	if Yes, Split on:	4.75	mm		
Material Exluded from Sieve:		No	Describe:				
Prior Testing on Sample:		No	Describe:				



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25	100
19	100
9.5	92
4.75	83
2	65
0.85	51
0.425	42
0.25	37
0.15	34
0.106	31
0.075	28

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
6.3	0	17	55	28	1.6	0.1	N/A	N/A	N/A

Sample Description: (SC) gravelly CLAYEY SAND, fine to coarse sand, fine sub-angular gravel; brown; cohesive, w<PL

USCS Classification: SC

Remarks:

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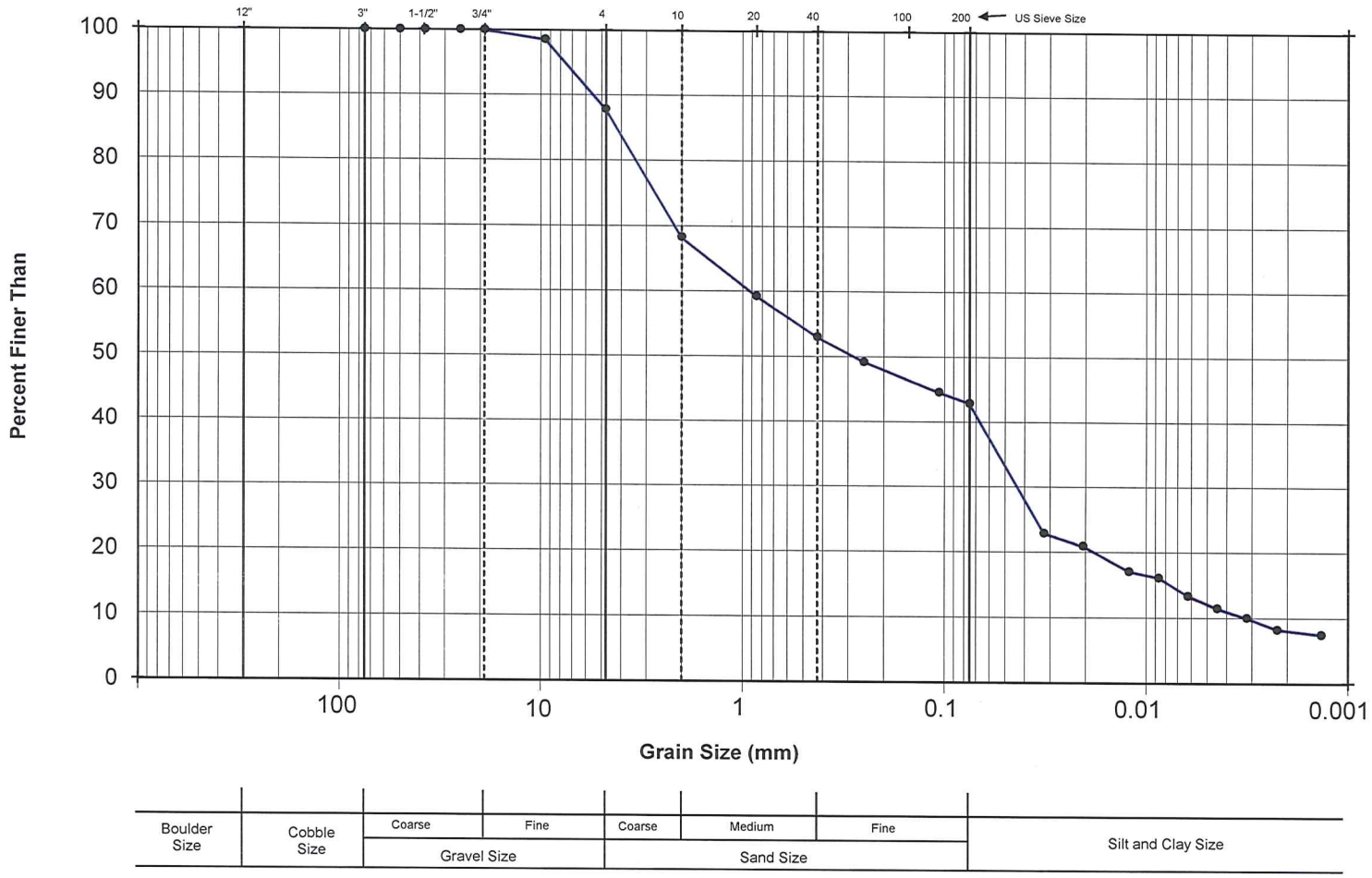
Calgary, AB T2A 6K1

Reviewed by: LS

Particle Size Analysis of Soil
(ASTM D422)

Project No.:	1406422	Lab No.:	B580-39
Project Title:	Benga/FeasibilityStudy/AB		
Borehole:	BH15-14	Sample No.:	SS1
Depth:	1.52 - 1.92 m		
Date Tested:	13-Aug-15	By:	DS



Diameter of Sieve (mm)	Percent Passing (%)
75.0	100.0
50.0	100.0
37.5	100.0
25.0	100.0
19.0	100.0
9.5	98.6
4.75	87.9
2.0	68.3
0.850	59.3
0.425	53.0
0.250	49.2
0.106	44.6
0.075	42.9
0.032	22.9
0.021	21.0
0.012	17.1
0.009	16.2
0.006	13.4
0.004	11.5
0.003	10.0
0.002	8.3
0.001	7.5

Comments:

Reviewed:

Golder Associates

Atterberg Limits (ASTM D 4318)

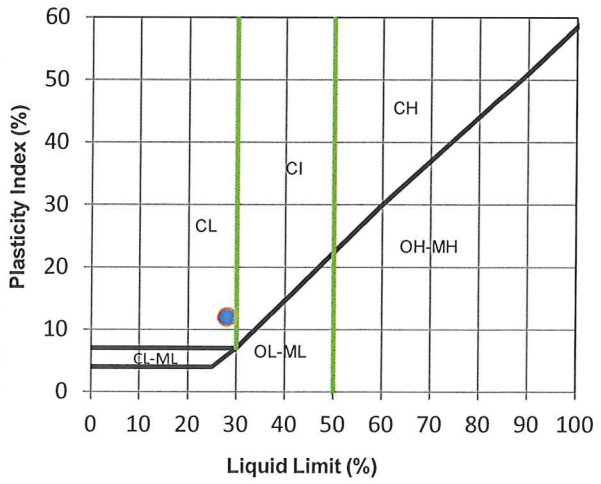
Project No.:	1406422	Phase:	-
Short Title:	Benga/FeasibilityStudy/AB	Lab No.:	B580-39
Tested By:	DS	Date:	13-Aug-15

Borehole: BH15-14 Sample No.: SS1 Depth: 1.52-1.92 m

Liquid Limit Determination:			Natural Water Content:		
Number of Blows	20	20	As Received Water Content (%)		4.7%
Blow Correction Factor	0.97	0.97	**Plastic Limit Determination:**		
Mass of wet sample + tare (g)	30.09	39.89	Mass of wet sample + tare (g)	19.11	19.53
Mass of dry sample + tare (g)	27.46	36.82	Mass of dry sample + tare (g)	17.76	18.28
Mass of tare (g)	18.40	26.17	Mass of tare (g)	9.37	10.45
Weight of Water (g)	2.63	3.07	Weight of Water (g)	1.35	1.25
Weight of dry soil (g)	9.06	10.65	Weight of dry soil (g)	8.39	7.83
Water Content (%)	29.0	28.8	Water Content (%)	16.09	15.96
Liquid Limit	28.0	28.0	Average Water Content (%)		16.03

Liquid Limit Test

Plasticity chart for soil passing 425 µm sieve



Liquid Limit =	28	%
Plastic Limit =	16	%
Plasticity Index =	12	

Comments: _____

Reviewed: _____

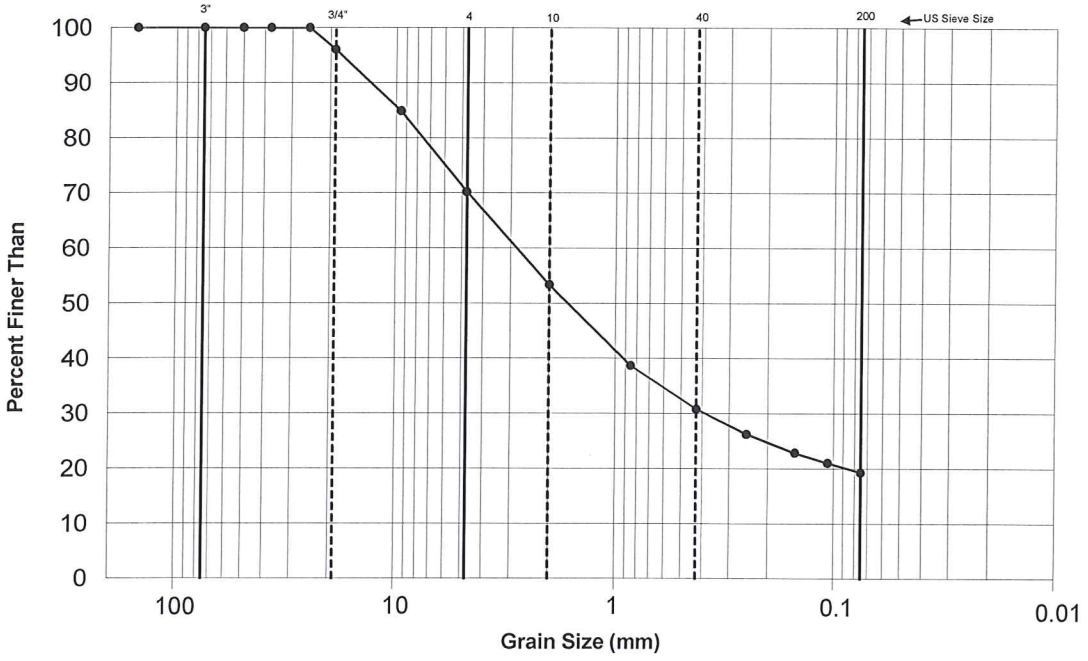
Golder Associates

Particle Size Distribution of Soils using Sieve Analysis

(ASTM D6913-04)

Project No.:	1406422	Phase:	-		Date:	13-Aug-15
Short Title:	Benga/FeasibilityStudy/AB					
Sub Sampled By:	DS	Washed By:	-		Sieved By:	CL
Field Tag No.:	-	Location:	-		BH or TP No.:	BH15-16
Lab No.:	B580-41&42	Northing:	-	m	Sample No.:	SS2&SS3
Sampled By:	Alex Kaul	Easting:	-	m	Depth From:	3.05 m
Sample Date:	24-Jul-15	Elevation:	-	m	Depth To:	5.03 m

Test Method:	A	Drying Method:	Oven	
Composite Sieve:	Yes	if Yes, Split on:	4.75	mm
Material Exluded from Sieve:	No	Describe:		
Prior Testing on Sample:	No	Describe:		



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25	100
19	96
9.5	85
4.75	70
2	53
0.85	39
0.425	31
0.25	26
0.15	23
0.106	21
0.075	19

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
5.3	0	30	51	19	3.1	0.4	N/A	N/A	N/A

Sample Description: (SC) gravelly CLAYEY SAND, medium to coarse sand, some fine sand, fine sub-angular gravel; dark grey to black; cohesive, w<PL

USCS Classification: SC

Remarks:

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Bay 8, 820 - 28 St. NE
Calgary, AB T2A 6K1

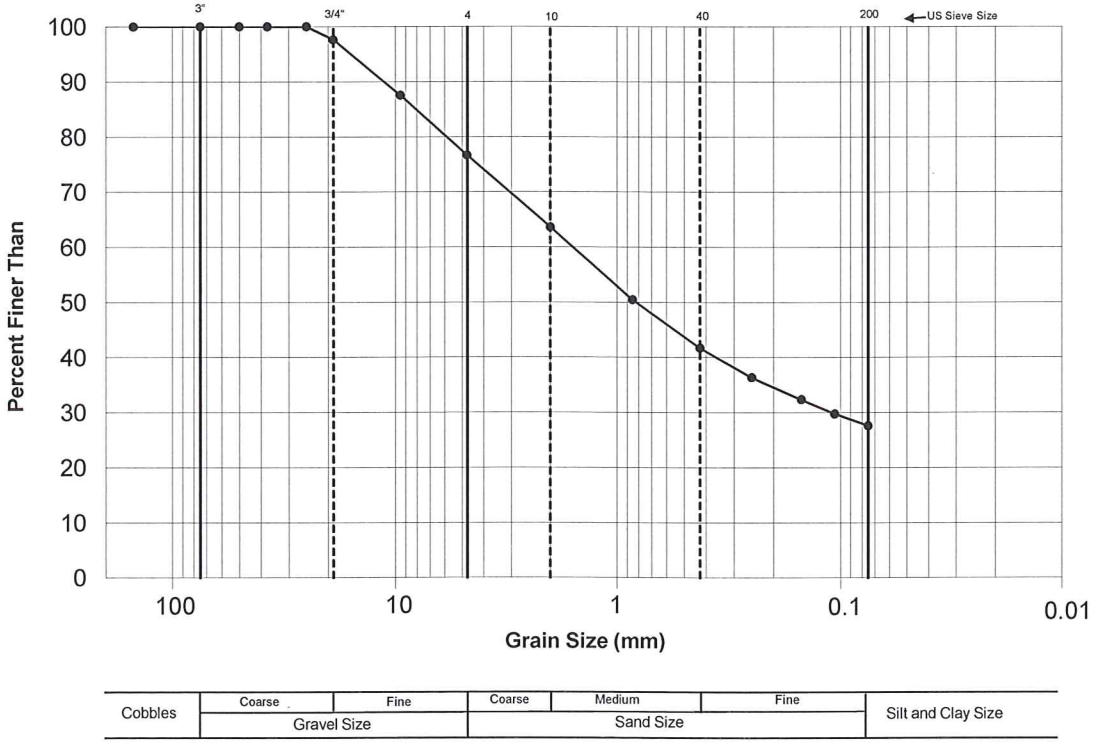
Reviewed by: _____

Particle Size Distribution of Soils using Sieve Analysis

(ASTM D6913-04)

Project No.:	1406422	Phase:	-		Date:	13-Aug-15
Short Title:	Benga/FeasibilityStudy/AB					
Sub Sampled By:	DS	Washed By:	CG		Sieved By:	CL
Field Tag No.:	-	Location:	-		BH or TP No.:	BH15-16
Lab No.:	B580-44&45	Northing:	-	m	Sample No.:	SS4&SS5
Sampled By:	Alex Kaul	Easting:	-	m	Depth From:	7.62 m
Sample Date:	24-Jul-15	Elevation:	-	m	Depth To:	9.6 m

Test Method:	A	Drying Method:	Oven	
Composite Sieve:	Yes	if Yes, Split on:	4.75	mm
Material Exluded from Sieve:	No	Describe:		
Prior Testing on Sample:	No	Describe:		



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25	100
19	98
9.5	88
4.75	77
2	64
0.85	50
0.425	42
0.25	36
0.15	32
0.106	30
0.075	28

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
6.7	0	23	49	28	1.7	0.1	N/A	N/A	N/A

Sample Description: (SC) gravelly CLAYEY SAND, fine to coarse sand, fine gravel; black; cohesive, w<PL

USCS Classification: SC

Remarks:

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Bay 8, 820 - 28 St. NE
Calgary, AB T2A 6K1

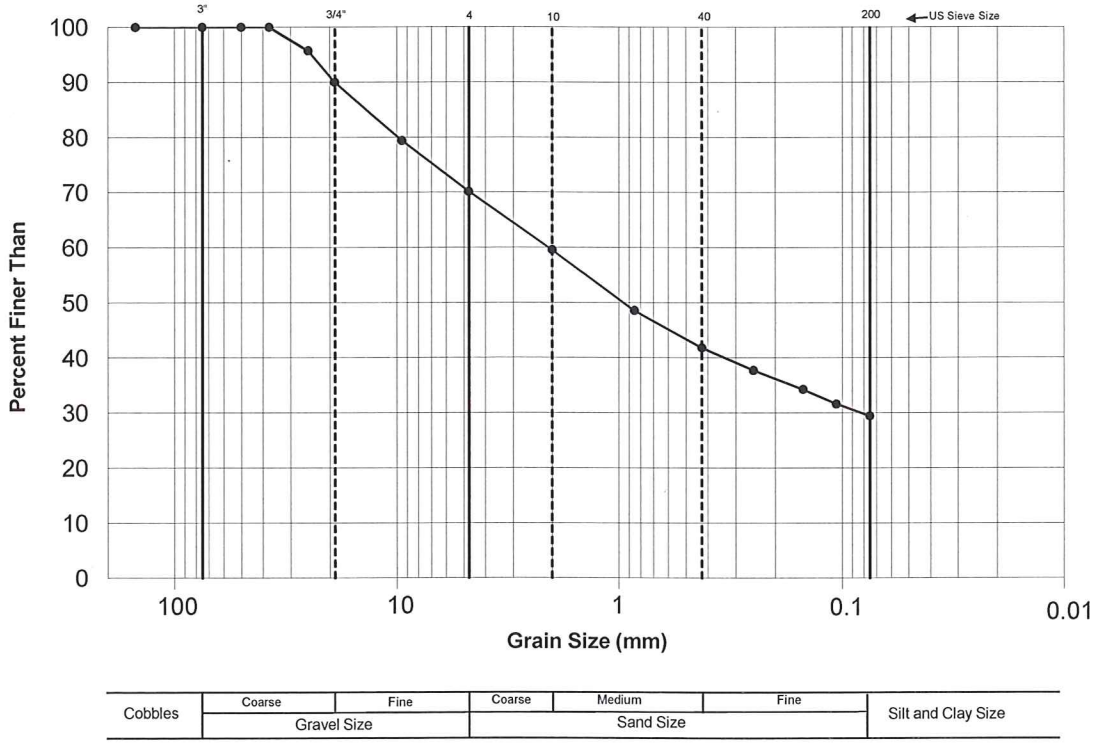
Reviewed by: _____

Particle Size Distribution of Soils using Sieve Analysis

(ASTM D6913-04)

Project No.:	1406422		Phase:	-		Date:	13-Aug-15
Short Title:	Benga/FeasibilityStudy/AB						
Sub Sampled By:	DS		Washed By:	-		Sieved By:	CL
Field Tag No.:	-		Location:	-		BH or TP No.:	BH15-16
Lab No.:	B580-46&47		Northing:	-	m	Sample No.:	SS7&SS8
Sampled By:	Alex Kaul		Easting:	-	m	Depth From:	10.67 m
Sample Date:	24-Jul-15		Elevation:	-	m	Depth To:	12.65 m

Test Method:	A	Drying Method:	Oven	
Composite Sieve:	Yes	if Yes, Split on:	4.75	mm
Material Exluded from Sieve:	No	Describe:		
Prior Testing on Sample:	No	Describe:		



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25	96
19	90
9.5	79
4.75	70
2	60
0.85	49
0.425	42
0.25	38
0.15	34
0.106	32
0.075	29

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
7.2	0	30	41	29	2.1	0.1	N/A	N/A	N/A

Sample Description: (SC) gravelly CLAYEY SAND, fine to coarse sand, fine sub-angular gravel, some coarse gravel; black; cohesive, w<PL

USCS Classification: SC

Remarks:

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Bay 8, 820 - 28 St. NE
Calgary, AB T2A 6K1

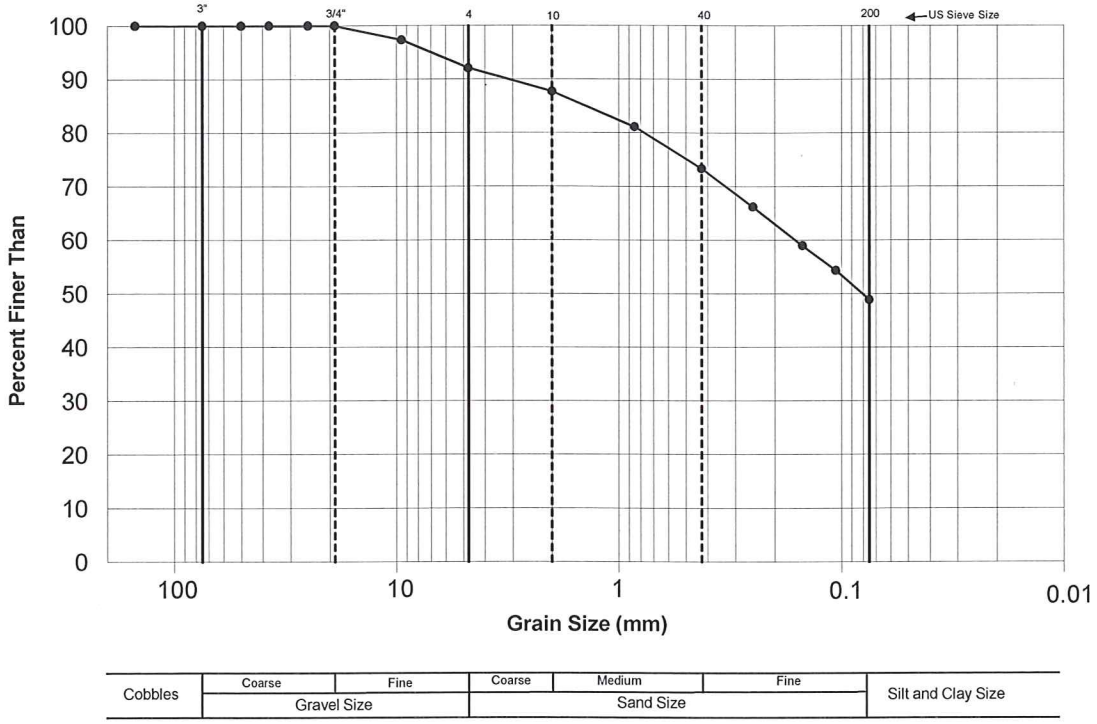
Reviewed by: _____

Particle Size Distribution of Soils using Sieve Analysis

(ASTM D6913-04)

Project No.:	1406422	Phase:	-		Date:	13-Aug-15
Short Title:	Benga/FeasibilityStudy/AB					
Sub Sampled By:	DS	Washed By:	-		Sieved By:	CL
Field Tag No.:	-	Location:	-		BH or TP No.:	BH15-21
Lab No.:	B580-54	Northing:	-	m	Sample No.:	SS1
Sampled By:	AK	Easting:	-	m	Depth From:	1.52 m
Sample Date:	23-Jul-15	Elevation:	-	m	Depth To:	1.98 m

Test Method:	A	Drying Method:	Oven	
Composite Sieve:	Yes	if Yes, Split on:	4.75	mm
Material Exluded from Sieve:	No	Describe:		
Prior Testing on Sample:	No	Describe:		



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25	100
19	100
9.5	97
4.75	92
2	88
0.85	81
0.425	73
0.25	66
0.15	59
0.106	54
0.075	49

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
19.1	0	8	43	49	0.2	N/A	N/A	N/A	N/A

Sample Description: (SC) CLAYEY SAND, fine to medium sand, some fine sub-angular gravel; brown; cohesive, w≈PL

USCS Classification: SC

Remarks:

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Bay 8, 820 - 28 St. NE
Calgary, AB T2A 6K1

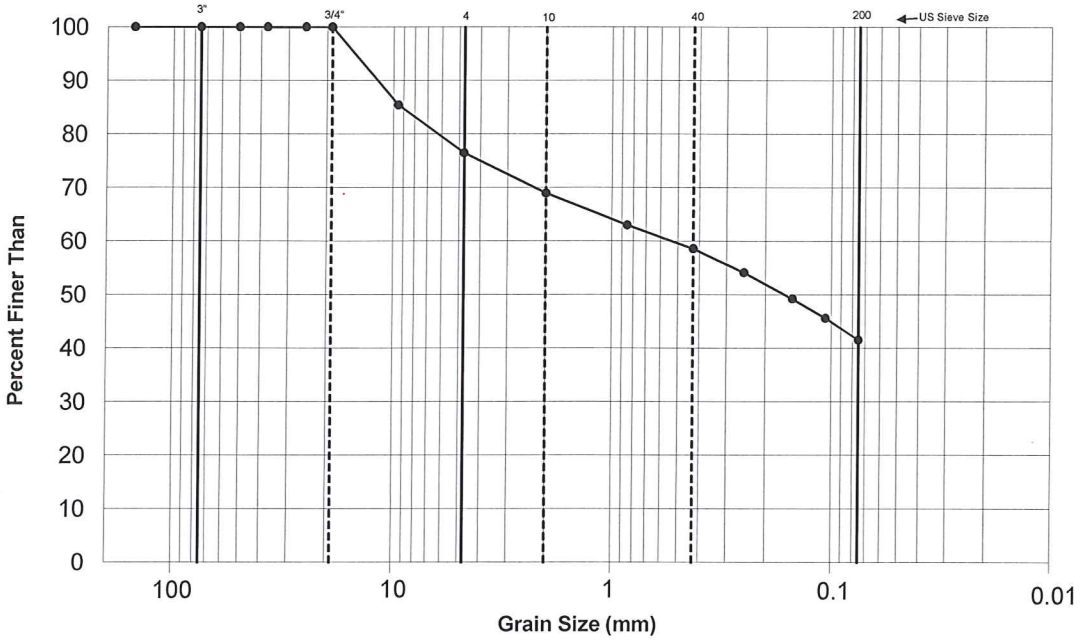
Reviewed by: _____

Particle Size Distribution of Soils using Sieve Analysis

(ASTM D6913-04)

Project No.:	1406422	Phase:	-		Date:	13-Aug-15
Short Title:	Benga/FeasibilityStudy/AB					
Sub Sampled By:	DS	Washed By:	-		Sieved By:	CL
Field Tag No.:	-	Location:	-		BH or TP No.:	BH15-21
Lab No.:	B580-56	Northing:	-	m	Sample No.:	AS1
Sampled By:	AK	Easting:	-	m	Depth From:	3.51 m
Sample Date:	23-Jul-15	Elevation:	-	m	Depth To:	4.57 m

Test Method:	A	Drying Method:	Oven	
Composite Sieve:	Yes	if Yes, Split on:	4.75	mm
Material Exluded from Sieve:	No	Describe:		
Prior Testing on Sample:	No	Describe:		



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25	100
19	100
9.5	85
4.75	76
2	69
0.85	63
0.425	59
0.25	54
0.15	49
0.106	46
0.075	42

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
15.0	0	24	35	42	0.6	N/A	N/A	N/A	N/A

Sample Description: (SC) gravelly CLAYEY SAND, fine to medium sand, some coarse sand, fine sub-angular gravel; dark g cohesive, w>PL

USCS Classification: SC

Remarks:

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Bay 8, 820 - 28 St. NE
Calgary, AB T2A 6K1

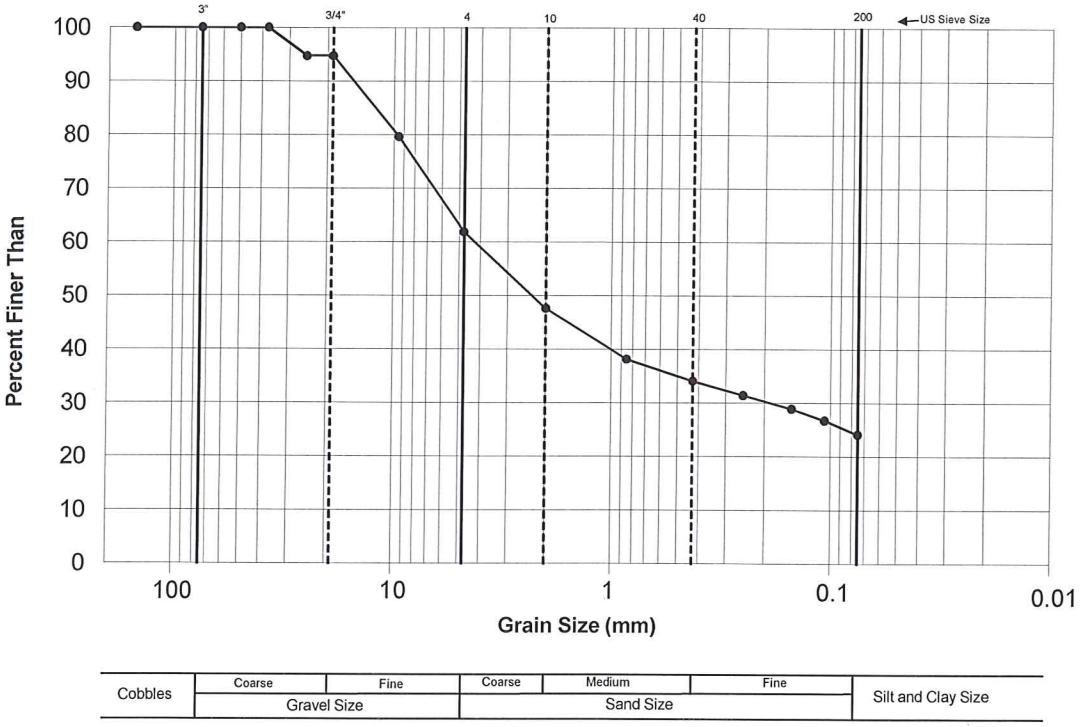
Reviewed by: _____

Particle Size Distribution of Soils using Sieve Analysis

(ASTM D6913-04)

Project No.:	1406422		Phase:	-		Date:	13-Aug-15
Short Title:	Benga/FeasibilityStudy/AB						
Sub Sampled By:	DS		Washed By:	-		Sieved By:	-
Field Tag No.:	-		Location:	-		BH or TP No.:	BH15-21
Lab No.:	B580-58		Northing:	-	m	Sample No.:	SS4
Sampled By:	AK		Easting:	-	m	Depth From:	6.1 m
Sample Date:	23-Jul-15		Elevation:	-	m	Depth To:	6.55 m

Test Method:	A	Drying Method:	Oven	
Composite Sieve:	Yes	if Yes, Split on:	4.75	mm
Material Exluded from Sieve:	No	Describe:		
Prior Testing on Sample:	No	Describe:		



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25	95
19	95
9.5	80
4.75	62
2	48
0.85	38
0.425	34
0.25	31
0.15	29
0.106	27
0.075	24

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
10.6	0	38	38	24	4.4	0.2	N/A	N/A	N/A

Sample Description: (GC) CLAYEY GRAVEL and SAND, fine sub-angular gravel, medium to coarse sand, some fine sand; dark grey; cohesive, w>PL

USCS Classification: GC

Remarks:

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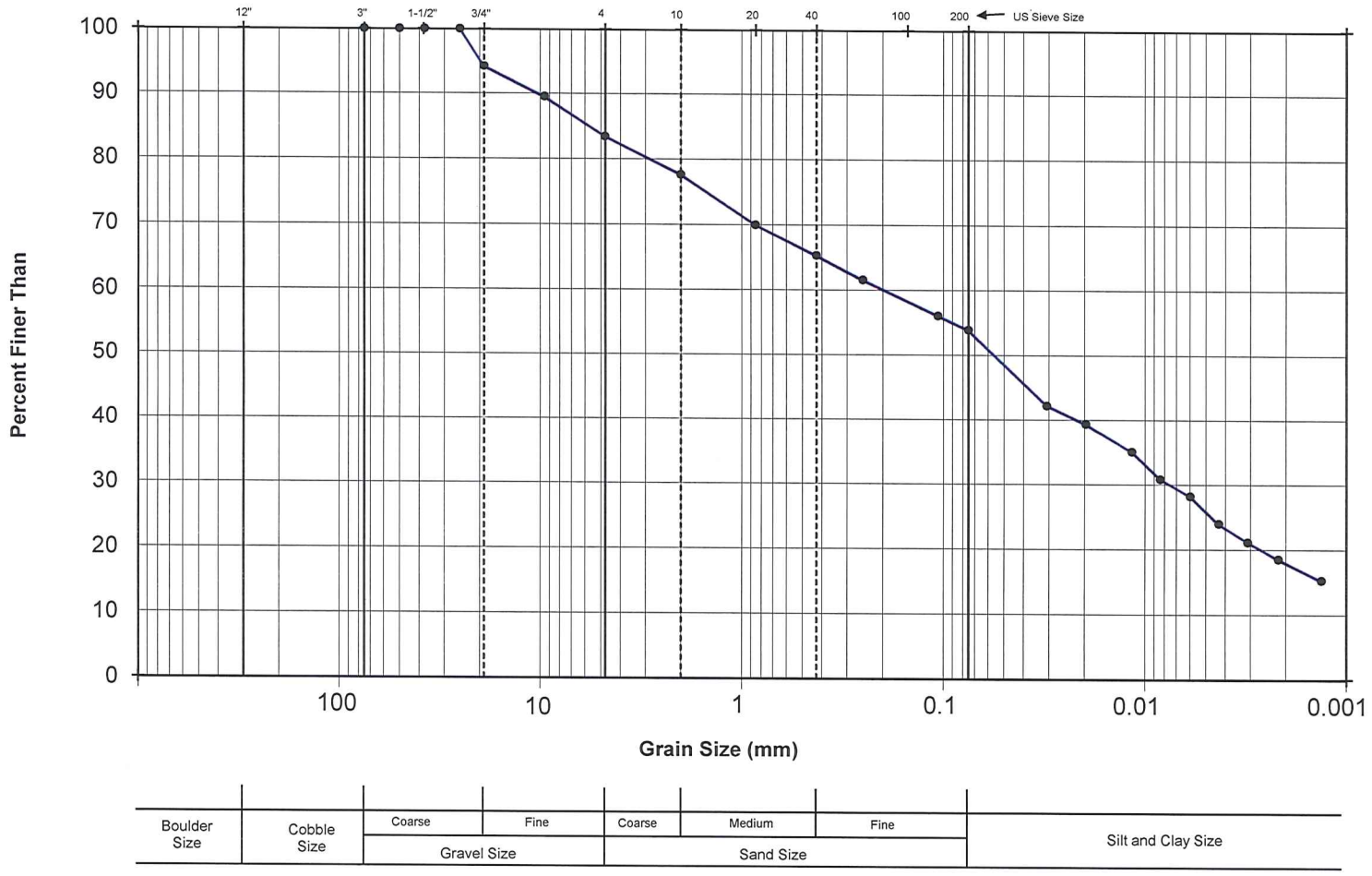
Bay 8, 820 - 28 St. NE
Calgary, AB T2A 6K1

Reviewed by: _____

Golder Associates

Particle Size Analysis of Soil
(ASTM D422)

Project No.:	1406422	Lab No.:	B580-63
Project Title:	Benga/FeasibilityStudy/AB		
Borehole:	BH15-22	Sample No.:	SS4
Depth:	6.10 - 6.55 m		
Date Tested:	13-Aug-15	By:	DS



Diameter of Sieve (mm)	Percent Passing (%)
75.0	100.0
50.0	100.0
37.5	100.0
25.0	100.0
19.0	94.2
9.5	89.5
4.75	83.5
2.0	77.6
0.850	70.0
0.425	65.3
0.250	61.6
0.106	56.1
0.075	53.9
0.031	42.2
0.020	39.4
0.012	35.1
0.008	30.9
0.006	28.2
0.004	24.0
0.003	21.2
0.002	18.5
0.001	15.3

Comments:

Reviewed:

Golder Associates

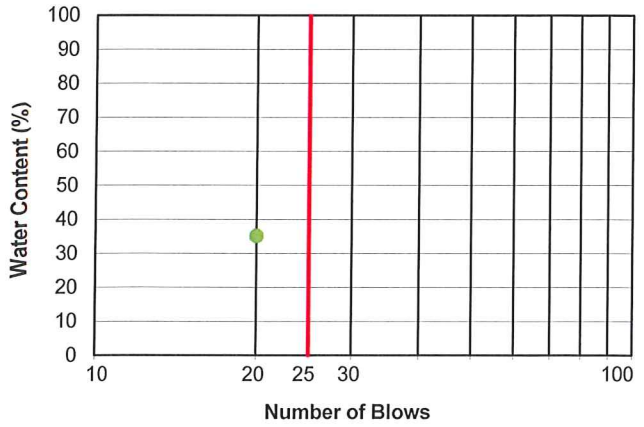
Atterberg Limits (ASTM D 4318)

Project No.:	1406422	Phase:	-
Short Title:	Benga/FeasibilityStudy/AB	Lab No.:	B580-63
Tested By:	DS	Date:	13-Aug-15

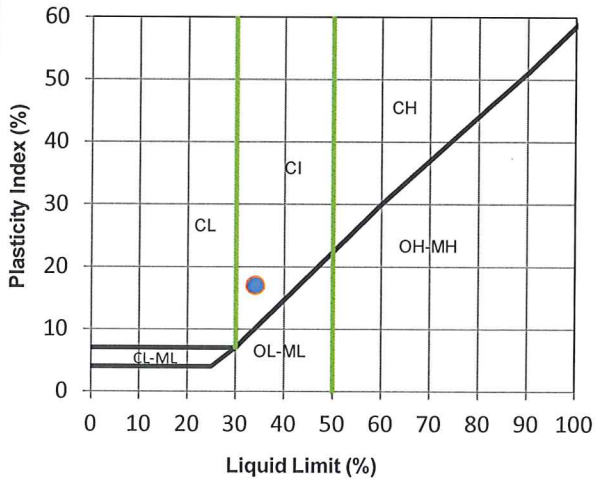
Borehole: BH15-22 Sample No.: SS4 Depth: 6.10-6.55 m

Liquid Limit Determination:			Natural Water Content:		
Number of Blows	20	20	As Received Water Content (%)		16.1%
Blow Correction Factor	0.97	0.97	**Plastic Limit Determination:**		
Mass of wet sample + tare (g)	29.42	33.95	Mass of wet sample + tare (g)	17.85	18.38
Mass of dry sample + tare (g)	26.22	30.13	Mass of dry sample + tare (g)	16.79	17.14
Mass of tare (g)	17.13	19.23	Mass of tare (g)	10.40	9.81
Weight of Water (g)	3.2	3.82	Weight of Water (g)	1.06	1.24
Weight of dry soil (g)	9.09	10.9	Weight of dry soil (g)	6.39	7.33
Water Content (%)	35.2	35.0	Water Content (%)	16.59	16.92
Liquid Limit	34.0	34.0	Average Water Content (%)		16.75

Liquid Limit Test



Plasticity chart for soil passing 425 µm sieve



Liquid Limit =	34	%
Plastic Limit =	17	%
Plasticity Index =	17	

Comments: _____

Reviewed: _____

Golder Associates

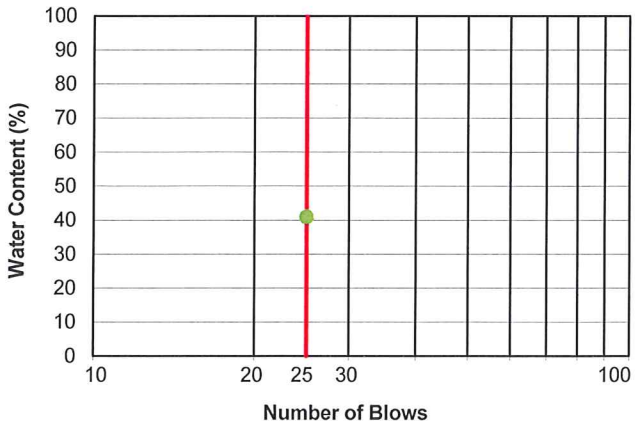
Atterberg Limits (ASTM D 4318)

Project No.:	1406422	Phase:	-
Short Title:	Benga/FeasibilityStudy/AB	Lab No.:	B580-64
Tested By:	DS	Date:	13-Aug-15

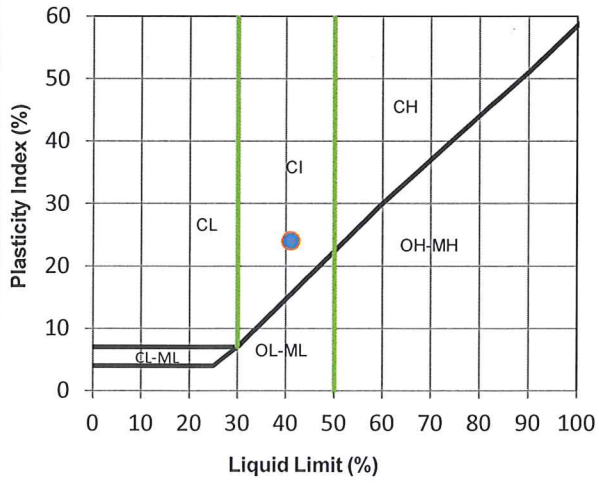
Borehole: BH15-22 Sample No.: SS5 Depth: 7.62-8.08 m

Liquid Limit Determination:			Natural Water Content:		
Number of Blows	25	25	As Received Water Content (%)		14.8%
Blow Correction Factor	1.00	1.00	**Plastic Limit Determination:**		
Mass of wet sample + tare (g)	42.21	32.33	Mass of wet sample + tare (g)	19.00	20.01
Mass of dry sample + tare (g)	38.43	28.21	Mass of dry sample + tare (g)	17.73	18.68
Mass of tare (g)	29.21	18.13	Mass of tare (g)	10.26	10.80
Weight of Water (g)	3.78	4.12	Weight of Water (g)	1.27	1.33
Weight of dry soil (g)	9.22	10.08	Weight of dry soil (g)	7.47	7.88
Water Content (%)	41.0	40.9	Water Content (%)	17.00	16.88
Liquid Limit	41.0	41.0	Average Water Content (%)		16.94

Liquid Limit Test



Plasticity chart for soil passing 425 µm sieve



Liquid Limit =	41	%
Plastic Limit =	17	%
Plasticity Index =	24	

Comments: _____

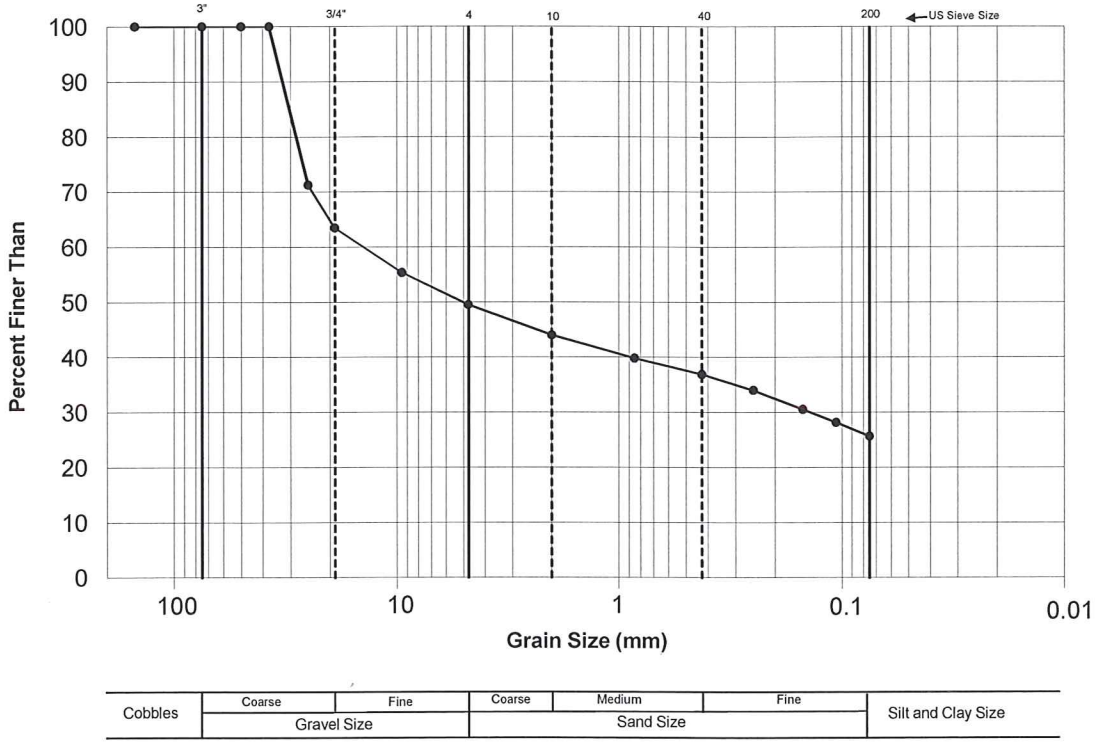
Reviewed: _____

Particle Size Distribution of Soils using Sieve Analysis

(ASTM D6913-04)

Project No.:	1406422	Phase:	-		Date:	13-Aug-15
Short Title:	Benga/FeasibilityStudy/AB					
Sub Sampled By:	DS	Washed By:	-		Sieved By:	CL
Field Tag No.:	-	Location:	-		BH or TP No.:	BH15-23
Lab No.:	B580-67&68	Northing:	-	m	Sample No.:	SS2&SS3
Sampled By:	Alex Kaul	Easting:	-	m	Depth From:	3.05 m
Sample Date:	22-Jul-15	Elevation:	-	m	Depth To:	5.03 m

Test Method:	A	Drying Method:	Oven	
Composite Sieve:	Yes	if Yes, Split on:	4.75	mm
Material Exluded from Sieve:	No	Describe:		
Prior Testing on Sample:	No	Describe:		



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25	71
19	64
9.5	55
4.75	50
2	44
0.85	40
0.425	37
0.25	34
0.15	31
0.106	28
0.075	26

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
7.5	0	50	24	26	14.9	0.1	N/A	N/A	N/A

Sample Description: (GC) sandy CLAYEY GRAVEL, fine to coarse sub-angular gravel, fine to coarse sand; brown; cohesive, w≈PL

USCS Classification: GC

Remarks:

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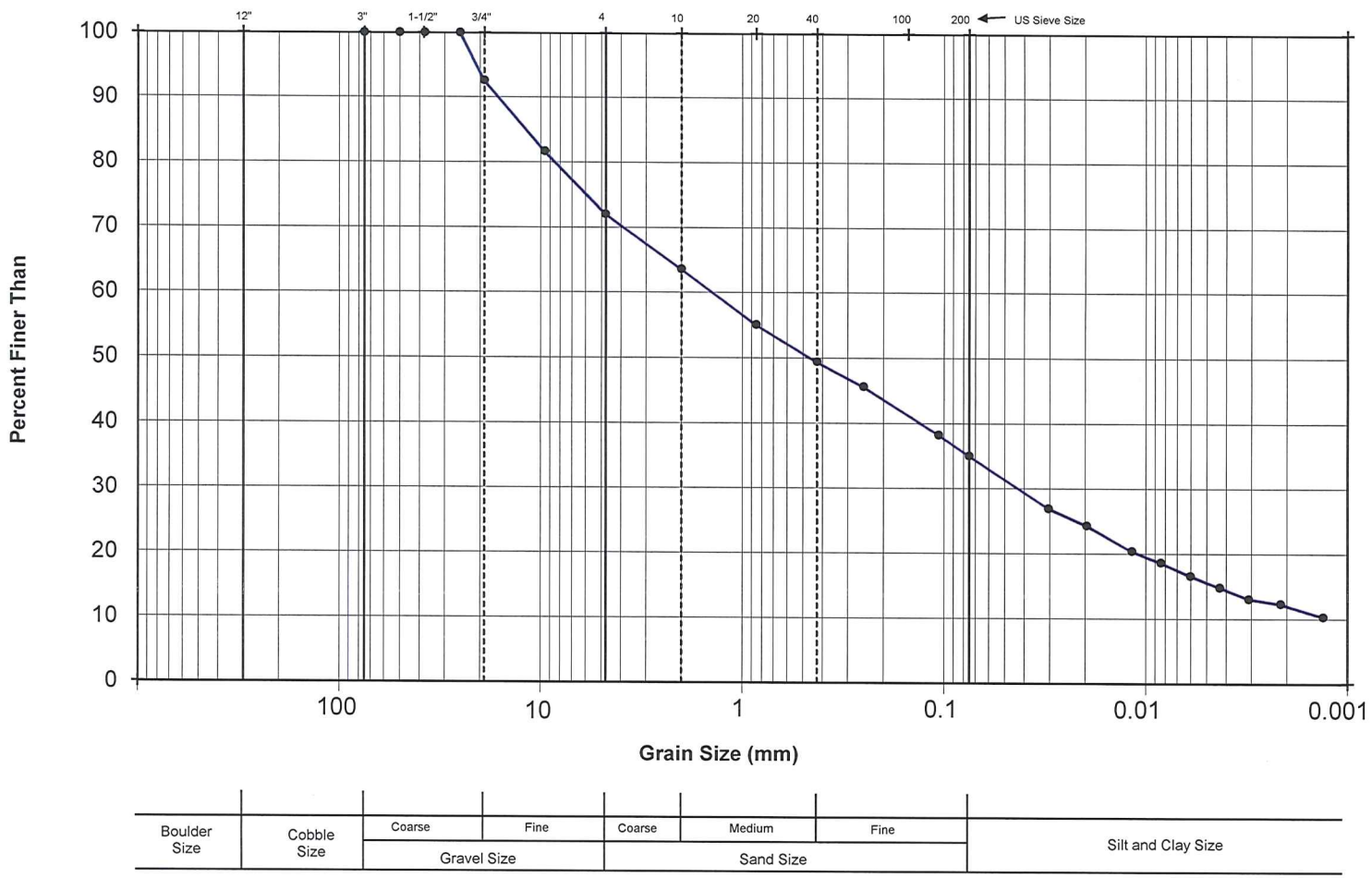
Calgary, AB T2A 6K1

Reviewed by: _____

Golder Associates

Particle Size Analysis of Soil
(ASTM D422)

Project No.:	1406422	Lab No.:	B580-71
Project Title:	Benga/FeasibilityStudy/AB		
Borehole:	BH15-23	Sample No.:	SS6
Depth:	9.14 - 9.60 m		
Date Tested:	13-Aug-15	By:	DS



Diameter of Sieve (mm)	Percent Passing (%)
75.0	100.0
50.0	100.0
37.5	100.0
25.0	100.0
19.0	92.6
9.5	81.7
4.75	72.0
2.0	63.6
0.850	55.1
0.425	49.4
0.250	45.6
0.106	38.3
0.075	35.1
0.030	27.0
0.020	24.4
0.012	20.4
0.008	18.7
0.006	16.6
0.004	14.9
0.003	13.1
0.002	12.4
0.001	10.3

Comments:

Reviewed:

Golder Associates

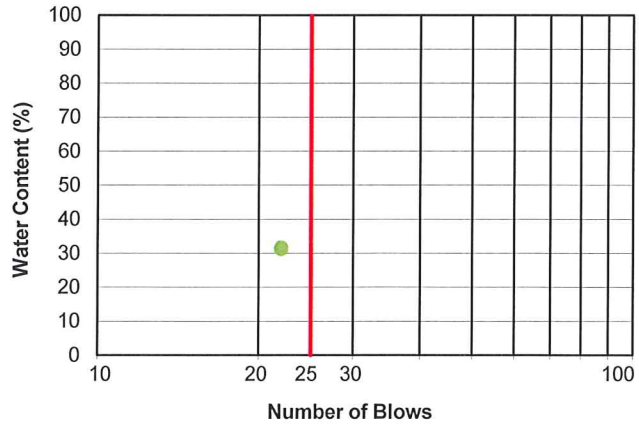
Atterberg Limits (ASTM D 4318)

Project No.:	1406422	Phase:	-
Short Title:	Benga/FeasibilityStudy/AB	Lab No.:	B580-71
Tested By:	DS	Date:	13-Aug-15

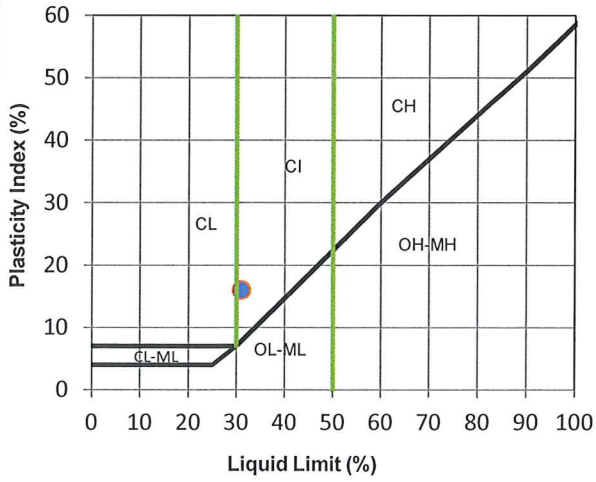
Borehole: BH15-23 Sample No.: SS6 Depth: 9.14-9.60 m

Liquid Limit Determination:			Natural Water Content:		
Number of Blows	22	22	As Received Water Content (%)		8.5%
Blow Correction Factor	0.99	0.99	**Plastic Limit Determination:**		
Mass of wet sample + tare (g)	38.65	31.80	Mass of wet sample + tare (g)	20.27	20.10
Mass of dry sample + tare (g)	35.48	29.00	Mass of dry sample + tare (g)	19.06	18.93
Mass of tare (g)	25.46	20.05	Mass of tare (g)	10.72	10.87
Weight of Water (g)	3.17	2.8	Weight of Water (g)	1.21	1.17
Weight of dry soil (g)	10.02	8.95	Weight of dry soil (g)	8.34	8.06
Water Content (%)	31.6	31.3	Water Content (%)	14.51	14.52
Liquid Limit	31.0	31.0	Average Water Content (%)		14.51

Liquid Limit Test



Plasticity chart for soil passing 425 µm sieve



Liquid Limit =	31	%
Plastic Limit =	15	%
Plasticity Index =	16	

Comments: _____

Reviewed: _____

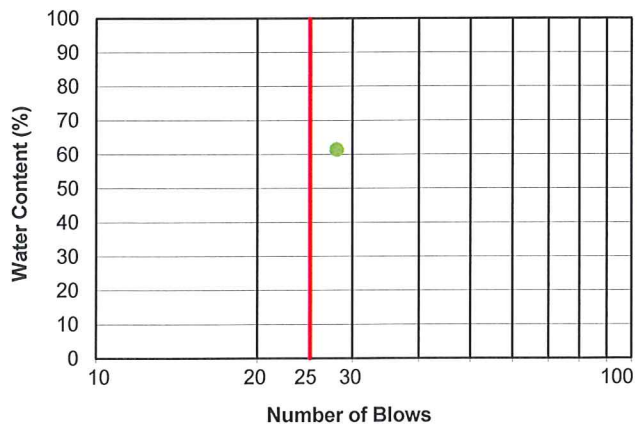
Golder Associates

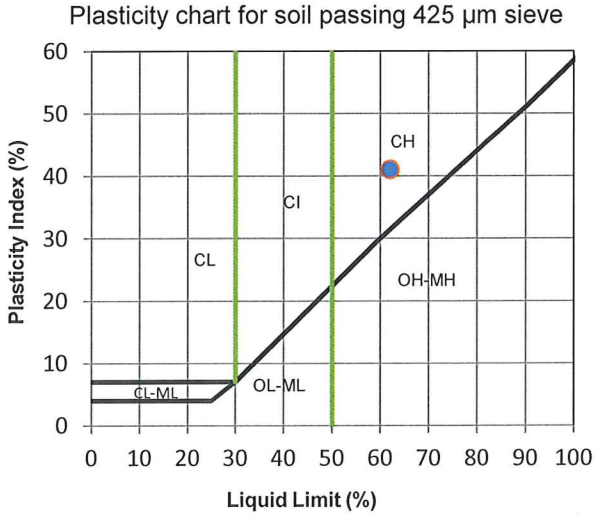
Atterberg Limits (ASTM D 4318)

Project No.:	1406422	Phase:	-
Short Title:	Benga/FeasibilityStudy/AB	Lab No.:	B580-77
Tested By:	DS	Date:	13-Aug-15

Borehole: BH15-25 Sample No.: AS1 Depth: 5.03-6.10 m

Liquid Limit Determination:			Natural Water Content:		
Number of Blows	28	28	As Received Water Content (%)		18.5%
Blow Correction Factor	1.01	1.01	**Plastic Limit Determination:**		
Mass of wet sample + tare (g)	38.20	32.71	Mass of wet sample + tare (g)	19.89	20.60
Mass of dry sample + tare (g)	33.32	28.01	Mass of dry sample + tare (g)	18.26	18.98
Mass of tare (g)	25.37	20.36	Mass of tare (g)	10.48	11.09
Weight of Water (g)	4.88	4.7	Weight of Water (g)	1.63	1.62
Weight of dry soil (g)	7.95	7.65	Weight of dry soil (g)	7.78	7.89
Water Content (%)	61.4	61.4	Water Content (%)	20.95	20.53
Liquid Limit	62.0	62.0	Average Water Content (%)		20.74





Liquid Limit =	62	%
Plastic Limit =	21	%
Plasticity Index =	41	

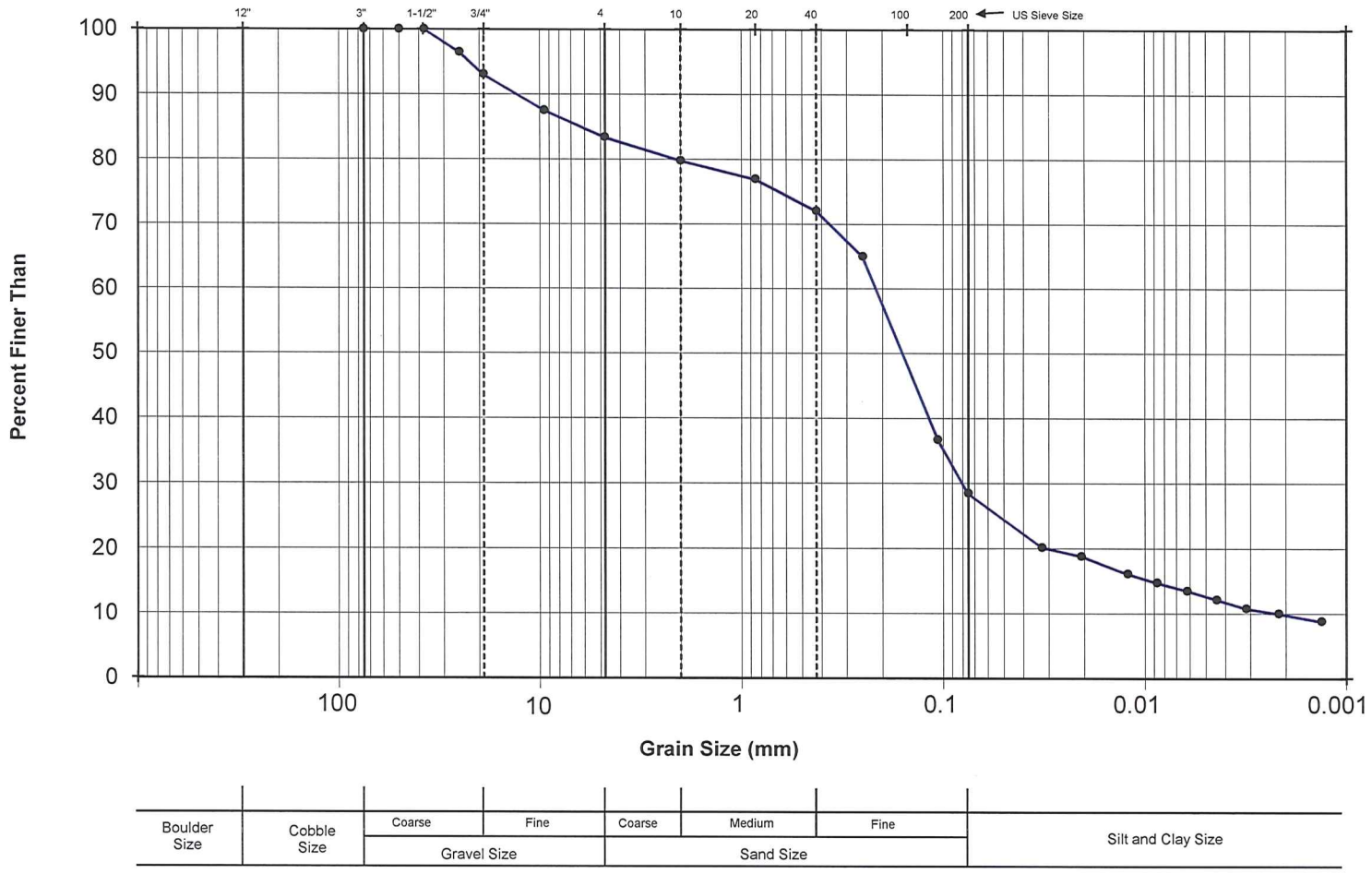
Comments: _____

Reviewed: _____

Golder Associates

Particle Size Analysis of Soil
(ASTM D422)

Project No.:	1406422	Lab No.:	B580-79
Project Title:	Benga/FeasibilityStudy/AB		
Borehole:	BH15-25	Sample No.:	SS5
Depth:	7.62 - 8.08 m		
Date Tested:	13-Aug-15	By:	DS



Diameter of Sieve (mm)	Percent Passing (%)
75.0	100.0
50.0	100.0
37.5	100.0
25.0	96.5
19.0	93.1
9.5	87.6
4.75	83.5
2.0	79.8
0.850	77.0
0.425	72.1
0.250	65.0
0.106	36.8
0.075	28.5
0.032	20.2
0.021	18.9
0.012	16.1
0.009	14.8
0.006	13.6
0.004	12.2
0.003	10.8
0.002	10.1
0.001	8.9

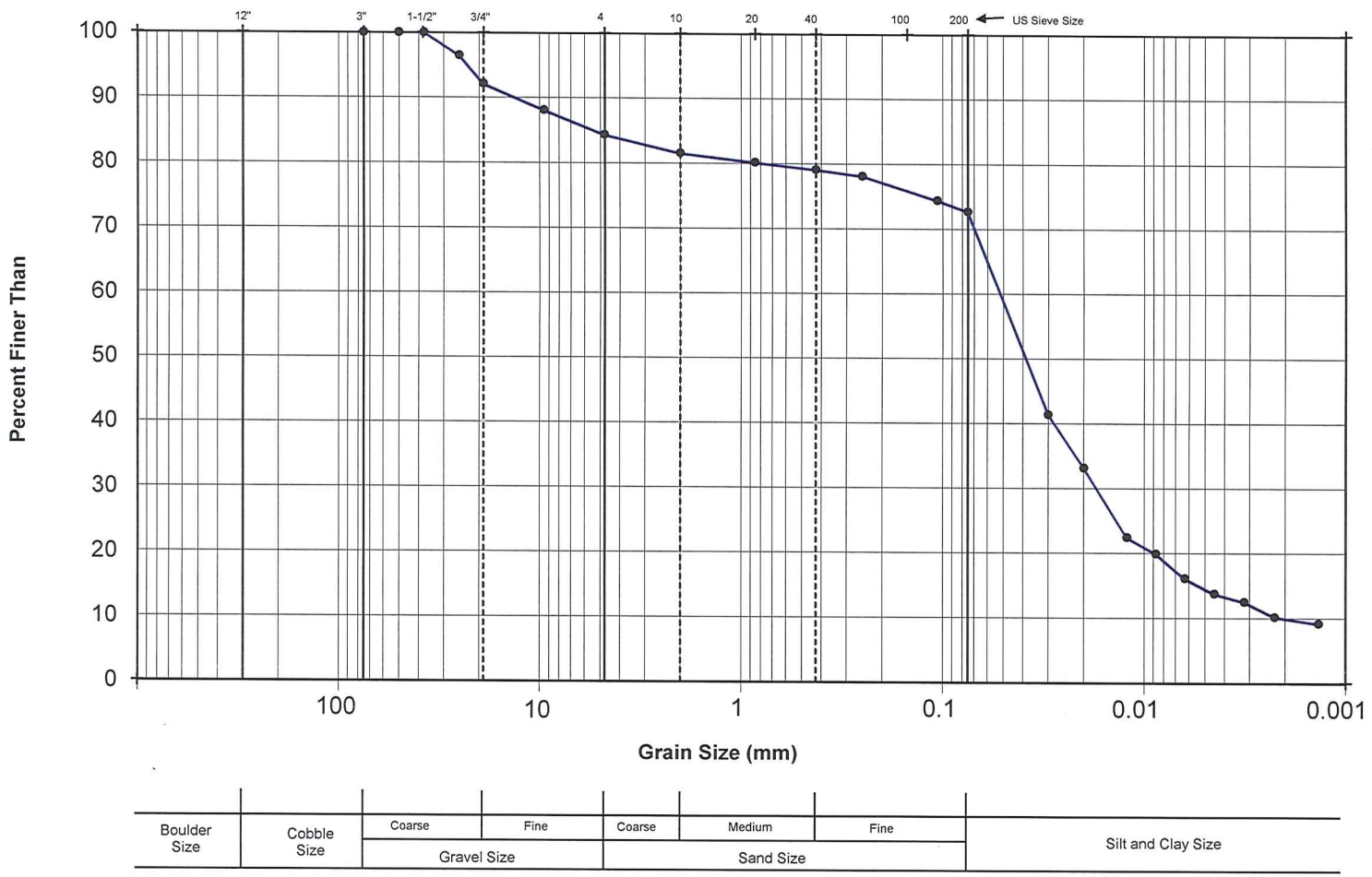
Comments:

Reviewed:

Golder Associates

Particle Size Analysis of Soil
(ASTM D422)

Project No.:	1406422	Lab No.:	B580-81
Project Title:	Benga/FeasibilityStudy/AB		
Borehole:	BH15-25	Sample No.:	SS7
Depth:	10.67 - 10.81 m		
Date Tested:	13-Aug-15	By:	DS



Diameter of Sieve (mm)	Percent Passing (%)
75.0	100.0
50.0	100.0
37.5	100.0
25.0	96.5
19.0	92.1
9.5	88.1
4.75	84.4
2.0	81.6
0.850	80.2
0.425	79.1
0.250	78.1
0.106	74.4
0.075	72.7
0.030	41.4
0.020	33.2
0.012	22.4
0.009	19.9
0.006	16.1
0.004	13.8
0.003	12.5
0.002	10.2
0.001	9.2

Comments:

Reviewed:

Golder Associates

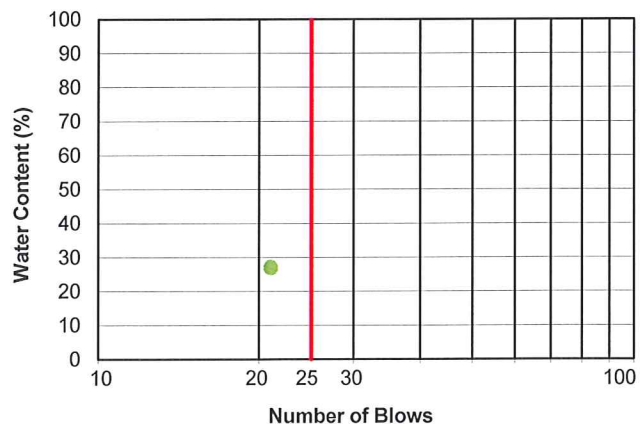
Atterberg Limits (ASTM D 4318)

Project No.:	1406422	Phase:	-
Short Title:	Benga/FeasibilityStudy/AB	Lab No.:	B580-81
Tested By:	DS	Date:	13-Aug-15

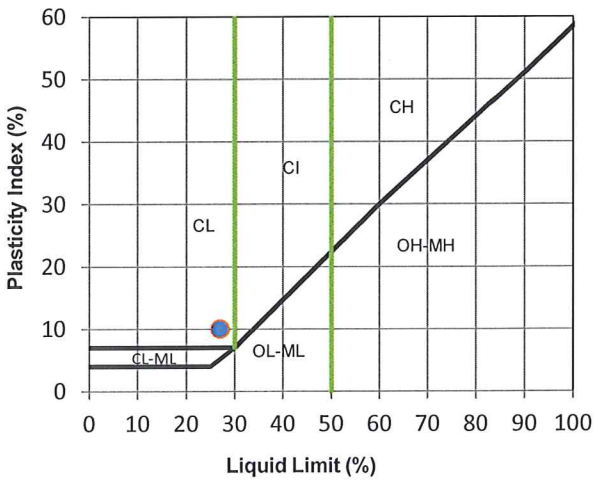
Borehole: BH15-25 Sample No.: SS7 Depth: 10.67-10.81 m

Liquid Limit Determination:			Natural Water Content:		
Number of Blows	21	21	As Received Water Content (%)		15.1%
Blow Correction Factor	0.98	0.98	**Plastic Limit Determination:**		
Mass of wet sample + tare (g)	38.32	31.89	Mass of wet sample + tare (g)	20.28	20.19
Mass of dry sample + tare (g)	35.73	30.01	Mass of dry sample + tare (g)	18.88	18.88
Mass of tare (g)	26.20	23.02	Mass of tare (g)	10.78	11.10
Weight of Water (g)	2.59	1.88	Weight of Water (g)	1.40	1.31
Weight of dry soil (g)	9.53	6.99	Weight of dry soil (g)	8.10	7.78
Water Content (%)	27.2	26.9	Water Content (%)	17.28	16.84
Liquid Limit	27.0	26.0	Average Water Content (%)		17.06

Liquid Limit Test



Plasticity chart for soil passing 425 µm sieve



Liquid Limit =	27	%
Plastic Limit =	17	%
Plasticity Index =	10	

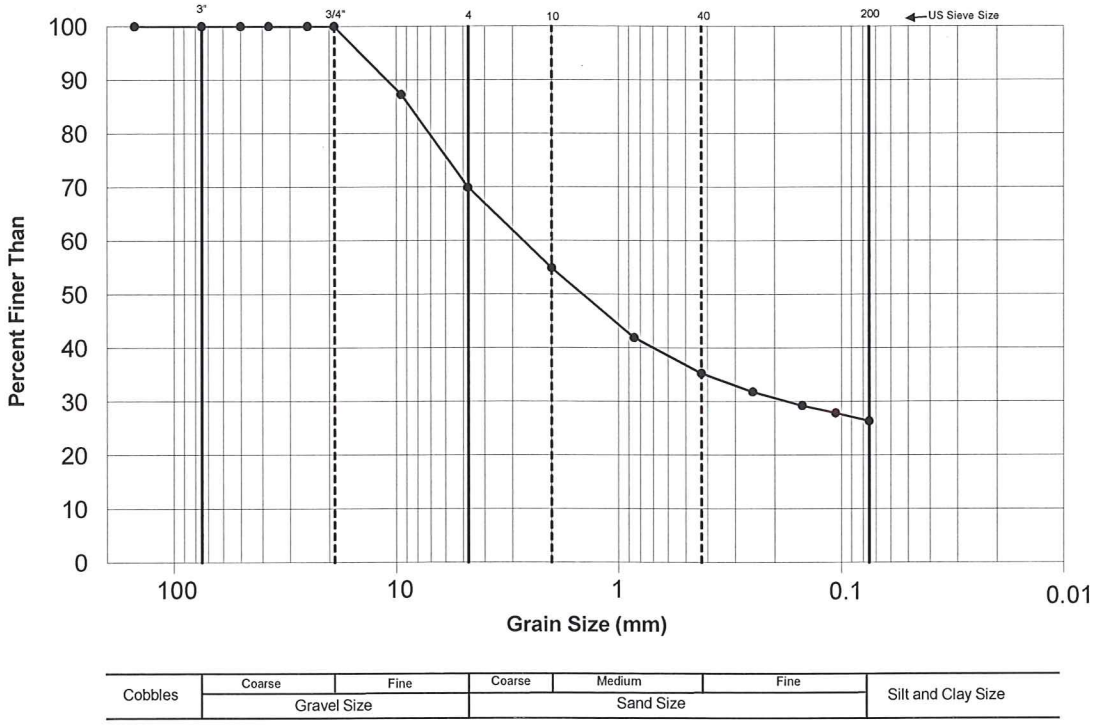
Comments: _____

Reviewed: _____

Particle Size Distribution of Soils using Sieve Analysis
(ASTM D6913-04)

Project No.:	1406422	Phase:	-		Date:	13-Aug-15
Short Title:	Benga/FeasibilityStudy/AB					
Sub Sampled By:	DS	Washed By:	-		Sieved By:	-
Field Tag No.:	-	Location:	-		BH or TP No.:	BH15-26
Lab No.:	B580-84	Northing:	-	m	Sample No.:	SS2
Sampled By:	AK	Easting:	-	m	Depth From:	3.05 m
Sample Date:	22-Jul-15	Elevation:	-	m	Depth To:	3.51 m

Test Method:	A	Drying Method:	Oven	
Composite Sieve:	Yes	if Yes, Split on:	4.75	mm
Material Exluded from Sieve:	No	Describe:		
Prior Testing on Sample:	No	Describe:		



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25	100
19	100
9.5	87
4.75	70
2	55
0.85	42
0.425	35
0.25	32
0.15	29
0.106	28
0.075	26

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
9.1	0	30	44	26	2.9	0.2	N/A	N/A	N/A

Sample Description: (SC) gravelly CLAYEY SAND, medium to coarse sand, some fine sand, fine sub-angular gravel; brown w<PL

USCS Classification: SC

Remarks:

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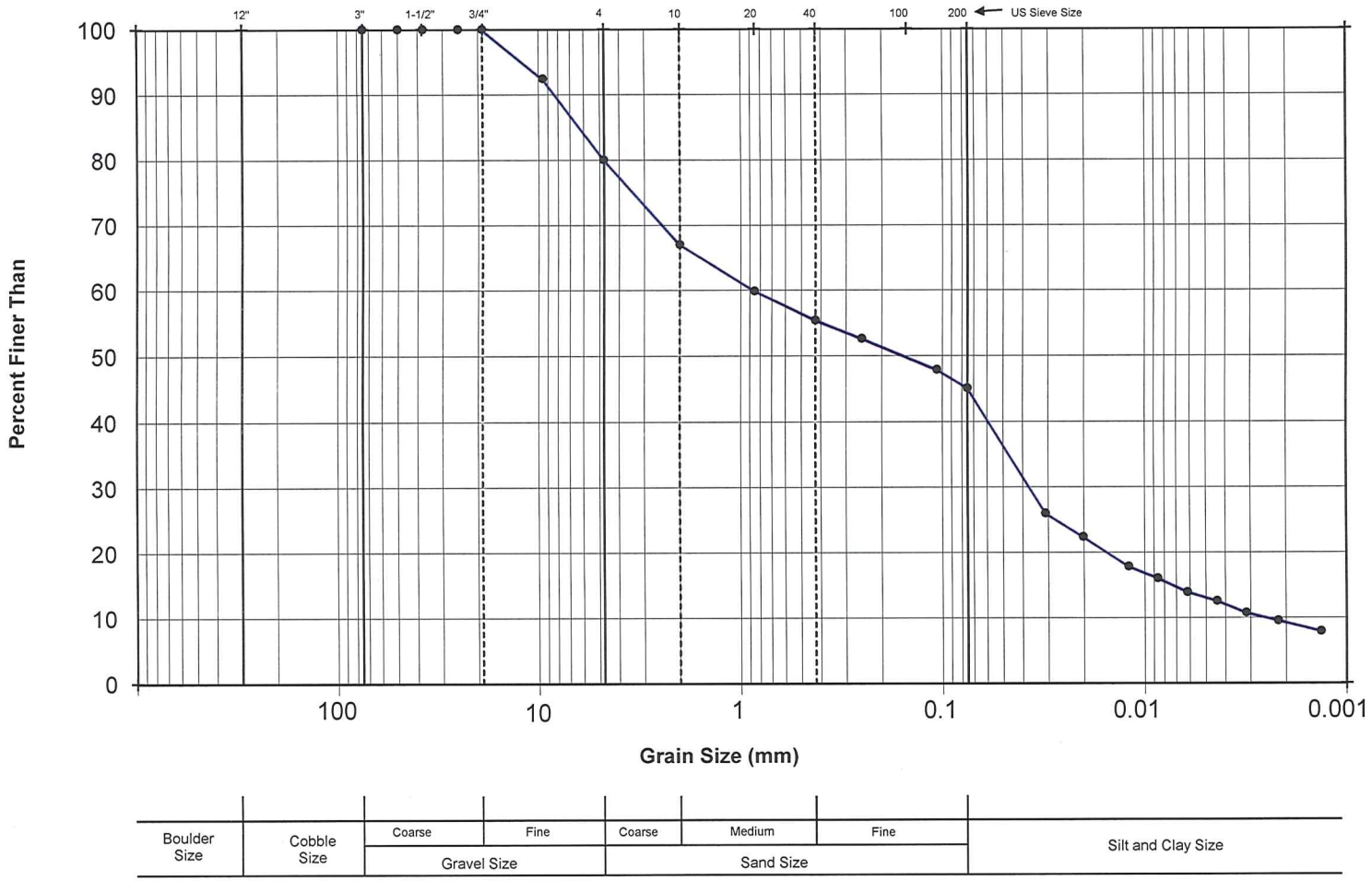
Bay 8, 820 - 28 St. NE
Calgary, AB T2A 6K1

Reviewed by: _____

Golder Associates

Particle Size Analysis of Soil
(ASTM D422)

Project No.:	1406422	Lab No.:	B580-87
Project Title:	Benga/FeasibilityStudy/AB		
Borehole:	BH15-26	Sample No.:	SS4
Depth:	6.10 - 6.38 m		
Date Tested:	13-Aug-15	By:	DS



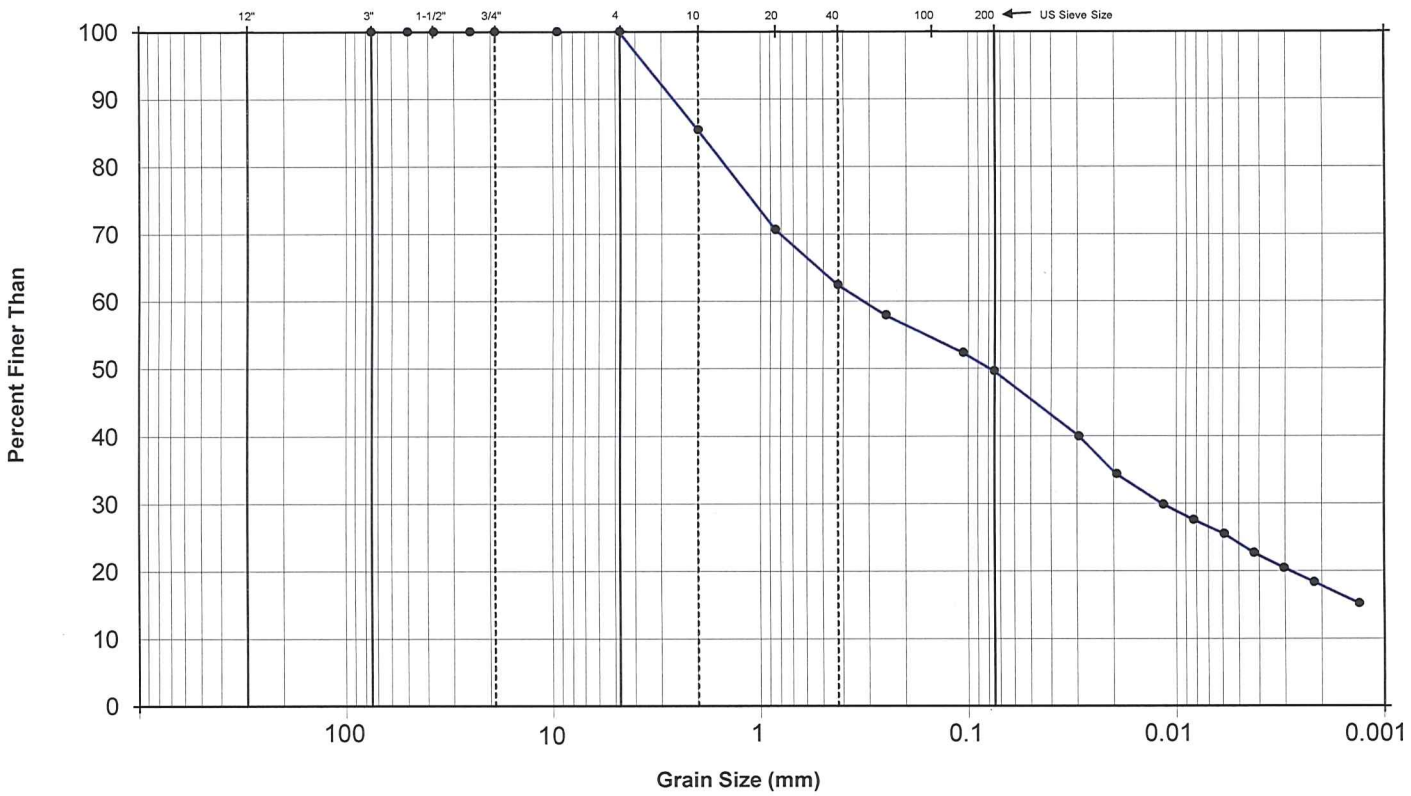
Diameter of Sieve (mm)	Percent Passing (%)
75.0	100.0
50.0	100.0
37.5	100.0
25.0	100.0
19.0	100.0
9.5	92.5
4.75	80.1
2.0	67.0
0.850	59.9
0.425	55.4
0.250	52.6
0.106	47.9
0.075	45.1
0.031	26.0
0.020	22.4
0.012	17.9
0.009	16.1
0.006	14.0
0.004	12.6
0.003	10.8
0.002	9.6
0.001	7.9

Comments:

Reviewed:

Project No.:	1406422	Lab No.:	B580-90
Project Title:	Benga/FeasibilityStudy/AB		
Borehole:	BH15-28	Sample No.:	SS1
Depth:	1.52-1.57 m		
Date Tested:	13-Aug-15	By:	DS

Particle Size Analysis of Soil
(ASTM D422)



Diameter of Sieve (mm)	Percent Passing (%)
75.0	100.0
50.0	100.0
37.5	100.0
25.0	100.0
19.0	100.0
9.5	100.0
4.75	100.0
2.0	85.5
0.850	70.7
0.425	62.4
0.250	58.0
0.106	52.4
0.075	49.6
0.029	40.0
0.019	34.4
0.012	29.9
0.008	27.6
0.006	25.6
0.004	22.7
0.003	20.5
0.002	18.4
0.001	15.3

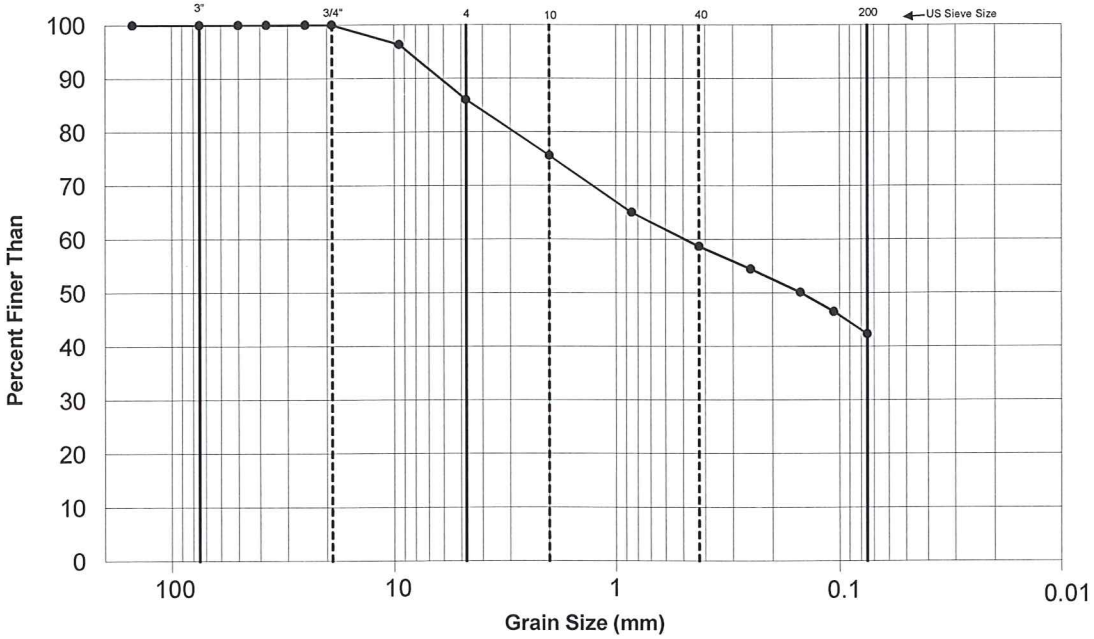
Comments:

Reviewed:

Particle Size Distribution of Soils using Sieve Analysis
(ASTM D6913-04)

Project No.:	1406422	Phase:	-		Date:	13-Aug-15
Short Title:	Benga/FeasibilityStudy/AB					
Sub Sampled By:	DS	Washed By:	-		Sieved By:	CL
Field Tag No.:	-	Location:	-		BH or TP No.:	P215-02
Lab No.:	B580-91	Northing:	-	m	Sample No.:	SS1
Sampled By:	AK	Easting:	-	m	Depth From:	1.51 m
Sample Date:	27-Jul-15	Elevation:	-	m	Depth To:	1.73 m

Test Method:	A	Drying Method:	Oven	
Composite Sieve:	Yes	if Yes, Split on:	4.75	mm
Material Exluded from Sieve:	No	Describe:		
Prior Testing on Sample:	No	Describe:		



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25	100
19	100
9.5	96
4.75	86
2	76
0.85	65
0.425	59
0.25	55
0.15	50
0.106	47
0.075	42

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
8.5	0	14	44	42	0.5	N/A	N/A	N/A	N/A

Sample Description: (SC) gravelly CLAYEY SAND, fine to coarse sand, fine sub-angular gravel; dark grey; cohesive, w<PL

USCS Classification: SC

Remarks:

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Bay 8, 820 - 28 St. NE
Calgary, AB T2A 6K1

Reviewed by: _____

Uniaxial Compressive Strength of Rock

Project No.: 1406422 Phase: -

Short Title: Benga/FeasibilityStudy/AB

Tested By: FC Date: 20-Aug-15

Borehole No.	Sample No.	Sample Depth (m)	Diameter (cm)	Height (cm)	Mass (g)	Density (kg/m^3)	Peak Force (kN)	Peak Load (MPa)
P215-01	RC9	11.0	6.020	10.646	766.27	2528.8	21.6	**7.6**
P215-01	RC13	12.8	6.040	7.332	525.91	2503.4	3.0	**1.0**
P215-02	RC9	8.5	5.970	8.672	618.99	2549.9	26.2	**9.4**
P215-02	RC23	17.1	6.030	12.430	930.55	2621.5	120.8	**42.3**

Reviewed: Digitally signed by Derek Hudson Date: 2015.08.27 14:18:32 -06'00'

Bay 8 - 820 28th Street N.E
Calgary, AB
T2A 6K1

Unconfined Compressive Strength

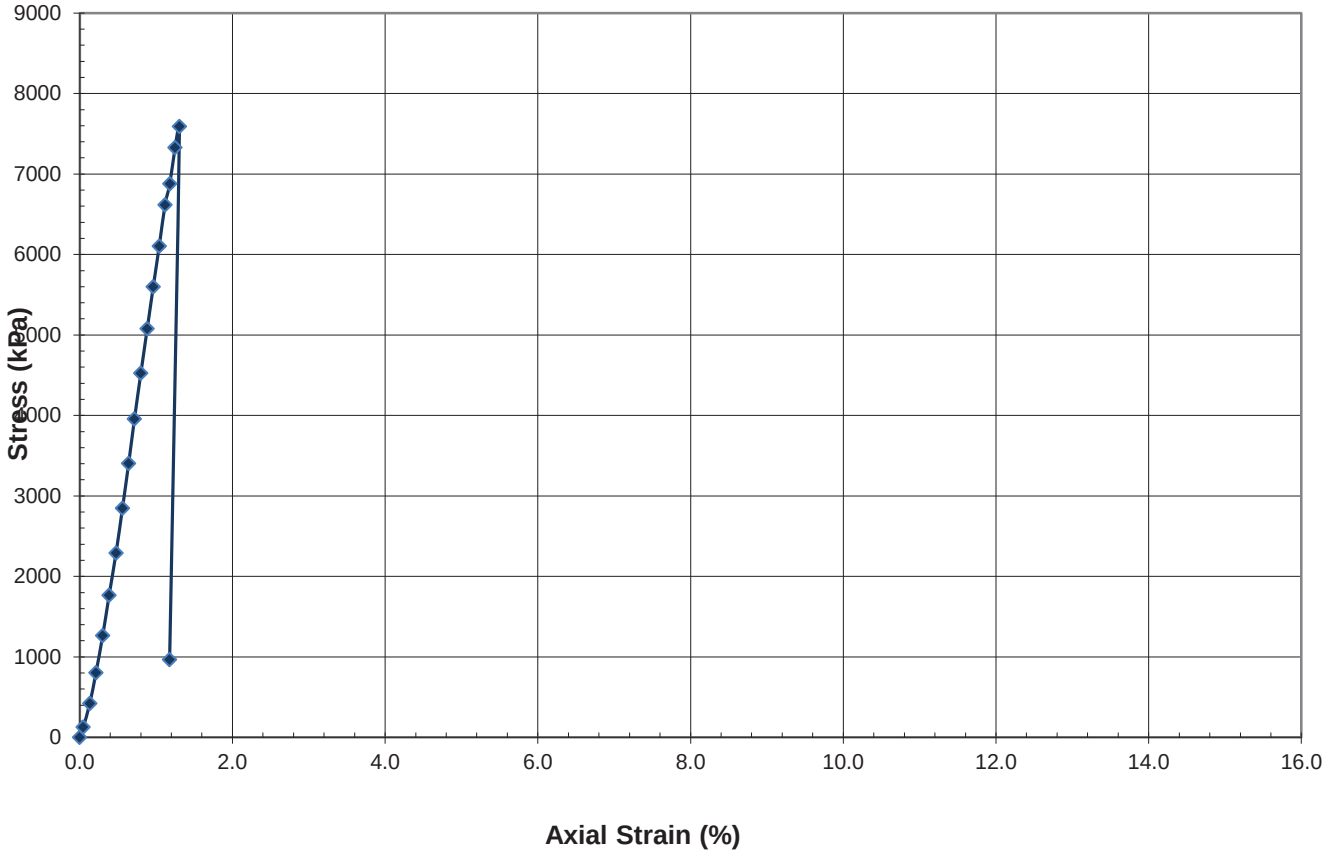
(ASTM D2166 - 06)

Project No.:	1406422	Phase:	-
Short Title:	Benga/FeasibilityStudy/AB		
Tested By:	FC	Date:	17-Aug-15

Borehole No.: P215-01 Sample No.: RC9 Depth: 11 m Lab No.: B581-01
Location: -
Visual Description: Clay Stone (Rock)

Compressive Strength (q_u):	**7591** kPa	Diameter:	6.02 cm
Shear Strength (s_u):	**3795** kPa	Height:	10.65 cm
Strain at Failure:	**1.3** %	H/D Ratio:	1.77
		Dry Density:	2443 kg/m^3
Load Rate:	0.07 MPa/sec	Water Content:	3.5 % on entire sample (posttest)
Failure Type:	Diagonal Shear	Sample Type:	Undisturbed

Plot of Unconfined Compression Test



Remarks:

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Calgary, AB T2A 6K1

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Date: 2015.08.27 14:20:39 -06'00'

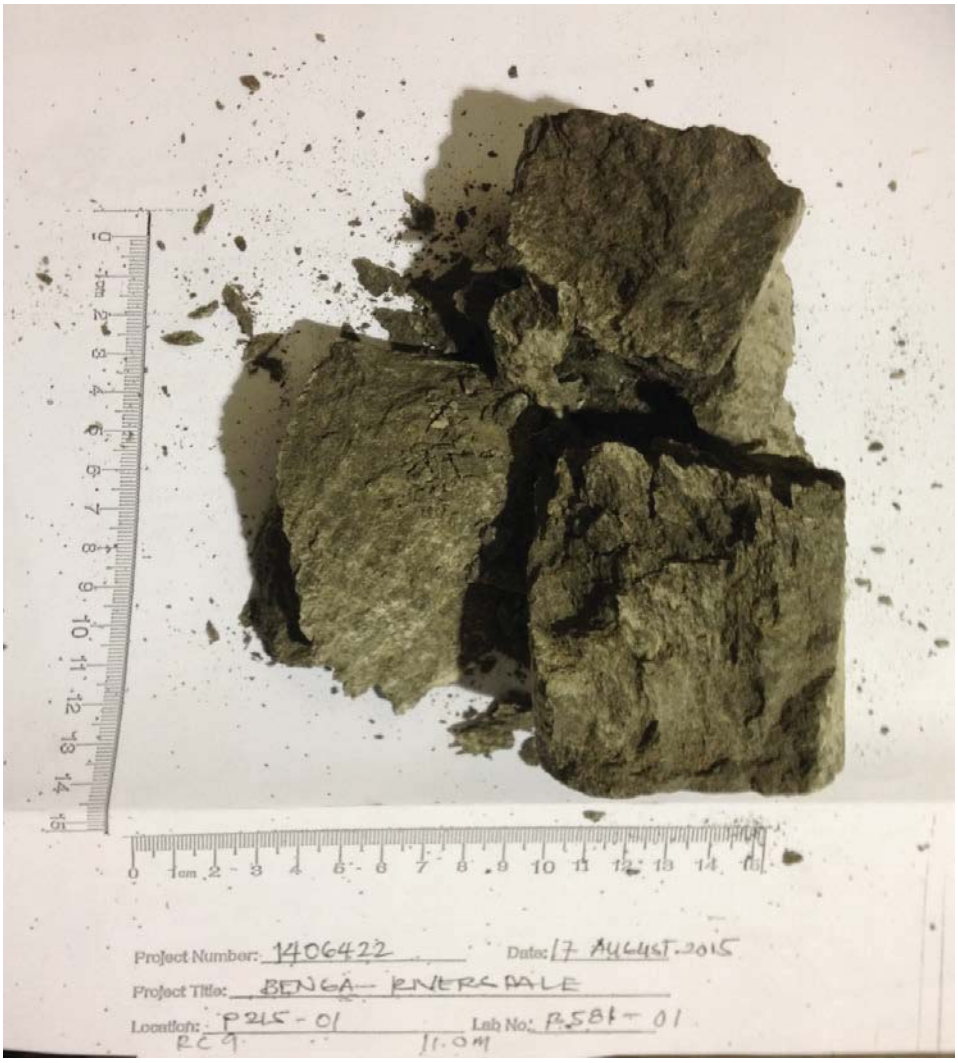
Reviewed by: _____

Unconfined Compressive Strength

(ASTM D2166 - 06)

Project No.:	1406422						Phase:	-	
Short Title:	Benga/FeasibilityStudy/AB								
Tested by:	FC						Date:	17-Aug-15	
Borehole No.:	P215-01	Sample No.:	RC9	Depth:	11	m	Lab No.:	B581-01	
Location:	-								
Visual Description:	Clay Stone (Rock)								

Post Test Photo or Sketch



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Calgary, AB T2A 6K1

Unconfined Compressive Strength

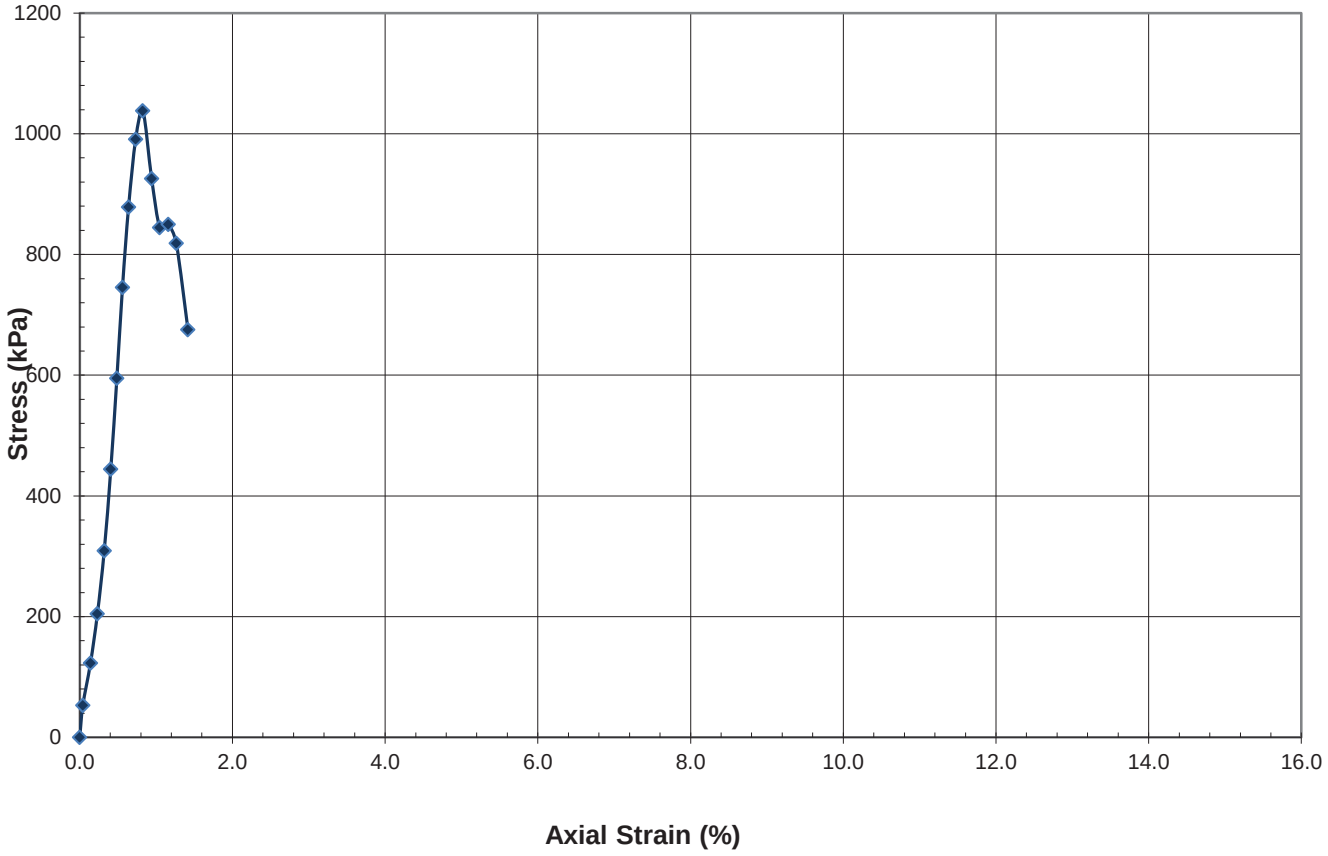
(ASTM D2166 - 06)

Project No.:	1406422	Phase:	-
Short Title:	Benga/FeasibilityStudy/AB		
Tested By:	FC	Date:	17-Aug-15

Borehole No.: P215-01 Sample No.: RC13 Depth: 12.8 m Lab No.: B581-02
Location: -
Visual Description: rock

Compressive Strength (q_u):	**1038** kPa	Diameter:	6.04 cm
Shear Strength (s_u):	**519** kPa	Height:	7.33 cm
Strain at Failure:	**0.8** %	H/D Ratio:	1.21
		Dry Density:	2412 kg/m^3
Load Rate:	0.02 MPa/sec	Water Content:	3.8 % on entire sample (posttest)
Failure Type:	Vertical Split	Sample Type:	Undisturbed

Plot of Unconfined Compression Test



Remarks:
Some vertical cracks on the end of the sample.

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Digitally signed by Derek Hudson
Date: 2015.08.27 14:20:10 -06'00'

Reviewed by: _____

Unconfined Compressive Strength

(ASTM D2166 - 06)

Project No.:	1406422	Phase:	-
Short Title:	Benga/FeasibilityStudy/AB		
Tested by:	FC	Date:	17-Aug-15

Borehole No.:	P215-01	Sample No.:	RC13	Depth:	12.8	m	Lab No.:	B581-02
Location:	-							
Visual Description:	rock							

Post Test Photo or Sketch

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Bay 8, 820 - 28 St. NE
Calgary, AB T2A 6K1

Unconfined Compressive Strength

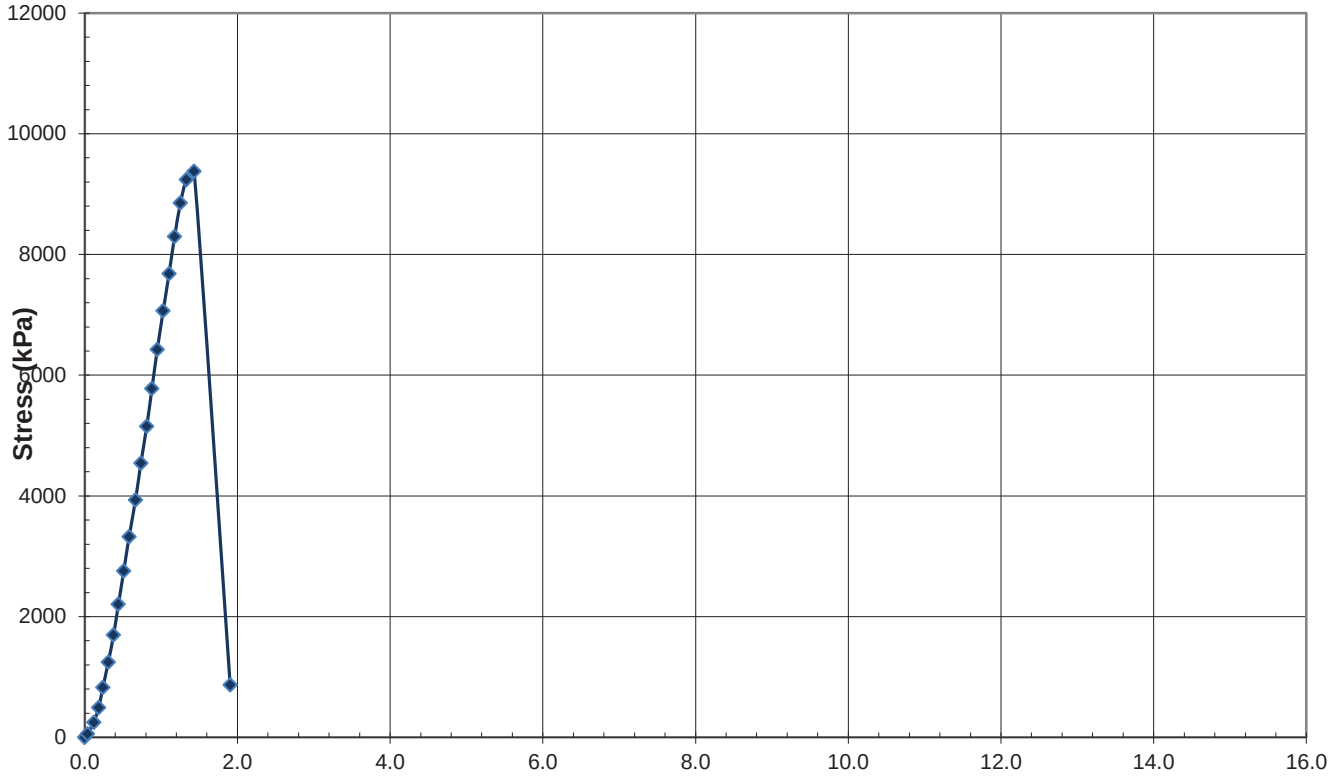
(ASTM D2166 - 06)

Project No.:	1406422	Phase:	-
Short Title:	Benga/FeasibilityStudy/AB		
Tested By:	FC	Date:	17-Aug-15

Borehole No.: P215-02 Sample No.: RC9 Depth: 8.5 m Lab No.: B581-03
Location: -
Visual Description: Rock

Compressive Strength (q_u):	**9375** kPa	Diameter:	5.97 cm
Shear Strength (s_u):	**4687** kPa	Height:	8.67 cm
Strain at Failure:	**1.4** %	H/D Ratio:	1.45
		Dry Density:	2488 kg/m^3
Load Rate:	0.10 MPa/sec	Water Content:	2.5 % on entire sample (posttest)
Failure Type:	Diagonal Shear	Sample Type:	Undisturbed

Plot of Unconfined Compression Test



Remarks:

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Calgary, AB T2A 6K1

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Date: 2015.08.27 14:21:12 -06'00'

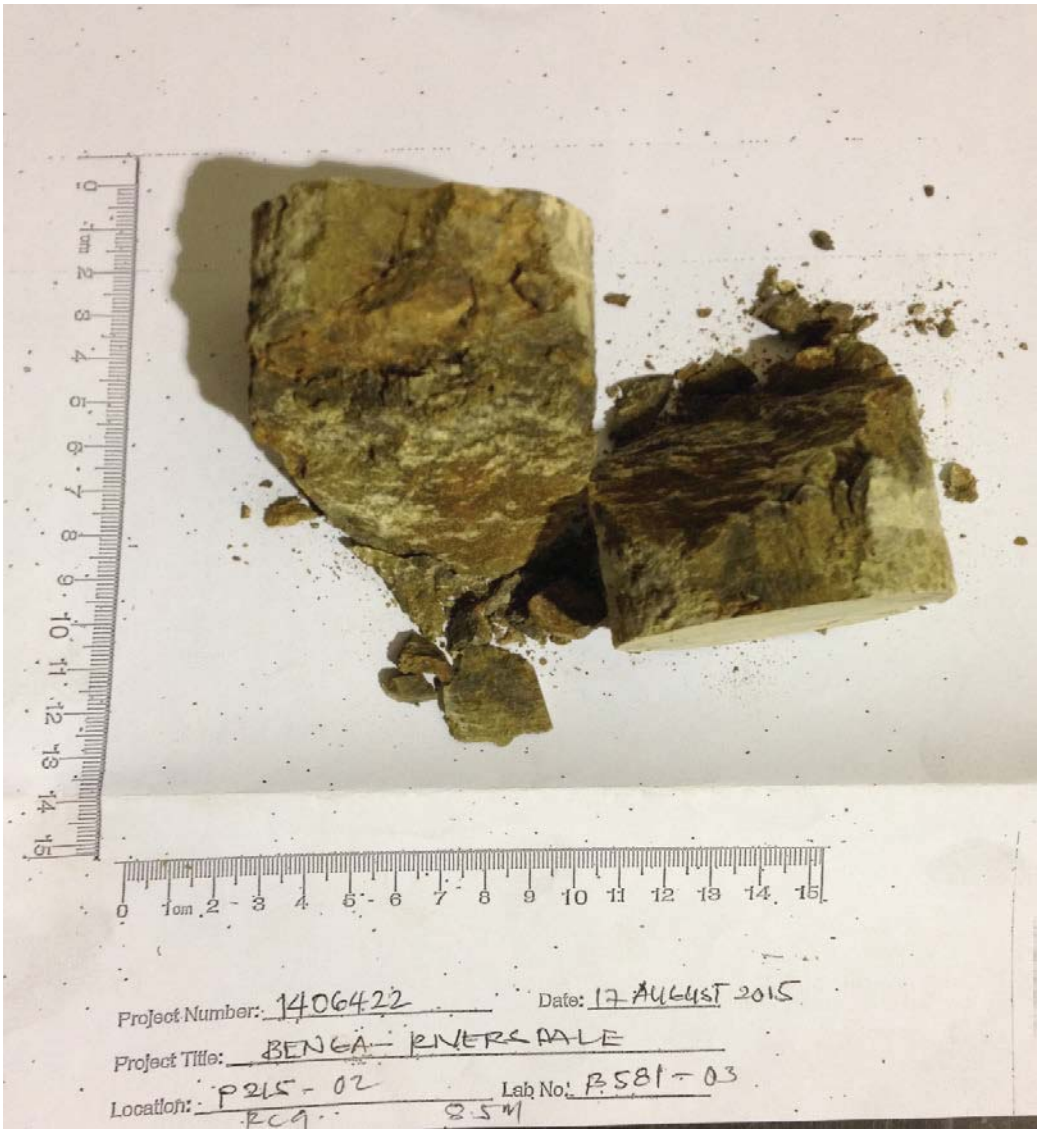
Reviewed by: _____

Unconfined Compressive Strength

(ASTM D2166 - 06)

Project No.:	1406422							Phase:	-
Short Title:	Benga/FeasibilityStudy/AB								
Tested by:	FC							Date:	17-Aug-15
Borehole No.:	P215-02	Sample No.:	RC9	Depth:	8.5	m	Lab No.:	B581-03	
Location:	-								
Visual Description:	Rock								

Post Test Photo or Sketch



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Bay 8, 820 - 28 St. NE
Calgary, AB T2A 6K1

Golder Associates

General Lab Testing Summary

Project No.: 1406422
Short Title: Benga/FeasibilityStudy/AB - Grassy Mountain - Waste Dump/Pond
Tested By: DS

Phase: -
Sched: B683
Date: 10-Nov-15

Sample Identification					Laboratory Test Results					
Borehole No.	Sample No.	Depth (m) from	Depth (m) to	Lab No.	Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	SPMDD (kg/m^3)	Optimum w (%)
BH15-01	SS4	3.05	3.51	B683-04	17.7					
	SS6	4.57	5.03	B683-06	17.3	33	15	18		
	SS8	6.10	6.55	B683-08	10.0					
	SS10	7.62	8.08	B683-10	12.0					
	SS12A	9.14	9.47	B683-12	10.3					
	SS14	10.67	11.00	B683-15	4.9					
BH15-02	SS4	3.05	3.51	B683-19	12.7					
	SS6	4.57	5.03	B683-21	11.1					
	SS8	6.10	6.55	B683-23	11.1	30	16	14		
	SS10	7.62	8.08	B683-25	6.9					
BH15-04	SS2	1.52	1.98	B683-29	5.4					
BH15-29	SS2	1.52	1.98	B683-35	5.7					
BH15-29A	SS4	3.05	3.51	B683-37	5.6					

Reviewed By:

Golder Associates

General Lab Testing Summary

Project No.: 1406422
Short Title: Benga/FeasibilityStudy/AB - Grassy Mountain - Waste Dump/Pond
Tested By: DS

Phase: -
Sched: B683
Date: 10-Nov-15

Sample Identification					Laboratory Test Results					
Borehole No.	Sample No.	Depth (m) from	Depth (m) to	Lab No.	Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	SPMDD (kg/m^3)	Optimum w (%)
BH15-30	SS2	1.52	1.98	B683-41	9.1					
	SS4	3.05	3.51	B683-43	18.0					
	SS6	4.57	5.03	B683-45	12.2					
	SS8	6.10	6.55	B683-47	19.2					
	SS10	7.62	8.08	B683-49	18.3					
	SS12	9.14	9.60	B683-51	11.0					
BH15-31	SS2	1.52	1.98	B683-55	21.3					
	SS4	3.05	3.51	B683-57	12.6					
	SS6	4.57	5.03	B683-59	20.3					
	SS8	6.10	6.55	B683-61	19.1					
	SS10	7.62	8.08	B683-63	23.5	37	16	21		
	SS12	9.14	9.60	B683-65	28.1					
	SS14	10.67	11.13	B683-67	16.3					

Reviewed By: _____

Golder Associates

General Lab Testing Summary

Project No.: 1406422 Phase: -
Short Title: Benga/FeasibilityStudy/AB - Grassy Mountain - Waste Dump/Pond Sched: B683
Tested By: DS Date: 10-Nov-15

Sample Identification					Laboratory Test Results					
Borehole No.	Sample No.	Depth (m) from	Depth (m) to	Lab No.	Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	SPMDD (kg/m^3)	Optimum w (%)
BH15-32	SS2	1.52	1.98	B683-69	11.1					
	SS4	3.05	3.51	B683-72	16.6					
	SS6	4.57	5.03	B683-74	25.4					
	SS8	6.10	6.55	B683-76	24.2					
	SS10	7.62	8.08	B683-78	25.1					
	SS12	9.14	9.60	B683-80	24.9					
	SS14	10.67	11.13	B683-82	19.6					
TP15-01A	GS1	3.5	3.6	B683-83	15.6					
TP15-04	GS1	3.7	3.8	B683-86	19.3					
TP15-05	GS1	2.6	2.9	B683-88	17.4					
TP15-06	GS1	3.5	3.6	B683-90	13.6					
TP15-07	GS1	3.2	3.3	B683-91	10.5					
TP15-08	GS2	3.3	3.4	B683-93	13.0					
TP15-10	GS1	4	4.1	B683-96	13.5					
TP15-11	GS1	3.8	3.9	B683-97	9.6					

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Golder Associates

Atterberg Limits (ASTM D 4318)

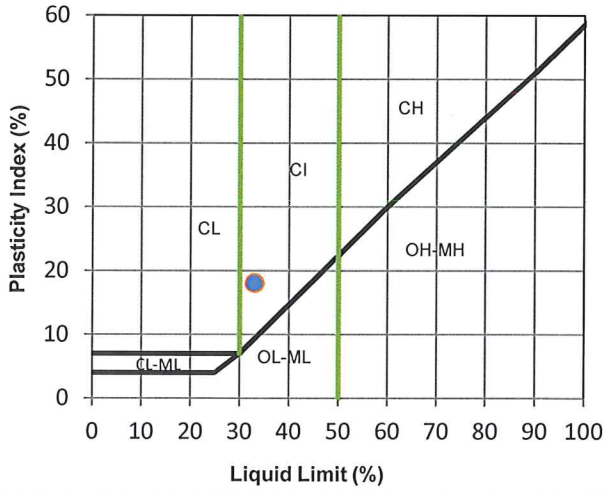
Project No.:	1406422	Phase:	-
Short Title:	Benga/FeasibilityStudy/AB - Grassy Mountain - Waste Dump/Pond	Lab No.:	B683-06
Tested By:	DS	Date:	10-Nov-15

Borehole: BH15-01 Sample No.: SS6 Depth: 4.57-5.03 m

Liquid Limit Determination:			Natural Water Content:		
Number of Blows	20	20	As Received Water Content (%)		17.3%
Blow Correction Factor	0.97	0.97	**Plastic Limit Determination:**		
Mass of wet sample + tare (g)	32.48	40.08	Mass of wet sample + tare (g)	21.91	20.23
Mass of dry sample + tare (g)	28.84	36.51	Mass of dry sample + tare (g)	20.48	19.03
Mass of tare (g)	18.25	26.02	Mass of tare (g)	10.83	11.06
Weight of Water (g)	3.64	3.57	Weight of Water (g)	1.43	1.20
Weight of dry soil (g)	10.59	10.49	Weight of dry soil (g)	9.65	7.97
Water Content (%)	34.4	34.0	Water Content (%)	14.82	15.06
Liquid Limit	33.0	33.0	Average Water Content (%)		14.94

Liquid Limit Test

Plasticity chart for soil passing 425 µm sieve



Liquid Limit =	33	%
Plastic Limit =	15	%
Plasticity Index =	18	

Comments: _____

Reviewed: _____

Golder Associates

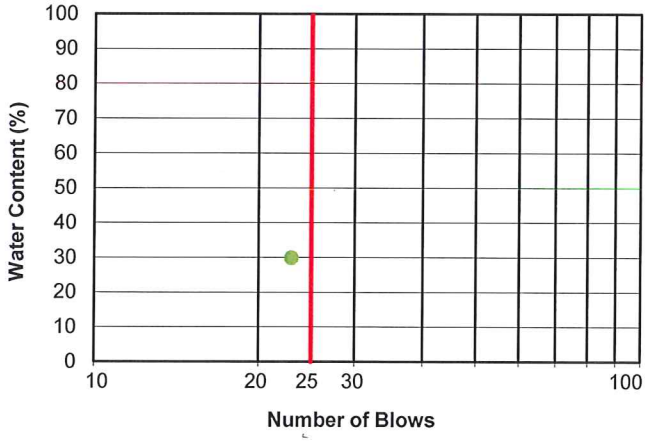
Atterberg Limits (ASTM D 4318)

Project No.:	1406422	Phase:	-
Short Title:	Benga/FeasibilityStudy/AB - Grassy Mountain - Waste Dump/Pond	Lab No.:	B683-23
Tested By:	DS	Date:	10-Nov-15

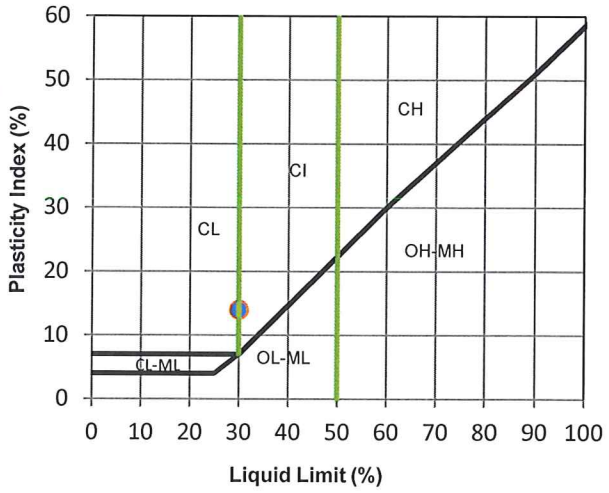
Borehole: BH15-02 Sample No.: SS8 Depth: 6.10-6.55 m

Liquid Limit Determination:			Natural Water Content:		
Number of Blows	23	23	As Received Water Content (%)		11.1%
Blow Correction Factor	0.99	0.99	**Plastic Limit Determination:**		
Mass of wet sample + tare (g)	37.99	35.09	Mass of wet sample + tare (g)	20.60	20.66
Mass of dry sample + tare (g)	34.80	31.50	Mass of dry sample + tare (g)	19.30	19.30
Mass of tare (g)	24.16	19.50	Mass of tare (g)	11.06	10.65
Weight of Water (g)	3.19	3.59	Weight of Water (g)	1.30	1.36
Weight of dry soil (g)	10.64	12	Weight of dry soil (g)	8.24	8.65
Water Content (%)	30.0	29.9	Water Content (%)	15.78	15.72
Liquid Limit	30.0	30.0	Average Water Content (%)		15.75

Liquid Limit Test



Plasticity chart for soil passing 425 µm sieve



Liquid Limit = 30 %
Plastic Limit = 16 %
Plasticity Index = 14

Comments: _____

Reviewed: _____

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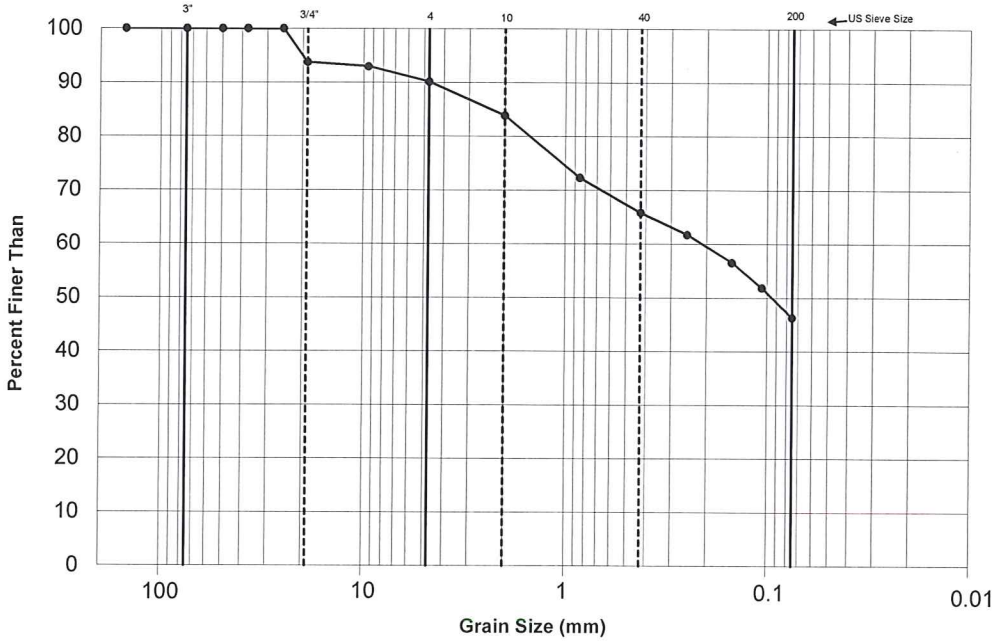
Particle Size Distribution of Soils using Sieve Analysis

(ASTM D6913-04)

Project No.:	1406422	Phase:	-	Date:	10-Nov-15
Short Title:	Benga/FeasibilityStudy/AB - Grassy Mountain - Waste Dump/Pond				
Sub Sampled By:	DS	Washed By:	DS	Sieved By:	DS
Field Tag No.:	-	Location:	-	BH or TP No.:	BH15-30
Lab No.:	B683-47	Northing:	- m	Sample No.:	SS8
Sampled By:	H. Marwasi	Easting:	- m	Depth From:	6.10 m
Sample Date:	4-Nov-15	Elevation:	- m	Depth To:	6.55 m

Test Method:	A	Drying Method:	Oven	
Composite Sieve:	Yes	if Yes, Split on:	4.75	mm
Material Exluded from Sieve:	No	Describe:		
Prior Testing on Sample:	No	Describe:		



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25	100
19	94
9.5	93
4.75	90
2	84
0.85	72
0.425	66
0.25	62
0.15	57
0.106	52
0.075	46

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
19.2	0	10	44	46	0.2	N/A	N/A	N/A	N/A

Sample Description: (SC) CLAYEY SAND, fine to medium sand, some coarse sand, trace fine sub-angular gravel; dark brown; cohesive, w > PL

USCS Classification: SC

Remarks:

The testing services reported herein have been performed in accordance with the indicated recognized standard, or in accordance with local industry practice. This report is for the sole use of the designated client. This report constitutes a testing service only and does not represent any results interpretation or opinion regarding specification compliance or material suitability. Engineering interpretation can be provided by Golder Associates Ltd. upon request.

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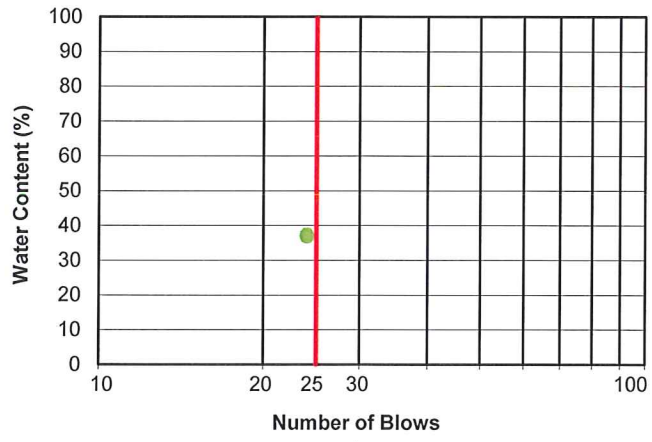
Atterberg Limits (ASTM D 4318)

Project No.:	1406422	Phase:	-
Short Title:	Benga/FeasibilityStudy/AB - Grassy Mountain - Waste Dump/Pond	Lab No.:	B683-63
Tested By:	DS	Date:	10-Nov-15

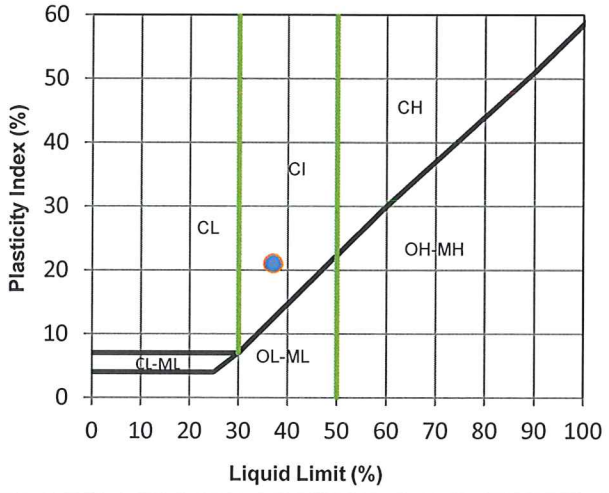
Borehole: BH15-31 Sample No.: SS10 Depth: 7.62-8.08 m

Liquid Limit Determination:			Natural Water Content:		
Number of Blows	24	24	As Received Water Content (%)		23.5%
Blow Correction Factor	1.00	1.00	**Plastic Limit Determination:**		
Mass of wet sample + tare (g)	40.01	40.79	Mass of wet sample + tare (g)	20.52	20.67
Mass of dry sample + tare (g)	36.45	36.87	Mass of dry sample + tare (g)	19.16	19.27
Mass of tare (g)	26.90	26.25	Mass of tare (g)	10.80	10.73
Weight of Water (g)	3.56	3.92	Weight of Water (g)	1.36	1.40
Weight of dry soil (g)	9.55	10.62	Weight of dry soil (g)	8.36	8.54
Water Content (%)	37.3	36.9	Water Content (%)	16.27	16.39
Liquid Limit	37.0	37.0	Average Water Content (%)		16.33

Liquid Limit Test



Plasticity chart for soil passing 425 µm sieve



Liquid Limit =	37	%
Plastic Limit =	16	%
Plasticity Index =	21	

Comments: _____

Reviewed: _____

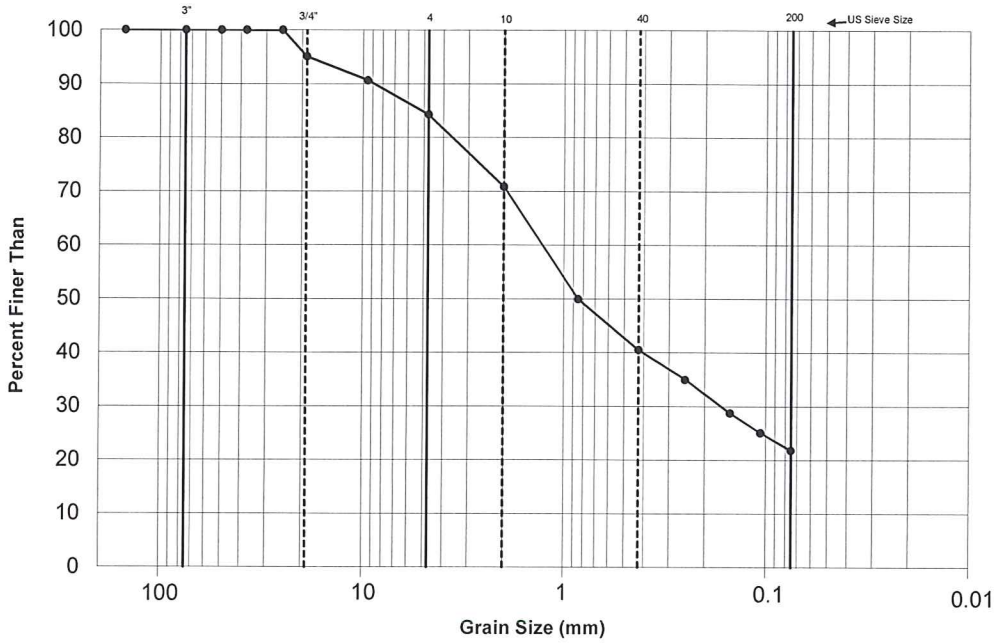
Golder Associates

Particle Size Distribution of Soils using Sieve Analysis

(ASTM D6913-04)

Project No.:	1406422	Phase:	-			Date:	10-Nov-15
Short Title:	Benga/FeasibilityStudy/AB - Grassy Mountain - Waste Dump/Pond						
Sub Sampled By:	DS	Washed By:	DS			Sieved By:	DS
Field Tag No.:	-	Location:	-			BH or TP No.:	TP15-02
Lab No.:	B683-84	Northing:	-	m		Sample No.:	GS1
Sampled By:	H. Marwasi	Easting:	-	m		Depth From:	1.50 m
Sample Date:	6-Nov-15	Elevation:	-	m		Depth To:	2.00 m

Test Method:	A	Drying Method:	Oven	
Composite Sieve:	Yes	if Yes, Split on:	4.75	mm
Material Exluded from Sieve:	No	Describe:		
Prior Testing on Sample:	Yes	Describe:	1 pc gravel (retaining 50mm sieve) 286 g	



Sieve Size (mm)	Passing %
150	100
75	100
50	100
37.5	100
25	100
19	95
9.5	91
4.75	84
2	71
0.85	50
0.425	41
0.25	35
0.15	29
0.106	25
0.075	22

Received Water Content (%)	Cobbles (%)	Gravel (%)	Sand (%)	Fines (%)	D60 (mm)	D30 (mm)	D10 (mm)	Cu	Cc
10.5	0	16	62	22	1.4	0.2	N/A	N/A	N/A

Sample Description: (SM) gravelly SILTY SAND, fine to coarse sand, some fine sub-angular gravel; orange-brown; non-cohesive, moist

USCS Classification: SM

Remarks:

The testing services reported herein have been performed in accordance with the indicated recognized standard, or in accordance with local industry practice. This report is for the sole use of the designated client. This report constitutes a testing service only and does not represent any results interpretation or opinion regarding specification compliance or material suitability. Engineering interpretation can be provided by Golder Associates Ltd. upon request.

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Golder Associates

Appendix 9b

Preliminary Pit Slope Stability Assessment (Golder, April 2015)

April 24, 2015

REPORT ON

Grassy Mountain Preliminary Pit Slope Stability Assessment

Submitted to:
Riversdale Resources Ltd
PO Box 660
12331 20th Avenue
Blairmore Alberta
T0K 0E0

Attention: David Leslie

Reference Number: 1406422-001-R-Rev0-2.0
Client Number: 2850-MN-0001-0

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REPORT

Golder Associates

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Table of Contents

STUDY LIMITATIONS ..... **i**

1.0 INTRODUCTION **1**

1.1 Project Background 1

1.2 Site Description 2

2.0 GEOLOGICAL CONDITIONS **3**

2.1 Geology 3

2.1.1 Coal 3

2.1.2 Soil and Weathered Bedrock Cover 4

2.2 Structural Geology 4

3.0 FIELD INVESTIGATIONS **5**

3.1 Geotechnical Drilling Program 5

3.2 Rock Strength Testing 6

3.3 Downhole Geophysical Logging 6

3.4 Hydrogeological Field Program 7

4.0 GRASSY MOUNTAIN ENGINEERING GEOLOGY **8**

4.1 Intact Rock Strength 8

4.1.1 Field Strength Estimate 8

4.1.2 Laboratory UCS Rock Strength 9

4.1.3 Point Load Strength Index 11

4.2 Discontinuity Characterization 12

4.2.1 Rock Structure 12

4.2.2 Joint Condition Rating 12

4.3 Rock Mass Quality 14

4.4 Hydrogeological Characterization 16

4.4.1 Hydraulic Conductivity 16

5.0 COAL GEOLOGY AND FAULT INTERPRETATION MODEL **17**

6.0 GENERAL COAL MINE PIT SLOPE STABILITY CONSIDERATIONS **20**

6.1 Rock Slope Failure Mechanisms 20

6.2 Slope Design Definitions 20
6.3 Slope Design Methodology 22
6.3.1 Footwall Slope 22
6.3.2 Highwall Slopes 23
6.3.3 Endwall Slope 23
6.3.4 Soil and Extremely Weak Rock Slopes 24
7.0 GRASSY MOUNTAIN SPECIFIC SLOPE DESIGN CRITERIA 25
7.1 Kinematic Bench-Scale Assessment 25
7.1.1 West Pit 25
7.1.1.1 Highwall Slope Design Criteria 26
7.1.1.2 Footwall Slope Design Criteria 26
7.1.2 Central Pit 27
7.1.2.1 Highwall Slope Design Criteria 27
7.1.2.2 Footwall Slope Design Criteria 28
7.1.3 East Pit 28
7.1.3.1 Highwall Slope Design Criteria 28
7.1.3.2 Footwall Slope Design Criteria 29
7.1.4 Endwalls 29
8.0 SUMMARY OF RECOMMENDED BENCH DESIGN CRITERIA 30
9.0 FURTHER GEOTECHNICAL ASSESSMENT 35
9.1 Slope Stability Analysis 35
9.2 Geotechnical Site Investigation 35
9.3 Confirmatory Investigations 35
10.0 CLOSURE 37

TABLES

Table 1: Summary of Observed Coal Thickness (Norwest, 2013) 3
Table 2: Summary of Geotechnical Drilling Program 5
Table 3: Summary of UCS Test Results 10
Table 4: Summary of Point Load Strength Index Results 11
Table 5: Rock Mass Rating System (Bieniawski, 1976) 14

Table 6: Summary of Weighted RMR_{76} Classification Values 15

Table 7: Summary of Recommended Design Criteria and Slope Stability Considerations – 12 m Bench Heights..... 31

Table 8: Summary of Recommended Design Criteria and Slope Stability Considerations – 15 m Bench Heights..... 33

PLATES

Plate 1: Planar Feature on Borehole Wall (left) and Sinusoid in Unwrapped Televiewer Image (right) 7

Plate 2: ISRM Estimated Field Strength by Geological Formation 9

Plate 3: Distribution of Geotechnical Interval Joint Condition Rating (JCR) Values for 2014 Geotechnical Drilling Program..... 13

Plate 4: RMR_{76} Distribution - All Borehole Data..... 15

Plate 5: Schematic Representation of Bench Face Angle (BFA), Inter-ramp Angle (IRA) and Overall Slope Angle (OSA) 21

APPENDICES

APPENDIX A
Site Photographs

APPENDIX B
Core Logging Data Downhole Borehole Plots

APPENDIX C
Rock Strength Assessment

APPENDIX D
Discontinuity Characterization

APPENDIX E
Rock Mass Quality Assessment

APPENDIX F
Hydrogeological Field Data Technical Memo

APPENDIX G
Geological Cross Sections

APPENDIX H
Pit Slope Stability Considerations

APPENDIX I
Pit Slope Stability Assessment

1.0 INTRODUCTION

Riversdale Resources Limited (Riversdale), through its wholly owned subsidiary Benga Mining Limited, is preparing a Feasibility level study to assess open pit coal mining operations for the Grassy Mountain Project, located near Blairmore in southwest Alberta. Golder Associates Ltd. (Golder) has been retained by Riversdale to carry out a pit slope stability assessment of the proposed open pit development at the Grassy Mountain and to provide preliminary pit slope design criteria.

The pit slope stability assessment consisted of a field investigation and data collection phase, and an analysis and design reporting phase. The purpose of this work is to provide geotechnical design criteria for the feasibility level mine design. This report presents the results of the field investigations, slope stability assessment and recommended pit slope design criteria.

The results of the hydrogeological field investigation are presented in the Golder's report entitled "Packer Testing and Nested Vibrating Wire Piezometer Installation" (Golder, 2014a), presented in Appendix E.

The work was carried out in general accordance with the Golder proposal referenced P1406646, dated June 20, 2014.

1.1 Project Background

Riversdale are currently preparing a Feasibility level study to assess open pit coal mining operations for the Grassy Mountain Project. Riversdale have completed a National Instrument (NI) 403-101 preliminary economic assessment study for the Grassy Mountain project. The PEA study was prepared by Norwest Corporation (Norwest), report referenced 529-1 and dated April 5, 2013 (Norwest, 2013). The coal is suitable as a source for coking and pulverised coal injection for the production of the coke for the steel making, in additional for use as thermal coal.

Historically, the Grassy Mountain site has been subjected to several mining campaigns, including both surface open pit and underground workings. Underground mining operations commenced in in the Grassy Mountain area in 1913 with the start-up of the Greenhill Mine. Underground operations ceased in 1960. Open pits operated within the Grassy Mountain surface mine area from 1956 to 1960, and 1974 to 1975. The last exploration activities within the Grassy Mountain surface mine area took place in 1975.

Coal is planned to be transported by conveyor from the on-site coal handling processing plant to rail loading facilities located in Blairmore. Coal is to then to be transported on the main Canadian Pacific rail line to Westshore or Neptune port facilities in Vancouver.

1.2 Site Description

The proposed open pit coal mine area is located 6.5 km north of the town of Blairmore, in southwest Alberta (Figure 1). The site can be accessed via the gravel Grassy Mountain road, located on Benga Mining Limited freehold property, which connects directly with Alberta Highway No.3. The site is bounded to the east by privately held property and to the west by Blairmore Creek. The natural Grassy Mountain catchment drains into the two creeks which flow south into the Crowsnest River, located near Blairmore.

Topographic elevations at Grassy Mountain range from approximately 2,100 metres to 1,460 metres. Topography is steep at the highest elevations, characterised by a narrow north to south trending ridgeline with local bedrock cliffs formed by fault scarps. Topography becomes moderate to gentle sloping towards the lower elevations of the site. A combination of hill slope processes and materials transported in natural drainage paths have formed gentle sloping and hummocky in the lowest elevations at Grassy Mountain.

Privately held property surrounds the Grassy Mountain site. Established forestry roads, and newly formed exploration trails provide site access for four-wheel drive vehicles, and drilling and earthmoving equipment.

A record of site photography obtained during the site geotechnical investigations carried out for this study is presented in Appendix A.

2.0 GEOLOGICAL CONDITIONS

2.1 Geology

The Grassy Mountain Project site is located in southwest Alberta within the Rocky Mountain foreland fold and thrust belt. The coal that will be mined from the Grassy Mountain development is located within the coal-bearing Mist Mountain Formation, which is part of the Lower Cretaceous Kootenay Group sedimentary sequence.

The Mist Mountain Formation typically consists of interbedded mudstones, siltstones, and sandstones with inter-bedded, thick, bituminous coal seams. The coal seams constitute approximately 8 to 12 percent of the total thickness of the formation, and individual seams vary from less than 1 metre to more than 15 m in thickness. The mudstones generally occur as thin beds immediately adjacent to the coal seams. These beds normally grade to thicker siltstone and sandstone beds within a few metres of the coal seams, and the majority of the rocks in the sedimentary sequence consist of competent siltstones and sandstones.

The Mist Mountain Formation is overlain disconformably by the thickly-bedded Cadomin conglomerate, situated at the base of the Blairmore Group. At Grassy Mountain the conglomerate forms an erosional contact, with the upper half of the Mist Mountain formation removed by erosion processes. However, the Mist Mountain Formation and Blairmore Group exhibit similar bedding dips. Above the Cadomin conglomerate, the Blairmore Group comprises gradationally deposited sandstone, siltstone and mudstones of the Gladstone member.

The Mist Mountain Formation overlies the upper member of the Morissey Formation. The upper member is Moose Mountain sandstone. The Moose Mountain member is mainly composed of massive-bedded sandstone, but can contain thin beds of mudstone, shale and bituminous coal.

2.1.1 Coal

Three major coal zones are defined at the Grassy Mountain area, denoted Seam 1, Seam 2 and Seam 4 (Norwest, 2013). Seam 1 and Seam 4 typically comprises one or more coal seams. Seam 2 is generally represented by a single coal seam. The high degree of structural complexity in the rocks has contributed to a highly sheared coal rock mass which can be observed in the recovered rock core.

A summary of the coal geology is presented in Table 1.

Table 1: Summary of Observed Coal Thickness (Norwest, 2013)

Coal Seam	Thickness Range (m)	Average Thickness (m)
1A	0.6 – 9.3	2.9
1B	0.6 – 8.7	2.3
2	1.4 – 24.2	8.6
4A	0.9 – 15.7	4.0
4B	0.6 – 11.0	2.8

2.1.2 Soil and Weathered Bedrock Cover

The soil and weathered bedrock cover at Grassy Mountain was not cored in the geotechnical boreholes. The non-cored portion generally ranges in thickness from 10 to 20 m in from ground surface and is expected to comprise highly to extremely weathered bedrock overlain by colluvium and till soils. The colluvium and till is generally described as silty sand, fine to coarse grained within some gravel, cobbles and boulders of detached weathered bedrock.

An overburden thickness of approximately 50 m was encountered in borehole RGSC-0005. This hole located at the lowest site elevations, toward the south of the Grassy Mountain site. The soil profile is likely to be related to a former creek drainage path, possible associated with the Blairmore Creek or Gold Creek.

Bedrock in the higher elevations is located close to or at surface and is generally composed of weathered conglomerates, sandstones and siltstones of the lower Blairmore Group. In several road cuts weathered bedrock is exposed, as shown in Photograph No. 1, Appendix A.

Waste rock dumps have been formed over natural topography along the west and east slopes of Grassy Mountain. Site observations and aerial imagery indicate that the waste rock dumps can be generally characterised as either Mist Mountain Formation interburden rocks or the overlying Cadomin Group conglomerate (Photograph No. 6). The former waste rock dumps are anticipated to be located inside of the proposed feasibility level pit footprint.

2.2 Structural Geology

Grassy Mountain is situated within a succession of generally west-dipping, north to south trending thrust faults and associated folds (Norris, 1994). The mine is located approximately 6.5 km west of the surface trace of the regionally continuous Livingstone Thrust. The Livingston Thrust is the boundary between the foothills and front ranges of the Rocky Mountains.

The Grassy Mountain project site lies between the Livingstone Thrust Fault and another regionally continuous fault, the Coleman Thrust Fault, which is located to the west (Norwest, 2013). In between these faults, the Kootenay Group rocks are folded and faulted. Two major site continuous west-dipping thrust faults; the McConnell and Turtle Mountain Thrusts intersect the Mist Mountain Formation.

The site has been divided into three structural geological domains. The domains, located from west to east, are briefly described below:

- **Western Structural Domain:** Sedimentary strata generally dip at 25 to 30 degrees towards the west at the southern end of Domain 1, increasing to 40 to 60 degrees at the northern end. The McConnell Thrust Fault forms the eastern boundary of the outcropping Mist Mountain in this domain.
- **Central Structural Domain:** Sedimentary strata generally dip at 25 to 35 degrees towards the west-north west, increasing to about 50 degrees dip angle at the northern end of the Domain. The Turtle Mountain Thrust Fault separates the Central Domain from the Eastern Domain.
- **Eastern Structural Domain:** Sedimentary strata generally dip at 60 to 70 degrees towards the east. This domain is characterised by an overturned anticline. The Turtle Mountain Thrust Fault defines the western boundary of this domain and is replaced by major folds in the north.

3.0 FIELD INVESTIGATIONS

A geotechnical and hydrogeological field investigation program was carried out by Golder at the Grassy Mountain site from August 5 through September 21, 2014. The field program consisted of the following activities:

- Surface reconnaissance (see photographs in Appendix A);
- Drilling of seven HQ-3, diamond cored geotechnical holes;
- Geotechnical data collection including the description of structural discontinuities;
- Field assessment of rock strength and point load strength testing;
- Hydrogeological characterization through hydraulic conductivity (packer) testing;
- Collection of rock core samples for laboratory strength testing; and
- Installation of three grout-in-place vibrating wire piezometer nests.

The investigation is discussed further in the following sections.

3.1 Geotechnical Drilling Program

The locations of the boreholes are shown in Figure 2 and a summary of the drilling program is provided in Table 2. The locations of the boreholes were nominated to target representative geotechnical conditions within possible highwall, endwall, and footwall slopes based on the Norwest PEA mine footprint.

Table 2: Summary of Geotechnical Drilling Program

Borehole	Date Completed	Easting (m)	Northing (m)	Elevation (m)	Length (m)	Inclination (°)	Azimuth (°)	Piezometer Installation
RGSC-0004	8/18/2014	685,490	5506218	1755	173.71	70	100	Yes
RGSC-0005	8/24/2014	685,118	5504574	1507	149.00	70	075	Yes
RGSC-0006	8/29/2014	685,577	5507161	1825	161.21	90	-	No
RGSC-0007	9/6/2014	685,627	5507655	1912	176.68	90	-	No
RGSC-0008	9/9/2014	686,638	5507638	1955	87.45	90	-	No
RGSC-0009	9/16/2014	686,742	5509160	1912	158.92	70	020	Yes
RGSC-0010	9/19/2014	686,807	5510108	1774	170.92	90	-	No

Detailed geotechnical core logging was carried out at the drill site by engineers from Golder's Vancouver office and geologists from Riversdale. Geotechnical logging was undertaken in accordance with Golder's Geotechnical Core Logging Guidelines (Golder, 2014b) that were developed specifically for the Grassy Mountain Project. The descriptive terms and standards used by Golder to describe the geotechnical characteristics of the encountered rock are broadly consistent with terminology recommended by the American Society for Testing and Materials (ASTM), and the International Society for Rock Mechanics (Brown, 1981).

Downhole plots of the geotechnical borehole logging data are presented in Appendix B.

3.2 Rock Strength Testing

Point Load Strength Index (Point Load) testing was carried out by Golder and Riversdale personnel after the core was logged and photographed. Point Load testing was carried out on representative rock types, generally at 3 m to 4 m depth intervals. Point Load testing raw data is presented in Appendix C.

Rock core samples were from the recovered rock core. Rock samples were sent to Golder's laboratory in Burnaby, British Columbia for Uniaxial Compressive Strength testing. Uniaxial Compressive Strength test results are summarized in Section 4.1.2 and are presented in Appendix C.

3.3 Downhole Geophysical Logging

Downhole geophysical surveys were conducted by Century Wireline Services Ltd. (Century) in all seven boreholes. Century carried out the following downhole geophysical logging methods:

- Borehole deviation (azimuth and tilt);
- Caliper;
- Fluid resistivity;
- Gamma;
- Neutron density;
- Formation Dip Meter; and
- Acoustic televiewer (ATV) surveys.

The televiewer surveys provide images of the borehole wall and can be used to collect structural geological orientation data. Planar features intersecting the borehole wall appear as sinusoidal traces on the televiewer image, as illustrated in the Plate 1. Using the reference direction recorded during geophysical logging, these sinusoids can be processed to estimate the feature's dip and dip direction.

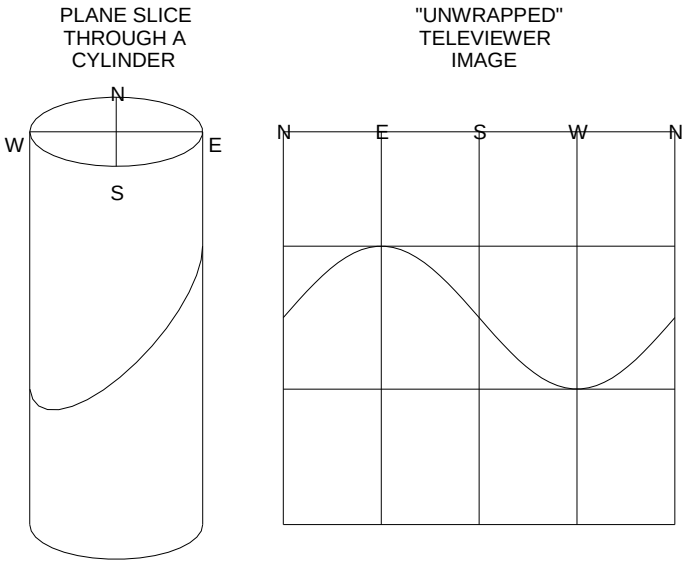

Plate 1: Planar Feature on Borehole Wall (left) and Sinusoid in Unwrapped Televiewer Image (right)

The raw televiewer images were processed by Riversdale and oriented to true north. Riversdale used a rotation of 14° 50' to correct the data for local magnetic declination.

3.4 Hydrogeological Field Program

Hydraulic conductivity (packer) testing was concurrently carried out with the geotechnical drilling program. In total, 14 successful packer tests were conducted in the seven geotechnical boreholes. Additionally, Golder installed Vibrating Wire Piezometers (VWP) in three boreholes (RGSC-0004, RGSC-0005, and RGSC-0009). The VWP's each comprised three pressure gauges installed at a shallow, intermediate, and deep depth interval to provide nominal spatial distribution of formation pressures along the model.

The results of the hydrogeological field program is presented in the Technical Memorandum (Golder, 2014a) presented in Appendix F.

4.0 GRASSY MOUNTAIN ENGINEERING GEOLOGY

The site engineering geology model derived from the results of the field investigations and from previous experience at the other open pit coal mines located nearby in the Elk Valley is discussed in the following subsections.

4.1 Intact Rock Strength

Intact rock strength data was collected during the field investigation as follows:

- Field estimates of intact rock strength collected during core logging;
- Laboratory Uniaxial Compressive Strength (UCS) on selected rock core samples; and
- Field point load testing on rock core samples.

The results of the intact rock strength assessment is summarized in the following sections and detailed in Appendix C.

4.1.1 Field Strength Estimate

During the 2014 field investigation, approximately 1,080 m of rock core from Grassy Mountain was geotechnically logged. Field estimates of intact rock strength were collected by Golder and Riversdale personnel during geotechnical core logging, using the International Society of Rock Mechanics (ISRM) methods (Brown, 1981).

A histogram of the field estimates of intact rock strength by geological formation is presented in Plate 2 below.

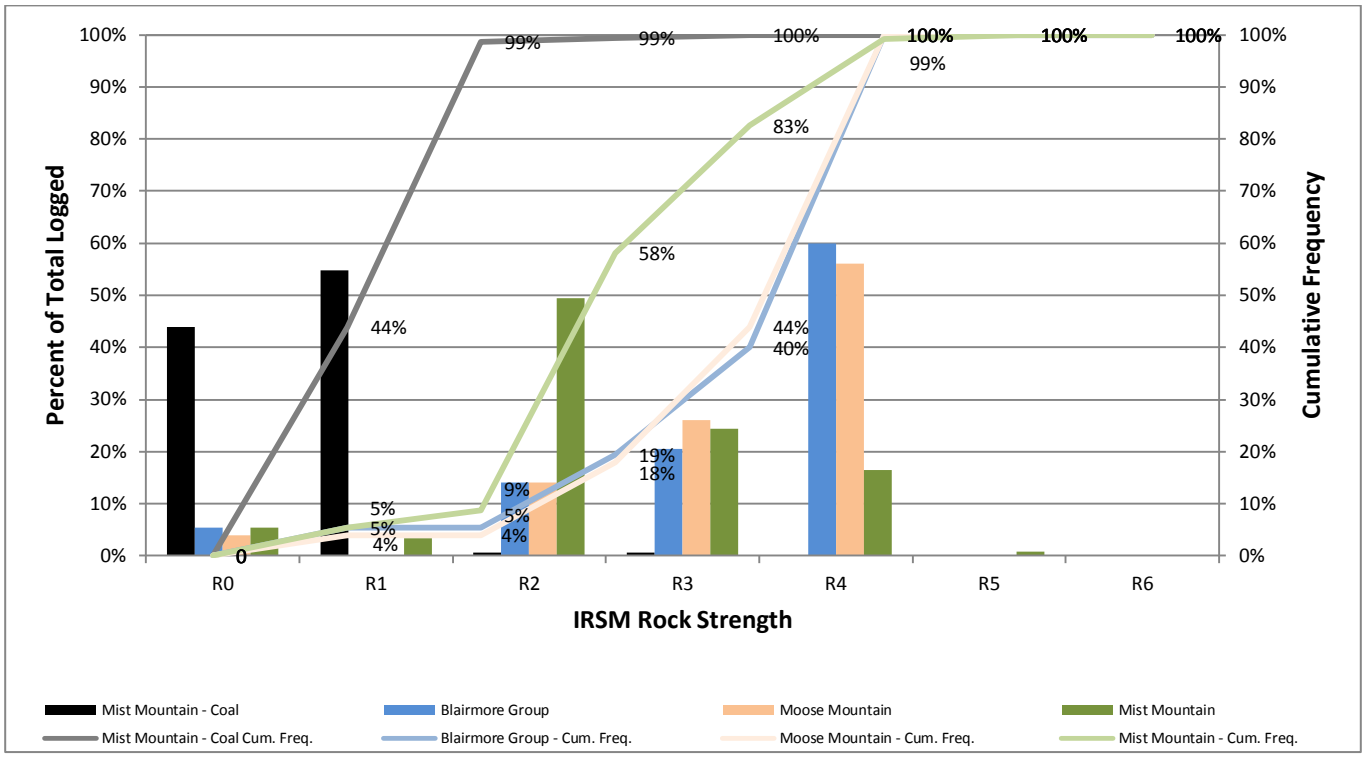

Plate 2: ISRM Estimated Field Strength by Geological Formation

The following observations have been made with respect to the field strength estimate data:

- The average logged rock strength for coal of the Mist Mountain Formation typically ranges from R0 (extremely weak rock) to R1 (very weak rock). Approximately forty-four percent of the coal was logged as R0 and fifty-six percent logged as R1. The average estimated rock strength the coal is R1 (very weak).
- The average logged strength of all rock types of the Mist Mountain Formation is R2 (weak rock). However, 48% of the rocks logged are estimated as R3 (strong rock) or better. The weak rock (R0 to R2) component accounts for 58% of the Mist Mountain and is considered representative of the carbonaceous mudstone and finely bedded siltstone. The strong rock (R3 to R5) component is representative of the well bedded siltstones and sandstones.
- The average logged strength of the Blairmore Group is R4 (moderately strong rock) and the average strength of the Moose Mountain is R4.

4.1.2 Laboratory UCS Rock Strength

A total of 10 rock core samples were selected for UCS testing. The samples were chosen to reflect the representative lithologies at Grassy Mountain. The UCS test results are summarised in Table 3. Laboratory test certifications are provided in Appendix C.

Table 3: Summary of UCS Test Results

Borehole	Depth From (mah)[1]	Depth To (mah)[1]	Rock Type[2]	Geological Formation	Wet Density (kg/m^3)	UCS (MPa)	Failure Mode[3]
RGSC-0004	73.96	74.23	Mudstone	Mist Mountain	2,598	59.1	2/4
RGSC-0004	99.98	100.21	Siltstone	Mist Mountain	2,598	96.9	4
RGSC-0005	66.12	66.41	Sandstone	Blairmore Group	2,591	179.1	4
RGSC-0005	86.16	86.46	Conglomerate	Blairmore Group	2,634	106.5	2
RGSC-0006	100.29	100.51	Mudstone	Mist Mountain	2,631	40.8	4/2
RGSC-0007	106.26	106.54	Sandstone	Mist Mountain	2,613	89.8	4/2
RGSC-0008	15.19	15.45	Sandstone	Blairmore Group	2,711	133.4	2/4
RGSC-0009	137.38	137.61	Mudstone	Mist Mountain	2,440	35.3	4/2
RGSC-0010	38.07	38.33	Conglomerate	Blairmore Group	2,620	93.5	2/4
RGSC-0010	168.22	168.47	Sandstone	Mist Mountain	2,564	47.0	4

Notes: 1) mah = metres along borehole, relative to ground surface. 2) Rock type logged by Golder/Riversdale personnel during sample collection. 3) Codes for failure mode as follows: 1 – diagonal shear plane(s); 2 – vertical fracture; 3 – vertical splitting; 4 – shear along discontinuity; 5 – conical; 6 – spalling; 7 – other.

The laboratory UCS testing results are discussed below.

- **Mist Mountain - Coal**

The average estimated rock strength of coal from the 2014 drilling investigations was R1 (very weak). It is typically difficult to conduct UCS tests on weak rocks (UCS values less than 25 MPa), as weaker rocks are often not sampled or break during transport. As a result, UCS test results tend to be biased towards samples of higher strengths. No laboratory UCS testing was carried out on any coal samples from the Mist Mountain Formation.

- **Mist Mountain Formation**

Laboratory UCS testing has been carried out on six samples of rock from the Mist Mountain Formation comprising sandstone, siltstone or mudstone. The UCS of these samples ranged from 35.3 MPa to 96.9 MPa, with an average of 61.5 MPa. Of the six samples, three tests were carried out on mudstones with an average UCS of 45 MPa, two tests on sandstone with an average UCS of 68.4 MPa, and one test on a siltstone with a UCS value of 96.9 MPa. This is generally consistent with test results from other mines in the nearby Elk Valley.

The average estimated rock strength of these rocks from the 2014 geotechnical logging was R2 (weak). However, the laboratory UCS test results indicate that the Mist Mountain rocks can exhibit high intact rock strengths (i.e., R3 to R4 strength range) in the more competent siltstone and sandstone rock types.

- **Blairmore Group**

Laboratory UCS testing has been carried out on four samples of Blairmore group, comprising two tests from the Cadomin conglomerate and two tests from the overlying Gladstone member. The UCS of these samples ranged from 93.5 MPa to 179.1 MPa, with an average of 128.2 MPa.

The average estimated rock strength of these rocks from the 2014 geotechnical logging was R4 (moderately strong rock) which is consistent with the UCS test results.

- **Moose Mountain Member**

No laboratory UCS testing was carried out on any rock core samples from the Moose Mountain member of the Morrissey Formation. The average estimated rock strength of sandstone from the 2014 drilling investigations was R4 (moderately strong rock) and is generally consistent with the strengths encountered in the Moose Mountain located in the mine in the nearby Elk Valley.

4.1.3 Point Load Strength Index

Point load strength index testing was carried out to provide a continuous record of rock strength along the borehole. A summary of the point load strength index results is presented in Table 4, and the raw data can be found in Appendix C.

Table 4: Summary of Point Load Strength Index Results

Point Load Strength ($Is_{(50)}$ MPa)		Diametral Point Load Test			Axial Point Load Test		
		Blairmore Group	Mist Mountain[(a)]	Moose Mountain	Blairmore Group	Mist Mountain[(a)]	Moose Mountain
Range	Maximum	10.3	9.0	9.0	11.0	19.8	8.5
	Minimum	0.1	0.1	1.4	0.9	0.4	3.0
Average		4.5	2.1	4.9	4.6	4.9	6.0
Median		4.3	1.7	5.9	4.0	3.4	6.3
Standard Deviation		2.8	1.9	2.4	2.8	4.7	2.3

a) Mist Mountain Formation includes all rock types (mudstone, carbonaceous mudstone and siltstone) with the exception of the sandstone and coal data.

Due to the limited UCS sample set, it is difficult to determine an accurate UCS-Point Load Strength (Is_{50} MPa) correlation for the rocks at Grassy Mountain. In addition, due to the heterogeneous nature of the sedimentary rock, a large number of UCS and point load tests would have to be carried out on each rock type to establish a reliable UCS-Point Load Strength correlation. This is not considered to be necessary. Rather, the point load strength results provide a continuous record of estimated intact rock strength along the length of the borehole, shown in the Downhole Borehole Plots (Appendix B). The combined UCS and Point Load Strength testing demonstrate that the rocks at the Grassy Mountain project exhibit similar intact rock mass strengths to the rock exposed at the other coal mines in the nearby Elk Valley.

4.2 Discontinuity Characterization

4.2.1 Rock Structure

As part of the 2014 geotechnical drilling investigations, orientation data for geological discontinuities were collected using downhole televiewer surveys, which were interpreted by Riversdale. Lower hemisphere, equal area stereographic projections of the structural orientation data have been produced using the Rocscience software Dips (Version 6.0). The stereographic projections of the structural orientation data from the televiewer surveys, and a full discussion of the observed structures in each borehole are included in Appendix D.

The bedding in the Rocky Mountains have been observed to be continuous over hundreds of metres. Bedding spacing varies by rock type, with mudstones exhibiting a spacing between one and 10 centimetres and more massive sandstones exhibiting a fracture spacing between one and three metres.

Sedimentary strata also typically contain two prominent cross-joint sets. One set typically strikes parallel or near-parallel to the bedding strike and dips orthogonal to the bedding. The second set typically strikes perpendicular to the strike of the bedding and to the first joint set. These cross-joint sets and bedding define an orthogonal fracture pattern, in that both joint sets are mutually perpendicular and are oriented perpendicular to the bedding.

For the sake of clarity, Golder commonly refers to these joints as the JS1 and JS2 joint sets, where the JS1 joint set strikes parallel to the strike of the bedding and the JS2 set strikes perpendicular to the strike of the bedding.

4.2.2 Joint Condition Rating

The Joint Condition Rating (JCR) is used to describe the small-scale surface characteristics of the joint discontinuities in the RMR_{76} rock mass classification system (Bieniawski, 1976). A discrete numeric value between 0 and 25 is assigned based on the evaluation of the shape, roughness and wall rock alteration of the discontinuity surface.

During the 2014 field investigations, Golder engineers and Riversdale geologists collected JCR values for individual discontinuities and estimated an overall JCR for each geotechnical interval logged using the standard RMR_{76} JCR values of 0, 6, 12, 20 and 25. The interval JCR was assigned based on the most representative joint condition observed within an interval.

The discontinuity JCR data do not take into account intervals of lost core or very weak rock, where features were not able to be logged the JCR was assigned 0. In other words, the feature JCR data only represents the quality of features that were able to be observed and logged. The logged JCR values for the geotechnical intervals by lithology are summarised in Plate 3. The JCR frequency histograms for all the boreholes are provided in Appendix D.

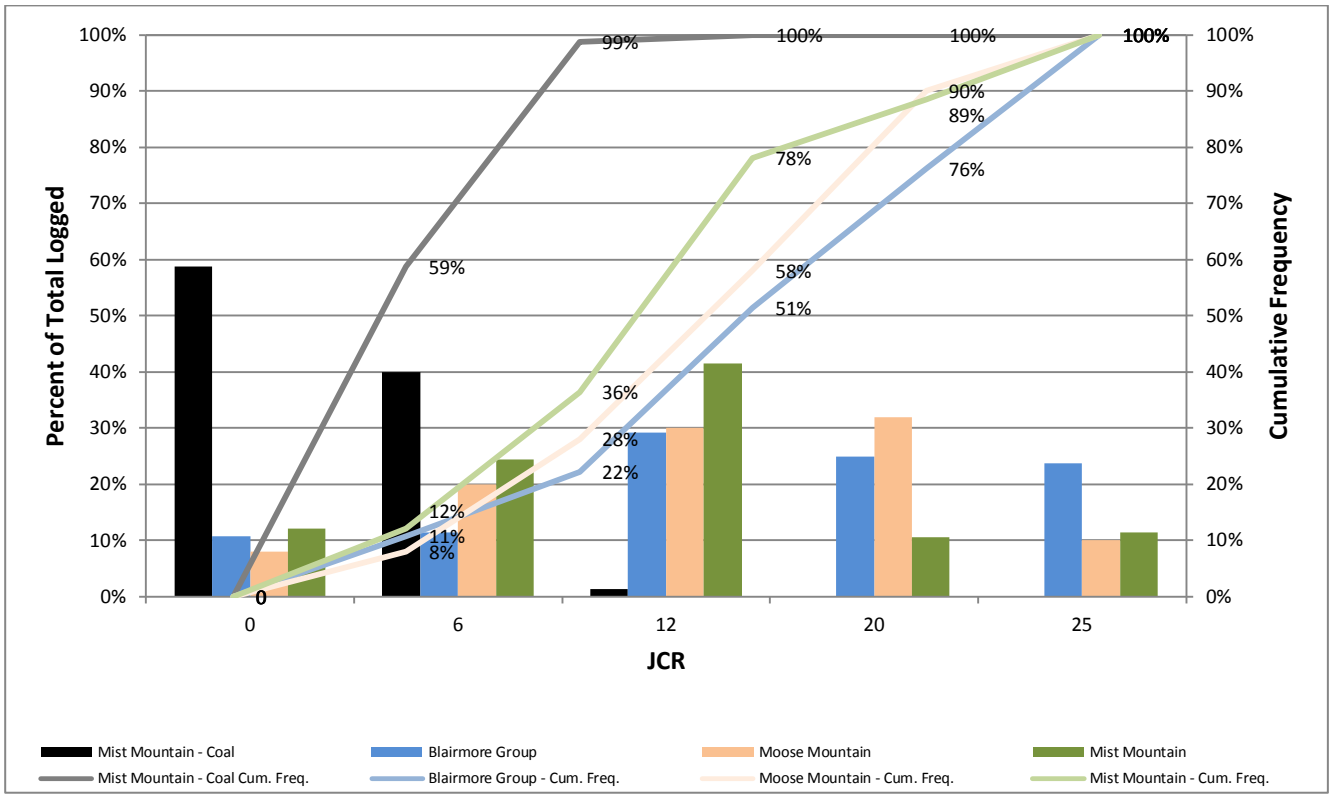

Plate 3: Distribution of Geotechnical Interval Joint Condition Rating (JCR) Values for 2014 Geotechnical Drilling Program

The following observations have been made with respect to the interval JCR data:

- The logged interval JCR values are generally higher in the Blairmore Group and Moose Mountain rocks.
- The coal of the Mist Mountain was generally assigned an interval JCR value of 0 or 6. Fifty-nine percent of the coal was assigned an interval JCR value of 0 and forty percent assigned 6.
- The average interval JCR logged in the remainder of the Mist Mountain formation rocks is 12, Moose Mountain is 12, and the Blairmore Group is 20.
- Interval JCR values of 12 and 20 were logged for approximately fifty-three percent of the Mist Mountain formation rocks. Thirty-six percent was logged with an interval JCR of 0 or 6 and eleven percent was logged with an interval JCR of 25.
- An Interval JCR value of 12 was logged for approximately thirty percent of the Moose Mountain. Thirty-two percent logged as 20; twenty percent logged as 6, ten percent was logged as 25 and eight percent as a 0.
- An Interval JCR value of 20 was logged for approximately twenty-five percent of the Blairmore Group. Twenty-four percent logged as 25; twenty-nine percent logged as 12, eleven percent was logged as 6 and eleven percent as a 0.

4.3 Rock Mass Quality

An assessment of the overall quality of the rock masses that will be exposed in the Grassy Mountain Pit has been prepared using the Rock Mass Rating (RMR^{76}) rock mass classification system (Bieniawski 1976), based the data collected from the 2014 geotechnical drilling investigation.

The RMR_{76} classification system ranks the following five geotechnical parameters:

- *R1* = rating for the strength of intact rock material (rating = 0 to 15).
- *R2* = rating for drill core quality, Rock Quality Designation, RQD (rating = 3 to 20).
- *R3* = rating for spacing of joints (rating = 5 to 30).
- *R4* = rating for condition of joints, JCR (rating = 0 to 25).
- *R5* = rating for groundwater (rating = 0 to 10).

The overall rock mass quality is determined by summing the individual rankings as follows.

$$\boldsymbol{RMR_{76}} = R1 + R2 + R3 + R4 + R5$$

The rock mass class as a function of rock mass rating as summarized in Table 5.

Table 5: Rock Mass Rating System (Bieniawski, 1976)

RMR_{76} Rating	Rock Mass Class	Legend
81 to 100	Class I – Very Good Rock	
61 to 80	Class II – Good Rock	
41 to 60	Class III – Fair Rock	
21 to 40	Class IV – Poor Rock	
20 or less	Class V – Very Poor Rock	

A groundwater rating of 10 (i.e., dry conditions) has been assumed for the rock mass classification as the groundwater conditions have been added directly to the limit equilibrium slope stability analyses.

The four geotechnical parameters logged and the resulting RMR_{76} for each geotechnical interval are shown in the borehole plots presented in Appendix B. Down-hole borehole plots of the RMR_{76} values for each geotechnical interval for the geotechnical boreholes are presented as overlays on the pit cross sections in Appendix H.

The following rules have been applied for RMR_{76} calculations:

- RMR_{76} classification parameters are not assigned to overburden materials;
- RQD values for soil and weak rock (R0 and R1 rock strengths) are assigned 0%. This is consistent with standard industry practice, where RQD is considered to apply to rock with an intact rock strength of R2 or greater; and
- JCR values for soil and weak rock (i.e., soft joint wall conditions) are assigned a maximum value of 12.

A JCR value for broken core was assigned based on the representative surface characteristics of the fractured rock pieces within the interval. A JCR value of 0 was assigned for lost core intervals.

Plate 10 presents the RMR_{76} frequency histogram for all eight boreholes. RMR_{76} frequency histograms for each borehole are provided in Appendix E.

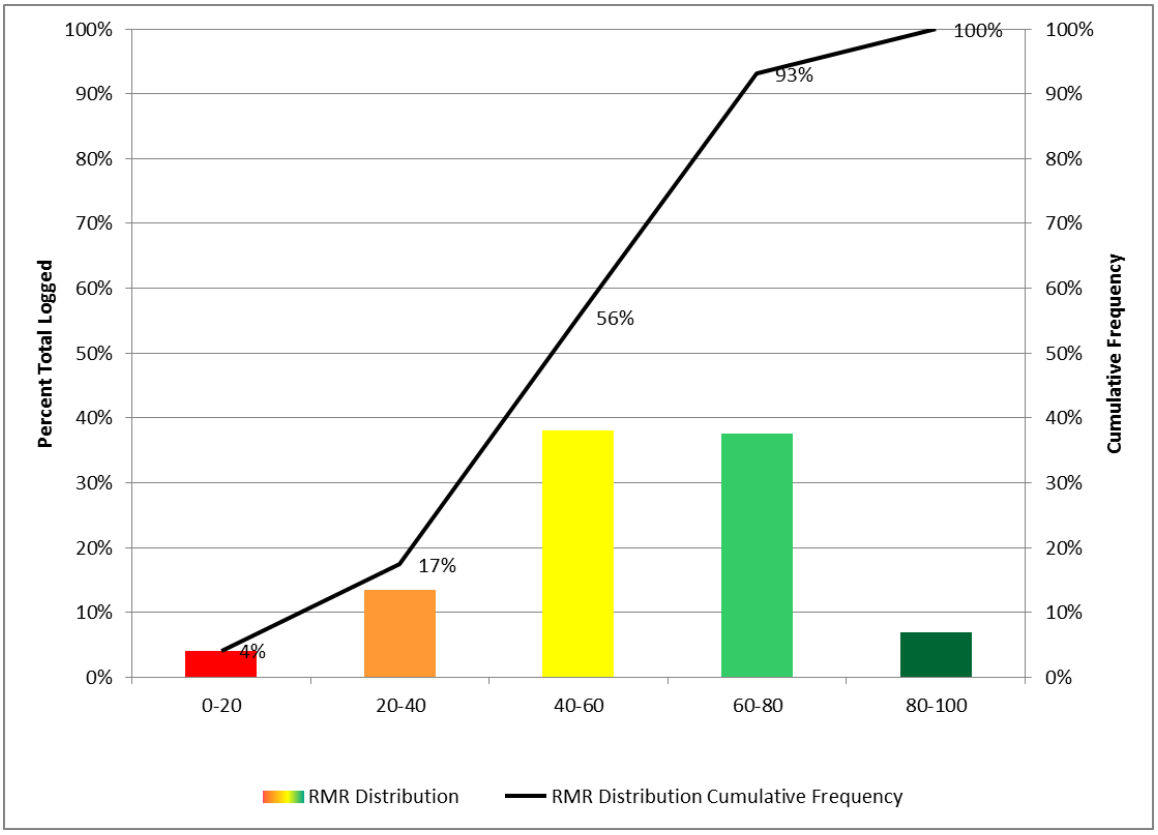

Plate 4: RMR_{76} Distribution - All Borehole Data

The rock mass quality data have been divided based on the geological formations encountered at Grassy Mountain. The average RMR_{76} values were determined using a weighted average based on the variable geotechnical interval lengths (Table 6).

Table 6: Summary of Weighted RMR_{76} Classification Values

Dataset	Rock Type / Formation	RMR_{76} (Weighted Average)	Rock Mass Classification (RMR_{76})
All Boreholes	Mist Mountain – Coal	25	Poor Rock
	Mist Mountain [(b)]	58	Fair Rock
	Blairmore Group	61	Good Rock
	Moose Mountain	62	Good Rock
	All Data	**56**	**Fair Rock**

(a) RMR_{76} values were determined using a weighted average based on the variable geotechnical interval lengths.
(b) Mist Mountain Formation includes all rock types (mudstone, carbonaceous mudstone and siltstone) with the exception of the sandstone coal data.

4.4 Hydrogeological Characterization

4.4.1 Hydraulic Conductivity

The hydrogeological testing data collected was analyzed with HydroBench (Version 3.7.0), an internally developed software package used to analyze different types of hydrogeological tests. The analyses performed are described in a Golder technical memorandum (Golder 2014a, presented in Appendix F). These analyses provided values of the rock mass transmissivity and bulk hydraulic conductivity. The profiles of transmissivity and hydraulic conductivity are shown in the figures in Appendix F.

Estimated bulk hydraulic conductivity values range from 5×10^{-6} m per second to 5×10^{-9} m per second. The geometric mean of all tests is 1×10^{-7} m per second. The three order difference in magnitude in hydraulic conductivity values is partially related to the interbedded nature of the Mist Mountain Formation. Based on experience, the magnitude of values are consistent with the Mist Mountain Formation in the nearby Elk Valley.

Due to the orientation of the boreholes, which were drilled either vertical or near perpendicular to the bedding, these bulk hydraulic conductivity values are more representative of the hydraulic conductivity of the continuous bedding. The cross joints that are oriented perpendicular to the bedding are not as continuous as the bedding, as these feature terminate against the bedding. Consequently, the permeability perpendicular to bedding is expected to be less than the permeability parallel to bedding. This creates an anisotropic flow condition, which is common in bedded sedimentary rocks.

5.0 COAL GEOLOGY AND FAULT INTERPRETATION MODEL

The Grassy Mountain coal geology and large-scale fault structures were interpreted by Riversdale using the geological data collected during the 2014 Riversdale exploration program. The model was provided to Golder in January 2015, in three-dimensional data format.

Geological cross sections were cut perpendicular to bedding strike for use in the geotechnical stability assessments. Geological sections through each of the geotechnical borehole locations are presented in Appendix G. The Grassy Mountain coal geology and large-scale fault model is described below, in addition to the probable Grassy Mountain pit development.

Coal Geology

The coal geology can be generally characterised into three areas which each show similar structural geology. For continuity with the descriptions used previously in Section 2.2 these areas are denoted the western, central and eastern structural domains for the purposes of this assessment.

The sedimentary strata within the western domain of the proposed mine footprint are generally moderately to steeply dipping (approximately 25 to 50 degrees) towards the west. The continuous, steeply west dipping thrust faults are shown to offset the coal seams. The maximum coal offset is approximately 25 m within this domain.

The sedimentary strata within the central domain of the proposed mine footprint are offset and folded. The geology is this area is likely to be the most disturbed and deformed of the three domains. The coal seams are interpreted to be broadly folded; the model shows a synclinal fold structure with a moderately to steeply east dipping limb and a moderately to steep dipping west dipping limb. The continuous, steeply west dipping thrust faults are shown to locally disturb and re-orientate the dip of the coal seams, particularly on the upper portions of the western limb of the fold.

The eastern domain is characterised by steeply east dipping to sub-vertical coal seams which are related to a probable anticlinal fold which has been subsequently eroded above the level of existing ground.

Fault Interpretation

Approximately 12 continuous thrust faults have been identified within the mine area. The faults are steep, west dipping to sub-vertical, trending north-south, and roughly striking parallel to the strike of the sedimentary strata at Grassy Mountain

Five steep, west dipping thrust faults are located within the western domain. The faults are shown to offset the coal seams, and to have created minor drag folding of the bedding along the fault contacts. The faults have resulted in a repeated coal geology sequence in places, as encountered in boreholes RGSC-0006 and RGSC-0007.

Three faults are located along the west limb of the syncline located in the central domain. The coal geology and fault model shows that these fault structures have offset and locally dragged folded the coal seams. The faults are more closely spaced within the west limb of the syncline. The model shows that bedding is locally steep in the vicinity of the faults, particularly as these faults converge towards the north.

Three to four thrust faults are shown within the east limb of the syncline located in the central domain. Localised drag folding and steepening of the coal seams is shown in the area of these faults.

Probable Pit Development

Based on the coal geology model and previous preliminary pit design work carried out by Norwest (2013) and by Xenith Consulting Pty Ltd (Xenith), the mine development is likely to comprise three adjacent pits that will trend north-south. The location and geometry of each pit is related to the local stratigraphy within each structural geological domain described previously; the western, central and eastern domains.

For the purposes of this study, the pits names are assigned to the structural domains and are denoted the West Pit (i.e., western structural geological domain), Central Pit and East Pit. A brief summary of the probable ultimate pit development is described below. It should be noted that these configurations may change based on the economics of the coal resource.

- **West Pit:** The West Pit is likely to be excavated as a west facing benched and/or unbenched footwall slope along the base of Coal Seam 4, with a benched highwall along the western side of the pit.

  The maximum overall footwall slope height may range from approximately 325 to 375 vertical metres, as shown in the Geological Sections, Appendix G. The coal geology model indicates that bedding is to dip between 20 and 45 degrees along this footwall. An intermediate east facing pit wall slope is shown to be excavated along the centre of the footwall and separates an upper and lower footwall slope. The pit wall configuration is related to offsetting of the coal seams along one to two of the continuous thrust faults. The vertical height of the benched portion between the upper and lower footwall slopes is about 25 m, and corresponds with the maximum length of offset between the coal seams.

  The highwall is likely to be excavated to vertical slope heights between about 125 and 175 m. The coal model shows that bedding generally dips between 30 and 50 degrees into the highwall. The model shows that the Mist Mountain Formation is likely to be exposed in the lower portions of the highwall slope, and the rocks of the Cadomin and Gladstone member of the Blairmore Group will be exposed in the upper portion of the highwall.

- **Central Pit:** The central portion of the mine footprint is characterised by a syncline which is likely to be excavated as a benched highwall and footwall, and an unbenched footwall along the eastern limb (west dipping), with a benched and unbenched footwall along the western limb (east dipping).

  The model shows that bedding dips are flat lying to shallow in the southern portions of the Central Pit. Bedding dips are shown to dip up to approximately 45 degrees along the west limb of the syncline and up to approximately 60 degrees along the east limb. Localised roll of the stratigraphy sequences is shown in the model. The heights of the pit walls within this Pit range from about 50 to 275 vertical metres.

The coal geology model shows the coal seams are likely to be more disturbed by faulting in the area of the west limb of the syncline resulting in significant offsetting and localised steeping of the coal seams. The upper portions of western limb of the syncline is likely to be excavated as a benched footwall slope and the lower portion of the western limb as an unbenched footwall as bedding becomes shallower in dip. The heights of this pit slope may range from about 50 to 250 m. The stratigraphy in the eastern limb of the syncline is shown to be less influenced by the thrust faulting.

- **East Pit:** The stratigraphy is characterised by steep,-east dipping to sub-vertical bedding structures. A benched footwall is likely to be excavated along the west side of the East Pit and a benched highwall along the east side of the East Pit. The heights of the slopes within the East Pit may range from about 75 to 125 vertical metres.

The model shows that the highwall on the east side is likely to be composed of the Cadomin and Gladstone members of the Blairmore Group. The Moose Mountain member of the Morrissey Formation is shown to be encountered within the benched footwall slope on the west side.

6.0 GENERAL COAL MINE PIT SLOPE STABILITY CONSIDERATIONS

The following section describes general coal mine slope stability considerations and design procedures. The application of these considerations to the Grassy Mountain pit slope design criteria is discussed in Section 7.0.

6.1 Rock Slope Failure Mechanisms

Rock slope design procedures are intended to establish pit wall design criteria based on the anticipated failure modes, as determined by the expected site geologic and geotechnical conditions. In this context, instability in rock slopes can generally be classified according to two principal failure mechanisms:

- **Structurally Controlled Failure Mechanisms**: Structurally controlled failure in rock occurs as the result of sliding along pre-existing geologic discontinuities (kinematic failures).
- **Rock Mass Strength Failure:** Slopes excavated in weak or heavily fractured rock masses, or very high slopes, can be susceptible to overall rock mass failure, which involves the development of pseudo-circular type failure zones through intact rock.

Structurally controlled failures can be further sub-divided into the following types based on the pit slope type:

- Structural controlled failure in benched highwall, footwall and endwall rock slopes are planar failure, wedge failure and toppling failure; and
- Structurally controlled failure in unbenched footwall slopes are planar sliding failure, ploughing failure, bi-linear sliding failure and buckling failure.

The magnitude and frequency of structurally controlled failures are directly related to the continuity of the structures along which sliding can occur. Structures that exhibit limited continuity, such as the cross joints at Grassy Mountain, may result in small bench-scale failures that are rarely of consequence to overall slope stability, but may affect access ramps or fixed equipment adversely. Conversely, larger scale failures can occur along continuous, through-going structures, such as bedding and major faults at Grassy Mountain. It is, therefore, these more continuous structures that are of primary concern to overall slope stability.

These mechanisms of potential slope failure are briefly discussed in Appendix H.

6.2 Slope Design Definitions

A pit slope has three major components: bench configuration, inter-ramp slope, and overall slope, as illustrated in Plate 5. The bench configuration is defined by the vertical bench separation (bench height), catch bench width (or bench width), and **bench face angle (BFA)** or batter angle. The inter-ramp slope is formed by a series of uninterrupted benches. Final overall slope angles are formed by a series of inter-ramp slopes separated by haul roads or wide geotechnical benches.

The **inter-ramp angle (IRA)** corresponds to the angle subtended by a line joining the toes of the benches on the wall and the horizontal. The **overall slope angle (OSA)** corresponds to the angle formed by the line joining the toe of the lowest bench with the pit crest and the horizontal. The incorporation of ramps onto a wall will result in a slope that has a shallower overall slope angle than the inter-ramp angle.

It is common practice to establish catch-benches on a pit slope to retain loose material that may fall from either the immediate bench face above or from the upper part of the slope. Where conditions are suitable, it is also common practice to place catch-benches at vertical intervals of two (or occasionally more) bench heights, creating a multi-bench slope configuration.

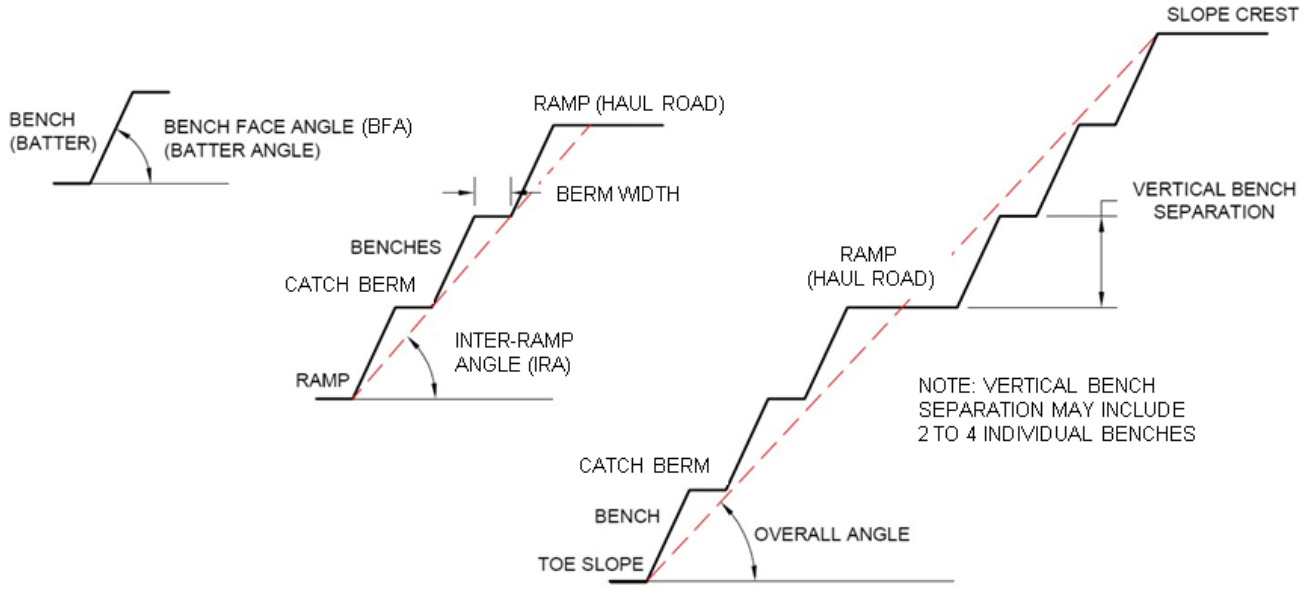

Plate 5: Schematic Representation of Bench Face Angle (BFA), Inter-ramp Angle (IRA) and Overall Slope Angle (OSA)

- **Bench Height**

For the purpose of this feasibility slope design study both single and double benched configurations have been recommended for the ultimate highwall pit walls, and single, double and triple bench configurations for benched footwall slopes. A double bench configuration can be utilized in the endwalls where there are no adverse influences from structures (kinematics) or where adequate overall rock mass quality exists. Design recommendations have been provided for 12 and 15 m bench heights.

- **Catch Bench Width**

Catch benches are required for the catchment of rock fall from the bench face, and to prevent falling rocks from impacting the operational areas below. Bench widths are often optimized based on operating practices, effective perimeter blasting and proper wall scaling, all of which result in reduced risks of rock fall and can warrant narrower bench widths.

The design bench width should have an adequate width to maintain the potential failed rock volumes (i.e., from planar or wedge failure types) from the bench above. Typically, the minimum allowable catch-bench width in operating mines is eight metres. Increased bench widths may be required for slopes exposed in lower rock mass qualities where ravelling or localized failures are expected to result in increased detached rock collecting on the benches. As catch benches are designed to provide safe working conditions below the slope, it is equally important to develop effective catch-benches for both ultimate and interim slopes, since the safety risks are identical for both cases.

6.3 Slope Design Methodology

The following subsections describe general methodology used to design pit slopes in bedded coal mines located within the Rocky Mountain foreland fold and thrust belt, in British Columbia and Alberta.

6.3.1 Footwall Slope

Unbenched Footwall Slope

Unbenched footwalls are typically designed in sedimentary sequences which exhibit bedding dip angles are less than about 35 degrees and where the footwall rock is expected exhibit adequate rock mass quality to support the stability of the overall slope. The maximum achievable overall slope height is dependent on these two geological components in addition to any continuous fault surfaces which intersect the footwall slope, and may result in a footwall slope shallower than bedding dip.

The strike of the footwall should be orientated parallel to the strike of bedding to reduce the probability of exposing bedding structures within the excavated slope face. The footwall slope should be excavated along bedding structures (i.e., the base of the target coal seam) to reduce undercutting and subsequent planar sliding failure mechanisms out of the slope. Where significant geological structures are adversely orientated with respect to the footwall, such as extensional normal fault behind the slope face, the slope may have to be benched and/or excavated at a shallower angle than the dip of bedding.

Benched Footwall Slope

Benched footwalls are typically designed for footwalls which are excavated along steeply dipping bedding, which have significantly high vertical slope heights and/or which have identified geological features adversely affect the overall stability of the footwall, including:

- The dip of bedding is steeper than about 35 degrees and/or where there is significant folding (or roll) within the footwall resulting in local over steepening of the footwall rocks;
- Where unsatisfactory rock mass quality is exhibited within the slope and subsequently the rock is unable to support the overall stability of the slope; and
- The presence of continuous faults structures which are orientated adversely to the slope resulting in kinematic failure mechanisms (i.e., planar, wedge) out of the footwall slope face.

Benched footwalls should be excavated with a bench face angle which follows the bedding dip slope to reduce the probability of undercutting bedding structures exposed within the slope face. At Grassy Mountain, local variability in bedding dips between the western, central and eastern domain rocks results in recommendations for both benched and unbenched footwall slopes. A summary of the design recommendations for each of the likely pit developments is presented in Section 7.0.

6.3.2 Highwall Slopes

A recommended benched configuration is based on the quality of the rock mass within the highwall slope, the dip of bedding exposed in the wall and the presence of continuous geological structures that could result in structurally controlled slope instability.

The selection of single or highwall bench configurations are Grassy Mountain is based on the expected geological conditions, summarised below.

- A single bench height configuration is typically selected where adverse slope stability conditions are expected to exist and where a higher probability of bench scale or overall slope failure exists. Factors which may attribute to adverse slope stability conditions may include steeper bedding dips, poorer rock mass conditions, and the presence of continuous fault surfaces.
- A double bench height configuration is typically selected where the highwall is expected to exhibit adequate bench scale and overall slope stability conditions, and a resultant lower probability of failure.

Catch bench widths are designed to contain the expected rock fall from the bench faces. The achievable inter-ramp slope will be a function of the bench face angle, bench height and catch bench width.

At Grassy Mountain, the approximately north-south striking, discontinuous JS1 joint set is expected to be oriented perpendicular to the bedding, and to dip out of the highwall slopes. Individual bench faces are expected to break back to these joints and the cross joint orientation will control the achievable bench face angles. The persistence of these joints is generally restricted by the spacing of the bedding surfaces, and the joints will not be continuous over the entire bench height. Consequently, the bench faces are expected to exhibit a saw-tooth bench face profile along the steeply dipping joints and the flat lying bedding, and localised back-break during blasting.

6.3.3 Endwall Slope

Endwalls should be orientated perpendicular to the bedding strike or such that bedding dips parallel to the wall or into the endwall to reduce the probability of undercutting of bedding surfaces or kinematic failure mechanisms along discontinuous, steeply dipping joint sets. As discussed in Section 6.3.2, the design bench configuration is based on the anticipated bench scale and overall slope instability mechanisms.

Endwalls are preferably orientated perpendicular to bedding strike. Endwalls which are obliquely orientated to bedding strike have a higher probability of forming wedge type failure mechanisms along the steeply dipping joint surfaces. The orthogonal orientated joints (with respect to bedding) have a higher probability of forming wedges, with an intersection plunging out of the slope face within an obliquely orientated pit walls.

At Grassy Mountain, the approximate east-west striking, discontinuous JS2 joint set is expected to be oriented perpendicular or obliquely to the endwall slope face. Individual bench faces are expected to break back to these joints and the cross joint orientation will control the achievable bench face angles. The persistence of these joints is generally restricted by the spacing of the bedding surfaces, and the joints will not be continuous over the entire bench height.

6.3.4 Soil and Extremely Weak Rock Slopes

Slopes excavated in soil and extremely weak rocks are susceptible to circular type failure mechanisms through the intact soil or rock substance. These materials are typically encountered within the upper ground elevations, soil cover (i.e., colluvium and till) or through waste rock materials dumped at Grassy Mountain. Slopes excavated in these materials are typically designed at a 2 Horizontal: 1 Vertical profile.

Waste rock dumped from previous mining operations is located inside of the current mine footprint, and therefore these materials are not expected to have an influence on the ultimate pit slope stability.

7.0 GRASSY MOUNTAIN SPECIFIC SLOPE DESIGN CRITERIA

The stability of the pit slope in the Grassy Mtn. Pit is expected to be controlled by the orientations of the geologic structures that are exposed in the pit walls. Accordingly, the pit slope design recommendations are based on a kinematic assessment of the orientations of the expected geologic structures with respect to the prosed pit wall, together with an assessment of the quality of the rock that will be exposed in the various areas of the pits. The proposed pits are expected to exhibit adequate rock mass strength to preclude the development of deep-seated overall rock mass failure mechanisms. Moreover, the pit designs and depths are expected to change as additional exploration drilling and economic mine planning assessments are carried out. Therefore, overall slope stability analyses have not been carried out as part of this study. However, it is recommended that these confirmatory, overall slope analyses be carried out for the higher and more critical pit walls once the pit optimization studies are completed, and before excavation of the pits begin.

For this preliminary study overall pit slope stability has not been assessed with two-dimensional limit equilibrium methods. Following completion of the feasibility level mine design overall slope stability can be analyzed to determine Factor of Safety values for the respective critical pit walls.

A qualitative stability assessment has been carried out to assess bench scale stability with respect to major geological structure and kinematic failure mechanisms. Consequently, a probability of failure approach is not appropriate for this study as there is insufficient data to support the development of reliable probability distributions for the various input parameters required to support a comprehensive probabilistic assessment.

7.1 Kinematic Bench-Scale Assessment

The bench scale stability of the highwall, endwall and footwall slopes will be controlled by the orientation and persistence of geologic structures. The geologic structures that will control pit slope stability are the continuous faults and bedding surfaces and the discontinuous, systematic joints sets. The coal geology model indicates that the stratigraphy is complex, with localised areas of poor rock mass quality due to deformation associated with the continuous faults and related fold structures.

The anticipated bench scale kinematic stability performance of the various proposed walls in the pit is discussed in the following sections. Recommended feasibility level pit slope design criteria are presented in bench design tables. The application of these recommendations to the pit designs in each of the structural domains are annotated on the geological sections in Appendix I. Bench slope design criteria have been provided for both 12 m and 15 m bench heights for mine design purposes.

The general location of each pit is shown in Figure I-1. The recommended pit wall design for each pit are discussed in the following sections.

7.1.1 West Pit

A description of the anticipated geological conditions within a likely West Pit is provided in Section 5.0. The West Pit is generally characterised by west dipping stratigraphy that is offset by the continuous thrust faults. Stratigraphy within the west pit generally becomes steeper in dip with depth.

7.1.1.1 Highwall Slope Design Criteria

The design bench configuration for the highwall slopes that are to be excavated along the western side of the West Pit are based on rock quality and on the dip of bedding into the slope and the expected quality of rock quality. Highwall design tables are provided in Appendix I to determine the recommended bench face angle, catch bench width and inter-ramp slopes.

Approximate bedding dip angles in the area of the highwall are presented in the geological sections, Appendix G. The lower portions of the highwall are anticipated to be excavated in rock of the Mist Mountain Formation and the upper portions of the highwall are to be excavated in rock of the Blairmore Group. The results of the rock mass quality assessment, which includes data from the nearby located RGSC-0004, RGSC-0005 and RGSC-0006 boreholes, indicate that the highwall is anticipated to be excavated in *good competent rock.* Therefore, Table I-2 or I-4 may be used to design the highwall bench configuration within the West Pit, depending on the operating bench height, 12 or 15 m, respectively.

The geological sections show that bedding is anticipated to dip into the highwall at angles between 30 and 50 degrees; however, the majority of bedding dipping is shown to dip between approximately 30 to 40 degrees. For a dip angle less than 40 degrees in good competent rock a double benched configuration is expected to provide adequate bench scale stability conditions.

The coal geology model indicates that bedding dip angles increase to about 50 degrees in the area of borehole RGSC-006. To provide adequate bench scale stability conditions for a 50 degree dip slope a single benched configuration is recommended for this portion of the highwall slope (see Table I-2 or I-4). Alternatively, a double benched configuration should provide adequate stability providing catch bench widths are increased to 10 m in this area. A higher probability of bench scale failure is anticipated for a double benched configuration within these steep dipping bedding slopes, and therefore the additional rock catchment is required. The higher probability of failure is related to sliding and back-break along the JS1 joint set, described below.

The approximately north-south striking, discontinuous JS1 joint set is expected to be oriented perpendicular to the bedding, and to dip toward the east at steep to moderate inclinations. As discussed in Section 6.3.2, bench faces are expected to break back to these discontinuous joints and to exhibit a saw-tooth bench face profile along the steeply dipping joints, and localised back-break during blasting.

7.1.1.2 Footwall Slope Design Criteria

The design of the footwall that is to be excavated along the east side of the West Pit is dependent on the dip of bedding. The ultimate footwall slope is to be excavated below Coal Seam 4, which is anticipated to comprise *good competent rock* of the Moose Mountain sandstone. The coal geology model shows that bedding generally dips between 25 and 45 degrees towards the west within a Coal Seam 4 footwall slope. The model shows some locally steeper bedding dip slopes up to about 59 degrees related the thrust faults (Figure G-5).

Benched Footwall Slope

The coal geology models shows that steeper bedding dips are expected in the lower portions of the footwall slope. These dips are generally steeper than 35 degrees, and therefore acceptable overall stability conditions will require the footwall to be excavated in a benched configuration with design bench face angles excavated along the dip of bedding. The lower portions of this footwall can be designed with a triple bench configuration using the design charts provided in Table I-2 and I-6, Appendix I.

The coal geology model does show an area of the lower portion of the footwall to dip at angles of less than 35 degrees (Figure G-6). This area is located in the north of the West Pit and can be designed with an unbenched excavation as discussed below.

Unbenched Footwall Slope

The stratigraphy of the upper footwall slope is shown to dip at angles less than 35 degrees. An unbenched slope is expected to provide adequate overall stability conditions. Bedding dips become shallower in a portion of the lower footwall slope located in the north of the pit and therefore an unbenched slope should provide adequate stability in this area (Figure G-6).

7.1.2 Central Pit

A description of the anticipated geological conditions within a likely Central Pit is provided in Section 5.0. The central pit is characterised by a synclinal fold that is offset by continuous thrust faults. The complex geologic conditions within this pit will require an ongoing design approach, and an accurate geologic model which incorporates data collected from future exploration drilling and mapping during pit excavations.

7.1.2.1 Highwall Slope Design Criteria

The upper portion of the west limb of the syncline contains four steep, west dipping continuous thrust faults that have likely created disturbed rock mass conditions. The coal geology model shows variable bedding dips in this area, ranging from 9 to 60 degrees (Figures G-4 to G-6). The coal seams are shown to be offset and locally drag folded between the respective fault surfaces. No geotechnical boreholes were drilling during the 2014 field investigation to investigation rock quality in this area.

A single benched configuration should be adopted for the upper slope in order to limit bench scale instabilities and to provide adequate catchment for the rock failure debris in the disturbed rock mass. A conservative design approach should be used for this feasibility level design with the following parameters.

- Bench Height: 12 or 15 m.
- Bench Face Angle: 60 degrees.
- Bench Catch Width: 10 m.
- Inter-ramp Angle: 35.3 or 38.8 degrees.

7.1.2.2 Footwall Slope Design Criteria

The design of the footwall slopes that are to be excavated along the east and west sides of the Central Pit is dependent on the dip of bedding. The ultimate footwall slopes are to be excavated below Coal Seam 4, which is anticipated to comprise *good competent rock* of the Moose Mountain sandstone. The coal geology model shows that bedding dips between 6 and 60 degrees within the likely footwall slopes.

Benched Footwall Slope

The bedding dip angle of the mid to lower portion of the west limb of the syncline ranges from 6 to 42 degrees, although generally ranging between 20 and 42 degrees. A benched footwall should be used in the area of borehole RGSC-007 and RGSC-008 where bedding dips are shown to exceed 35 degrees (Figure G-5 and G-6). The rock below the Coal Seam 4 footwall is expected to comprise *good competent* sandstone of the Moose Mountain member. A triple benched footwall configuration should be adopted using design bench face angles which follow the dip of bedding (Table I-6 and I-8).

The eastern limb of the syncline is characterised by bedding dip angles of between 8 and 60 degrees, although generally ranging between 34 and 55 degrees. As discussed, a triple benched footwall configuration should be used where bedding dips are interpreted to exceed 35 degrees, using a design bench face angle that follows the bedding dip.

The Footwall design tables for *less competent* rock are provided in Tables I-5 and I-7 to determine bench height, catch bench width and inter-ramp slopes within the east limb of the syncline. The rock in the area of the Coal Seam 4 is likely to exhibit poorer rock mass quality due to the presence of the numerous thrust faults.

Unbenched Footwall Slope

The coal geology model shows that stratigraphy is expected to dip at angles less than 35 degrees in the southern and northern ends of the central pit footprint. An unbenched slope is expected to provide adequate overall stability conditions.

7.1.3 East Pit

A description of the anticipated geological conditions within a likely Central Pit is provided in Section 5.0.

7.1.3.1 Highwall Slope Design Criteria

The design bench configuration for the highwall slopes that are to be excavated along the east side of the East Pit are based on the dip of bedding into the slope, expected quality of rock quality and anticipated bench scale instability mechanisms. Highwall design tables are provided in Appendix I to determine the recommended bench face angle, catch bench width and inter-ramp slopes.

The highwall is anticipated to be excavated within rock of the Blairmore Group, comprising Cadomin Conglomerate and Gladstone member which can be considered *good competent rock*. Bedding is anticipated to dip at angles between 75 and 85 degrees into the highwall (Figure G-2 to G-7). The continuous bedding structures are expected to result in adverse bench face toppling instabilities. Significant back-break along the bedding structures will attribute to a regressive slope profile and it will be difficult to maintain design bench crests. Catch-benches are expected to filled and over-topped with detached rock forming a ravel debris slope close to the angle of repose of the debris, about 37 degrees.

With respect to the significant toppling instabilities, a single bench configuration is recommended to achieve an inter-ramp slope angle of about 37 degrees. The highwall design charts (Table I-2 and I-4) provides the recommended configuration for the East Pit highwall.

7.1.3.2 Footwall Slope Design Criteria

A single benched footwall slope should be excavated along the west side of the East Pit where bedding structures are shown to dip at angles between 75 and 85 degrees towards the east (Figure G-2 to G-7). Bi-linear or ploughing slope instability mechanisms can be expected to occur in an unbenched footwall in these steeper bedding dips. A benched footwall configuration will improve overall footwall stability conditions and provide additional catchment for the anticipated rock fall instabilities.

The individual bench faces are expected to break back along the steep bedding surfaces and it will be difficult to maintain the design bench crest. The steepness of the bedding (75 to 90 degrees) dipping out of the slope will reduce the volume of rock fall from the individual benches.

The coal geology model and the rock encountered borehole RGSC-0008 and RGSC-0010 indicates that the benched footwall is expected to comprise the Moose Mountain member of the Morrissey Formation. The geotechnical core logging indicates that these rocks are expected to be of sufficient rock quality to be excavated in a benched footwall configuration.

Should bedding become shallower than about 70 degrees the bench face angle should be revised to follow the dip angle of the bedding exposed within the footwall.

7.1.4 Endwalls

The pit development will require endwalls to be excavated at the north and south ends of the proposed pits. Endwalls should be orientated perpendicular to the bedding strike, such that wall is parallel to the bedding dip or the bedding dips into the endwall to limit the probability of undercutting of bedding surfaces and developing toppling failure mechanisms along any continuous, steeply dipping joint sets.

High-angled planar sliding failure mechanisms are expected within endwall bench faces as the steeply dipping JS2 is orientated perpendicular to bedding strike and to the strike of the endwall. The persistence of these joints are generally restricted by bedding surfaces within the bedding Mist Mountain Formation. A saw-tooth bench face profile can be expected to develop along the bedding and the joints. With careful blasting and excavation techniques the following endwall design parameters are recommended:

- Bench Height: 24 or 30 m (double bench)
- Bench Face Angle: 70 degrees
- Catch Bench Width: 10 m
- Inter-ramp Angle: 52.0 or 55.1 degrees

8.0 SUMMARY OF RECOMMENDED BENCH DESIGN CRITERIA

A summary of the recommended pit slope design criteria is presented in Table 7 for 12 metre bench heights and in Table 8 for 15 m bench heights. Geological cross sections showing the application of the recommended bench design criteria to the geologic interpretation are presented in Figure I-2 to I-8, Appendix I. Additionally, the application of the recommendations are also shown in plan, Figure I-9.

Table 7: Summary of Recommended Design Criteria and Slope Stability Considerations – 12 m Bench Heights

Proposed Pit	Major Wall	Bench Design Criteria				Bench Scale Stability Conditions	Overall Stability Considerations
		Bench Height (metres)	Bench Face Angle (degrees)	Catch-bench Width (metres)	Inter-ramp Angle (degrees)		
Western	**Highwall:** Southern and Northern Portions of Pit.	24	60	8	51.4	Benches expected to break back to and be controlled by the steeply dipping JS1 joints.	Highwall is expected to exhibit adequate overall stability. Limit-equilibrium overall stability analysis to confirm.
	Highwall: Central Portions.	24	60	10	45.2		
	Footwall: Lower Slope Portions.	36	Follow bedding dip angle.	8	Dependant on dip of bedding.	Footwall excavated as benched slope. Bench faces to be excavated along bedding dip to limit potential planar sliding mechanisms.	Footwall to be excavated as a benched configuration where bedding dips are inclined greater than 35 degrees. Bench slopes to be excavated along bedding dips to reduce the probability of exposing bedding structures. Limit-equilibrium stability analysis required to confirm overall slope stability.
	Footwall: Upper Slope Portions, North East Lower Slope Portion.	Unbenched, excavate along bedding.				Footwall to be excavated as an unbenched slope. See overall slope stability conditions.	Footwall to be excavated as an unbenched slope along competent Moose Mountain Sandstone where bedding dips are inclined at less than 35 degrees. Footwall expected to exhibit adequate overall stability providing that bedding is not undercut.

Proposed Pit	Major Wall	Bench Design Criteria				Bench Scale Stability Conditions	Overall Stability Considerations
		Bench Height (metres)	Bench Face Angle (degrees)	Catch-bench Width (metres)	Inter-ramp Angle (degrees)		
Central	**Highwall:** Western Slope.	12	60	10	35.3	Benches expected to break back to and be controlled by the steeply dipping JS1 joints.	Highwall is expected to exhibit adequate overall stability. Limit-equilibrium overall slope stability analysis to confirm.
	Footwall: Western and Eastern slopes greater than 35 degree bedding dips.	36	Follow bedding dip angle.	8	Follow bedding dip angle.	Footwall excavated as benched slope. Bench faces to be excavated along bedding dip to limit potential planar sliding mechanisms.	Footwall to be excavated as a benched configuration where bedding dips are inclined greater than 35 degrees. Bench slopes to be excavated along bedding dips to reduce the probability of exposing bedding structures. Limit-equilibrium stability analysis required to confirm overall slope stability.
	Footwall: Western and Eastern slopes less than 35 degree bedding dips.	Unbenched, excavate along bedding.				Footwall to be excavated as an unbenched slope. See overall slope stability conditions.	Footwall to be excavated as an unbenched slope along competent Moose Mountain Sandstone where bedding dips is inclined at less than 35 degrees. Footwall expected to exhibit adequate overall stability providing that bedding is not undercut.
Eastern	**Highwall**	12	60	9.5	36.1	Significant toppling failure mechanisms are expected. Benches expected to break back along steeply east-dipping bedding structures, forming a ravel slope close to a 37 degree angle of repose.	Highwall is expected to exhibit adequate overall stability. Highwall is to form a talus slope of failure rock debris.
	Footwall	12	70	8	44.1	Footwall excavated as benched slope. Bench faces to be excavated along bedding dip to limit potential planar sliding mechanisms.	Footwall to be excavated as a benched configuration where bedding dips are inclined greater than 35 degrees. Bench slopes to be excavated along bedding dips to reduce the probability of exposing bedding structures.
-	**Endwalls**	24	70	10	52.0	Bench faces expected to break back to and be controlled by JS2 joints.	The endwall slope is expected to exhibit adequate overall slope stability.

Table 8: Summary of Recommended Design Criteria and Slope Stability Considerations – 15 m Bench Heights

Pit	Pit Slope	Bench Design Criteria				Bench Scale Stability Conditions	Overall Stability Considerations
		Height (metres)	Bench Face Angle (degrees)	Catch Bench Width (metres)	Inter-ramp Angle (degrees)		
Western	**Highwall:** Southern and Northern Portions of Pit.	30	70	12	52.6	Benches expected to break back to and be controlled by the steeply dipping JS1 joints.	Highwall is expected to exhibit adequate overall stability. Limit-equilibrium overall stability analysis to confirm.
	Highwall: Central Portions.	30	65	12	45.7		
	Footwall: Lower Slope Portions.	45	Follow bedding dip angle.	8	Dependant on dip of bedding.	Footwall excavated as benched slope. Bench faces to be excavated along bedding dip to limit potential planar sliding mechanisms.	Footwall to be excavated as a benched configuration where bedding dips are inclined greater than 35 degrees. Bench slopes to be excavated along bedding dips to reduce the probability of exposing bedding structures. Limit-equilibrium stability analysis required to confirm overall slope stability.
	Footwall: Upper Slope Portions, North East Lower Slope Portion.	Unbenched, excavate along bedding.				Footwall to be excavated as an unbenched slope. See overall slope stability conditions.	Footwall to be excavated as an unbenched slope along competent Moose Mountain Sandstone where bedding dips are inclined at less than 35 degrees. Footwall expected to exhibit adequate overall stability providing that bedding is not undercut.
Central	**Highwall:** Western Slope.	15	60	10	38.8	Benches expected to break back to and be controlled by the steeply dipping JS1 joints.	Highwall is expected to exhibit adequate overall stability. Limit-equilibrium overall slope stability analysis to confirm.
	Footwall: Western and Eastern slopes greater than 35 degree bedding dips.	45	follow bedding dip angle	8*	Follow bedding dip angle.	Footwall excavated as benched slope. Bench faces to be excavated along bedding dip to limit potential planar sliding mechanisms.	Footwall to be excavated as a benched configuration where bedding dips are inclined greater than 35 degrees. Bench slopes to be excavated along bedding dips to reduce the probability of exposing bedding structures. Limit-equilibrium stability analysis required to confirm overall slope stability.
	Footwall: Western and Eastern slopes less than 35 degree bedding dips.	Unbenched, excavate along bedding.				Footwall to be excavated as an unbenched slope. See overall slope stability conditions.	Footwall to be excavated as an unbenched slope along competent Moose Mountain Sandstone where bedding dips is inclined at less than 35 degrees. Footwall expected to exhibit adequate overall stability providing that bedding is not undercut.

Pit	Pit Slope	Bench Design Criteria				Bench Scale Stability Conditions	Overall Stability Considerations
		Height (metres)	Bench Face Angle (degrees)	Catch Bench Width (metres)	Inter-ramp Angle (degrees)		
Eastern	**Highwall**	15	60	11	37.3	Significant toppling failure mechanisms are expected. Benches expected to break back along steeply east-dipping bedding structures forming a ravel slope close to a 37 degree angle of repose.	Highwall is expected to exhibit adequate overall stability. Highwall is to form a talus slope of failure rock debris.
	Footwall	15	70	8	48.1	Footwall excavated as benched slope. Bench faces to be excavated along bedding dip to limit potential planar sliding mechanisms.	Footwall to be excavated as a benched configuration where bedding dips are inclined greater than 35 degrees. Bench slopes to be excavated along bedding dips to reduce the probability of exposing bedding structures.
-	**Endwalls**	30	70	10	55.1	Bench faces expected to break back to and be controlled by JS2 joints.	The endwall slope is expected to exhibit adequate overall slope stability.

9.0 FURTHER GEOTECHNICAL ASSESSMENT

9.1 Slope Stability Analysis

Further optimisation of the current pit shell design is required following additional geological resource modelling (i.e., coal quality), and therefore, slope stability analysis using limit equilibrium methods has not been carried out for this current study. Following optimisation of the feasibility level mine design, limit-equilibrium analysis should be carried out on the most critical highwall, footwall and endwall slope sections.

The results of the hydrogeological field data analysis would be incorporated into these slope stability analyses to model anticipated groundwater pressures within the pit slopes.

9.2 Geotechnical Site Investigation

The stability assessment presented in this report is intended to support feasibility-level mine design. Further geotechnical site investigations will be required to increase the current level of understanding in the geologic conditions at Grassy Mountain to enable final design, and for due diligence purposes.

We recommend the following geotechnical investigations for detailed design.

- An updated geological model to support future geotechnical slope stability assessment and pit design. Additional geological information collected during exploration drilling activities should be included into the current geological model, including interpretation of the fault structures and the present coal seam interpretation. Currently, there are significant uncertainties in the geologic interpretation at depth.
- Drilling of three deep geotechnical boreholes to investigate the most critical pit slopes and support slope stability analysis. The four boreholes should comprise:
  - One borehole inclined towards the west pit footwall to investigate rock mass conditions within the excavation and to assess the geological conditions below Coal Seam 4. The borehole should be drilled to 30 to 40 m below the footwall.
  - One borehole inclined towards the western side of the central pit to investigation rock mass conditions within the highwall/footwall slope. The borehole should be drilled into the slope to investigate the orientation and composition of the thrust faults, as shown in the coal geology model. The borehole should be drilled to 40 m below the proposed central pit floor elevation.
  - One borehole inclined towards the eastern side of the Central pit to investigation rock mass conditions within the proposed footwall, and geological conditions below Coal Seam 4. The borehole should be drilled to 30 to 40 m below the footwall.

9.3 Confirmatory Investigations

The design of the Grassy Mountain pit slopes will require optimisation during the geological resource modelling and mine design work. It is expected that revisions will be made to the geologic model and feasibility level mine design based on further exploration drilling. In addition, an observational pit slope design approach should be adhered to during pit excavation to include mapping and stability performance monitoring, as subsurface geology is exposed during mining.

Geologic Mapping

The recommended slope design criteria are based on our current understanding of the geology. In order to improve our understanding of the geology, routine geologic mapping should be carried out as the slopes are excavated. Particular attention should be paid to the following:

- The orientation and character of the systematic rock fabric and continuous structures with respect to the interpreted orientation, as the slope designs are based on the orientation of these features; and
- The presence and orientation of faults in the pit walls.

The potential adverse impacts of these structures on the stability of the slopes should be assessed as they are identified. Mapping techniques should include the use of conventional geology and geotechnical mapping, as well as remote techniques such as Lidar or photogrammetry.

Slope Stability Monitoring

A major part of any the pit slope stability monitoring program is regular visual inspection of the bench faces and crest areas for early evidence of slope instability. The crest and benches should be examined for signs of cracking or instability at least once every two weeks, and more frequently during the spring runoff. The observations should be recorded in a diary so that a record of the stability performance is available should it be required in the event of instability.

Slope stability instrumentation including prisms, GPS and Radar monitoring should be incorporated into a monitoring program. The monitoring frequency of prisms that may be installed on the slope will depend upon the stability of the slopes, the time of year, the rate of mining and the nature of the mining being carried out along the slopes. Assuming the slopes are stable, prism monitoring should be carried out on a monthly basis, and increased as necessary should instability develop. The GPS and radar units provide continuous, ongoing monitoring.

Groundwater Monitoring

Vibrating Wire Piezometers (VWP) were installed in three boreholes (RGSC-0004, RGSC-0005, and RGSC-0009) following the completion of drilling. Permanent data loggers where connected to the VWP's to continuously record groundwater pressures. The data should be uploaded on a regular basis (i.e., quarterly) to establish site groundwater trends prior to mining.

10.0 CLOSURE

This report should be read in conjunction with the ***"Study Limitations"*** which is appended at the beginning of the report. The reader's attention is specifically drawn to this information, as it is essential that it be followed for the proper use and interpretation of this report.

We trust this report satisfies your current requirements. If you have any questions or require further assistance, please do not hesitate to contact the undersigned.

GOLDER ASSOCIATES LTD.

Ed Saunders, M.EngSci
Rock Mechanics Specialist

Al Chance, P.Eng.
Principal, Mining Division

EAS/AVC/ls/rs/bb

\\golder.gds\calgary\active_2014\1396\1406422 - benga - riversdale\06_technical\pit slope stability report\1406422-001-r-rev0-2.0-riversdale geotechnical report 24apr_15.docx

REFERENCES

Bieniawski, Z.T. 1976. *Rock Mass Classifications in Rock Engineering.* November 1-5, 1976 Proceedings of the Symposium on Exploration for Rock Engineering. Johannesburg, pp. 97–107.

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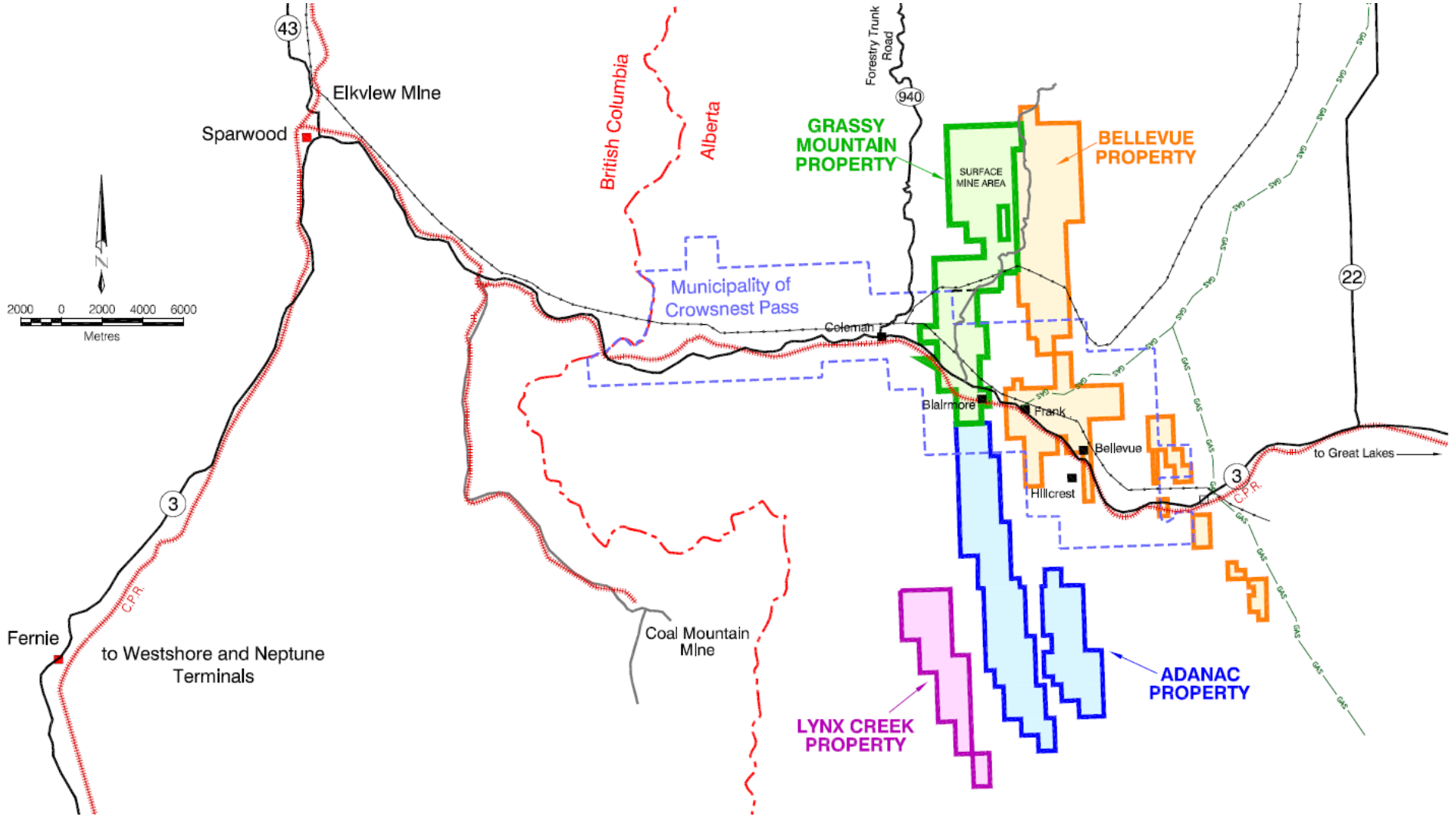

NOTE:

- FIGURE PREPARED BY NORWEST CORPORATION (TECHNICAL REPORT, GRASSY MOUNTAIN PROPERTY, ALBERTA, CANADA. REPORT DATED APRIL 5, 2013).

CLIENT
RIVERSDALE RESOURCES LIMITED

PROJECT
GRASSY MOUNTAIN PRELIMINARY PIT SLOPE ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2014-10-14
PREPARED	AGH
DESIGN	AGH
REVIEW	EAS
APPROVED	AVC

TITLE
FIGURE 1 – GRASSY MOUNTAIN SITE LOCATION

PROJECT No.	Rev.	FIGURE
2850-MN-0001-0	**0**	**1**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
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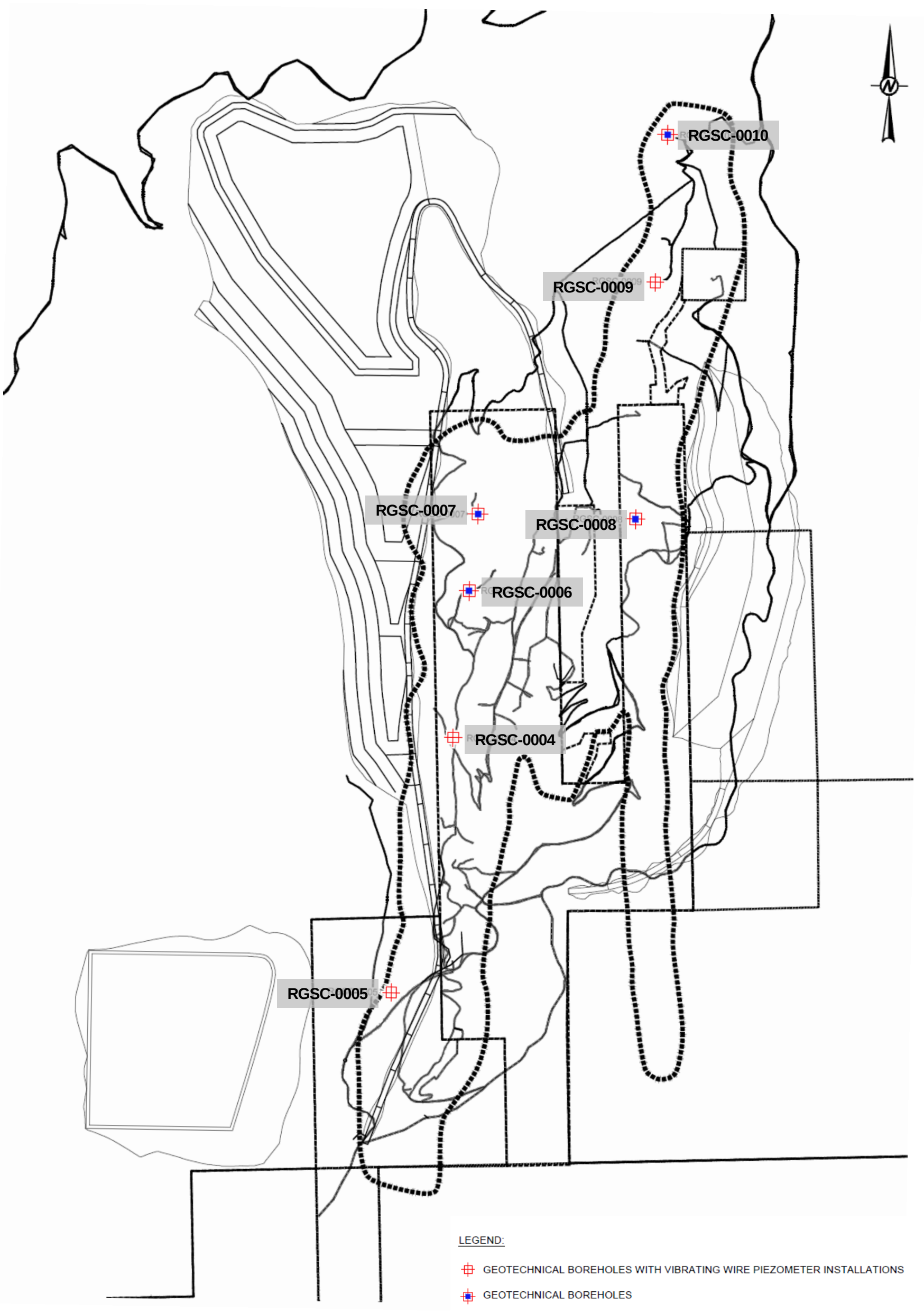

NOTE: MINE DESIGN SHOWN IS INDICATIVE AND NOT REPRESENTATIVE OF FEASIBILITY LEVEL PIT DESIGN

CLIENT
RIVERSDALE RESOURCES LIMITED

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-02-20
PREPARED	TGT
DESIGN	EAS
REVIEW	EAS
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PRELIMINARY PIT SLOPE STABILITY ASSESSMENT

TITLE
BOREHOLE LOCATION PLAN

PROJECT No.	Rev.	FIGURE
2850-MN-0001-0	0	2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B
1 in
0

APPENDIX A

Site Photographs

Path: ----- |

PHOTOGRAPH LOOKING NORTH

ENGINEERING GEOLOGICAL DESCRIPTION – SANDSTONE

- FINE TO MEDIUM GRAINED, MASSIVE & BEDDED TEXTURE, BROWN-ORANGE, ASSESSED MODERATELY WEATHERED, ESTIMATED MODERATELY STRONG TO STRONG ROCK (R3 TO R4).
- TWO JOINT SETS AND BEDDING, BEDDING IS UNDULATING AND ROUGH, SPACING 200-50mm.
- FOLDING OBSERVED IN OUTCROP, POTENTIAL FAULTING AND OFFSET OF GEOLOGICAL UNITS

ENGINEERING GEOLOGICAL DESCRIPTION –COAL

- FINE GRAINED, MASSIVE & CLEATED TEXTURE, DARK GREY-BLACK, ESTIMATED WEAK ROCK (R1 TO R2), ASSESSED SLIGHTLY TO MODERATELY WEATHERED.
- COAL DISPLAYS SHEARED SURFACES, 1-5mm IN THICKNESS AND POLISHED SURFACE CONDITION

ENGINEERING GEOLOGICAL DESCRIPTION – CONGLOMERATE

- FINE TO COARSE GRAINED, MASSIVE TEXTURE, LIGHT-DARK GREY, ESTIMATED STRONG ROCK (R4 TO R5), ASSESSED MODERATELY WEATHERED.

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PROJECT
GRASSY MOUNTAIN GEOTECHNICAL PIT SLOPE ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2014-09-30
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DESIGN	AGH
REVIEW	EAS
APPROVED	AVC

TITLE
SITE PHOTOGRAPH NO. 1

PROJECT No. **2850-MN-0001-0** | Rev. **0** | FIGURE **A-1**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
0

Path: ----- |

PHOTOGRAPH LOOKING SOUTHEAST

COAL SILTSTONE, SANDSTONE , MUDSTONE (MIST MOUNTAIN FORMATION)

CADOMIN CONGLOMERATE (BLAIRMORE GROUP)

OPEN CUT EXCAVATIONS FROM PREVIOUS MINE OPERATIONS

ENGINEERING GEOLOGICAL DESCRIPTION

- **CONGLOMERATE:** FINE TO COARSE GRAINED, MASSIVE TEXTURE, LIGHT-DARK GREY, ESTIMATED STRONG ROCK (R4 TO R5), ASSESSED MODERATELY WEATHERED.
- **SANDSTONE:** FINE TO MEDIUM GRAINED, MASSIVE & BEDDED TEXTURE, BROWN-ORANGE, ASSESSED MODERATELY WEATHERED, ESTIMATED MODERATELY STRONG TO STRONG ROCK (R3 TO R4).
- **SILTSTONE:** FINE GRAINED, BEDDED TEXTURE, DARK GREY, ESTIMATED MODERATELY STRONG ROCK (R3), ASSESSED SLIGHTLY WEATHERED.
- **MUDSTONE:** GREY TO DARK GREY, FINE GRAINED, LAMINATED AND THINLY BEDDING, ESTIMATED WEAK TO MODERATELY WEAK ROCK (R1-R2). ASSESSED SLIGHTLY TO MODERATELY WEATHERED.
- **COAL:** FINE GRAINED, MASSIVE & CLEATED TEXTURE, DARK GREY-BLACK, ESTIMATED WEAK ROCK (R1 TO R2), ASSESSED SLIGHTLY TO MODERATELY WEATHERED.

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GRASSY MOUNTAIN GEOTECHNICAL PIT SLOPE ASSESSMENT

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DESIGN	AGH
REVIEW	EAS
APPROVED	AVC

TITLE
SITE PHOTOGRAPH NO. 2

PROJECT No.
2850-MN-0001-0

Rev.
0

FIGURE
A-2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
0

Path: ----- |

PHOTOGRAPH LOOKING NORTH

ENGINEERING GEOLOGICAL DESCRIPTION - MIST MOUNTAIN FORMATION

- **SANDSTONE:** FINE TO MEDIUM GRAINED, MASSIVE & BEDDED TEXTURE, BROWN-ORANGE, ASSESSED MODERATELY WEATHERED, ESTIMATED MODERATELY STRONG TO STRONG ROCK (R3 TO R4).
- **SILTSTONE:** FINE GRAINED, BEDDED TEXTURE, DARK GREY, ESTIMATED MODERATELY STRONG ROCK (R3), ASSESSED SLIGHTLY WEATHERED.
- **COAL:** FINE GRAINED, MASSIVE & CLEATED TEXTURE, DARK GREY-BLACK, ESTIMATED WEAK ROCK (R1 TO R2), ASSESSED SLIGHTLY TO MODERATELY WEATHERED.

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PROJECT
GRASSY MOUNTAIN GEOTECHNICAL PIT SLOPE ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2014-09-30
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DESIGN	AGH
REVIEW	EAS
APPROVED	AVC

TITLE
SITE PHOTOGRAPH NO. 3

PROJECT No.
2850-MN-0001-0

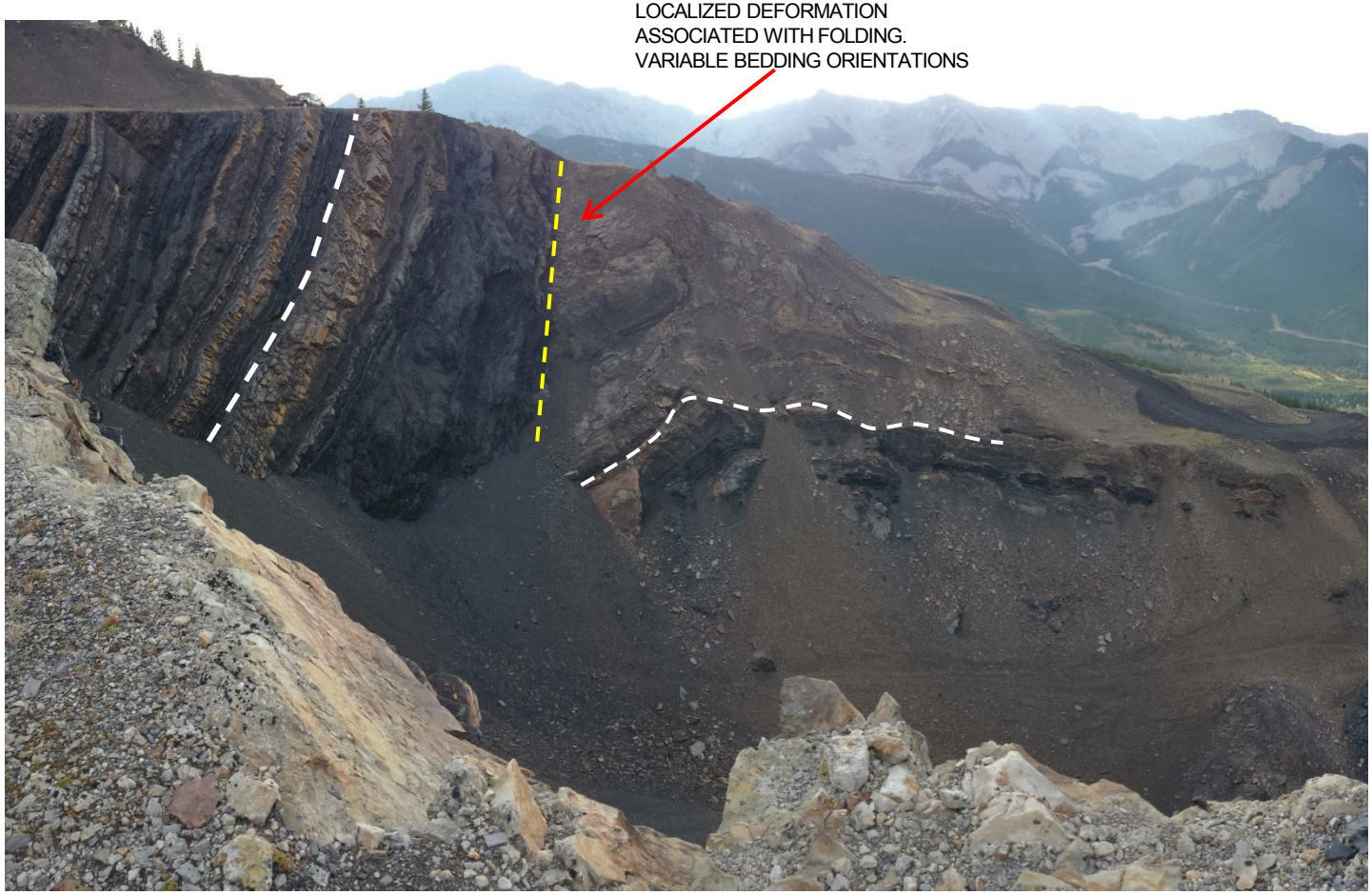
Rev.
0

FIGURE
A-3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
0

Path: ----- |

PHOTOGRAPH LOOKING NORTHEAST



ENGINEERING GEOLOGICAL DESCRIPTION - MIST MOUNTAIN FORMATION

- **SANDSTONE:** FINE TO MEDIUM GRAINED, MASSIVE & BEDDED TEXTURE, BROWN-ORANGE, ASSESSED MODERATELY WEATHERED, ESTIMATED MODERATELY STRONG TO STRONG ROCK (R3 TO R4).
- **SILTSTONE:** FINE GRAINED, BEDDED TEXTURE, DARK GREY, ESTIMATED MODERATELY STRONG ROCK (R3), ASSESSED SLIGHTLY WEATHERED.
- **COAL:** FINE GRAINED, MASSIVE & CLEATED TEXTURE, DARK GREY-BLACK, ESTIMATED WEAK ROCK (R1 TO R2), ASSESSED SLIGHTLY TO MODERATELY WEATHERED.

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CONSULTANT
Golder Associates

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DESIGN	AGH
REVIEW	EAS
APPROVED	AVC

TITLE
SITE PHOTOGRAPH NO. 4

PROJECT No. **2850-MN-0001-0** | Rev. **0** | FIGURE **A-4**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
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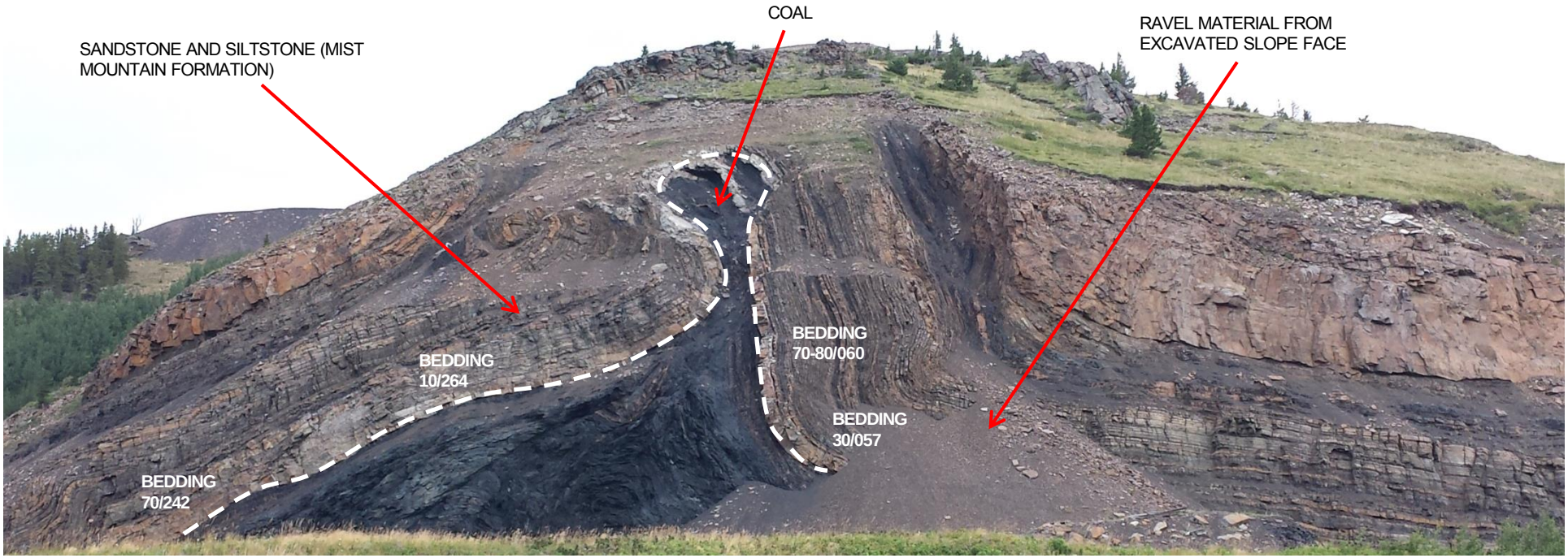
Path: ----- |

PHOTOGRAPH LOOKING NORTH



ENGINEERING GEOLOGICAL DESCRIPTION –SANDSTONE

- FINE TO MEDIUM GRAINED, BEDDED TEXTURE, LIGHT GREY ON FRESH SURFACE AND ORANGE TO LIGHT BROWN ON OXIDIZED SURFACE, ESTIMATED MODERATELY STRONG TO STRONG ROCK (R3 TO R4);
- ORIENTED BEDDING PLUS JOINT SET ORTHOGONAL TO BEDDING, SPACING 20-40 CM, 1M CONTINUITY.

ENGINEERING GEOLOGICAL DESCRIPTION –COAL

- DARK GREY TO BLACK, FINE GRAINED, BEDDED TEXTURE, ESTIMATED WEAK ROCK (R1 TO R2), POLISHED SURFACES;
- INTER-BEDDED WITH CARBONACEOUS MUDSTONE, MUDSTONE AND SILTSTONE;
- LARGE AND SMALL SCALE FOLDING.

ENGINEERING GEOLOGICAL DESCRIPTION –SILTSTONE

- GREY TO DARK GREY, FINE GRAINED, THINLY BEDDED, ESTIMATED MODERATELY WEAK ROCK (R2). INTER-BEDDED WITH CARBONACEOUS MUDSTONE, MUDSTONE AND SILTSTONE; BEDDING SPACING 10-20 CM

ENGINEERING GEOLOGICAL DESCRIPTION –MUDSTONE

- GREY TO DARK GREY, FINE GRAINED, LAMINATED AND THINLY BEDDING, ESTIMATED WEAK TO MODERATELY WEAK ROCK (R1-R2). INTER-BEDDED WITH SILTSTONE; BEDDING SPACING 3-10 CM

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TITLE
SITE PHOTOGRAPH NO. 5

PROJECT No.
2850-MN-0001-0

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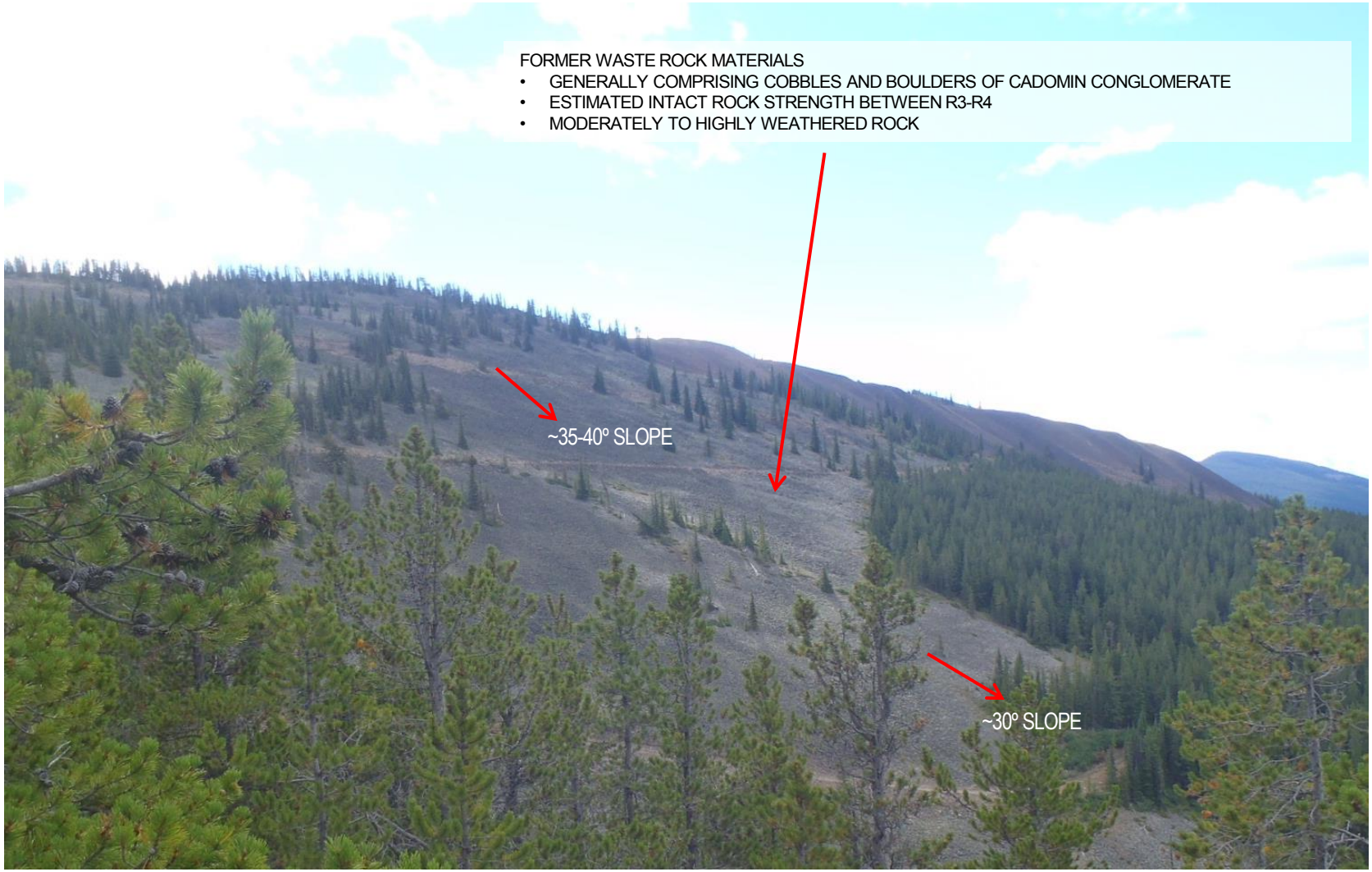
0

FIGURE
A-5

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
0

Path: ----- |

PHOTOGRAPH LOOKING SOUTHEAST



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GRASSY MOUNTAIN GEOTECHNICAL PIT SLOPE ASSESSMENT

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YYYY-MM-DD	2014-09-30
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DESIGN	AGH
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TITLE
SITE PHOTOGRAPH NO. 6

PROJECT No.
2850-MN-0001-0

Rev.
0

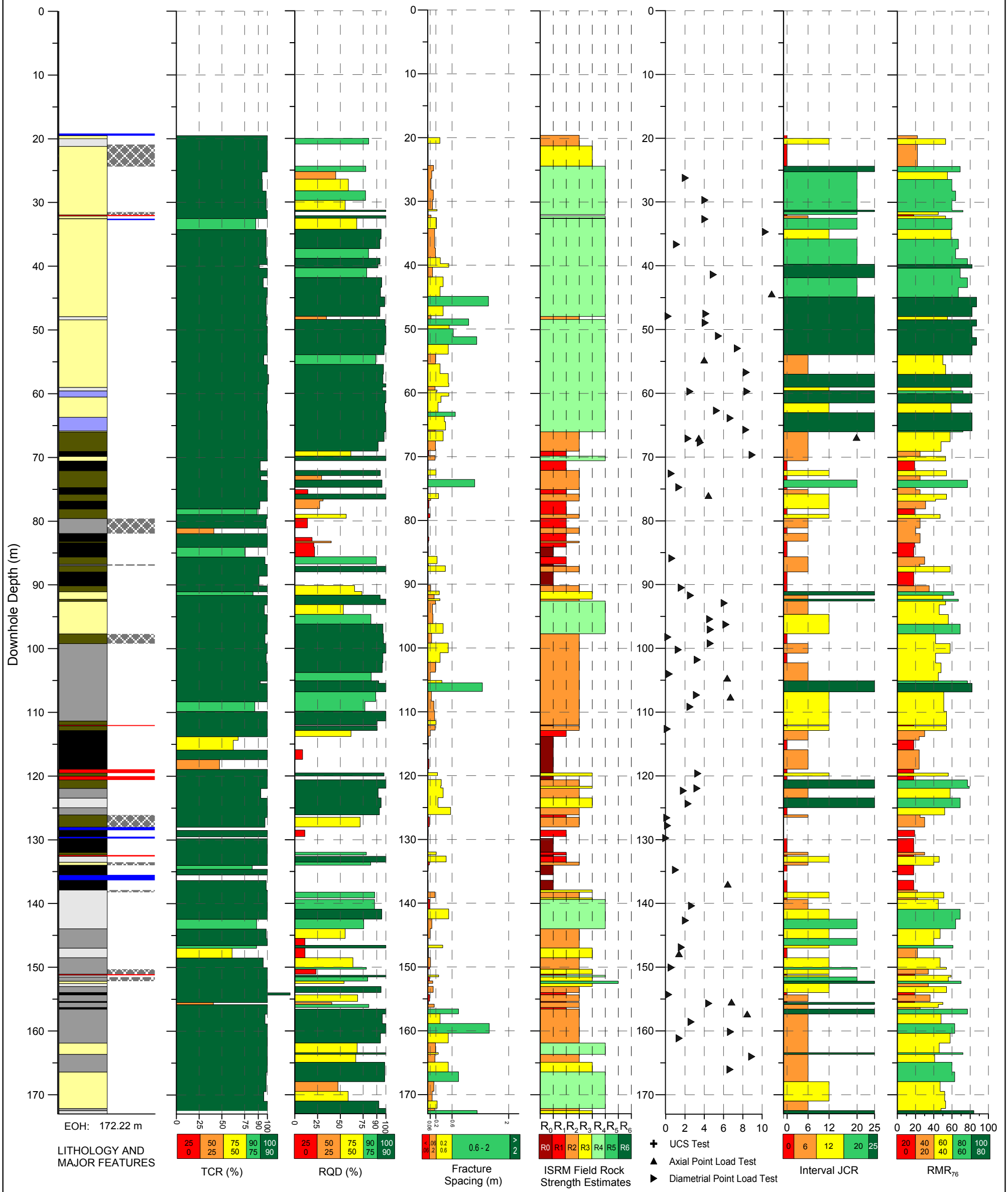
FIGURE
A-6

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
0

APPENDIX B

Core Logging Data Downhole Borehole Plots

Northing (m):	685490.0	Azimuth:	100°	Borehole ID:	RGSC-0004
Easting (m):	5506218.0	Inclination:	70°		
Elevation (m.a.s.l.):	1755.0	Length (m):	172.22		



LITHOLOGY

- Coal
- Carbonaceous Mudstone
- Mudstone
- Siltstone
- Sandstone
- Conglomerate

MAJOR FEATURES

- Fault
- Broken Core
- Core Loss

Rev. 0

FIGURE B1

PROJECT
GRASSY MOUNTAIN PREFEASIBILITY GEOTECHNICAL PIT SLOPE INVESTIGATION

CLIENT
RIVERSDALE RESOURCES LIMITED

TITLE
GEOTECHNICAL SUMMARY LOG RGSC-0004

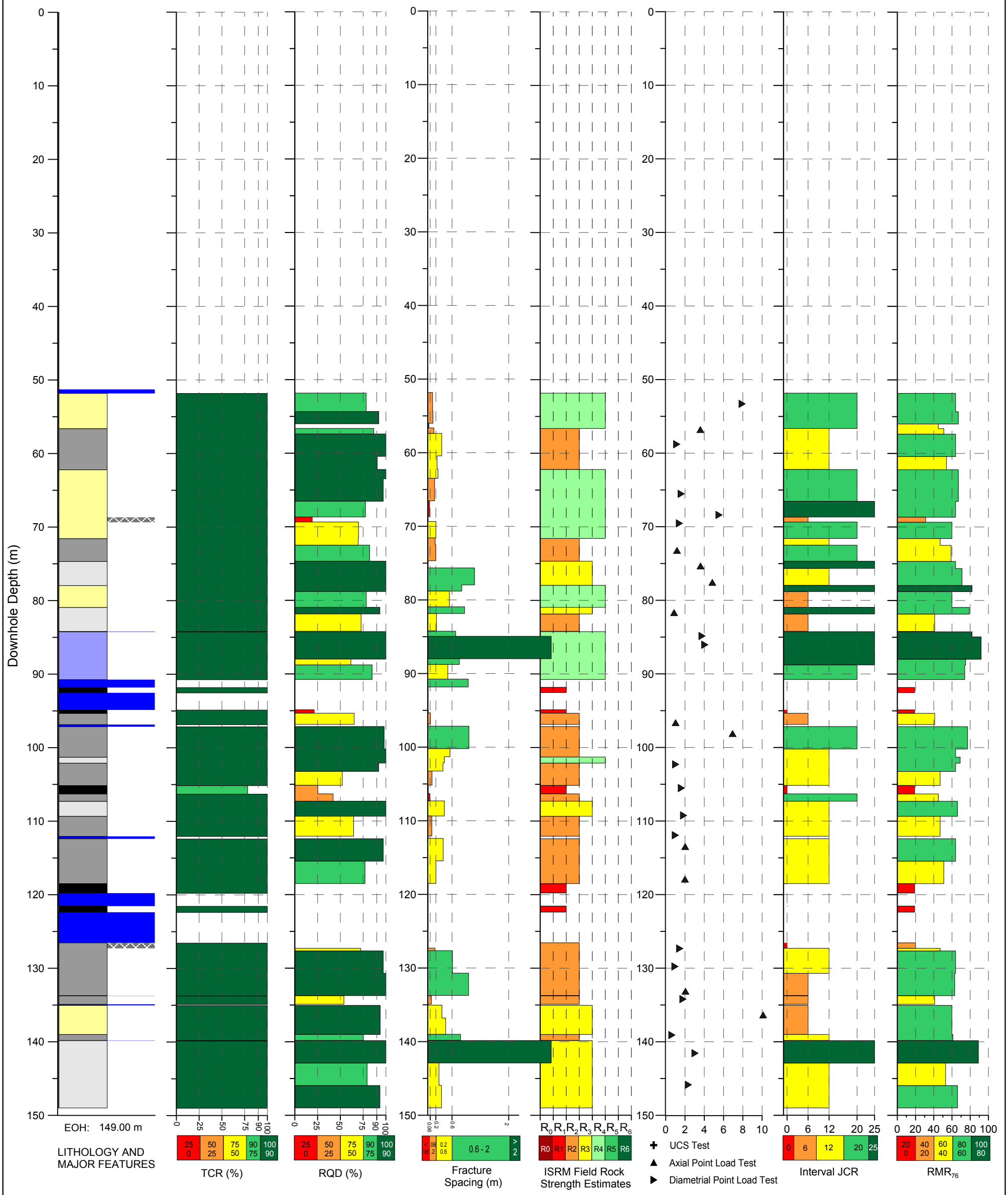
CONSULTANT
Golder Associates

PROJECT No.
2850-MN-0001-0

YYYY-MM-DD	2014-10-02
PREPARED	TGT
CAD	TGT
CHECK	EAS
REVIEW	AVC

0 1 in IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

Northing (m):	685118.0	Azimuth:	075°	Borehole ID:	RGSC-0005
Easting (m):	5504574.0	Inclination:	70°		
Elevation (m.a.s.l.):	1507.0	Length (m):	149.00		



LITHOLOGY

- Coal
- Carbonaceous Mudstone
- Mudstone
- Siltstone
- Sandstone
- Conglomerate

MAJOR FEATURES

- Fault
- Broken Core
- Core Loss

Rev. 0

PROJECT
GRASSY MOUNTAIN PREFEASIBILITY GEOTECHNICAL
PIT SLOPE INVESTIGATION

CLIENT
RIVERSDALE RESOURCES LIMITED

TITLE
GEOTECHNICAL SUMMARY LOG
RGSC-0005

CONSULTANT
Golder Associates

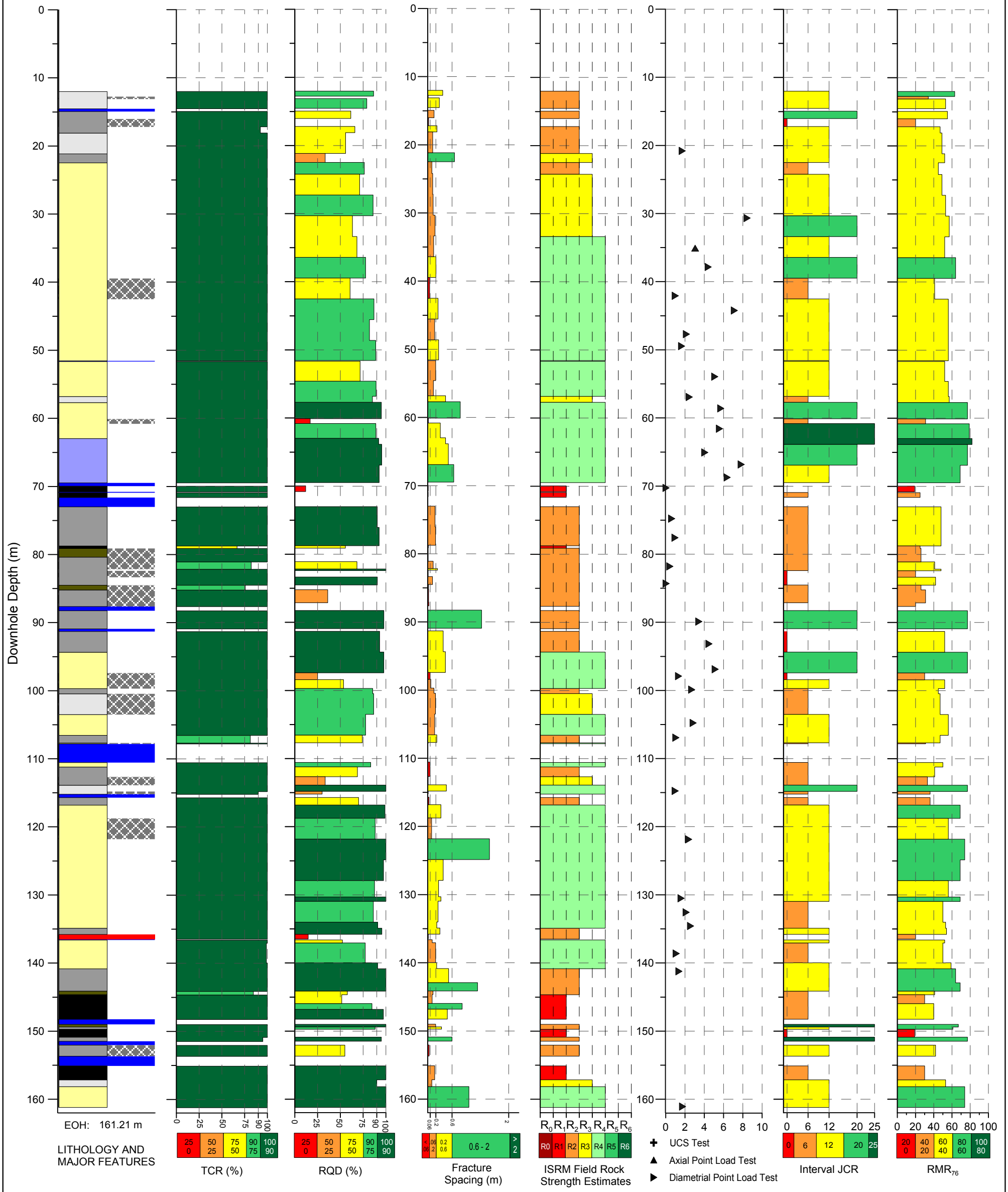
YYYY-MM-DD	2014-10-02
PREPARED	TGT
CAD	TGT
CHECK	EAS
REVIEW	AVC

PROJECT No.
2850-MN-0001-0

FIGURE **B2**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

Northing (m):	685577.0	Azimuth:	°	Borehole ID:	RGSC-0006
Easting (m):	5507161.0	Inclination:	90°		
Elevation (m.a.s.l.):	1825.0	Length (m):	161.21		



LITHOLOGY

- Coal
- Carbonaceous Mudstone
- Mudstone
- Siltstone
- Sandstone
- Conglomerate

MAJOR FEATURES

- Fault
- Broken Core
- Core Loss

Rev. 0

PROJECT
GRASSY MOUNTAIN PREFEASIBILITY GEOTECHNICAL PIT SLOPE INVESTIGATION

CLIENT
RIVERSDALE RESOURCES LIMITED

TITLE
GEOTECHNICAL SUMMARY LOG
RGSC-0006

CONSULTANT
Golder Associates

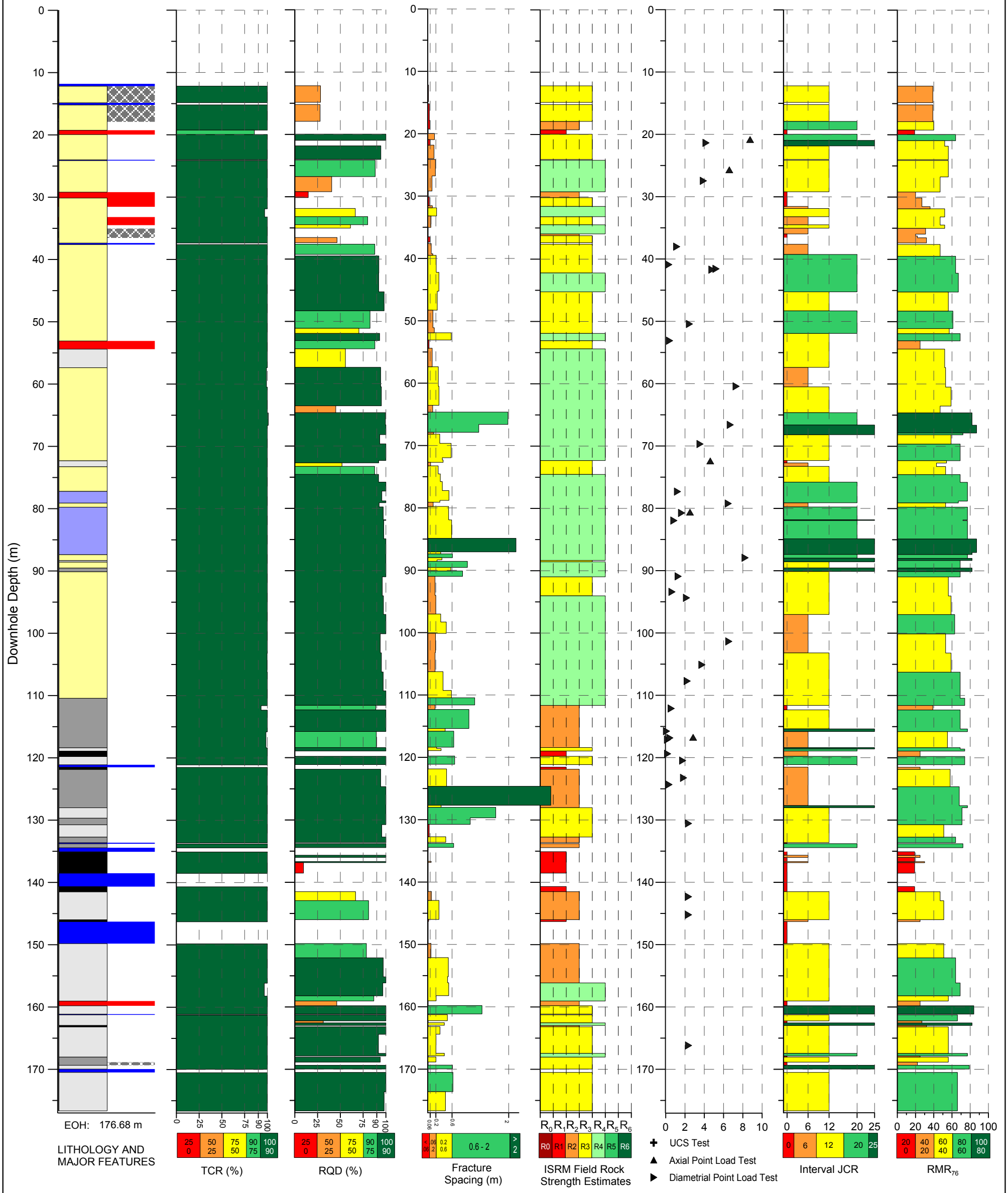
PROJECT No.
2850-MN-0001-0

YYYY-MM-DD	2014-10-02
PREPARED	TGT
CAD	TGT
CHECK	EAS
REVIEW	AVC

FIGURE **B3**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

Northing (m):	685627.0	Azimuth:	°	Borehole ID:	RGSC-0007
Easting (m):	5507655.0	Inclination:	90°		
Elevation (m.a.s.l.):	1912.0	Length (m):	176.68		



LITHOLOGY

- Coal
- Carbonaceous Mudstone
- Mudstone
- Siltstone
- Sandstone
- Conglomerate

MAJOR FEATURES

- Fault
- Broken Core
- Core Loss

Rev. 0

FIGURE B4

PROJECT
GRASSY MOUNTAIN PREFEASIBILITY GEOTECHNICAL PIT SLOPE INVESTIGATION

CLIENT
RIVERSDALE RESOURCES LIMITED

TITLE
GEOTECHNICAL SUMMARY LOG RGSC-0007

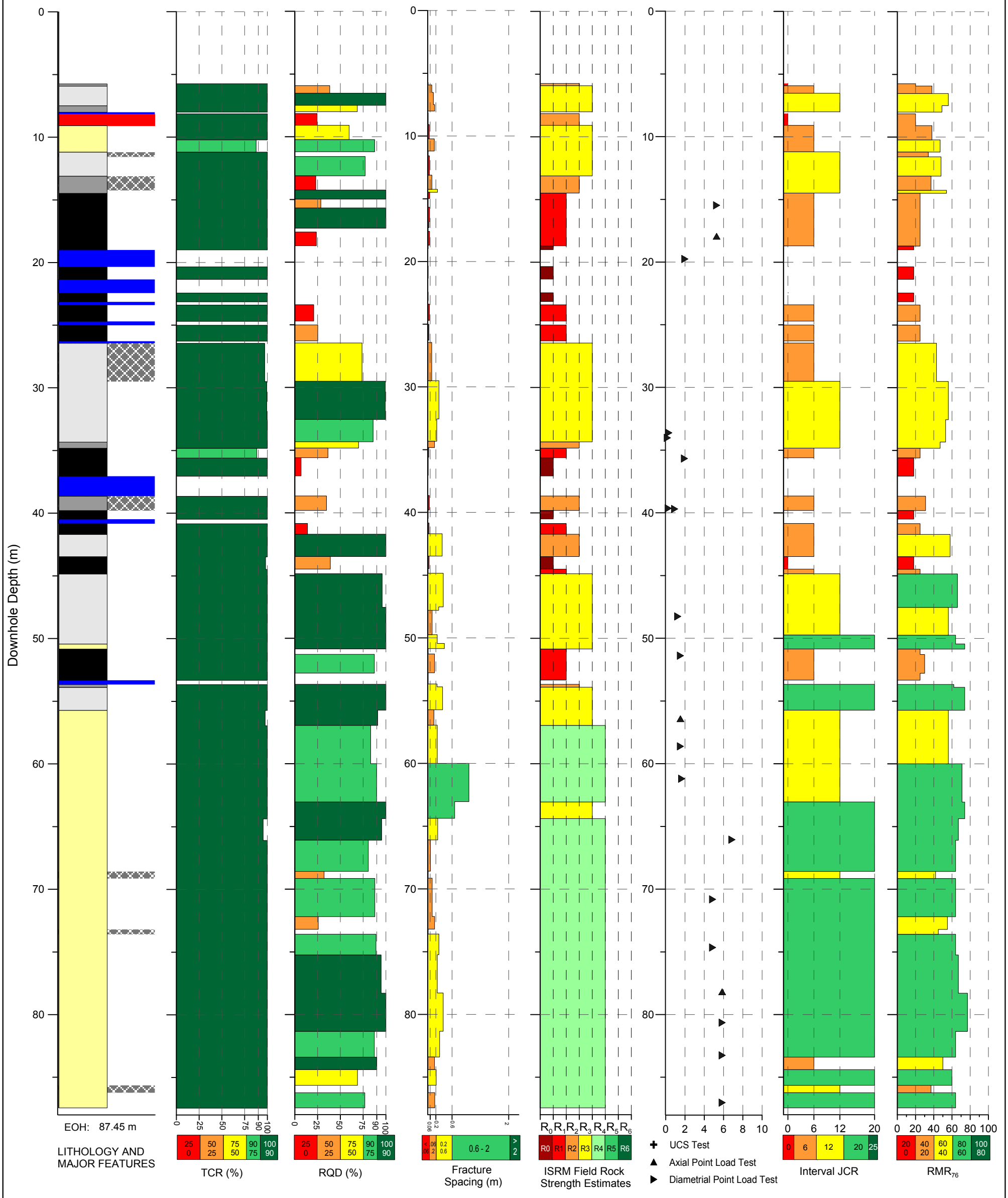
CONSULTANT
Golder Associates

PROJECT No.
2850-MN-0001-0

YYYY-MM-DD	2014-10-02
PREPARED	TGT
CAD	TGT
CHECK	EAS
REVIEW	AVC

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

Northing (m):	686638.0	Azimuth:	°	Borehole ID:	RGSC-0008
Easting (m):	5507638.0	Inclination:	90°		
Elevation (m.a.s.l.):	1955.0	Length (m):	87.45		



LITHOLOGY

- Coal
- Carbonaceous Mudstone
- Mudstone
- Siltstone
- Sandstone
- Conglomerate

MAJOR FEATURES

- Fault
- Broken Core
- Core Loss

Rev. 0

PROJECT
GRASSY MOUNTAIN PREFEASIBILITY GEOTECHNICAL
PIT SLOPE INVESTIGATION

CLIENT
RIVERSDALE RESOURCES LIMITED

TITLE
GEOTECHNICAL SUMMARY LOG
RGSC-0008

CONSULTANT
Golder Associates

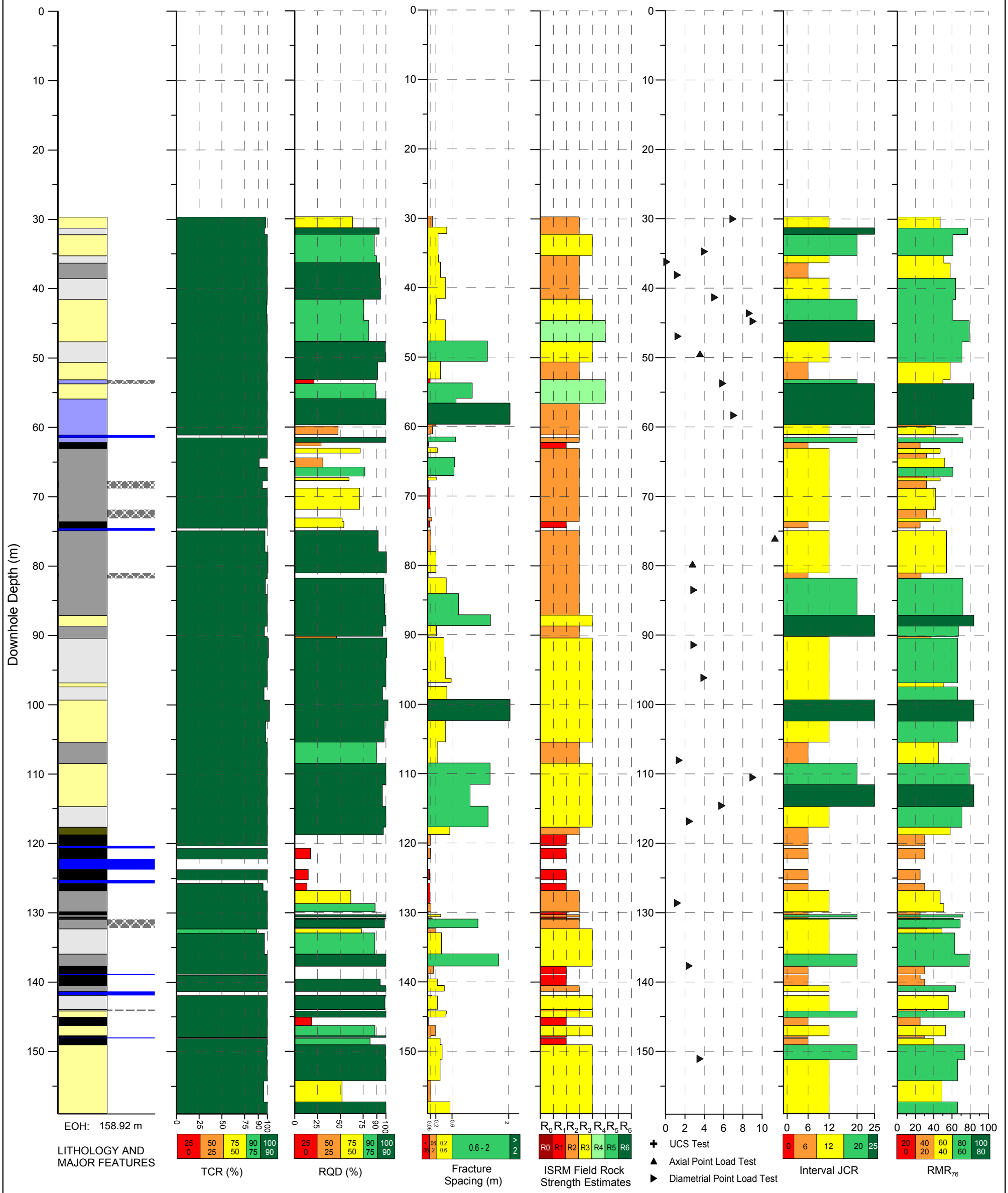
PROJECT No.
2850-MN-0001-0

FIGURE
B5

YYYY-MM-DD	2014-10-02
PREPARED	TGT
CAD	TGT
CHECK	EAS
REVIEW	AVC

0 1 in IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

Northing (m):	686742.0	Azimuth:	020°	Borehole ID:	RGSC-0009
Easting (m):	5509160.0	Inclination:	70°		
Elevation (m.a.s.l.):	1912.0	Length (m):	158.92		



LITHOLOGY

- Coal
- Carbonaceous Mudstone
- Mudstone
- Siltstone
- Sandstone
- Conglomerate

MAJOR FEATURES

- Fault
- Broken Core
- Core Loss

Rev. 0

PROJECT
GRASSY MOUNTAIN PREFEASIBILITY GEOTECHNICAL
PIT SLOPE INVESTIGATION

CLIENT
RIVERSDALE RESOURCES LIMITED

TITLE
GEOTECHNICAL SUMMARY LOG
RGSC-0009

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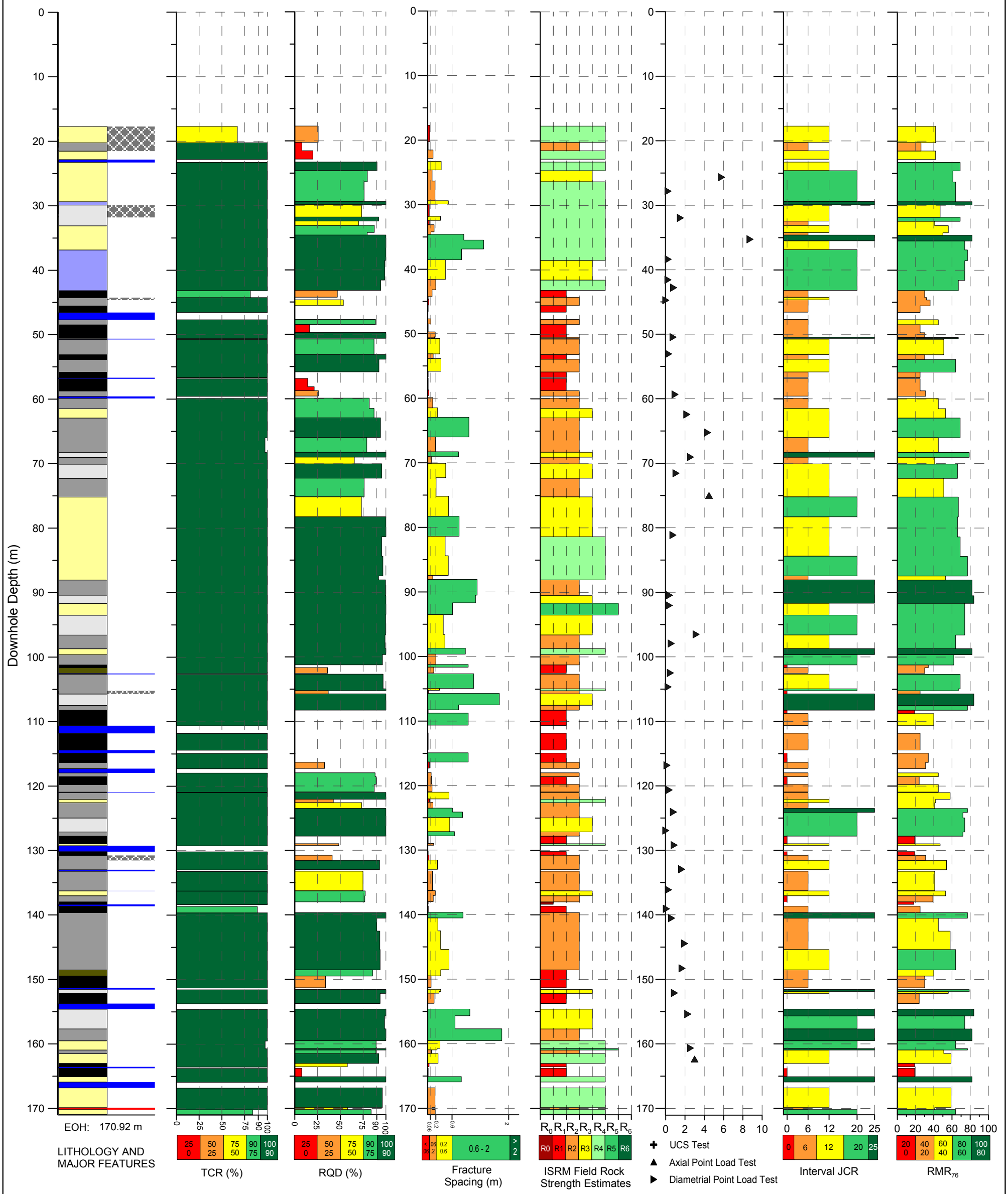
PROJECT No.
2850-MN-0001-0

FIGURE
B6

YYYY-MM-DD	2014-10-02
PREPARED	TGT
CAD	TGT
CHECK	EAS
REVIEW	AVC

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

Northing (m):	686807.0	Azimuth:	°	Borehole ID:	RGSC-0010
Easting (m):	5510108.0	Inclination:	90°		
Elevation (m.a.s.l.):	1774.0	Length (m):	170.92		



LITHOLOGY

- Coal
- Carbonaceous Mudstone
- Mudstone
- Siltstone
- Sandstone
- Conglomerate

MAJOR FEATURES

- Fault
- Broken Core
- Core Loss

Rev. 0

PROJECT
GRASSY MOUNTAIN PREFEASIBILITY GEOTECHNICAL PIT SLOPE INVESTIGATION

CLIENT
RIVERSDALE RESOURCES LIMITED

TITLE
GEOTECHNICAL SUMMARY LOG RGSC-0010

CONSULTANT
Golder Associates

PROJECT No.
2850-MN-0001-0

FIGURE B7

YYYY-MM-DD	2014-10-02
PREPARED	TGT
CAD	TGT
CHECK	EAS
REVIEW	AVC

0 1 in IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

APPENDIX C

Rock Strength Assessment

1.0 INTACT ROCK STRENGTH

Intact rock strength data was collected during the field investigation as follows:

- Field estimates of intact rock strength collected during core logging;
- Laboratory Uniaxial Compressive Strength (UCS) testing on selected rock core samples; and
- Field point load testing on rock core samples.

The results of the intact rock strength assessment is summarized and discussed in the following sections.

1.1 Estimated Field Strength

Field estimates of intact rock strength were collected by Golder and Riversdale during geotechnical core logging. The field estimates of intact rock strength are discussed below, and are based on the International Society of Rock Mechanics (ISRM) methods (Brown, 1981) summarized in Table G-1.

Table G-1: Summary of ISRM Intact Rock Strength Estimates (Brown 1981)

Grade	Description	Field Identification	Approx. Range of Uniaxial Compressive Strength (MPa)
R0	Extremely Weak Rock	Indented by thumbnail.	0.25 - 1.0
R1	Very Weak Rock	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife.	1.0 - 5.0
R2	Weak Rock	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer.	5.0 – 25
R3	Medium Strong Rock	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer.	25 – 50
R4	Strong Rock	Specimen requires more than one blow of geological hammer to fracture it.	50 – 100
R5	Very Strong Rock	Specimen requires many blows of geological hammer to fracture it.	100 - 250
R6	Extremely Strong Rock	Specimen can only be chipped with geological hammer.	>250

Histograms of the ISRM field estimates of intact rock strength are presented in Plates C-1 to C-7.

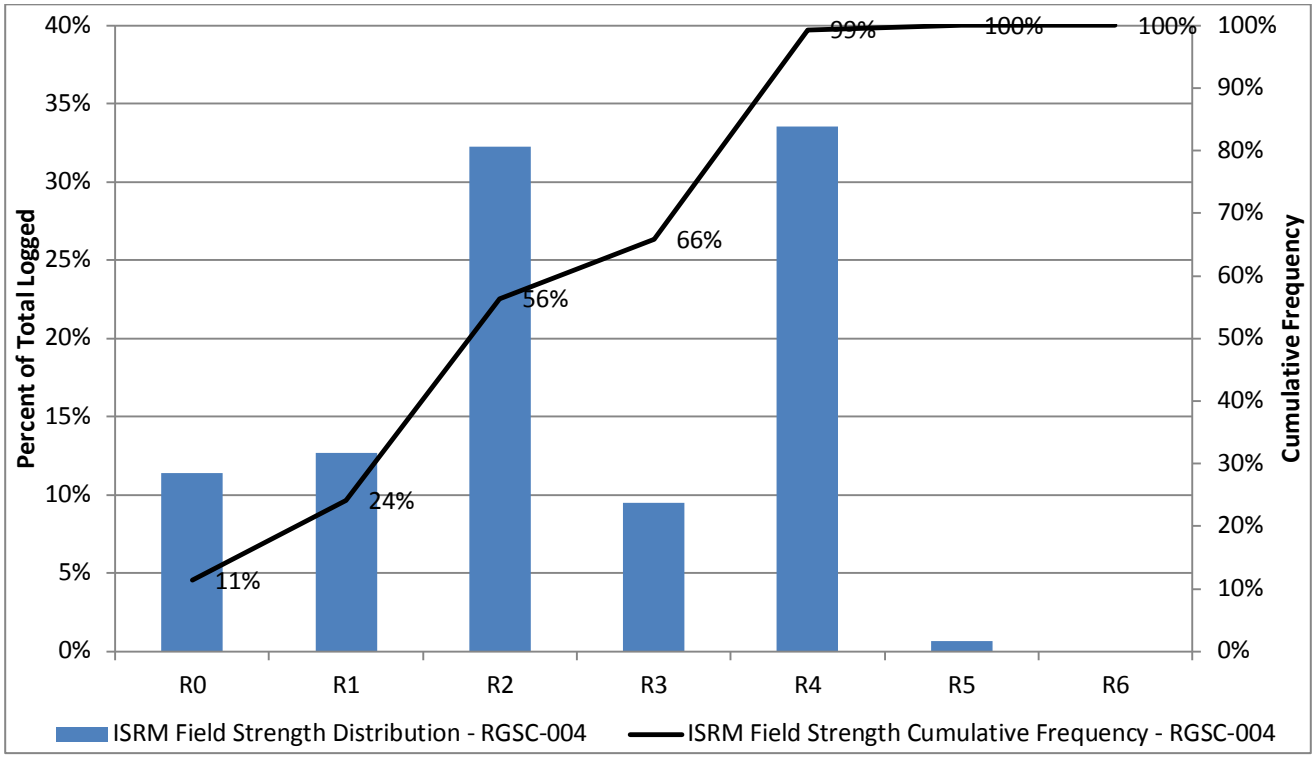


Plate C-1: ISRM Field Strength Interval Distribution – RGSC-0004

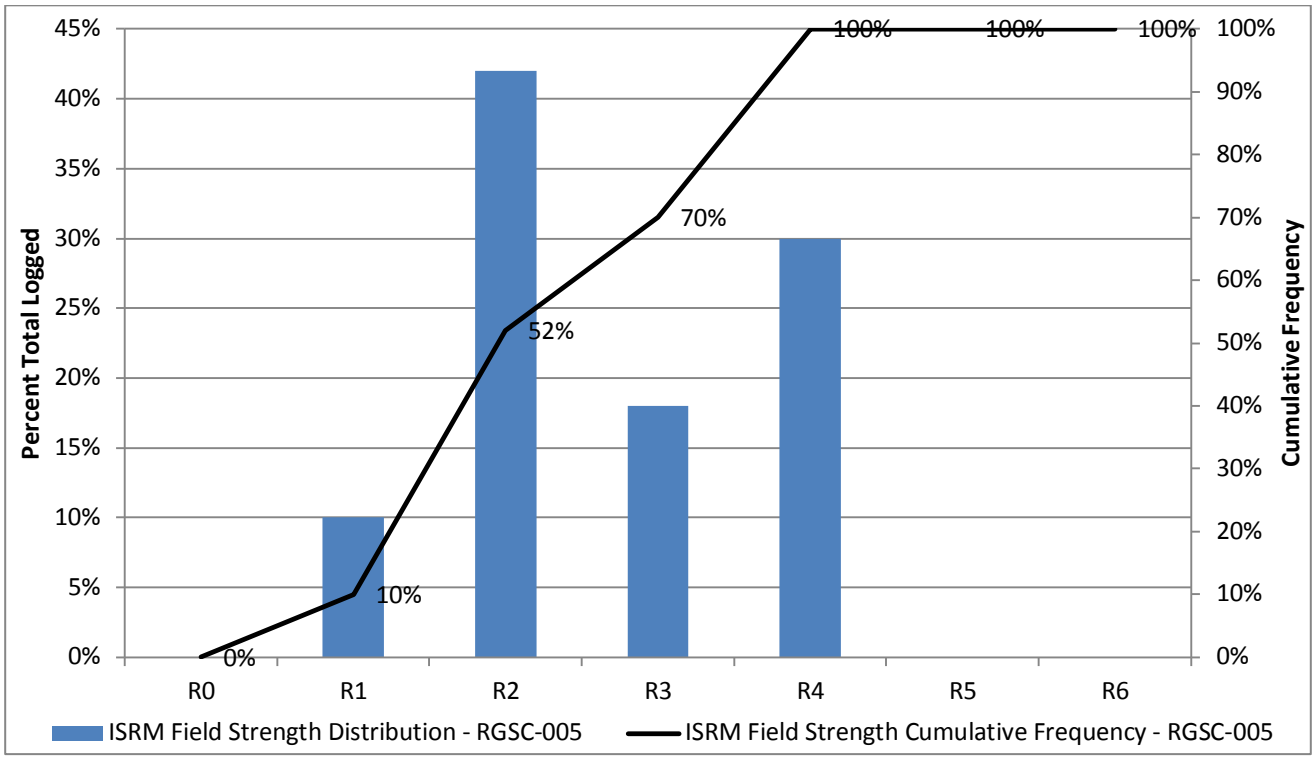


Plate C-2: ISRM Field Strength Interval Distribution – RGSC-0005

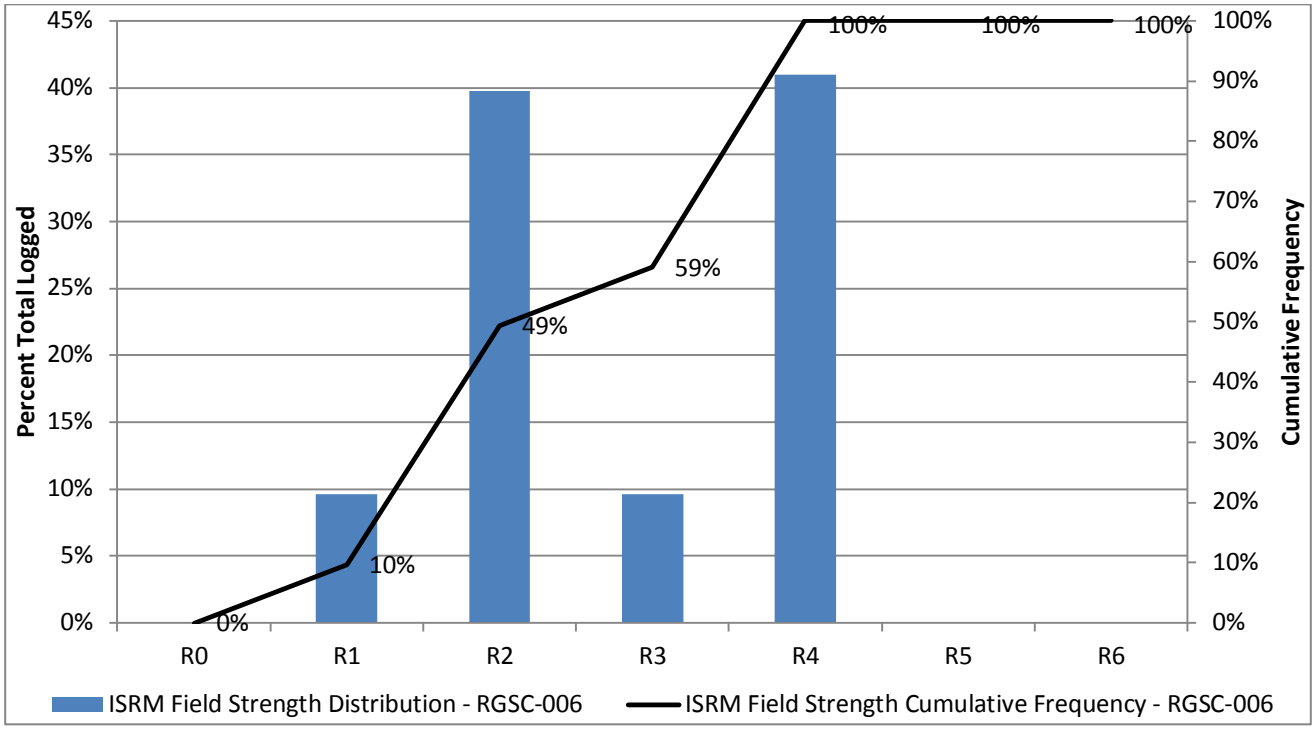


Plate C-3: ISRM Field Strength Interval Distribution – RGSC-0006

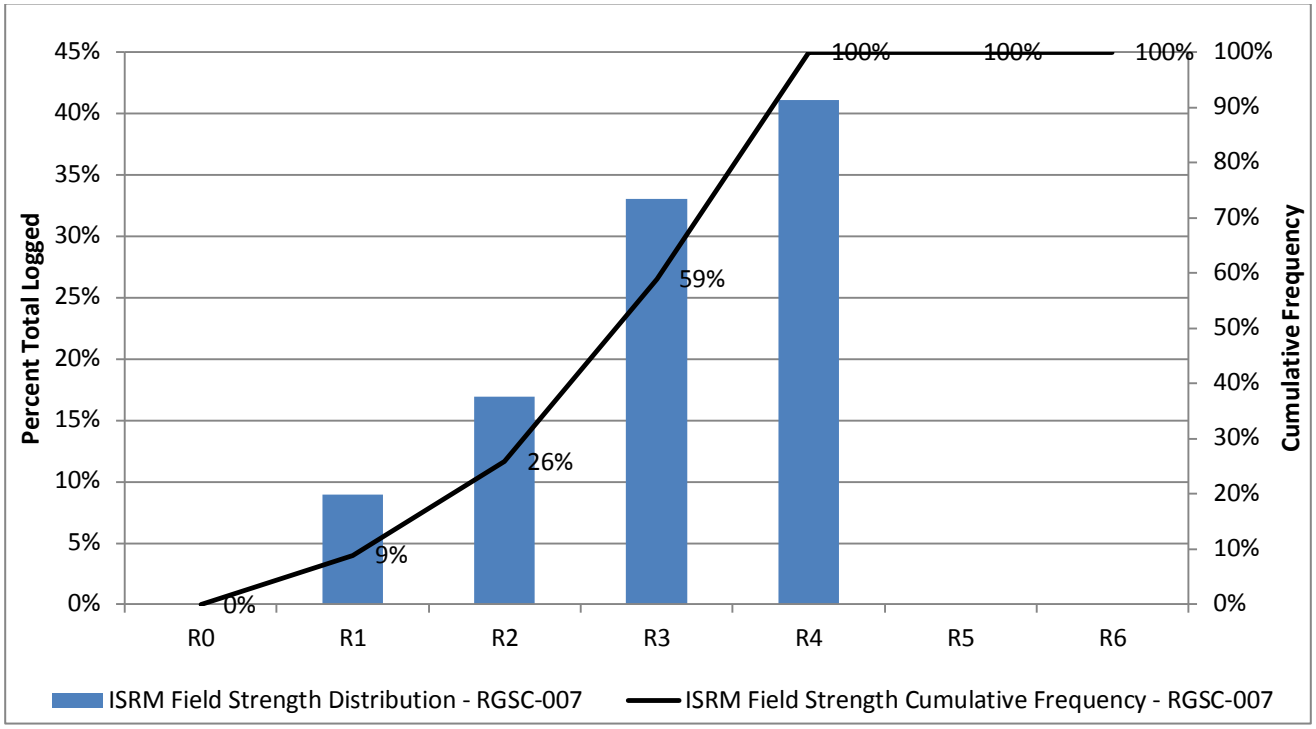


Plate C-4: ISRM Field Strength Interval Distribution – RGSC-0007

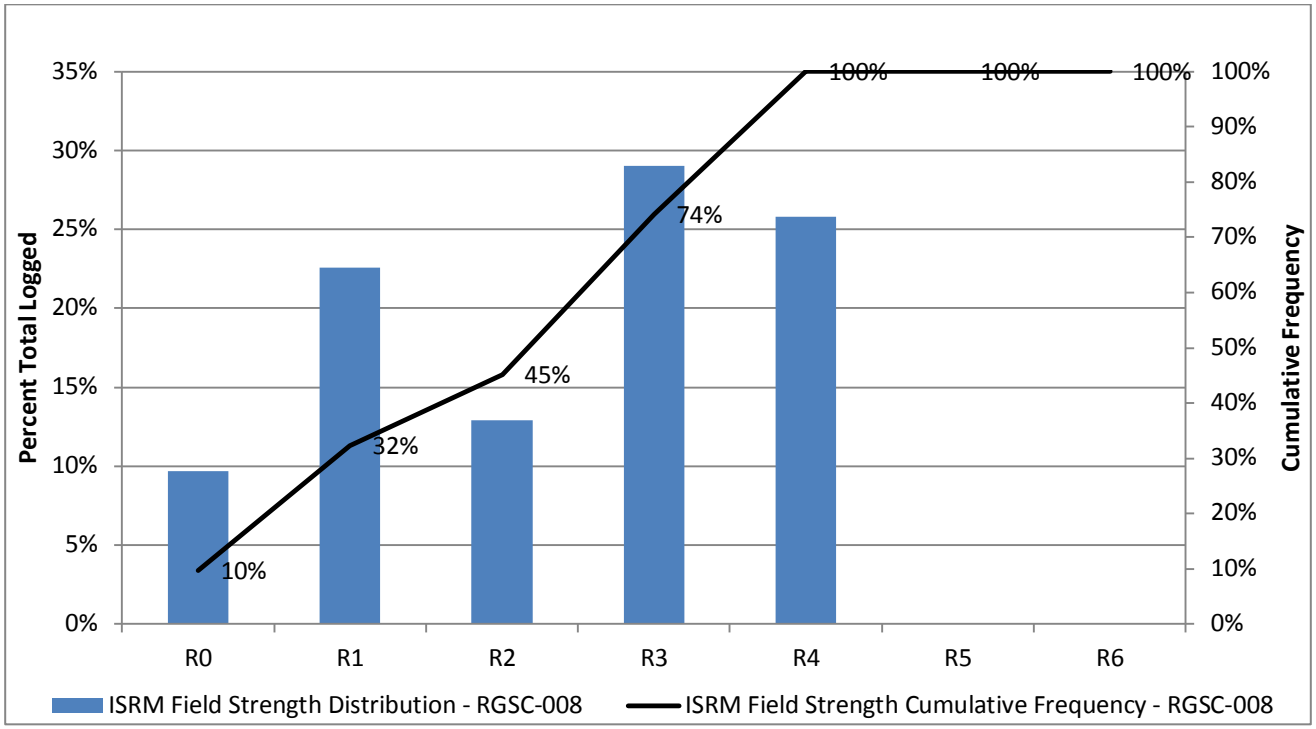


Plate C-5: ISRM Field Strength Interval Distribution –RGSC-0008

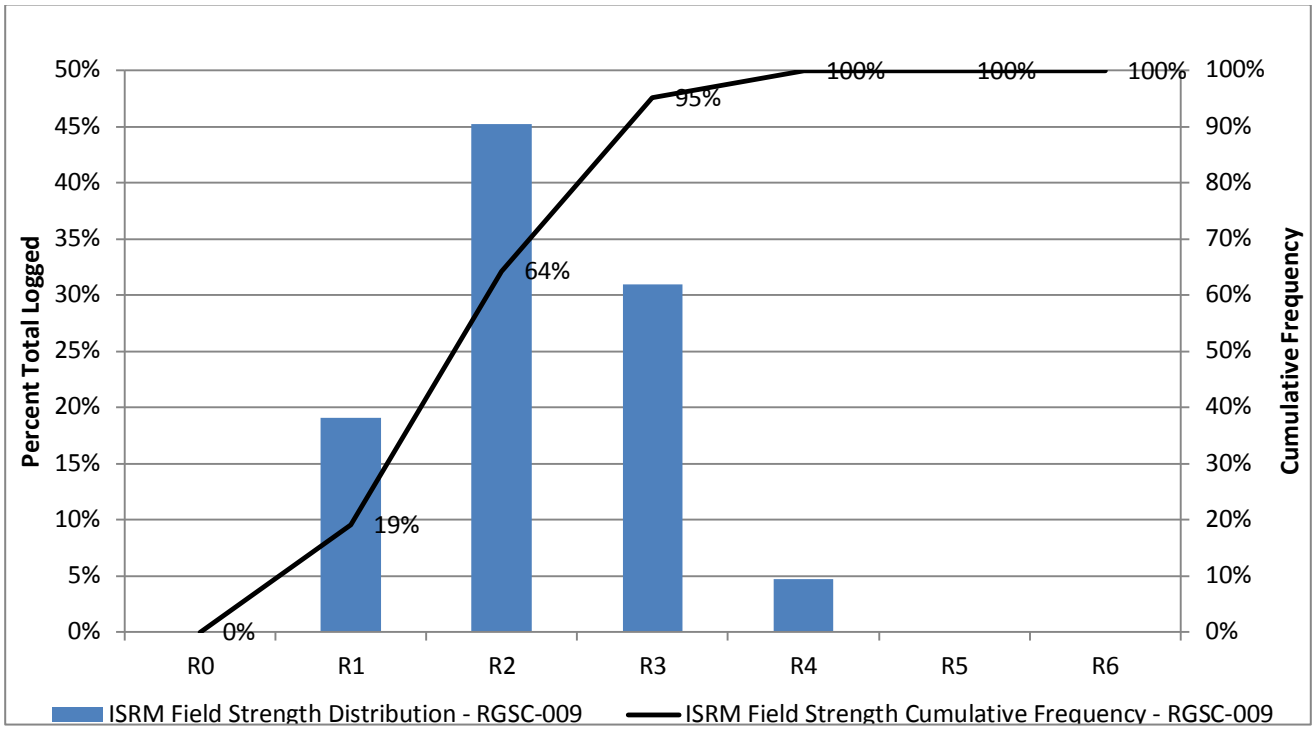


Plate C-6: ISRM Field Strength Interval Distribution – RGSC-0009

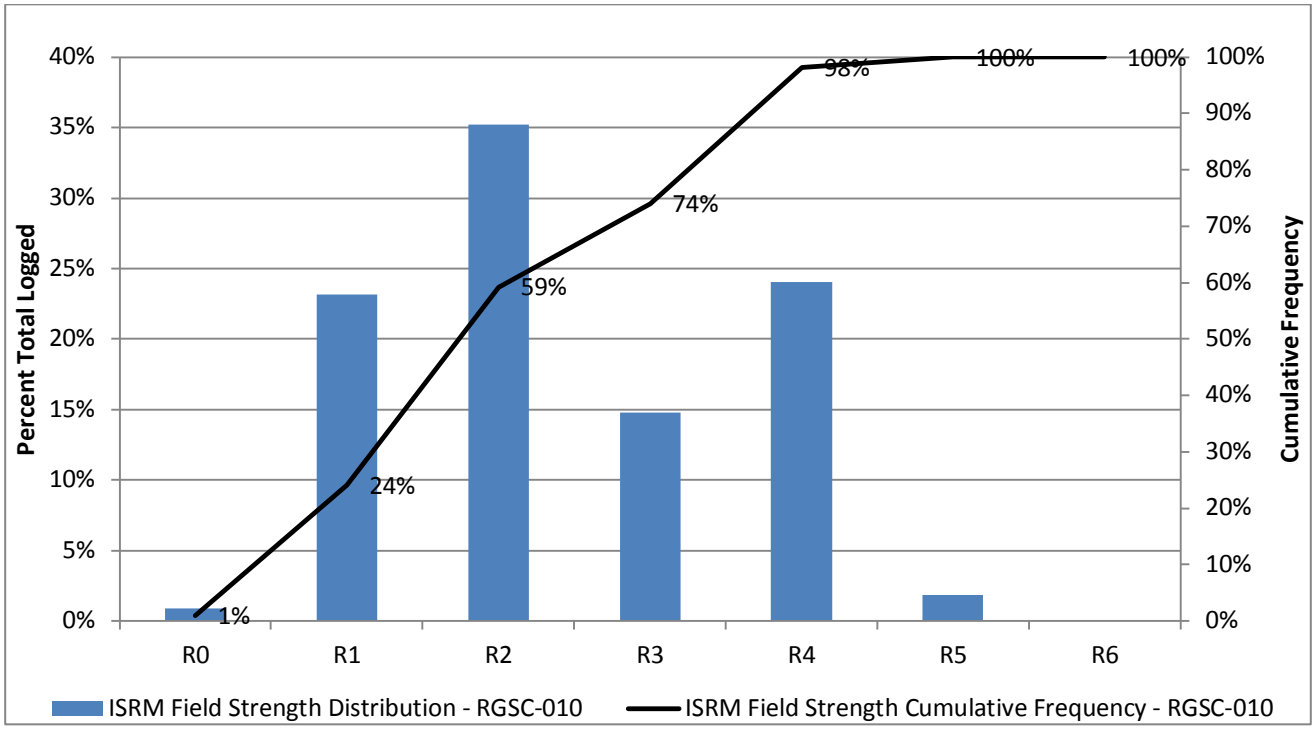


Plate C-7: ISRM Field Strength Interval Distribution – RGSC-0010

Histograms of the field estimates of intact rock strength by lithology are presented in Plate C-8 to C-14.

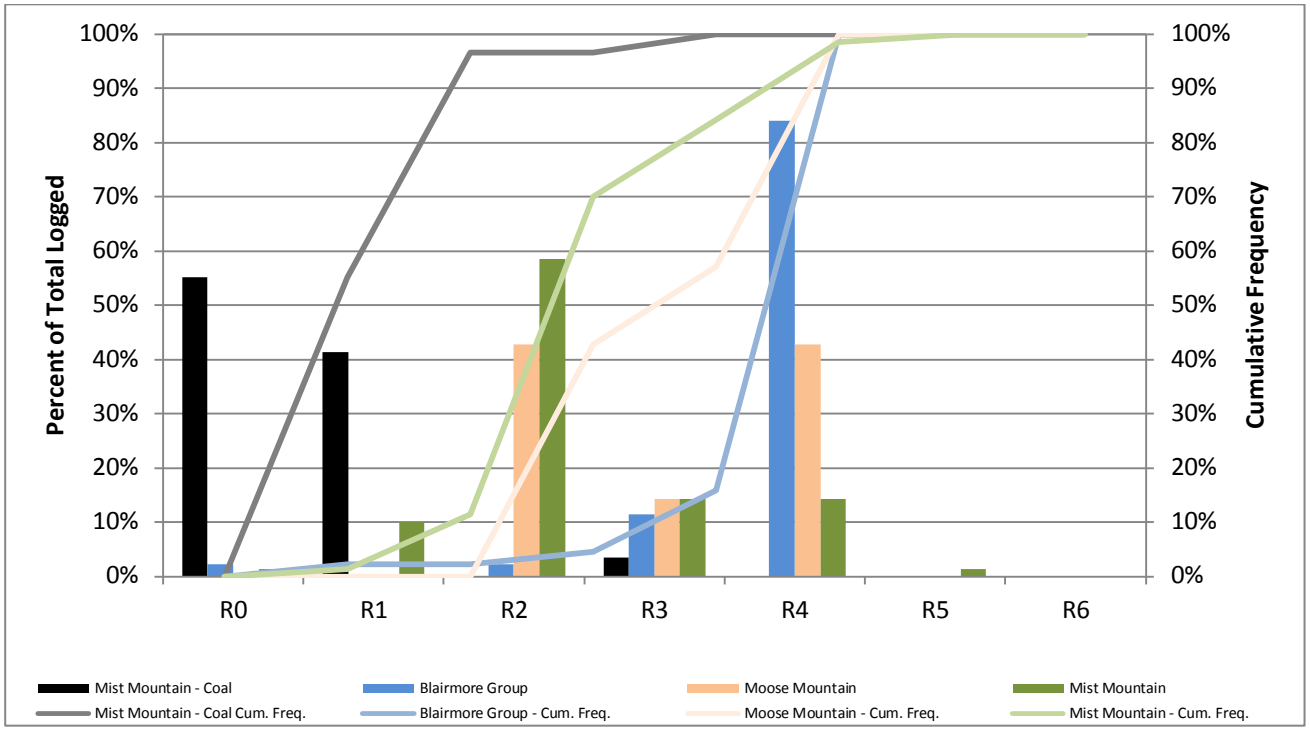


Plate C-8: ISRM Field Strength Interval Distribution by Lithology – RGSC-0004

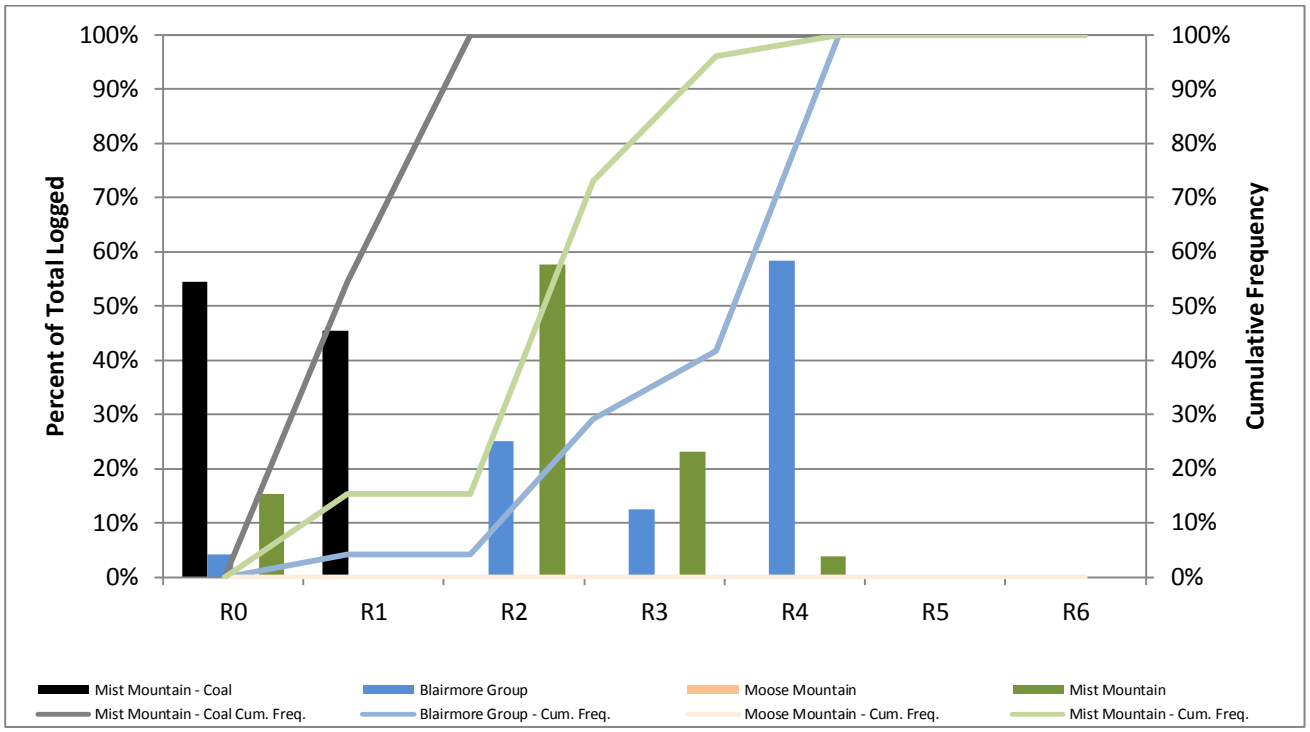


Plate C-9: ISRM Field Strength Interval Distribution by Lithology – RGSC-0005

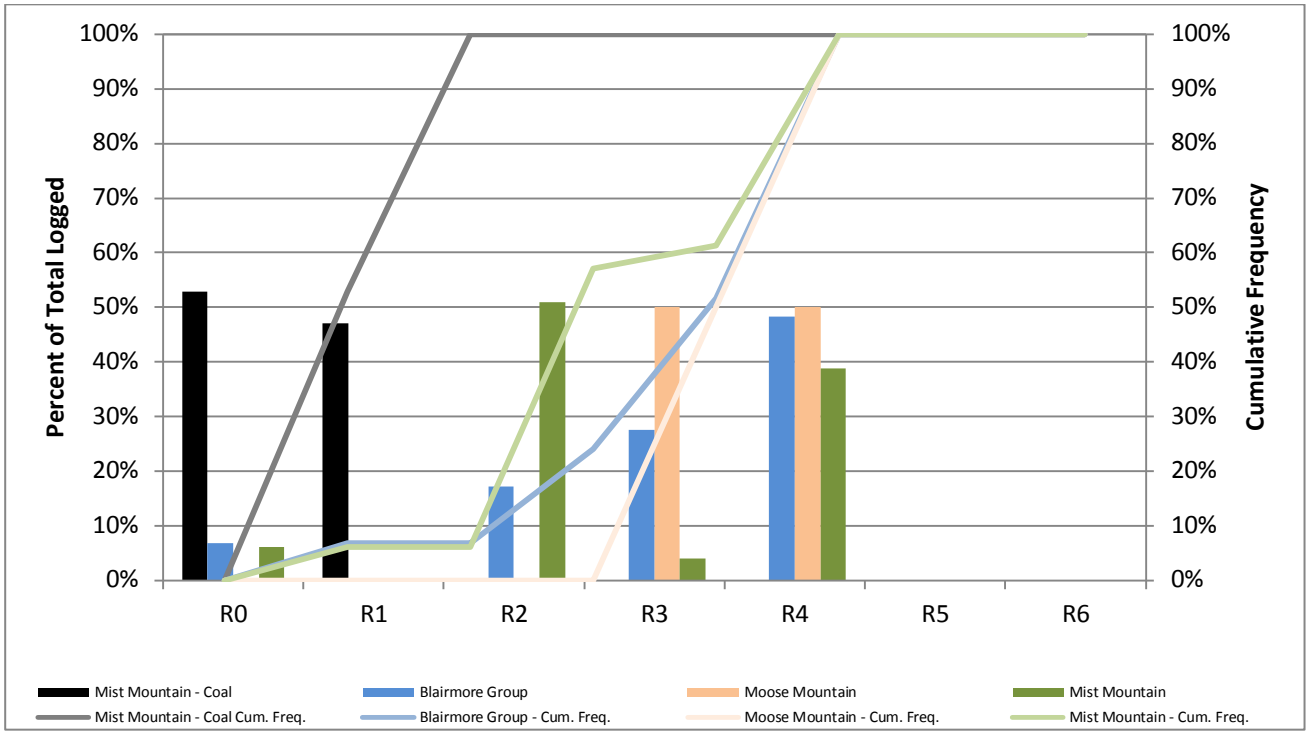


Plate C-10: ISRM Field Strength Interval Distribution by Lithology – RGSC-0006

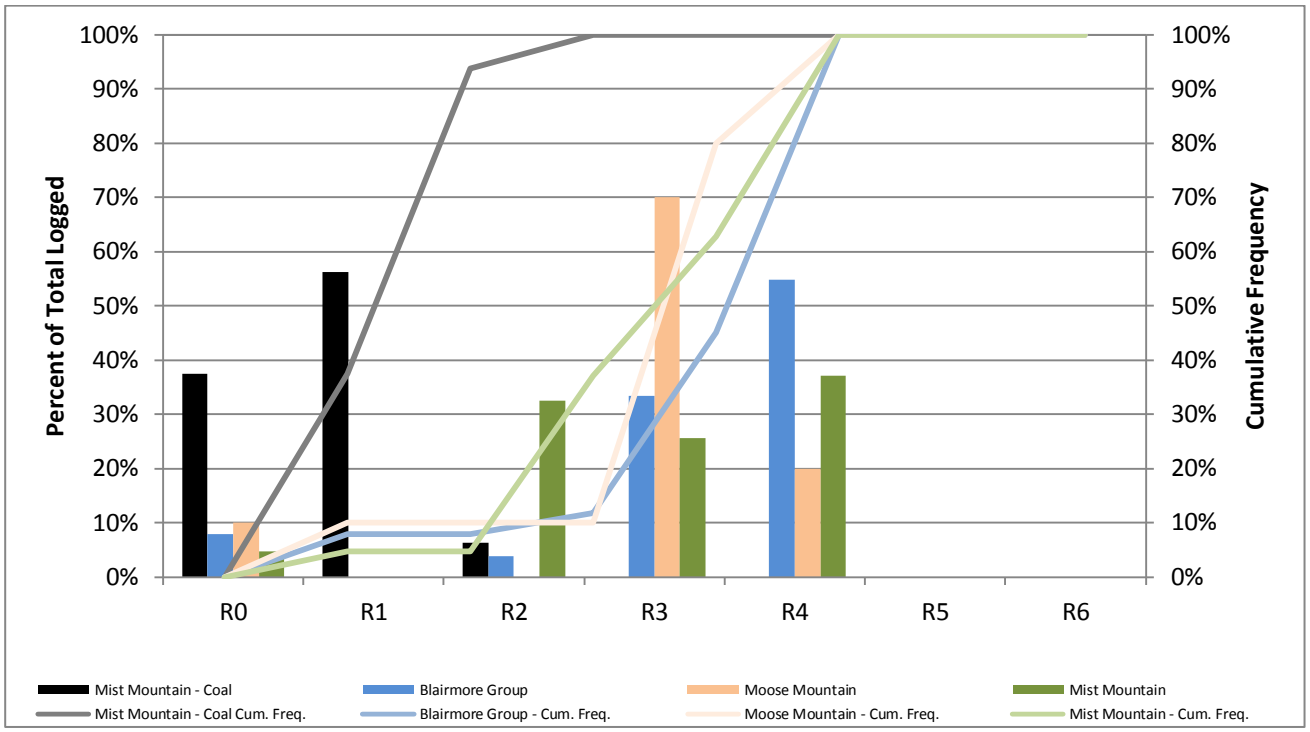


Plate C-11: ISRM Field Strength Interval Distribution by Lithology – RGSC-0007

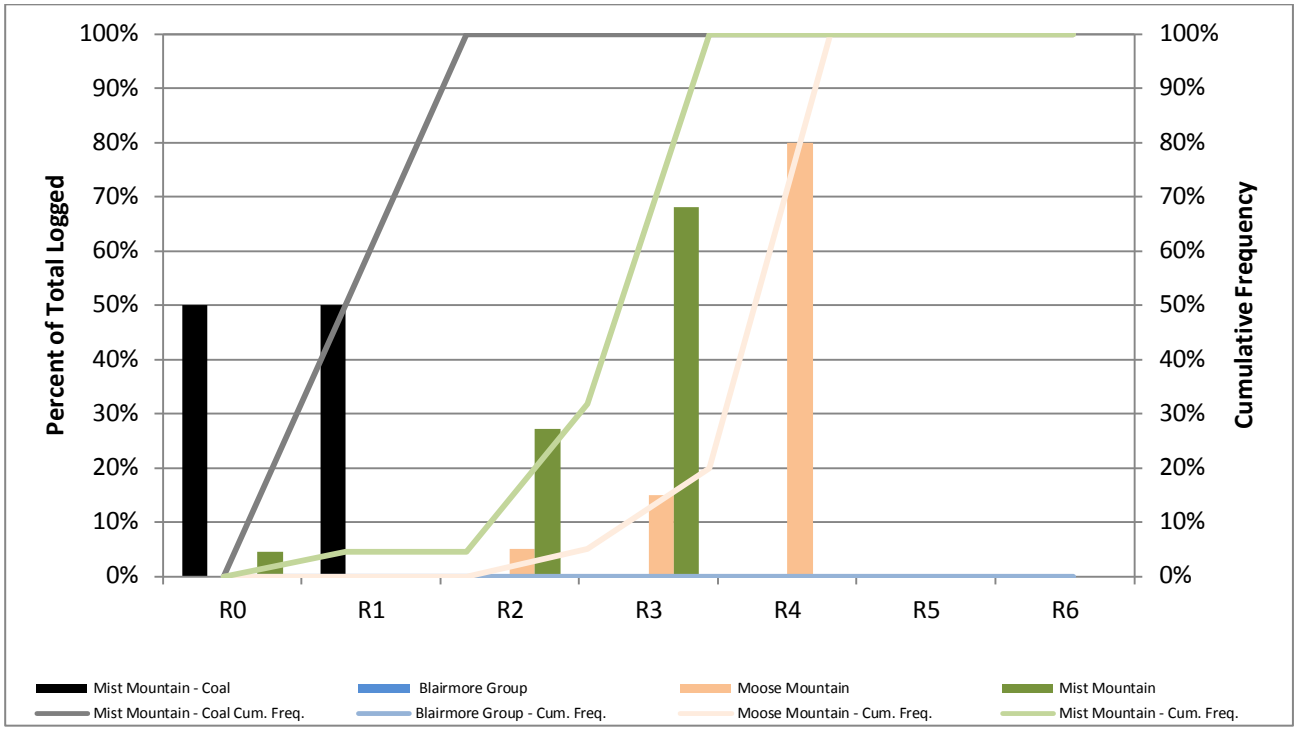


Plate C-12: ISRM Field Strength Interval Distribution by Lithology – RGSC-0008

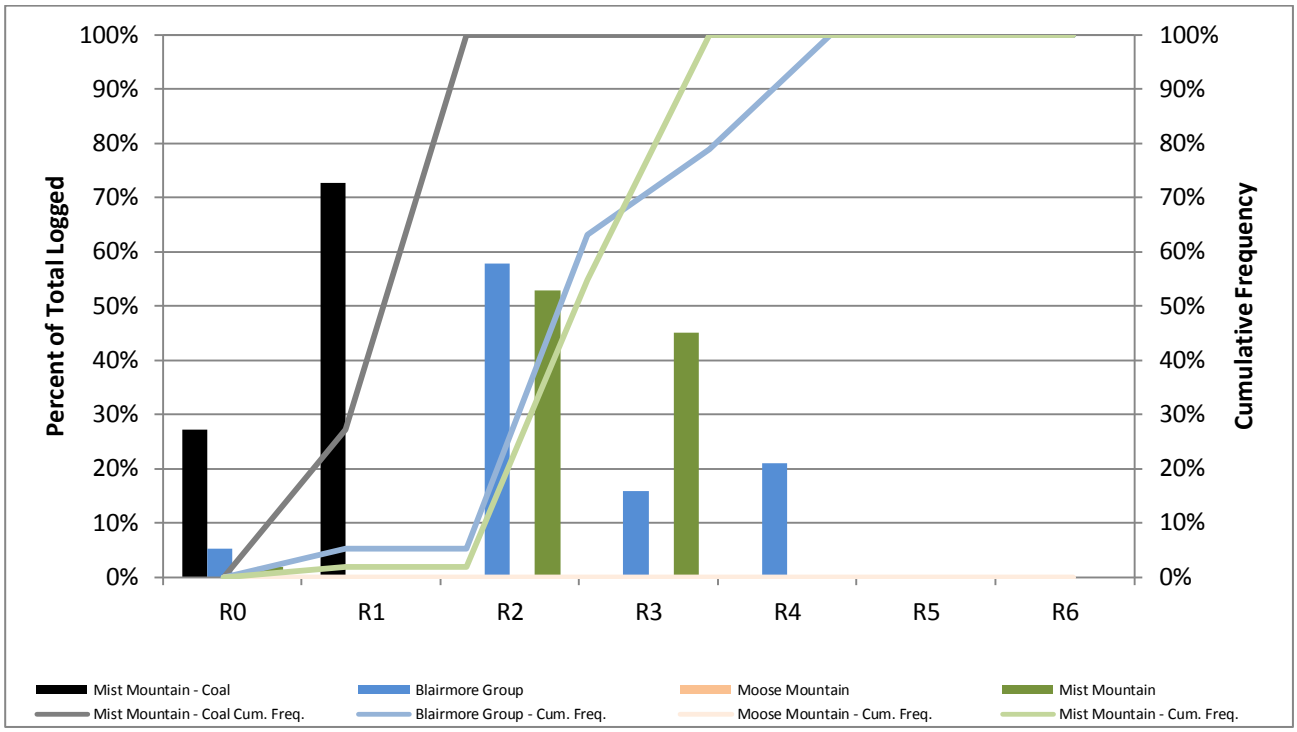


Plate C-13: ISRM Field Strength Interval Distribution by Lithology – RGSC-0009

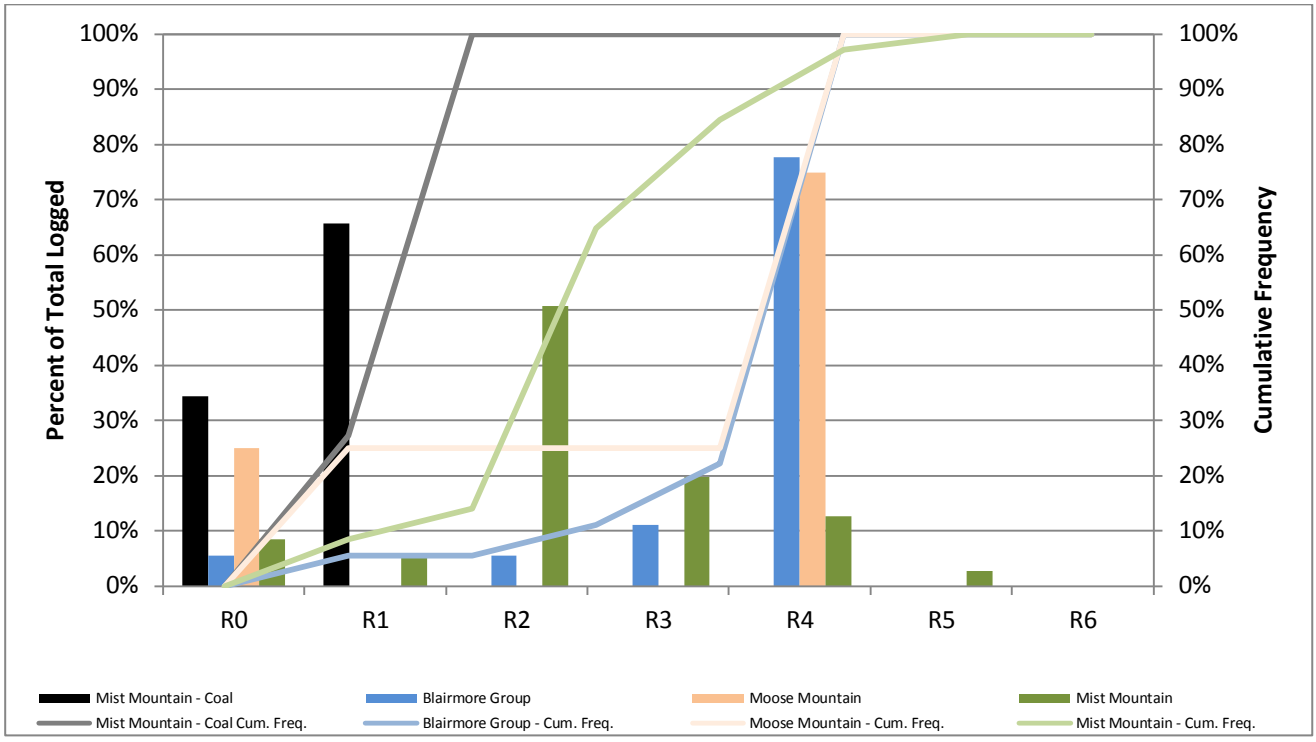


Plate C-14: ISRM Field Strength Interval Distribution by Lithology – RGSC-0010

A summary histogram of the field estimates of intact rock strength by lithology is presented in G-15.

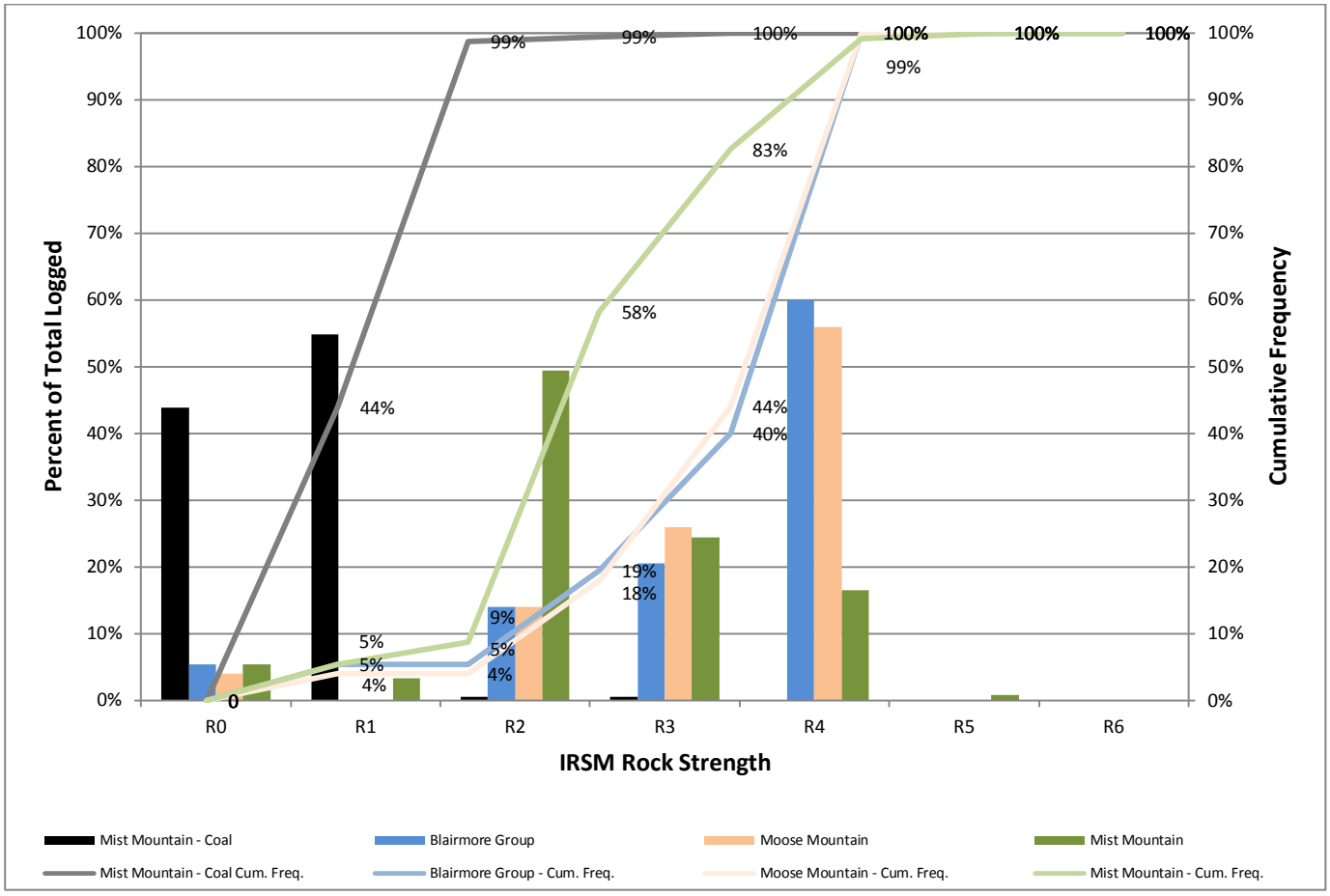


Plate C-15: ISRM Estimated Field Strength by Lithology Frequency – All Boreholes

The following observations have been made with respect to the field strength estimate data:

- The average logged rock strength for coal of the Mist Mountain Formation typically ranges from R0 (extremely weak rock) to R1 (very weak rock). Approximately forty-four percent of the coal was logged as R0 and fifty-six percent logged as R1. The average estimated rock strength the coal is R1 (very weak).
- The average logged strength of all rock types within the Mist Mountain Formation is R2 (weak rock). However, 48% of the rock logged are estimated as R3 (strong rock) or better. The weak rock (R0 to R2) component accounts for 58% of the Mist Mountain and is considered representative of the carbonaceous mudstone and finely bedded siltstone. The strong rock (R3 to R5) component is representative of the well bedded siltstones and sandstones.
- The average logged strength of the Blairmore Group is R4 (moderately strong rock) and the average strength of the Moose Mountain is R4.

1.2 Laboratory UCS Rock Strength

A total of 10 rock core samples were selected for UCS testing. The samples were chosen to reflect the representative lithologies at Grassy Mountain. The UCS test results are summarised in Table C. Laboratory test certifications are provided in Appendix C.

Table C-2: Summary of UCS Test Results

Borehole	Depth From (mah)[1]	Depth To (mah)[1]	Rock Type[2]	Geological Formation	Wet Density (kg/m^3)	UCS (MPa)	Failure Mode[3]
RGSC-0004	73.96	74.23	Mudstone	Mist Mountain	2,598	59.1	2/4
RGSC-0004	99.98	100.21	Siltstone	Mist Mountain	2,598	96.9	4
RGSC-0005	66.12	66.41	Sandstone	Blairmore Group	2,591	179.1	4
RGSC-0005	86.16	86.46	Conglomerate	Blairmore Group	2,634	106.5	2
RGSC-0006	100.29	100.51	Mudstone	Mist Mountain	2,631	40.8	4/2
RGSC-0007	106.26	106.54	Sandstone	Mist Mountain	2,613	89.8	4/2
RGSC-0008	15.19	15.45	Sandstone	Blairmore Group	2,711	133.4	2/4
RGSC-0009	137.38	137.61	Mudstone	Mist Mountain	2,440	35.3	4/2
RGSC-0010	38.07	38.33	Conglomerate	Blairmore Group	2,620	93.5	2/4
RGSC-0010	168.22	168.47	Sandstone	Mist Mountain	2,564	47.0	4

Notes: 1) mah = metres along borehole, relative to ground surface. 2) Rock type logged by Golder/Riversdale personnel during sample collection. 3) Codes for failure mode as follows: 1 – diagonal shear plane(s); 2 – vertical fracture; 3 – vertical splitting; 4 – shear along discontinuity; 5 – conical; 6 – spalling; 7 – other

The laboratory UCS testing results are discussed below.

- **Mist Mountain - Coal**

The average estimated rock strength of coal from the 2014 drilling investigations was R1 (very weak). It is typically difficult to conduct UCS tests on weak rocks (UCS values less than 25 MPa), as weaker rocks are often not sampled or break during transport. As a result, UCS test results tend to be biased towards samples of higher strengths. No laboratory UCS testing was carried out on any coal samples from the Mist Mountain Formation.

- **Mist Mountain Formation**

Laboratory UCS testing has been carried out on six samples of rock from the Mist Mountain Formation comprising sandstone, siltstone or mudstone. The UCS of these samples ranged from 35.3 MPa to 96.9 MPa, with an average of 61.5 MPa. Of the six samples, three tests were carried out on mudstones with an average UCS of 45 MPa, two tests on sandstone with an average UCS of 68.4 MPa, and one test on a siltstone with a UCS value of 96.9 MPa. This is generally consistent with test results from other mines in the nearby Elk Valley.

The average estimated rock strength of these rocks from the 2014 geotechnical logging was R2 (weak). However, the laboratory UCS test results indicate that the Mist Mountain rocks can exhibit high intact rock strengths (i.e., R3 to R4 strength range) in the more competent siltstone and sandstone rock types.

- **Blairmore Group**

Laboratory UCS testing has been carried out on four samples of Blairmore group, comprising two tests from the Cadomin conglomerate and two tests from the overlying Gladstone member. The UCS of these samples ranged from 93.5 MPa to 179.1 MPa, with an average of 128.2 MPa.

The average estimated rock strength of these rocks from the 2014 geotechnical logging was R4 (moderately strong rock) which is consistent with the UCS test results.

- **Moose Mountain Member**

No laboratory UCS testing was carried out on any rock core samples from the Moose Mountain member of the Morrissey Formation. The average estimated rock strength of sandstone from the 2014 drilling investigations was R4 (moderately strong rock) and is generally consistent with the strengths encountered in the Moose Mountain located in the mine in the nearby Elk Valley.

1.3 Point Load Strength Index

Point load strength index testing was carried out to provide a continuous record of rock strength along the borehole. A summary of the point load strength index test results is presented in Table 4, and the raw data can be found in Appendix C.

Table C-3: Summary of Point Load Strength Index Results

Point Load Strength ($Is_{(50)}$) MPa)		Diametrical Point Load Test			Axial Point Load Test		
		Blairmore Group	Mist Mountain[(a)]	Moose Mountain	Blairmore Group	Mist Mountain[(a)]	Moose Mountain
Range	Maximum	10.3	9.0	9.0	11.0	19.8	8.5
	Minimum	0.1	0.1	1.4	0.9	0.4	3.0
Average		4.5	2.1	4.9	4.6	4.9	6.0
Median		4.3	1.7	5.9	4.0	3.4	6.3
Standard Deviation		2.8	1.9	2.4	2.8	4.7	2.3

a) Mist Mountain Formation includes all rock types (mudstone, carbonaceous mudstone and siltstone) with the exception of the sandstone and coal data.

Golder Associates Ltd. - Burnaby Lab
#300 - 3811 North Fraser Way
Burnaby, B.C. Canada V5J 5J2

Uniaxial Compressive Strength of Intact Rock Core Specimens

Reference
ASTM D7012-14 Method C

Project No.:	1406422 Phase 2.0
Project:	Grassy Mountain
Client:	Riverdale Resources
Location:	Blairmore, Canada
Lab ID	338

Failure Mode

(1) Diagonal shear plane(s) (5) Conical
(2) Vertical fracture(s) (6) Spalling
(3) Vertical splitting (7) Other
(4) Shear along foliation / discontinuity Note: (deg) measured from core axis

No.	Borehole	Sample	Depth	Dia	Ht	A	V	Mass	Wet Density	W	Dry Density	Maximum Load	Stress σ_u	Rock Type	Failure Mode	
	#	#	(m)	(mm)	(mm)	(cm^2)	(cm^3)	(g)	(kg/m^3)	(%)	(kg/m^3)	(kN)	(MPa)		Type	(deg)
1	RGSC 0004	6	73.96-74.23	60.48	127.78	28.73	367.09	953.80	2598	0.93	2574	169.80	59.1	Mudstone	2/4	40
2	RGSC 0004	8	99.98-100.21	60.59	127.92	28.83	368.83	958.30	2598	0.33	2590	279.30	96.9	Siltstone	4	30
3	RGSC 0005	2	66.12-66.41	61.25	126.54	29.46	372.85	966.00	2591	0.89	2568	527.60	179.1	Sandstone	4	40
4	RGSC 0005	3	86.16-86.46	60.95	126.52	29.18	369.14	972.30	2634	0.32	2625	310.60	106.5	Conglomerate	2	N/A
5	RGSC 0006	6	100.29-100.51	60.79	127.75	29.02	370.78	975.40	2631	1.06	2603	118.50	40.8	Mudstone	4/2	45
6	RGSC 0007	4	106.26-106.54	60.82	126.78	29.05	368.33	962.50	2613	0.33	2605	260.80	89.8	Sandstone	4/2	25
7	RGSC 0008	1	15.19-15.45	60.93	129.22	29.16	376.77	1021.60	2711	0.49	2698	388.90	133.4	Sandstone	2/4	40
8	RGSC 0009	10	137.38-137.61	60.96	127.03	29.19	370.75	904.70	2440	1.10	2414	103.00	35.3	Mudstone	4/2	45
9	RGSC 0010	2	38.07-38.33	60.76	128.46	29.00	372.47	975.70	2620	0.75	2600	271.00	93.5	Conglomerate	2/4	35
10	RGSC 0010	9	168.22-168.47	60.91	126.84	29.14	369.59	947.80	2564	0.63	2548	136.90	47.0	Sandstone	4	45

M. Miller/ G. Patton	October 15, 2014	E. Saunders	October 21, 2014
TESTED BY	DATE	CHECKED BY	DATE

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Burnaby, B.C. Canada V5J 5J2

Uniaxial Compressive Strength of Intact Rock Core Specimens

Reference
ASTM D7012-14 Method C

Project No.:	1406422 Phase 2.0	**Borehole:**	**RGSC 0004**
Project:	Grassy Mountain	**Sample Number:**	6
Location:	Blairmore, Canada	**Depth (m):**	73.96-74.23
Client:	Riverdale Resources	**Lab ID No:**	338

Testing Results

Max Load (kN)	**169.80**
Stress σ_u (MPa)	**59.1**
Pace Rate (kN/s)	1.25
Lithology	Mudstone

Sample Measurements

Diameter (mm)	60.48
Height (mm)	127.78
Area (cm^2)	28.73
Volume (cm^3)	367.09
Mass (g)	953.80
Moisture Content (%)	0.93
Wet Density (kg/m^3)	2598.25
Dry Density (kg/m^3)	2574.22

Failure Mode

Type: **2/4**

Degrees:* **40**

* 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

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

M. Miller/ G. Patton	October 15, 2014	E. Saunders	October-21-14
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates Ltd. - Burnaby Lab
#300 - 3811 North Fraser Way
Burnaby, B.C. Canada V5J 5J2

Uniaxial Compressive Strength of Intact Rock Core Specimens

Reference
ASTM D7012-14 Method C

Project No.:	1406422 Phase 2.0	**Borehole:**	**RGSC 0004**
Project:	Grassy Mountain	**Sample Number:**	8
Location:	Blairmore, Canada	**Depth (m):**	99.98-100.21
Client:	Riverdale Resources	**Lab ID No:**	338

Testing Results

Max Load (kN)	**279.30**
Stress σ_u (MPa)	**96.9**
Pace Rate (kN/s)	1.25
Lithology	Siltstone

Sample Measurements

Diameter (mm)	60.59
Height (mm)	127.92
Area (cm^2)	28.83
Volume (cm^3)	368.83
Mass (g)	958.30
Moisture Content (%)	0.33
Wet Density (kg/m^3)	2598.19
Dry Density (kg/m^3)	2589.70

Failure Mode

Type: **4**

Degrees:* **30**

* 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

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

M. Miller/ G. Patton	October 15, 2014	E. Saunders	October-21-14
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates Ltd. - Burnaby Lab
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Burnaby, B.C. Canada V5J 5J2

Uniaxial Compressive Strength of Intact Rock Core Specimens

Reference
ASTM D7012-14 Method C

Project No.:	1406422 Phase 2.0	**Borehole:**	**RGSC 0005**
Project:	Grassy Mountain	**Sample Number:**	2
Location:	Blairmore, Canada	**Depth (m):**	66.12-66.41
Client:	Riverdale Resources	**Lab ID No:**	338

Testing Results

Max Load (kN)	**527.60**
Stress σ_u (MPa)	**179.1**
Pace Rate (kN/s)	1.25
Lithology	Sandstone

Sample Measurements

Diameter (mm)	61.25
Height (mm)	126.54
Area (cm^2)	29.46
Volume (cm^3)	372.85
Mass (g)	966.00
Moisture Content (%)	0.89
Wet Density (kg/m^3)	2590.88
Dry Density (kg/m^3)	2567.92

Failure Mode

Type: **4**

Degrees:* **40**

* 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

Comments

BEFORE TEST

AFTER TEST

** 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.*

M. Miller/ G. Patton	October 15, 2014	E. Saunders	October-21-14
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates Ltd. - Burnaby Lab
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Uniaxial Compressive Strength of Intact Rock Core Specimens

Reference
ASTM D7012-14 Method C

Project No.:	1406422 Phase 2.0	**Borehole:**	**RGSC 0005**
Project:	Grassy Mountain	**Sample Number:**	3
Location:	Blairmore, Canada	**Depth (m):**	86.16-86.46
Client:	Riverdale Resources	**Lab ID No:**	338

Testing Results

Max Load (kN)	**310.60**
Stress σ_u (MPa)	**106.5**
Pace Rate (kN/s)	1.25
Lithology	Conglomerate

Sample Measurements

Diameter (mm)	60.95
Height (mm)	126.52
Area (cm^2)	29.18
Volume (cm^3)	369.14
Mass (g)	972.30
Moisture Content (%)	0.32
Wet Density (kg/m^3)	2633.93
Dry Density (kg/m^3)	2625.41

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

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

M. Miller/ G. Patton	October 15, 2014	E. Saunders	October-21-14
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates Ltd. - Burnaby Lab
#300 - 3811 North Fraser Way
Burnaby, B.C. Canada V5J 5J2

Uniaxial Compressive Strength of Intact Rock Core Specimens

Reference
ASTM D7012-14 Method C

Project No.:	1406422 Phase 2.0	**Borehole:**	**RGSC 0006**
Project:	Grassy Mountain	**Sample Number:**	6
Location:	Blairmore, Canada	**Depth (m):**	100.29-100.51
Client:	Riverdale Resources	**Lab ID No:**	338

Testing Results

Max Load (kN)	**118.50**
Stress σ_u (MPa)	**40.8**
Pace Rate (kN/s)	1.25
Lithology	Mudstone

Sample Measurements

Diameter (mm)	60.79
Height (mm)	127.75
Area (cm^2)	29.02
Volume (cm^3)	370.78
Mass (g)	975.40
Moisture Content (%)	1.06
Wet Density (kg/m^3)	2630.68
Dry Density (kg/m^3)	2603.12

Failure Mode

Type: **4/2**

Degrees:* **45**

* Degrees measured with respect to core axis.

Notes

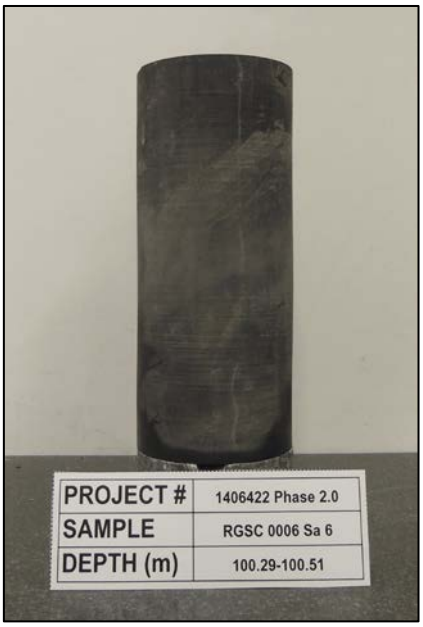
- Water content as received

Mode:

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

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

M. Miller/ G. Patton	October 15, 2014	E. Saunders	October-21-14
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates Ltd. - Burnaby Lab
#300 - 3811 North Fraser Way
Burnaby, B.C. Canada V5J 5J2

Uniaxial Compressive Strength of Intact Rock Core Specimens

Reference
ASTM D7012-14 Method C

Project No.:	1406422 Phase 2.0	**Borehole:**	**RGSC 0007**
Project:	Grassy Mountain	**Sample Number:**	4
Location:	Blairmore, Canada	**Depth (m):**	106.26-106.54
Client:	Riverdale Resources	**Lab ID No:**	338

Testing Results

Max Load (kN)	**260.80**
Stress σ_u (MPa)	**89.8**
Pace Rate (kN/s)	1.25
Lithology	Sandstone

Sample Measurements

Diameter (mm)	60.82
Height (mm)	126.78
Area (cm^2)	29.05
Volume (cm^3)	368.33
Mass (g)	962.50
Moisture Content (%)	0.33
Wet Density (kg/m^3)	2613.17
Dry Density (kg/m^3)	2604.68

Failure Mode

Type: **4/2**

Degrees:* **25**

* 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

Comments

BEFORE TEST

AFTER TEST

** 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.*

M. Miller/ G. Patton	October 15, 2014	E. Saunders	October-21-14
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates Ltd. - Burnaby Lab
#300 - 3811 North Fraser Way
Burnaby, B.C. Canada V5J 5J2

Uniaxial Compressive Strength of Intact Rock Core Specimens

Reference
ASTM D7012-14 Method C

Project No.:	1406422 Phase 2.0	**Borehole:**	**RGSC 0008**
Project:	Grassy Mountain	**Sample Number:**	1
Location:	Blairmore, Canada	**Depth (m):**	15.19-15.45
Client:	Riverdale Resources	**Lab ID No:**	338

Testing Results

Max Load (kN)	**388.90**
Stress σ_u (MPa)	**133.4**
Pace Rate (kN/s)	1.25
Lithology	Sandstone

Sample Measurements

Diameter (mm)	60.93
Height (mm)	129.22
Area (cm^2)	29.16
Volume (cm^3)	376.77
Mass (g)	1021.60
Moisture Content (%)	0.49
Wet Density (kg/m^3)	2711.43
Dry Density (kg/m^3)	2698.34

Failure Mode

Type: **2/4**

Degrees:* **40**

* Degrees measured with respect to core axis.

Notes

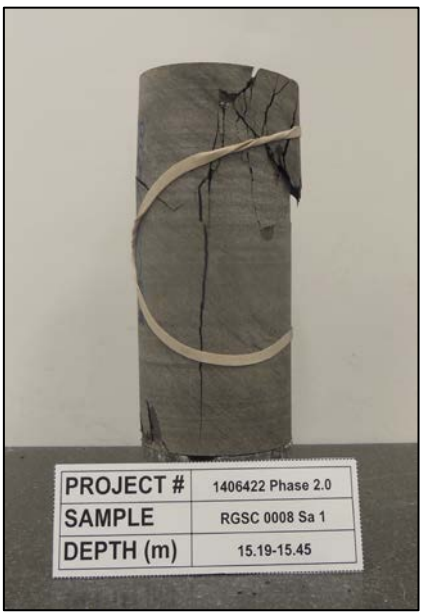
- Water content as received

Mode:

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

Comments

BEFORE TEST



AFTER TEST

** 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.*

M. Miller/ G. Patton	October 15, 2014	E. Saunders	October-21-14
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates Ltd. - Burnaby Lab
#300 - 3811 North Fraser Way
Burnaby, B.C. Canada V5J 5J2

Uniaxial Compressive Strength of Intact Rock Core Specimens

Reference
ASTM D7012-14 Method C

Project No.:	1406422 Phase 2.0	**Borehole:**	**RGSC 0009**
Project:	Grassy Mountain	**Sample Number:**	10
Location:	Blairmore, Canada	**Depth (m):**	137.38-137.61
Client:	Riverdale Resources	**Lab ID No:**	338

Testing Results

Max Load (kN)	**103.00**
Stress σ_u (MPa)	**35.3**
Pace Rate (kN/s)	1.25
Lithology	Mudstone

Sample Measurements

Diameter (mm)	60.96
Height (mm)	127.03
Area (cm^2)	29.19
Volume (cm^3)	370.75
Mass (g)	904.70
Moisture Content (%)	1.10
Wet Density (kg/m^3)	2440.16
Dry Density (kg/m^3)	2413.68

Failure Mode

Type: **4/2**

Degrees:* **45**

* 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

Comments

BEFORE TEST

AFTER TEST

** 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.*

M. Miller/ G. Patton	October 15, 2014	E. Saunders	October-21-14
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates Ltd. - Burnaby Lab
#300 - 3811 North Fraser Way
Burnaby, B.C. Canada V5J 5J2

Uniaxial Compressive Strength of Intact Rock Core Specimens

Reference
ASTM D7012-14 Method C

Project No.:	1406422 Phase 2.0	**Borehole:**	**RGSC 0010**
Project:	Grassy Mountain	**Sample Number:**	2
Location:	Blairmore, Canada	**Depth (m):**	38.07-38.33
Client:	Riverdale Resources	**Lab ID No:**	338

Testing Results

Max Load (kN)	**271.00**
Stress σ_u (MPa)	**93.5**
Pace Rate (kN/s)	1.25
Lithology	Conglomerate

Sample Measurements

Diameter (mm)	60.76
Height (mm)	128.46
Area (cm^2)	29.00
Volume (cm^3)	372.47
Mass (g)	975.70
Moisture Content (%)	0.75
Wet Density (kg/m^3)	2619.53
Dry Density (kg/m^3)	2599.91

Failure Mode

Type: **2/4**

Degrees:* **35**

* 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

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

M. Miller/ G. Patton	October 15, 2014	E. Saunders	October-21-14
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates Ltd. - Burnaby Lab
#300 - 3811 North Fraser Way
Burnaby, B.C. Canada V5J 5J2

Uniaxial Compressive Strength of Intact Rock Core Specimens

Reference
ASTM D7012-14 Method C

Project No.:	1406422 Phase 2.0	**Borehole:**	**RGSC 0010**
Project:	Grassy Mountain	**Sample Number:**	9
Location:	Blairmore, Canada	**Depth (m):**	168.22-168.47
Client:	Riverdale Resources	**Lab ID No:**	338

Testing Results

Max Load (kN)	**136.90**
Stress σ_u (MPa)	**47.0**
Pace Rate (kN/s)	1.25
Lithology	Sandstone

Sample Measurements

Diameter (mm)	60.91
Height (mm)	126.84
Area (cm^2)	29.14
Volume (cm^3)	369.59
Mass (g)	947.80
Moisture Content (%)	0.63
Wet Density (kg/m^3)	2564.45
Dry Density (kg/m^3)	2548.45

Failure Mode

Type: **4**

Degrees:* **45**

* 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

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

M. Miller/ G. Patton	October 15, 2014	E. Saunders	October-21-14
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates Ltd.
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C8

POINT LOAD STRENGTH INDEX TEST

Reference
ASTM D5731 - 08

Client: Riversdale Resources Limited
Project: Grassy Mountain
Location: RGSC-0004

Project No: 1406422
Test Date: August 9-18, 2014
Tested By: AGH, TCD, TGT

Axial Test

Test #	Borehole No.	Depth m	D mm	W mm	Guage Reading kN	Load P MN	$D_e^2=4WD/p$ mm^2	$I_s = P/D_e^2$ MPa	$F = (D_e/50)^{0.45}$	$I_{s(50)}$ MPa	Type	Direction	Remarks
1	RGSC-0004	44.58	49.00	63.00	26.63	0.02663	2401.0	11.09	0.991	**10.99**	a		
2	RGSC-0004	54.95	60.00	63.00	13.24	0.01324	3600.0	3.68	1.086	**3.99**	a		
3	RGSC-0004	67.09	30.00	63.00	22.42	0.02242	900.0	24.91	0.795	**19.80**	a		Valid - Intact Rock
4	RGSC-0004	67.20	45.00	63.00	7.29	0.00729	2025.0	3.60	0.954	**3.43**	a		Invalid - Slipped
5	RGSC-0004	76.19	41.00	63.00	8.14	0.00814	1681.0	4.84	0.915	**4.43**	a		Valid - Intact Rock
6	RGSC-0004	82.3	48.00	63.00	0.91	0.00091	2304.0	0.39	0.982	**0.39**	a		Invalid - Rock crumbled under slightest pressure
7	RGSC-0004	104.83	40.00	63.00	11.29	0.01129	1600.0	7.06	0.904	**6.38**	a		Valid - Intact Rock
8	RGSC-0004	107.81	59.00	63.00	21.69	0.02169	3481.0	6.23	1.077	**6.71**	a		Valid - Intact Rock
9	RGSC-0004	137.15	31.00	63.00	7.67	0.00767	961.0	7.98	0.806	**6.44**	a		Valid - Intact Rock
10	RGSC-0004	148.06	40.00	63.00	2.43	0.00243	1600.0	1.52	0.904	**1.37**	a		Valid - Intact Rock
11	RGSC-0004	155.64	45.00	63.00	14.49	0.01449	2025.0	7.16	0.954	**6.82**	a		Valid - Intact Rock
12	RGSC-0004	157.5	58.00	63.00	26.60	0.02660	3364.0	7.91	1.069	**8.45**	a		Valid - Intact Rock

$I_{s(50)}$ = Size Corrected Point Load Strength
$I_{s(50)} = FI_s$

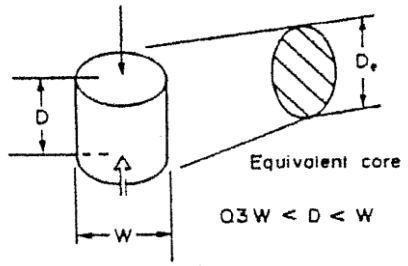
I_s = Uncorrected Point Load Strength
$I_s = P/D_e^2$

F = Size Correction Factor
$F = (D_e/50)^{0.45}$

D_e = equivalent core diameter (mm)
$D_e^2 = 4/p*D*W = (mm^2)$

Direction
\\ = parallel
p = perpendicular to planes of weakness

Axial Test



Tested By AGH, TCD, TGT	Date : October 15, 2014	Checked By EAS	Date : October 16, 2014

Golder Associates Ltd.
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C8

Golder Associates

POINT LOAD STRENGTH INDEX TEST

Reference
ASTM D5731 - 08

Client: Riversdale Resources Limited
Project: Grassy Mountain
Location: RGSC-0004

Project No: 1406422
Test Date: August 9-18, 2014
Tested By: AGH, TCD, TGT

Diametral Test

Test #	Borehole No.	Depth m	D mm	L mm	Guage Reading kN	Load P MN	$D_e^2 = D^2$ mm^2	$I_s = P/D_e^2$ MPa	$F = (D_e/50)^{0.45}$	$I_{s(50)}$ MPa	Type	Direction	Remarks
1	RGSC-0004	26.23	63.00	42.50	7.29	0.00729	3969.0	1.84	1.110	**2.04**	d		Valid - Intact Rock
2	RGSC-0004	29.70	63.00	45.00	14.55	0.01455	3969.0	3.67	1.110	**4.07**	d		Valid - Intact Rock
3	RGSC-0004	32.69	63.00	38.00	14.55	0.01455	3969.0	3.67	1.110	**4.07**	d		Valid - Intact Rock
4	RGSC-0004	34.69	63.00	43.00	36.99	0.03699	3969.0	9.32	1.110	**10.34**	d		Valid - Intact Rock
5	RGSC-0004	36.65	63.00	41.50	4.00	0.00400	3969.0	1.01	1.110	**1.12**	d		Valid - Bedding
6	RGSC-0004	41.39	63.00	36.50	17.67	0.01767	3969.0	4.45	1.110	**4.94**	d		Valid - Intact Rock
7	RGSC-0004	47.53	63.00	32.00	14.93	0.01493	3969.0	3.76	1.110	**4.17**	d		Valid - Intact Rock
8	RGSC-0004	47.92	63.00	35.00	0.89	0.00089	3969.0	0.22	1.110	**0.25**	d		Valid - Intact Rock
9	RGSC-0004	48.95	63.00	45.00	14.66	0.01466	3969.0	3.69	1.110	**4.10**	d		Valid - Intact Rock
10	RGSC-0004	51.01	63.00	40.00	19.59	0.01959	3969.0	4.94	1.110	**5.48**	d		Valid - Intact Rock
11	RGSC-0004	52.96	63.00	45.00	26.60	0.02660	3969.0	6.70	1.110	**7.44**	d		Valid - Intact Rock
12	RGSC-0004	56.72	63.00	70.00	29.89	0.02989	3969.0	7.53	1.110	**8.36**	d		Valid - Intact Rock
13	RGSC-0004	59.72	63.00	32.50	8.98	0.00898	3969.0	2.26	1.110	**2.51**	d		Valid - Intact Rock
14	RGSC-0004	59.72	63.00	60.00	30.17	0.03017	3969.0	7.60	1.110	**8.43**	d		Valid - Intact Rock
15	RGSC-0004	62.72	63.00	35.00	18.86	0.01886	3969.0	4.75	1.110	**5.27**	d		Valid - Intact Rock
16	RGSC-0004	63.90	63.00	65.00	23.93	0.02393	3969.0	6.03	1.110	**6.69**	d		Valid - Intact Rock
17	RGSC-0004	65.72	63.00	50.00	29.73	0.02973	3969.0	7.49	1.110	**8.31**	d		Valid - Intact Rock
18	RGSC-0004	67.09	63.00	37.50	8.29	0.00829	3969.0	2.09	1.110	**2.32**	d		Invalid - Slipped
19	RGSC-0004	67.72	63.00	60.00	12.86	0.01286	3969.0	3.24	1.110	**3.60**	d		Valid - Intact Rock
20	RGSC-0004	69.66	63.00	37.50	32.09	0.03209	3969.0	8.09	1.110	**8.97**	d		Valid - Intact Rock
21	RGSC-0004	72.59	63.00	42.50	2.06	0.00206	3969.0	0.52	1.110	**0.58**	d		Valid - Intact Rock
22	RGSC-0004	74.66	63.00	54.00	2.13	0.00213	3969.0	0.54	1.110	**0.60**	d		Invalid - Didn't go through entire rock
23	RGSC-0004	74.74	63.00	42.00	4.88	0.00488	3969.0	1.23	1.110	**1.36**	d		Valid - Intact rock
24	RGSC-0004	85.88	63.00	70.00	2.29	0.00229	3969.0	0.58	1.110	**0.64**	d		Valid - Intact rock
25	RGSC-0004	90.48	63.00	50.00	5.78	0.00578	3969.0	1.46	1.110	**1.62**	d		Valid - Intact rock
26	RGSC-0004	91.70	63.00	40.00	9.20	0.00920	3969.0	2.32	1.110	**2.57**	d		Valid - Intact rock
27	RGSC-0004	92.90	63.00	65.00	21.71	0.02171	3969.0	5.47	1.110	**6.07**	d		Valid - Intact rock
28	RGSC-0004	95.42	63.00	65.00	16.33	0.01633	3969.0	4.11	1.110	**4.57**	d		Valid - Intact rock
29	RGSC-0004	97.05	63.00	25.00	16.58	0.01658	3969.0	4.18	1.110	**4.64**	d		Valid - Intact rock
30	RGSC-0004	96.26	63.00	62.50	22.37	0.02237	3969.0	5.64	1.110	**6.25**	d		Valid - Intact rock
31	RGSC-0004	98.23	63.00	60.00	0.80	0.00080	3969.0	0.20	1.110	**0.22**	d		Valid - Intact rock
32	RGSC-0004	100.21	63.00	45.00	4.67	0.00467	3969.0	1.18	1.110	**1.31**	d		Valid - Bedding
33	RGSC-0004	99.23	63.00	55.00	16.53	0.01653	3969.0	4.16	1.110	**4.62**	d		Valid - Intact rock
34	RGSC-0004	101.79	63.00	57.50	11.72	0.01172	3969.0	2.95	1.110	**3.28**	d		Valid - Intact rock
35	RGSC-0004	104.02	63.00	50.00	1.31	0.00131	3969.0	0.33	1.110	**0.37**	d		Valid - Intact rock
36	RGSC-0004	107.32	63.00	55.00	11.41	0.01141	3969.0	2.87	1.110	**3.19**	d		Valid - Bedding
37	RGSC-0004	109.17	63.00	70.00	9.02	0.00902	3969.0	2.27	1.110	**2.52**	d		Valid - Bedding
38	RGSC-0004	112.64	63.00	47.50	0.58	0.00058	3969.0	0.15	1.110	**0.16**	d		Valid - Intact Rock
39	RGSC-0004	119.63	63.00	50.00	11.92	0.01192	3969.0	3.00	1.110	**3.33**	d		Valid - Intact Rock (took 2 attempts)

Golder Associates Ltd.
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C8

POINT LOAD STRENGTH INDEX TEST

Reference
ASTM D5731 - 08

Client: Riversdale Resources Limited
Project: Grassy Mountain
Location: RGSC-0004

Project No: 1406422
Test Date: August 9-18, 2014
Tested By: AGH, TCD, TGT

Diametral Test

Test #	Borehole No.	Depth m	D mm	L mm	Guage Reading kN	Load P MN	$D_e^2 = D^2$ mm^2	$I_s = P/D_e^2$ MPa	$F = (D_e/50)^{0.45}$	$I_{s(50)}$ MPa	Type	Direction	Remarks
40	RGSC-0004	121.96	63.00	35.00	11.60	0.01160	3969.0	2.92	1.110	**3.24**	d		Valid - Intact Rock
41	RGSC-0004	122.33	63.00	47.50	6.57	0.00657	3969.0	1.66	1.110	**1.84**	d		Valid - Intact Rock
42	RGSC-0004	124.37	63.00	50.00	8.31	0.00831	3969.0	2.09	1.110	**2.32**	d		Valid - Intact Rock
43	RGSC-0004	126.57	63.00	50.00	0.42	0.00042	3969.0	0.11	1.110	**0.12**	d		Valid - Intact Rock
44	RGSC-0004	127.80	63.00	55.00	0.68	0.00068	3969.0	0.17	1.110	**0.19**	d		Valid - Intact Rock
45	RGSC-0004	129.75	63.00	47.50	0.03	0.00003	3969.0	0.01	1.110	**0.01**	d		Valid - Intact Rock
46	RGSC-0004	134.74	63.00	55.00	3.63	0.00363	3969.0	0.91	1.110	**1.01**	d		Valid - Bedding
47	RGSC-0004	140.37	63.00	50.00	9.60	0.00960	3969.0	2.42	1.110	**2.68**	d		Valid - Intact Rock
48	RGSC-0004	142.68	63.00	58.00	7.33	0.00733	3969.0	1.85	1.110	**2.05**	d		Valid - Intact Rock
49	RGSC-0004	146.88	63.00	56.00	5.81	0.00581	3969.0	1.46	1.110	**1.62**	d		Valid - Bedding
50	RGSC-0004	150.05	63.00	50.00	2.01	0.00201	3969.0	0.51	1.110	**0.56**	d		Valid - Bedding
51	RGSC-0004	154.29	63.00	45.00	1.08	0.00108	3969.0	0.27	1.110	**0.30**	d		Valid - Intact Rock
52	RGSC-0004	155.68	63.00	27.50	15.98	0.01598	3969.0	4.03	1.110	**4.47**	d		Valid - Intact Rock
53	RGSC-0004	158.58	63.00	39.00	9.42	0.00942	3969.0	2.37	1.110	**2.63**	d		Valid - Intact Rock
54	RGSC-0004	160.14	63.00	55.00	24.05	0.02405	3969.0	6.06	1.110	**6.72**	d		Valid - Intact Rock
55	RGSC-0004	161.15	63.00	35.00	4.99	0.00499	3969.0	1.26	1.110	**1.40**	d		Valid - Bedding
56	RGSC-0004	164.02	63.00	85.00	31.91	0.03191	3969.0	8.04	1.110	**8.92**	d		Valid - Intact Rock
57	RGSC-0004	166.04	63.00	42.50	23.87	0.02387	3969.0	6.01	1.110	**6.67**	d		Valid - Intact Rock

$I_{s(50)}$ = Size Corrected Point Load Strength
$I_{s(50)} = FI_s$

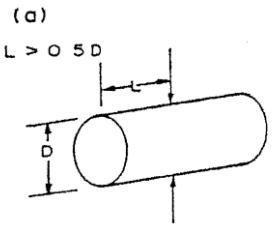
I_s = Uncorrected Point Load Strength
$I_s = P/D_e^2$

F = Size Correction Factor
$F = (D_e/50)^{0.45}$

D_e = equivalent core diameter (mm)
$D_e^2 = D^2$ (mm^2)

Direction
\\ = parallel
p = perpendicular to planes of weakness

Diametral Test



Tested By AGH, TCD, TGT	Date : October 15, 2014	Checked By EAS	Date : October 16, 2014

Golder Associates Ltd.
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C8

POINT LOAD STRENGTH INDEX TEST

Reference
ASTM D5731 - 08

Client: Riversdale Resources Limited
Project: Grassy Mountain
Location: RGSC-0005

Project No: 1406422
Test Date: August 21-24, 2014
Tested By: TCD,TGT

Axial Test

Test #	Borehole No.	Depth m	D mm	W mm	Guage Reading kN	Load P MN	$D_e^2=4WD/p$ mm^2	$I_s = P/D_e^2$ MPa	$F = (D_e/50)^{0.45}$	$I_{s(50)}$ MPa	Type	Direction	Remarks
1	RGSC-0005	56.94	52.00	63.00	9.54	0.00954	2704.0	3.53	1.018	**3.59**	a		Valid - Intact Rock
2	RGSC-0005	73.36	75.00	63.00	5.48	0.00548	5625.0	0.97	1.200	**1.17**	a		Valid - Intact Rock
3	RGSC-0005	75.47	65.00	63.00	13.55	0.01355	4225.0	3.21	1.125	**3.61**	a		Valid - Intact Rock
4	RGSC-0005	77.705	45.00	63.00	10.27	0.01027	2025.0	5.07	0.954	**4.84**	a		Valid - Intact Rock
5	RGSC-0005	81.81	40.00	63.00	1.53	0.00153	1600.0	0.96	0.904	**0.86**	a		Valid - Intact Rock
6	RGSC-0005	96.77	60.00	63.00	3.39	0.00339	3600.0	0.94	1.086	**1.02**	a		Valid - Intact Rock
7	RGSC-0005	98.25	39.00	63.00	11.80	0.01180	1521.0	7.76	0.894	**6.94**	a		Valid - Intact Rock
8	RGSC-0005	113.61	40.00	63.00	3.57	0.00357	1600.0	2.23	0.904	**2.02**	a		Invalid - Chipping
9	RGSC-0005	118.04	35.00	63.00	2.87	0.00287	1225.0	2.34	0.852	**2.00**	a		Valid - Intact Rock
10	RGSC-0005	133.27	70.00	63.00	8.62	0.00862	4900.0	1.76	1.163	**2.05**	a		Invalid - Chipping
11	RGSC-0005	136.50	47.00	63.00	22.95	0.02295	2209.0	10.39	0.973	**10.10**	a		Valid - Intact Rock

$I_{s(50)}$ = Size Corrected Point Load Strength
$I_{s(50)} = FI_s$

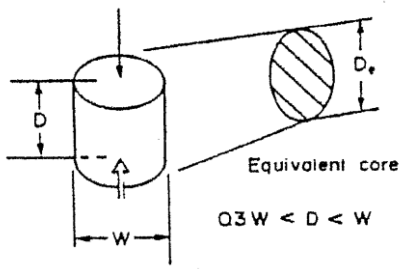
I_s = Uncorrected Point Load Strength
$I_s = P/D_e^2$

F = Size Correction Factor
$F = (D_e/50)^{0.45}$

D_e = equivalent core diameter (mm)
$D_e^2 = 4/p*D*W = (mm^2)$

Direction
\\ = parallel
p = perpendicular to planes of weakness

Axial Test



Tested By TCD, TGT	Date : October 15, 2014	Checked By EAS	Date : October 16, 2014

Golder Associates Ltd.
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C8

POINT LOAD STRENGTH INDEX TEST

Reference
ASTM D5731 - 08

Client: Riversdale Resources Limited
Project: Grassy Mountain
Location: RGSC-0005

Project No: 1406422
Test Date: August 21-24, 2014
Tested By: TCD,TGT

Diametral Test

Test #	Borehole No.	Depth m	D mm	L mm	Guage Reading kN	Load P MN	$D_e^2 = D^2$ mm^2	$I_s = P/D_e^2$ MPa	$F = (D_e/50)^{0.45}$	$I_{s(50)}$ MPa	Type	Direction	Remarks
1	RGSC-0005	53.3	63.00	125.00	28.36	0.02836	3969.0	7.15	1.110	**7.93**	d		Valid - Intact rock
2	RGSC-0005	58.79	63.00	83.00	4.08	0.00408	3969.0	1.03	1.110	**1.14**	d		Valid - Intact rock
3	RGSC-0005	65.53	63.00	112.00	5.73	0.00573	3969.0	1.44	1.110	**1.60**	d		Valid - Bedding
4	RGSC-0005	68.4	63.00	109.00	19.79	0.01979	3969.0	4.99	1.110	**5.53**	d		Valid - Intact Rock
5	RGSC-0005	69.54	63.00	70.00	5.07	0.00507	3969.0	1.28	1.110	**1.42**	d		Valid - Intact Rock
6	RGSC-0005	84.85	63.00	90.00	13.47	0.01347	3969.0	3.39	1.110	**3.77**	d		Valid - Intact Rock
7	RGSC-0005	86.04	63.00	125.00	14.50	0.01450	3969.0	3.65	1.110	**4.05**	d		Valid - Intact Rock
8	RGSC-0005	102.30	63.00	90.00	3.68	0.00368	3969.0	0.93	1.110	**1.03**	d		Valid - Intact Rock
9	RGSC-0005	105.52	63.00	80.00	5.81	0.00581	3969.0	1.46	1.110	**1.62**	d		Valid - Intact Rock
10	RGSC-0005	109.24	63.00	68.00	6.62	0.00662	3969.0	1.67	1.110	**1.85**	d		Valid - Intact Rock
11	RGSC-0005	111.93	63.00	80.00	3.57	0.00357	3969.0	0.90	1.110	**1.00**	d		Valid - Intact Rock
12	RGSC-0005	127.33	63.00	70.00	5.19	0.00519	3969.0	1.31	1.110	**1.45**	d		Valid - Intact Rock
13	RGSC-0005	129.77	63.00	55.00	3.42	0.00342	3969.0	0.86	1.110	**0.96**	d		Invalid - Chipping
14	RGSC-0005	134.21	63.00	82.00	6.39	0.00639	3969.0	1.61	1.110	**1.79**	d		Valid - Intact Rock
15	RGSC-0005	139.09	63.00	125.00	2.29	0.00229	3969.0	0.58	1.110	**0.64**	d		Valid - Bedding, and some carbonaceous material
16	RGSC-0005	141.56	63.00	130.00	10.87	0.01087	3969.0	2.74	1.110	**3.04**	d		Valid - Intact Rock
17	RGSC-0005	145.85	63.00	100.00	8.41	0.00841	3969.0	2.12	1.110	**2.35**	d		Valid - Intact Rock

$I_{s(50)}$ = Size Corrected Point Load Strength
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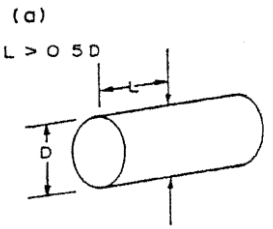
I_s = Uncorrected Point Load Strength
$I_s = P/D_e^2$

F = Size Correction Factor
$F = (D_e/50)^{0.45}$

D_e = equivalent core diameter (mm)
$D_e^2 = D^2$ (mm^2)

Direction
\\ = parallel
p = perpendicular to planes of weakness

Diametral Test



Tested By TCD, TGT	Date : October 15, 2014	Checked By EAS	Date : October 16, 2014

Golder Associates Ltd.
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C8

POINT LOAD STRENGTH INDEX TEST

Reference
ASTM D5731 - 08

Client	Riversdale Resources Limited	Project No	1406422
Project	Grassy Mountain	Test Date	August 26-29, 2014
Location	RGSC-0006	Tested By	TGT, JMR, DTL

Axial Test

Test #	Borehole	Depth	D	W	Guage Reading	Load P	$D_e^2=4WD/p$	$I_s = P/D_e^2$	$F = (D_e/50)^{0.45}$	$I_{s(50)}$	Type	Direction	Remarks
	No.	m	mm	mm	kN	MN	mm^2	MPa		MPa			
1	RGSC006	29.2	63.00	50.00	17.13	0.01713	3969.0	4.32	1.110	**4.79**	a		Invalid - Broke along preexisting joint
2	RGSC006	35.23	63.00	70.00	12.85	0.01285	3969.0	3.24	1.110	**3.59**	a		Valid - Broke along core axis
3	RGSC006	151.42	63.00	55.00	1.44	0.00144	3969.0	0.36	1.110	**0.40**	a		Invalid - Chipped along preexisting joint

$I_{s(50)}$ = Size Corrected Point Load Strength
$I_{s(50)} = FI_s$

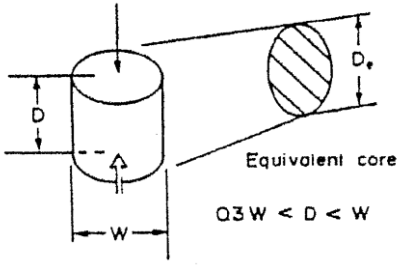
I_s = Uncorrected Point Load Strength
$I_s = P/D_e^2$

F = Size Correction Factor
$F = (D_e/50)^{0.45}$

D_e = equivalent core diameter (mm)
$D_e^2 = 4/p*D*W = (mm^2)$

Direction
\\ = parallel
p = perpendicular to planes of weakness

Axial Test



Tested By TGT, JMR, DTL	Date : October 15, 2014	Checked By EAS	Date : October 16, 2014

Golder Associates Ltd.
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C8

Golder Associates

POINT LOAD STRENGTH INDEX TEST

Reference
ASTM D5731 - 08

Client	Riversdale Resources Limited	Project No	1406422
Project	Grassy Mountain	Test Date	August 26-29, 2014
Location	RGSC-0006	Tested By	TGT, JMR, DTL

Diametral Test

Test #	Borehole No.	Depth m	D mm	L mm	Guage Reading kN	Load P MN	$D_e^2 = D^2$ mm^2	$I_s = P/D_e^2$ MPa	$F = (D_e/50)^{0.45}$	$I_{s(50)}$ MPa	Type	Direction	Remarks
1	RGSC006	20.8	61.00	150.00	5.83	0.00583	3721.0	1.57	1.094	**1.71**	d		Valid-intact rock
2	RGSC006	23.43	61.00	120.00	24.33	0.02433	3721.0	6.54	1.094	**7.15**	d		Invalid chipped rock
3	RGSC006	30.66	61.00	65.00	28.74	0.02874	3721.0	7.72	1.094	**8.45**	d		Valid - intact rock
4	RGSC006	37.84	61.00	85.00	14.99	0.01499	3721.0	4.03	1.094	**4.41**	d		Valid - intact rock
5	RGSC006	42.07	61.00	104.00	3.37	0.00337	3721.0	0.91	1.094	**0.99**	d		Valid - Bedding
6	RGSC006	44.23	61.00	170.00	24.22	0.02422	3721.0	6.51	1.094	**7.12**	d		Valid - intact rock
7	RGSC006	47.70	61.00	150.00	7.30	0.00730	3721.0	1.96	1.094	**2.15**	d		Valid - intact rock
8	RGSC006	49.46	61.00	110.00	5.60	0.00560	3721.0	1.50	1.094	**1.65**	d		Valid - Bedding
9	RGSC006	53.94	61.00	80.00	17.31	0.01731	3721.0	4.65	1.094	**5.09**	d		Valid - intact rock
10	RGSC006	56.93	61.00	115.00	8.31	0.00831	3721.0	2.23	1.094	**2.44**	d		Valid - Bedding
11	RGSC006	58.60	61.00	105.00	19.42	0.01942	3721.0	5.22	1.094	**5.71**	d		Valid - intact rock
12	RGSC006	61.58	61.00	105.00	18.97	0.01897	3721.0	5.10	1.094	**5.58**	d		Valid - Bedding
13	RGSC006	65.07	61.00	110.00	13.79	0.01379	3721.0	3.71	1.094	**4.05**	d		Valid - intact rock
14	RGSC006	66.83	61.00	95.00	26.64	0.02664	3721.0	7.16	1.094	**7.83**	d		Valid - intact rock
15	RGSC006	68.73	61.00	150.00	21.69	0.02169	3721.0	5.83	1.094	**6.37**	d		Valid - intact rock
16	RGSC006	70.27	61.00	100.00	0.11	0.00011	3721.0	0.03	1.094	**0.03**	d		Valid - intact rock
17	RGSC006	74.78	61.00	115.00	2.10	0.00210	3721.0	0.56	1.094	**0.62**	d		Valid - intact rock
18	RGSC006	77.58	61.00	80.00	3.27	0.00327	3721.0	0.88	1.094	**0.96**	d		Valid - intact rock
19	RGSC006	81.79	61.00	90.00	1.46	0.00146	3721.0	0.39	1.094	**0.43**	d		Valid - intact rock
20	RGSC006	84.31	61.00	105.00	0.14	0.00014	3721.0	0.04	1.094	**0.04**	d		Valid - intact rock
21	RGSC006	89.89	61.00	90.00	11.69	0.01169	3721.0	3.14	1.094	**3.44**	d		Valid - intact rock
22	RGSC006	93.16	61.00	120.00	15.27	0.01527	3721.0	4.10	1.094	**4.49**	d		Valid - intact rock
23	RGSC006	96.89	61.00	110.00	17.46	0.01746	3721.0	4.69	1.094	**5.13**	d		Valid - intact rock
24	RGSC006	97.90	61.00	100.00	4.52	0.00452	3721.0	1.21	1.094	**1.33**	d		Valid - Bedding
25	RGSC006	99.88	61.00	105.00	9.16	0.00916	3721.0	2.46	1.094	**2.69**	d		Valid - Bedding
26	RGSC006	104.77	61.00	110.00	9.68	0.00968	3721.0	2.60	1.094	**2.84**	d		Valid - Bedding
27	RGSC006	106.93	61.00	85.00	3.58	0.00358	3721.0	0.96	1.094	**1.05**	d		Valid - Bedding
28	RGSC006	110.95	61.00	110.00	5.82	0.00582	3721.0	1.56	1.094	**1.71**	d		Invalid - chipping
29	RGSC006	114.75	61.00	120.00	3.34	0.00334	3721.0	0.90	1.094	**0.98**	d		Valid - Bedding
30	RGSC006	118.88	61.00	65.00	25.35	0.02535	3721.0	6.81	1.094	**7.45**	d		Invalid - chipping
31	RGSC006	121.86	61.00	80.00	8.10	0.00810	3721.0	2.18	1.094	**2.38**	d		Valid - intact rock
32	RGSC006	127.79	61.00	95.00	27.69	0.02769	3721.0	7.44	1.094	**8.14**	d		Invalid - chipping
33	RGSC006	130.51	61.00	110.00	5.41	0.00541	3721.0	1.45	1.094	**1.59**	d		Valid - intact rock
34	RGSC006	132.57	61.00	80.00	7.21	0.00721	3721.0	1.94	1.094	**2.12**	d		Valid - Bedding
35	RGSC006	134.58	61.00	125.00	8.77	0.00877	3721.0	2.36	1.094	**2.58**	d		Valid - Bedding
36	RGSC006	138.62	61.00	165.00	3.70	0.00370	3721.0	0.99	1.094	**1.09**	d		Valid - Bedding
37	RGSC006	141.23	61.00	140.00	4.66	0.00466	3721.0	1.25	1.094	**1.37**	d		Valid - Bedding
38	RGSC006	161.08	61.00	125.00	5.94	0.00594	3721.0	1.60	1.094	**1.75**	d		Valid-broke along joint

$I_{s(50)}$ = Size Corrected Point Load Strength
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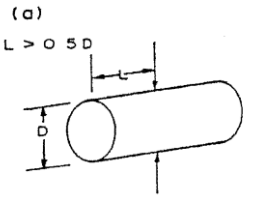
I_s = Uncorrected Point Load Strength
$I_s = P/D_e^2$

F = Size Correction Factor
$F = (D_e/50)^{0.45}$

D_e = equivalent core diameter (mm)
$D_e^2 = D^2$ (mm^2)

Direction
\\ = parallel
p = perpendicular to planes of weakness

Diametral Test



Tested By TGT, JMR, DTL	Date : October 15, 2014	Checked By EAS	Date : October 16, 2014

Golder Associates Ltd.
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C8

POINT LOAD STRENGTH INDEX TEST

Reference
ASTM D5731 - 08

Client	Riversdale Resources Limited	Project No	1406422
Project	Grassy Mountain	Test Date	August 31 - September 6, 2014
Location	RGSC-0007	Tested By	AGH, JMR, DTL

Axial Test

Test #	Borehole No.	Depth m	D mm	W mm	Guage Reading kN	Load P MN	$D_e^2=4WD/p$ mm^2	$I_s = P/D_e^2$ MPa	$F = (D_e/50)^{0.45}$	$I_{s(50)}$ MPa	Type	Direction	Remarks
1	**RGSC-0007**	**21.00**	50.00	63.00	21.88	0.02188	2500.0	8.75	1.000	**8.75**	**a**		Valid - Intact rock
2	**RGSC-0007**	**25.86**	60.00	63.00	21.88	0.02188	3600.0	6.08	1.086	**6.60**	**a**		Valid - Intact rock
3	**RGSC-0007**	**72.57**	50.00	63.00	11.55	0.01155	2500.0	4.62	1.000	**4.62**	**a**		Invaild-chipped
4	**RGSC-0007**	**80.79**	40.00	63.00	4.45	0.00445	1600.0	2.78	0.904	**2.52**	**a**		Valid - Intact rock
5	**RGSC-0007**	**116.91**	65.00	63.00	10.67	0.01067	4225.0	2.53	1.125	**2.84**	**a**		Valid - Intact rock

$I_{s(50)}$ = Size Corrected Point Load Strength
$I_{s(50)} = FI_s$

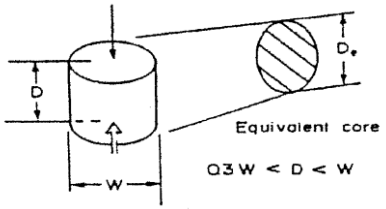
I_s = Uncorrected Point Load Strength
$I_s = P/D_e^2$

F = Size Correction Factor
$F = (D_e/50)^{0.45}$

D_e = equivalent core diameter (mm)
$D_e^2 = 4/p*D*W = (mm^2)$

Direction
\\ = parallel
p = perpendicular to planes of weakness

Axial Test



Tested By AGH, JMR, DTL	Date : October 15, 2014	Checked By EAS	Date : October 16, 2014

Golder Associates Ltd.
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C8

Golder Associates

POINT LOAD STRENGTH INDEX TEST

Reference
ASTM D5731 - 08

Client Riversdale Resources Limited
Project Grassy Mountain
Location RGSC-0008

Project No 1406422
Test Date September 8-9, 2014
Tested By AGH, JMR, DTL

Diametral Test

Test #	Borehole No.	Depth m	D mm	L mm	Guage Reading kN	Load P MN	$D_e^2 = D^2$ mm^2	$I_s = P/D_e^2$ MPa	$F = (D_e/50)^{0.45}$	$I_{s(50)}$ MPa	Type	Direction	Remarks
1	RGSC0008	12.27	63.00	100.00	4.00	0.00400	3969.0	1.01	1.110	**1.12**	d		Invalid - broke along joint
2	RGSC0008	15.48	63.00	115.00	18.88	0.01888	3969.0	4.76	1.110	**5.28**	d		Valid - Intact Rock
3	RGSC0008	19.76	63.00	83.00	7.10	0.00710	3969.0	1.79	1.110	**1.98**	d		Valid - Intact Rock
4	RGSC0008	33.62	63.00	125.00	1.13	0.00113	3969.0	0.28	1.110	**0.32**	d		Valid - Intact Rock
5	RGSC0008	34.02	63.00	140.00	0.59	0.00059	3969.0	0.15	1.110	**0.16**	d		Valid - Intact Rock
6	RGSC0008	35.67	63.00	160.00	6.94	0.00694	3969.0	1.75	1.110	**1.94**	d		Valid - Bedding
7	RGSC0008	39.64	63.00	85.00	0.94	0.00094	3969.0	0.24	1.110	**0.26**	d		Valid - Intact Rock
8	RGSC0008	39.69	63.00	150.00	3.30	0.00330	3969.0	0.83	1.110	**0.92**	d		Valid - Intact Rock
9	RGSC0008	48.26	63.00	112.00	4.46	0.00446	3969.0	1.12	1.110	**1.25**	d		Valid - Intact Rock
10	RGSC0008	51.39	63.00	105.00	5.45	0.00545	3969.0	1.37	1.110	**1.52**	d		Valid- Intact Rock
11	RGSC0008	58.62	63.00	135.00	5.45	0.00545	3969.0	1.37	1.110	**1.52**	d		Valid- Intact Rock
12	RGSC0008	61.2	63.00	110.00	5.91	0.00591	3969.0	1.49	1.110	**1.65**	d		Valid - Bedding
13	RGSC0008	66.06	63.00	90.00	24.57	0.02457	3969.0	6.19	1.110	**6.87**	d		Valid- Intact Rock
14	RGSC0008	66.49	63.00	110.00		0.00000	3969.0	0.00	1.110	**0.00**	d		Invalid - broke along joint
15	RGSC0008	70.82	63.00	120.00	17.39	0.01739	3969.0	4.38	1.110	**4.86**	d		Valid- intact Rock
16	RGSC0008	74.66	63.00	105.00	17.39	0.01739	3969.0	4.38	1.110	**4.86**	d		Valid- intact Rock
17	RGSC0008	80.65	63.00	100.00	20.94	0.02094	3969.0	5.28	1.110	**5.85**	d		Valid- intact Rock
18	RGSC0008	83.26	63.00	110.00	20.94	0.02094	3969.0	5.28	1.110	**5.85**	d		Valid- intact Rock
19	RGSC0008	87.03	63.00	100.00	20.94	0.02094	3969.0	5.28	1.110	**5.85**	d		Valid- intact Rock
20	RGSC0008	88.65	63.00	110.00	20.94	0.02094	3969.0	5.28	1.110	**5.85**	d		Valid- intact Rock

$I_{s(50)}$ = Size Corrected Point Load Strength
$I_{s(50)} = FI_s$

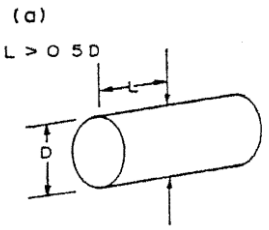
I_s = Uncorrected Point Load Strength
$I_s = P/D_e^2$

F = Size Correction Factor
$F = (D_e/50)^{0.45}$

D_e = equivalent core diameter (mm)
$D_e^2 = D^2$ (mm^2)

Direction
\\ = parallel
p = perpendicular to planes of weakness

Diametral Test



Tested By AGH, JMR, DTL	Date : October 15, 2014	Checked By EAS	Date : October 16, 2014

Golder Associates Ltd.
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C8

POINT LOAD STRENGTH INDEX TEST

Reference
ASTM D5731 - 08

Client	Riversdale Resources Limited	Project No	1406422
Project	Grassy Mountain	Test Date	September 8-9, 2014
Location	RGSC-0008	Tested By	AGH, JMR, DTL

Axial Test

Test #	Borehole No.	Depth m	D mm	W mm	Guage Reading kN	Load P MN	$D_e^2=4WD/p$ mm^2	$I_s = P/D_e^2$ MPa	$F = (D_e/50)^{0.45}$	$I_{s(50)}$ MPa	Type	Direction	Remarks
1	RGSC0008	18.03	63.00	55.00	18.88	0.01888	3969.0	4.76	1.110	**5.28**	a		Vaid - Intact rock
2	RGSC0008	56.5	63.00	65.00	5.45	0.00545	3969.0	1.37	1.110	**1.52**	a		Invalid
3	RGSC0008	78.27	63.00	65.00	20.94	0.02094	3969.0	5.28	1.110	**5.85**	a		Invalid - rock not intact

$I_{s(50)}$ = Size Corrected Point Load Strength
$I_{s(50)} = FI_s$

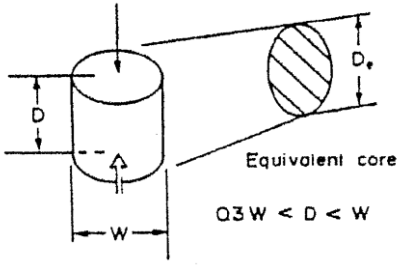
I_s = Uncorrected Point Load Strength
$I_s = P/D_e^2$

F = Size Correction Factor
$F = (D_e/50)^{0.45}$

D_e = equivalent core diameter (mm)
$D_e^2 = 4/p*D*W = (mm^2)$

Direction
\\ = parallel
p = perpendicular to planes of weakness

Axial Test



Tested By AGH, JMR, DTL	Date : October 15, 2014	Checked By EAS	Date : October 16, 2014

Golder Associates Ltd.
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C8

POINT LOAD STRENGTH INDEX TEST

Reference
ASTM D5731 - 08

Client: Riversdale Resources Limited
Project: Grassy Mountain
Location: RGSC-0008

Project No: 1406422
Test Date: September 8-9, 2014
Tested By: AGH, JMR, DTL

Diametral Test

Test #	Borehole No.	Depth m	D mm	L mm	Guage Reading kN	Load P MN	$D_e^2 = D^2$ mm^2	$I_s = P/D_e^2$ MPa	$F = (D_e/50)^{0.45}$	$I_{s(50)}$ MPa	Type	Direction	Remarks
1	RGSC0008	12.27	63.00	100.00	4.00	0.00400	3969.0	1.01	1.110	**1.12**	d		Invalid - broke along joint
2	RGSC0008	15.48	63.00	115.00	18.88	0.01888	3969.0	4.76	1.110	**5.28**	d		Valid - Intact Rock
3	RGSC0008	19.76	63.00	83.00	7.10	0.00710	3969.0	1.79	1.110	**1.98**	d		Valid - Intact Rock
4	RGSC0008	33.62	63.00	125.00	1.13	0.00113	3969.0	0.28	1.110	**0.32**	d		Valid - Intact Rock
5	RGSC0008	34.02	63.00	140.00	0.59	0.00059	3969.0	0.15	1.110	**0.16**	d		Valid - Intact Rock
6	RGSC0008	35.67	63.00	160.00	6.94	0.00694	3969.0	1.75	1.110	**1.94**	d		Valid - Bedding
7	RGSC0008	39.64	63.00	85.00	0.94	0.00094	3969.0	0.24	1.110	**0.26**	d		Valid - Intact Rock
8	RGSC0008	39.69	63.00	150.00	3.30	0.00330	3969.0	0.83	1.110	**0.92**	d		Valid - Intact Rock
9	RGSC0008	48.26	63.00	112.00	4.46	0.00446	3969.0	1.12	1.110	**1.25**	d		Valid - Intact Rock
10	RGSC0008	51.39	63.00	105.00	5.45	0.00545	3969.0	1.37	1.110	**1.52**	d		Valid- Intact Rock
11	RGSC0008	58.62	63.00	135.00	5.45	0.00545	3969.0	1.37	1.110	**1.52**	d		Valid- Intact Rock
12	RGSC0008	61.2	63.00	110.00	5.91	0.00591	3969.0	1.49	1.110	**1.65**	d		Valid - Bedding
13	RGSC0008	66.06	63.00	90.00	24.57	0.02457	3969.0	6.19	1.110	**6.87**	d		Valid- Intact Rock
14	RGSC0008	66.49	63.00	110.00		0.00000	3969.0	0.00	1.110	**0.00**	d		Invalid - broke along joint
15	RGSC0008	70.82	63.00	120.00	17.39	0.01739	3969.0	4.38	1.110	**4.86**	d		Valid- intact Rock
16	RGSC0008	74.66	63.00	105.00	17.39	0.01739	3969.0	4.38	1.110	**4.86**	d		Valid- intact Rock
17	RGSC0008	80.65	63.00	100.00	20.94	0.02094	3969.0	5.28	1.110	**5.85**	d		Valid- intact Rock
18	RGSC0008	83.26	63.00	110.00	20.94	0.02094	3969.0	5.28	1.110	**5.85**	d		Valid- intact Rock
19	RGSC0008	87.03	63.00	100.00	20.94	0.02094	3969.0	5.28	1.110	**5.85**	d		Valid- intact Rock
20	RGSC0008	88.65	63.00	110.00	20.94	0.02094	3969.0	5.28	1.110	**5.85**	d		Valid- intact Rock

$I_{s(50)}$ = Size Corrected Point Load Strength
$I_{s(50)} = FI_s$

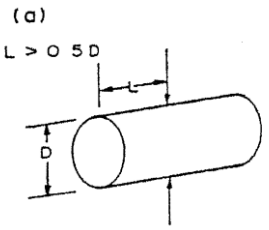
I_s = Uncorrected Point Load Strength
$I_s = P/D_e^2$

F = Size Correction Factor
$F = (D_e/50)^{0.45}$

D_e = equivalent core diameter (mm)
$D_e^2 = D^2$ (mm^2)

Direction
\\ = parallel
p = perpendicular to planes of weakness

Diametral Test



Tested By AGH, JMR, DTL	Date : October 15, 2014	Checked By EAS	Date: October 16, 2014

Golder Associates Ltd.
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C8

POINT LOAD STRENGTH INDEX TEST

Reference
ASTM D5731 - 08

Client	Riversdale Resources Limited	Project No	1406422
Project	Grassy Mountain	Test Date	September 14-16, 2014
Location	Near Blairmore, Alberta	Tested By	TGT, JMR, DTL

Axial Test

Test #	Borehole No.	Depth m	D mm	W mm	Guage Reading kN	Load P MN	$D_e^2=4WD/p$ mm^2	$I_s = P/D_e^2$ MPa	$F = (D_e/50)^{0.45}$	$I_{s(50)}$ MPa	Type	Direction	Remarks
1	RGSC-0009	49.59	68.00	61.00	14.32	0.01432	4624.0	3.10	1.148	**3.56**	a		Valid - Intact Rock
2	RGSC-0009	76.18	45.00	61.00	24.05	0.02405	2025.0	11.88	0.954	**11.33**	a		Valid - Intact Rock
3	RGSC-0009	79.91	63.00	61.00	9.95	0.00995	3969.0	2.51	1.110	**2.78**	a		Valid - Intact Rock

$I_{s\,(50)}$ = Size Corrected Point Load Strength
$I_{s(50)} = FI_s$

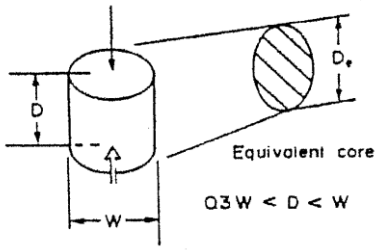
I_s = Uncorrected Point Load Strength
$I_s = P/D_e^2$

F = Size Correction Factor
$F = (D_e/50)^{0.45}$

D_e = equivalent core diameter (mm)
$D_e^2 = 4/p*D*W = (mm^2)$

Direction
\\ = parallel
p = perpendicular to planes of weakness

Axial Test



Tested By TGT, JRM, DTL	Date : October 15, 2014	Checked By EAS	Date : October 16, 2014

Golder Associates Ltd.
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C8

POINT LOAD STRENGTH INDEX TEST

Reference
ASTM D5731 - 08

Client: Riversdale Resources Limited
Project: Grassy Mountain
Location: RGSC-0009

Project No: 1406422
Test Date: September 14-16, 2014
Tested By: TGT, JMR, DTL

Diametral Test

Test #	Borehole No.	Depth m	D mm	L mm	Guage Reading kN	Load P MN	$D_e^2 = D^2$ mm^2	$I_s = P/D_e^2$ MPa	$F = (D_e/50)^{0.45}$	$I_{s(50)}$ MPa	Type	Direction	Remarks
1	RGSC-0009	30.02	61.00	110.00	23.76	0.02376	3721.0	6.39	1.094	**6.98**	d		Valid - Intact Rock
2	RGSC-0009	34.72	61.00	120.00	13.68	0.01368	3721.0	3.68	1.094	**4.02**	d		Valid - Intact Rock
3	RGSC-0009	36.21	61.00	100.00	0.40	0.00040	3721.0	0.11	1.094	**0.12**	d		Valid - Failed along plane of weakness
4	RGSC-0009	38.10	61.00	140.00	4.15	0.00415	3721.0	1.12	1.094	**1.22**	d		Valid - Intact Rock
5	RGSC-0009	41.32	61.00	95.00	17.34	0.01734	3721.0	4.66	1.094	**5.10**	d		Valid - Failed along plane of weakness
6	RGSC-0009	43.62	61.00	75.00	29.52	0.02952	3721.0	7.93	1.094	**8.68**	d		Valid - Intact Rock
7	RGSC-0009	44.77	61.00	110.00	30.86	0.03086	3721.0	8.29	1.094	**9.07**	d		Valid - Intact Rock
8	RGSC-0009	46.93	61.00	95.00	4.34	0.00434	3721.0	1.17	1.094	**1.28**	d		Valid - Failed along plane of weakness
9	RGSC-0009	53.72	61.00	195.00	20.16	0.02016	3721.0	5.42	1.094	**5.93**	d		Valid - Intact Rock
11	RGSC-0009	58.33	61.00	160.00	24.05	0.02405	3721.0	6.46	1.094	**7.07**	d		Valid - Intact Rock
15	RGSC-0009	83.5	61.00	120.00	9.95	0.00995	3721.0	2.67	1.094	**2.92**	d		Valid - Intact Rock
16	RGSC-0009	91.42	61.00	120.00	9.97	0.00997	3721.0	2.68	1.094	**2.93**	d		Valid - Intact Rock
17	RGSC-0009	96.15	61.00	100.00	13.51	0.01351	3721.0	3.63	1.094	**3.97**	d		Valid - Intact Rock
20	RGSC-0009	108.04	61.00	145.00	4.74	0.00474	3721.0	1.27	1.094	**1.39**	d		Valid - Intact Rock
21	RGSC-0009	110.51	61.00	80.00	30.78	0.03078	3721.0	8.27	1.094	**9.05**	d		Valid - Intact Rock
22	RGSC-0009	114.59	61.00	110.00	19.82	0.01982	3721.0	5.33	1.094	**5.83**	d		Valid - Bedding
23	RGSC-0009	116.84	61.00	74.00	8.43	0.00843	3721.0	2.27	1.094	**2.48**	d		Valid - Intact Rock
24	RGSC-0009	128.62	61.00	150.00	4.16	0.00416	3721.0	1.12	1.094	**1.22**	d		Valid - Intact Rock
26	RGSC-0009	137.67	61.00	105.00	8.28	0.00828	3721.0	2.23	1.094	**2.43**	d		Valid - Intact Rock
28	RGSC-0009	151.07	61.00	150.00	12.12	0.01212	3721.0	3.26	1.094	**3.56**	d		Valid - Intact Rock

$I_{s(50)}$ = Size Corrected Point Load Strength
$I_{s(50)} = FI_s$

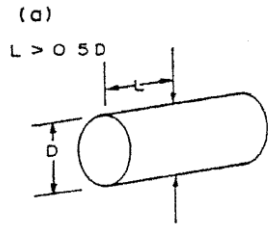
I_s = Uncorrected Point Load Strength
$I_s = P/D_e^2$

F = Size Correction Factor
$F = (D_e/50)^{0.45}$

D_e = equivalent core diameter (mm)
$D_e^2 = D^2$ (mm^2)

Direction
\\ = parallel
p = perpendicular to planes of weakness

Diametral Test



Tested By TGT, JRM, DTL	Date : October 15, 2014	Checked By EAS	Date : October 16, 2014

Golder Associates Ltd.
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C8

POINT LOAD STRENGTH INDEX TEST

Reference
ASTM D5731 - 08

Client	Riversdale Resources Limited	Project No	1406422
Project	Grassy Mountain	Test Date	September 17-19, 2014
Location	RGSC-0010	Tested By	TGT, DTL

Axial Test

Test #	Borehole No.	Depth m	D mm	W mm	Guage Reading kN	Load P MN	$D_e^2=4WD/p$ mm^2	$I_s = P/D_e^2$ MPa	$F = (D_e/50)^{0.45}$	$I_{s(50)}$ MPa	Type	Direction	Remarks
1	**RGSC-0010**	**75.14**	35.00	61.00	6.46	0.00646	1225.0	5.27	0.852	**4.49**	**a**		Valid - Intact rock
2	**RGSC-0010**	**162.51**	50.00	61.00	7.49	0.00749	2500.0	3.00	1.000	**3.00**	**a**		Valid - Intact rock

$I_{s\,(50)}$ = Size Corrected Point Load Strength
$I_{s(50)} = FI_s$

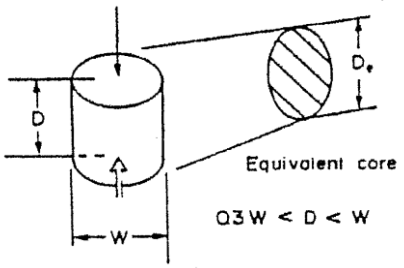
I_s = Uncorrected Point Load Strength
$I_s = P/D_e^2$

F = Size Correction Factor
$F = (D_e/50)^{0.45}$

D_e = equivalent core diameter (mm)
$D_e^2 = 4/p*D*W = (mm^2)$

Direction
\\ = parallel
p = perpendicular to planes of weakness

Axial Test



Tested By TGT, DTL	Date : October 15, 2014	Checked By EAS	Date : October 16, 2014

Golder Associates Ltd.
4280 Still Creek Drive
Burnaby, B.C. Canada V5C 6C8

Golder Associates

POINT LOAD STRENGTH INDEX TEST

Reference
ASTM D5731 - 08

Client: Riversdale Resources Limited
Project: Grassy Mountain
Location: RGSC-0010

Project No: 1406422
Test Date: September 17-19, 2014
Tested By: TGT, DTL

Diametral Test

Test #	Borehole No.	Depth m	D mm	L mm	Guage Reading kN	Load P MN	$D_e^2 = D^2$ mm^2	$I_s = P/D_e^2$ MPa	$F = (D_e/50)^{0.45}$	$I_{s(50)}$ MPa	Type	Direction	Remarks
1	RGSC-0010	18.64	61.00	110.00	21.48	0.02148	3721.0	5.77	1.094	**6.31**	d		Invalid - chipped
2	RGSC-0010	25.66	61.00	115.00	19.71	0.01971	3721.0	5.30	1.094	**5.79**	d		Vaild - intact rock
3	RGSC-0010	27.82	61.00	130.00	0.82	0.00082	3721.0	0.22	1.094	**0.24**	d		Vaild - Bedding plane
4	RGSC-0010	31.97	61.00	70.00	5.17	0.00517	3721.0	1.39	1.094	**1.52**	d		Vaild - Bedding plane
5	RGSC-0010	35.28	61.00	100.00	29.76	0.02976	3721.0	8.00	1.094	**8.75**	d		Vaild - Bedding plane
6	RGSC-0010	38.38	61.00	70.00	0.85	0.00085	3721.0	0.23	1.094	**0.25**	d		Vaild - intact rock
7	RGSC-0010	41.56	61.00	60.00	0.79	0.00079	3721.0	0.21	1.094	**0.23**	d		Vaild - intact rock
8	RGSC-0010	42.78	61.00	85.00	2.78	0.00278	3721.0	0.75	1.094	**0.82**	d		Invalid - chipped
9	RGSC-0010	44.73	61.00	95.00	0.04	0.00004	3721.0	0.01	1.094	**0.01**	d		Vaild - intact rock
10	RGSC-0010	50.45	61.00	140.00	2.59	0.00259	3721.0	0.70	1.094	**0.76**	d		Vaild - intact rock
11	RGSC-0010	53.05	61.00	60.00	1.02	0.00102	3721.0	0.27	1.094	**0.30**	d		Vaild - intact rock
12	RGSC-0010	59.33	61.00	80.00	3.29	0.00329	3721.0	0.88	1.094	**0.97**	d		Vaild - Bedding plane
13	RGSC-0010	62.43	61.00	90.00	7.46	0.00746	3721.0	2.00	1.094	**2.19**	d		Vaild - Bedding plane
14	RGSC-0010	65.24	61.00	90.00	14.76	0.01476	3721.0	3.97	1.094	**4.34**	d		Vaild - intact rock
15	RGSC-0010	69.04	61.00	90.00	8.73	0.00873	3721.0	2.35	1.094	**2.57**	d		Vaild - intact rock
16	RGSC-0010	71.55	61.00	70.00	3.63	0.00363	3721.0	0.98	1.094	**1.07**	d		Vaild - Bedding plane
17	RGSC-0010	81.13	61.00	60.00	2.55	0.00255	3721.0	0.69	1.094	**0.75**	d		Vaild - Bedding plane
18	RGSC-0010	84.44	61.00	90.00	18.08	0.01808	3721.0	4.86	1.094	**5.31**	d		Invalid - chipped
19	RGSC-0010	90.46	61.00	90.00	1.30	0.00130	3721.0	0.35	1.094	**0.38**	d		Vaild - intact rock
20	RGSC-0010	92.04	61.00	70.00	1.23	0.00123	3721.0	0.33	1.094	**0.36**	d		Vaild - intact rock
21	RGSC-0010	96.52	61.00	150.00	10.74	0.01074	3721.0	2.89	1.094	**3.16**	d		Vaild - intact rock
22	RGSC-0010	97.94	61.00	120.00	1.92	0.00192	3721.0	0.52	1.094	**0.56**	d		Invalid - chipped
23	RGSC-0010	102.50	61.00	100.00	1.62	0.00162	3721.0	0.44	1.094	**0.48**	d		Vaild - Bedding plane
24	RGSC-0010	104.67	61.00	90.00	0.83	0.00083	3721.0	0.22	1.094	**0.24**	d		Vaild - Bedding plane
25	RGSC-0010	116.82	61.00	80.00	0.44	0.00044	3721.0	0.12	1.094	**0.13**	d		Vaild - Bedding plane
26	RGSC-0010	120.64	61.00	120.00	1.19	0.00119	3721.0	0.32	1.094	**0.35**	d		valid-bedding plane
27	RGSC-0010	124.06	61.00	140.00	2.72	0.00272	3721.0	0.73	1.094	**0.80**	d		valid-bedding plane
28	RGSC-0010	126.93	61.00	120.00	0.04	0.00004	3721.0	0.01	1.094	**0.01**	d		Vaild - intact rock
29	RGSC-0010	129.19	61.00	150.00	2.97	0.00297	3721.0	0.80	1.094	**0.87**	d		Vaild - intact rock
30	RGSC-0010	132.93	61.00	120.00	5.63	0.00563	3721.0	1.51	1.094	**1.65**	d		Vaild - intact rock
31	RGSC-0010	136.11	61.00	105.00	0.94	0.00094	3721.0	0.25	1.094	**0.28**	d		valid-bedding plane
32	RGSC-0010	139.06	61.00	55.00	0.22	0.00022	3721.0	0.06	1.094	**0.06**	d		valid-bedding plane, coal
33	RGSC-0010	140.51	61.00	130.00	2.06	0.00206	3721.0	0.55	1.094	**0.61**	d		valid-bedding plane
34	RGSC-0010	144.44	61.00	105.00	6.66	0.00666	3721.0	1.79	1.094	**1.96**	d		Vaild - intact rock
35	RGSC-0010	148.29	61.00	85.00	5.77	0.00577	3721.0	1.55	1.094	**1.70**	d		Vaild - intact rock
36	RGSC-0010	152.11	61.00	105.00	3.08	0.00308	3721.0	0.83	1.094	**0.91**	d		valid-bedding plane
37	RGSC-0010	155.38	61.00	120.00	7.80	0.00780	3721.0	2.10	1.094	**2.29**	d		Vaild - intact rock
38	RGSC-0010	160.65	61.00	70.00	8.72	0.00872	3721.0	2.34	1.094	**2.56**	d		valid-bedding plane
39	RGSC-0010	165.82	61.00	115.00	30.50	0.03050	3721.0	8.20	1.094	**8.96**	d		Invalid - chipped
40	RGSC-0010	168.95	61.00	90.00	21.48	0.02148	3721.0	5.77	1.094	**6.31**	d		Invalid - chipped

$I_{s(50)}$ = Size Corrected Point Load Strength
$I_{s(50)} = FI_s$

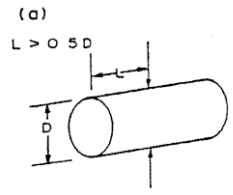
I_s = Uncorrected Point Load Strength
$I_s = P/D_e^2$

F = Size Correction Factor
$F = (D_e/50)^{0.45}$

D_e = equivalent core diameter (mm)
$D_e^2 = D^2$ (mm^2)

Direction
\\ = parallel
p = perpendicular to planes of weakness

Diametral Test



Tested By TGT, DTL	Date : October 15, 2014	Checked By EAS	Date : October 16, 2014

APPENDIX D

Discontinuity Characterization

1.0 DISCONTINUITY CHARACTERIZATION

The Joint Condition Rating (JCR) is used to describe the small-scale surface characteristics of the joint discontinuities in the RMR_{76} rock mass classification system (Bieniawski, 1976). A discrete numeric value between 0 and 25 is assigned based on the evaluation of the shape, roughness and wall rock alteration of the discontinuity surface.

During the 2014 field investigations, Golder engineers and Riversdale geologists collected JCR values for individual discontinuities and estimated an overall JCR for each geotechnical interval logged using the standard RMR_{76} JCR values of 0, 6, 12, 20 and 25. The interval JCR was assigned based on the most representative joint condition observed within an interval.

The discontinuity JCR data do not take into account intervals of lost core or very weak rock, where features were not able to be logged. In other words, the feature JCR data only represents the quality of features that were able to be observed and logged. A JCR value of 0 was assigned to Lost Core intervals.

JCR frequency histograms for all the boreholes are presented in Plate D-1 to D-7.

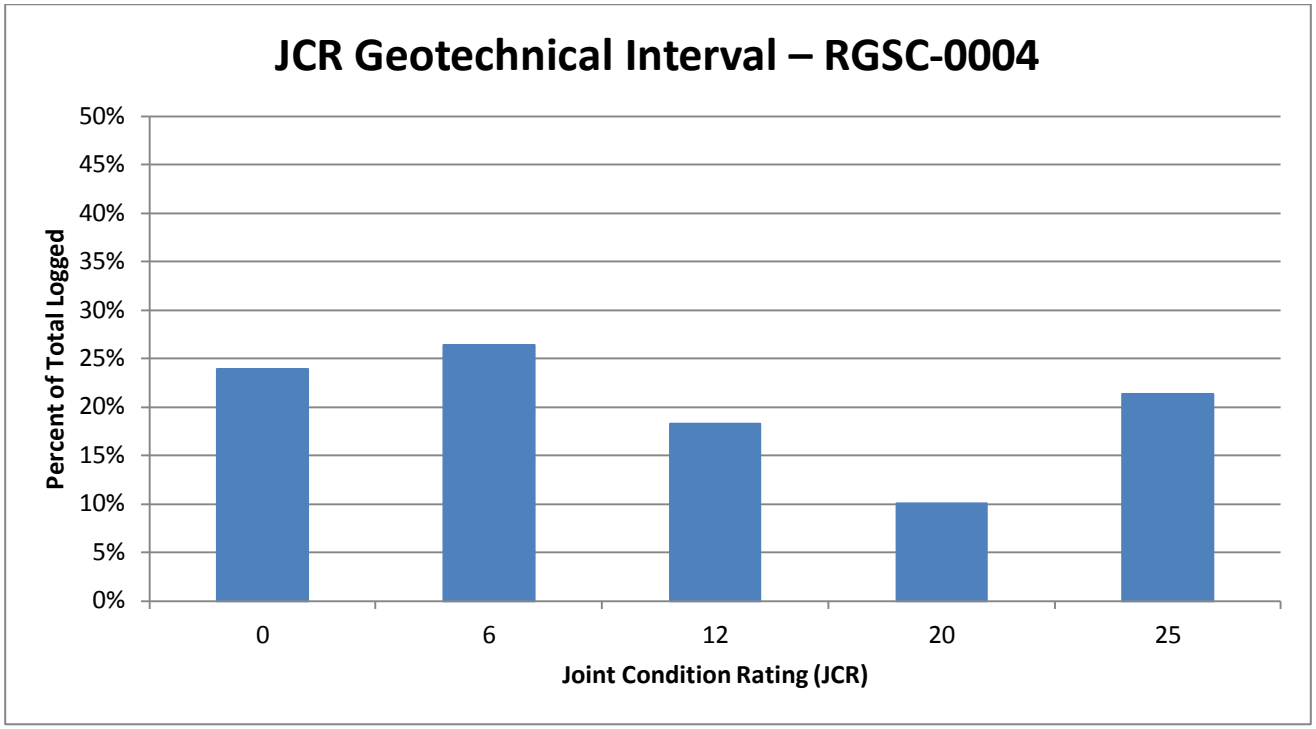


Plate D-1: JCR Interval Distribution – RGSC-0004

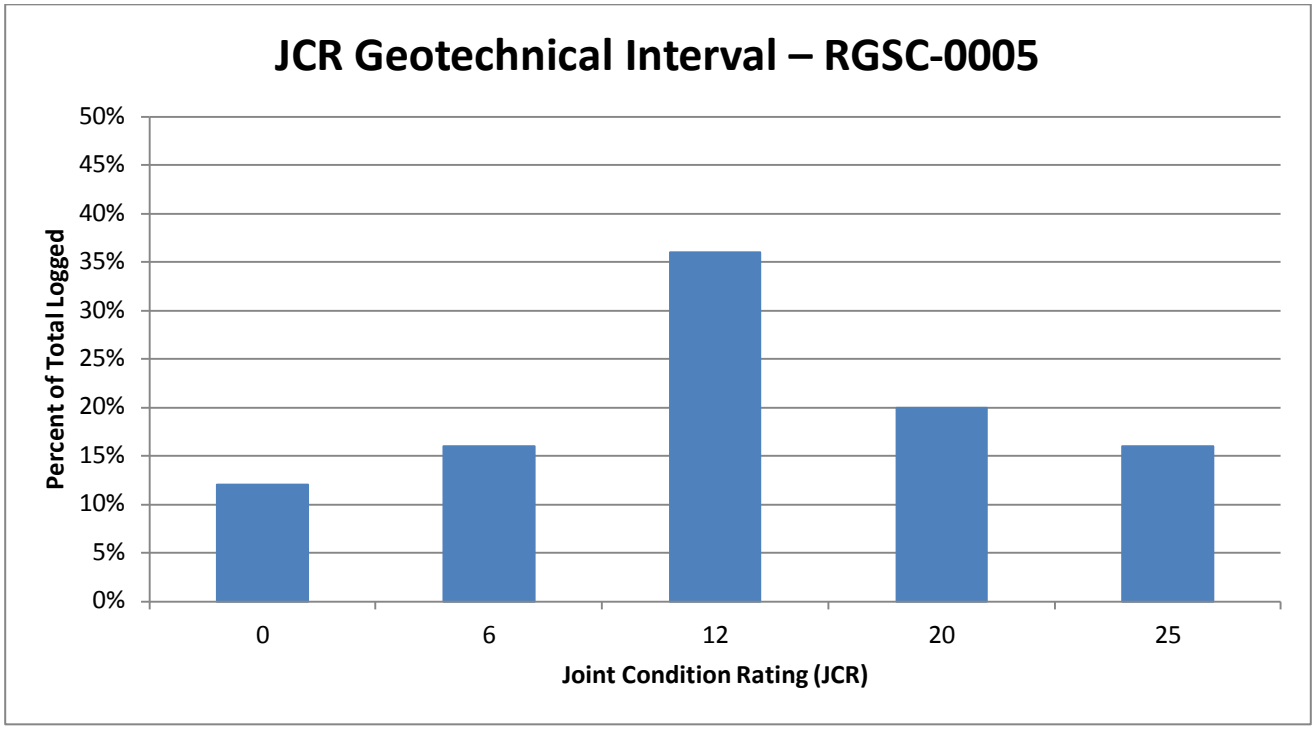


Plate D-2: JCR Interval Distribution – RGSC-0005

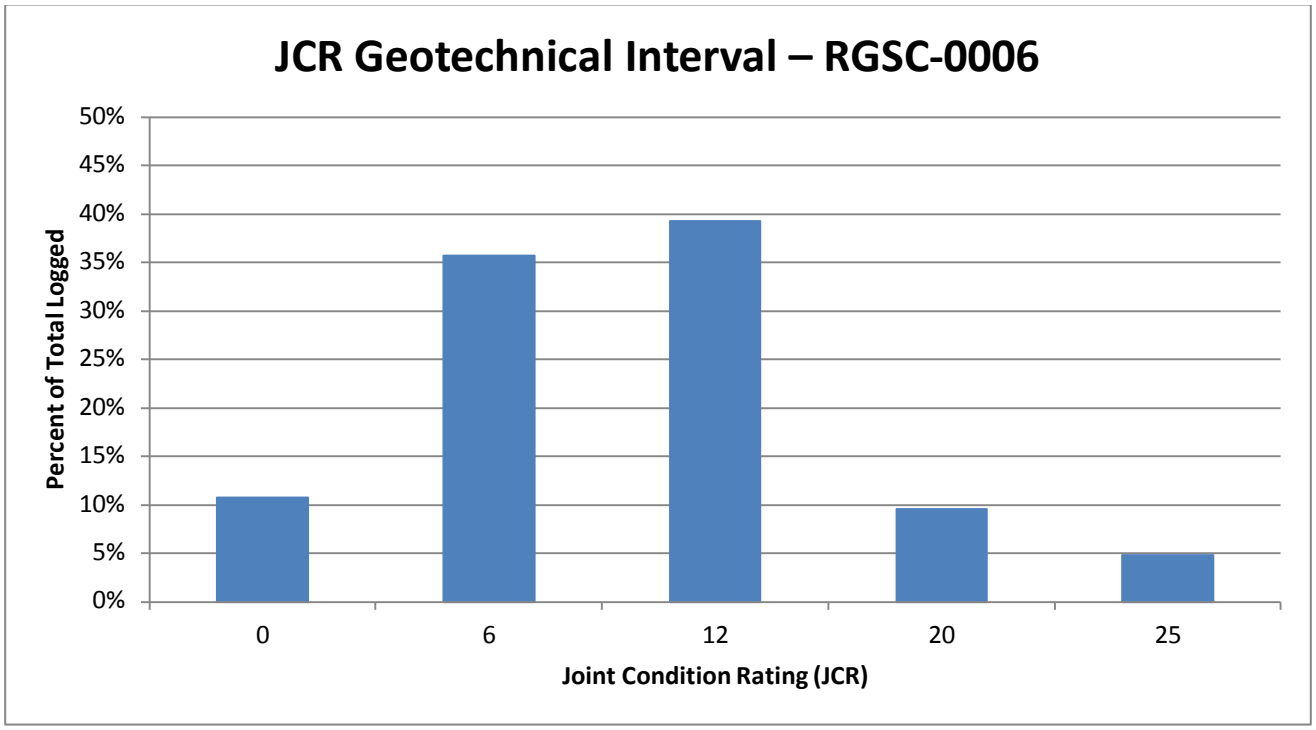


Plate D-3: JCR Interval Distribution – RGSC-0006

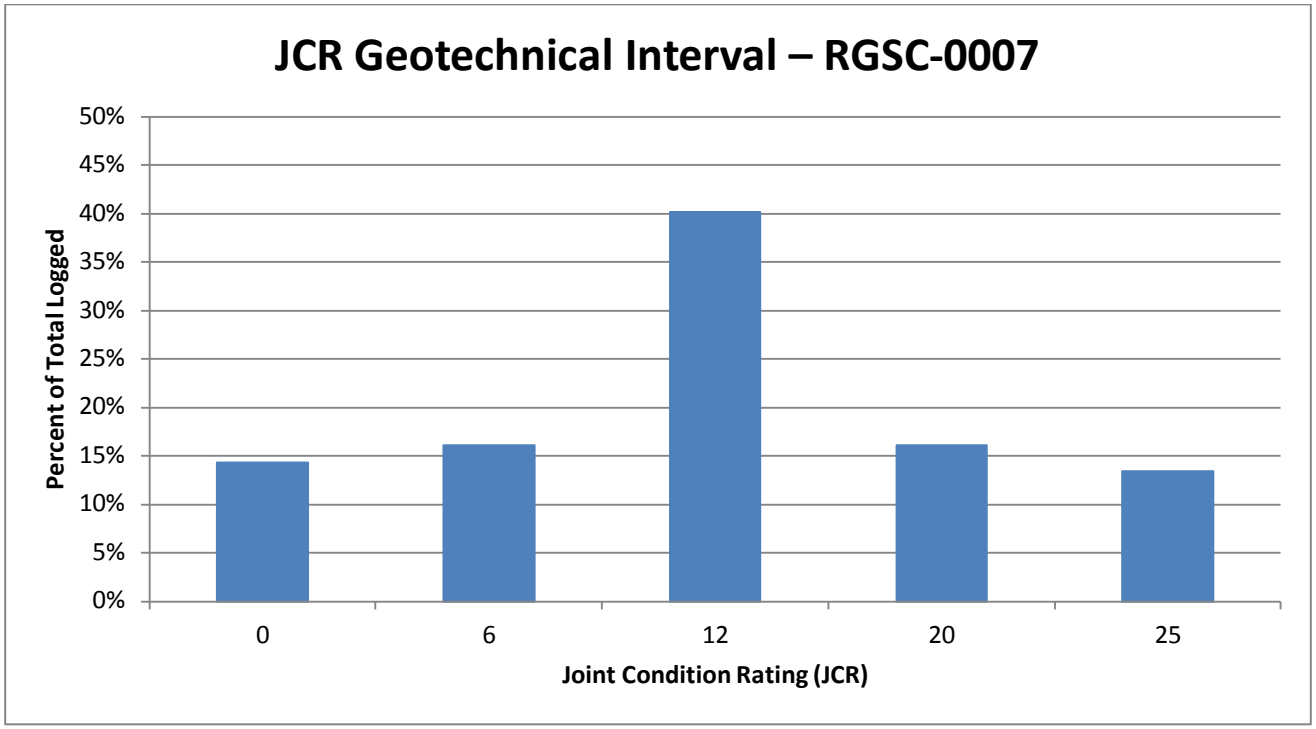


Plate D-4: JCR Interval Distribution – RGSC-0007

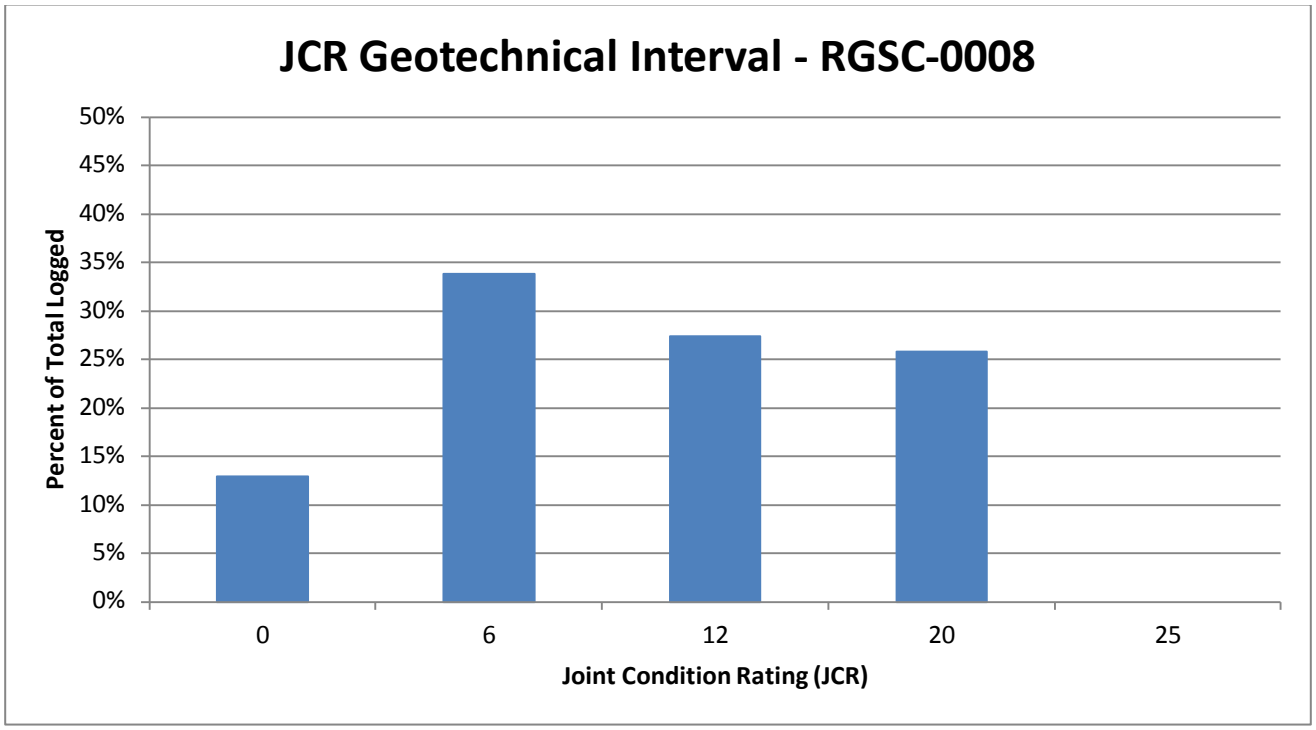


Plate D-5: JCR Interval Distribution –RGSC-0008

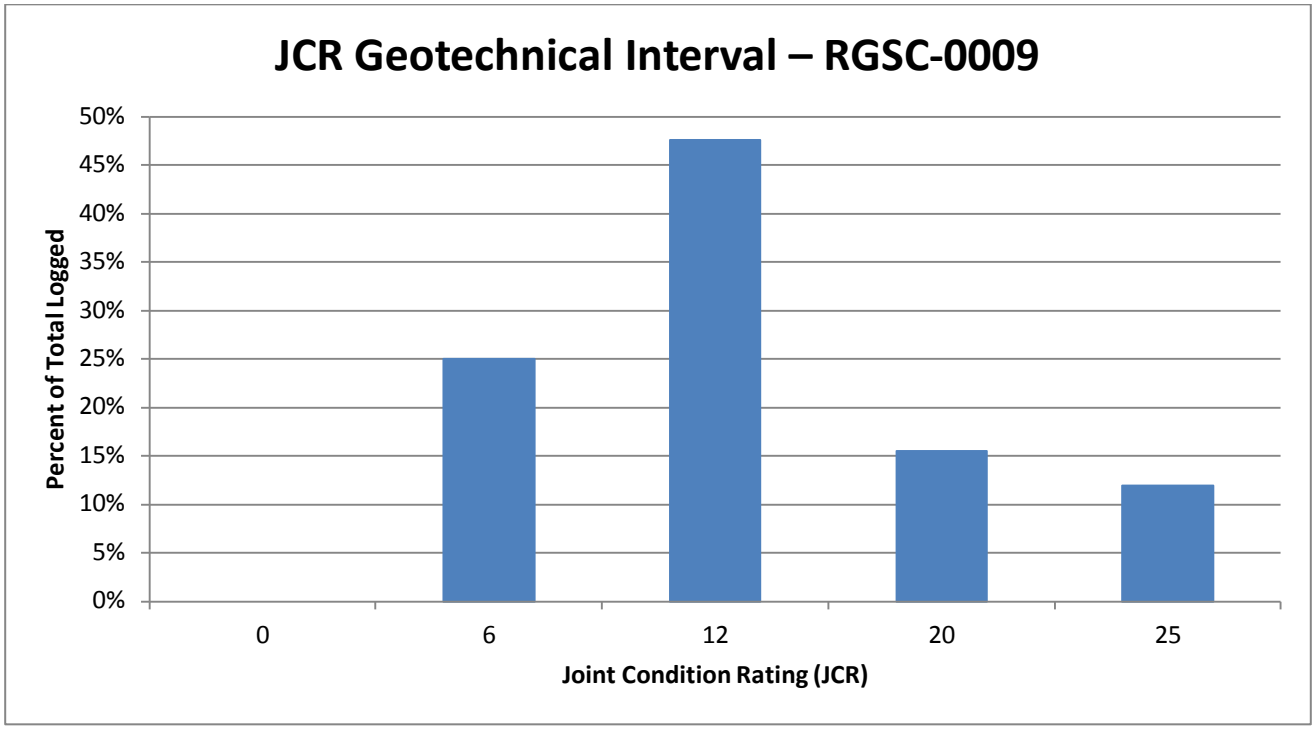


Plate D-6: JCR Interval Distribution – RGSC-0009

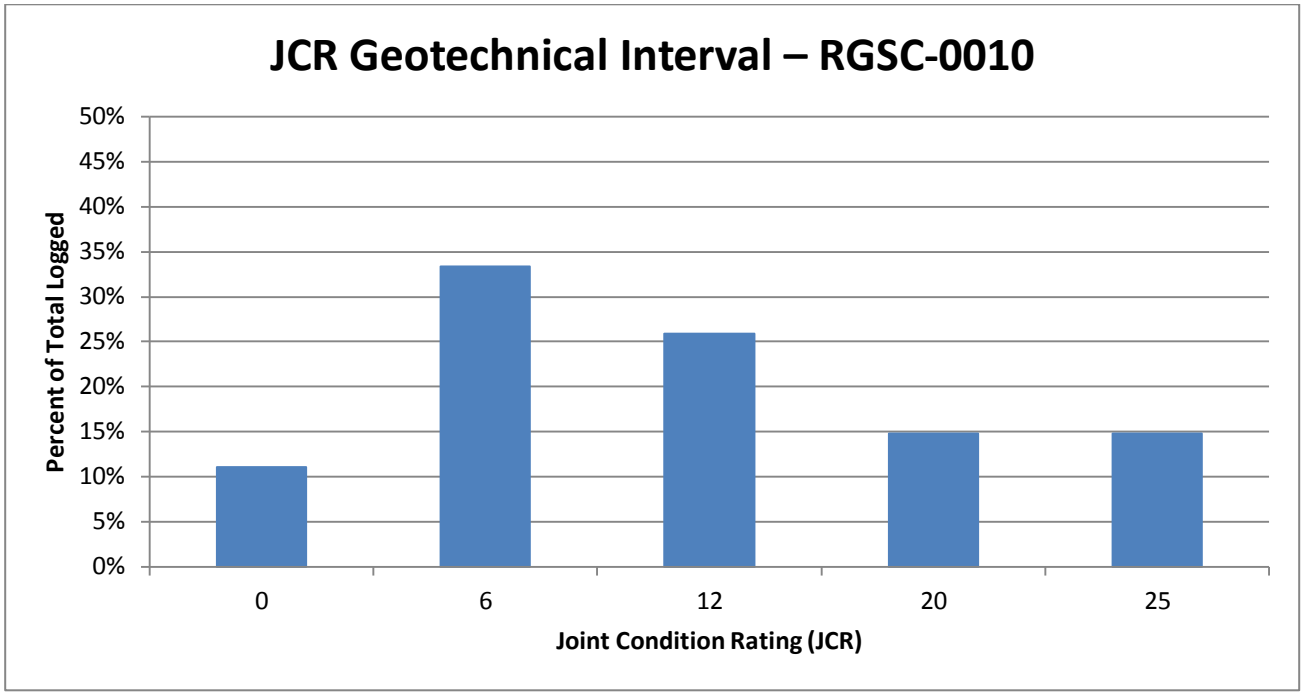


Plate D-7: JCR Interval Distribution – RGSC-0010

The logged JCR values for the geotechnical intervals by lithology are summarized in Plate D-8.

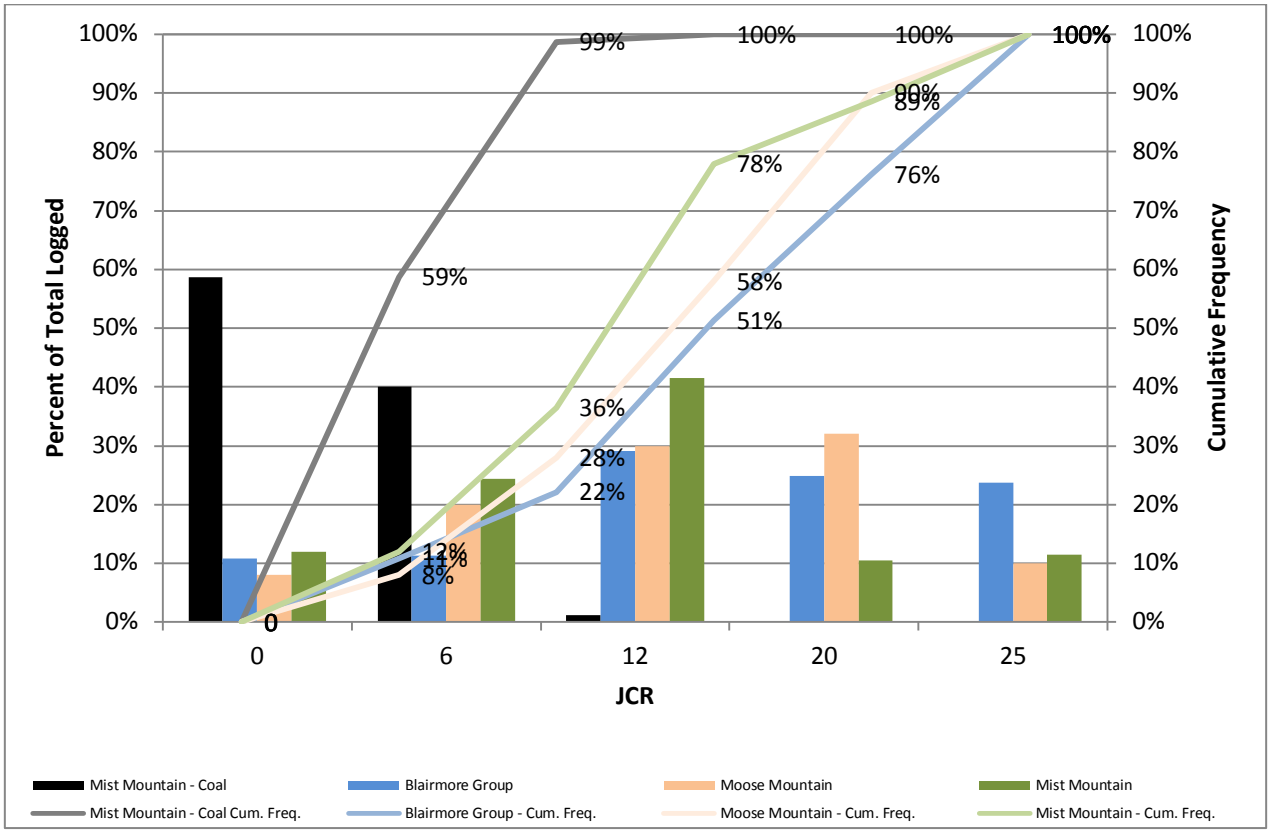


Plate D-8: Distribution of Geotechnical Interval Joint Condition Rating (JCR) Values for 2014 Geotechnical Drilling Program

The following observations have been made with respect to the interval JCR data:

- The logged interval JCR values are generally higher in the Blairmore Group and Moose Mountain rocks.
- The coal of the Mist Mountain was generally assigned an interval JCR value of 0 or 6. Fifty-nine percent of the coal was assigned an interval JCR value of 0 and forty percent assigned 6.
- The average interval JCR logged in the remainder of the Mist Mountain formation rocks is 12, Moose Mountain is 12, and the Blairmore Group is 20.
- Interval JCR values of 12 and 20 were logged for approximately fifty-three percent of the Mist Mountain formation rocks. Thirty-six percent was logged with an interval JCR of 0 or 6 and eleven percent was logged with an interval JCR of 25.
- An Interval JCR value of 12 was logged for approximately thirty percent of the Moose Mountain. Thirty-two percent logged as 20; twenty percent logged as 6, ten percent was logged as 25 and eight percent as a 0.
- An Interval JCR value of 20 was logged for approximately twenty-five percent of the Blairmore Group. Twenty-four percent logged as 25; twenty-nine percent logged as 12, eleven percent was logged as 6 and eleven percent as a 0.

1.0 INTRODUCTION

As part of the 2014 geotechnical investigation, orientation data from discontinuities were collected on site by Century Wireline Services (Century). Century used Acoustic Televiewer (ATV) logging techniques to collect structural geologic data within each borehole.

The raw televiewer images were processed by Riversdale and reoriented to true north. Riversdale used a rotation of plus 14° 45' to correct the data for local magnetic declination. Pertinent geological features (i.e., bedding, joints, and faults) were picked from the ATV logs, and the processed structural orientation data were provided to Golder. In addition, Riversdale provided Golder with Formation Dip surveys which provide a record of bedding dip and dip direction with depth in each borehole. This data has been used for confirmatory purposes to provide more confidence in the bedding orientation data.

Lower hemisphere, equal area stereographic projections of the geological orientation data have been produced using the Rocscience software Dips (Version 6.0), (Figures D-1 to D-12). The orientation data shown on the stereographic projections is referenced to true north. The observed structures are discussed in the following sections.

1.1 Cross Joints and Bedding Structures

The bedding fractures in the sedimentary strata in the Rocky Mountains have been observed to be continuous over hundreds of metres. Bedding spacing varies by rock type, with mudstones exhibiting a spacing between one and 10 centimetres, and the more massive sandstones exhibiting a fracture spacing between one and three metres. The bedding typically strikes north-northwest-south-southeast.

Sedimentary strata also typically contain two prominent cross-joint sets. One set typically strikes parallel or near-parallel to bedding and dips orthogonal to the bedding. The second set typically strikes perpendicular to the strike of the bedding and to the first joint set. These cross-joint sets and bedding define an orthogonal fracture pattern, in that both joint sets are mutually perpendicular and are oriented perpendicular to the bedding.

For the sake of clarity, Golder commonly refers to these joints as the JS1 and JS2 joint sets, where the JS1 joint set strikes parallel to the strike of the bedding and the JS2 set strikes perpendicular to the strike of the bedding. The JS1/JS2 joint set nomenclature is used in the following summary of the structural data.

1.2 Structural Data Interpretation

1.2.1 RGSC-0004

Data collected from the ATV surveys indicate that the bedding dips at a moderate to steep angle (45 to 70 degrees) towards the southwest to west (230° to 270° azimuth). The stereographic projection also shows a cluster of steeply-west dipping joints surfaces which may be indicative of steeper bedding surfaces or JS1 joints (Figure D-1). The Formation Dip data indicates that bedding dips between 30 to 70 degrees towards southwest-west (240° to 300° azimuth). The bedding orientation data collected from the ATV and the Formation Dip surveys conforms to the Riversdale coal geology model.

JS1 and JS2 joint sets are evident in the stereographic projection (Figure D-1). JS1 is orientated near parallel to bedding strike, dipping at approximately 50 to 70 degrees towards the east (050° to 120° azimuth). JS2 dips toward the south, orientated near-perpendicular to the bedding strike. JS2 dips at approximately 50 to 70 degrees towards the south (160° to 190° azimuth).

The Riversdale fault interpretation, shown in the geological sections, indicates that major faults dip at about 60 to 90 degrees towards the west (250° and 290° azimuth). The faults exhibit the same dip direction as the major bedding set. Three discrete faults that were geotechnically logged in the field were picked up by the interpretation data. However, the faults do not appear to disturb the bedding orientation.

1.2.2 RGSC-0005

Processing of geological features in borehole RGSC-0005 was unable to be carried out due to a poor ATV logging image.

1.2.3 RGSC-0006

Data collected from the ATV surveys indicate that bedding generally dips at a shallow to moderate angles (30 to 60° degrees) towards the southwest and west (240° to 290° azimuth). The geotechnical logging and ATV survey suggests some increase in dip angle with depth (Figure D-17). The Formation Dip data suggests that bedding dips between 40 to 70 degrees towards the west (250° to 280° azimuth). Bedding orientation data collected from the ATV and Formation Dip surveys conforms to the Riversdale coal geology model.

A fault which was geotechnically logged in the rock core and was selected in the interpreted structural data. The fault dips at approximately 75 degrees towards the southeast (130° azimuth). Bedding below the fault appears to steeper. This may be reflective of some displacement or drag folding associated with the fault. There does appear to be a correlation between the dip of bedding below the fault. The bedding dip does get slightly steeper with depth.

Joint Set JS1 and JS2 are evident in the stereographic projection (Figure D-3). Steeply dipping joints were encountered in the borehole. However, these were observed in the sandstone and conglomerate units only, from about 10 to 70 meters. The JS1 set is orientated near parallel to bedding strike, and dips at approximately 50 to 85 degrees towards the northeast (040° to 080° azimuth). JS2 dips steeply between 70 to 85 degrees towards the northwest (300° to 350° azimuth) and southeast (130° to 170° azimuth).

1.2.4 RGSC-0007

Data collected from the ATV and Formation Dip surveys indicate that bedding is shallow dipping between 5 and 40 degrees towards the southwest and west (200° to 270° azimuth). Bedding data was collected from a borehole depth of about 70 meters to borehole termination depth (176.7 metres). Bedding orientations appear to be consistent along the length of the borehole (Figure D-19).

Joint Set JS1 and JS2 are evident in the stereographic projection (Figure D-5), however, geological picking of the joints is low in frequency. JS1 orientated near parallel to bedding strike, dipping between 60 to 80 degrees towards the east (060 to 100 degrees). JS2 is steeply dipping (70 to 90 degrees) towards the south (170 to 190 degrees) and the north (330 to 020 degrees).

1.2.5 RGSC-0008

Data collected from the ATV indicate that bedding dips at between 50 to 80 degrees towards the west (260° to 290° azimuth). The bedding dip appears to steepen slightly with depth (Figure D-21 and D-22). The Formation Dip data suggests that bedding is moderately dipping between 40 and 60 degrees towards the west (260° to 290°). Bedding orientation data collected from the ATV and Formation Dip surveys conforms to the Riversdale coal geology model.

Joint Set JS1 and JS2 are evident in the stereographic projection (Figure D-9). JS1 strikes near parallel to bedding strike and is moderately to steeply dipping between 50 to 80 degrees towards the east (070° to 100° azimuth). JS2 strikes near-perpendicular to the bedding set and dips from 50 to 80 towards the southwest (190° to 210° azimuth) and the northeast (010° to 040° azimuth). The dip angle of JS1 and JS2 appears to steepen with depth. However, this does not appear to be related to any faulting observed in the geotechnical logging or Riversdale geological model, and may be simply be related to folding.

1.2.6 RGSC-0009

Data collected from the ATV indicate that bedding is shallowly dipping (20 to 35 degrees) towards the west (260° to 280° azimuth). The Formation Dip data shows a shallow dipping bedding set (20 to 30 degrees) towards the west and southwest (210° to 260° azimuth). Dip and dip direction are consistent along the length of the borehole (Figure D-23). Bedding orientation data collected from the ATV and Formation Dip surveys conforms to the Riversdale coal geology model.

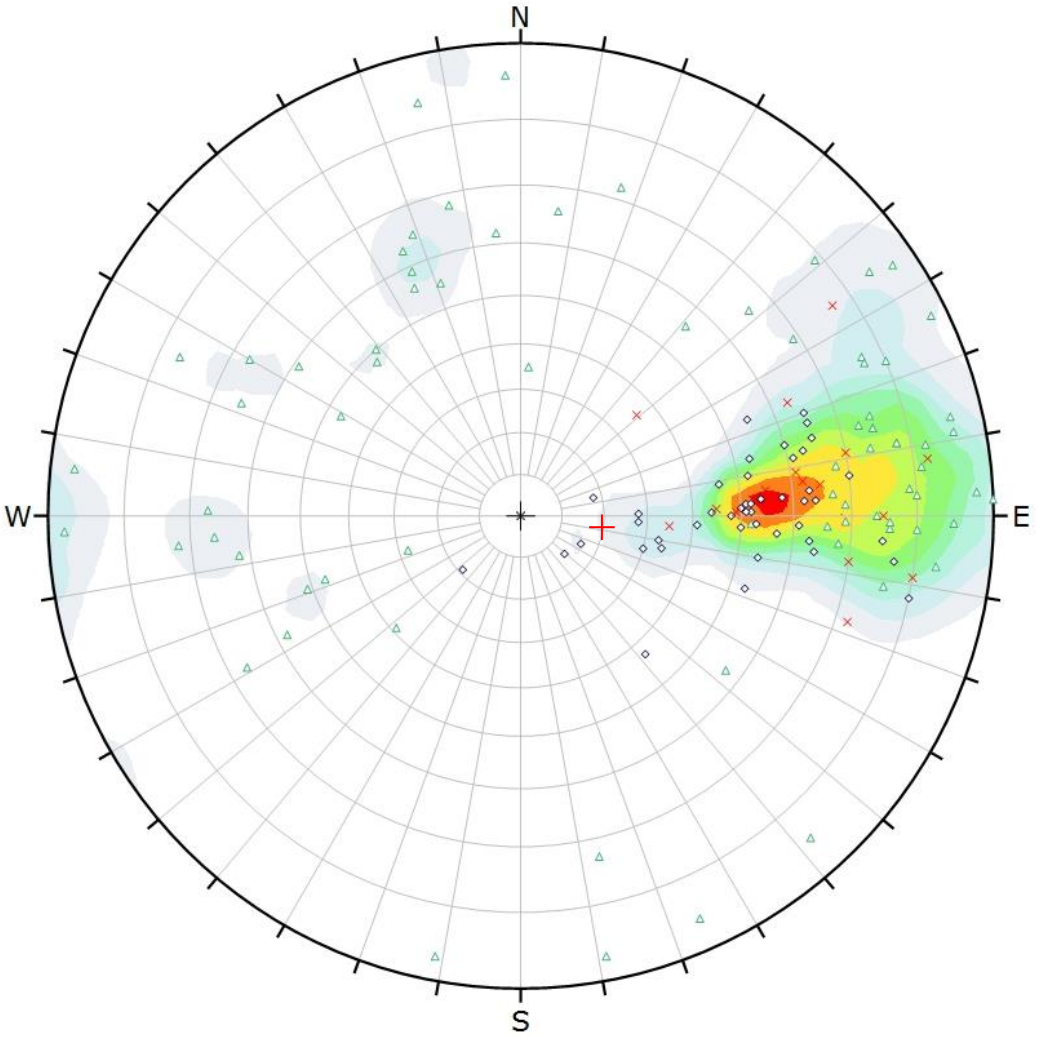
Joint Set JS1 and JS2 are evident in RGSC-0009 (Figure D-9). JS1 dips moderately between 40 to 70 degrees towards the east-southeast (080° to 130° azimuth). The dip angle for JS1 exhibits high variability from about 100 to 130 meters borehole depth (30 to 70 degree dip angles), but becomes more consistent below about 130 meters (40 to 60 degree dip angles). The JS2 set strikes near-perpendicular to the bedding, and is steeply dipping (80 to 90 degrees) towards the south and north.

1.2.7 RGSC-0010

Data collected from the ATV and Formation Dip surveys indicate that bedding dips between 20 to 50 degrees towards the northwest (280° to 340° azimuth), as shown in Figure D-11 and D-12. Bedding orientation data collected from the ATV and Formation Dip surveys conforms to the Riversdale coal geology model. Bedding appears to steepen in localised zones (i.e., 140 to 150 meters depth) which may be related to faulting observed in the geotechnical logging, and shown in the geological sections.

Joint Set JS1 and JS2 are evident in RGSC-0009 (Figure D-11). JS1 dips between 60 to 80 degrees towards the east (050° to 110° azimuth). JS2, striking orthogonal to the bedding strike, dips between 60 to 80 degrees towards the south-southwest (170° to 200° azimuth).

A fault which was geotechnically logged in the rock core (169 metres borehole length) and was picked in the ATV interpretation. The fault dips at approximately 63 degrees towards the southeast (175° azimuth).



Symbol	FEATURES	Quantity
◇	bedding	46
×	fault	16
△	joint	76

Color	Density Concentrations
	0.00 - 1.40
	1.40 - 2.80
	2.80 - 4.20
	4.20 - 5.60
	5.60 - 7.00
	7.00 - 8.40
	8.40 - 9.80
	9.80 - 11.20
	11.20 - 12.60
	12.60 - 14.00

Maximum Density	13.34%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	138 (138 Entries)
Hemisphere	Lower
Projection	Equal Angle

RGSC-0004 BOREHOLE TREND & PLUNGE
70° INCLINATION TOWARDS 100° AZIMUTH

NOTE:
- STEREOGRAPHIC PROJECTIONS TO TRUE NORTH
- STEREOGRAPHIC PLOTS PREPARED USING ROCSCIENCE DIPS VERSION 6.0

CLIENT
RIVERSDALE RESOURCES LIMITED

PROJECT
GRASSY MOUNTAIN PRELIMINARY PIT SLOPE ASSESSMENT

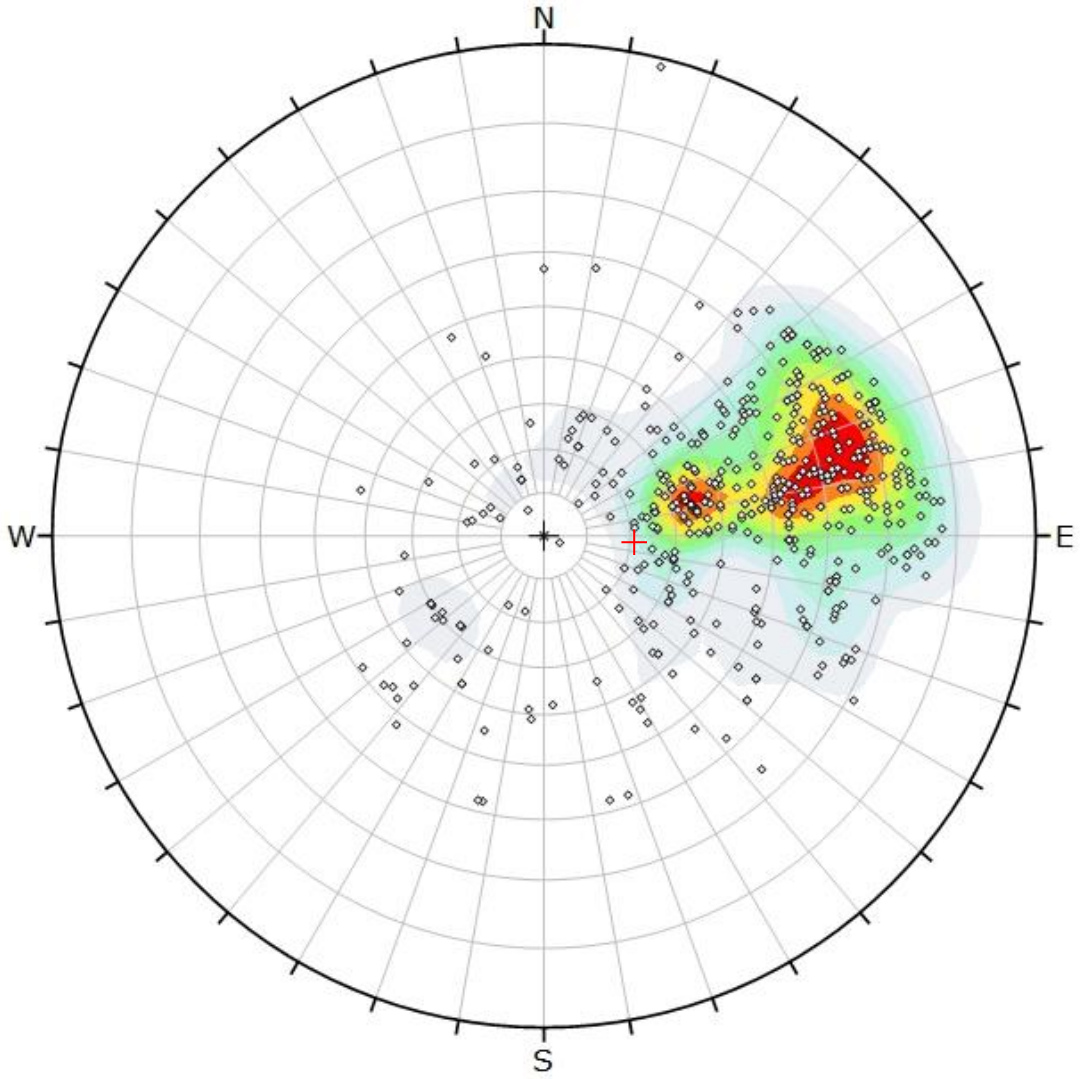
CONSULTANT
Golder Associates

YYYY-MM-DD	2014-10-14
PREPARED	AGH
DESIGN	AGH
REVIEW	EAS
APPROVED	AVC

TITLE
STEREOGRAPHIC PROJECTION – RGSC-0004
SYMBOLIC POLE PLOT

PROJECT No. **2850-MN-0001-0** | Rev. **0** | FIGURE **D-1**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
0



Symbol	Feature
◇	Pole Vectors

Color	Density Concentrations
	0.00 - 1.20
	1.20 - 2.40
	2.40 - 3.60
	3.60 - 4.80
	4.80 - 6.00
	6.00 - 7.20
	7.20 - 8.40
	8.40 - 9.60
	9.60 - 10.80
	10.80 - 12.00

Maximum Density	11.91%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	494 (494 Entries)
Hemisphere	Lower
Projection	Equal Angle

RGSC-0004 BOREHOLE TREND & PLUNGE
70º INCLINATION TOWARDS 100º AZIMUTH

NOTE:
- STEREOGRAPHIC PROJECTIONS TO TRUE NORTH
- STEREOGRAPHIC PLOTS PREPARED USING ROCSCIENCE DIPS VERSION 6.0

CLIENT
RIVERSDALE RESOURCES LIMITED

PROJECT
GRASSY MOUNTAIN PRELIMINARY PIT SLOPE ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2014-10-14
PREPARED	AGH
DESIGN	AGH
REVIEW	EAS
APPROVED	AVC

TITLE
STEREOGRAPHIC PROJECTION – RGSC-0004
POLE PLOT OF FORMATION DATA

PROJECT No.	Rev.	FIGURE
2850-MN-0001-0	**0**	**D-2**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
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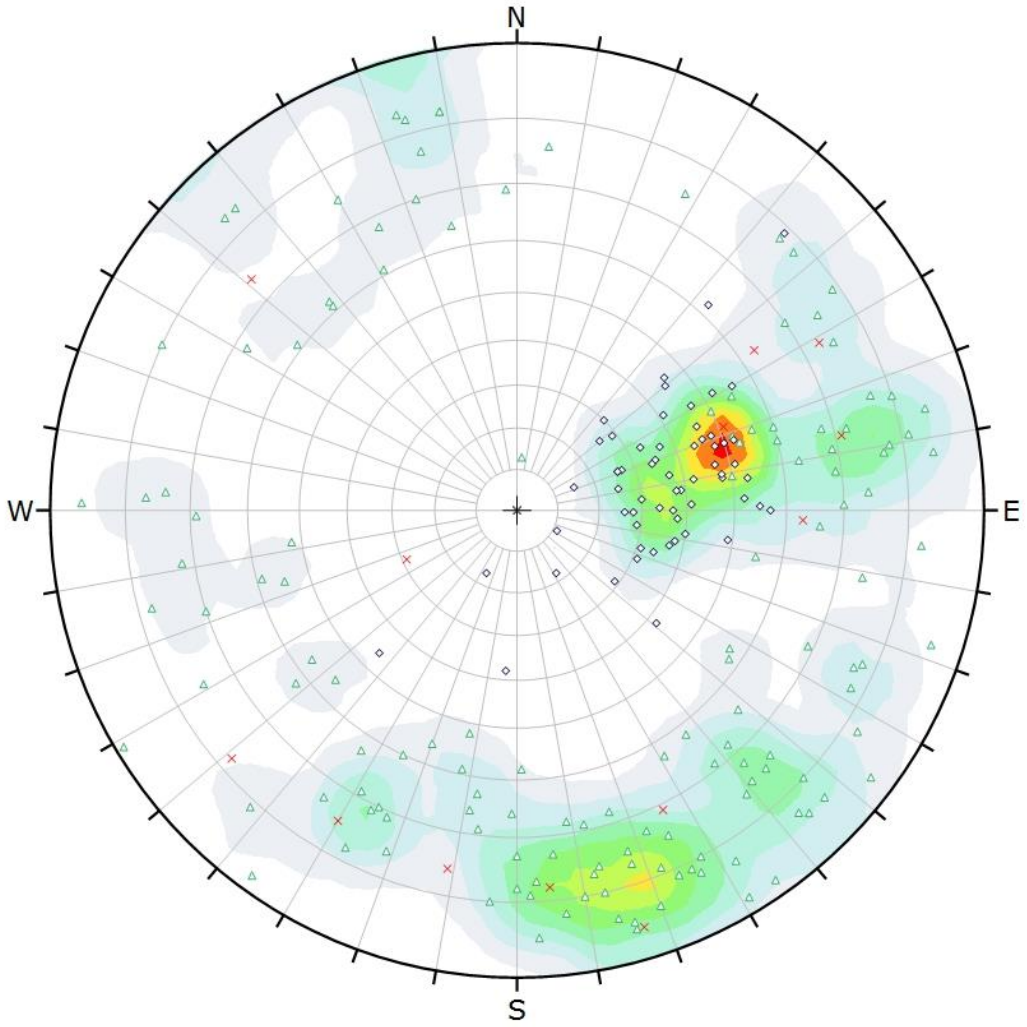

Symbol	FEATURES	Quantity
◇	bedding	61
×	fault	13
△	joint	141

Color	Density Concentrations
	0.00 - 0.80
	0.80 - 1.60
	1.60 - 2.40
	2.40 - 3.20
	3.20 - 4.00
	4.00 - 4.80
	4.80 - 5.60
	5.60 - 6.40
	6.40 - 7.20
	7.20 - 8.00

Maximum Density	7.47%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	215 (215 Entries)
Hemisphere	Lower
Projection	Equal Angle

RGSC-0006 DRILLED AT A VERTICAL INCLINATION (-90 DEGREES)

NOTE:
- STEREOGRAPHIC PROJECTIONS TO TRUE NORTH
- STEREOGRAPHIC PLOTS PREPARED USING ROCSCIENCE DIPS VERSION 6.0

CLIENT
RIVERSDALE RESOURCES LIMITED

PROJECT
GRASSY MOUNTAIN PRELIMINARY PIT SLOPE ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2014-10-14
PREPARED	AGH
DESIGN	AGH
REVIEW	EAS
APPROVED	AVC

TITLE
STEREOGRAPHIC PROJECTION – RGSC-0006
SYMBOLIC POLE PLOT

PROJECT No. **2850-MN-0001-0** | Rev. **0** | FIGURE **D-3**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
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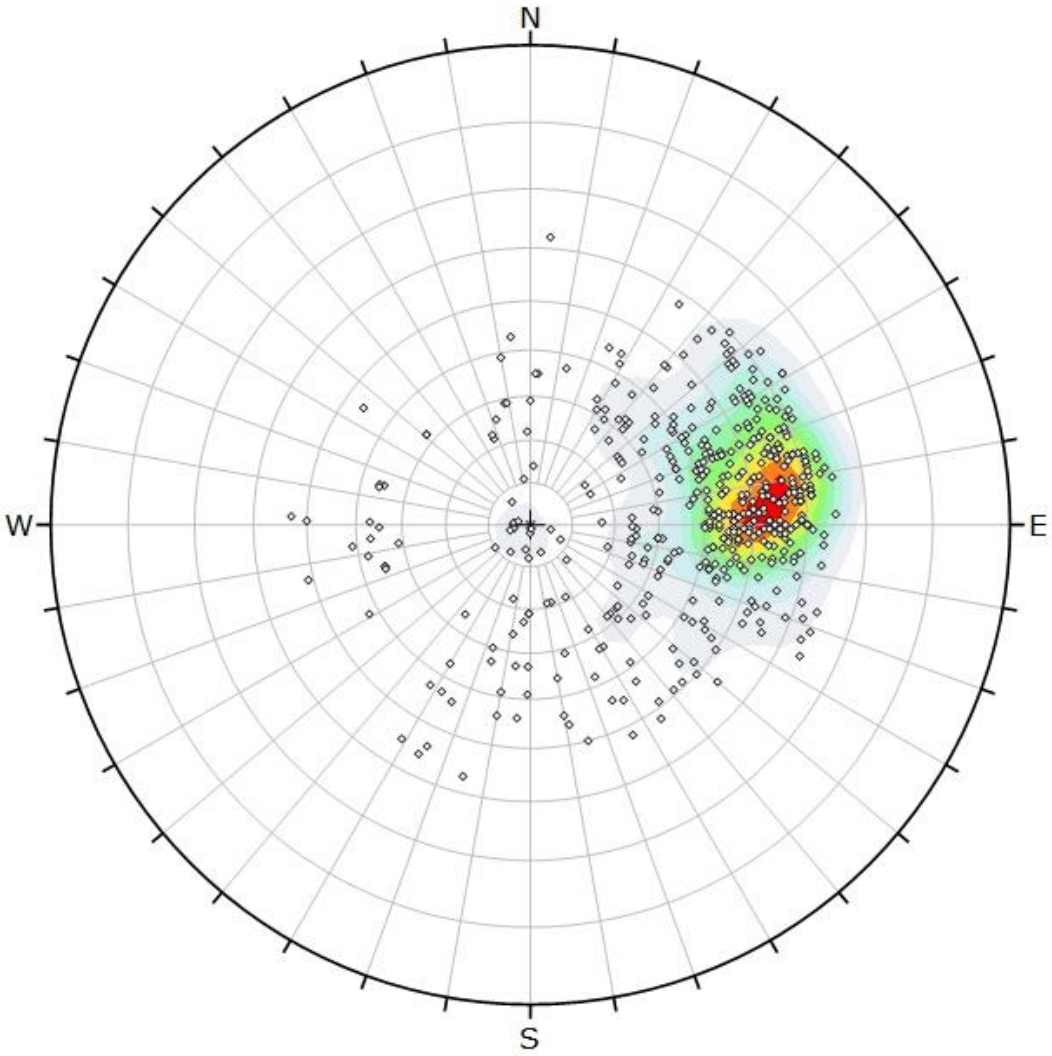

Symbol	Feature
◇	Pole Vectors

Color	Density Concentrations
	0.00 - 1.80
	1.80 - 3.60
	3.60 - 5.40
	5.40 - 7.20
	7.20 - 9.00
	9.00 - 10.80
	10.80 - 12.60
	12.60 - 14.40
	14.40 - 16.20
	16.20 - 18.00

Maximum Density	17.15%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	480 (480 Entries)
Hemisphere	Lower
Projection	Equal Angle

RGSC-0006 DRILLED AT A VERTICAL INCLINATION (-90 DEGREES)

NOTE:
- STEREOGRAPHIC PROJECTIONS TO TRUE NORTH
- STEREOGRAPHIC PLOTS PREPARED USING ROCSCIENCE DIPS VERSION 6.0

CLIENT
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PROJECT
GRASSY MOUNTAIN PRELIMINARY PIT SLOPE ASSESSMENT

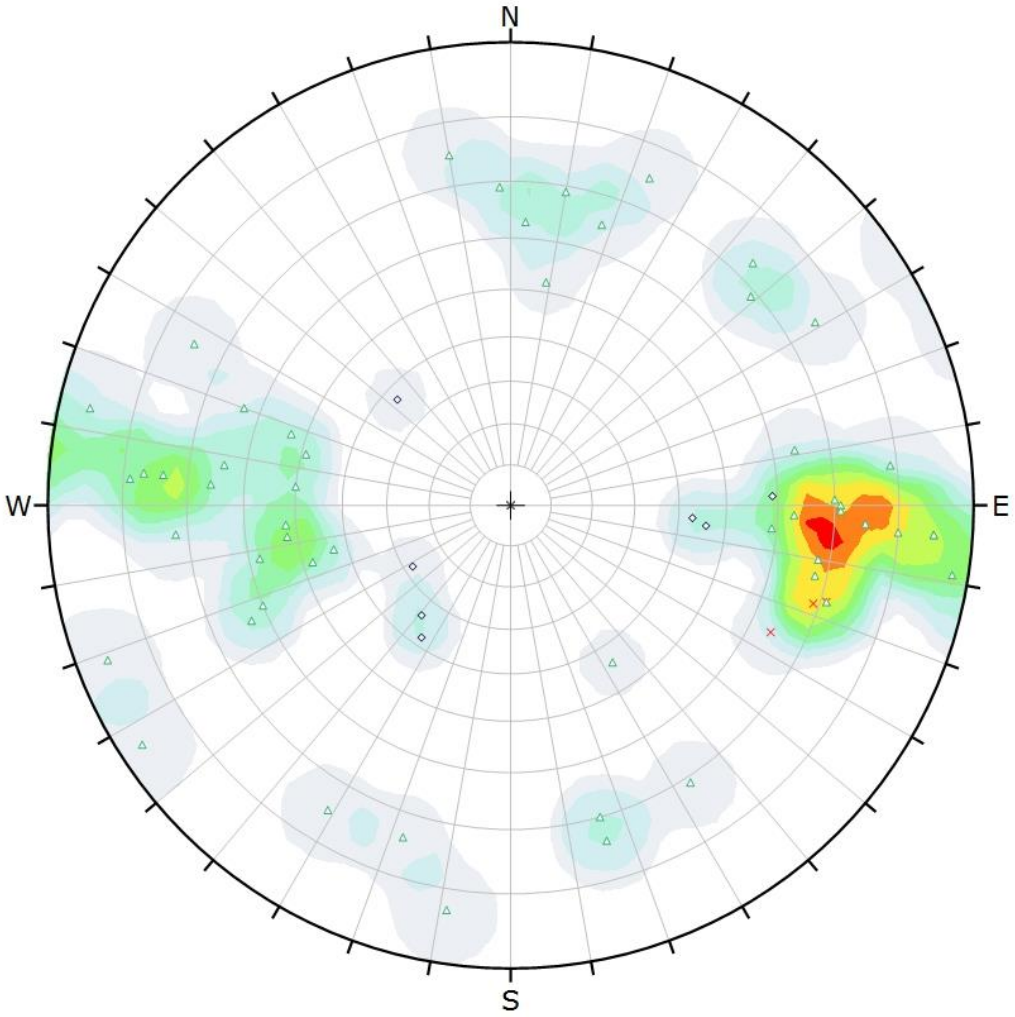
CONSULTANT
Golder Associates

YYYY-MM-DD	2014-10-14
PREPARED	AGH
DESIGN	AGH
REVIEW	EAS
APPROVED	AVC

TITLE
STEREOGRAPHIC PROJECTION – RGSC-0006
POLE PLOT OF FORMATION DATA

PROJECT No.	Rev.	FIGURE
2850-MN-0001-0	**0**	**D-4**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
0



Symbol	FEATURES	Quantity
◇	bedding	7
×	fault	3
△	joint	53

Color	Density Concentrations
	0.00 - 1.00
	1.00 - 2.00
	2.00 - 3.00
	3.00 - 4.00
	4.00 - 5.00
	5.00 - 6.00
	6.00 - 7.00
	7.00 - 8.00
	8.00 - 9.00
	9.00 - 10.00

Maximum Density	9.42%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	63 (63 Entries)
Hemisphere	Lower
Projection	Equal Angle

RGSC-0007 DRILLED AT A VERTICAL INCLINATION (-90 DEGREES)

NOTE:
- STEREOGRAPHIC PROJECTIONS TO TRUE NORTH
- STEREOGRAPHIC PLOTS PREPARED USING ROCSCIENCE DIPS VERSION 6.0

CLIENT
RIVERSDALE RESOURCES LIMITED

PROJECT
GRASSY MOUNTAIN PRELIMINARY PIT SLOPE ASSESSMENT

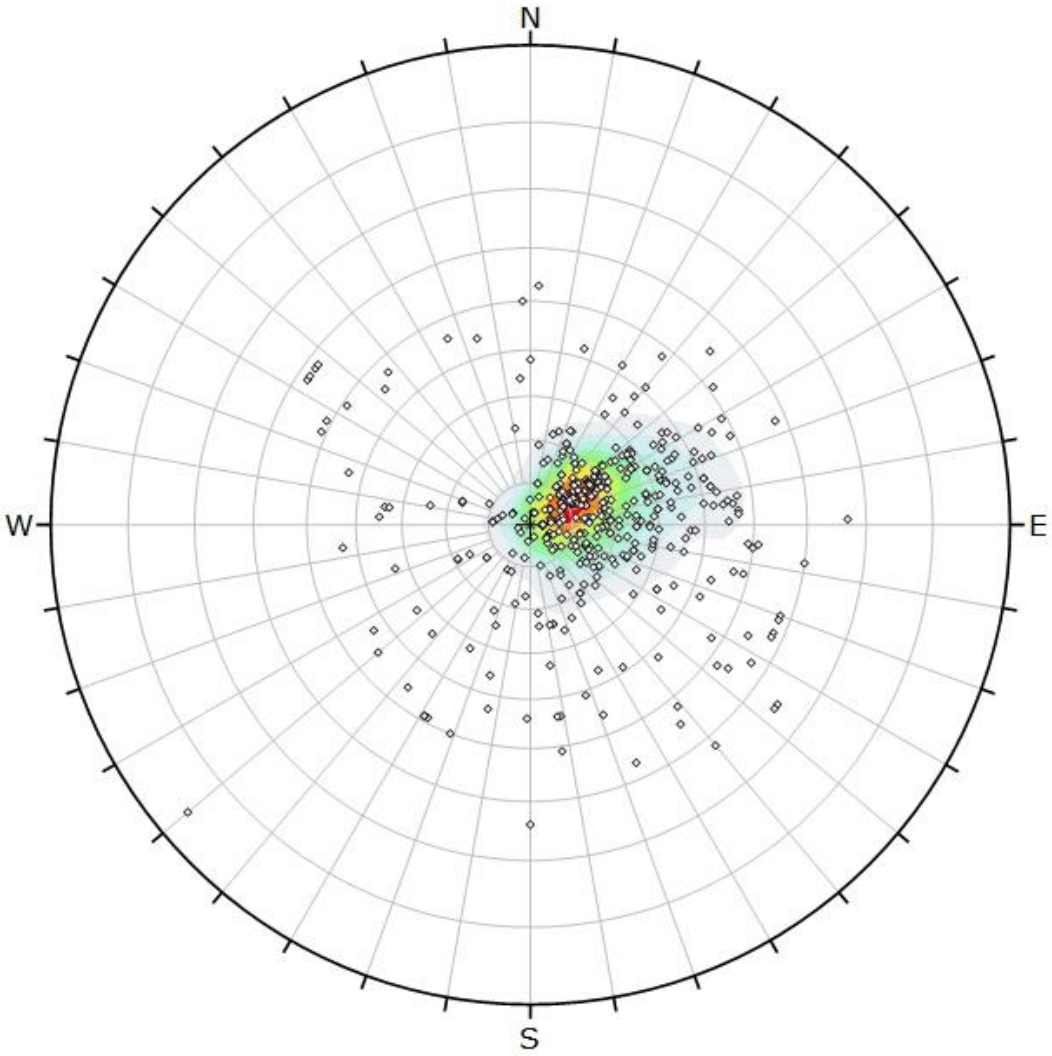
CONSULTANT
Golder Associates

YYYY-MM-DD	2014-10-14
PREPARED	AGH
DESIGN	AGH
REVIEW	EAS
APPROVED	AVC

TITLE
STEREOGRAPHIC PROJECTION – RGSC-0007
SYMBOLIC POLE PLOT

PROJECT No. **2850-MN-0001-0** | Rev. **0** | FIGURE **D-5**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0



Symbol	Feature
◇	Pole Vectors

Color	Density Concentrations
	0.00 - 2.50
	2.50 - 5.00
	5.00 - 7.50
	7.50 - 10.00
	10.00 - 12.50
	12.50 - 15.00
	15.00 - 17.50
	17.50 - 20.00
	20.00 - 22.50
	22.50 - 25.00

Maximum Density	24.96%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	476 (476 Entries)
Hemisphere	Lower
Projection	Equal Angle

RGSC-0007 DRILLED AT A VERTICAL INCLINATION (-90 DEGREES)

NOTE:
- STEREOGRAPHIC PROJECTIONS TO TRUE NORTH
- STEREOGRAPHIC PLOTS PREPARED USING ROCSCIENCE DIPS VERSION 6.0

CLIENT
RIVERSDALE RESOURCES LIMITED

PROJECT
GRASSY MOUNTAIN PRELIMINARY PIT SLOPE ASSESSMENT

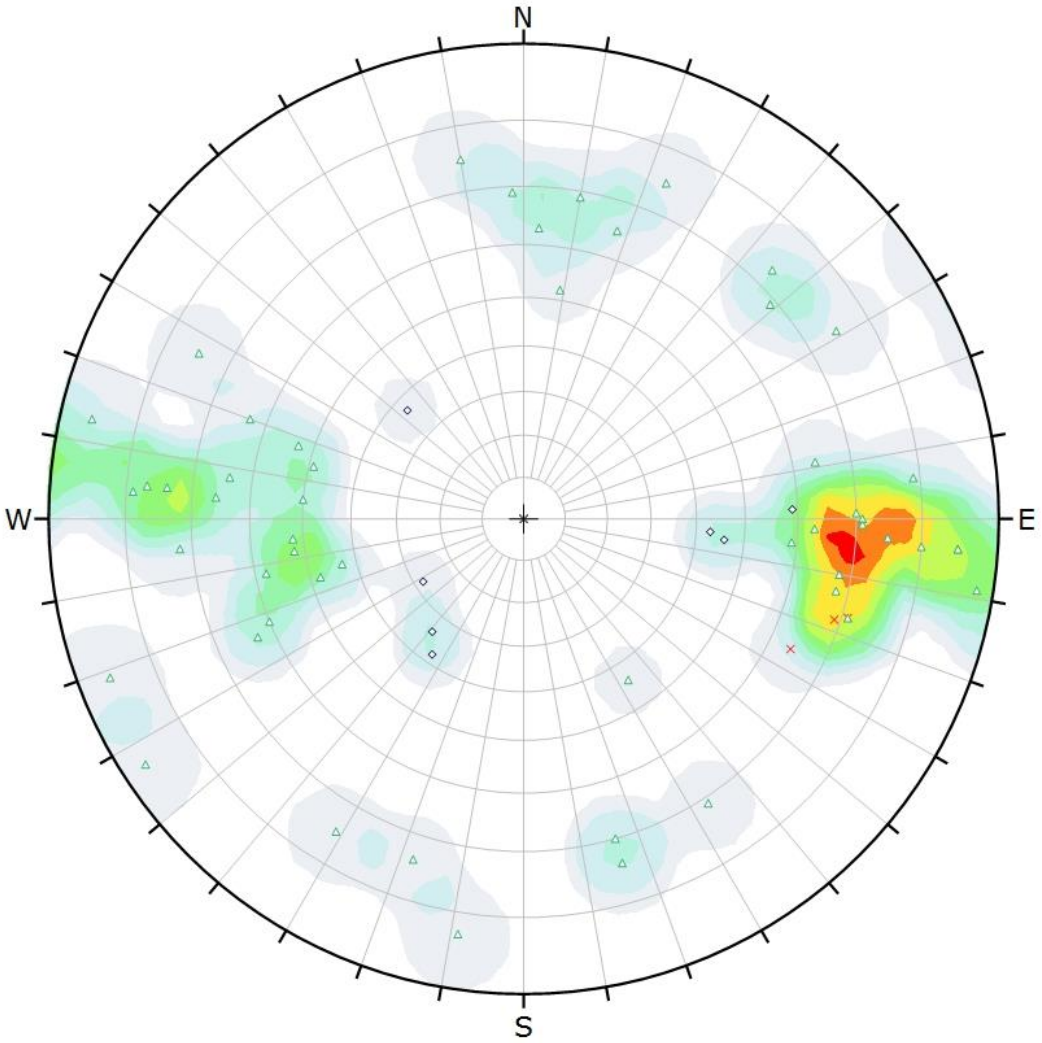
CONSULTANT
Golder Associates

YYYY-MM-DD	2014-10-14
PREPARED	AGH
DESIGN	AGH
REVIEW	EAS
APPROVED	AVC

TITLE
STEREOGRAPHIC PROJECTION – RGSC-0007
POLE PLOT OF FORMATION DATA

PROJECT No.	Rev.	FIGURE
2850-MN-0001-0	**0**	**D-6**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
0



Symbol	FEATURES	Quantity
◇	bedding	7
×	fault	3
△	joint	53

Color	Density Concentrations
	0.00 - 1.00
	1.00 - 2.00
	2.00 - 3.00
	3.00 - 4.00
	4.00 - 5.00
	5.00 - 6.00
	6.00 - 7.00
	7.00 - 8.00
	8.00 - 9.00
	9.00 - 10.00

Maximum Density	9.42%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	63 (63 Entries)
Hemisphere	Lower
Projection	Equal Angle

RGSC-0008 DRILLED AT A VERTICAL INCLINATION (-90 DEGREES)

NOTE:
- STEREOGRAPHIC PROJECTIONS TO TRUE NORTH
- STEREOGRAPHIC PLOTS PREPARED USING ROCSCIENCE DIPS VERSION 6.0

CLIENT
RIVERSDALE RESOURCES LIMITED

PROJECT
GRASSY MOUNTAIN PRELIMINARY PIT SLOPE ASSESSMENT

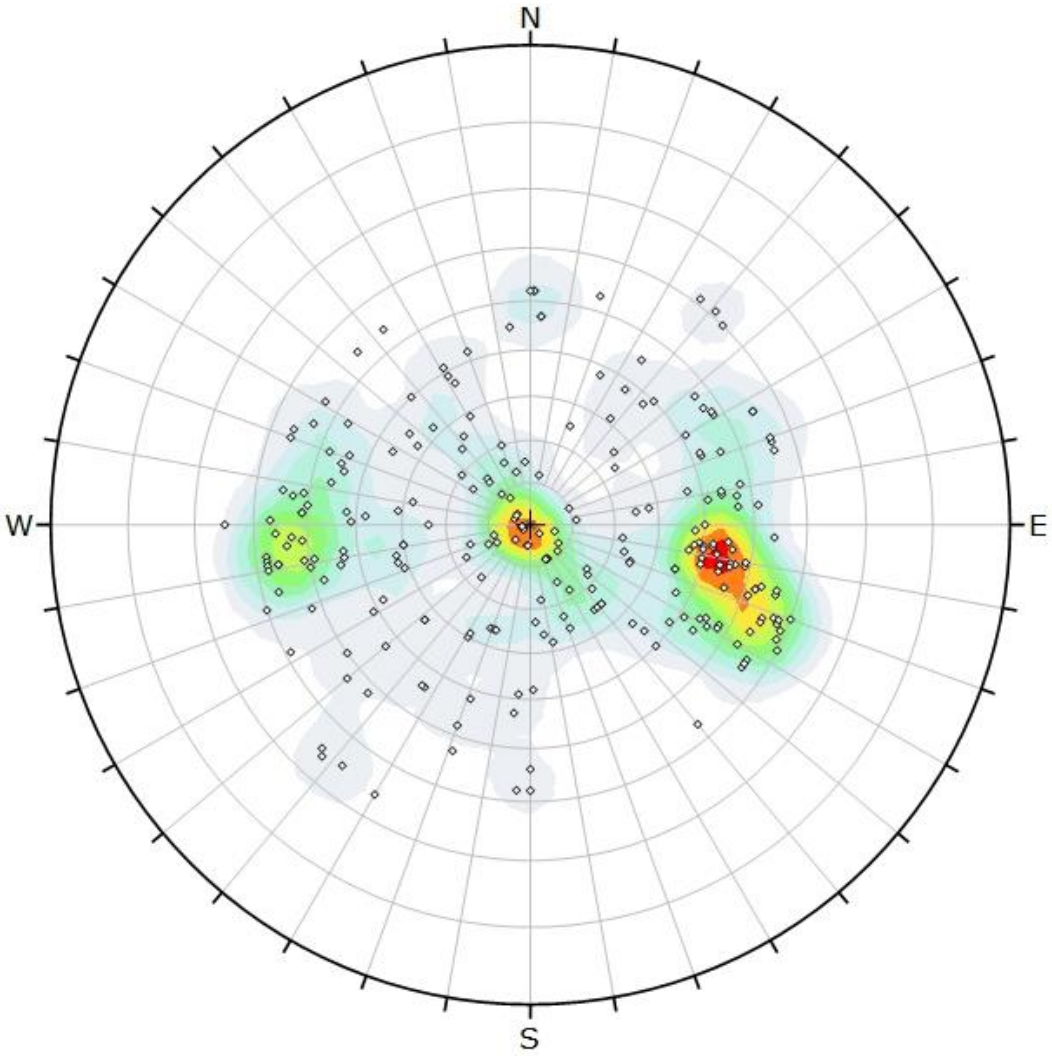
CONSULTANT
Golder Associates

YYYY-MM-DD	2014-10-14
PREPARED	AGH
DESIGN	AGH
REVIEW	EAS
APPROVED	AVC

TITLE
STEREOGRAPHIC PROJECTION – RGSC-0008
SYMBOLIC POLE PLOT

PROJECT No. **2850-MN-0001-0** | Rev. **0** | FIGURE **D-7**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0



Symbol	Feature
◇	Pole Vectors

Color	Density Concentrations
	0.00 - 0.90
	0.90 - 1.80
	1.80 - 2.70
	2.70 - 3.60
	3.60 - 4.50
	4.50 - 5.40
	5.40 - 6.30
	6.30 - 7.20
	7.20 - 8.10
	8.10 - 9.00

Maximum Density	8.51%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	254 (254 Entries)
Hemisphere	Lower
Projection	Equal Angle

RGSC-0008 DRILLED AT A VERTICAL INCLINATION (-90 DEGREES)

NOTE:
- STEREOGRAPHIC PROJECTIONS TO TRUE NORTH
- STEREOGRAPHIC PLOTS PREPARED USING ROCSCIENCE DIPS VERSION 6.0

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RIVERSDALE RESOURCES LIMITED

PROJECT
GRASSY MOUNTAIN PRELIMINARY PIT SLOPE ASSESSMENT

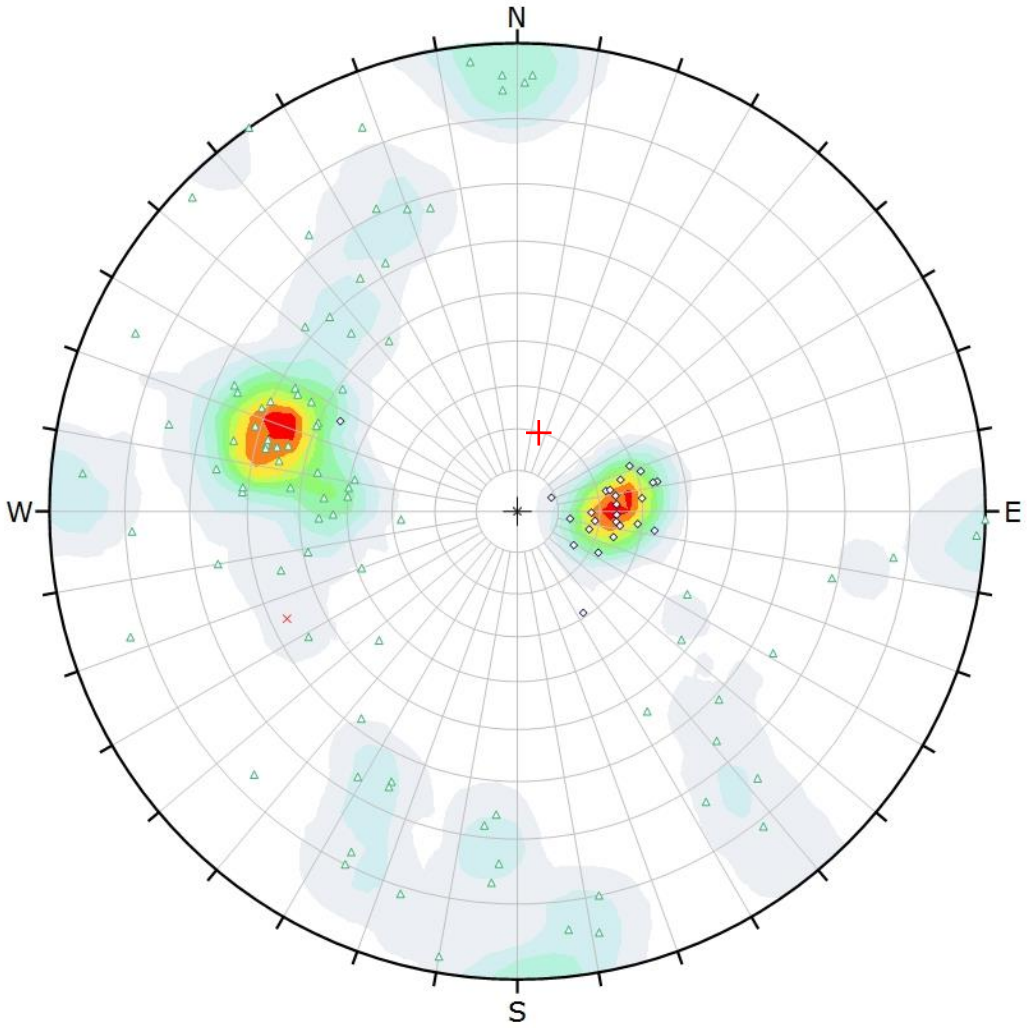
CONSULTANT
Golder Associates

YYYY-MM-DD	2014-10-14
PREPARED	AGH
DESIGN	AGH
REVIEW	EAS
APPROVED	AVC

TITLE
STEREOGRAPHIC PROJECTION – RGSC-0008
POLE PLOT OF FORMATION DATA

PROJECT No.	Rev.	FIGURE
2850-MN-0001-0	**0**	**D-8**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
0



Symbol	FEATURES	Quantity
◇	bedding	25
×	fault	1
△	joint	89

Color	Density Concentrations
	0.00 - 1.10
	1.10 - 2.20
	2.20 - 3.30
	3.30 - 4.40
	4.40 - 5.50
	5.50 - 6.60
	6.60 - 7.70
	7.70 - 8.80
	8.80 - 9.90
	9.90 - 11.00

Maximum Density	10.71%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	115 (115 Entries)
Hemisphere	Lower
Projection	Equal Angle

RGSC-0009 BOREHOLE TREND & PLUNGE
70° INCLINATION TOWARDS 020° AZIMUTH

NOTE:
- STEREOGRAPHIC PROJECTIONS TO TRUE NORTH
- STEREOGRAPHIC PLOTS PREPARED USING ROCSCIENCE DIPS VERSION 6.0

CLIENT
RIVERSDALE RESOURCES LIMITED

PROJECT
GRASSY MOUNTAIN PRELIMINARY PIT SLOPE ASSESSMENT

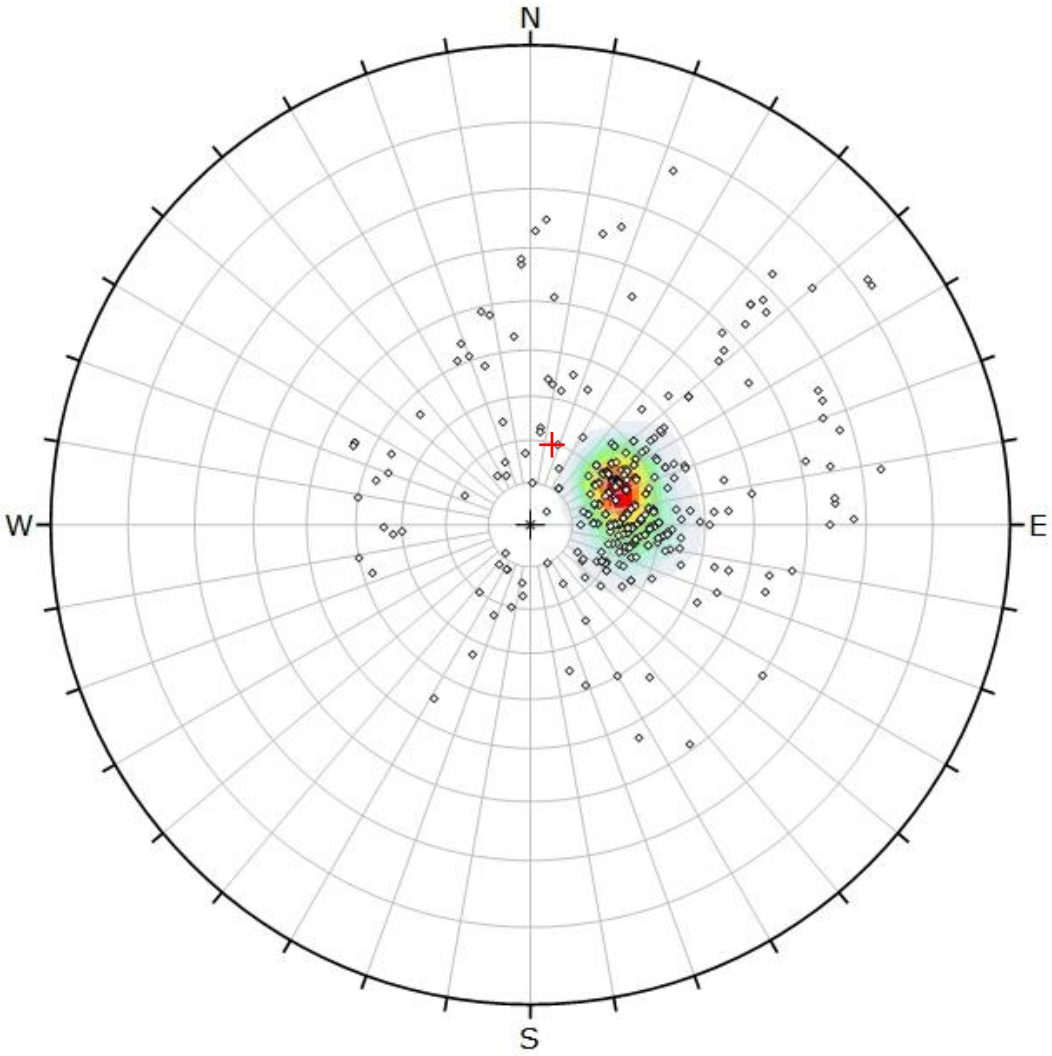
CONSULTANT
Golder Associates

YYYY-MM-DD	2014-10-14
PREPARED	AGH
DESIGN	AGH
REVIEW	EAS
APPROVED	AVC

TITLE
STEREOGRAPHIC PROJECTION – RGSC-0009
SYMBOLIC POLE PLOT

PROJECT No. **2850-MN-0001-0** | Rev. **0** | FIGURE **D-9**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0



Symbol	Feature
◇	Pole Vectors

Color	Density Concentrations
	0.00 - 3.80
	3.80 - 7.60
	7.60 - 11.40
	11.40 - 15.20
	15.20 - 19.00
	19.00 - 22.80
	22.80 - 26.60
	26.60 - 30.40
	30.40 - 34.20
	34.20 - 38.00

Maximum Density	37.57%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	401 (401 Entries)
Hemisphere	Lower
Projection	Equal Angle

RGSC-0009 BOREHOLE TREND & PLUNGE
70° INCLINATION TOWARDS 020° AZIMUTH

NOTE:
- STEREOGRAPHIC PROJECTIONS TO TRUE NORTH
- STEREOGRAPHIC PLOTS PREPARED USING ROCSCIENCE DIPS VERSION 6.0

CLIENT
RIVERSDALE RESOURCES LIMITED

PROJECT
GRASSY MOUNTAIN PRELIMINARY PIT SLOPE ASSESSMENT

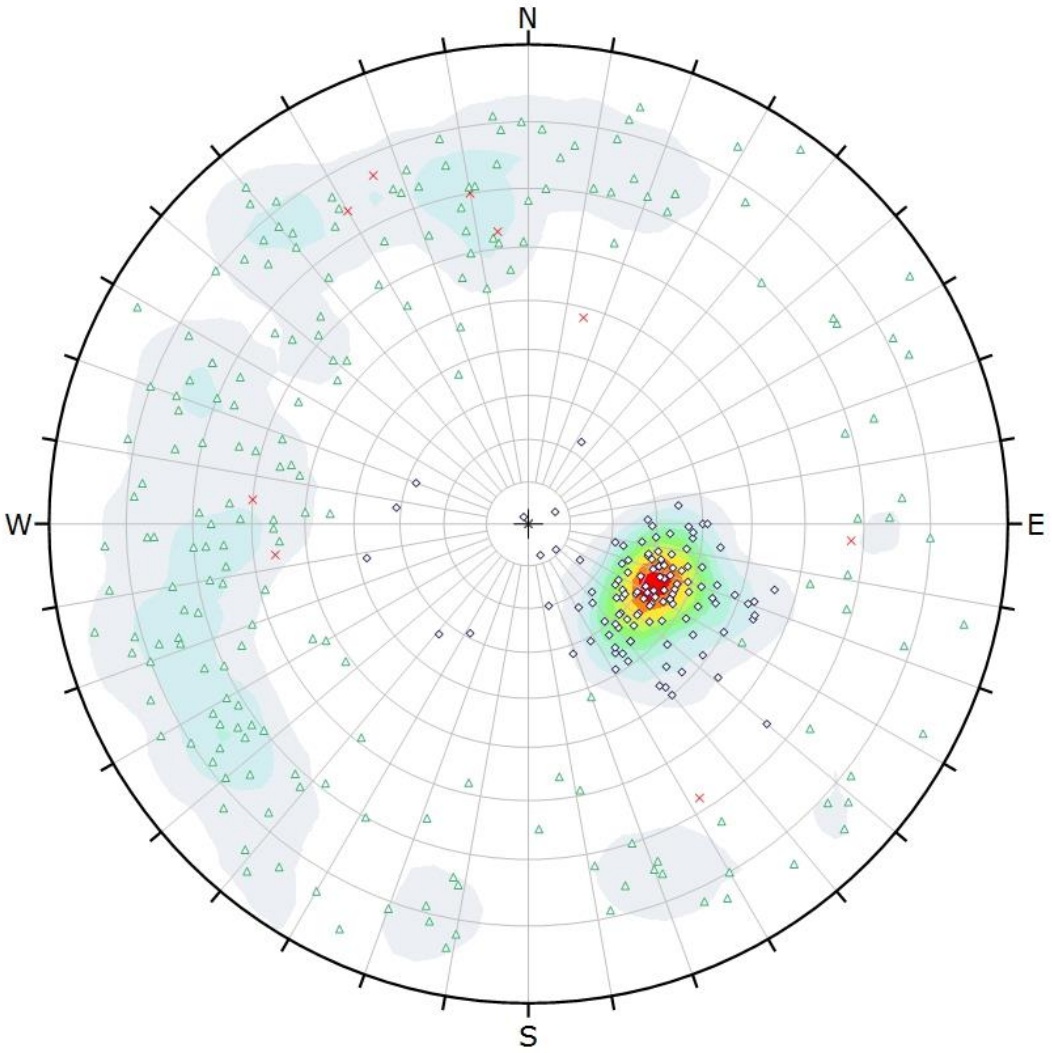
CONSULTANT
Golder Associates

YYYY-MM-DD	2014-10-14
PREPARED	AGH
DESIGN	AGH
REVIEW	EAS
APPROVED	AVC

TITLE
STEREOGRAPHIC PROJECTION – RGSC-0009
POLE PLOT OF FORMATION DATA

PROJECT No.	Rev.	FIGURE
2850-MN-0001-0	**0**	**D-10**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
0



Symbol	FEATURES	Quantity
◇	bedding	121
×	fault	9
△	joint	203

Color	Density Concentrations
	0.00 - 1.20
	1.20 - 2.40
	2.40 - 3.60
	3.60 - 4.80
	4.80 - 6.00
	6.00 - 7.20
	7.20 - 8.40
	8.40 - 9.60
	9.60 - 10.80
	10.80 - 12.00

Maximum Density	11.64%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	333 (333 Entries)
Hemisphere	Lower
Projection	Equal Angle

RGSC-0010 DRILLED AT A VERTICAL INCLINATION (-90 DEGREES)

NOTE:
- STEREOGRAPHIC PROJECTIONS TO TRUE NORTH
- STEREOGRAPHIC PLOTS PREPARED USING ROCSCIENCE DIPS VERSION 6.0

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RIVERSDALE RESOURCES LIMITED

PROJECT
GRASSY MOUNTAIN PRELIMINARY PIT SLOPE ASSESSMENT

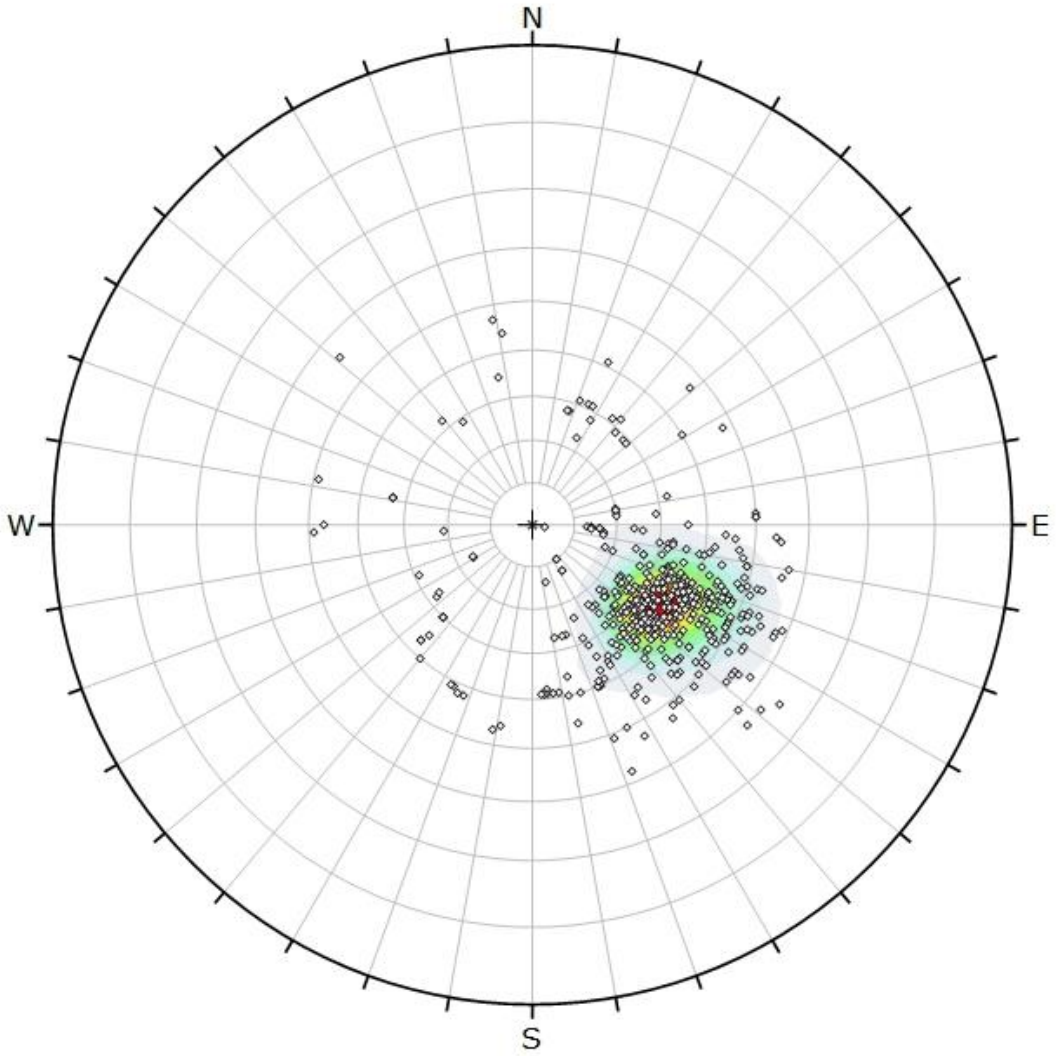
CONSULTANT
Golder Associates

YYYY-MM-DD	2014-10-14
PREPARED	AGH
DESIGN	AGH
REVIEW	EAS
APPROVED	AVC

TITLE
STEREOGRAPHIC PROJECTION – RGSC-0010
SYMBOLIC POLE PLOT

PROJECT No. **2850-MN-0001-0** | Rev. **0** | FIGURE **D-11**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
0



Symbol	Feature
◇	Pole Vectors

Color	Density Concentrations
	0.00 - 3.50
	3.50 - 7.00
	7.00 - 10.50
	10.50 - 14.00
	14.00 - 17.50
	17.50 - 21.00
	21.00 - 24.50
	24.50 - 28.00
	28.00 - 31.50
	31.50 - 35.00

Maximum Density	34.82%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	497 (497 Entries)
Hemisphere	Lower
Projection	Equal Angle

RGSC-0010 DRILLED AT A VERTICAL INCLINATION (-90 DEGREES)

NOTE:
- STEREOGRAPHIC PROJECTIONS TO TRUE NORTH
- STEREOGRAPHIC PLOTS PREPARED USING ROCSCIENCE DIPS VERSION 6.0

CLIENT
RIVERSDALE RESOURCES LIMITED

PROJECT
GRASSY MOUNTAIN PRELIMINARY PIT SLOPE ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2014-10-14
PREPARED	AGH
DESIGN	AGH
REVIEW	EAS
APPROVED	AVC

TITLE
STEREOGRAPHIC PROJECTION – RGSC-0010
POLE PLOT OF FORMATION DATA

PROJECT No.	Rev.	FIGURE
2850-MN-0001-0	**0**	**D-12**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
0

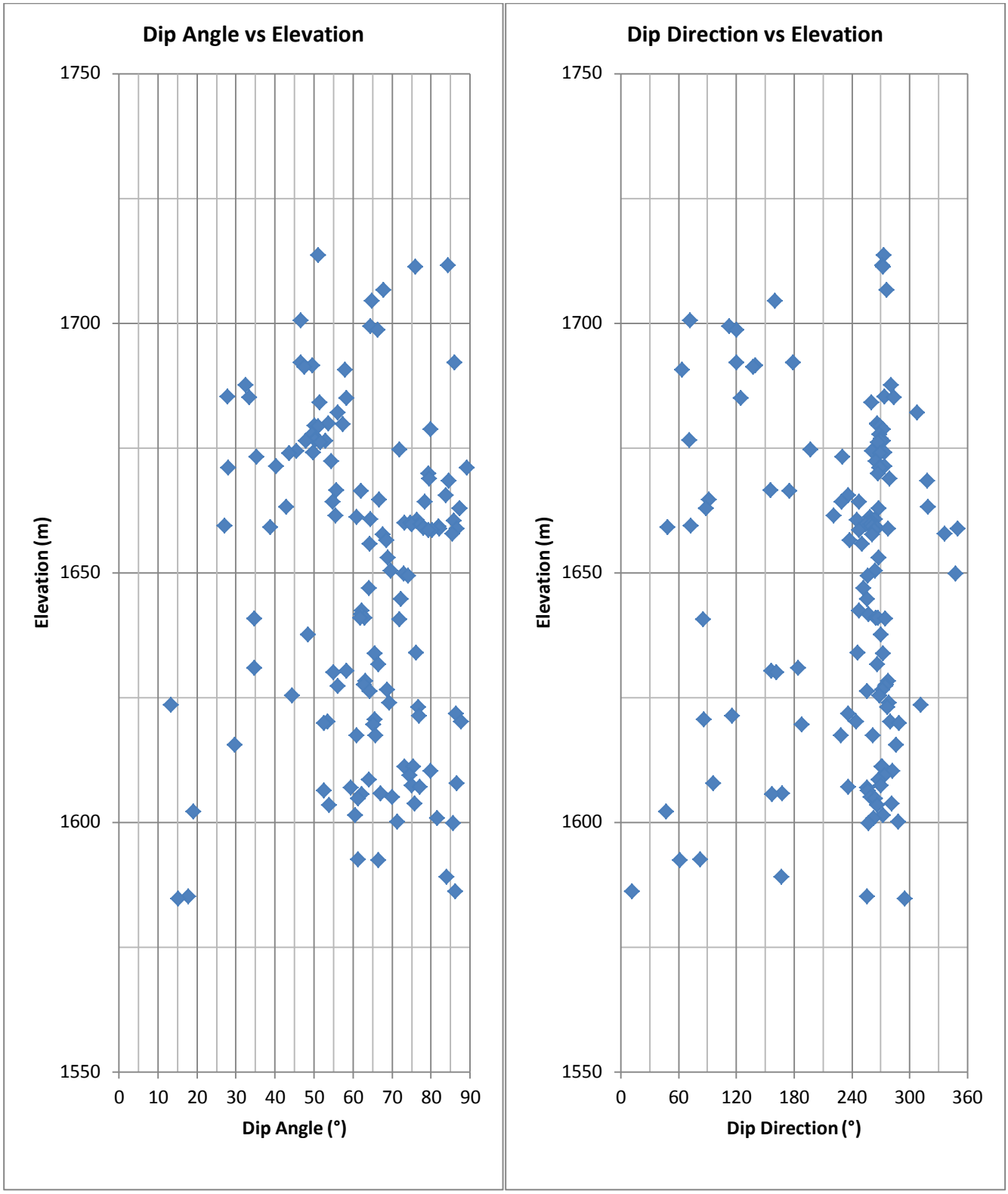


Figure D-14: RGSC-0004 Acoustic Televiewer Picks

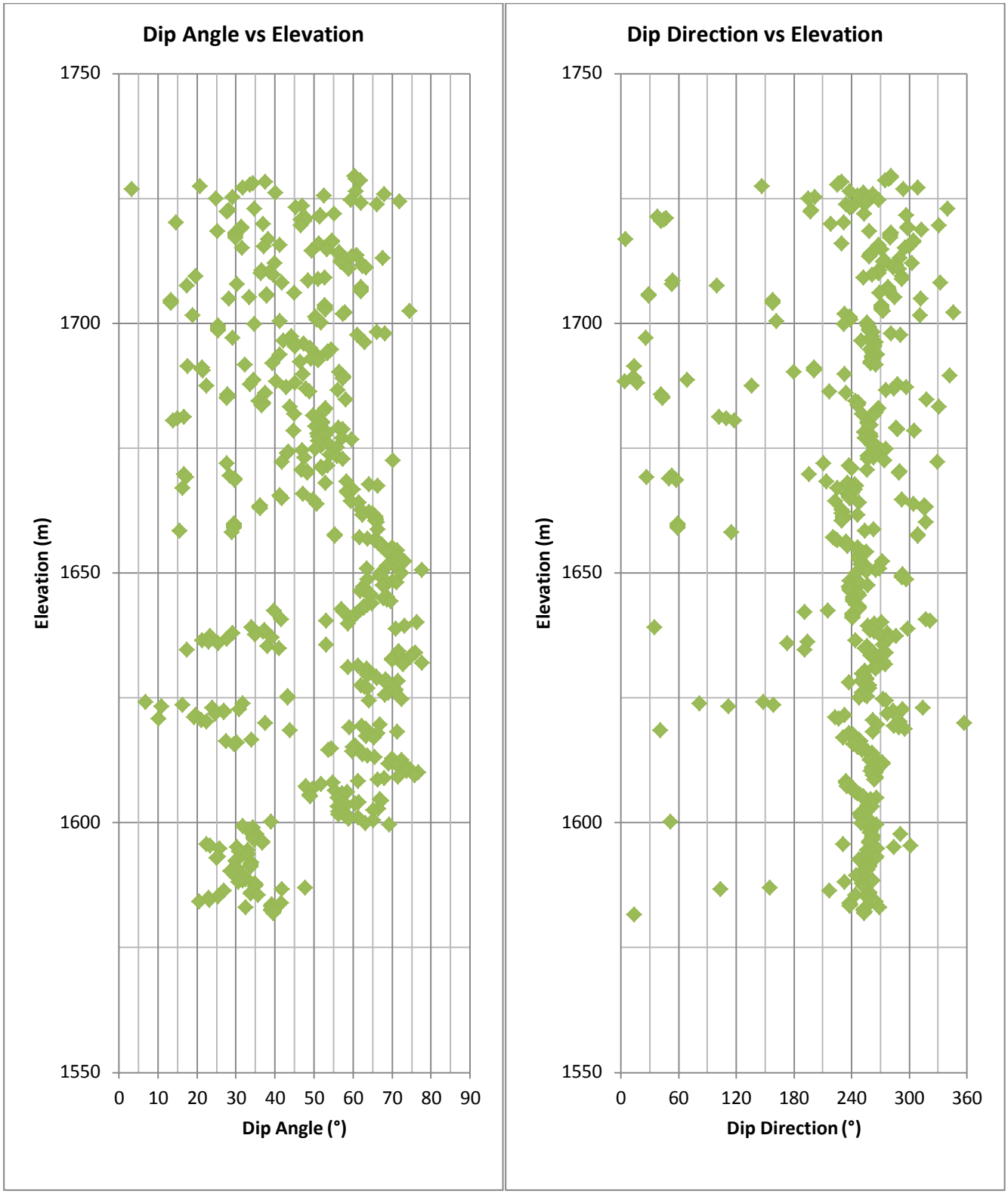


Figure D-15: RGSC-0004 Formation Dip Meter

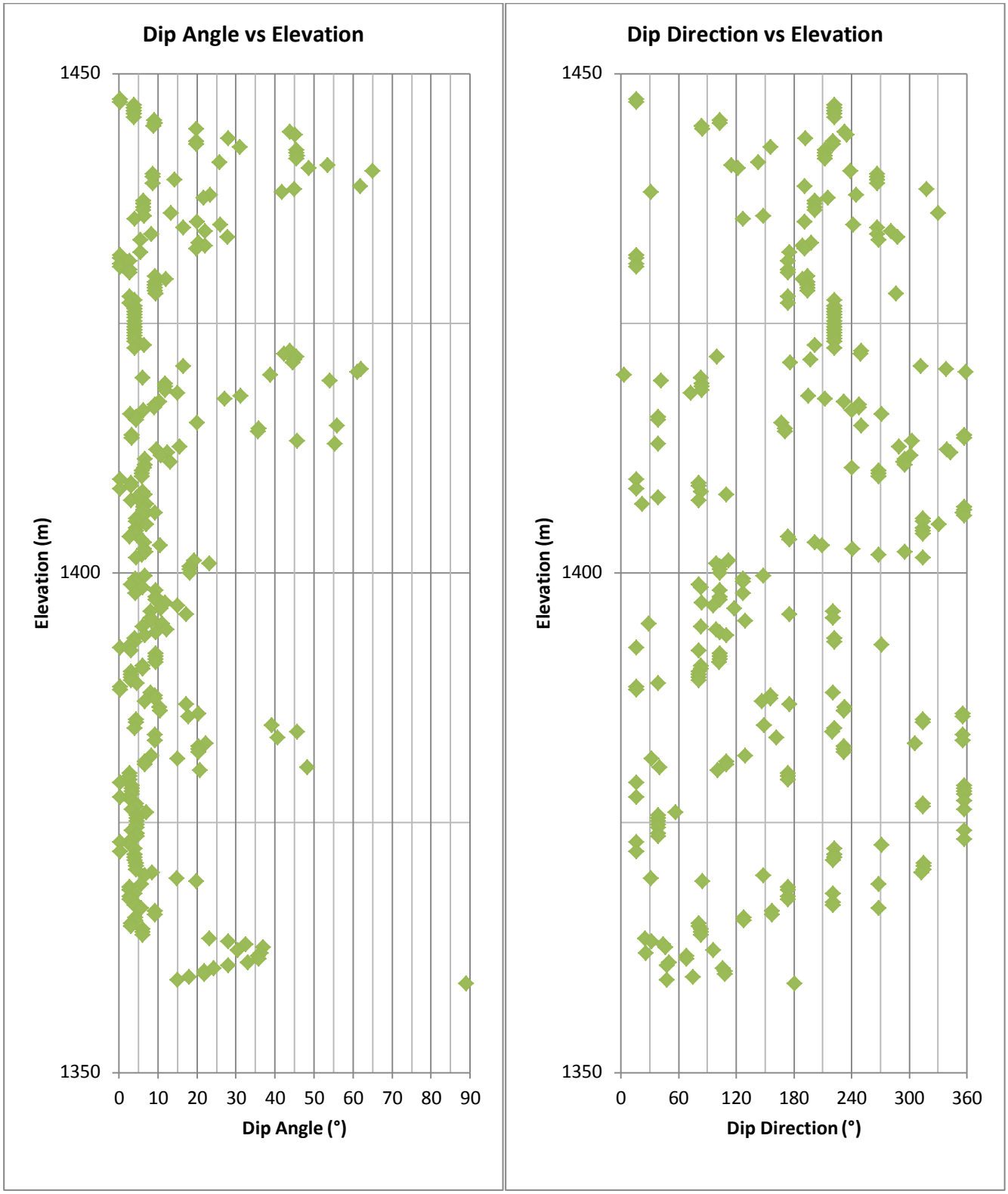


Figure D-16: RGSC-0005 Formation Dip Meter

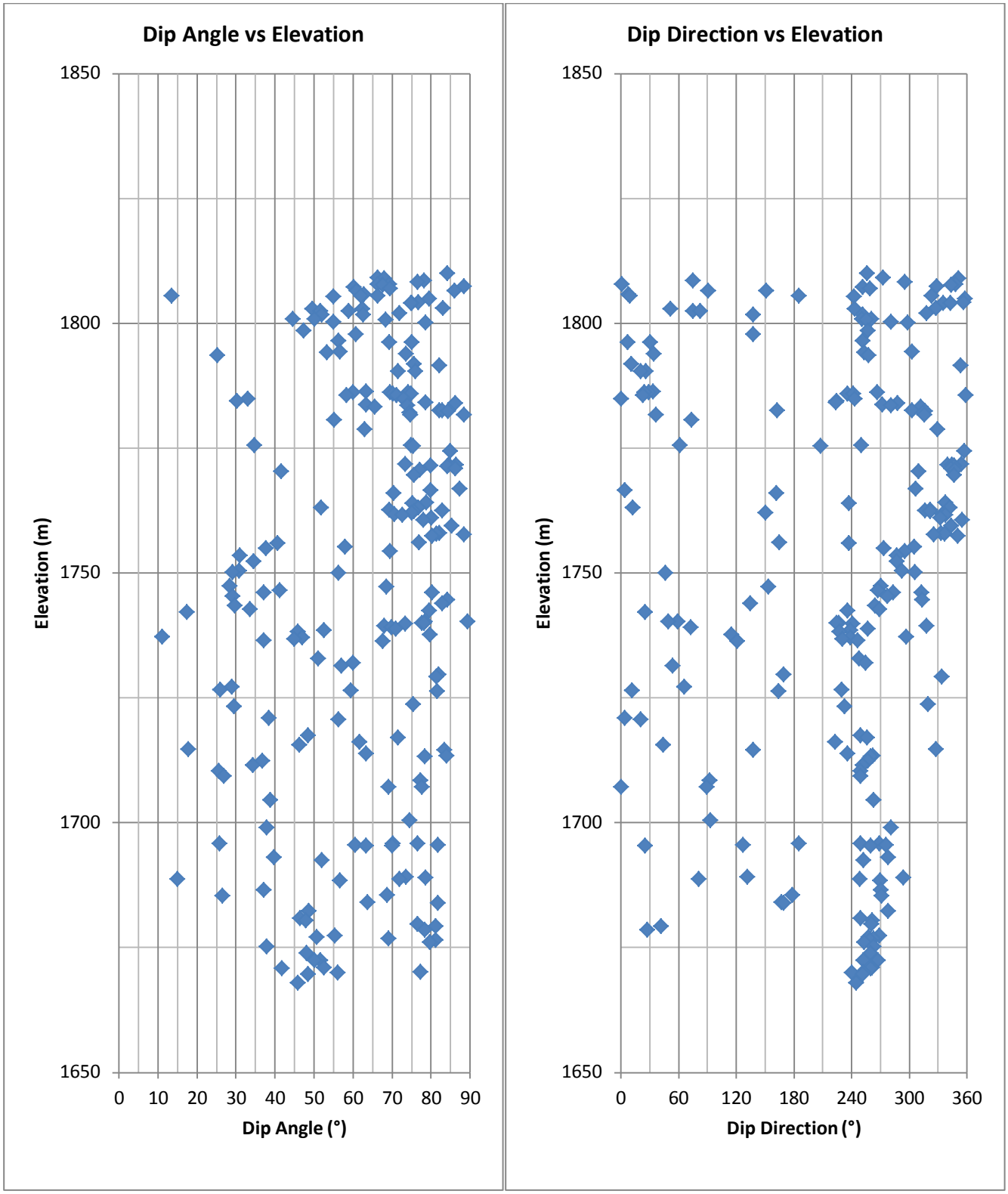


Figure D-17: RGSC-0006 Acoustic Televiewer Picks

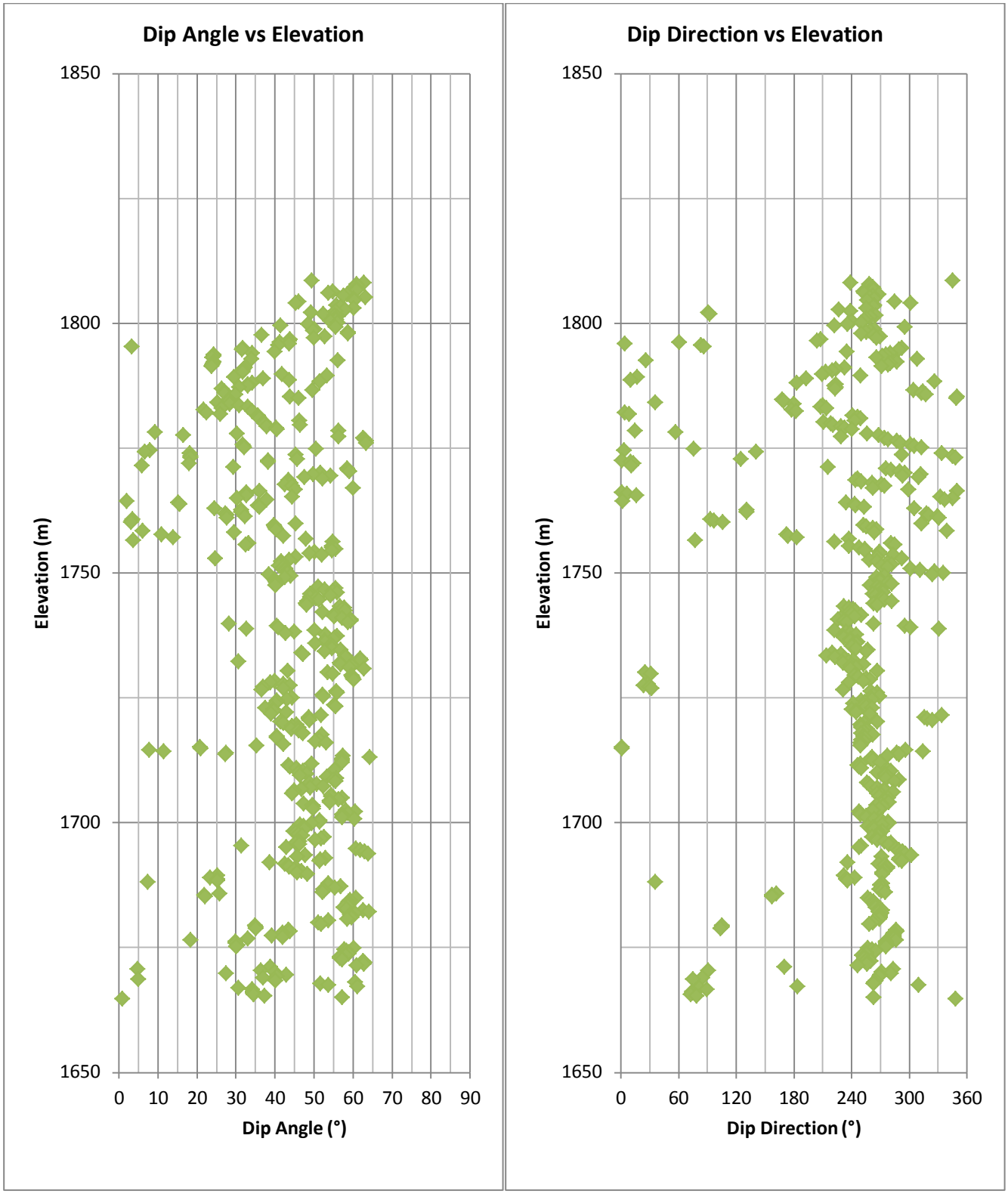


Figure D-18: RGSC-0006 Formation Dip Meter

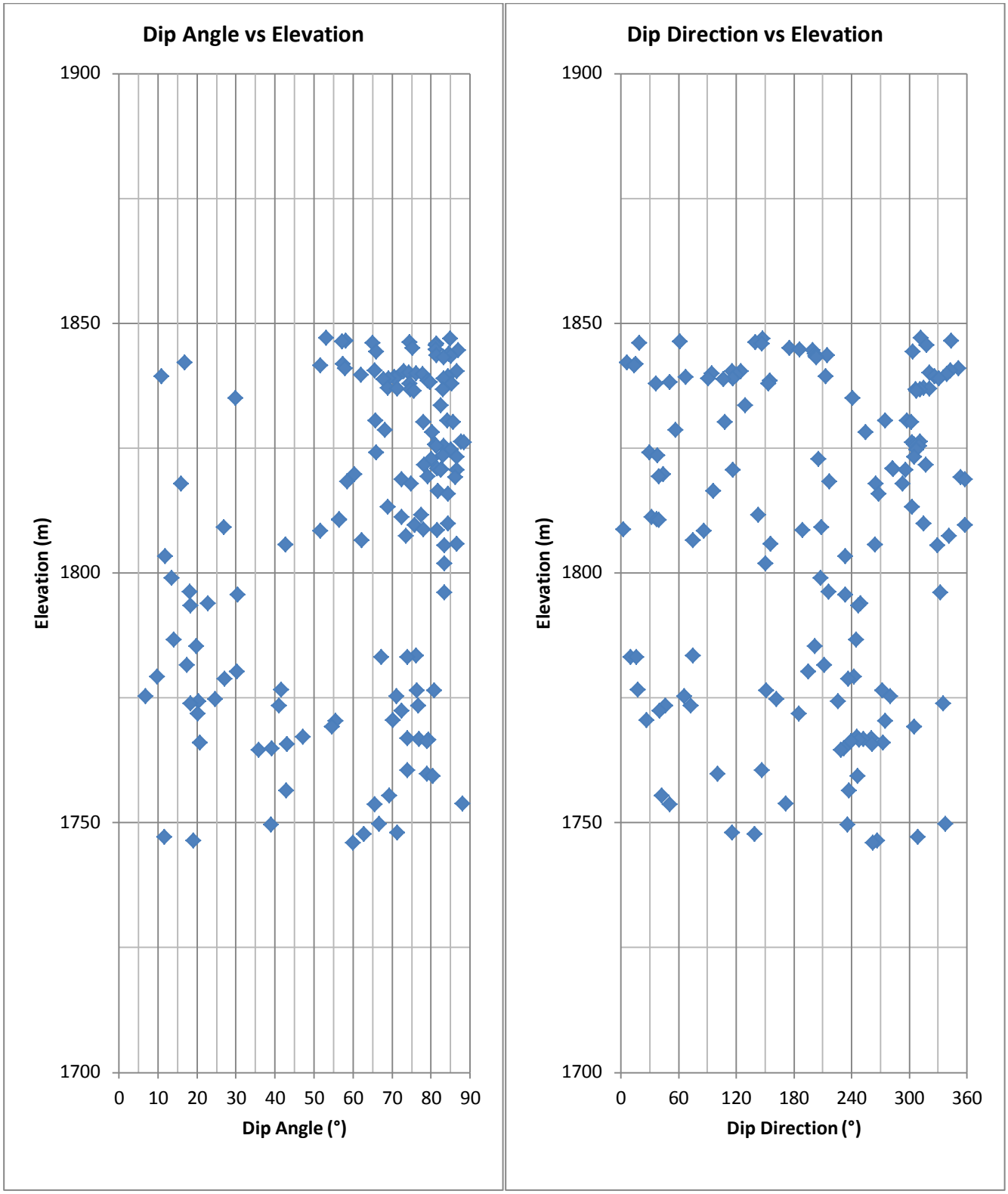


Figure D-19: RGSC-0007 Acoustic Televiewer Picks

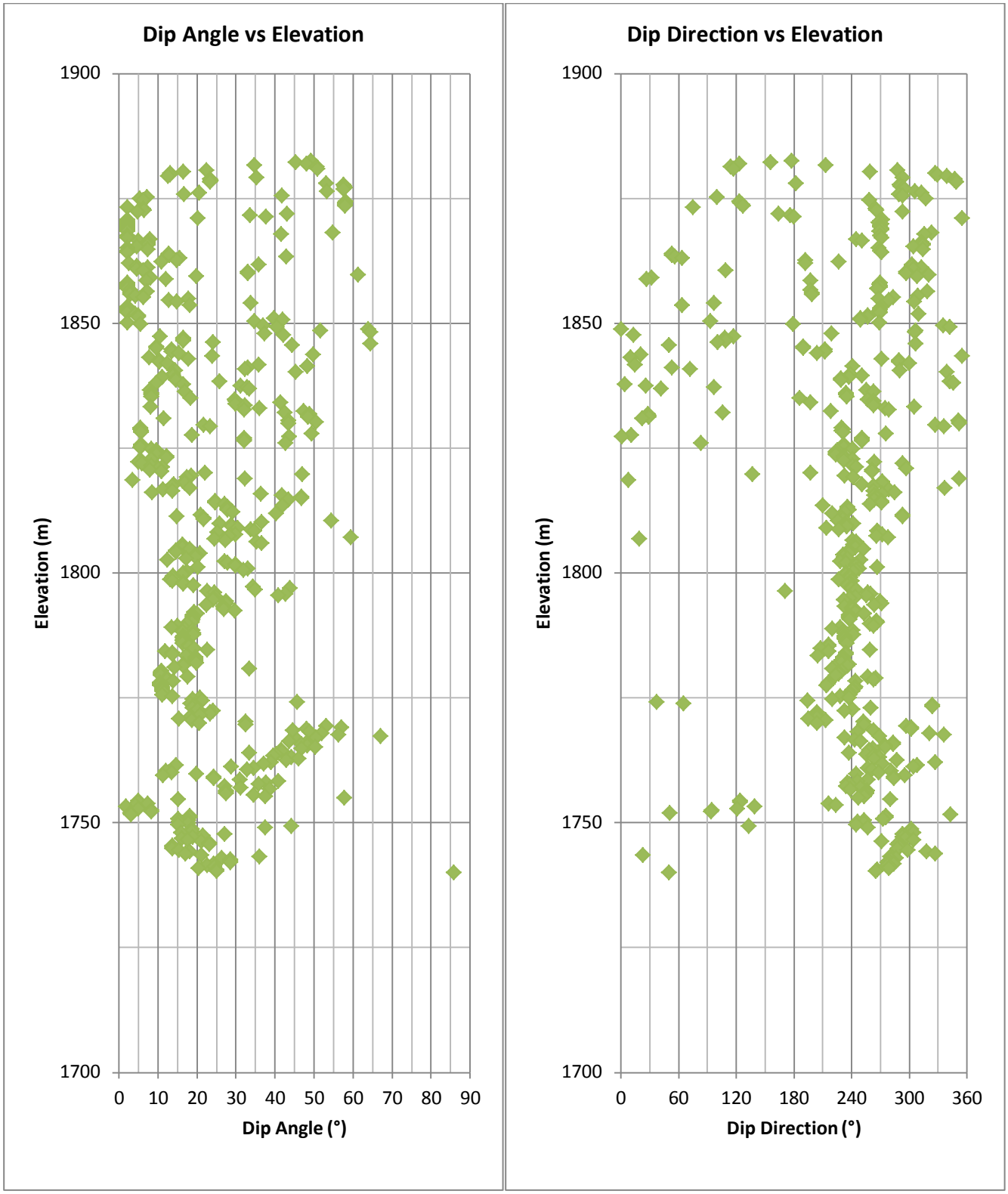


Figure D-20: RGSC-0007 Formation Dip Meter

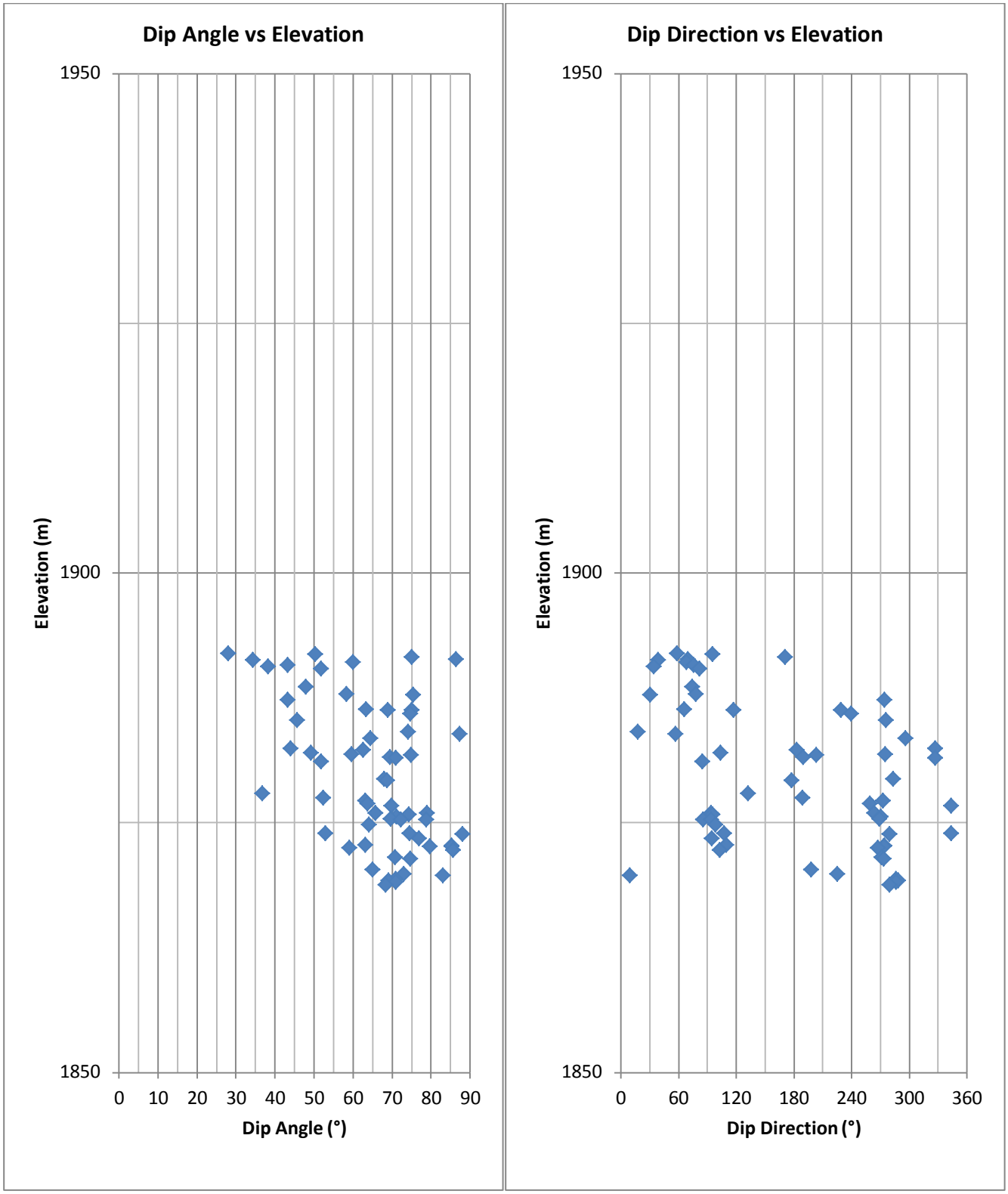


Figure D-21: RGSC-0008 Acoustic Televiewer Picks

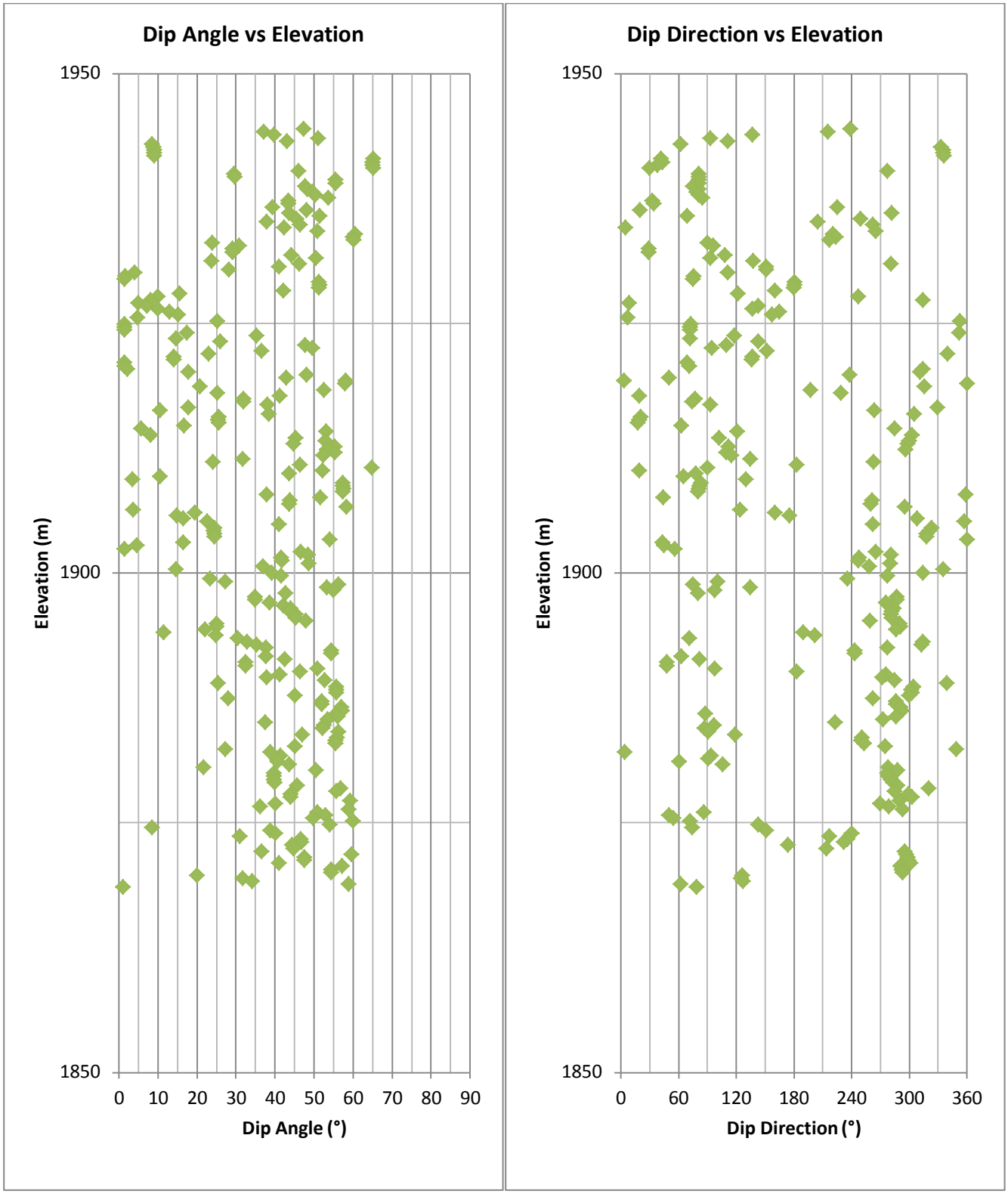


Figure D-22: RGSC-0008 Formation Dip Meter

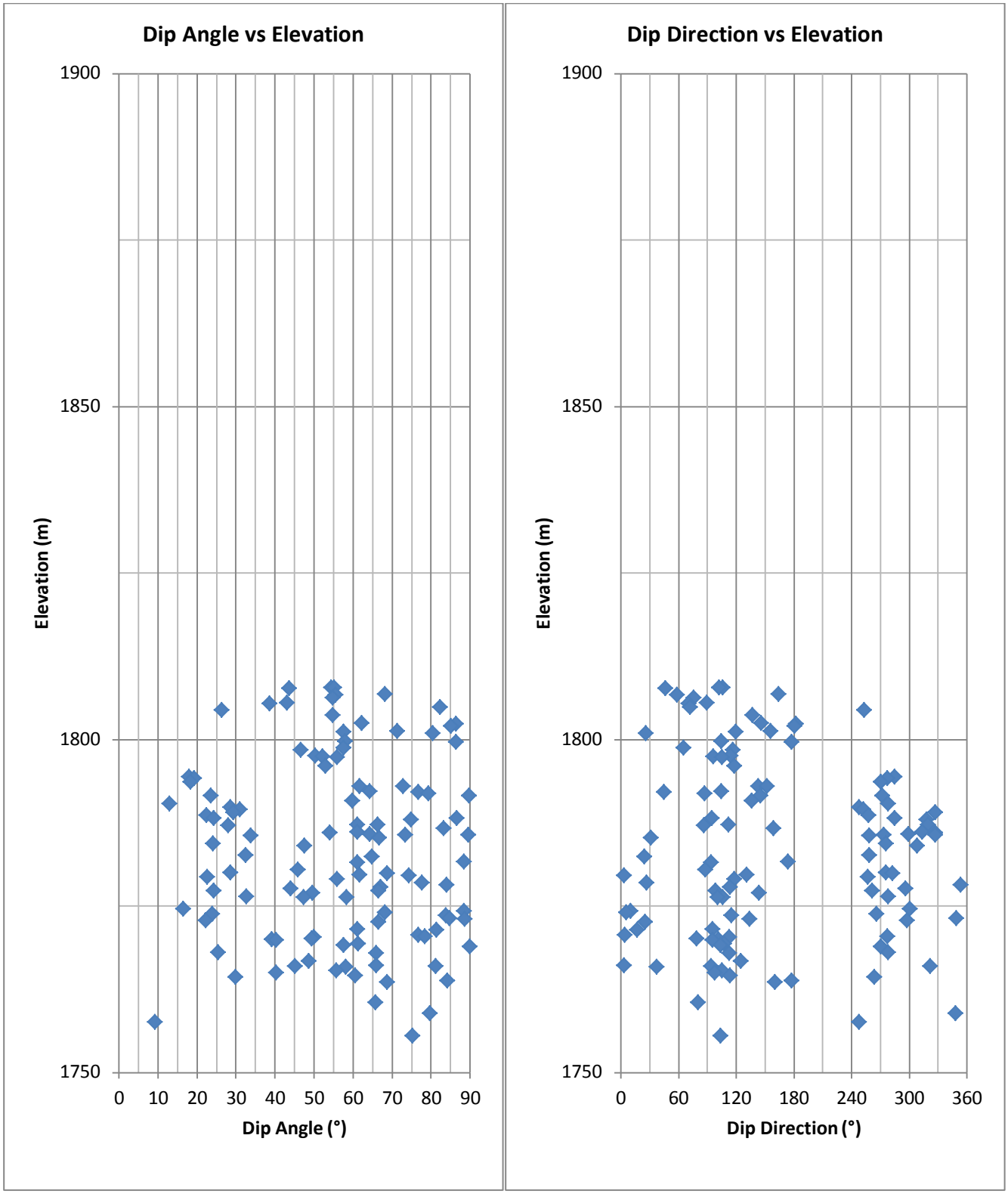


Figure D-23: RGSC-0009 Acoustic Televiewer Picks

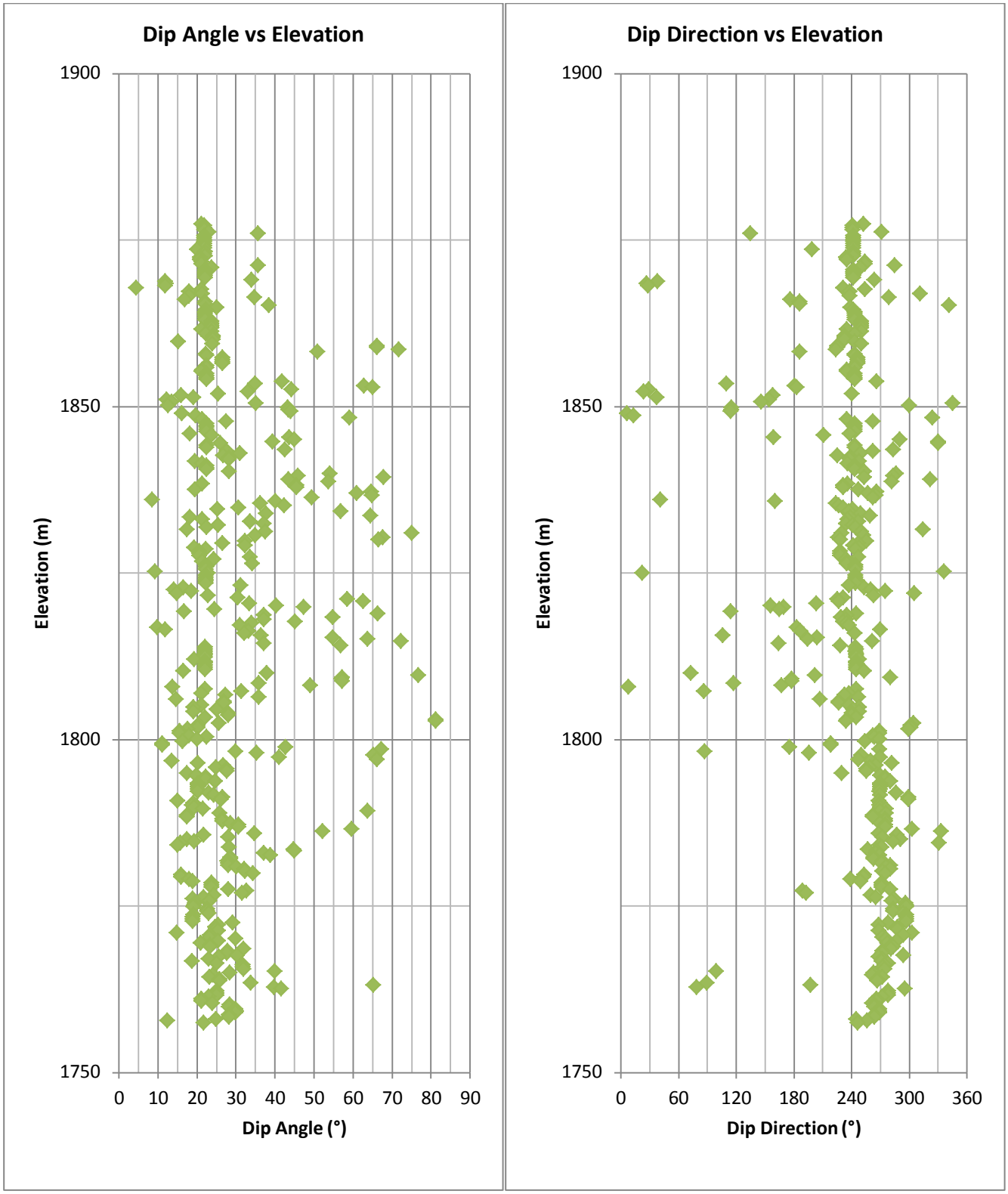


Figure D-24: RGSC-0009 Formation Dip Meter

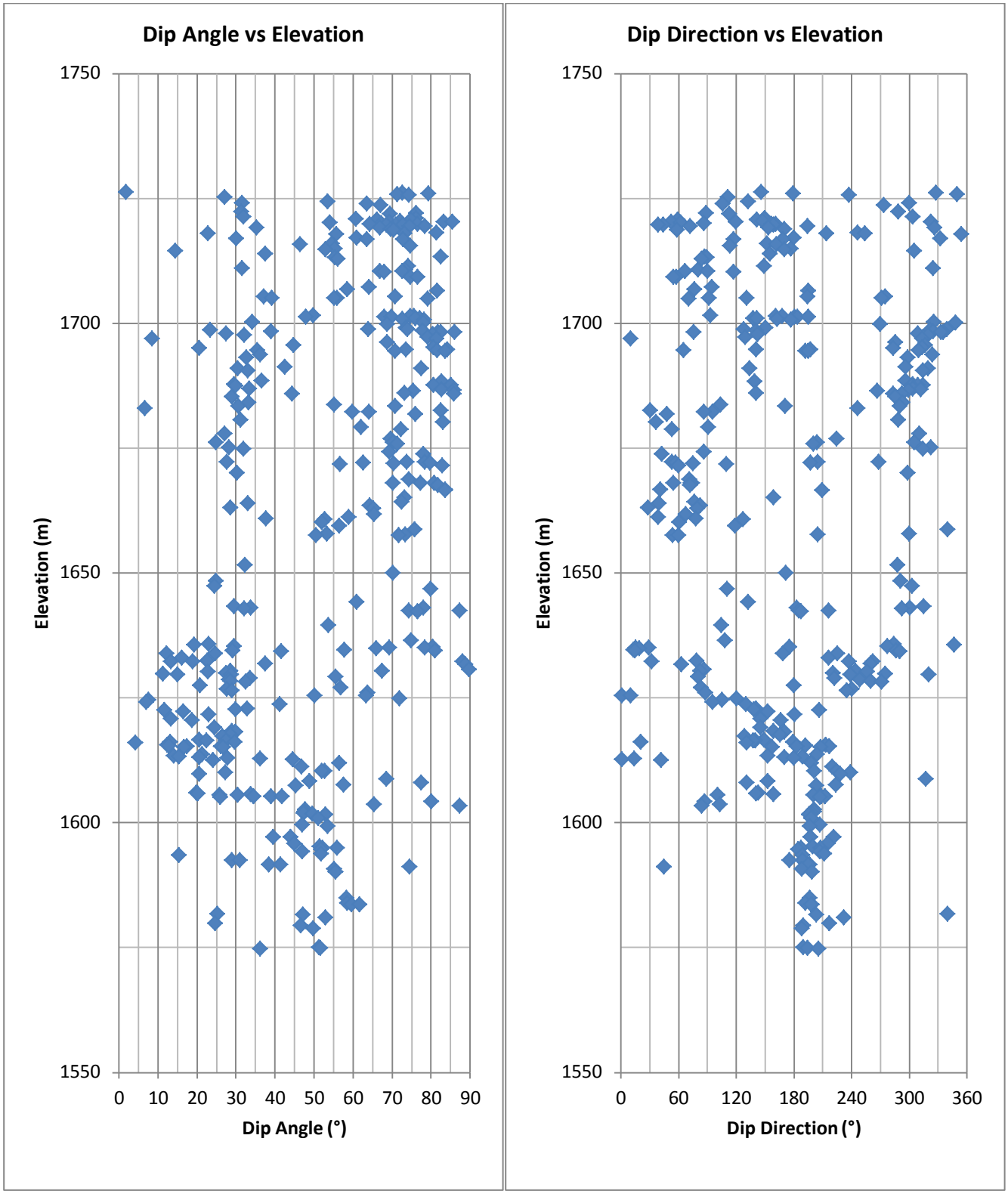


Figure D-25: RGSC-0010 Acoustic Televiewer Picks

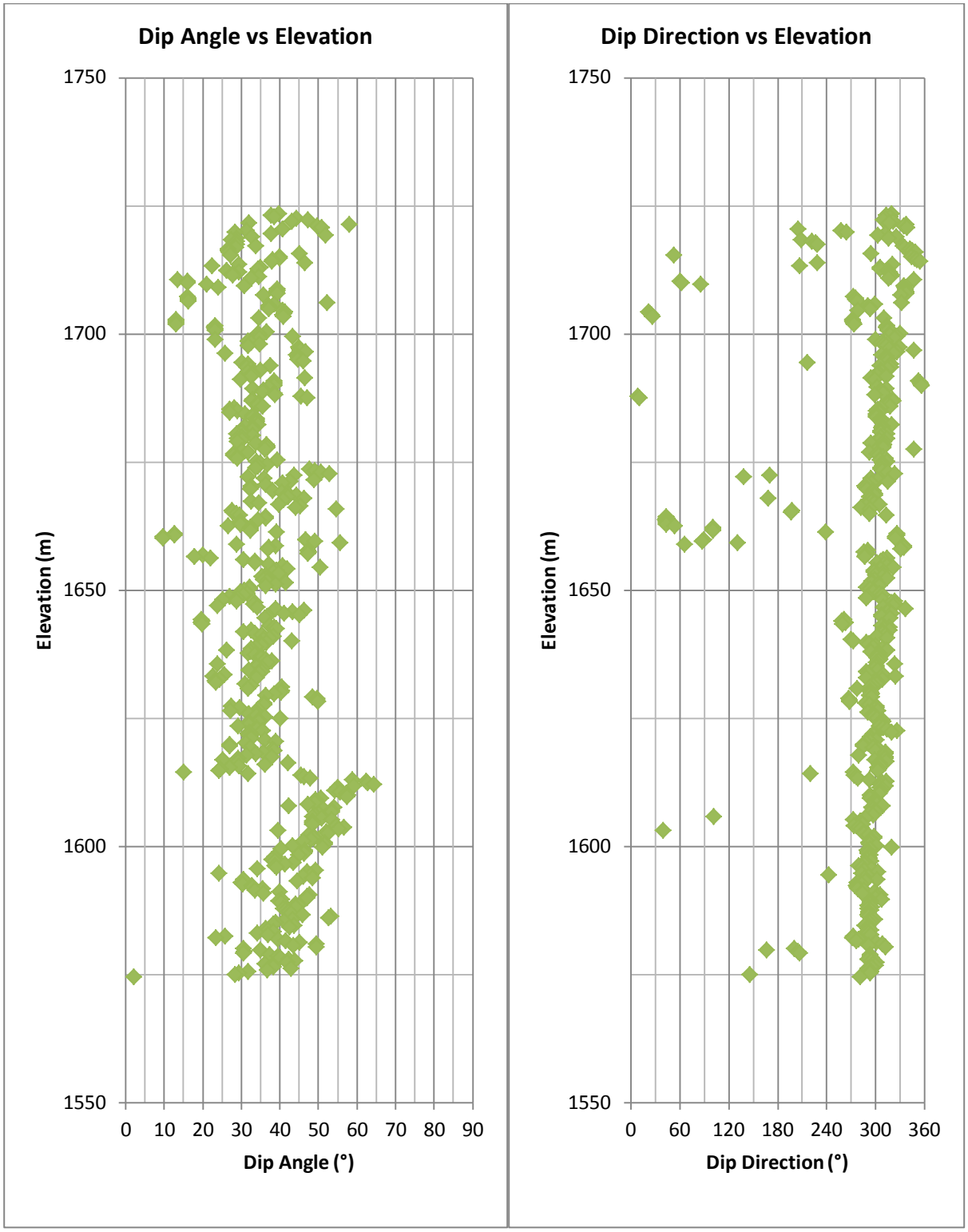


Figure D-26: RGSC-0010 Formation Dip Meter

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APPENDIX E

Rock Mass Quality Assessment

1.0 ROCK MASS CLASSIFICATION ASSESSMENT

An assessment of the overall quality of the rock masses that will be exposed in the Grassy Mountain pit has been prepared using the Rock Mass Rating (RMR^{76}) rock mass classification system (Bieniawski 1976), based on the data collected from the 2014 geotechnical drilling investigation.

The RMR_{76} classification system ranks the following five geotechnical parameters:

- *R1* = rating for the strength of intact rock material (rating = 0 to 15)
- *R2* = rating for drill core quality, Rock Quality Designation, RQD (rating = 3 to 20)
- *R3* = rating for spacing of joints (rating = 5 to 30)
- *R4* = rating for condition of joints, JCR (rating = 0 to 25)
- *R5* = rating for groundwater (rating = 0 to 10)

The overall rock mass quality is determined by summing the individual rankings as follows.

$$RMR_{76} = R1 + R2 + R3 + R4 + R5$$

The rock mass class as a function of rock mass rating as summarized in Table 4.

Table 1: Rock Mass Rating System (Bieniawski, 1976)

RMR_{76} Rating	Rock Mass Class	Legend
81 to 100	Class I – Very Good Rock	
61 to 80	Class II – Good Rock	
41 to 60	Class III – Fair Rock	
21 to 40	Class IV – Poor Rock	
20 or less	Class V – Very Poor Rock	

A groundwater rating of 10 (i.e., dry conditions) has been assumed for the rock mass classification as the groundwater conditions have been added directly to the limit equilibrium slope stability analyses.

The four geotechnical parameters logged and the resulting RMR_{76} for each geotechnical interval are shown in the borehole plots presented in Appendix B. Down-hole borehole plots of the RMR_{76} values for each geotechnical interval for the geotechnical boreholes are presented as overlays on the pit cross sections in Appendix H.

The following rules have been applied for RMR_{76} calculations:

- RMR_{76} classification parameters are not assigned to overburden materials;
- RQD values for soil and weak rock (R0 and R1 rock strengths) are assigned 0%. This is consistent with standard industry practice, where RQD is considered to apply to rock with an intact rock strength of R2 or greater; and
- JCR values for soil and weak rock (i.e., soft joint wall conditions) are assigned a maximum value of 12.

A JCR value for broken core was assigned based on the representative surface characteristics of the fractured rock pieces within the interval. A JCR value of 0 was assigned for lost core intervals.

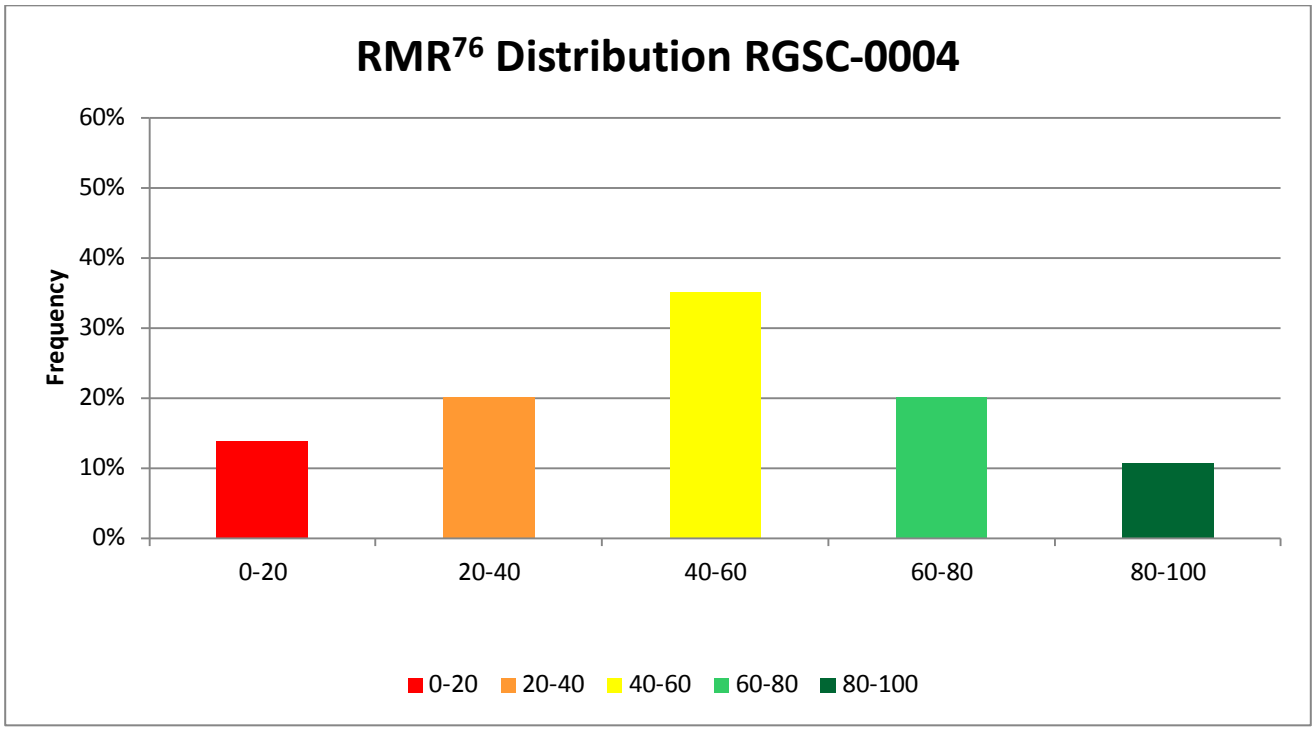


Plate E-1: RMR_{76} Interval Distribution – RGSC-0004

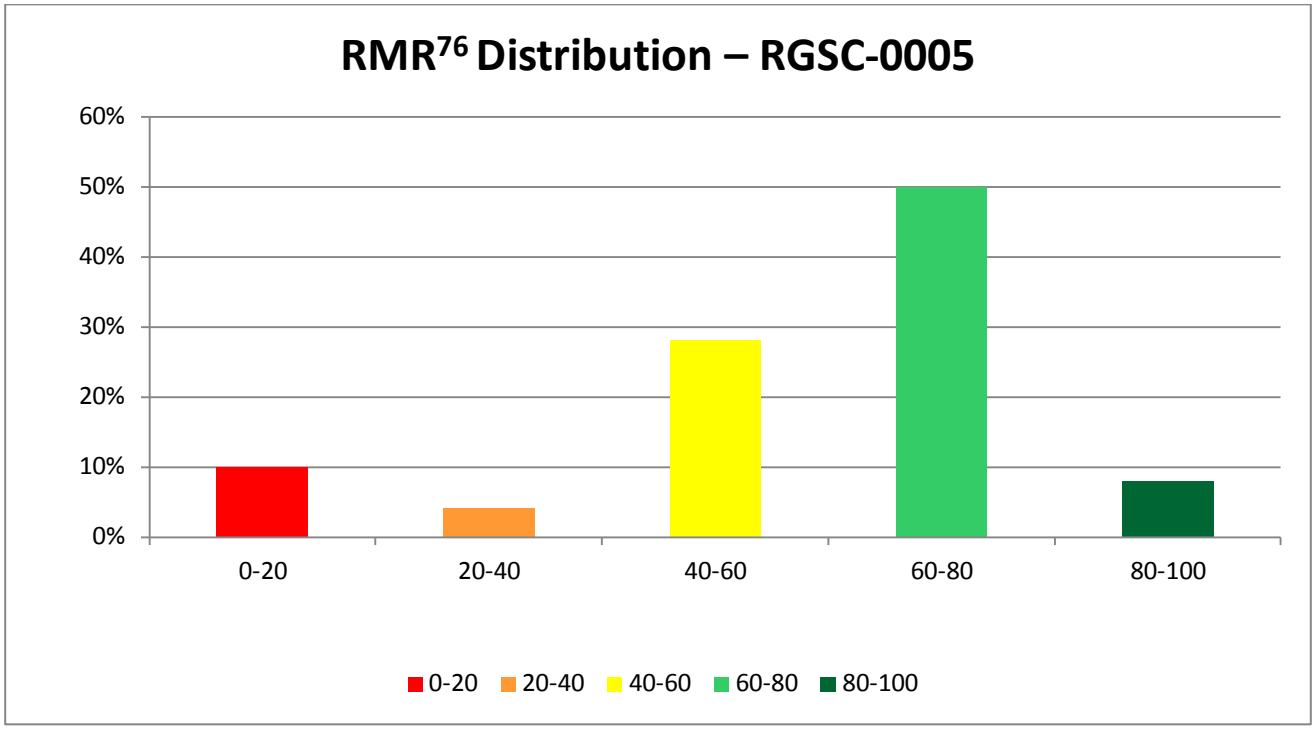


Plate E-2: RMR76 Interval Distribution – RGSC-0005

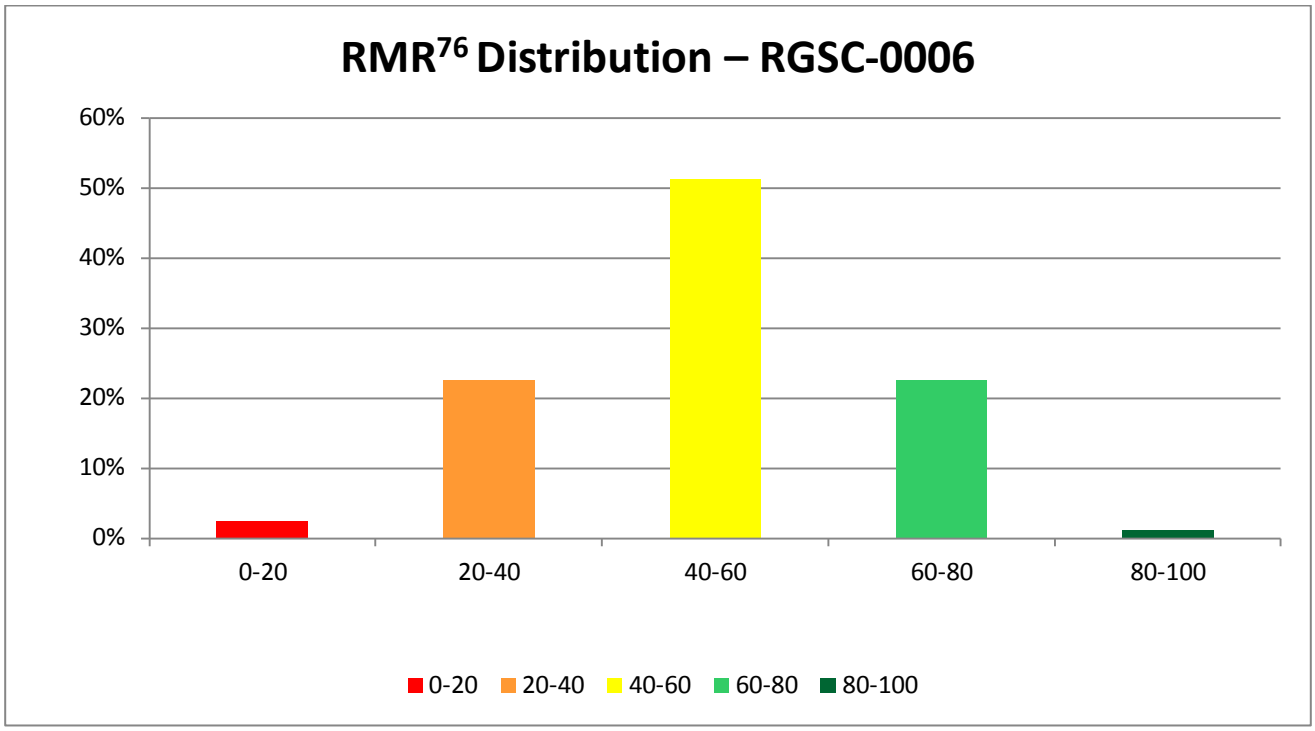


Plate E-3: RMR76 Interval Distribution – RGSC-0006

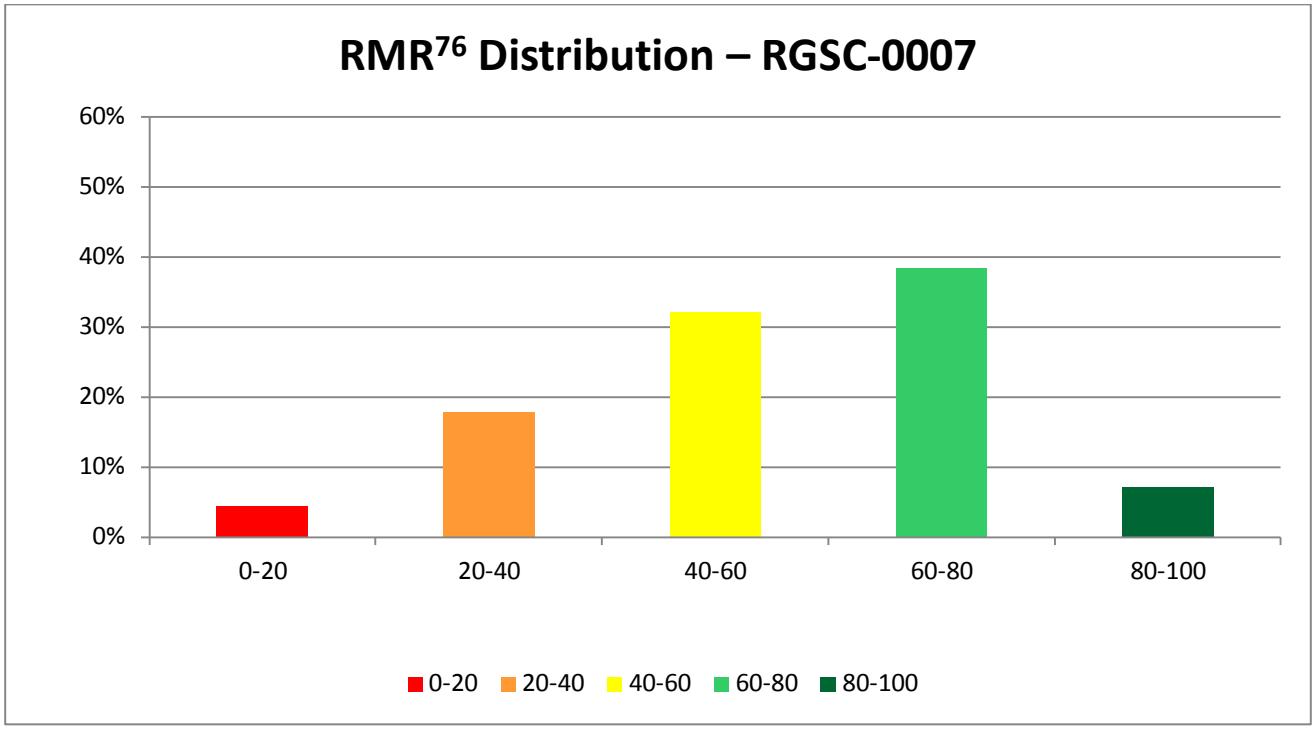


Plate E-4: RMR76 Interval Distribution – RGSC-0007

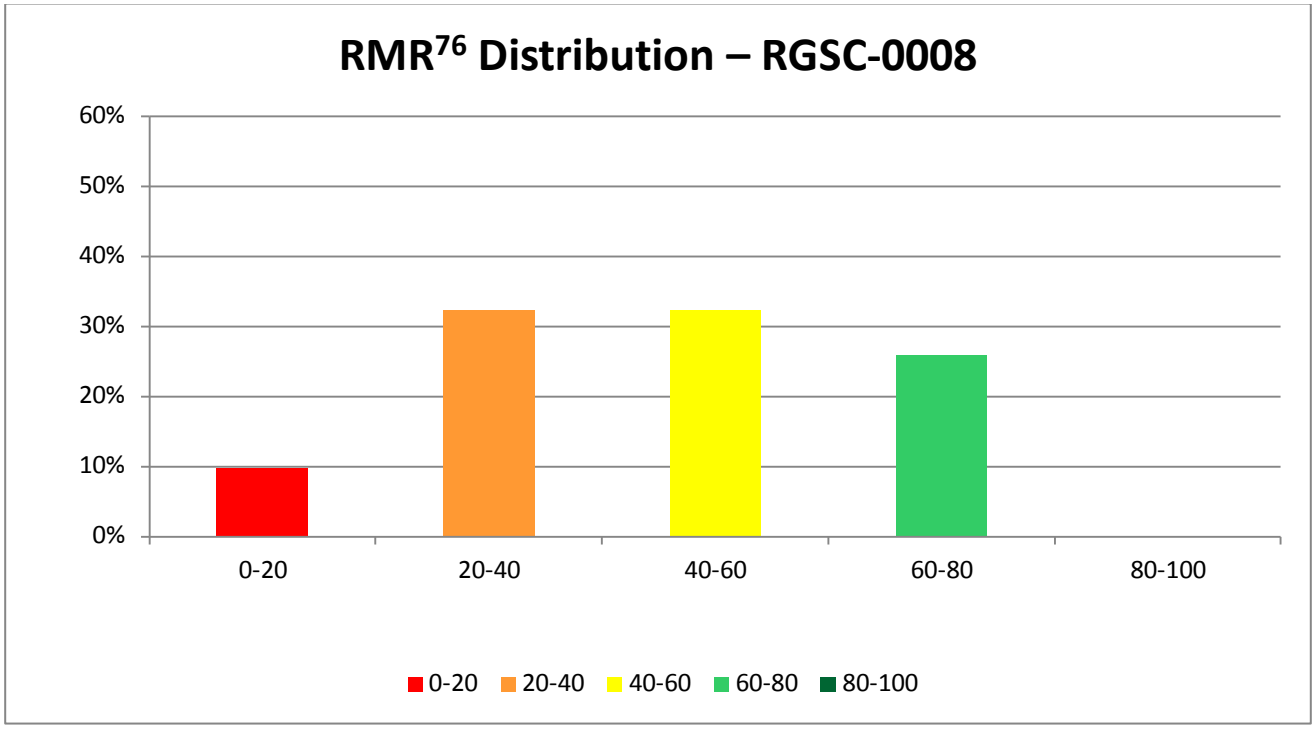


Plate E-5: RMR76 Interval Distribution –RGSC-0008

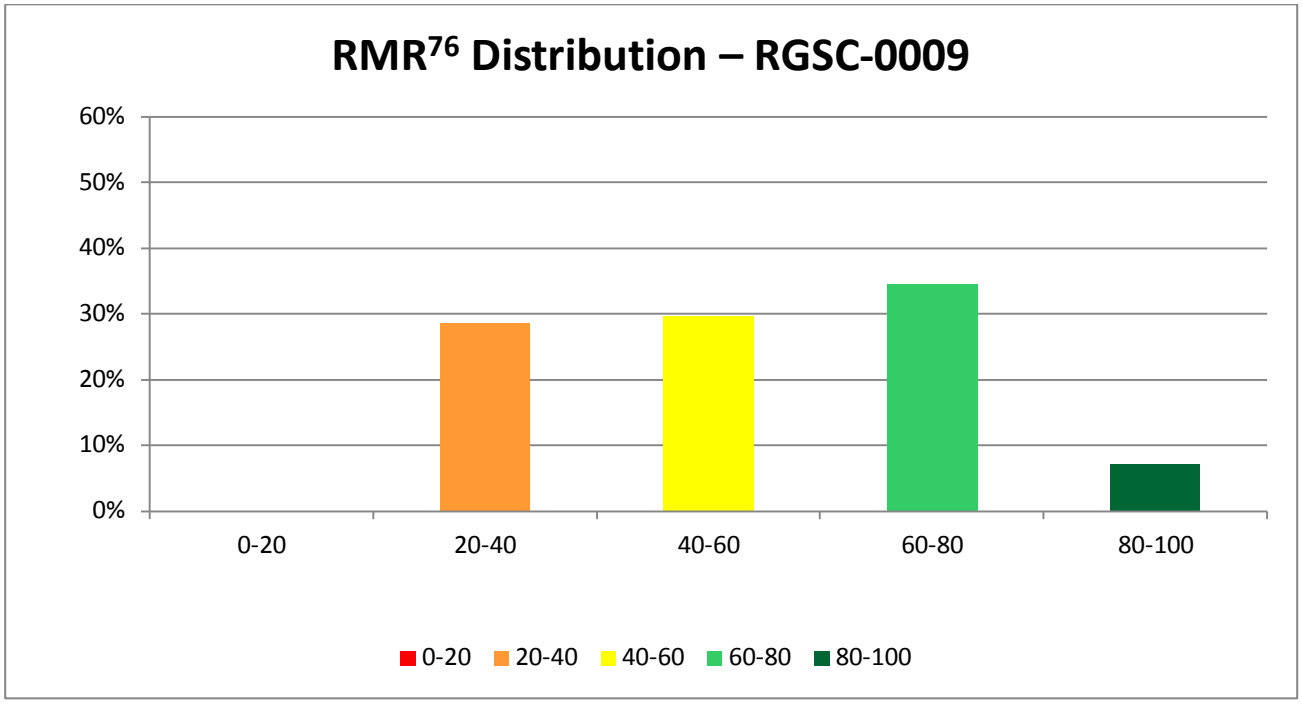


Plate E-6: RMR76 Interval Distribution – RGSC-0009

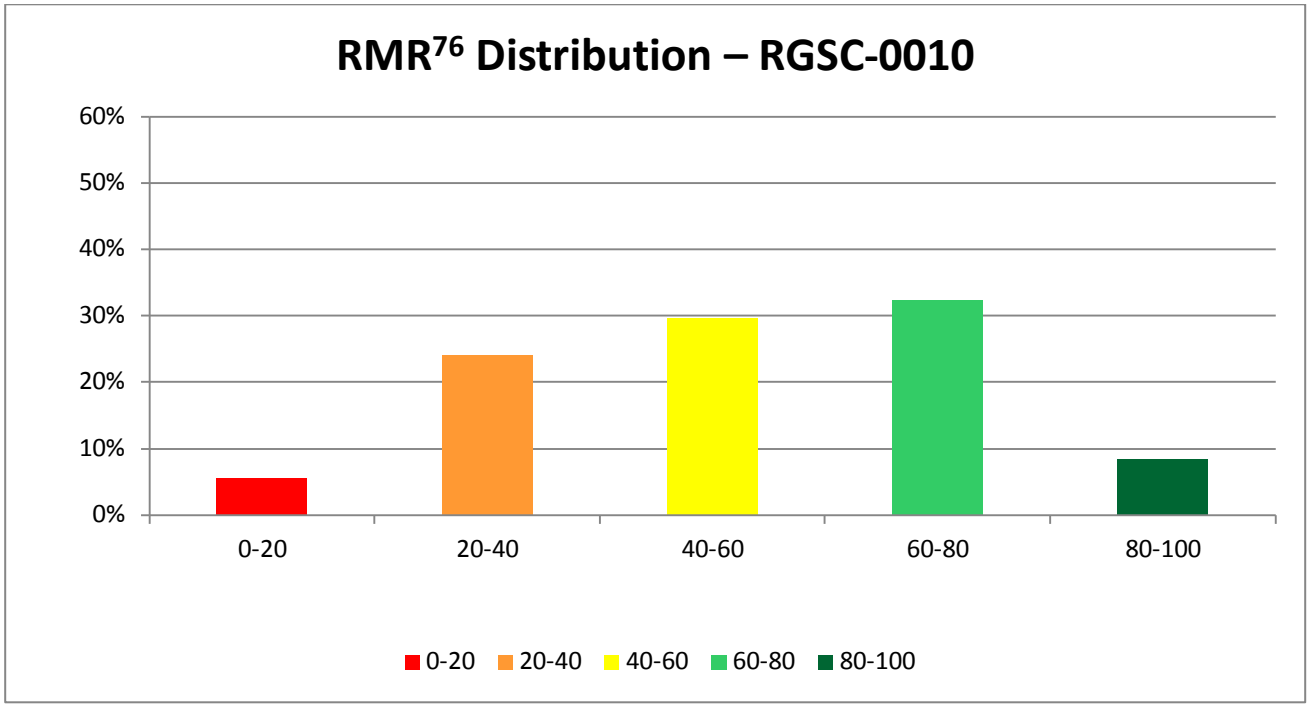
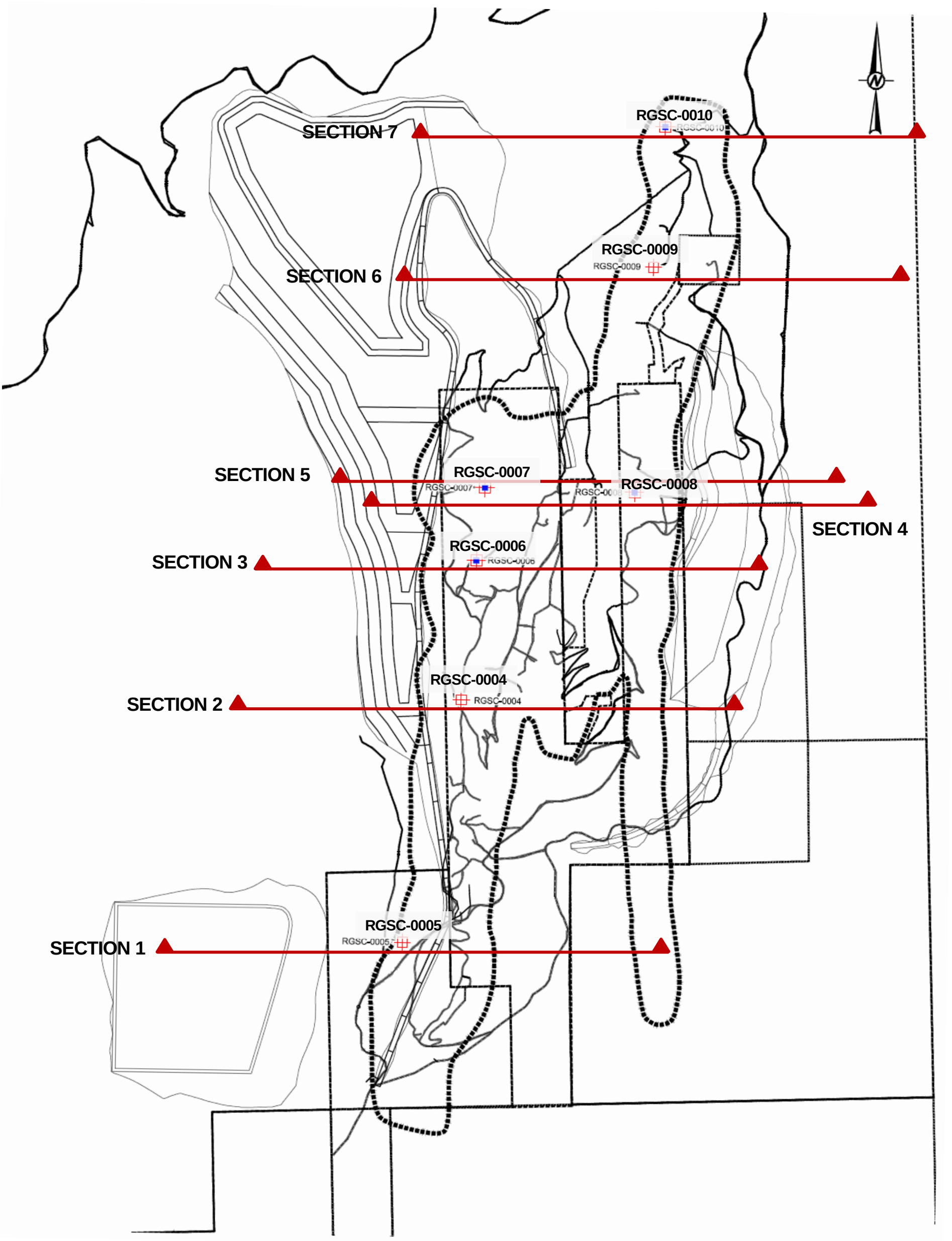


Plate E-7: RMR76 Interval Distribution – RGSC-0010

\\golder.gds\gal\burnaby\final\2014\dynamics numbers - mining division\1406422\1406422-001-r-rev0-2.0\appendix e - rock mass quality assessment\1. appendix e-rmr distributions.docx



NOTE: MINE DESIGN SHOWN IS INDICATIVE AND NOT REPRESENTATIVE OF FEASIBILITY LEVEL PIT DESIGN

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CONSULTANT
Golder Associates

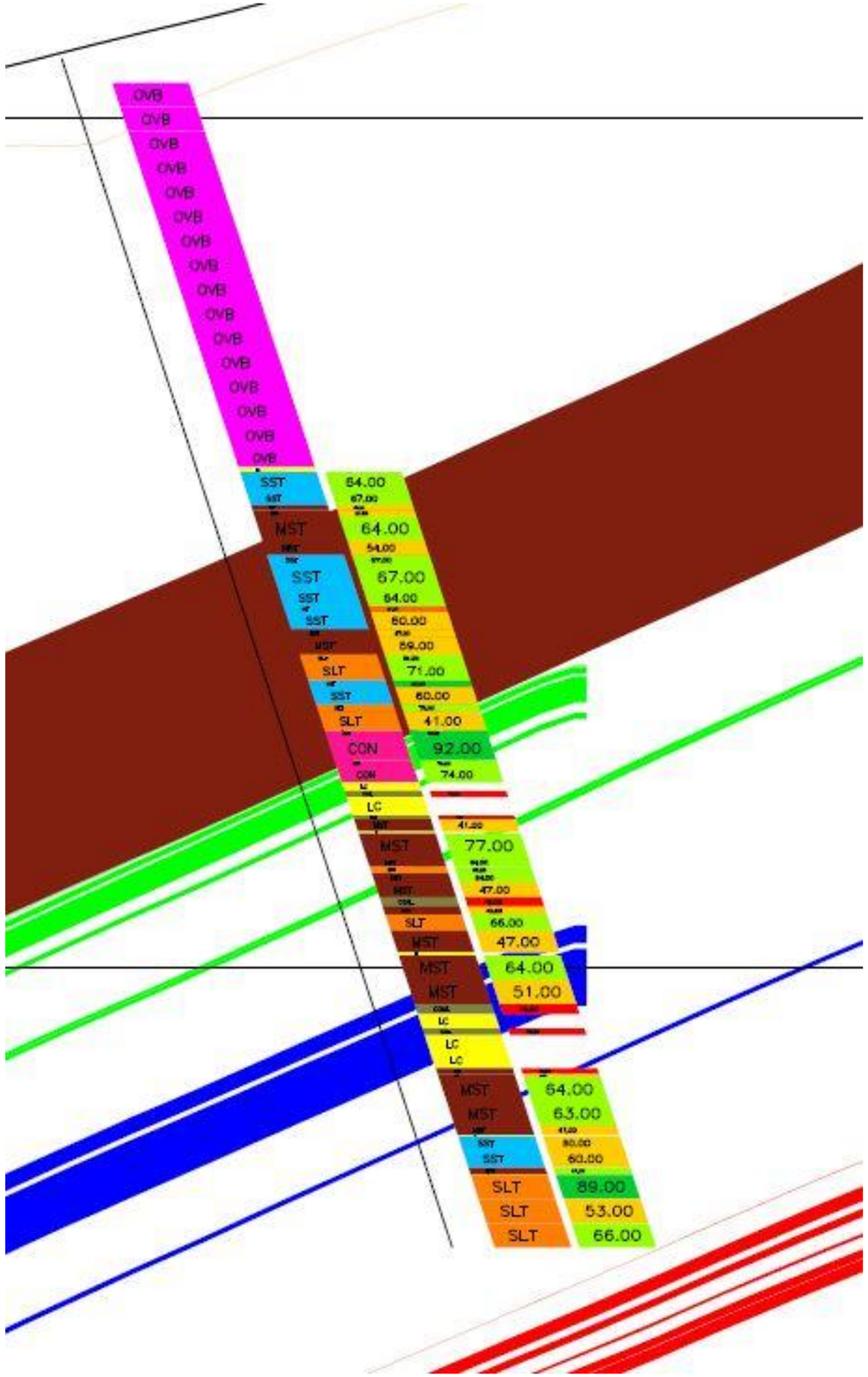
YYYY-MM-DD	2015-04-06
PREPARED	AGH
DESIGN	EAS
REVIEW	EAS
APPROVED	EAS

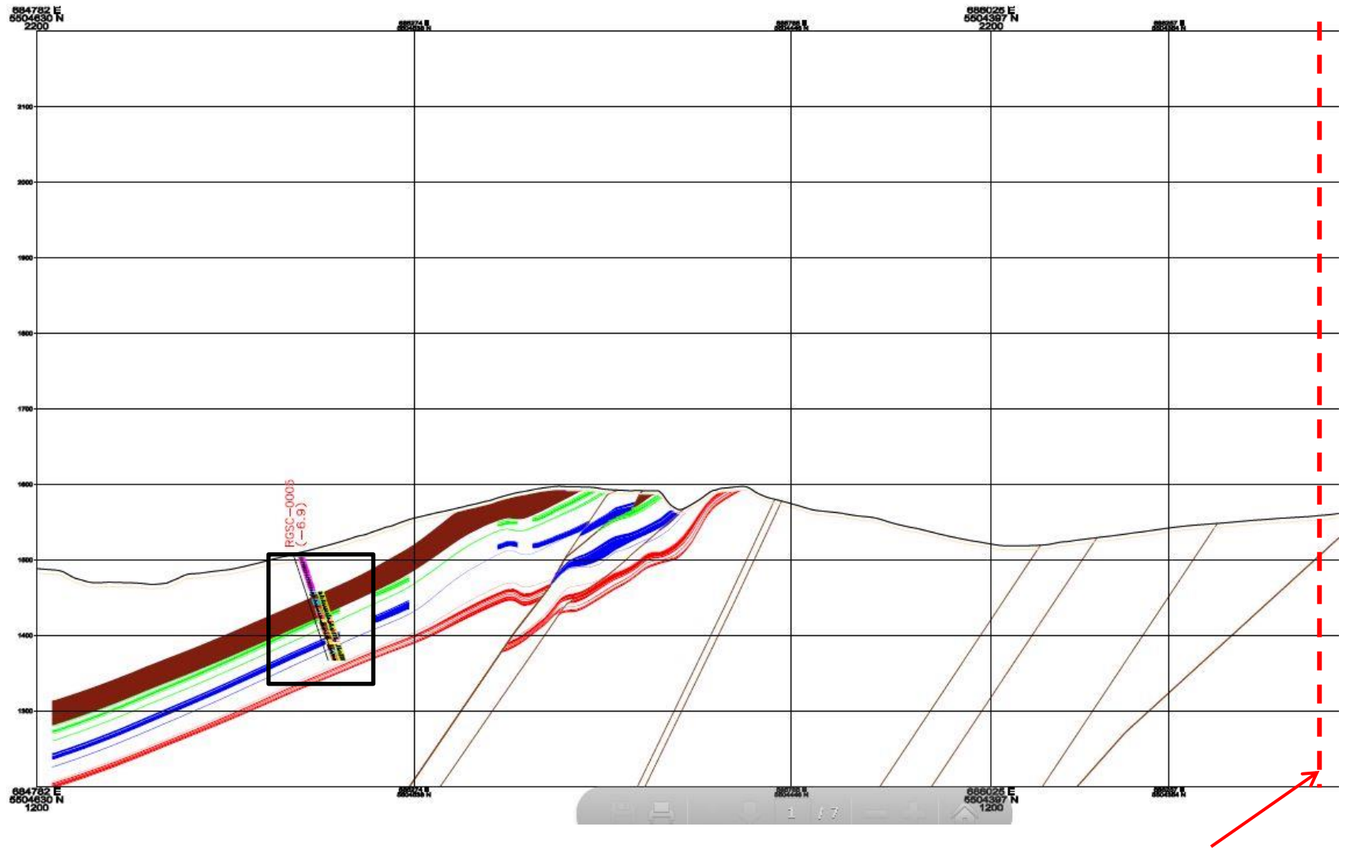
PROJECT
GRASSY MOUNTAIN PRELIMINARY PIT SLOPE STABILITY ASSESSMENT

TITLE
LOCATION OF GEOLOGICAL SECTIONS

PROJECT No.	Rev.	FIGURE
2850-MN-0001-0	0	E-1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B
1 in
0





REFERENCE LINE

Lithology	RMR_{76}
Overburden	0-20
Coal	20-40
Fault	40-60
Lost Core	60-80
Conglomerate	80-100
Sandstone	No Data
Siltstone	
Mudstone	
Carbonaceous Mudstone	

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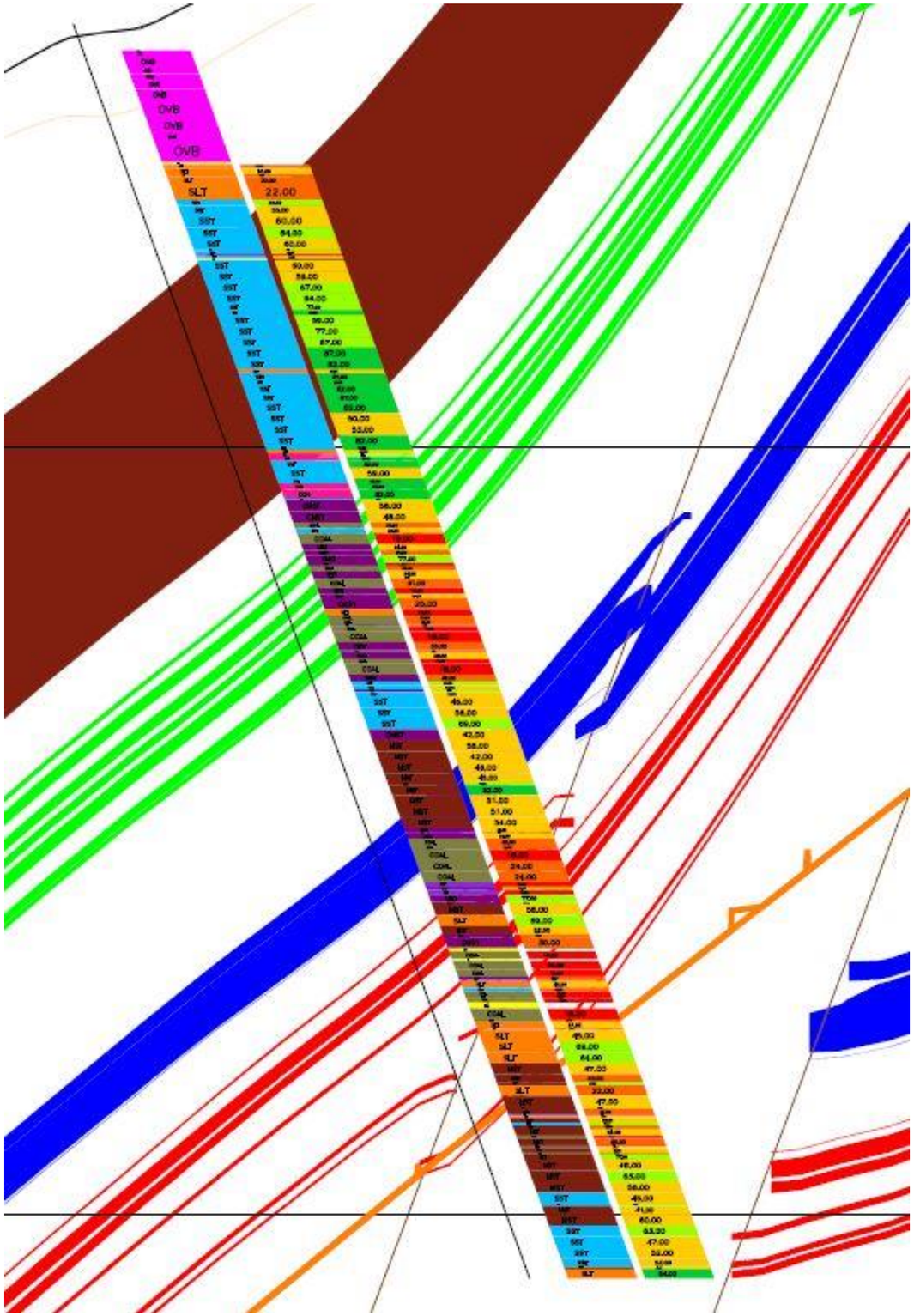
PREPARED	AGH
DESIGN	AGH
REVIEW	EAS
APPROVED	AVC

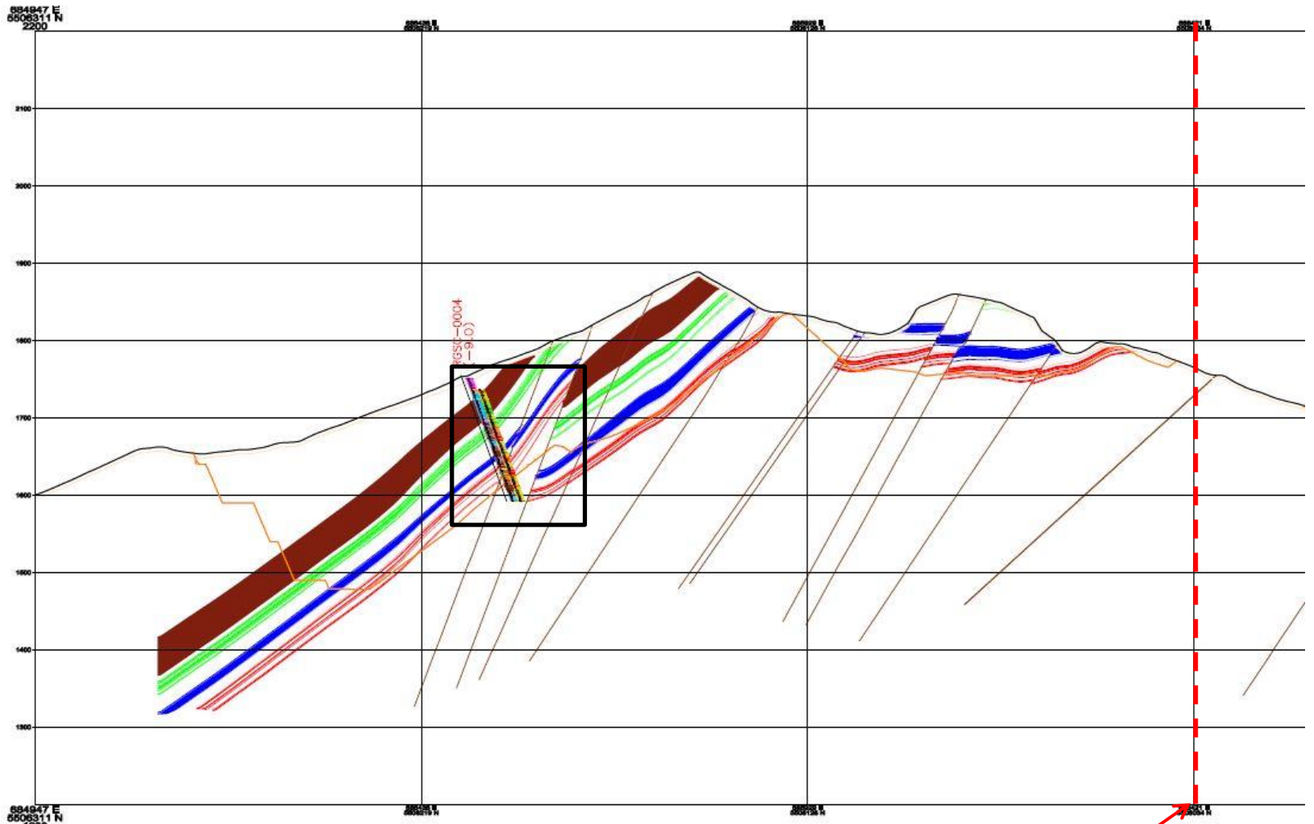
PROJECT
GRASSY MOUNTAIN PRELIMINARY PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 1 – RMR_{76} PLOT

PROJECT No. **2850-MN-0001-0** | Rev. **0** | FIGURE **E-2**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B





REFERENCE LINE

Lithology	RMR_{76}
Overburden	0-20
Coal	20-40
Fault	40-60
Lost Core	60-80
Conglomerate	80-100
Sandstone	No Data
Siltstone	
Mudstone	
Carbonaceous Mudstone	

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APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PRELIMINARY PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 2 – RMR_{76} PLOT

PROJECT No.	Rev.	FIGURE
2850-MN-0001-0	**0**	**E-3**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B
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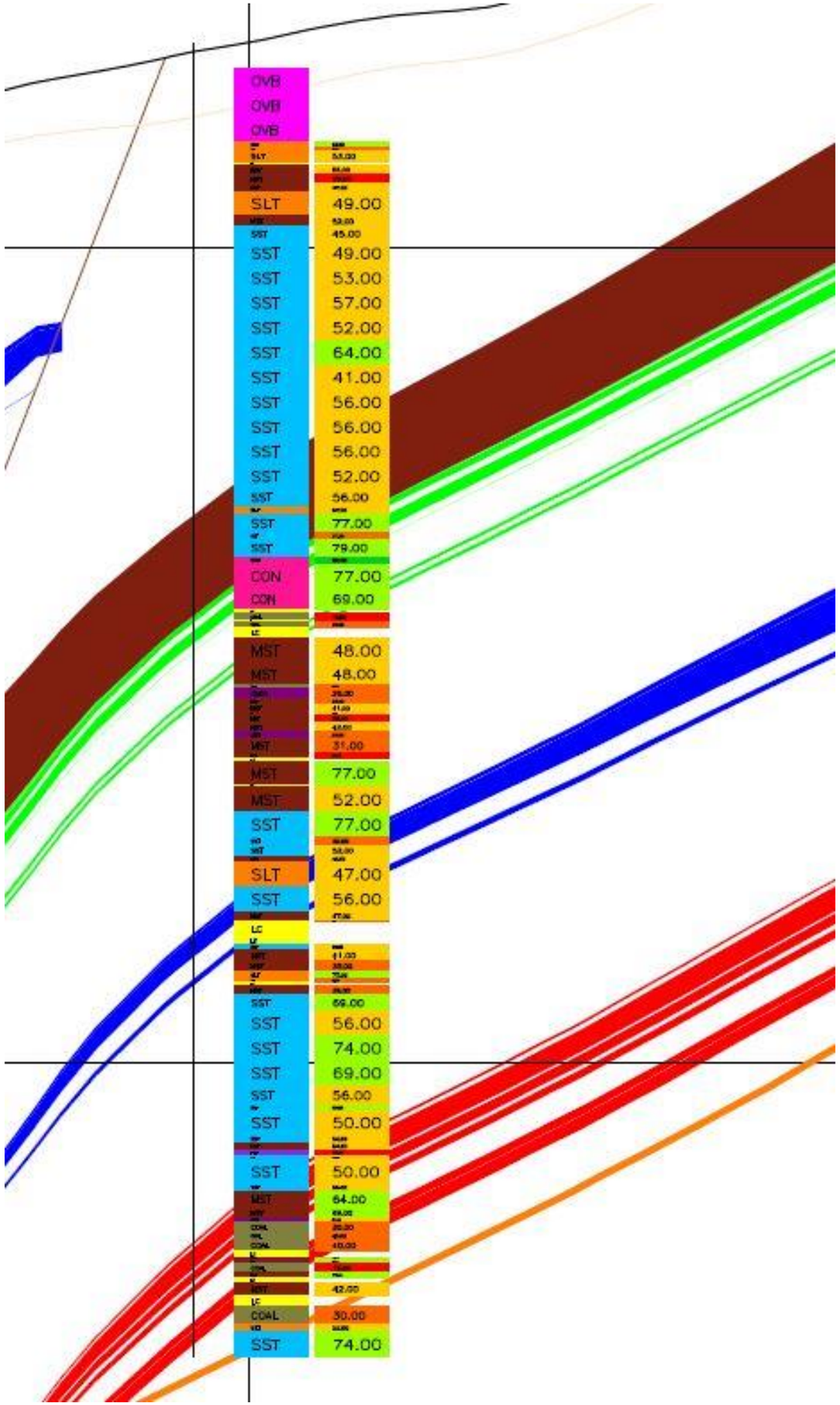

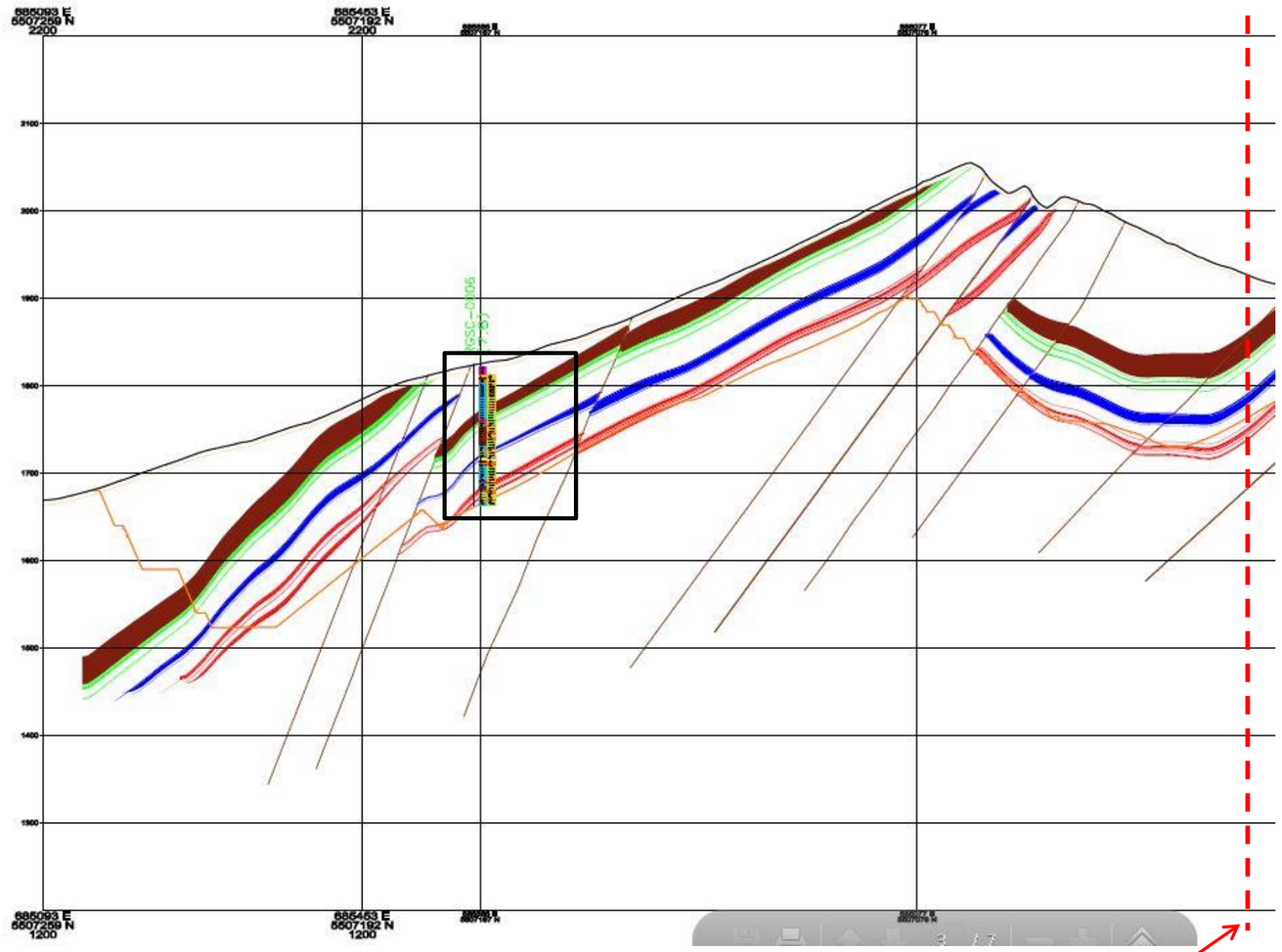

REFERENCE LINE

Lithology	RMR_{76}
Overburden	0-20
Coal	20-40
Fault	40-60
Lost Core	60-80
Conglomerate	80-100
Sandstone	No Data
Siltstone	
Mudstone	
Carbonaceous Mudstone	

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PROJECT
GRASSY MOUNTAIN PRELIMINARY PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 3 – RMR_{76} PLOT

PROJECT No. **2850-MN-0001-0** | Rev. **0** | FIGURE **E-4**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B
1 in
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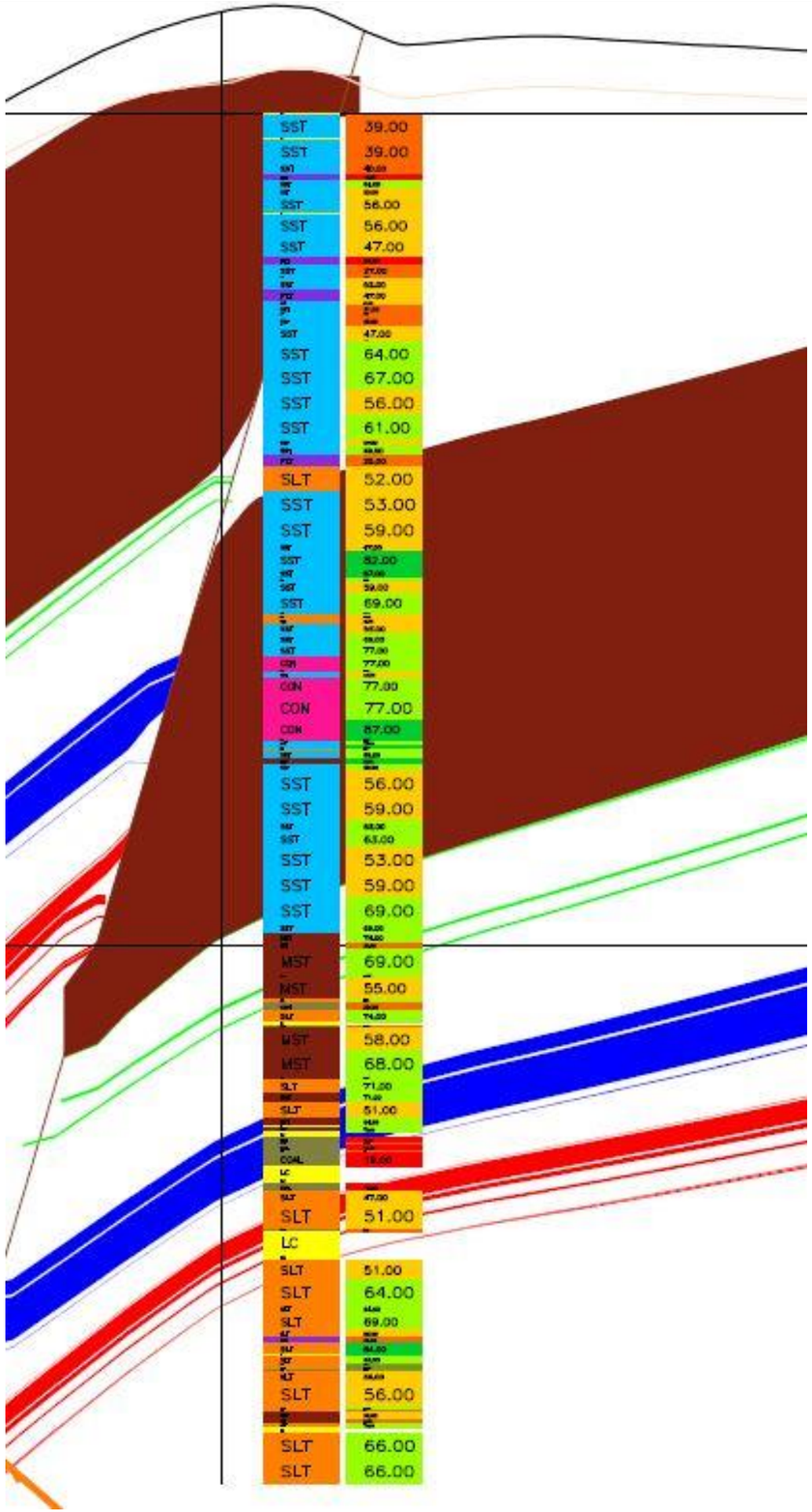

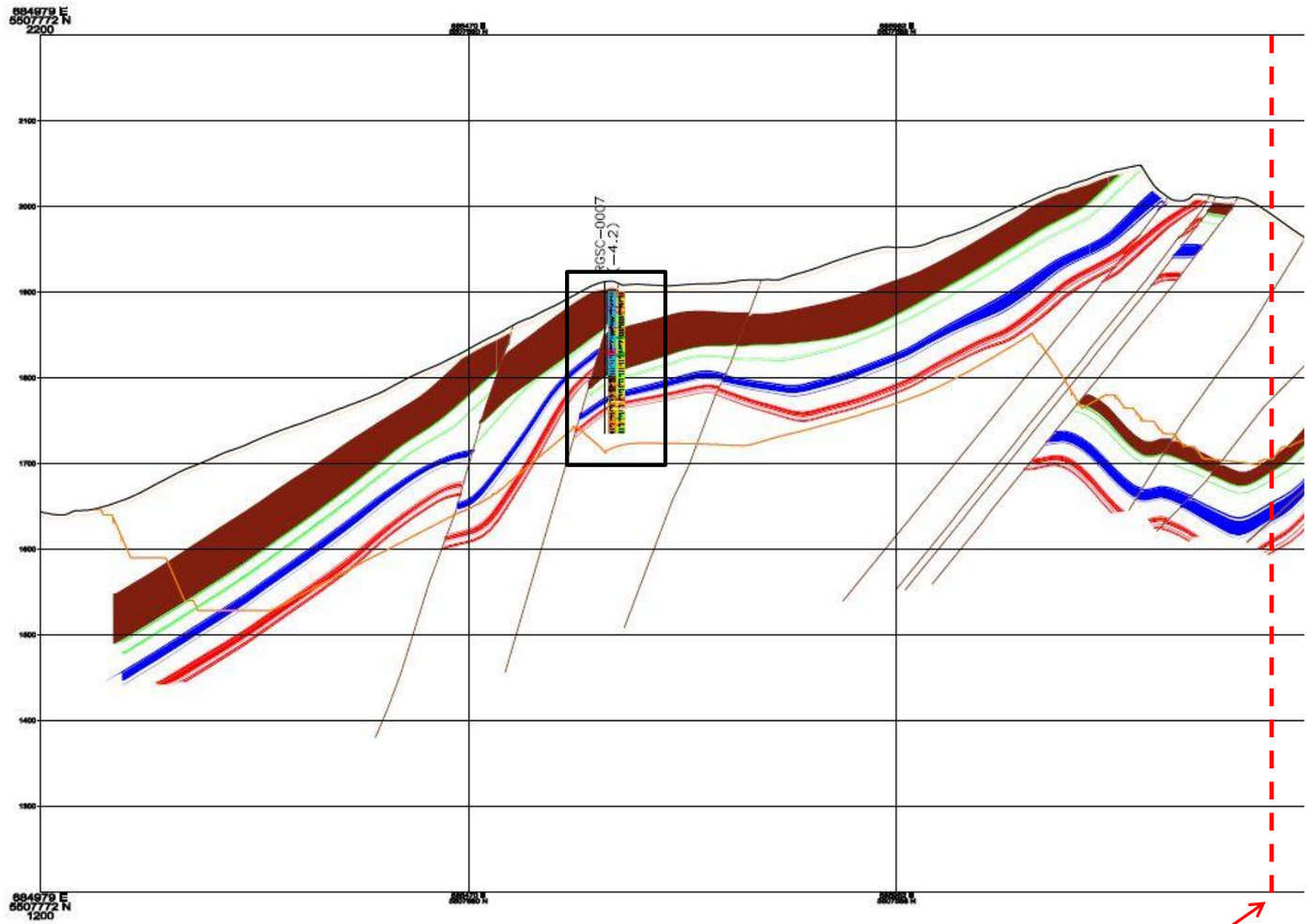

Lithology	RMR_{76}
Overburden	0-20
Coal	20-40
Fault	40-60
Lost Core	60-80
Conglomerate	80-100
Sandstone	No Data
Siltstone	
Mudstone	
Carbonaceous Mudstone	

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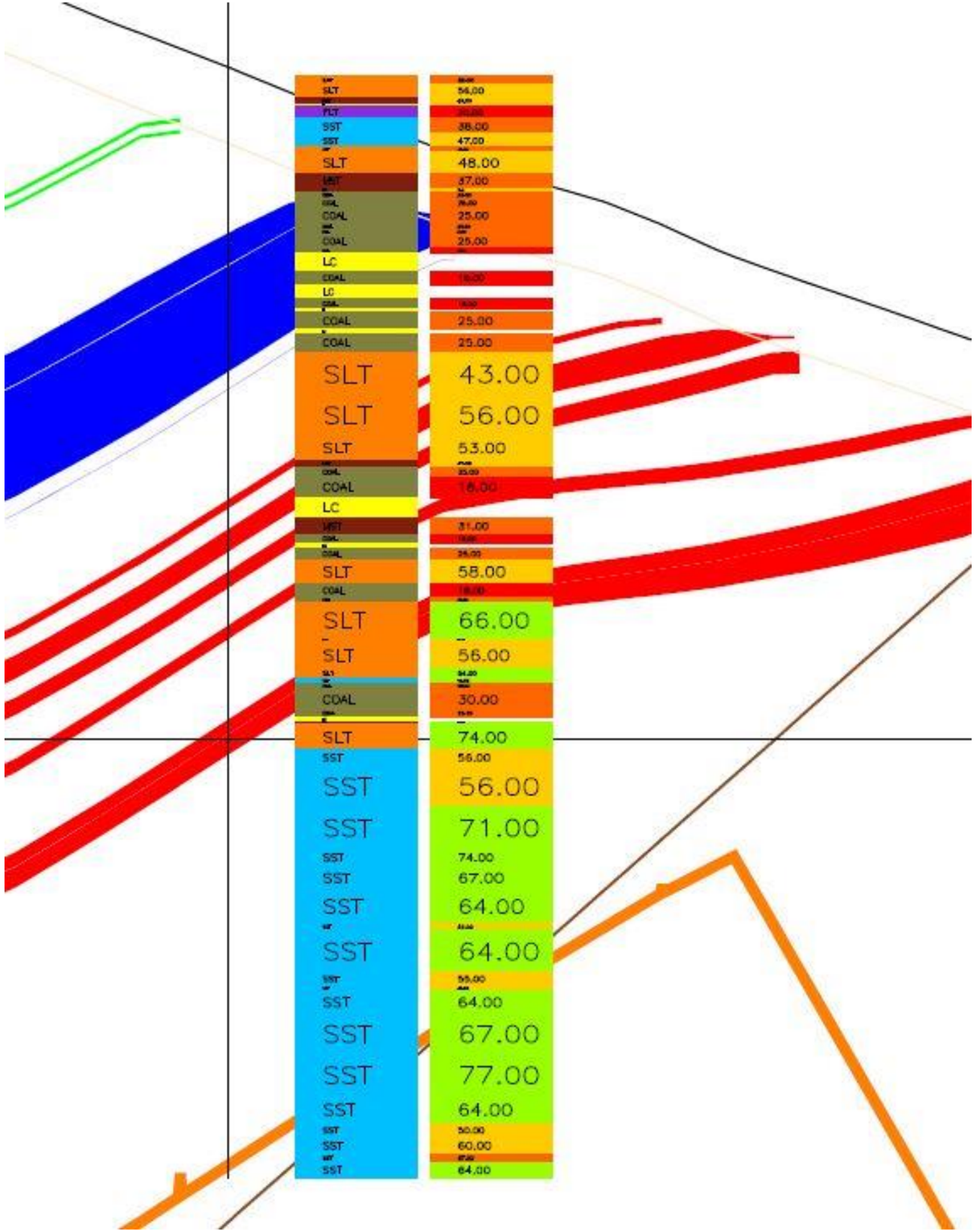
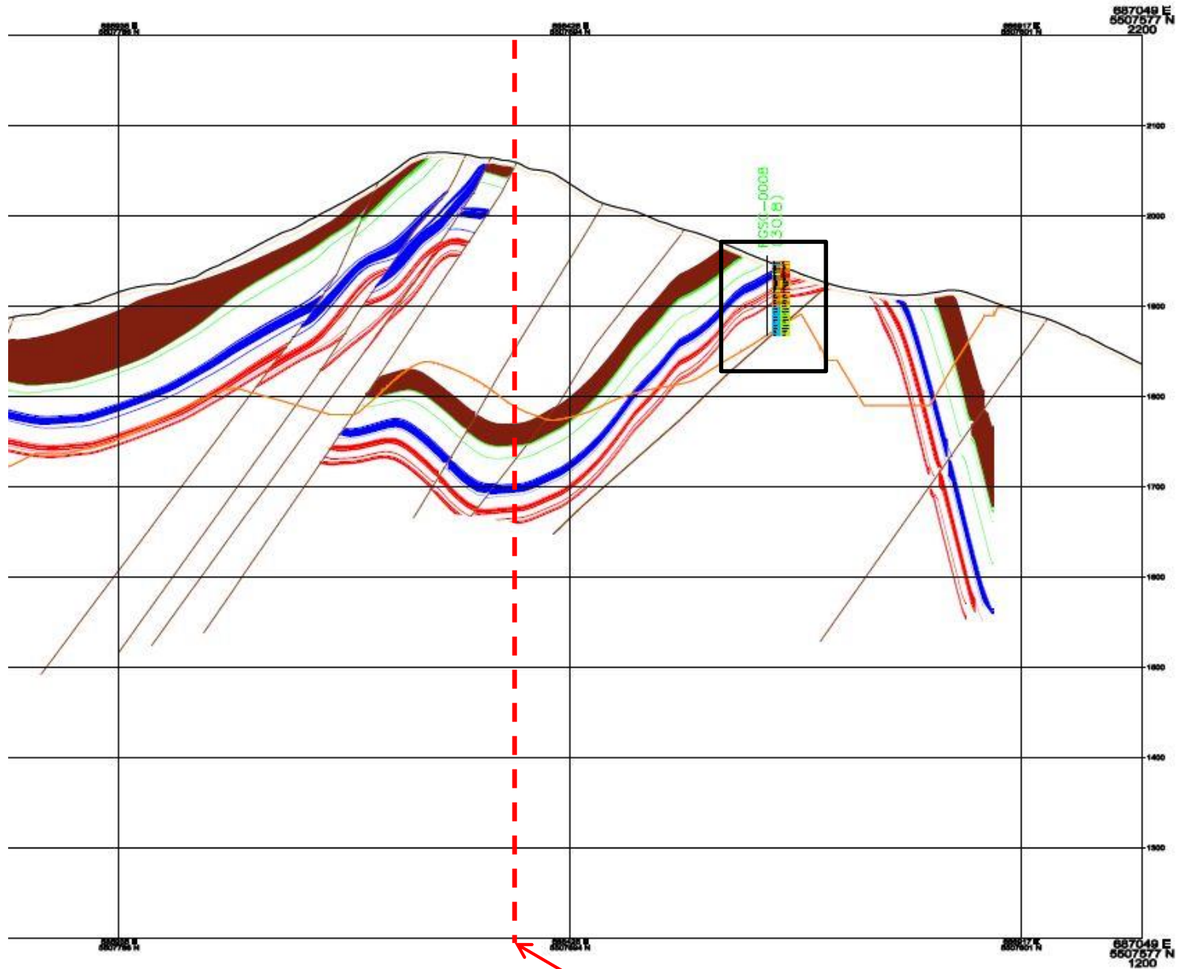
GRASSY MOUNTAIN PRELIMINARY PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 4 – RMR_{76} PLOT

PROJECT No. **2850-MN-0001-0** | Rev. **0** | FIGURE **E-5**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B
1 in
0





Lithology

- Overburden
- Coal
- Fault
- Lost Core
- Conglomerate
- Sandstone
- Siltstone
- Mudstone
- Carbonaceous Mudstone

RMR_{76}

- 0-20
- 20-40
- 40-60
- 60-80
- 80-100
- No Data

REFERENCE LINE

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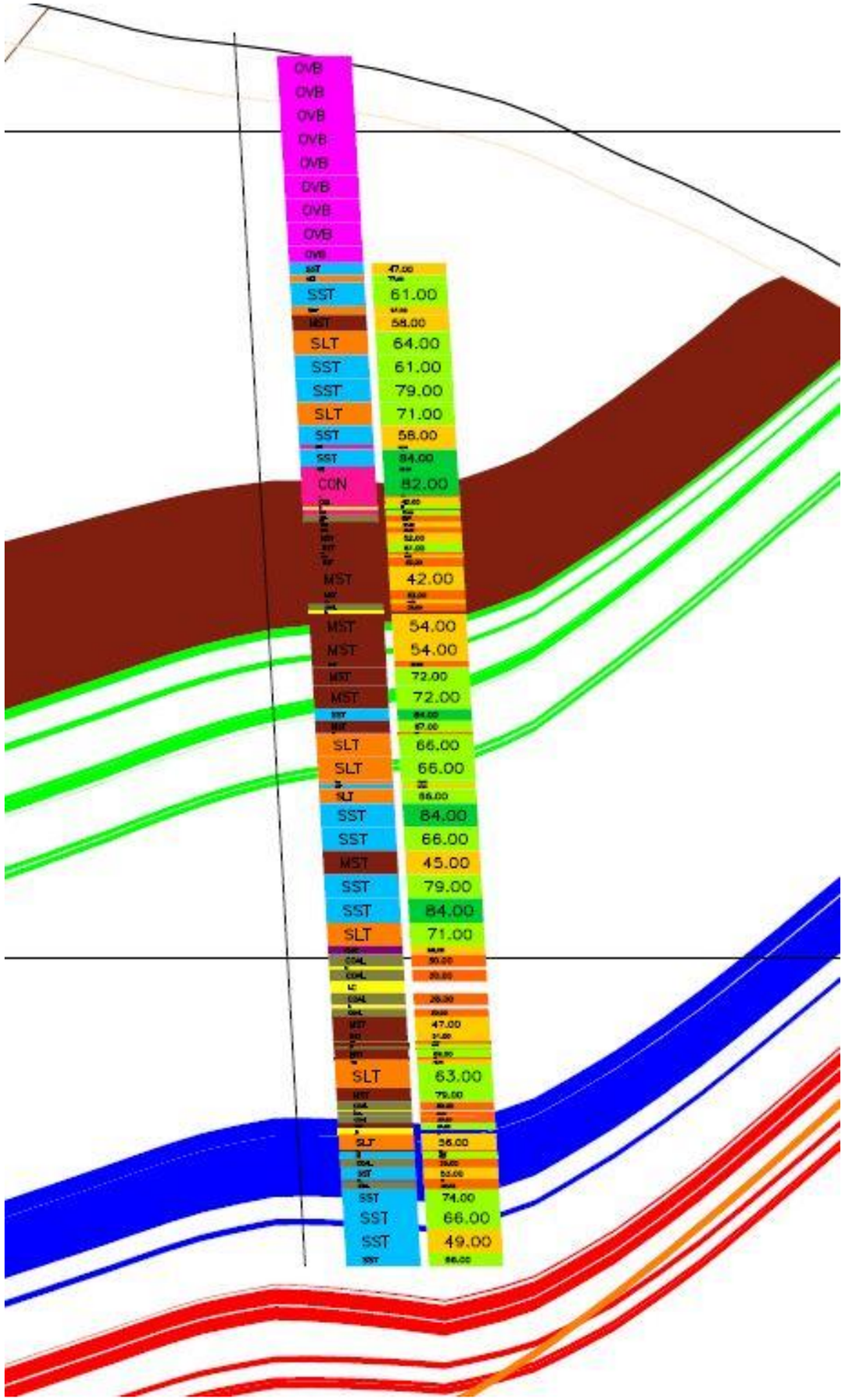
GRASSY MOUNTAIN PRELIMINARY PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 5 – RMR_{76} PLOT

PROJECT No. **2850-MN-0001-0**
Rev. **0**
FIGURE **E-6**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B


OVB
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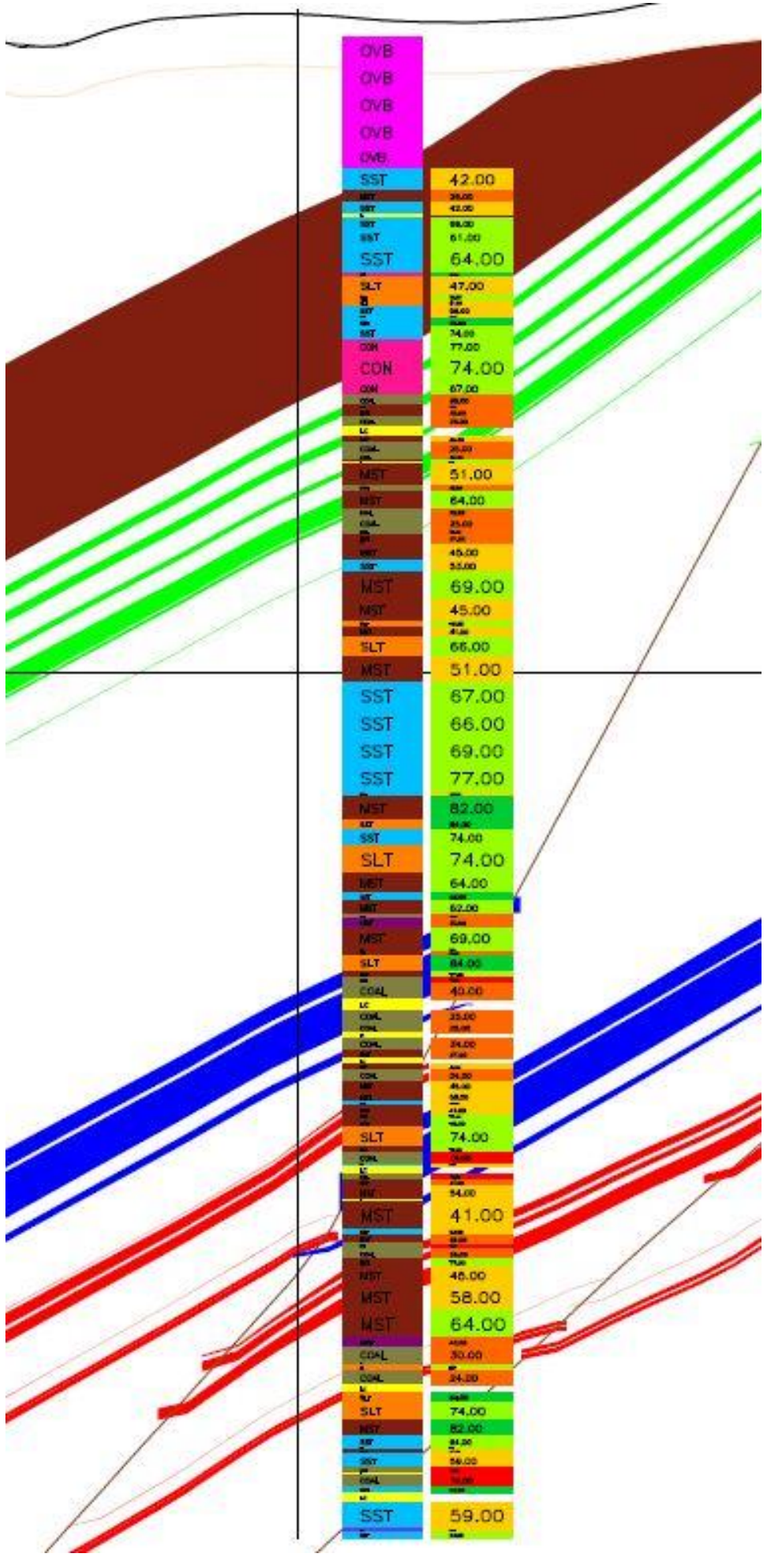
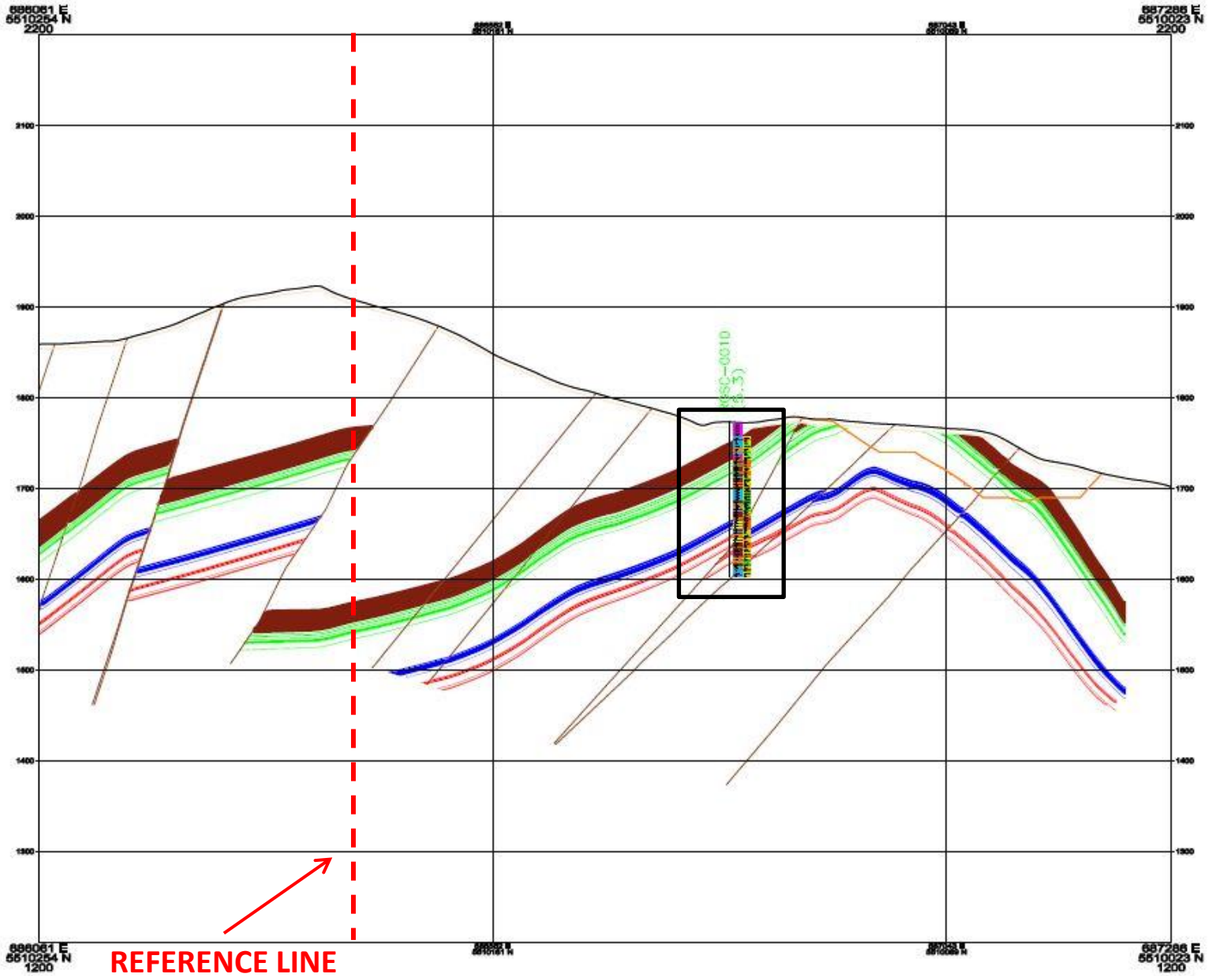
SLT
CON
MST
SST
SLT
MST
SST
SST
SLT
SST
SST
SST





Lithology	RMR_{76}
Overburden	0-20
Coal	20-40
Fault	40-60
Lost Core	60-80
Conglomerate	80-100
Sandstone	No Data
Siltstone	
Mudstone	
Carbonaceous Mudstone	

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PROJECT
GRASSY MOUNTAIN PRELIMINARY PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 7 – RMR_{76} PLOT

PROJECT No. **2850-MN-0001-0** | Rev. **0** | FIGURE **E-8**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B
1 in
0

APPENDIX F

Hydrogeological Field Data Technical Memo

April 24, 2015
Reference No. 1406422-001-R-Rev0-2.0
Client No. 2850-MN-0001-0

October 2014

RIVERSDALE RESOURCES LIMITED

Packer Testing and Nested Vibrating Wire Piezometer Installation

Submitted to:
Riversdale Resources Limited

REPORT

Report Number: 1406422

Golder Associates

Table of Contents

1.0 INTRODUCTION 1

2.0 METHODS 1

2.1 Rational for Packer Testing and Nested Vibrating Wire Piezometer Locations 1

2.2 Packer Testing 1

2.3 Packer Testing Data Analysis 2

2.4 Installation of Nested Vibrating Wire Piezometers 3

3.0 RESULTS 3

3.1 Packer Tests 3

3.2 Transmissivity and Hydraulic Conductivity 4

3.3 Installation of Nested Vibrating Wire Piezometers 4

4.0 CLOSURE 6

LIMITATIONS 7

REFERENCES 8

TABLES

Table 1: Summary of Geotechnical Boreholes

Table 2: Packer Testing Analysis

Table 3: Variation of Hydraulic Conductivity with Depth

Table 4: Summary of Nested Vibrating Wire Piezometer Installations

FIGURES

Figure 1: Geotechnical Boreholes and Vibrating Wire Piezometer Installations

Figure 2: Schematic for Single Packer Wireline Packer System

Figure 3: Schematic of Flow Control Board Used for Packer Testing

APPENDICES

APPENDIX A
Calibration Certificates for Vibrating Wire Piezometers

APPENDIX B
Analysis Plots of Packer Testing Data

APPENDIX C
Hydraulic Conductivity Borehole Profiles

APPENDIX D
Vibrating Wire Piezometer Installation Schematics

APPENDIX E
Vibrating Wire Piezometer Field Data Sheets

APPENDIX F
Vibrating Wire Piezometer Pressure Data Plots

1.0 INTRODUCTION

As part of the hydrogeology component of the Grassy Mountain Project Feasibility Study, the hydrogeology team performed hydraulic testing (packer testing) in each of the seven geotechnical boreholes and nested vibrating wire piezometer installations in three of the seven geotechnical holes. The objectives of these tasks were to collect data to support ongoing pit design as part of the Feasibility Study. The borehole locations are provided in Figure 1 and borehole information is provided in Table 1.

This report is an interim deliverable that includes methodology and results obtained from packer testing and nested vibrating wire piezometer installations for the hydrogeology component of the Feasibility Study.

2.0 METHODS

The following section describes the methods the packer testing and nested vibrating wire piezometer installations.

2.1 Rational for Packer Testing and Nested Vibrating Wire Piezometer Locations

Packer testing was performed in each of the seven geotechnical boreholes to gain an understanding of the bedrock hydraulic properties, specifically hydraulic conductivity, across the site. Nested vibrating wire piezometer installation locations were chosen to provide spatially distributed data for formation pressure across the site. The formation pressure is used to estimate the hydraulic head.

2.2 Packer Testing

Packer testing was performed in each borehole using the single packer testing method (Figure 2). The base case approach was to interrupt drilling approximately every 50 m and perform a packer test over the recently drilled interval. However, this nominal interval was adjusted based on borehole stability issues and logistical considerations. Details of the test procedure are discussed below.

Prior to lowering packer tool to the selected test depth, the borehole was flushed with water in an attempt to displace drilling fluid from the selected test interval. At the end of flushing, the drill bit was pulled back to near the top of the target test interval. A pressure transducer was placed in the bottom section of the packer tool to record downhole pressure and temperature. Once the gauge was installed, the wireline single-packer testing tool was lowered into the borehole, through the drill bit. When the single-packer testing tool had landed in the bit, the packers were inflated with nitrogen through an inflation line connecting the nitrogen bottle at surface to the packers, thereby isolating the bottom portion of the borehole.

The test consisted of the following steps:

- A nominal 30 minute equilibration period that allowed for the formation pressure to recover back towards static.
- Following the equilibration period, the rods were filled with clean water from surface and a slug test was performed to provide an indication for the order of magnitude transmissivity. The slug test method consists of adding a near-instantaneous slug of water into the test rods. After the slug placement, the water level inside the test rods was monitored for a 30 minute period.

- At the end of the slug recovery period, clean water was pumped for 30 minutes through a flow control board at the surface (Figure 3) before being directed into the test interval for a constant rate injection period. The build-up of surface pressure and cumulative volume flowing through the flow board were recorded at one minute intervals. Surface pressure was monitored during the test to ensure it did not exceed 50 psi, maximum operating pressure of surface equipment. If surface pressure was approaching 50 psi the flow rate was reduced by use of the bypass valve or the test was shut off.
- Following the 30 minute injection period, a 30 minute constant rate recovery period was monitored.
- The packer test was completed at the end of this 30 minute recovery period. Following deflation of packers, the equipment was removed from the borehole and the data from the transducer was uploaded to a laptop.
- Finally, the packer test data was forwarded for offsite senior review and comments were provided back to the field team for subsequent tests.

During the test, the packer pressure was continuously checked to confirm there were no leaks. In addition, the annulus was continuously checked for bypass flow around the packer, which would invalidate the test.

2.3 Packer Testing Data Analysis

The analyses of the packer testing data was carried out with HydroBench® (Version 3.7.0), a Golder internally-developed software package designed to analyse different types of hydrogeological tests. HydroBench® includes the deconvolution approach to analyze single-well response test data (Peres et al., 1989; Chakrabarty and Enachescu, 1997). Both homogeneous and composite flow models may be used to interpret the data. Composite models allow for matching a change in properties with distance from the well. In using the composite model, often the outer zone properties are considered more representative for the undisturbed formation properties as the inner zone parameters are often influenced by the filter pack and drilling disturbed zone near the well.

HydroBench® also includes a plot of the derivative of pressure (i.e., rate of pressure change) with respect to the natural logarithm of time (e.g. Gringarten, 2008) that has shown to significantly improve the diagnostic and quantitative analysis of slug tests (Spane and Wurstner, 1993).

Transmissivity was derived from the analysis and hydraulic conductivity was computed by dividing the transmissivity by the saturated thickness. In particular, transmissivity is derived from the pressure match to the radial flow period. The analysis emphasized the latter time data beyond the effects of the near well disturbed zone from drilling influenced effects.

The software HydroBench© was extensively verified with commercially available In-Situ test analysis software such as *Interpret 2009*® by Paradigm Ltd. or *nSights2.5*® by Sandia National Laboratories. Multiple forward simulations of hydrogeologic tests such as constant rate injection and withdrawal tests, slug injection, and withdrawal tests within different aquifer geometries and boundary conditions were carried out with the software packages and re-analyzed with HydroBench®. All aquifer parameters analyzed with HydroBench® showed no or only slight differences (less than 2%) to the input parameters used for the forward simulations. A documentation of the verification procedures of HydroBench® is available upon request.

2.4 Installation of Nested Vibrating Wire Piezometers

Nested vibrating wire piezometers were installed in three selected boreholes. Three piezometer pressure gauges were installed in each borehole and gauge depth was selected based on geology, groundwater elevation, and permeable formations and to provide nominal spatial distribution of formation pressure along the borehole. The planned depths were determined by the field hydrogeologist and further confirmed by a Golder senior hydrogeologist.

Prior to their installation, the pressure gauges were zeroed at the drill rig. This was completed by using the factory set calibration factors of each pressure gauge, and the pressure reading at surface. All zero readings were recorded for future reference. Pressure gauges were submerged in clean water for 24 hours to multiple days preceding the installation to ensure they remained saturated up until installation.

The pressure gauges were installed on one-inch diameter PVC rods with the pressure sensor facing upwards. The deepest pipe was bevelled on the lower end and the bottom six pipes were perforated to allow circulation of grout into base of borehole. This set up allowed for grout to fill the borehole from the bottom upwards, displacing fluid in the borehole to surface.

As the drill crew lowered the PVC rods to the total depth of the borehole, the gauges were taped to the PVC rods at the pre-determined depths. To protect the pressure gauge during lowering, a section of durable plastic was placed around each gauge. During lowering of the rods into the borehole, the vibrating wires that extend from the pressure gauges to surface were taped to the pipe, approximately every three meters.

Once the pipe was set at total depth, a grout mixture of water, cement and bentonite powder was mixed at surface and pumped down through the PVC pipe. The mixture was guided based on the recommendations in Mikkelsen and Green, 2003. This mixture consisted of approximately one 94-pound bag of cement for every 115 litres of fresh water, mixed with one-half of a 25-pound bag of bentonite powder. This mixture was based on the recommendations of Mikkelesen and Green, 2003, but was adapted to the meet the conditions of the drillers equipment on site.

Grout was pumped into the borehole until returned to surface via the annulus (maximum of three well volumes) borehole. Grout levels were measured multiple days following installations and bentonite chips were used to fill the annulus above the settled grout to a maximum of 15 metres below ground surface (mbgs).

To complete the surface installation, the vibrating wire bundles protruding out of the top of the borehole were connected into a data logger (DT2055B). The data logger was left on surface to continually record data at one hour intervals.

Factory calibration certificates of the nested vibrating wire piezometers are included as Appendix A.

3.0 RESULTS

3.1 Packer Tests

A total of 14 successful single-packer tests were performed in seven boreholes. Results of these tests, including date and time of test, test depth interval, average surface pressure and injection rate are summarized in Table 2.

3.2 Transmissivity and Hydraulic Conductivity

As discussed in Section 2.3, all analyses were conducted using Hydrobench®. Transmissivity values were derived in Hydrobench® and the bulk hydraulic conductivity values were computed by dividing the transmissivity by the test interval (Table 2). The log-log plots and match to entire simulation plots for each test from Hydrobench are included as Appendix B.

Estimated bulk hydraulic conductivity values range between $5x10^{-6}$ metres per second (m/s) and $5x10^{-9}$ m/s. The geometric mean of all tests is $1x10^{-7}$ m/s. Transmissivity and hydraulic conductivity profiles for each borehole are included as Appendix C. Coal seam intervals are also included on the profiles.

On a borehole basis, the geometric mean values are summarized below from lowest to highest:

- RGSC-0007: $3x10^{-8}$ m/s (3 tests);
- RGSC-0005: $4x10^{-8}$ m/s (2 tests);
- RGSC-0009: $5x10^{-8}$ m/s (2 tests);
- RGSC-0008: $1x10^{-7}$ m/s (1 tests);
- RGSC-0006: $2x10^{-7}$ m/s (2 tests);
- RGSC-0004: $8x10^{-7}$ m/s (2 tests); and
- RGSC-0010: $1x10^{-6}$ m/s (2 tests).

Based on experience and literature (Gentzis 2005), the magnitude of values is consistent with Mist Mountain in the Elk Valley, with typical values between 10^{-6} to 10^{-9} m/s (with majority 10^{-7} to 10^{-9} m/s) and with higher values often observed at shallow depths. Observations in the pit walls at the Elkview mine in the Elk Valley, B.C. show water flowing at the contact between interburden and select coal seams that suggests lower hydraulic conductivity in the underlying coal unit. In general burial and uplift, followed by various episodes of intense thrusting and folding, have exerted a profound effect in reducing the permeability of the coals in the Canadian Foothills and Mountains (Gentzis 2005).

Although a limited number of tests, the tests show a decrease in hydraulic conductivity with depth (Table 3).

No consistent correlation was observed between lithology and hydraulic conductivity.

3.3 Installation of Nested Vibrating Wire Piezometers

Table 4 provides a summary of the nested vibrating wire piezometer installation.

Nested vibrating wire piezometers were installed in three of the seven geotechnical boreholes. There were three gauges installed in each of the four boreholes, at deep, medium, and shallow depth intervals for a total of 9 gauges. Information regarding these nested vibrating wire piezometers including gauge tip depth, gauge serial number, and water level prior to grouting can be found in Table 4 and on installation schematics, provided as Appendix D. Appendix E presents the field-installation sheets of the vibrating wire piezometers.

In all boreholes, grout was returned to surface during grouting. An attempt was made to seal the entire annulus using grout; however, the grout fell to approximately 10 meters below ground surface at RGSC-0005 and

RGSC-0009. The remaining open annulus was filled with bentonite pellets to create a surface seal. In all installs, all 3 gauges were sealed with grout.

The gauges have been connected to a data logger at each location and are programmed to record pressure and temperature measurements at one hour intervals. All three data loggers were downloaded prior to leaving site. Plots of these data are provided in Appendix F and specific comments are provided below:

- The readings show a general decreasing trend with depth that indicates in a recharge area and consistent with higher topographic position.
- The shallow and intermediate piezometers in borehole RGSC-0006 show similar absolute readings that suggest the zones adjacent to the gauges are hydraulically well-connected.

4.0 CLOSURE

We trust the above meets your present requirements. If you have any questions or require additional details, please contact the undersigned.

GOLDER ASSOCIATES LTD.

APEGA Permit to Practice #05122

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Groundwater Scientist

Report reviewed by:

John Wozniewicz, M.Sc., P.Geol.
Principal, Senior Hydrogeologist

BW/JW/cs

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Mikkelsen, P. Erik and Gordan E. Green 2003. Piezometers in Fully Grouted Boreholes. FMFM 2003, Field Measurements in Geomechanics, Oslo, Norway.

Spane F.A. and S.K. Wurstner, 1993. DERIV: A computer program for calculating pressure derivatives for use in hydraulic test analysis. Ground Water, Vol. 31, no. 5, p. 814-822.

TABLES

Table 1:
Summary of Geotechnical Boreholes

Borehole Name	Easting	Northing	Elevation (masl)	Dip	Azimuth	Vibrating Wire Piezometer Installation
RGSC-0004	685490	5506218	1755	70	100	Yes
RGSC-0005	685118	5504574	1508	70	100	Yes
RGSC-0006	685577	5507161	1826	90	0	No
RGSC-0007	685627	5507655	1912	90	0	No
RGSC-0008	686638	5507638	1955.78	90	0	No
RGSC-0009	686742	5509160	1912.39	70	20	Yes
RGSC-0010	686807	5510108	1774.33	90	0	No

Table 2:
Packer Testing Analysis

Borehole Number	Packer Test No:	Test depth from	Test depth to	Lithology [1]	Average Injection Rate (l/min)	Maximum Injection Pressure (psi)	Transmissivity		Hydraulic Conductivity		Hydraulic Conductivity Geometric Mean	Comments
		mbgs	mbgs				m2/s (inner)	m2/s (outer)	m/s (inner)	m/s (outer)	m/s	
RGSC-0004	1	93.74	164.09	Coal Seam 2 & 4 (34m) and Interburden	114.50	5.5	4.E-04	-	5.E-06	-	8.E-07	
	2	47.91	164.09	Coal Seam 1 & 2 & 4 (55m) and Interburden	110.50	6.5	2.E-05	-	1.E-07	-		
RGSC-0005	1	57.42	92.00	Coal Seam 1 (25m) and Interburden	9.97	17.0	8.E-06	-	2.E-07	-	4.E-08	
	2	95.38	140.01	Coal Seam 1 (7m) and Interburden	0.86	46.0	3E-07	-	6E-09	-		
RGSC-0006	1	59.05	91.31	Coal Seam 1 (21m) and Interburden	40.10	40.0	4E-06	-	1E-07	-	1E-07	
	2	92.6	145.96	Coal Seam 1 (53m) and Interburden	32.63	9.0	9E-06	-	2E-07	-		
RGSC-0007	1	46.6	78.8	Interburden	15.40	46.0	2E-06	-	7E-08	-	3E-08	
	2	77.1	124.65	Interburden	11.70	46.0	8E-06	3E-07	2E-07	7E-09		Variable injection rates.
	3	125.9	176.7	Coal Seam 1 (11m) and Interburden	1.50	46.0	3E-07	-	5E-09	-		
RGSC-0008	1	18.63	93.55	Coal Seam 2 & 4 (27m) and Interburden	39.40	30.0	1E-05	-	1E-07	-	1E-07	Water level below transducer.
RGSC-0009	1	54.50	99.06	Interburden	81.00	16.0	2E-06	-	4E-08	-	5E-08	Water level was below transducer.
	2	99.01	149.34	Coal Seam 1 (30m)and Interburden	67.80	30.0	3E-06	-	6E-08	-		Water level was below transducer.
RGSC-0010	1	36.8	72.3	Coal Seam 1 (16m)and Interburden	32.84	8.0	1E-04	-	3E-06	-	1E-06	Water flowing out of casing during constant rate injection.
	2	76.43	151.57	Coal Seam 2 & 4 (35m) and Interburden	30.14	12.0	5.E-05	-	7.E-07	-		Water flowing out of casing during constant rate injection.

(-) No data
mbgs: metres below ground surface
m2/s: metres squared per second
m/s: metres per second
l/min: liters per minute

Table 3:
Variation of Hydraulic Conductivity with Depth

Measured Depths (mbgs)	Borehole and Test Number	Number of Tests	Single Value or Geometric Mean Hydraulic Conductivity (m/s)
Interval Between 37 to 72 m	RGSC-0010 Test 1	1	3.E-06
Test with Majority or All of Test Intervals Between 50 and 100 m	RGSC-0005 Test 1, RGSC-0006 Test 1, RGSC-0007 Test 1, RGSC-0008 Test 1, RGSC-0009 Test 1	5	6.E-07
Tests with Majority or All of Test Intervals Between 100 and 150 m	RGSC-0005 Test 2, RGSC-0006 Test 2, RGSC-0009 Test 2	3	3.E-07
Interval Between 126 m to 177 m	RGSC-0007 Test 3	1	5.E-09

Notes
m/s: metres per second
m: metres
mbgs: metres below ground surface

Table 4:
Summary of Nested Vibrating Wire Piezometer Installations

Borehole	Date of Installation	Borehole Angle from Horizontal (°)	Instrument Serial Number	Pressure Range (MPa)	Piezometer Depth (mAH)	Piezometer True Vertical Depth (mbgs)	Piezometer Elevation (masl)	Waterlevel Prior to Grouting (mbgs)
RGSC-0005	25-Aug-14	70	VW29689	1	62.1	58.3	1449.2	0.9
			VW29684	2	91.5	86.0	1421.5	
			VW29682	2	127.7	120.0	1387.5	
RGSC-0006	30-Aug-14	90.00	VW29688	1	39.8	39.8	1786.2	15.4
			VW29685	2	77.5	77.5	1748.4	
			VW29681	2	133.7	133.7	1692.3	
RGSC-0009	16-Sep-14	70.00	VW29687	1	64.3	60.4	1852.0	113.6
			VW29686	2	99.8	93.7	1818.6	
			VW29683	2	144.1	135.4	1777.0	

Notes

MPa: megapascals

(°): degrees

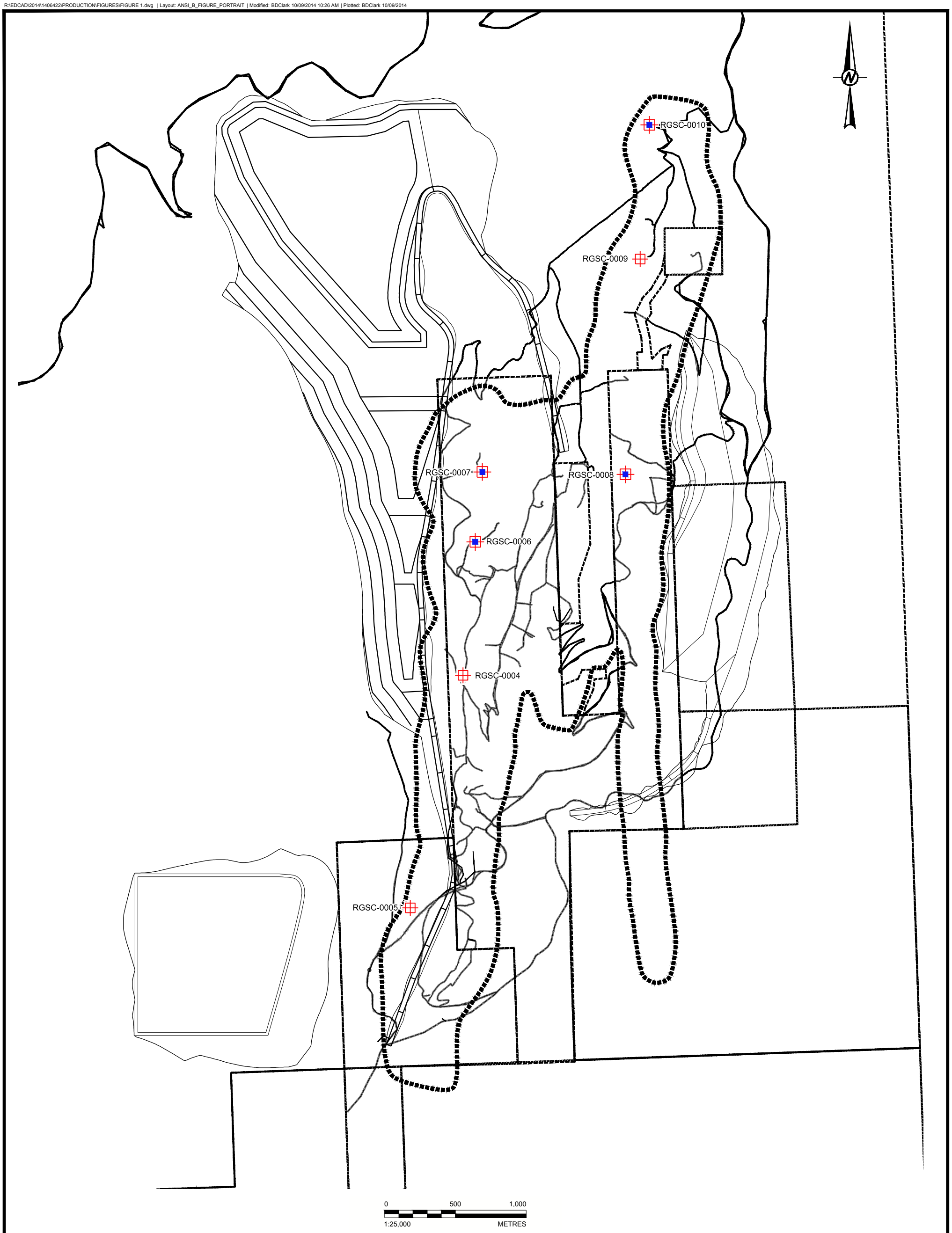
mAH: Metres along hole

mbgs: Metres below ground surface

(masl): metres above sea level

113.6 water level was unable to be obtained with a waterlevel sounder, therefore waterlevel presented was calculated based on pressure readings from the deep piezometer prior to grouting assuming 9.81 kpa/m of water.

FIGURES



LEGEND:

- GEOTECHNICAL BOREHOLES WITH VIBRATING WIRE PIEZOMETER INSTALLATIONS
- GEOTECHNICAL BOREHOLES

PROJECT

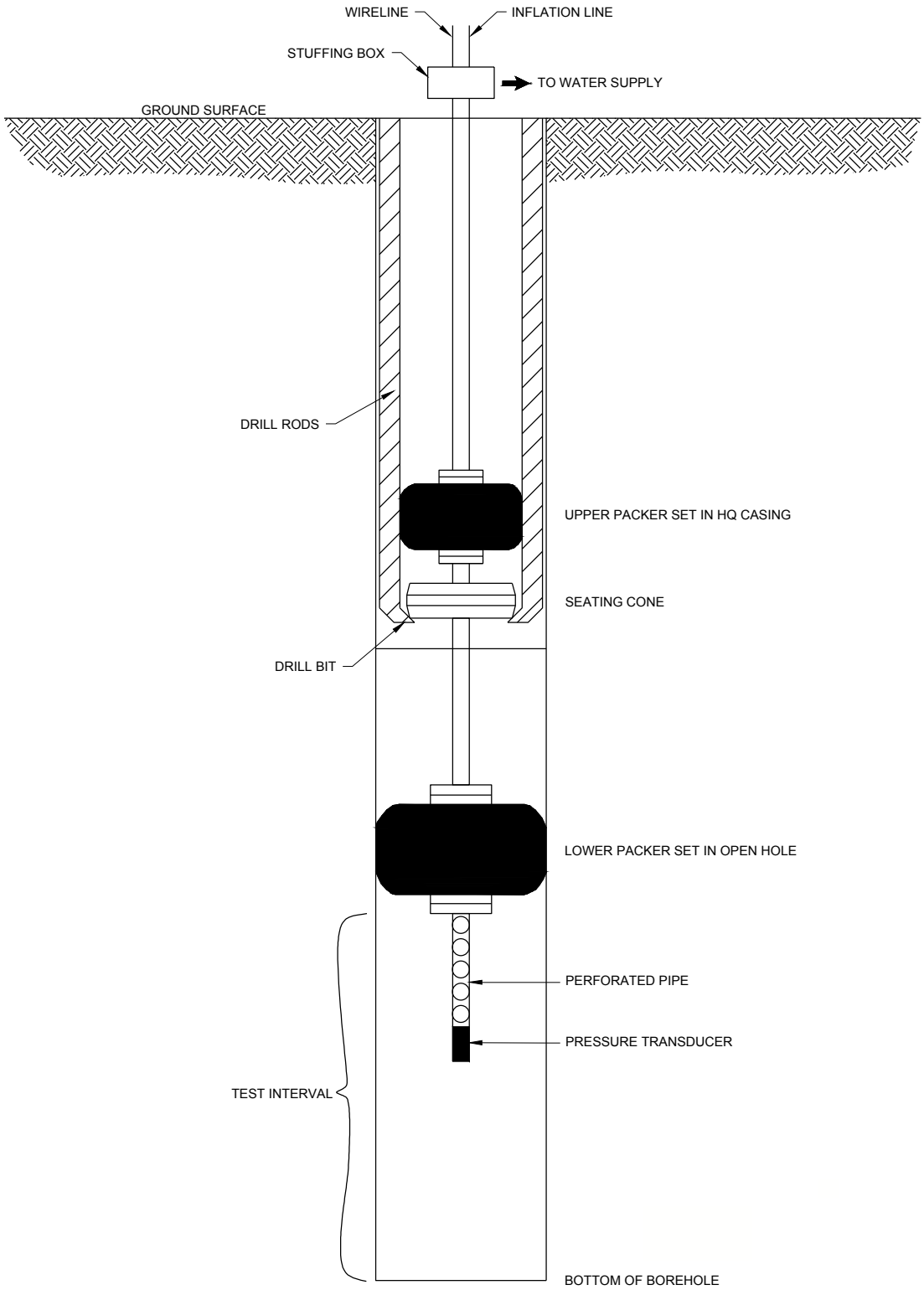
RIVERSDALE RESOURCES LIMITED
BENGA MINING LIMITED

TITLE

GEOTECHNICAL BOREHOLES AND VIBRATING WIRE PIEZOMETER INSTALLATIONS

Golder Associates

PROJECT No.		1406422	FILE No.	1406422FIG1
DESIGN	BW	14-10-09	SCALE	1:25000
CADD	BC	14-10-09	FIGURE	
CHECK	BW	14-10-16	1	
REVIEW	JW	14-10-09		



SCHEMATIC ONLY, NOT TO SCALE

PROJECT

Riversdale Resources

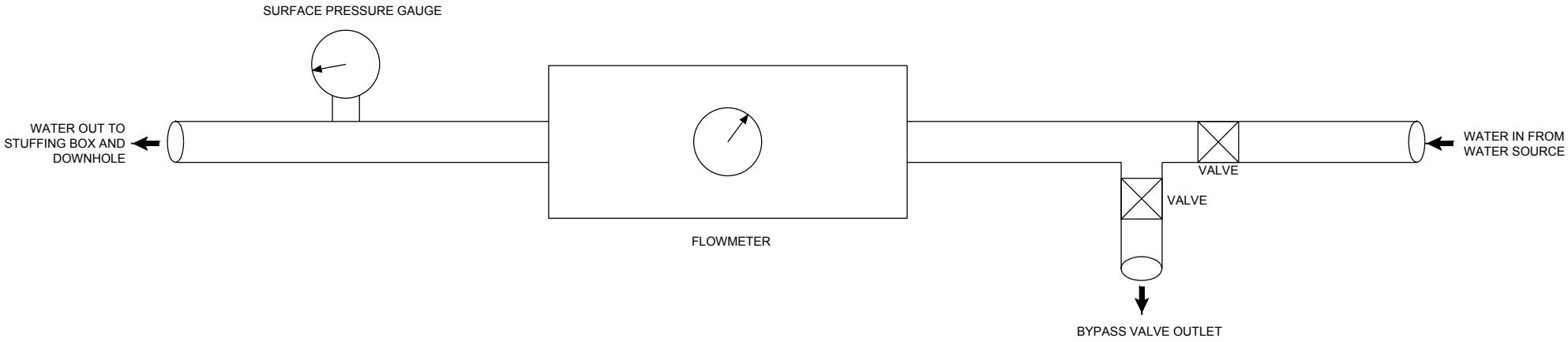
TITLE

SCHEMATIC FOR SINGLE PACKER WIRELINE PACKER SYSTEM

Golder Associates

PROJECT No. 1406422			FILE No.	1406422
DESIGN	TC	2012-11-16	SCALE	NOT TO SCALE
CADD	IPG	2012-11-16		
CHECK	BW	2014-10-16		
REVIEW	JW	2014-10-09		

FIGURE 2



SCHEMATIC ONLY, NOT TO SCALE

PROJECT

Riversdale Resources

TITLE

SCHEMATIC OF FLOW CONTROL BOARD USED FOR PACKER TESTING

Golder Associates

PROJECT No.	1406422		FILE No.	1406422
DESIGN	TC	2012-11-16	SCALE	NOT TO SCALE
CADD	IPG	2012-11-16		
CHECK	BW	2014-10-16		
REVIEW	JW	2014-10-09		

FIGURE 3

NOTE

MAXIMUM PRESSURE OF FLOW CONTROL BOARD SYSTEM IS 150 psi.

APPENDIX A

Calibration Certificates for Vibrating Wire Piezometers

RGSC-0005
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Calibration Record

RST Instruments Ltd., 11545 Kingston St., Maple Ridge, British Columbia, Canada V2X 0Z5
Tel: 604 540 1100 • Fax: 604 540 1005 • Toll Free: 1 800 665 5599 (North America only)
e-mail: info@rstinstruments.com • Website: www.rstinstruments.com

Vibrating Wire Piezometer

Customer:	GOLDER ASSOCIATES Ltd	
Model:	VW2100-1.0	
Serial Number:	**VW29689**	
Mfg Number:	1420924	
Range:	1.0	MPa
Temperature:	23.3	°C
Barometric Pressure:	988.3	millibars
Work Order Number:	204589	
Cable Length:	70	meters
Cable Markings:	535289 m - 535359 m	
Cable Colour Code:	Red / Black (Coil)	Green / White (Thermistor)
Cable Type:	EL380004	
Thermistor Type:	3	kΩ

Applied Pressure (MPa)	First Reading (B units)	Second Reading (B units)	Average Reading (B units)	Calculated Linear (MPa)	Linearity Error (% FS)	Polynomial Error (% FS)
0.0	8876	8877	8877	0.002	0.21	0.01
0.2	8193	8193	8193	0.199	-0.05	-0.01
0.4	7505	7505	7505	0.398	-0.18	-0.02
0.6	6810	6811	6811	0.599	-0.13	0.03
0.8	6115	6115	6115	0.800	-0.05	0.00
1.0	5414	5414	5414	1.002	0.20	-0.01
			Max. Error (%):		0.21	0.03

Linear Calibration Factor:	**C.F.=**	**0.00028876 MPa/B unit**
Regression Zero:	**At Calibration =**	**8883.8 B unit**
Temperature Correction Factor:	**Tk =**	**0.00009873 MPa/°C rise**

Polynomial Gage Factors (MPa) **A:** -1.2630E-09 **B:** -0.00027071 **C:** 2.5026

Pressure is calculated with the following equations:
Linear P(MPa) = C.F.(Li-Lc) - [Tk(Ti-Tc)] + [0.00010(Bi-Bc)]
Polynomial $P(MPa) = A(Lc)^2 + BLc + C + Tk(Tc-Ti) - [0.00010(Bc-Bi)]$

	Date (dd/mm/yy)	VW Readout Pos. B (Li)	Temp °C (Ti)	Baro (Bi)
Shipped Zero Readings:	5-Aug-14	8877	22.7	1016.7

Li, Lc = initial (at installation) and current readings
Ti, Tc = initial (at installation) and current temperature, in °C
Bi, Bc = initial (at installation) and current barometric pressure readings, in millibars
B units = B scale output of VW 2102, VW 2104, VW 2106 and DT 2011 readouts
B units = Hz^2 / 1000 ie: 1700Hz = 2890 B units

Technician: H. Chang <Original signed by> Date: 5-Aug-14

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1

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Calibration Record

RST Instruments Ltd., 11545 Kingston St., Maple Ridge, British Columbia, Canada V2X 0Z5
Tel: 604 540 1100 • Fax: 604 540 1005 • Toll Free: 1 800 665 5599 (North America only)
e-mail: info@rstinstruments.com • Website: www.rstinstruments.com

Vibrating Wire Piezometer

Customer:	GOLDER ASSOCIATES Ltd	
Model:	VW2100-2.0	
Serial Number:	VW29684	
Mfg Number:	1420342	
Range:	2.0 MPa	
Temperature:	23.6 °C	
Barometric Pressure:	984.4 millibars	
Work Order Number:	204589	
Cable Length:	105 meters	
Cable Markings:	534899 m - 535005 m	
Cable Colour Code:	Red / Black (Coil)	Green / White (Thermistor)
Cable Type:	EL380004	
Thermistor Type:	3 kΩ	

Applied Pressure (MPa)	First Reading (B units)	Second Reading (B units)	Average Reading (B units)	Calculated Linear (MPa)	Linearity Error (% FS)	Polynomial Error (% FS)
0.0	9059	9060	9060	0.004	0.20	-0.01
0.4	8382	8383	8383	0.400	-0.02	0.02
0.8	7703	7703	7703	0.797	-0.17	0.00
1.2	7018	7019	7019	1.196	-0.18	-0.01
1.6	6329	6330	6330	1.599	-0.05	-0.01
2.0	5635	5636	5636	2.004	0.22	0.01
				Max. Error (%):	0.22	0.02

Linear Calibration Factor: C.F.= **0.00058421 MPa/B unit**
Regression Zero: At Calibration = **9066.4 B unit**
Temperature Correction Factor: Tk = **0.0003230 MPa/°C rise**

Polynomial Gage Factors (MPa) A: -2.7372E-09 B: -0.00054398 C: 5.1527

Pressure is calculated with the following equations.
Linear P(MPa) = C F (Li-Lc) - [Tk(Ti-Tc)] + [0 00010(Bi-Bc)]
Polynomial P(MPa) = A(Lc)^2 + BLc + C + Tk(Tc-Ti) - [0 00010(Bc-Bi)]

	Date (dd/mm/yy)	VW Readout Pos. B (Li)	Temp °C (Ti)	Baro (Bi)
Shipped Zero Readings:	5-Aug-14	9067	22.8	1016.7

Li, Lc = initial (at installation) and current readings
Ti, Tc = initial (at installation) and current temperature, in °C
Bi, Bc = initial (at installation) and current barometric pressure readings, in millibars
B units = B scale output of VW 2102, VW 2104, VW 2106 and DT 2011 readouts
B units = Hz^2 / 1000 ie: 1700Hz = 2890 B units

<Original signed by>

Technician: H. Chang Date: 5-Aug-14

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Calibration Record

RST Instruments Ltd., 11545 Kingston St., Maple Ridge, British Columbia, Canada V2X 0Z5
Tel: 604 540 1100 • Fax: 604 540 1005 • Toll Free: 1 800 665 5599 (North America only)
e-mail: info@rstinstruments.com • Website: www.rstinstruments.com

Vibrating Wire Piezometer

Customer:	GOLDER ASSOCIATES Ltd	
Model:	VW2100-2.0	
Serial Number:	**VW29682**	
Mfg Number:	1420340	
Range:	2.0 MPa	
Temperature:	23.6 °C	
Barometric Pressure:	984.4 millibars	
Work Order Number:	204589	
Cable Length:	155 meters	
Cable Markings:	528989 m - 529149 m	
Cable Colour Code:	Red / Black (Coil)	Green / White (Thermistor)
Cable Type:	EL380004	
Thermistor Type:	3 kΩ	

Applied Pressure (MPa)	First Reading (B units)	Second Reading (B units)	Average Reading (B units)	Calculated Linear (MPa)	Linearity Error (% FS)	Polynomial Error (% FS)
0.0	8782	8783	8783	0.004	0.20	0.01
0.4	8109	8109	8109	0.399	-0.06	-0.02
0.8	7430	7430	7430	0.797	-0.15	0.00
1.2	6748	6748	6748	1.197	-0.15	0.00
1.6	6062	6062	6062	1.599	-0.03	0.01
2.0	5372	5373	5373	2.004	0.18	-0.01
				Max. Error (%):	0.20	0.02

Linear Calibration Factor:	**C.F.=**	**0.00058643 MPa/B unit**
Regression Zero:	**At Calibration =**	**8789.2 B unit**
Temperature Correction Factor:	**Tk =**	**-0.00001515 MPa/°C rise**

Polynomial Gage Factors (MPa) **A:** -2.4308E-09 **B:** -0.00055202 **C:** 5.0358

Pressure is calculated with the following equations.
Linear: $P(MPa) = C.F.(Li-Lc) - [Tk(Ti-Tc)] + [0.00010(Bi-Bc)]$
Polynomial: $P(MPa) = A(Lc)^2 + BLc + C + Tk(Tc-Ti) - [0.00010(Bc-Bi)]$

	Date (dd/mm/yy)	VW Readout Pos. B (Li)	Temp °C (Ti)	Baro (Bi)
Shipped Zero Readings:	5-Aug-14	8792	22.8	1016.7

Li, Lc = initial (at installation) and current readings
Ti, Tc = initial (at installation) and current temperature, in °C
Bi, Bc = initial (at installation) and current barometric pressure readings, in millibars
B units = B scale output of VW 2102, VW 2104, VW 2106 and DT 2011 readouts
B units = $Hz^2 / 1000$ ie: 1700Hz = 2890 B units

Technician: H. Chang <Original signed by> Date: 5-Aug-14

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Document Number: ELL0143H

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Calibration Record

RST Instruments Ltd., 11545 Kingston St., Maple Ridge, British Columbia, Canada V2X 0Z5
Tel: 604 540 1100 • Fax: 604 540 1005 • Toll Free: 1 800 665 5599 (North America only)
e-mail: info@rstinstruments.com • Website: www.rstinstruments.com

Vibrating Wire Piezometer

Customer:	GOLDER ASSOCIATES Ltd.	
Model:	VW2100-1.0	
Serial Number:	**VW29688**	
Mfg Number:	1420923	
Range:	1.0	MPa
Temperature:	23.3	°C
Barometric Pressure:	988.3	millibars
Work Order Number:	204589	
Cable Length:	70	meters
Cable Markings:	529300 m - 529369 m	
Cable Colour Code:	Red / Black (Coil)	Green / White (Thermistor)
Cable Type:	EL380004	
Thermistor Type:	3	kΩ

Applied Pressure (MPa)	First Reading (B units)	Second Reading (B units)	Average Reading (B units)	Calculated Linear (MPa)	Linearity Error (% FS)	Polynomial Error (% FS)
0.0	8921	8922	8922	0.001	0.13	0.00
0.2	8237	8238	8238	0.200	-0.02	0.00
0.4	7551	7551	7551	0.399	-0.10	0.00
0.6	6862	6862	6862	0.599	-0.11	-0.01
0.8	6169	6170	6170	0.800	-0.02	0.01
1.0	5475	5475	5475	1.001	0.13	0.00
				Max. Error (%):	0.13	0.01

Linear Calibration Factor:	**C.F.=**	**0.00029015 MPa/B unit**
Regression Zero:	**At Calibration =**	**8926.0 B unit**
Temperature Correction Factor:	**Tk =**	**-0.0001427 MPa/°C rise**

Polynomial Gage Factors (MPa) **A:** -8.3421E-10 **B:** -0.00027814 **C:** 2.5478

Pressure is calculated with the following equations:
Linear: $P(MPa) = C F.(Li-Lc) - [Tk(Ti-Tc)] + [0.00010(Bi-Bc)]$
Polynomial: $P(MPa) = A(Lc)^2 + BLc + C + Tk(Tc-Ti) - [0.00010(Bc-Bi)]$

	Date (dd/mm/yy)	VW Readout Pos B (Li)	Temp °C (Ti)	Baro (Bi)
Shipped Zero Readings:	5-Aug-14	8923	22.7	1016.7

Li, Lc = initial (at installation) and current readings
Ti, Tc = initial (at installation) and current temperature, in °C
Bi, Bc = initial (at installation) and current barometric pressure readings, in millibars
B units = B scale output of VW 2102, VW 2104, VW 2106 and DT 2011 readouts
B units = $Hz^2 / 1000$ ie: 1700Hz = 2890 B units

Technician: H. Chang <Original signed by> Date: 5-Aug-14

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1

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Document Number: ELL0143H

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Calibration Record

RST Instruments Ltd., 11545 Kingston St., Maple Ridge, British Columbia, Canada V2X 0Z5
Tel: 604 540 1100 • Fax: 604 540 1005 • Toll Free: 1 800 665 5599 (North America only)
e-mail: info@rstinstruments.com • Website: www.rstinstruments.com

Vibrating Wire Piezometer

Customer:		GOLDER ASSOCIATES Ltd.	
Model:		VW2100-2 0	
Serial Number:		**VW29685**	
Mfg Number:		1420693	
Range:		2.0 MPa	
Temperature:		23.7 °C	
Barometric Pressure:		987 4 millibars	
Work Order Number:		204589	
Cable Length:		105 meters	
Cable Markings:		535006 m - 535111 m	
Cable Colour Code:	Red / Black (Coil)	Green / White (Thermistor)	
Cable Type:		EL380004	
Thermistor Type:		3 kΩ	

Applied Pressure (MPa)	First Reading (B units)	Second Reading (B units)	Average Reading (B units)	Calculated Linear (MPa)	Linearity Error (% FS)	Polynomial Error (% FS)
0.0	8952	8952	8952	0.004	0.21	-0.02
0.4	8262	8262	8262	0.400	-0.02	0.03
0.8	7570	7570	7570	0.796	-0.18	0.00
1.2	6872	6873	6873	1.196	-0.19	-0 01
1.6	6170	6170	6170	1.599	-0.06	-0.01
2.0	5462	5462	5462	2.005	0.23	0.01
				Max. Error (%):	0.23	0.03

Linear Calibration Factor:	**C.F.=**	**0.00057320 MPa/B unit**
Regression Zero:	**At Calibration =**	**8959.3 B unit**
Temperature Correction Factor:	**Tk =**	**0.0004694 MPa/°C rise**

Polynomial Gage Factors (MPa) **A:** -2.7745E-09 **B:** -0.00053321 **C:** 4.9953

Pressure is calculated with the following equations:
Linear: $P(MPa) = C F (Li-Lc) - [Tk(Ti-Tc)] + [0 00010(Bi-Bc)]$
Polynomial: $P(MPa) = A(Lc)^2 + BLc + C + Tk(Tc-Ti) - [0 00010(Bc-Bi)]$

	Date (dd/mm/yy)	VW Readout Pos. B (Li)	Temp °C (Ti)	Baro (Bi)
Shipped Zero Readings:	5-Aug-14	8967	22 8	1016.7

Li, Lc = initial (at installation) and current readings
Ti, Tc = initial (at installation) and current temperature, in °C
Bi, Bc = initial (at installation) and current barometric pressure readings, in millibars
B units = B scale output of VW 2102, VW 2104, VW 2106 and DT 2011 readouts
B units = Hz^2 / 1000 ie: 1700Hz = 2890 B units

Technician: H. Chang <Original signed by> Date: 5-Aug-14

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Document Number: ELL0143H

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Calibration Record

RST Instruments Ltd., 11545 Kingston St., Maple Ridge, British Columbia, Canada V2X 0Z5
Tel: 604 540 1100 • Fax: 604 540 1005 • Toll Free: 1 800 665 5599 (North America only)
e-mail: info@rstinstruments.com • Website: www.rstinstruments.com

Vibrating Wire Piezometer

Customer:		GOLDER ASSOCIATES Ltd.
Model:		VW2100-2.0
Serial Number:		**VW29681**
Mfg Number:		1420339
Range:		2.0 MPa
Temperature:		23.6 °C
Barometric Pressure:		984.4 millibars
Work Order Number:		204589
Cable Length:		155 meters
Cable Markings:		529144 m - 529298 m
Cable Colour Code:	Red / Black (Coil)	Green / White (Thermistor)
Cable Type:		EL380004
Thermistor Type:		3 kΩ

Applied Pressure (MPa)	First Reading (B units)	Second Reading (B units)	Average Reading (B units)	Calculated Linear (MPa)	Linearity Error (% FS)	Polynomial Error (% FS)
0.0	8942	8943	8943	0.004	0.19	-0.01
0.4	8249	8249	8249	0.400	-0.01	0.03
0.8	7554	7554	7554	0.796	-0.18	-0.01
1.2	6853	6853	6853	1.197	-0.17	0.00
1.6	6148	6148	6148	1.599	-0.05	0.00
2.0	5438	5439	5439	2.004	0.21	0.00
			Max. Error (%):		0.21	0.03

Linear Calibration Factor:	**C.F.=**	**0.00057086 MPa/B unit**
Regression Zero:	**At Calibration =**	**8949.2 B unit**
Temperature Correction Factor:	**Tk =**	**0.00004120 MPa/°C rise**

Polynomial Gage Factors (MPa) **A:** -2.4914E-09 **B:** -0.00053503 **C:** 4.9835

Pressure is calculated with the following equations:
Linear P(MPa) = C.F.(Li-Lc) - [Tk(Ti-Tc)] + [0.00010(Bi-Bc)]
Polynomial P(MPa) = A(Lc)^2 + BLc + C + Tk(Tc-Ti) - [0.00010(Bc-Bi)]

	Date (dd/mm/yy)	VW Readout Pos. B (Li)	Temp °C (Ti)	Baro (Bi)
Shipped Zero Readings:	5-Aug-14	8951	22.5	1016.7

Li, Lc = initial (at installation) and current readings
Ti, Tc = initial (at installation) and current temperature, in °C
Bi, Bc = initial (at installation) and current barometric pressure readings, in millibars
B units = B scale output of VW 2102, VW 2104, VW 2106 and DT 2011 readouts
B units = Hz^2 / 1000 ie: 1700Hz = 2890 B units

<Original signed by>

Technician: H. Chang Date: 5-Aug-14

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1

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RGSC-0009
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Calibration Record

RST Instruments Ltd., 11545 Kingston St., Maple Ridge, British Columbia, Canada V2X 0Z5
Tel: 604 540 1100 • Fax: 604 540 1005 • Toll Free: 1 800 665 5599 (North America only)
e-mail: info@rstinstruments.com • Website: www.rstinstruments.com

Vibrating Wire Piezometer

Customer:	GOLDER ASSOCIATES Ltd.	
Model:	VW2100-1.0	
Serial Number:	**VW29687**	
Mfg Number:	1420922	
Range:	1.0	MPa
Temperature:	23.3	°C
Barometric Pressure:	988.3	millibars
Work Order Number:	204589	
Cable Length:	70	meters
Cable Markings:	535219 m - 535288 m	
Cable Colour Code:	Red / Black (Coil)	Green / White (Thermistor)
Cable Type:	EL380004	
Thermistor Type:	3	kΩ

Applied Pressure (MPa)	First Reading (B units)	Second Reading (B units)	Average Reading (B units)	Calculated Linear (MPa)	Linearity Error (% FS)	Polynomial Error (% FS)
0.0	9051	9052	9052	0.002	0.15	-0.01
0.2	8364	8364	8364	0.200	-0.01	0.03
0.4	7675	7676	7676	0.399	-0.14	0.00
0.6	6983	6983	6983	0.599	-0.15	-0.02
0.8	6286	6286	6286	0.800	-0.03	0.00
1.0	5586	5586	5586	1.002	0.17	0.00
				Max. Error (%):	0.17	0.03

Linear Calibration Factor:	**C.F.=**	**0.00028861 MPa/B unit**
Regression Zero:	**At Calibration =**	**9056.8 B unit**
Temperature Correction Factor:	**Tk =**	**0.0002029 MPa/°C rise**

Polynomial Gage Factors (MPa) **A:** -1.0356E-09 **B:** -0.00027345 **C:** 2.5598

Pressure is calculated with the following equations:
Linear P(MPa) = C.F.(Li-Lc) - [Tk(Ti-Tc)] + [0.00010(Bi-Bc)]
Polynomial P(MPa) = A(Lc)^2 + BLc + C + Tk(Tc-Ti) - [0.00010(Bc-Bi)]

	Date (dd/mm/yy)	VW Readout Pos B (Li)	Temp °C (Ti)	Baro (Bi)
Shipped Zero Readings:	5-Aug-14	9050	22.9	1016.7

Li, Lc = initial (at installation) and current readings
Ti, Tc = initial (at installation) and current temperature, in °C
Bi, Bc = initial (at installation) and current barometric pressure readings, in millibars
B units = B scale output of VW 2102, VW 2104, VW 2106 and DT 2011 readouts
B units = Hz^2 / 1000 ie: 1700Hz = 2890 B units

Technician: H. Chang <Original signed by> Date: 5-Aug-14

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1

Applied Science Technologists and Technicians of British Columbia
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AScT

Document Number: ELL0143H

Recycled
MG0106B

RGSC-0009
Intermediate

innovation in geotechnical instrumentation

Calibration Record

RST Instruments Ltd., 11545 Kingston St., Maple Ridge, British Columbia, Canada V2X 0Z5
Tel: 604 540 1100 • Fax: 604 540 1005 • Toll Free: 1 800 665 5599 (North America only)
e-mail: info@rstinstruments.com • Website: www.rstinstruments.com

Vibrating Wire Piezometer

Customer:	GOLDER ASSOCIATES Ltd.	
Model:	VW2100-2.0	
Serial Number:	**VW29686**	
Mfg Number:	1420694	
Range:	2.0	MPa
Temperature:	23.7	°C
Barometric Pressure:	987.4	millibars
Work Order Number:	204589	
Cable Length:	105	meters
Cable Markings:	535112 m - 535217 m	
Cable Colour Code:	Red / Black (Coil)	Green / White (Thermistor)
Cable Type:	EL380004	
Thermistor Type:	3	kΩ

Applied Pressure (MPa)	First Reading (B units)	Second Reading (B units)	Average Reading (B units)	Calculated Linear (MPa)	Linearity Error (% FS)	Polynomial Error (% FS)
0.0	9009	9010	9010	0.004	0.20	0.01
0.4	8330	8331	8331	0.399	-0.05	-0.01
0.8	7646	7647	7647	0.797	-0.16	0.00
1.2	6958	6959	6959	1.197	-0.15	0.01
1.6	6267	6267	6267	1.599	-0.04	0.00
2.0	5571	5571	5571	2.004	0.20	0.00
			Max. Error (%):		0.20	0.01

Linear Calibration Factor:	**C.F.=**	**0.00058160 MPa/B unit**
Regression Zero:	**At Calibration =**	**9016.5 B unit**
Temperature Correction Factor:	**Tk =**	**0.00003908 MPa/°C rise**

Polynomial Gage Factors (MPa) **A:** -2.5251E-09 **B:** -0.00054478 **C:** 5.1133

Pressure is calculated with the following equations

Linear: $P(MPa) = C.F.(Li-Lc) - [Tk(Ti-Tc)] + [0.00010(Bi-Bc)]$

Polynomial: $P(MPa) = A(Lc)^2 + BLc + C + Tk(Tc-Ti) - [0.00010(Bc-Bi)]$

	Date (dd/mm/yy)	VW Readout Pos B (Li)	Temp °C (Ti)	Baro (Bi)
Shipped Zero Readings:	5-Aug-14	9019	22.9	1016.7

Li, Lc = initial (at installation) and current readings
Ti, Tc = initial (at installation) and current temperature, in °C
Bi, Bc = initial (at installation) and current barometric pressure readings, in millibars
B units = B scale output of VW 2102, VW 2104, VW 2106 and DT 2011 readouts
B units = $Hz^2 / 1000$ ie: 1700Hz = 2890 B units

Technician: H. Chang <Original signed by> Date: 5-Aug-14

Applied Science Technologists and Technicians of British Columbia
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ASCT

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1

Document Number: ELL0143H

MIG0106B

RGSC-0009
Deep

innovation in geotechnical instrumentation

Calibration Record

RST Instruments Ltd., 11545 Kingston St., Maple Ridge, British Columbia, Canada V2X 0Z5
Tel: 604 540 1100 • Fax: 604 540 1005 • Toll Free: 1 800 665 5599 (North America only)
e-mail: info@rstinstruments.com • Website: www.rstinstruments.com

Vibrating Wire Piezometer

Customer:		GOLDER ASSOCIATES Ltd.
Model:		VW2100-2.0
Serial Number:		**VW29683**
Mfg Number:		1420341
Range:		2.0 MPa
Temperature:		23.6 °C
Barometric Pressure:		984.4 millibars
Work Order Number:		204589
Cable Length:		155 meters
Cable Markings:		528834 m - 528988 m
Cable Colour Code:	Red / Black (Coil)	Green / White (Thermistor)
Cable Type:		EL380004
Thermistor Type:		3 kΩ

Applied Pressure (MPa)	First Reading (B units)	Second Reading (B units)	Average Reading (B units)	Calculated Linear (MPa)	Linearity Error (% FS)	Polynomial Error (% FS)
0.0	8975	8972	8974	0.004	0.18	-0.01
0.4	8286	8286	8286	0.400	-0.02	0.01
0.8	7596	7596	7596	0.797	-0.16	-0.01
1.2	6901	6901	6901	1.197	-0.15	0.01
1.6	6203	6203	6203	1.599	-0.05	-0.01
2.0	5500	5500	5500	2.004	0.19	0.00
			Max. Error (%):		0.19	0.01

Linear Calibration Factor: C.F.= 0.00057585 MPa/B unit
Regression Zero: At Calibration = 8979.8 B unit
Temperature Correction Factor: Tk = -0.000005183 MPa/°C rise

Polynomial Gage Factors (MPa) A: -2.3337E-09 B: -0.00054207 C: 5.0521

Pressure is calculated with the following equations:
Linear P(MPa) = C.F.(Li-Lc) - [Tk(Ti-Tc)] + [0.00010(Bi-Bc)]
Polynomial P(MPa) = A(Lc)^2 + BLc + C + Tk(Tc-Ti) - [0.00010(Bc-Bi)]

	Date (dd/mm/yy)	VW Readout Pos B (Li)	Temp °C (Ti)	Baro (Bi)
Shipped Zero Readings:	5-Aug-14	8980	22.8	1016.7

Li, Lc = initial (at installation) and current readings
Ti, Tc = initial (at installation) and current temperature, in °C
Bi, Bc = initial (at installation) and current barometric pressure readings, in millibars
B units = B scale output of VW 2102, VW 2104, VW 2106 and DT 2011 readouts
B units = Hz^2 / 1000 ie: 1700Hz = 2890 B units

<Original signed by>

Technician: H. Chang Date: 5-Aug-14

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1

Applied Science Technologists and Technicians of British Columbia
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ASCT

Document Number: ELL0143H

Recycled
MIG01068

APPENDIX B

Analysis Plots of Packer Testing Data

RGSC-0004

Golder Associates

HYDROBENCH REPORT

Project	Riversdale
Site	RGSC-0004
Source Well	RGSC-0004
Test Name	RGSC-0004-Test 1
Test Date/Time	August 19, 2014
Interval	top: 99.76 m bottom: 174.62 m
Description	

Basic Data

Test Interval	74.86 m		
Porosity	0.05		
Well Radius	0.032 m	Tubing Radius	0.039 m
Inclination	20.0 deg		
Test Volume	237.076 l		
Well Type	Source		

Fluid Properties

Viscosity	0.001 Pa*s
Density	1000.0 kg/m³
Compressibility	2.0e-09 1/Pa

Analysis Results

Analysis "Analysis_1"

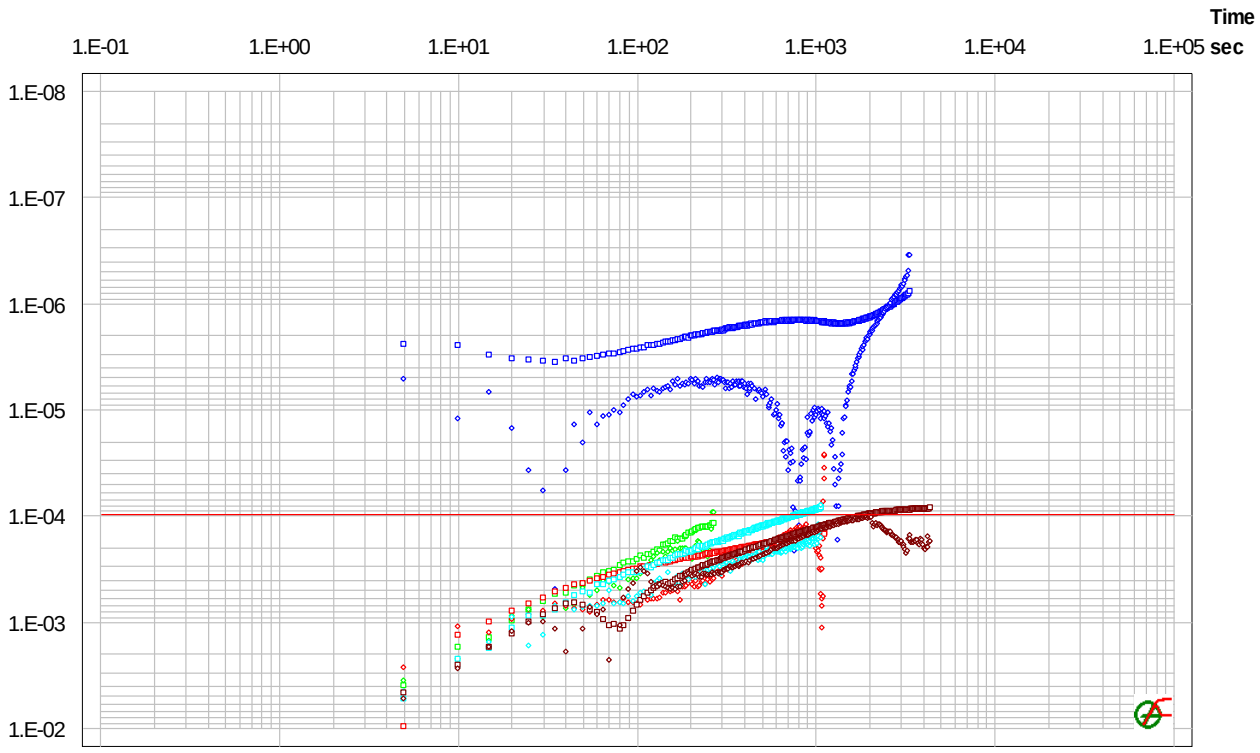
Static Pressure: 66.40 kPa

Shell Parameters:

Name	Transmissivity [m²/s]	Storativity [-]	Radius [m]	Flow Dimension [-]
Shell 1	3.6e-04	1.0e-04	- -	2.0

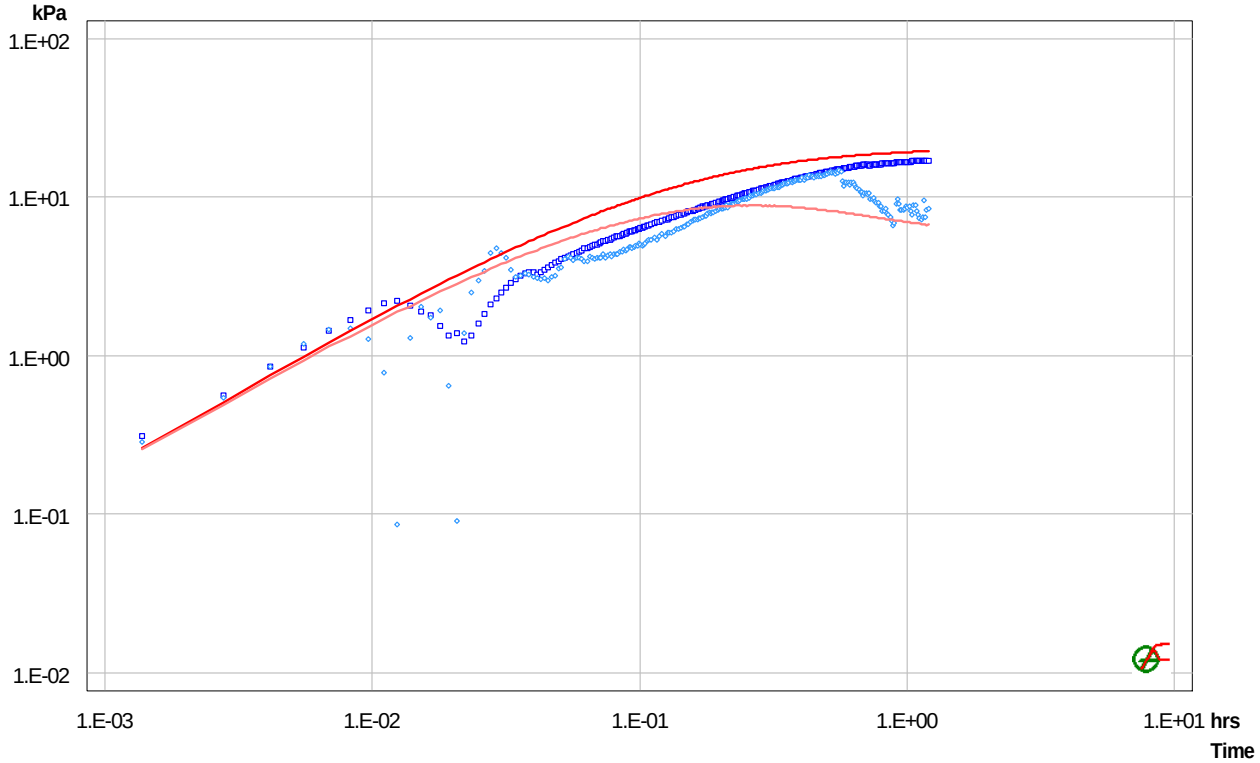
Sequence Parameters:

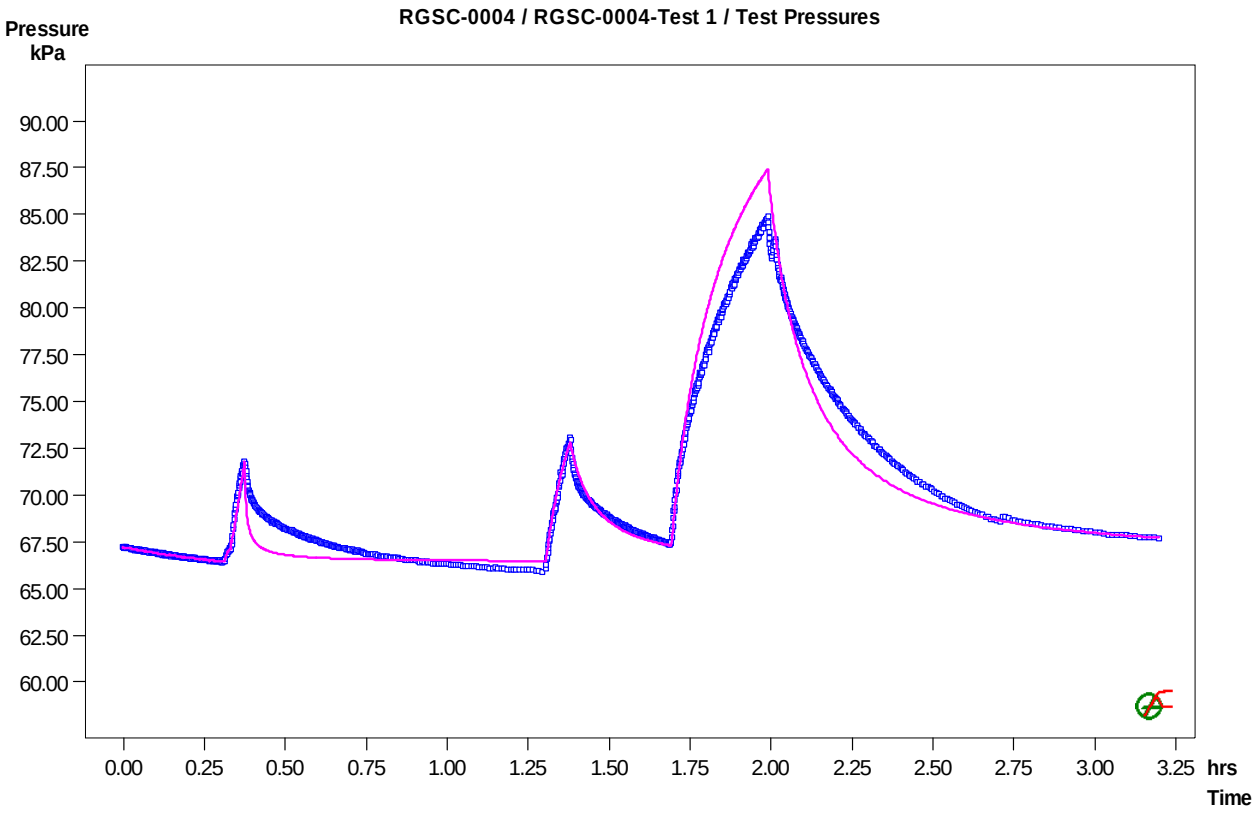
Name	Wellbore Storage [m³/Pa]	Skin [-]
Background	5.2e-07	-5.0
SI	5.2e-07	-5.0
SI Recovery	5.2e-07	-5.0
RI -1	2.4e-05	-5.0
RI-1 Recovery	2.4e-05	-5.0
RI-2	3.0e-05	-5.0
RI-2 Recovery	3.0e-05	-5.0



RGSC-0004 / RGSC-0004-Test 1 / LogLog Diagnosis - Analysis_1

RGSC-0004 / RGSC-0004-Test 1 / RI-2 Recovery: LogLog Plot




RGSC-0004 / RGSC-0004-Test 1 / Test Pressures
Pressure
kPa
90.00
87.50
85.00
82.50
80.00
77.50
75.00
72.50
70.00
67.50
65.00
62.50
60.00
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
3.00
3.25
hrs
Time

HYDROBENCH REPORT

Project	Riversdale
Site	Riversdale-Benga Project
Source Well	RGSC-0004
Test Name	RGSC-0004 Test 2
Test Date/Time	August 19, 2014
Interval	top: 50.99 m bottom: 174.62 m
Description	

Basic Data

Test Interval	123.63 m		
Porosity	0.05		
Well Radius	0.039 m	Tubing Radius	0.039 m
Inclination	20.0 deg		
Test Volume	587.723 l		
Well Type	Source		

Fluid Properties

Viscosity	0.001 Pa*s
Density	1000.0 kg/m³
Compressibility	2.0e-09 1/Pa

Sequence Definition

Name	Category	t(o) [hrs]	P(o) [kPa]	P(i) [kPa]	Rate [l/min]	C [m³/Pa]
Background	Variable Pressure	0.00000	200.89			5.2e-07
SI	dP-Event	0.61944	200.44	-25.1 *		5.2e-07
SI Recovery	Slug	0.63750	225.49	200.4		5.2e-07
RI	Constant Rate	1.37361	202.17		-1.10e+02	4.0e-06
Recovery	Recovery	1.88889	414.67			4.0e-06

Analysis Results

Analysis "Analysis_1"

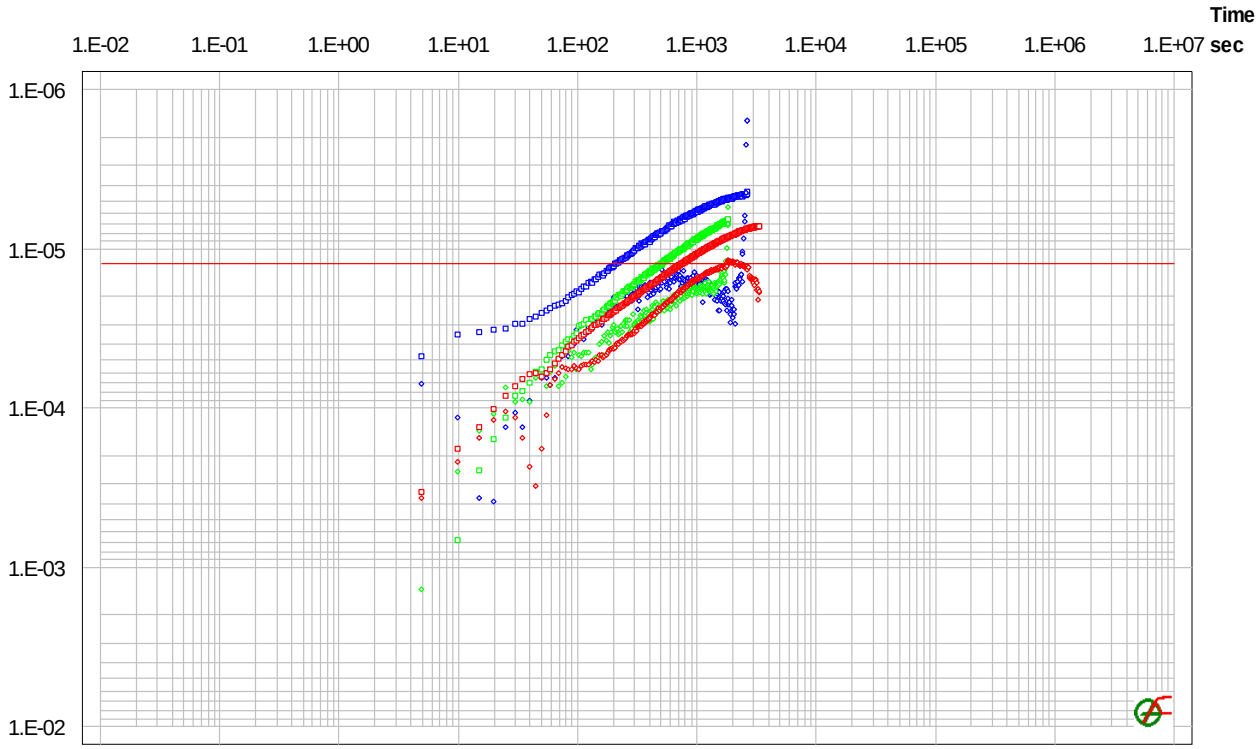
Static Pressure: 200.60 kPa

Shell Parameters:

Name	Transmissivity [m²/s]	Storativity [-]	Radius [m]	Flow Dimension [-]
Shell 1	1.8e-05	1.0e-04	- -	2.0

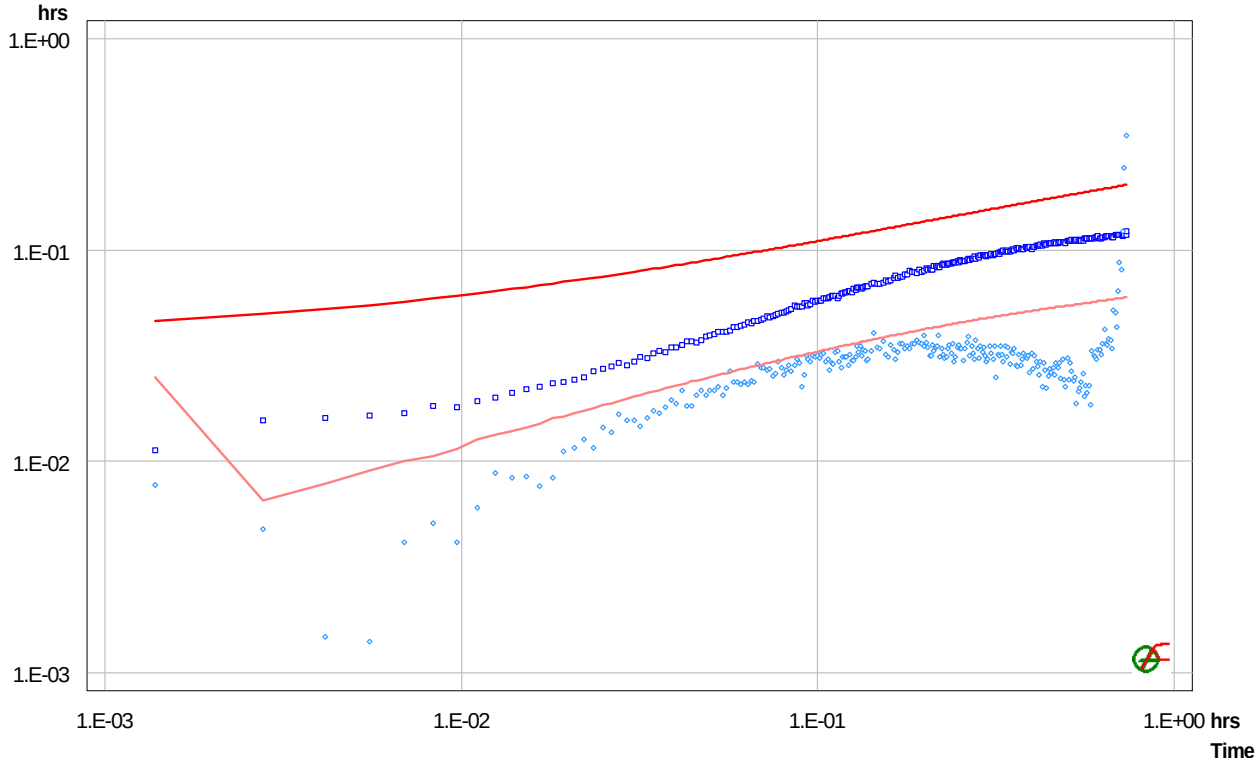
Sequence Parameters:

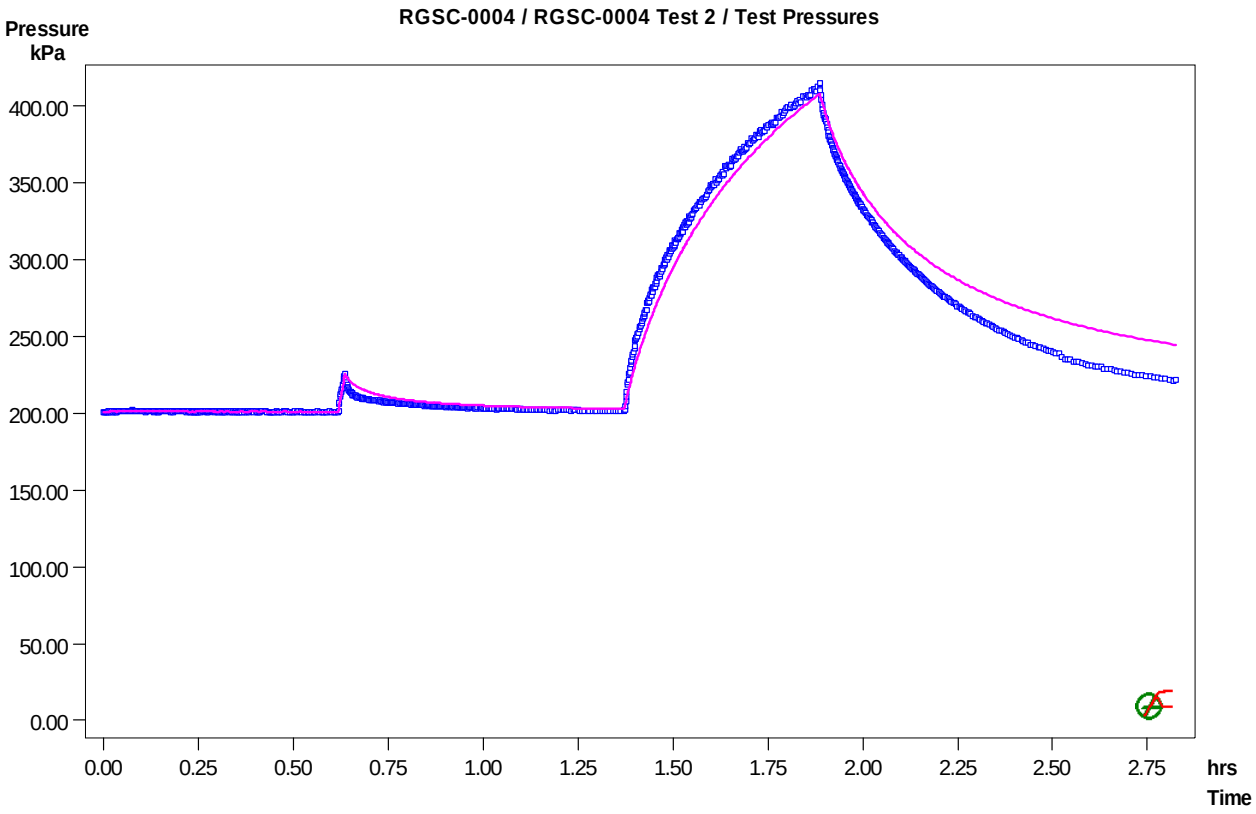
Name	Wellbore Storage [m³/Pa]	Skin [-]
Background	2.6e-06	-5.0
SI	2.6e-06	-5.0
SI Recovery	2.6e-06	-5.0
RI	4.0e-06	-5.0
Recovery	4.0e-06	-5.0



RGSC-0004 / RGSC-0004 Test 2 / LogLog Diagnosis - Analysis_1

RGSC-0004 / RGSC-0004 Test 2 / SI Recovery: LogLog Plot, constant P(i)




RGSC-0004 / RGSC-0004 Test 2 / Test Pressures
Pressure
kPa
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
hrs
Time

RGSC-0005

Golder Associates

HYDROBENCH REPORT

Project	Riversdale
Site	Riversdale
Source Well	RGSC-0005
Test Name	RGSC-0005 Test 1
Test Date/Time	August 23, 2014
Interval	top: 61.10 m bottom: 97.97 m
Description	Depths are mAH

Basic Data

Test Interval	36.87 m	
Porosity	0.05	
Well Radius	0.048 m	Tubing Radius
Inclination	20.0 deg	
Test Volume	266.873 l	
Well Type	Source	

Fluid Properties

Viscosity	0.001 Pa*s
Density	1000.0 kg/m³
Compressibility	2.0e-09 1/Pa

Sequence Definition

Name	Category	t(o) [hrs]	P(o) [kPa]	P(i) [kPa]	Rate [l/min]	C [m³/Pa]
Background	Variable Pressure	0.00000	701.63			2.6e-07
Constant Rate	Constant Rate	0.60417	700.97		-9.97e+00	2.6e-07
Recovery	Recovery	1.11806	849.26			2.6e-07

Analysis Results

Analysis "Analysis_1"

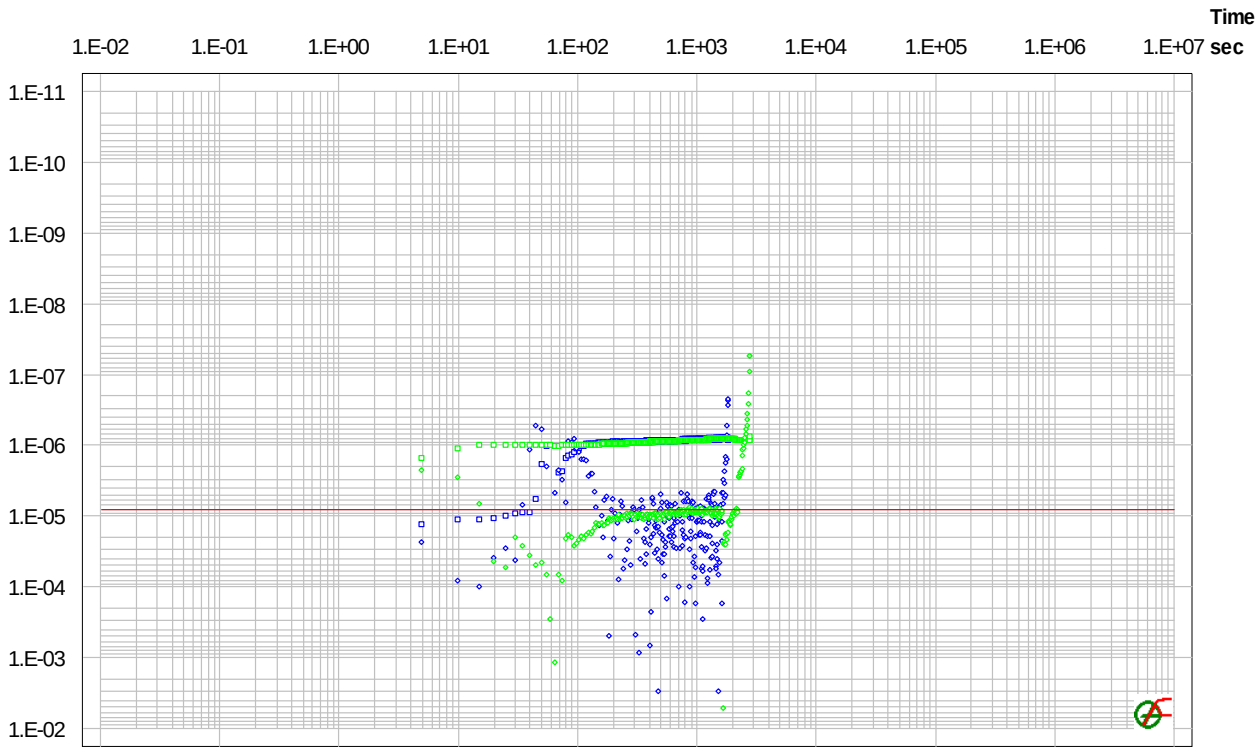
Static Pressure: 700.00 kPa

Shell Parameters:

Name	Transmissivity [m²/s]	Storativity [-]	Radius [m]	Flow Dimension [-]
Shell 1	8.4e-06	1.0e-04	- -	2.0

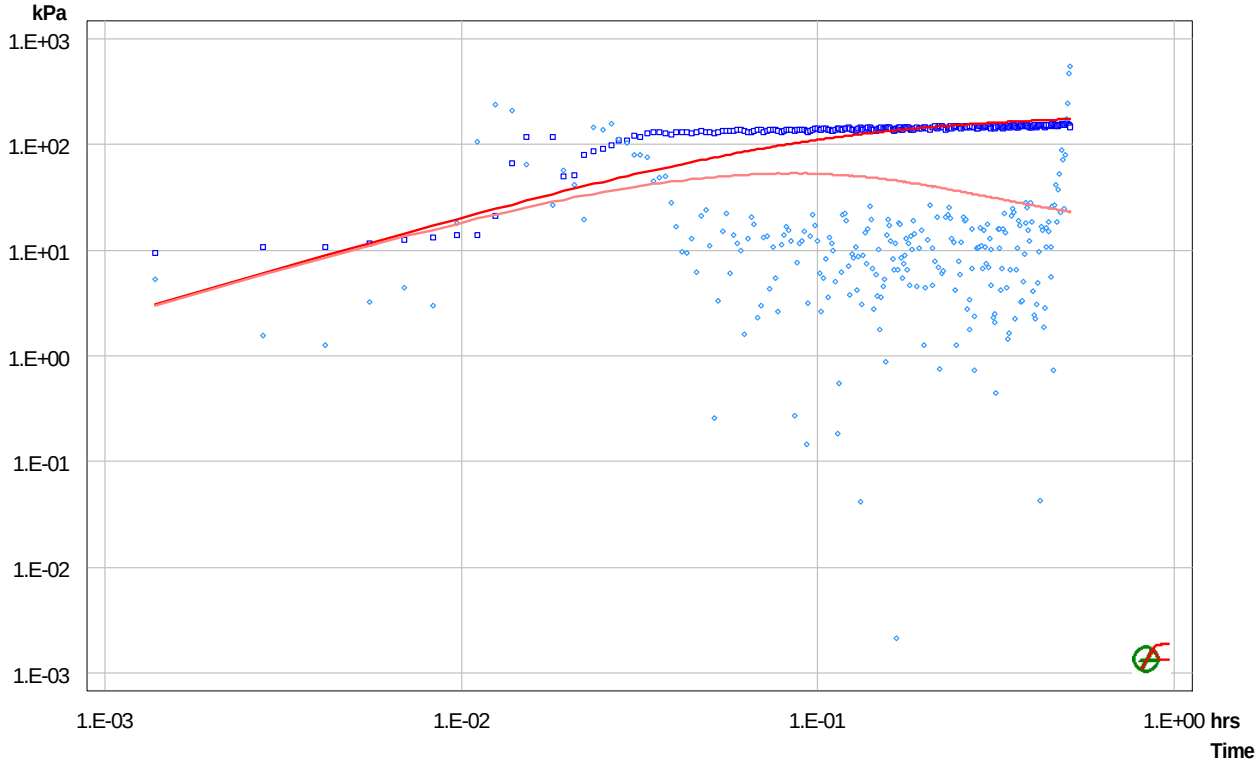
Sequence Parameters:

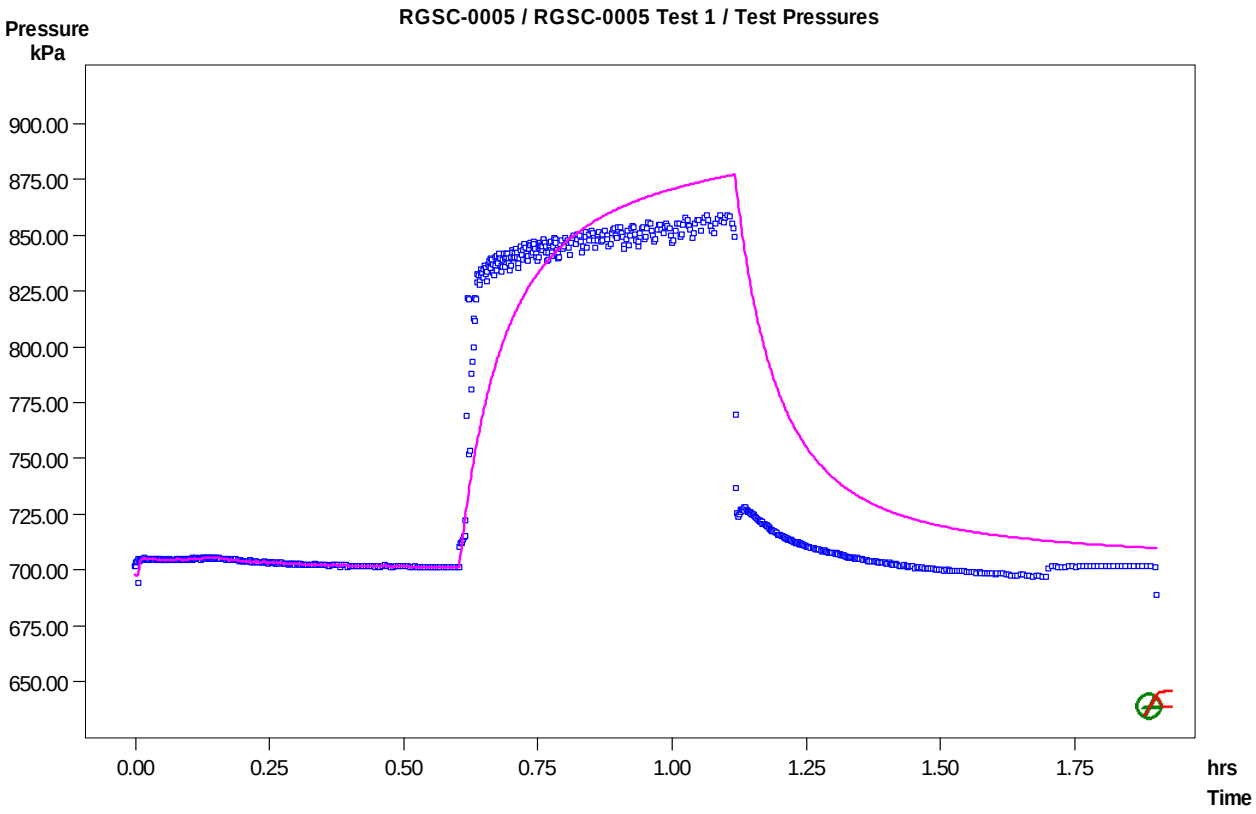
Name	Wellbore Storage [m³/Pa]	Skin [-]
Background	2.6e-07	0.0
Constant Rate	2.6e-07	0.0
Recovery	2.6e-07	0.0



RGSC-0005 / RGSC-0005 Test 1 / LogLog Diagnosis - Analysis_1

RGSC-0005 / RGSC-0005 Test 1 / Constant Rate: LogLog Plot




RGSC-0005 / RGSC-0005 Test 1 / Test Pressures
Pressure
kPa
900.00
875.00
850.00
825.00
800.00
775.00
750.00
725.00
700.00
675.00
650.00
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
hrs
Time

HYDROBENCH REPORT

Project	Riversdale
Site	Riversdale
Source Well	RGSC-0005
Test Name	RGSC-0005 Test 2
Test Date/Time	August 25, 2014
Interval	top: 101.50 m bottom: 149.00 m
Description	Depths are mAH

Basic Data

Test Interval	47.50 m	
Porosity	0.05	
Well Radius	0.048 m	Tubing Radius
Inclination	20.0 deg	
Test Volume	343.816 l	
Well Type	Source	

Fluid Properties

Viscosity	0.001 Pa*s
Density	1000.0 kg/m³
Compressibility	2.0e-09 1/Pa

Sequence Definition

Name	Category	t(o) [hrs]	P(o) [kPa]	P(i) [kPa]	Rate [l/min]	C [m³/Pa]
Background	Variable Pressure	0.00000	1027.09			1.2e-09
Constant Rate	Constant Rate	0.08333	1022.53		-8.60e-01	1.2e-09
Recovery	Recovery	0.58333	1376.40			1.2e-09

Analysis Results

Analysis "Analysis_1"

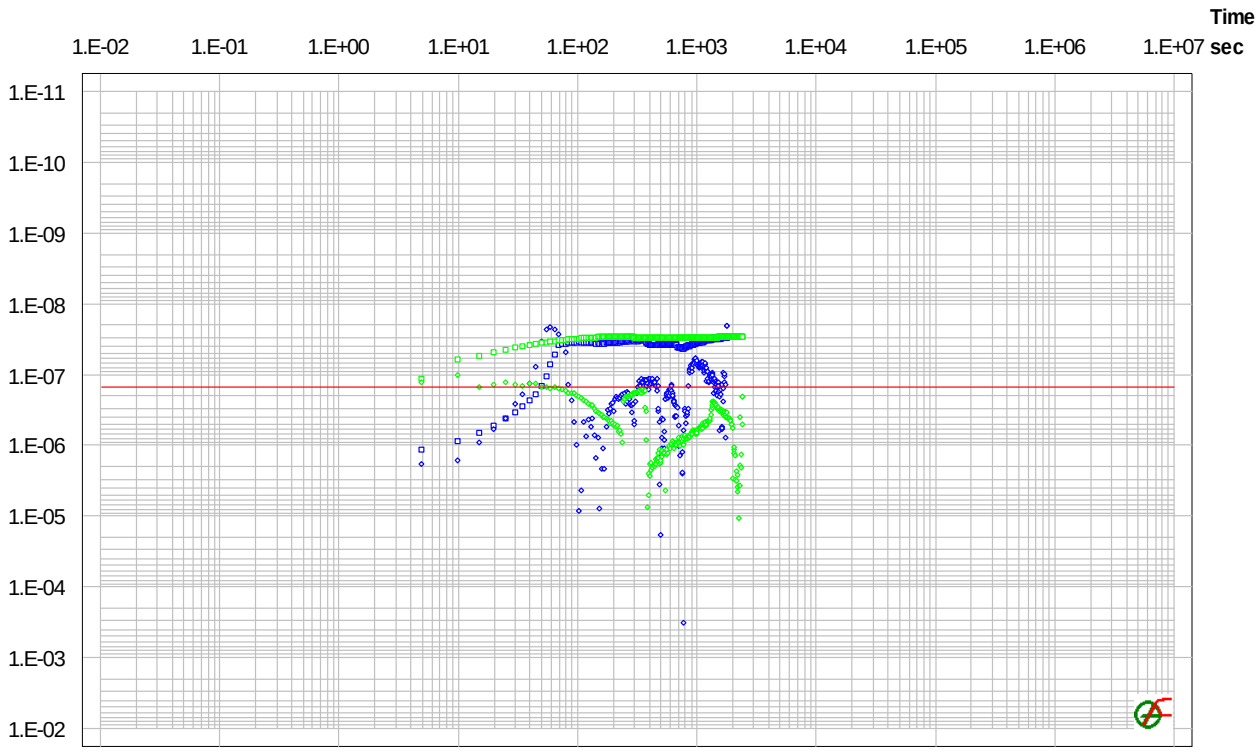
Static Pressure: 1015.00 kPa

Shell Parameters:

Name	Transmissivity [m²/s]	Storativity [-]	Radius [m]	Flow Dimension [-]
Shell 1	3.0e-07	1.0e-04	- -	2.0

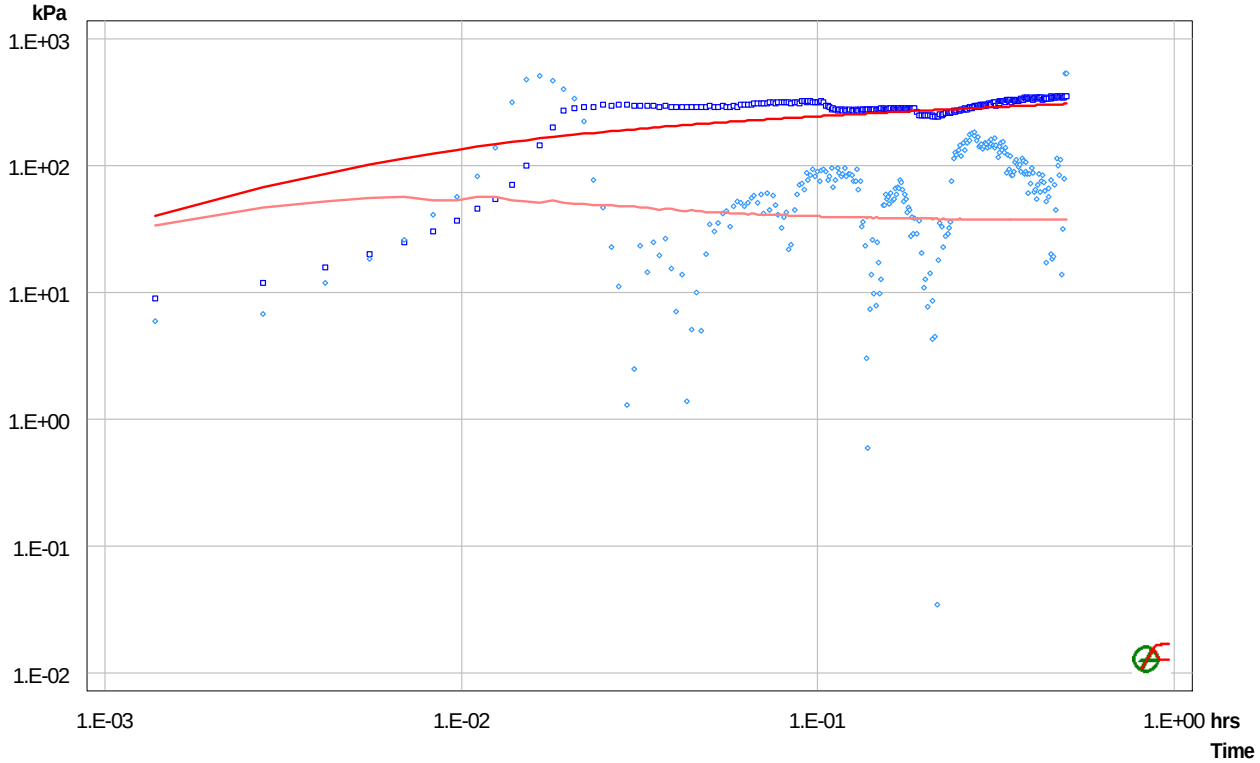
Sequence Parameters:

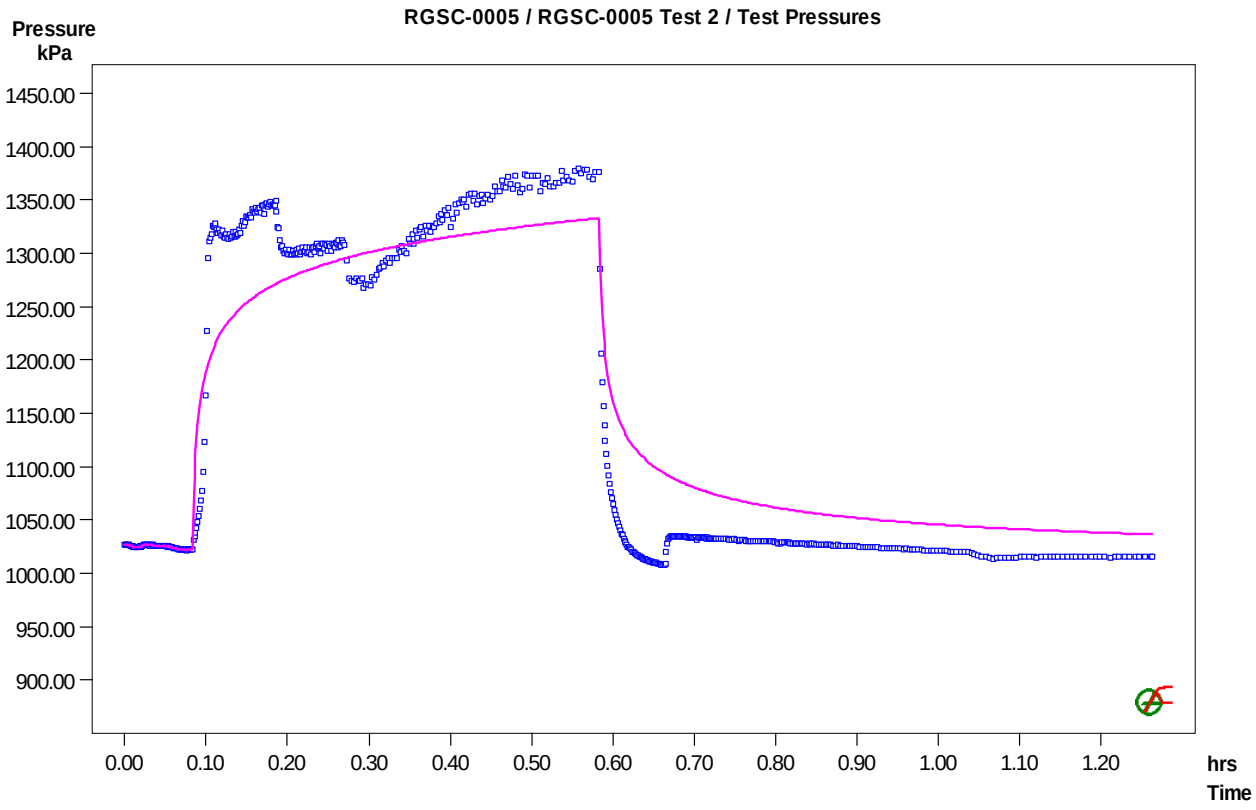
Name	Wellbore Storage [m³/Pa]	Skin [-]
Background	1.2e-09	0.0
Constant Rate	1.2e-09	0.0
Recovery	1.2e-09	0.0



RGSC-0005 / RGSC-0005 Test 2 / LogLog Diagnosis - Analysis_1

RGSC-0005 / RGSC-0005 Test 2 / Constant Rate: LogLog Plot




RGSC-0005 / RGSC-0005 Test 2 / Test Pressures
Pressure
kPa
1450.00
1400.00
1350.00
1300.00
1250.00
1200.00
1150.00
1100.00
1050.00
1000.00
950.00
900.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
1.10
1.20
hrs
Time

RGSC-0006

Golder Associates

HYDROBENCH REPORT

Project	Riversdale
Site	Riversdale
Source Well	RGSC-0006
Test Name	RGSC-0006 Test 1
Test Date/Time	August 28, 2014
Interval	top: 59.05 m bottom: 91.31 m
Description	

Basic Data

Test Interval	32.26 m		
Porosity	0.05		
Well Radius	0.048 m	Tubing Radius	0.039 m
Inclination	20.0 deg		
Test Volume	233.505 l		
Well Type	Source		

Fluid Properties

Viscosity	0.001 Pa*s
Density	1000.0 kg/m³
Compressibility	2.0e-09 1/Pa

Sequence Definition

Name	Category	t(o) [hrs]	P(o) [kPa]	P(i) [kPa]	Rate [l/min]	C [m³/Pa]
Background	Variable Pressure	0.00000	649.67			5.2e-07
Slug Test	dP-Event	0.41944	643.46	-48.8 *		5.2e-07
Recovery	Slug	0.43611	692.21	643.5		5.2e-07
Ri- Rate 1	Constant Rate	1.37639	645.11		-5.08e+01	7.2e-07
Ri-Rate 2	Constant Rate	1.60694	1027.04		-2.94e+01	7.2e-07
Recovery 2	Recovery	1.87778	995.68			7.2e-07

Analysis Results

Analysis "Analysis_1"

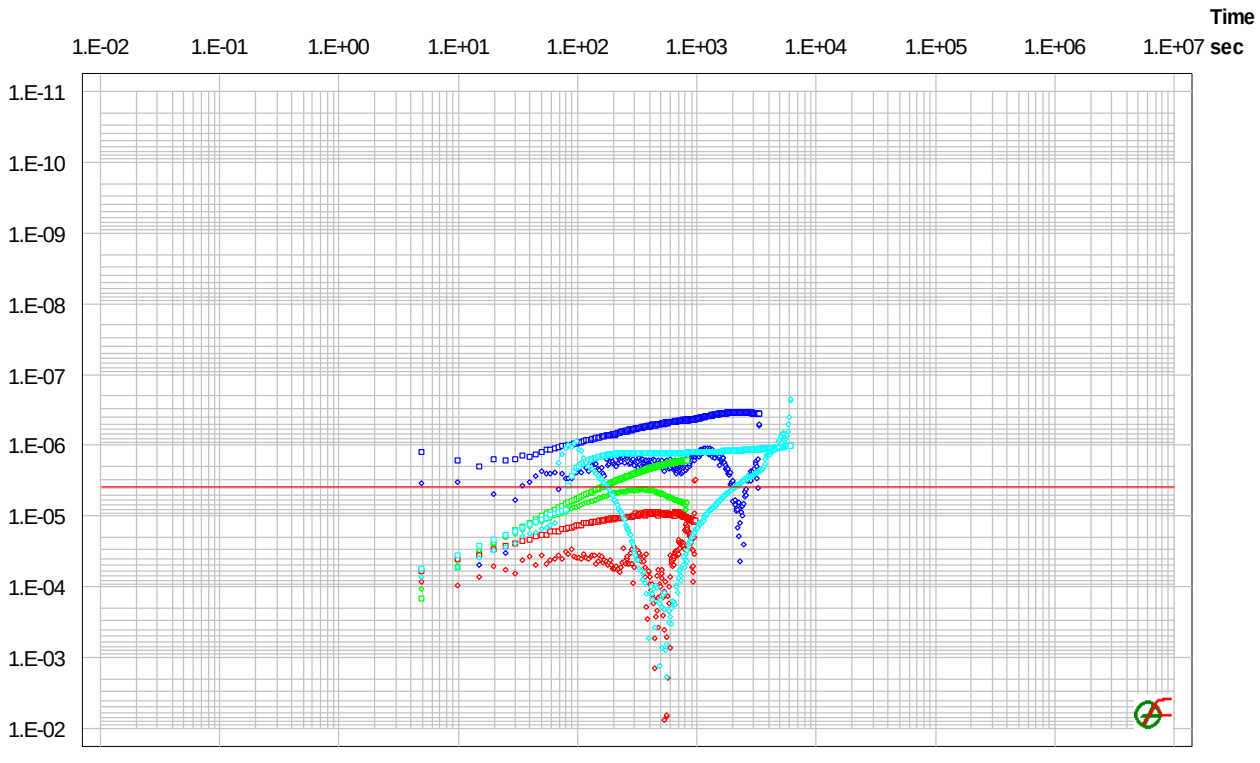
Static Pressure: 643.50 kPa

Shell Parameters:

Name	Transmissivity [m²/s]	Storativity [-]	Radius [m]	Flow Dimension [-]
Shell 1	4.3e-06	1.0e-04	- -	2.0

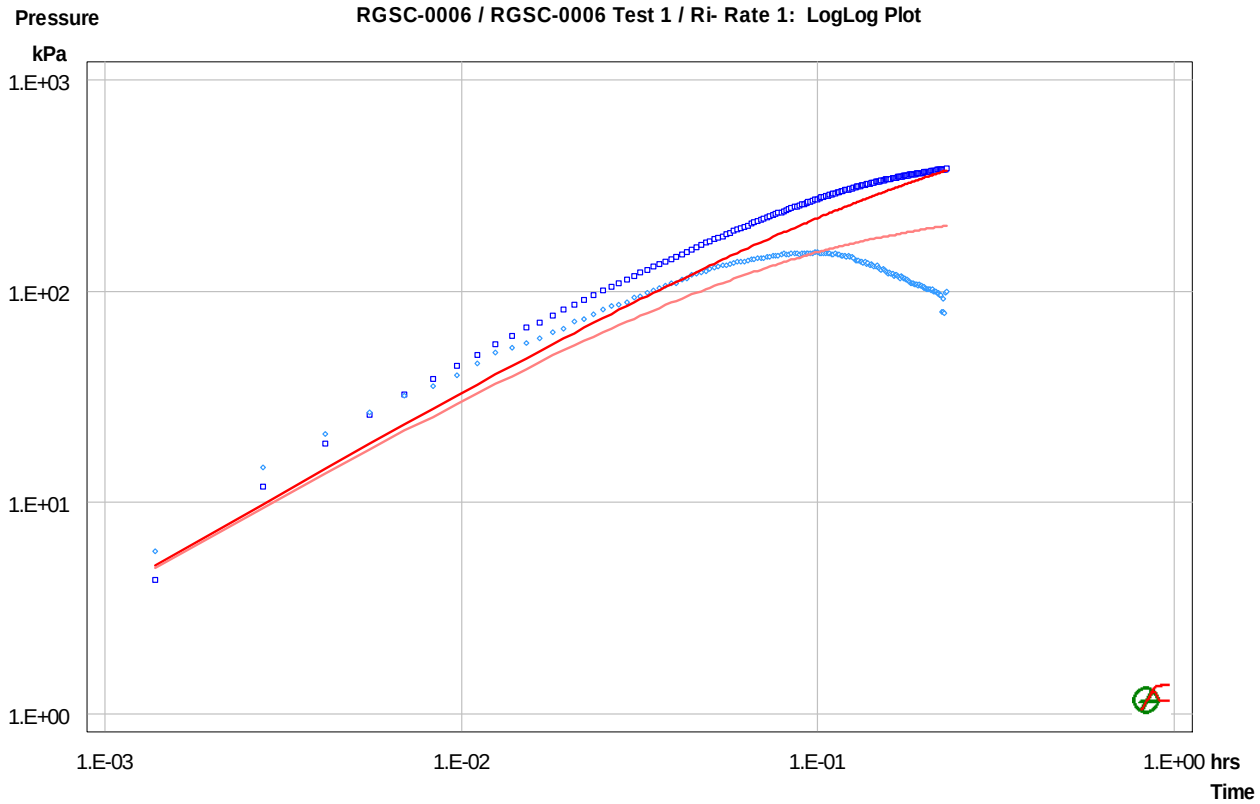
Sequence Parameters:

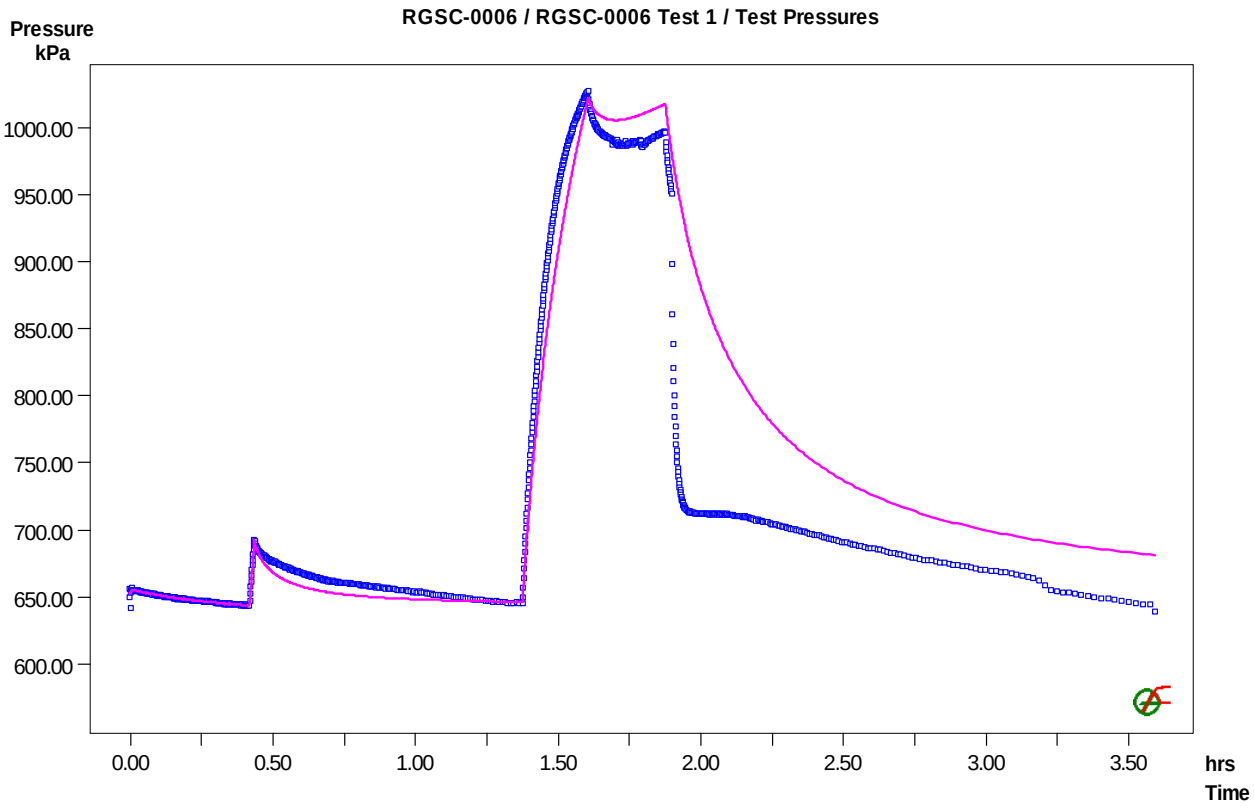
Name	Wellbore Storage [m³/Pa]	Skin [-]
Background	5.2e-07	-3.5
Slug Test	5.2e-07	-3.5
Recovery	5.2e-07	-3.5
Ri- Rate 1	7.2e-07	-3.5
Ri-Rate 2	7.2e-07	-3.5
Recovery 2	7.2e-07	-3.5



RGSC-0006 / RGSC-0006 Test 1 / LogLog Diagnosis - Analysis_1

RGSC-0006 / RGSC-0006 Test 1 / Ri- Rate 1: LogLog Plot




RGSC-0006 / RGSC-0006 Test 1 / Test Pressures
Pressure
kPa
1000.00
950.00
900.00
850.00
800.00
750.00
700.00
650.00
600.00
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
hrs
Time

HYDROBENCH REPORT

Project	Riversdale
Site	Riversdale
Source Well	RGSC-0006
Test Name	RGSC-0006-Test 2
Test Date/Time	August 29, 2014
Interval	top: 92.60 m bottom: 145.96 m
Description	

Basic Data

Test Interval	53.36 m		
Porosity	0.05		
Well Radius	0.048 m	Tubing Radius	0.039 m
Inclination	0.0 deg		
Test Volume	386.232 l		
Well Type	Source		

Fluid Properties

Viscosity	0.001 Pa*s
Density	1000.0 kg/m³
Compressibility	2.0e-09 1/Pa

Sequence Definition

Name	Category	t(o) [hrs]	P(o) [kPa]	P(i) [kPa]	Rate [l/min]	C [m³/Pa]
Background	Variable Pressure	0.00000	956.19			4.9e-07
dp event	dP-Event	0.41528	943.59	-54.6 *		4.9e-07
Slug Test	Slug	0.43194	998.18	943.6		4.9e-07
RI-1	Constant Rate	1.21389	937.04		-3.26e+01	8.2e-07
Recovery	Recovery	1.71250	1045.55			8.2e-07

Analysis Results

Analysis "Analysis_1"

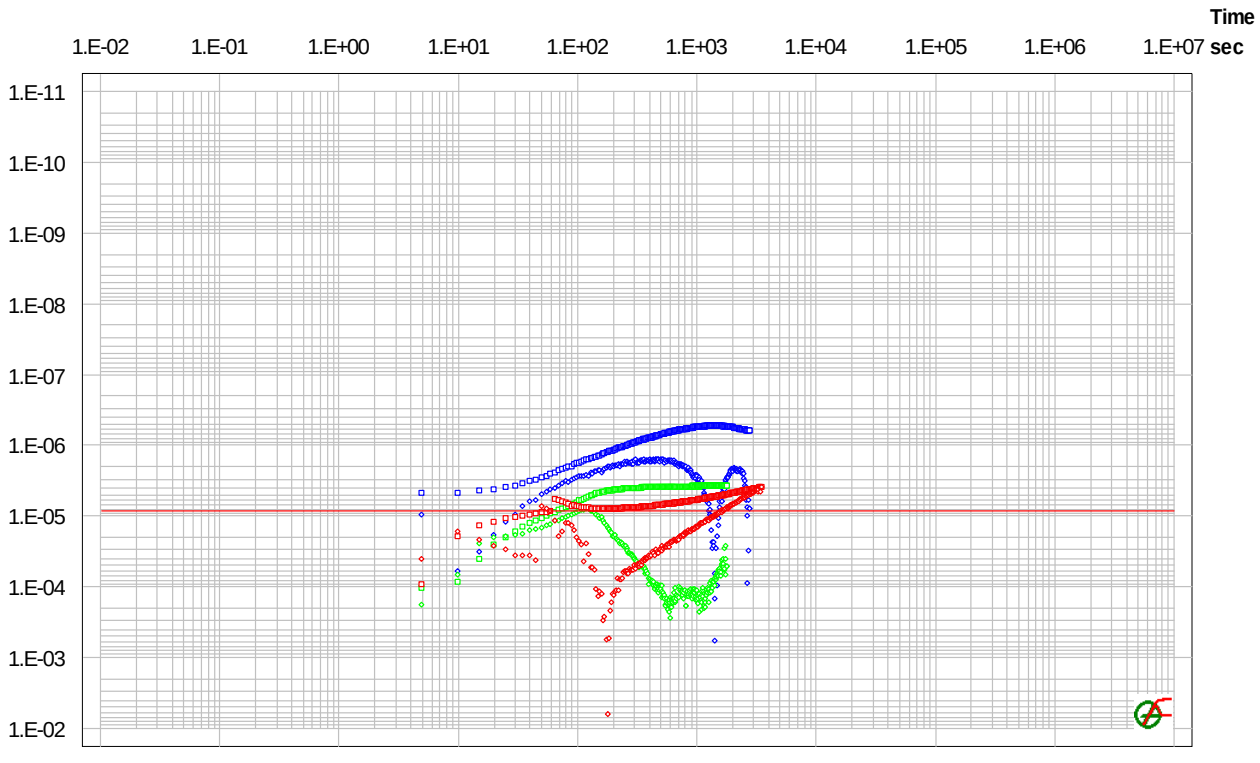
Static Pressure: 937.00 kPa

Shell Parameters:

Name	Transmissivity [m²/s]	Storativity [-]	Radius [m]	Flow Dimension [-]
Shell 1	8.7e-06	1.0e-04	- -	2.0

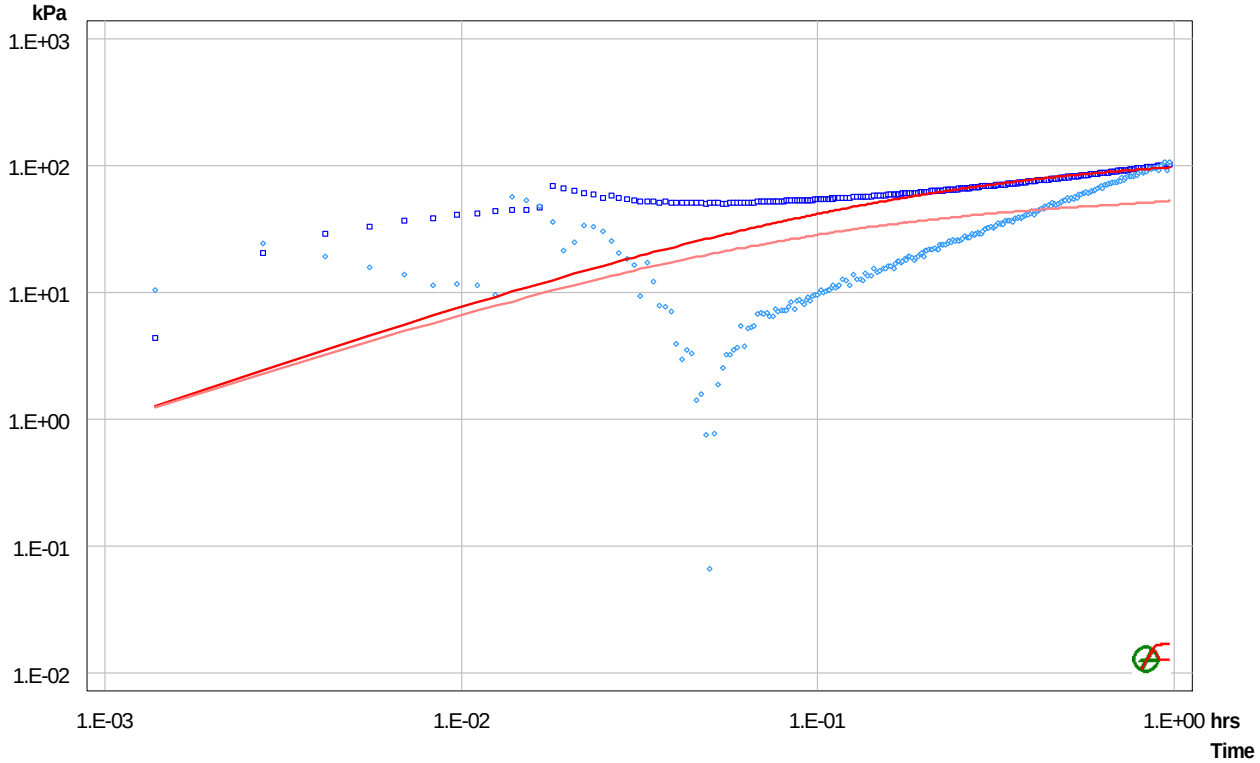
Sequence Parameters:

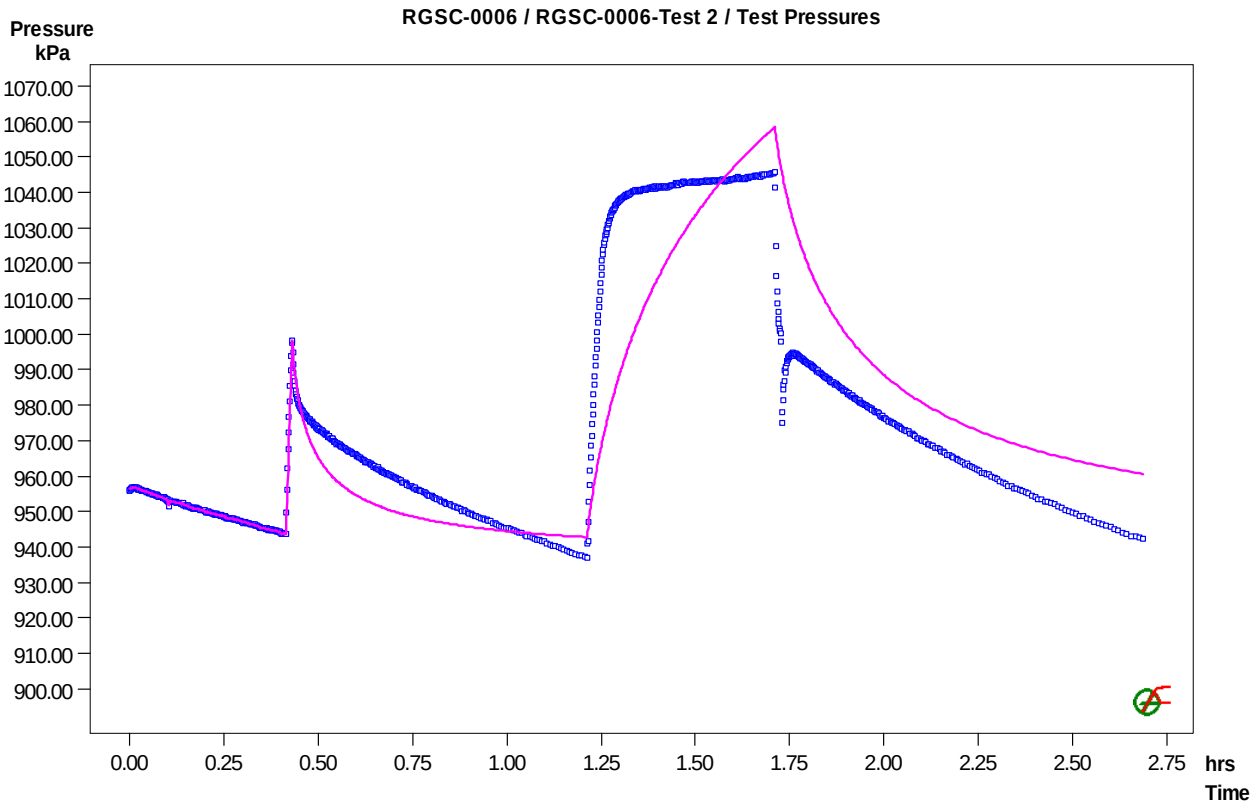
Name	Wellbore Storage [m³/Pa]	Skin [-]
Background	4.9e-07	-4.7
dp event	4.9e-07	-4.7
Slug Test	4.9e-07	-4.7
RI-1	8.2e-07	-4.7
Recovery	8.2e-07	-4.7



RGSC-0006 / RGSC-0006-Test 2 / LogLog Diagnosis - Analysis_1

RGSC-0006 / RGSC-0006-Test 2 / Recovery: LogLog Plot




RGSC-0006 / RGSC-0006-Test 2 / Test Pressures
Pressure
kPa
1070.00
1060.00
1050.00
1040.00
1030.00
1020.00
1010.00
1000.00
990.00
980.00
970.00
960.00
950.00
940.00
930.00
920.00
910.00
900.00
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
hrs
Time

RGSC-0007

Golder Associates

HYDROBENCH REPORT

Project	Riversdale
Site	Riversdale
Source Well	RGSC-0007
Test Name	RGSC-0007 Test 1
Test Date/Time	Sept 5, 2014
Interval	top: 46.60 m bottom: 78.80 m
Description	

Basic Data

Test Interval	32.20 m		
Porosity	0.05		
Well Radius	0.039 m	Tubing Radius	0.039 m
Inclination	0.0 deg		
Test Volume	153.075 l		
Well Type	Source		

Fluid Properties

Viscosity	0.001 Pa*s
Density	1000.0 kg/m³
Compressibility	2.0e-09 1/Pa

Sequence Definition

Name	Category	t(o) [hrs]	P(o) [kPa]	P(i) [kPa]	Rate [l/min]	C [m³/Pa]
Background	Variable Pressure	0.00000	150.23			4.8e-07
SI	dP-Event	0.95972	96.09	-154.5 *		4.8e-07
Slug	Slug	0.98611	250.55	96.1		4.8e-07
RI	Constant Rate	1.70972	194.63		-1.54e+01	7.8e-08
RI-b	Constant Rate	1.73056	484.84		-1.26e+01	7.8e-08
RI Recovery	Recovery	2.24167	832.01			7.8e-08

Analysis Results

Analysis "Analysis_1"

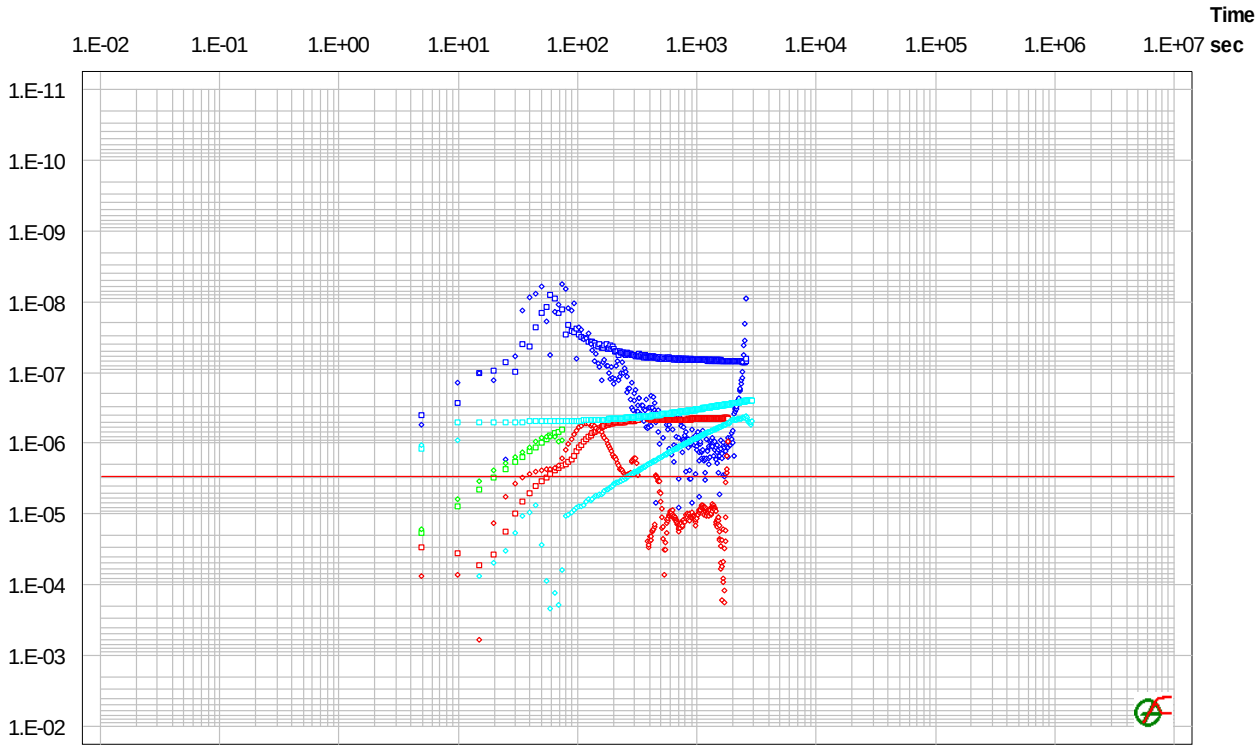
Static Pressure: 96.00 kPa

Shell Parameters:

Name	Transmissivity [m²/s]	Storativity [-]	Radius [m]	Flow Dimension [-]
Shell 1	2.3e-06	1.0e-04	- -	2.0

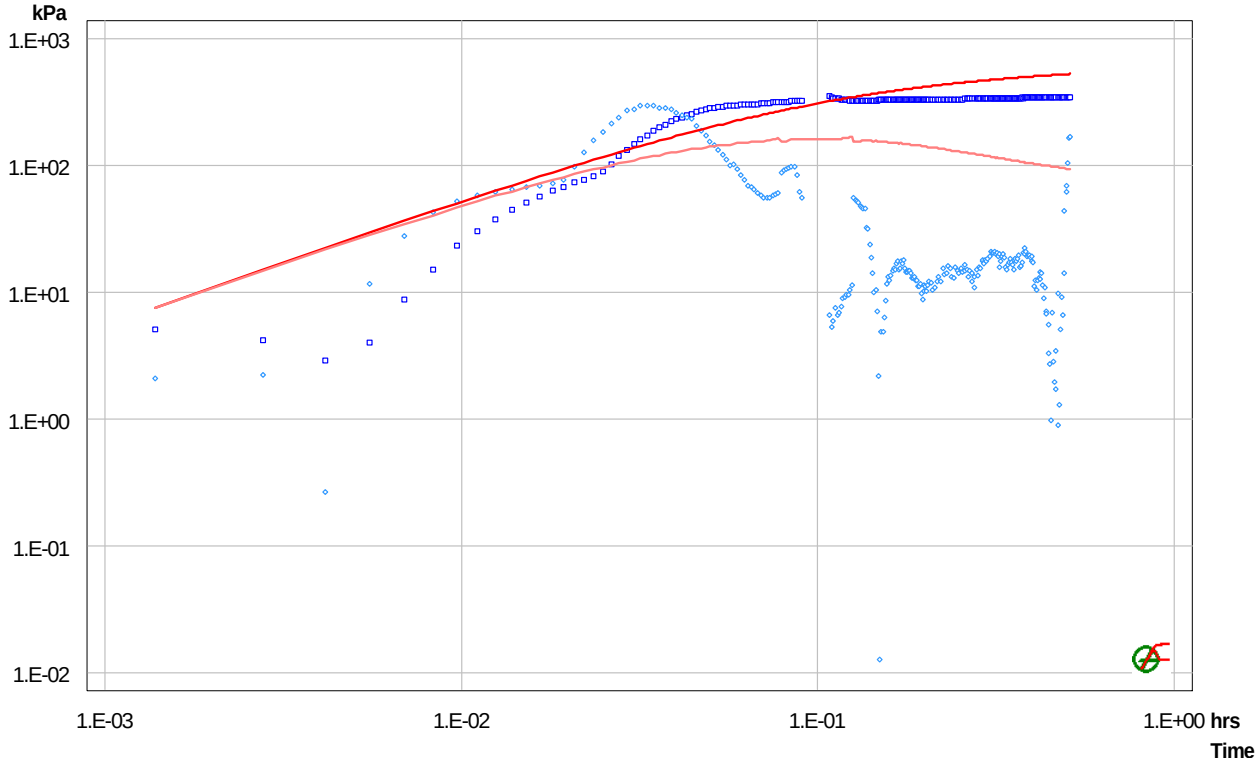
Sequence Parameters:

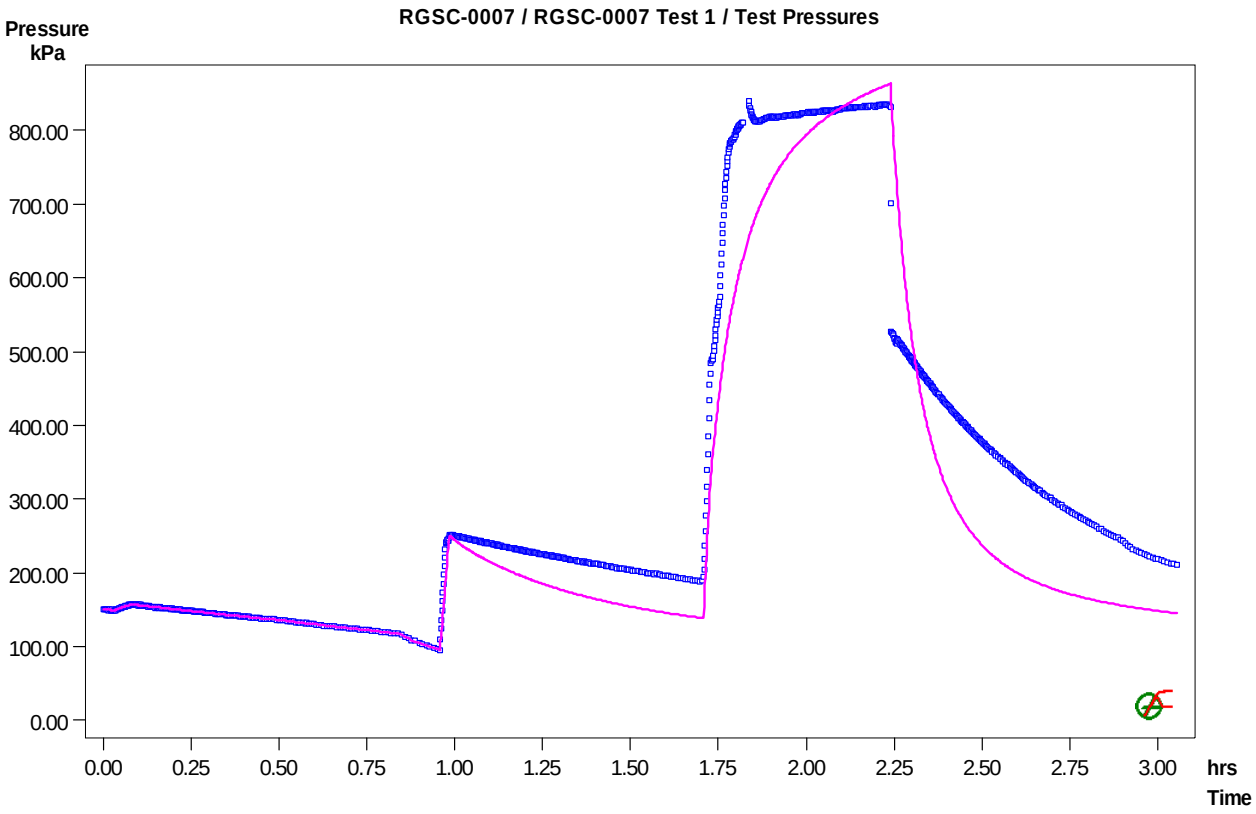
Name	Wellbore Storage [m³/Pa]	Skin [-]
Background	4.8e-07	0.0
SI	4.8e-07	0.0
Slug	4.8e-07	0.0
RI	7.8e-08	0.0
RI-b	7.8e-08	0.0
RI Recovery	7.8e-08	0.0



RGSC-0007 / RGSC-0007 Test 1 / LogLog Diagnosis - Analysis_1

RGSC-0007 / RGSC-0007 Test 1 / RI-b: LogLog Plot




RGSC-0007 / RGSC-0007 Test 1 / Test Pressures
Pressure
kPa
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
3.00
hrs
Time

HYDROBENCH REPORT

Project	Riversdale
Site	Riversdale
Source Well	RGSC-0007
Test Name	RGSC-0007 Test 2
Test Date/Time	Sept 6, 2014
Interval	top: 77.10 m bottom: 124.65 m
Description	

Basic Data

Test Interval	47.55 m		
Porosity	0.05		
Well Radius	0.039 m	Tubing Radius	0.039 m
Inclination	0.0 deg		
Test Volume	226.047 l		
Well Type	Source		

Fluid Properties

Viscosity	0.001 Pa*s
Density	1000.0 kg/m³
Compressibility	2.0e-09 1/Pa

Analysis Results

Analysis "Analysis_1"

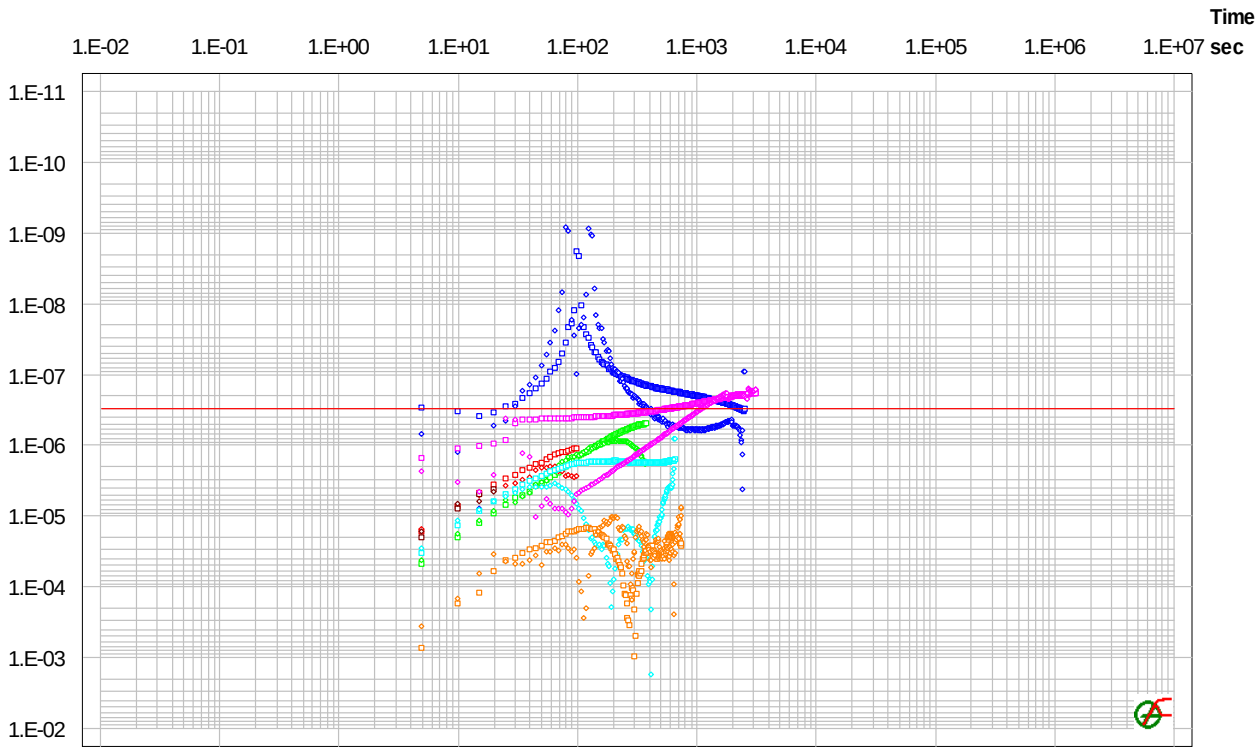
Static Pressure: 250.00 kPa

Shell Parameters:

Name	Transmissivity [m²/s]	Storativity [-]	Radius [m]	Flow Dimension [-]
Shell 1	8.3e-06	1.0e-04	1.00	2.0
Shell 2	3.2e-07	1.0e-04	- -	2.0

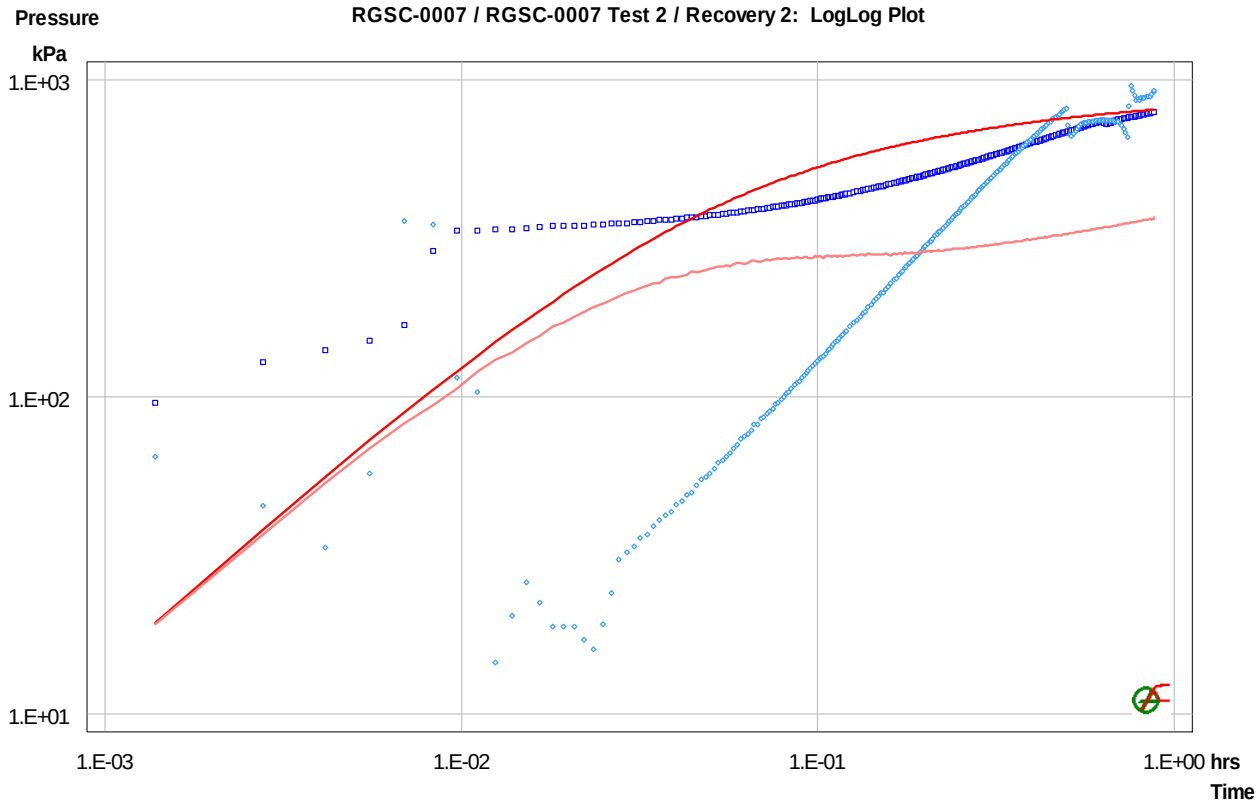
Sequence Parameters:

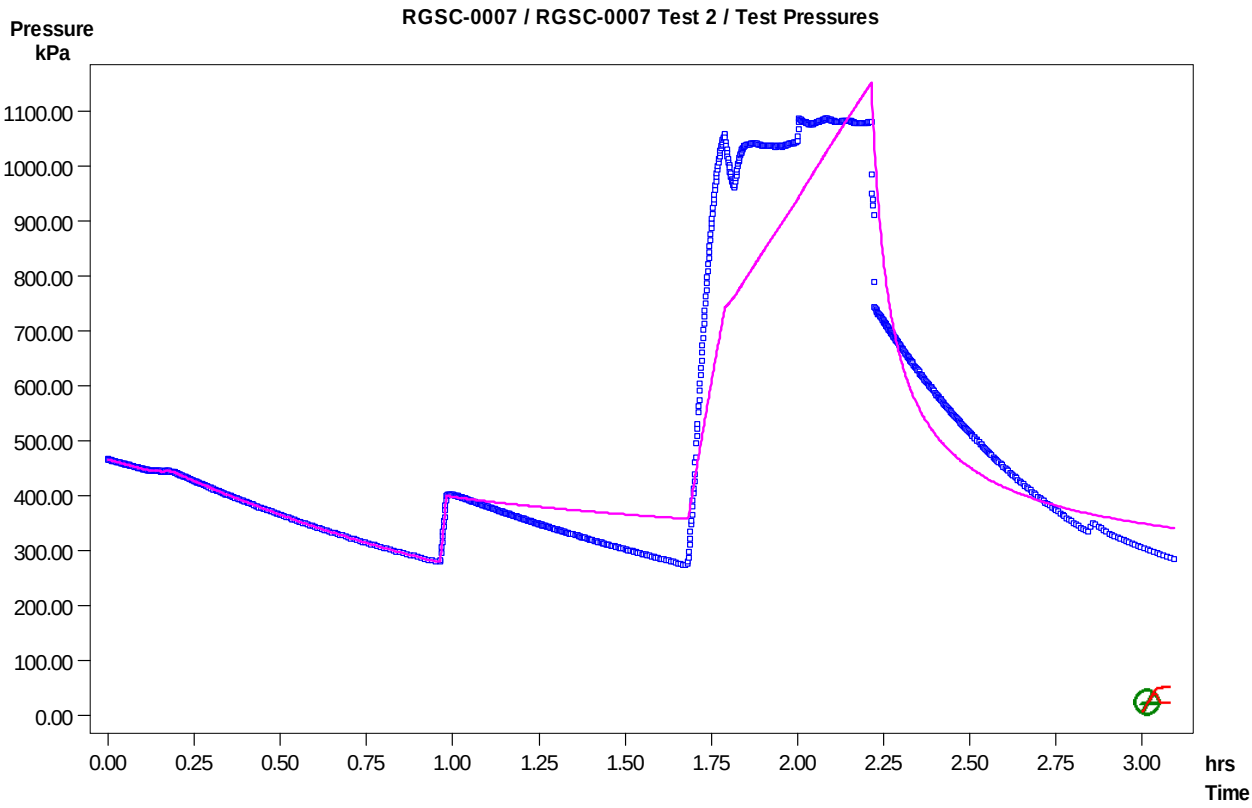
Name	Wellbore Storage [m³/Pa]	Skin [-]
Background	4.9e-07	35.0
SI	4.9e-07	35.0
Recovery	4.9e-07	35.0
RI-a	4.9e-07	35.0
RI-b	4.9e-07	35.0
RI-c	4.9e-07	35.0
RI-d	4.9e-07	35.0
RI-e	4.9e-07	35.0
Recovery 2	1.7e-08	35.0



RGSC-0007 / RGSC-0007 Test 2 / LogLog Diagnosis - Analysis_1

RGSC-0007 / RGSC-0007 Test 2 / Recovery 2: LogLog Plot




RGSC-0007 / RGSC-0007 Test 2 / Test Pressures
Pressure
kPa
1100.00
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
3.00
hrs
Time

HYDROBENCH REPORT

Project	Riversdale
Site	Riversdale
Source Well	RGSC-0007
Test Name	RGSC-0007 Test 3
Test Date/Time	Sept 7, 2014
Interval	top: 125.90 m bottom: 176.70 m
Description	

Basic Data

Test Interval	50.80 m		
Porosity	0.05		
Well Radius	0.039 m	Tubing Radius	0.039 m
Inclination	0.0 deg		
Test Volume	242.741 l		
Well Type	Source		

Fluid Properties

Viscosity	0.001 Pa*s
Density	1000.0 kg/m³
Compressibility	2.0e-09 1/Pa

Sequence Definition

Name	Category	t(o) [hrs]	P(o) [kPa]	P(i) [kPa]	Rate [l/min]	C [m³/Pa]
Background	Variable Pressure	0.00000	814.97			4.9e-07
SI	dP-Event	1.42083	809.23	-161.4 *		4.9e-07
SI Recovery	Slug	1.44028	970.62	809.2		4.9e-07
RI-a	Constant Rate	2.05417	956.96		-4.73e+00	4.8e-08
RI Recovery	Recovery	2.58333	1667.76			3.1e-06

Analysis Results

Analysis "Analysis_1"

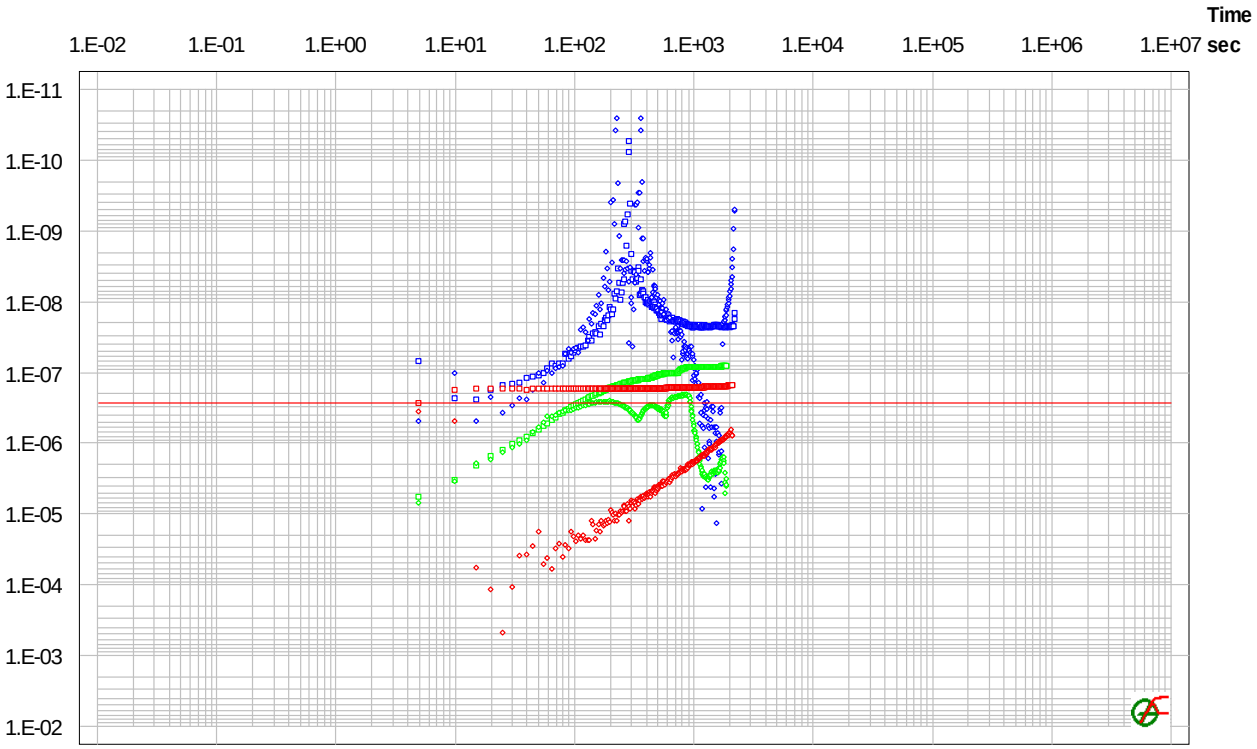
Static Pressure: 1200.00 kPa

Shell Parameters:

Name	Transmissivity [m²/s]	Storativity [-]	Radius [m]	Flow Dimension [-]
Shell 1	2.7e-07	1.0e-04	- -	2.0

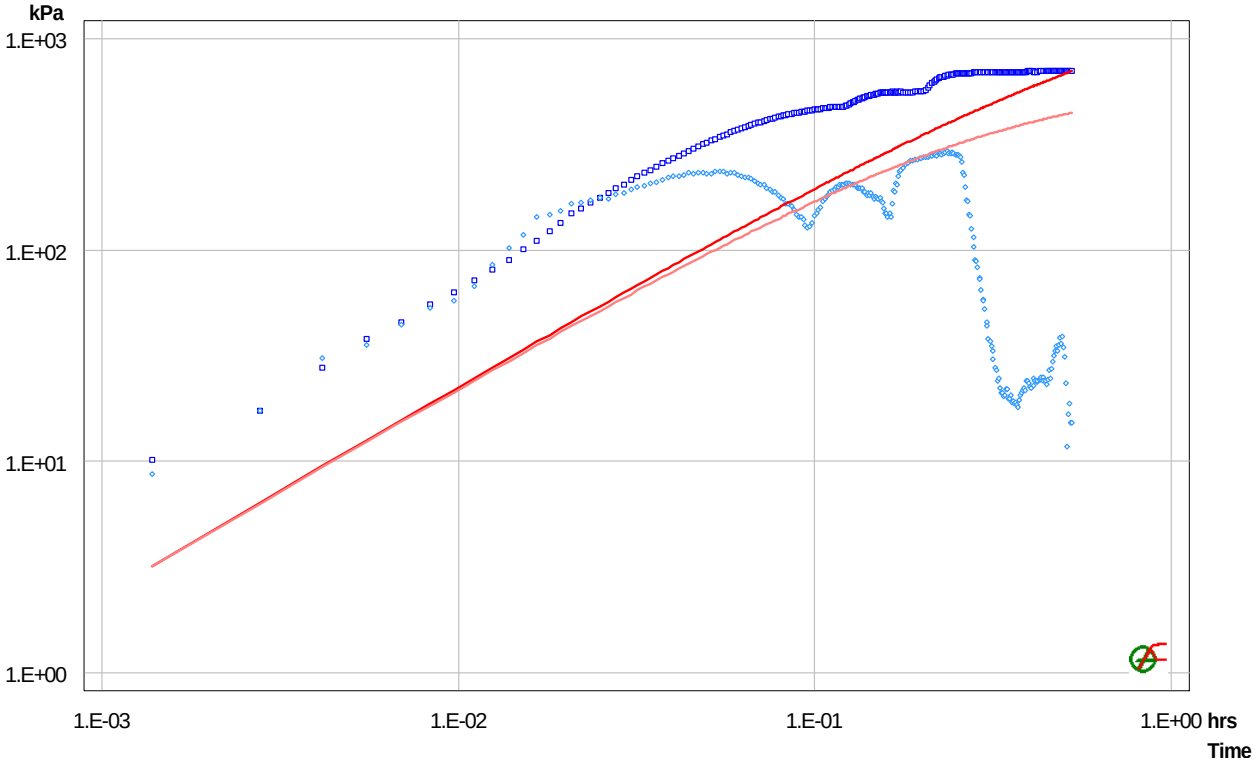
Sequence Parameters:

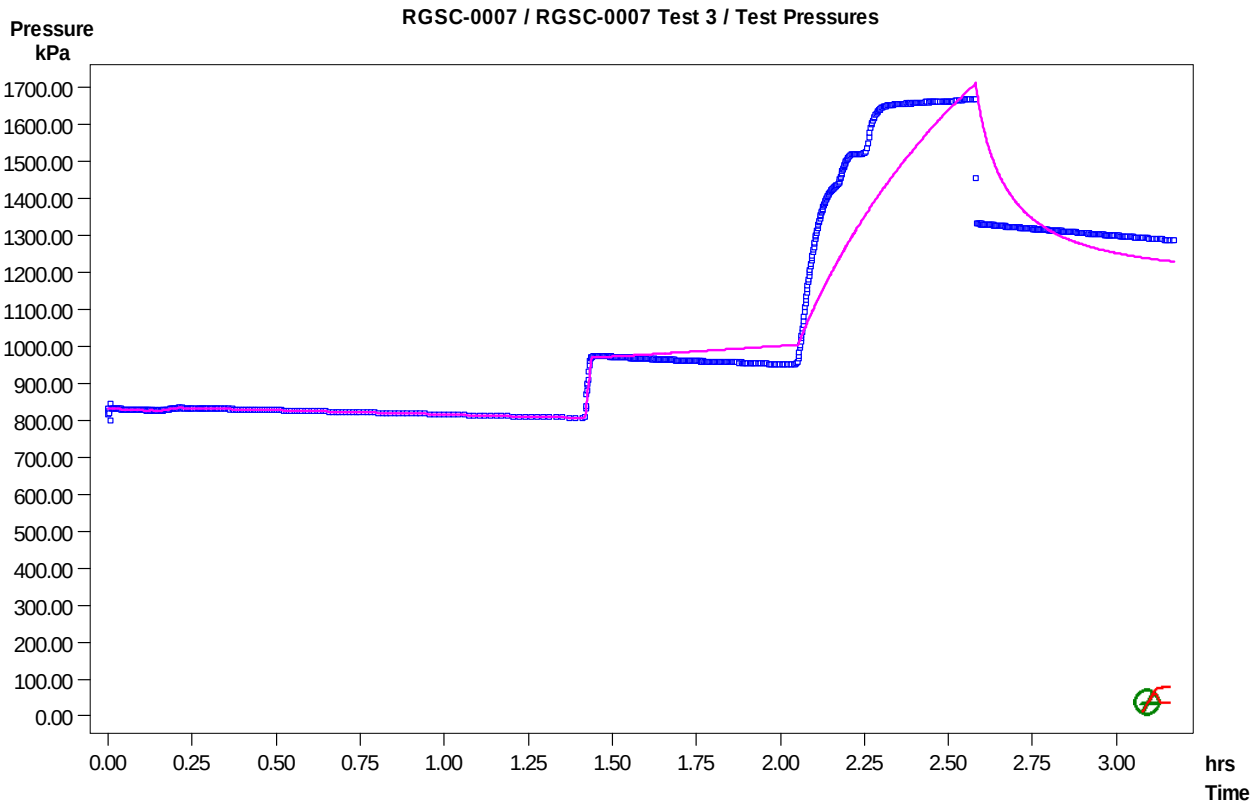
Name	Wellbore Storage [m³/Pa]	Skin [-]
Background	4.9e-07	-2.0
SI	4.9e-07	-2.0
SI Recovery	4.9e-07	-2.0
RI-a	1.3e-07	-2.0
RI Recovery	1.7e-08	-2.0



RGSC-0007 / RGSC-0007 Test 3 / LogLog Diagnosis - Analysis_1

RGSC-0007 / RGSC-0007 Test 3 / RI-a: LogLog Plot




RGSC-0007 / RGSC-0007 Test 3 / Test Pressures
Pressure
kPa
1700.00
1600.00
1500.00
1400.00
1300.00
1200.00
1100.00
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
2.50
2.75
3.00
hrs
Time

RGSC-0008

Golder Associates

HYDROBENCH REPORT

Project	Riversdale
Site	Riversdale
Source Well	RGSC-0008
Test Name	RGSC-0008 Test 1
Test Date/Time	Sept 11, 2014
Interval	top: 18.63 m bottom: 93.55 m
Description	

Basic Data

Test Interval	74.92 m		
Porosity	0.05		
Well Radius	0.039 m	Tubing Radius	0.039 m
Inclination	0.0 deg		
Test Volume	357.995 l		
Well Type	Source		

Fluid Properties

Viscosity	0.001 Pa*s
Density	1000.0 kg/m³
Compressibility	2.0e-09 1/Pa

Sequence Definition

Name	Category	t(o) [hrs]	P(o) [kPa]	P(i) [kPa]	Rate [l/min]	C [m³/Pa]
Background	Variable Pressure	0.00000	191.81			4.9e-07
SI	dP-Event	0.68750	80.41	-193.3 *		4.9e-07
SLug	Slug	0.73056	273.68	80.4		4.9e-07
RI	Constant Rate	1.07222	80.23		-3.94e+01	4.9e-07
Recovery	Recovery	1.48194	509.08			4.9e-07

Analysis Results

Analysis "Analysis_1"

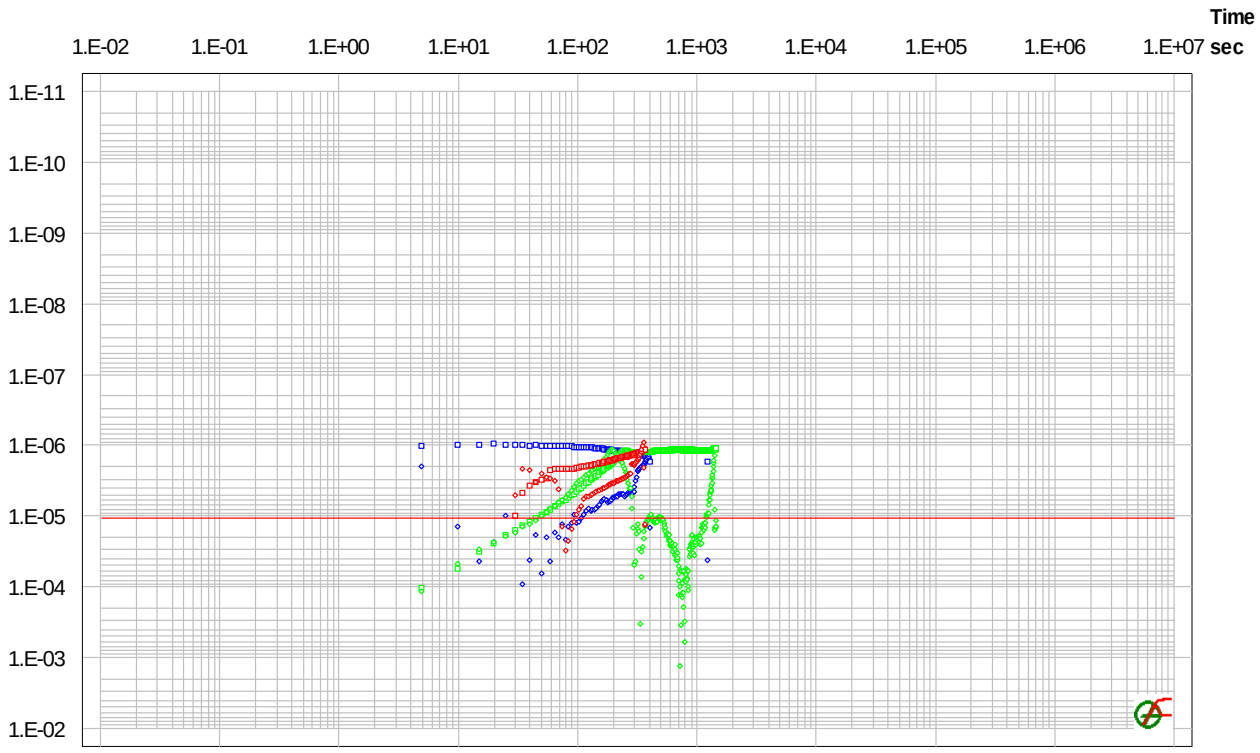
Static Pressure: 10.00 kPa

Shell Parameters:

Name	Transmissivity [m²/s]	Storativity [-]	Radius [m]	Flow Dimension [-]
Shell 1	1.1e-05	1.0e-04	- -	2.0

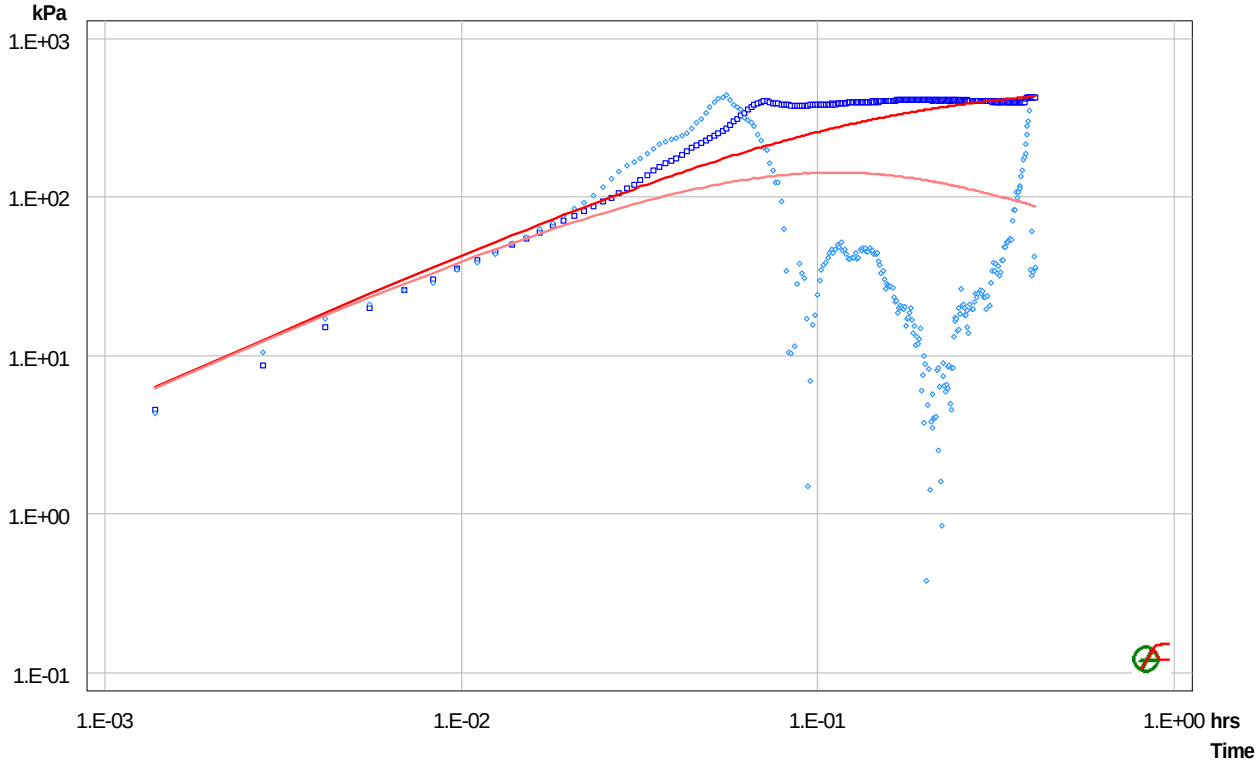
Sequence Parameters:

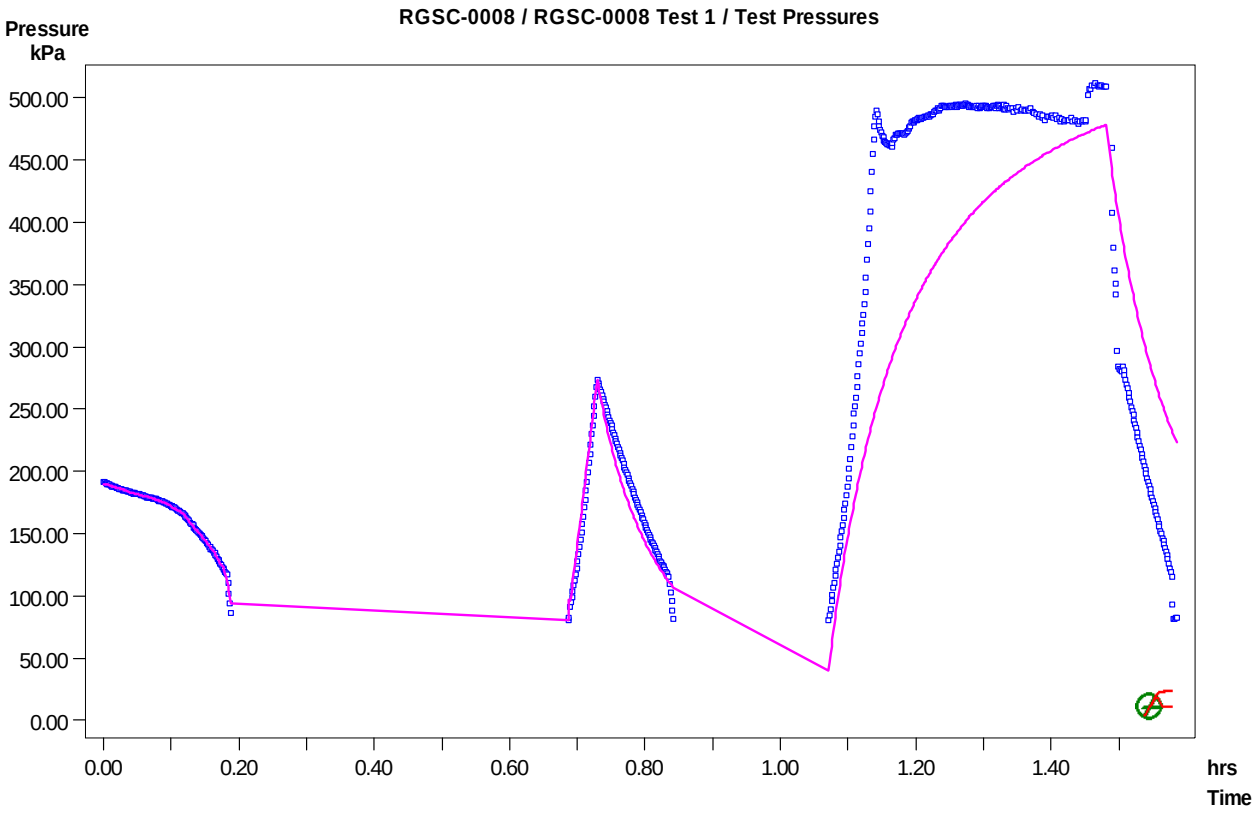
Name	Wellbore Storage [m³/Pa]	Skin [-]
Background	4.9e-07	-1.0
SI	4.9e-07	-1.0
SLug	4.9e-07	-1.0
RI	4.9e-07	-1.0
Recovery	4.9e-07	-1.0



RGSC-0008 / RGSC-0008 Test 1 / LogLog Diagnosis - Analysis_1

RGSC-0008 / RGSC-0008 Test 1 / RI: LogLog Plot




RGSC-0008 / RGSC-0008 Test 1 / Test Pressures
Pressure
kPa
500.00
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
hrs
Time

RGSC-0009

Golder Associates

HYDROBENCH REPORT

Project	Riversdale
Site	Riversdale
Source Well	RGSC-0009
Test Name	Test 1
Test Date/Time	
Interval	top: 53.21 m bottom: 54.46 m
Description	Depths are along hole.
	Unknown static water level. Used 113.6mbgs, the depth of water during the VWP installation.

Basic Data

Test Interval	1.25 m		
Porosity	0.05		
Well Radius	0.039 m	Tubing Radius	0.039 m
Inclination	20.0 deg		
Test Volume	5.973 l		
Well Type	Source		

Fluid Properties

Viscosity	0.001 Pa*s
Density	1000.0 kg/m³
Compressibility	2.0e-09 1/Pa

Sequence Definition

Name	Category	t(o) [hrs]	P(o) [kPa]	P(i) [kPa]	Rate [l/min]	C [m³/Pa]
Background	Variable Pressure	0.00000	81.14			5.2e-07
dp event	dP-Event	0.05694	81.14	-795.8 *		5.2e-07
Slug	Slug	0.11389	876.91	81.1		5.2e-07
RI	Constant Rate	0.72361	81.14		-8.10e+01	1.5e-08
RI - Recovery	Recovery	1.22361	1276.87			1.5e-07

Analysis Results

Analysis "Analysis_1"

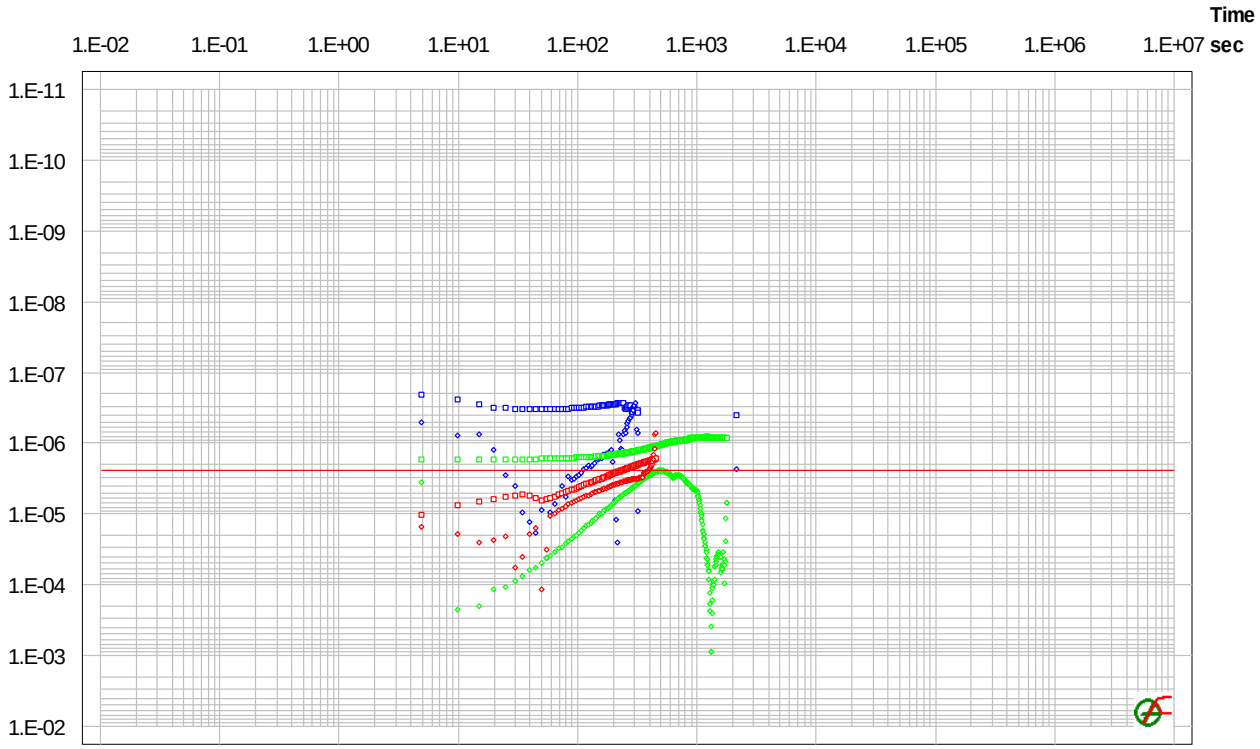
Static Pressure: 10.00 kPa

Shell Parameters:

Name	Transmissivity [m²/s]	Storativity [-]	Radius [m]	Flow Dimension [-]
Shell 1	2.0e-06	1.0e-04	- -	2.0

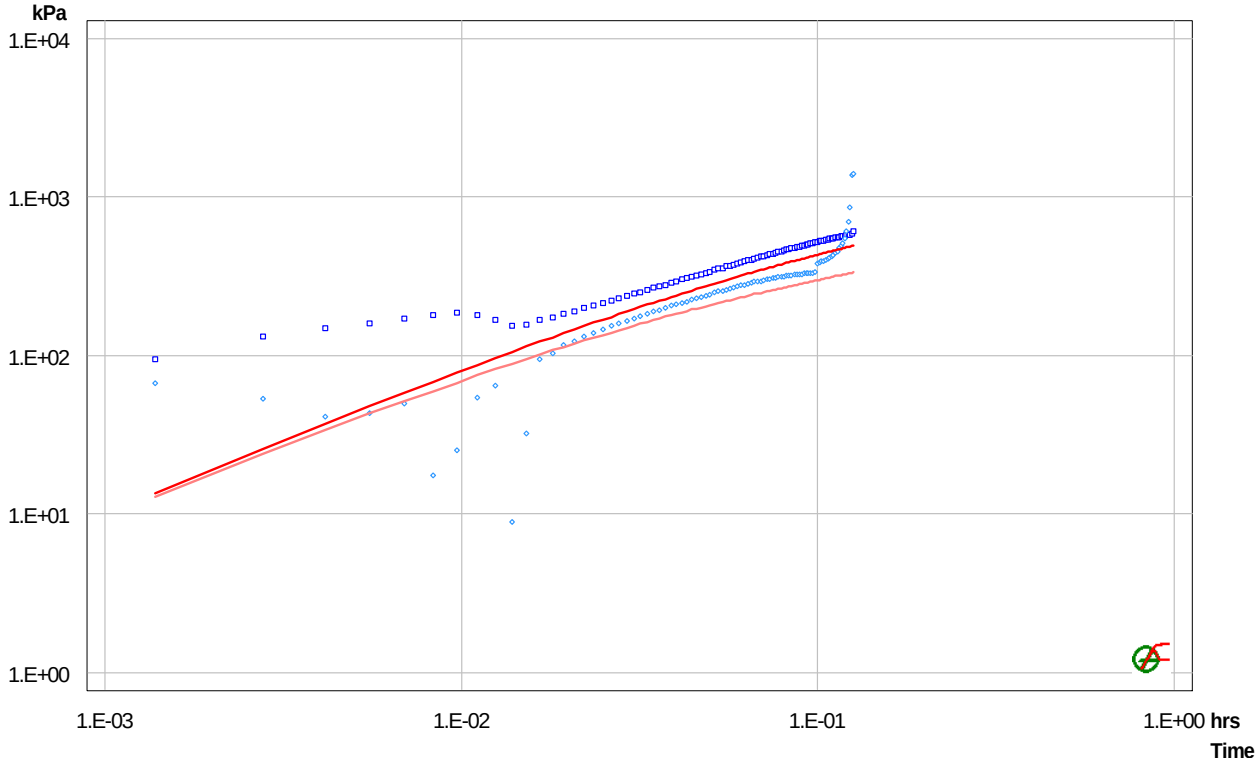
Sequence Parameters:

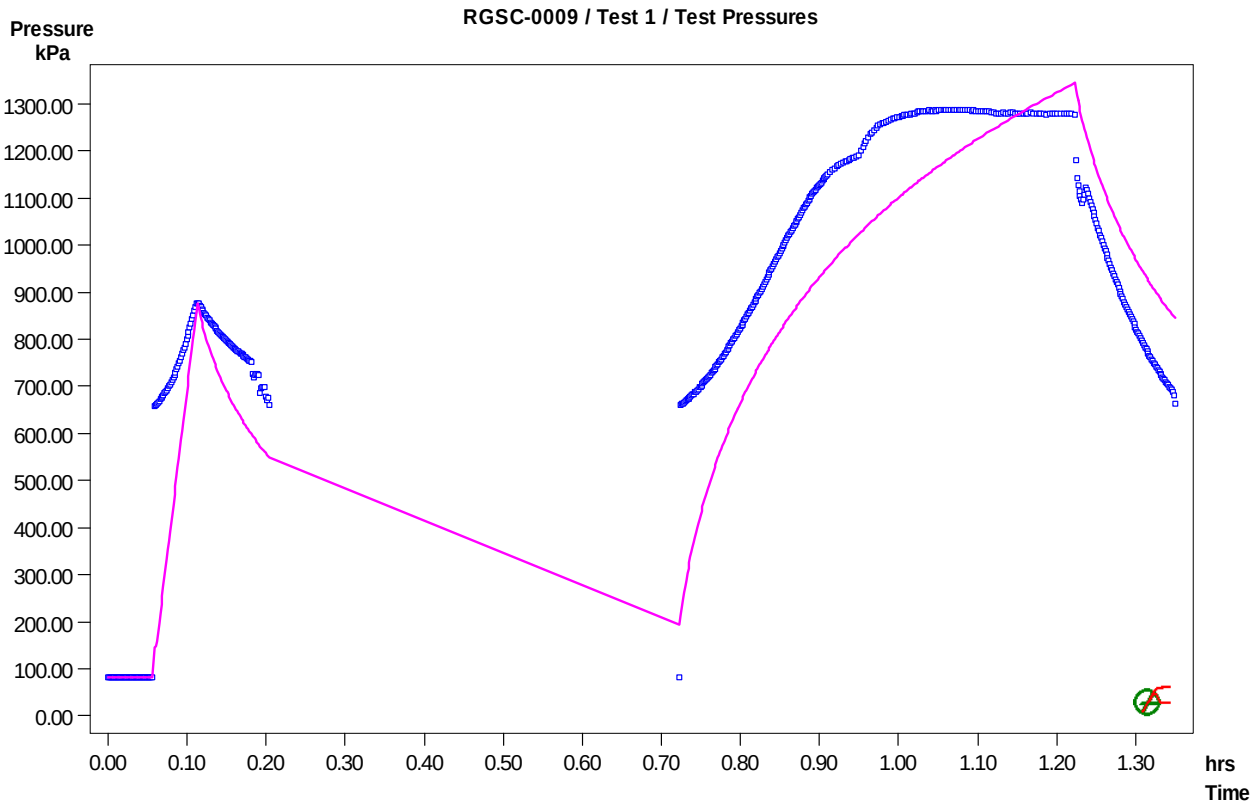
Name	Wellbore Storage [m³/Pa]	Skin [-]
Background	5.2e-07	-4.3
dp event	5.2e-07	-4.3
Slug	5.2e-07	-4.3
RI	1.5e-08	-4.3
RI - Recovery	1.5e-07	-4.3



RGSC-0009 / Test 1 / LogLog Diagnosis - Analysis_1

RGSC-0009 / Test 1 / RI - Recovery: LogLog Plot




RGSC-0009 / Test 1 / Test Pressures
Pressure
kPa
1300.00
1200.00
1100.00
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
1.10
1.20
1.30
hrs
Time

HYDROBENCH REPORT

Project	Riversdale
Site	Riversdale
Source Well	RGSC-0009
Test Name	Test 2
Test Date/Time	
Interval	top: 105.36 m bottom: 158.90 m
Description	Depths are mAH

Basic Data

Test Interval	53.54 m		
Porosity	0.05		
Well Radius	0.039 m	Tubing Radius	0.039 m
Inclination	20.0 deg		
Test Volume	255.833 l		
Well Type	Source		

Fluid Properties

Viscosity	0.001 Pa*s
Density	1000.0 kg/m³
Compressibility	2.0e-09 1/Pa

Sequence Definition

Name	Category	t(o) [hrs]	P(o) [kPa]	P(i) [kPa]	Rate [l/min]	C [m³/Pa]
Background	Variable Pressure	0.00000	74.28			5.2e-07
RI	Constant Rate	0.01528	74.28		-6.78e+01	5.2e-07
Recovery	Recovery	0.50972	1297.96			1.7e-07

Analysis Results

Analysis "Analysis_1"

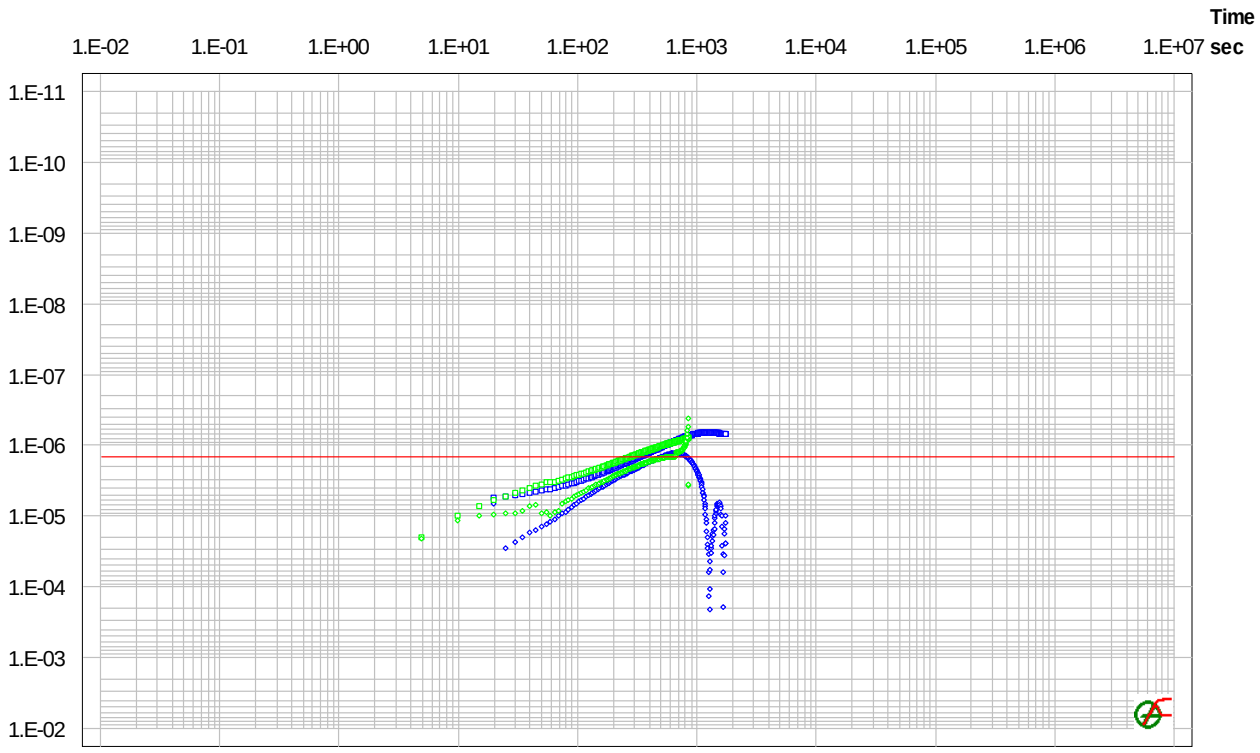
Static Pressure: 74.20 kPa

Shell Parameters:

Name	Transmissivity [m²/s]	Storativity [-]	Radius [m]	Flow Dimension [-]
Shell 1	3.0e-06	1.0e-03	- -	2.0

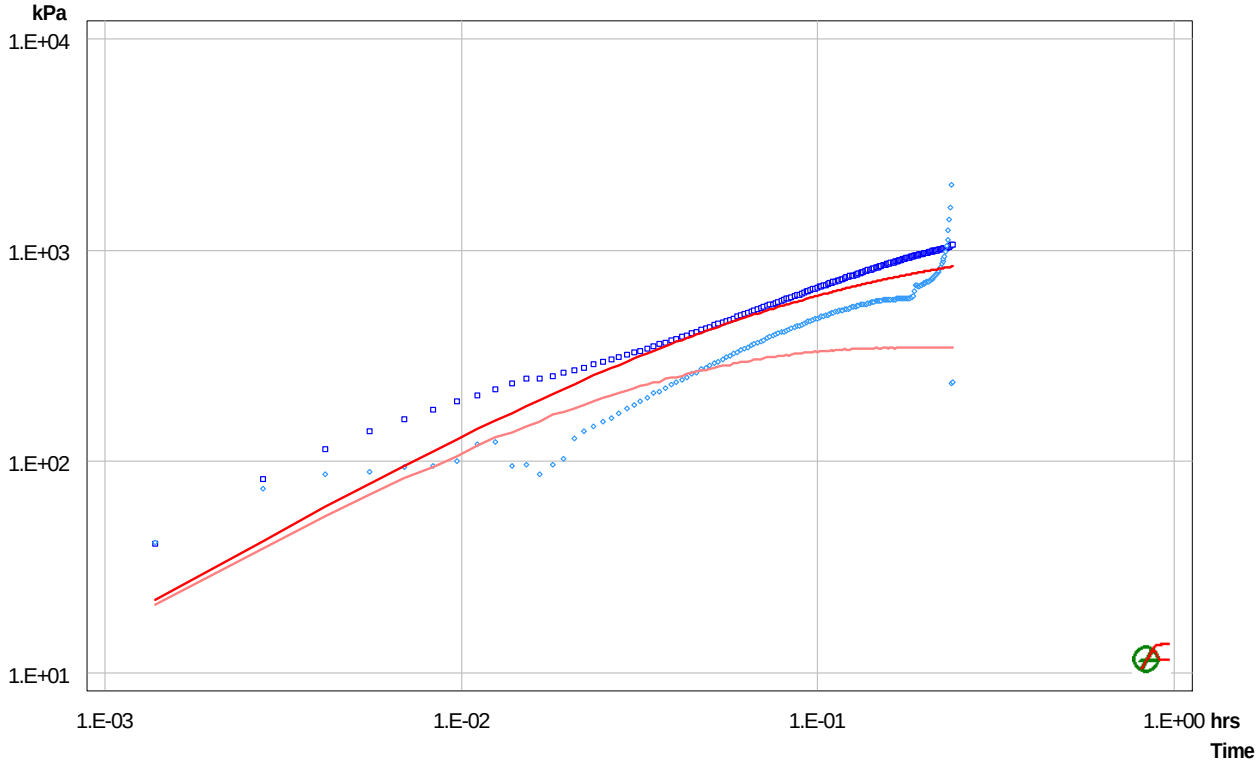
Sequence Parameters:

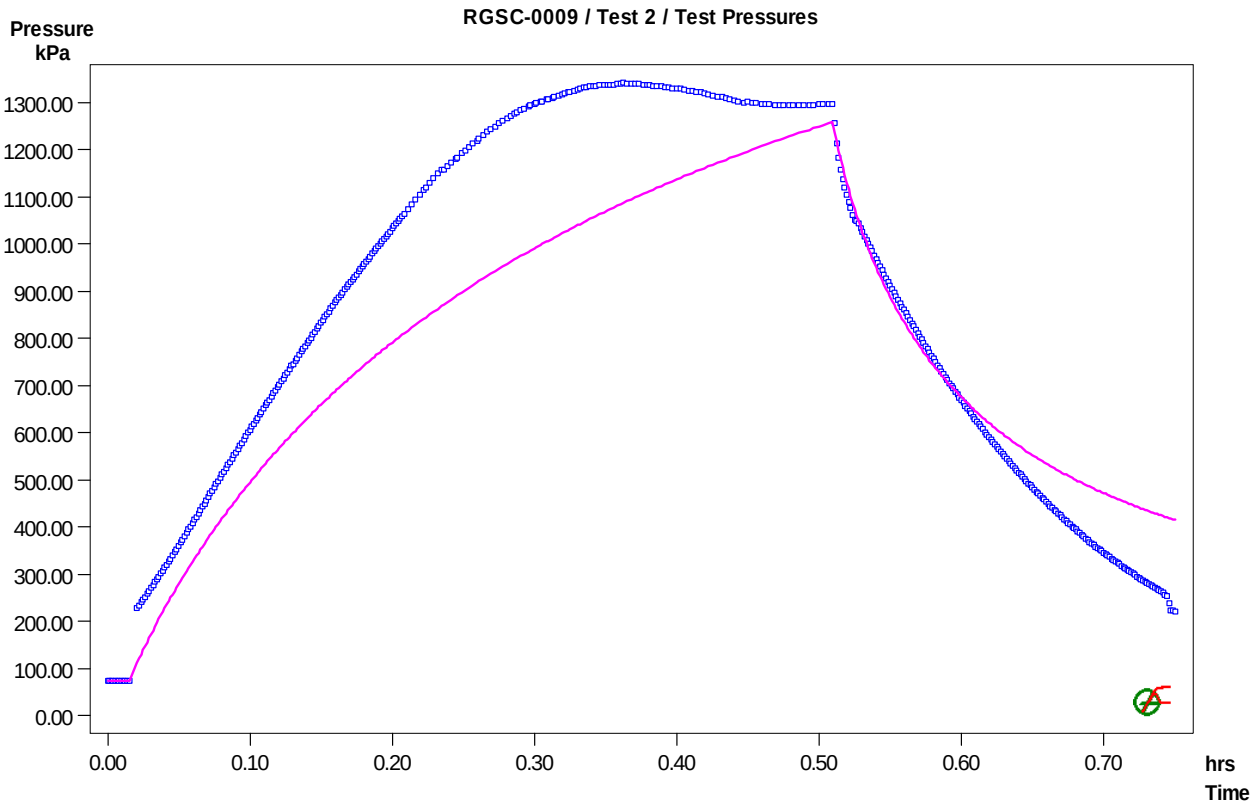
Name	Wellbore Storage [m³/Pa]	Skin [-]
Background	5.2e-07	-2.0
RI	5.2e-07	-2.0
Recovery	1.7e-07	-2.0



RGSC-0009 / Test 2 / LogLog Diagnosis - Analysis_1

RGSC-0009 / Test 2 / Recovery: LogLog Plot




RGSC-0009 / Test 2 / Test Pressures
Pressure
kPa
1300.00
1200.00
1100.00
1000.00
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
hrs
Time

RGSC-0010

Golder Associates

HYDROBENCH REPORT

Project	Riversdale
Site	Riversdale
Source Well	RGSC-0010
Test Name	RGSC-0010 Test 1
Test Date/Time	
Interval	top: 36.80 m bottom: 72.30 m
Description	Water flowing out of casing

Basic Data

Test Interval	35.50 m		
Porosity	0.05		
Well Radius	0.039 m	Tubing Radius	0.039 m
Inclination	0.0 deg		
Test Volume	169.632 l		
Well Type	Source		

Fluid Properties

Viscosity	0.001 Pa*s
Density	1000.0 kg/m³
Compressibility	2.0e-09 1/Pa

Sequence Definition

Name	Category	t(o) [hrs]	P(o) [kPa]	P(i) [kPa]	Rate [l/min]	C [m³/Pa]
Background	Variable Pressure	0.00000	450.15			4.9e-07
SI	dP-Event	0.32778	448.05	-22.6 *		4.9e-07
SI Recovery	Slug	0.33194	470.68	448.1		4.9e-07
RI	Constant Rate	0.99861	445.68		-3.28e+01	4.9e-07
RI Recovery	Recovery	1.49861	520.09			4.9e-07

Analysis Results

Analysis "Analysis_1"

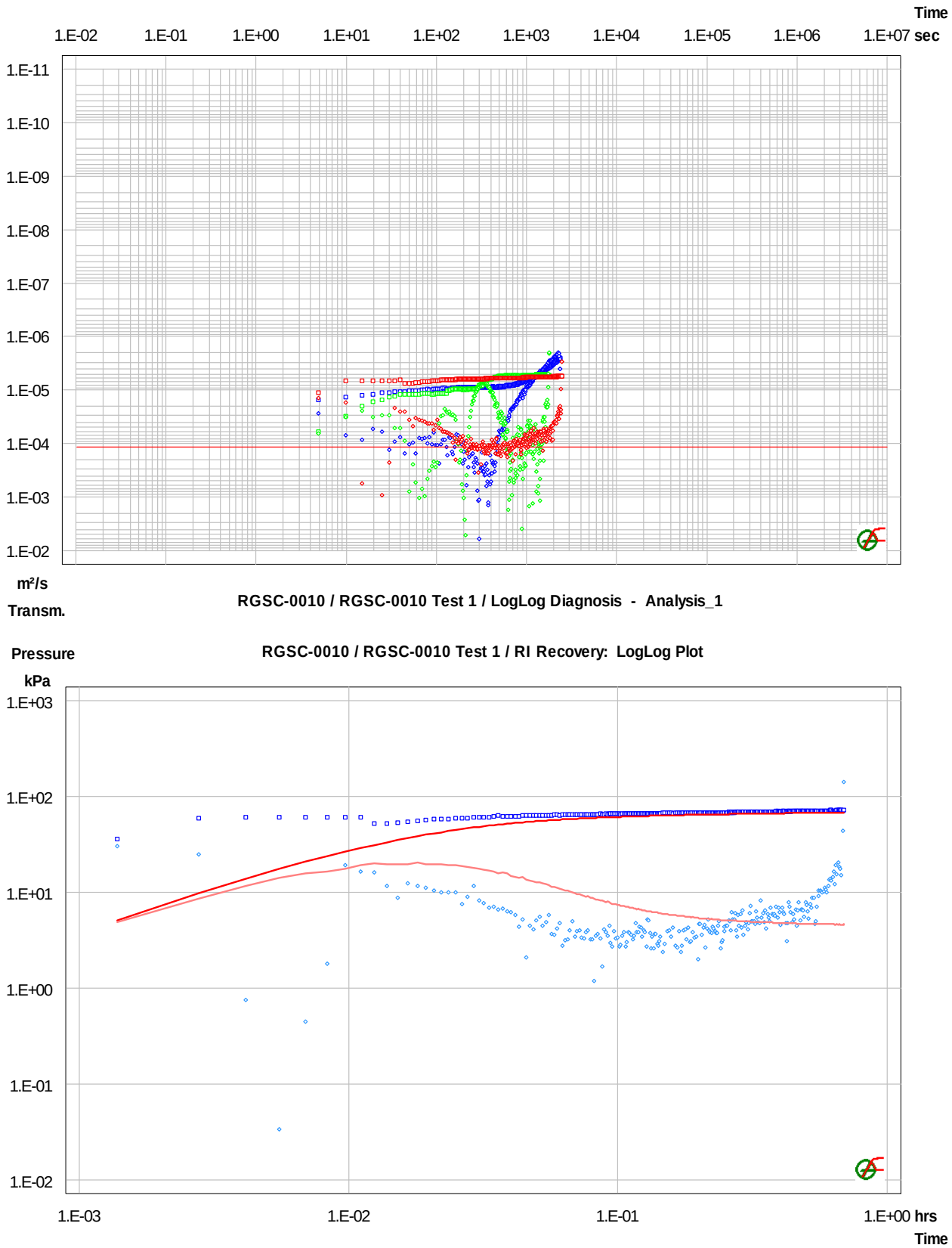
Static Pressure: 450.15 kPa

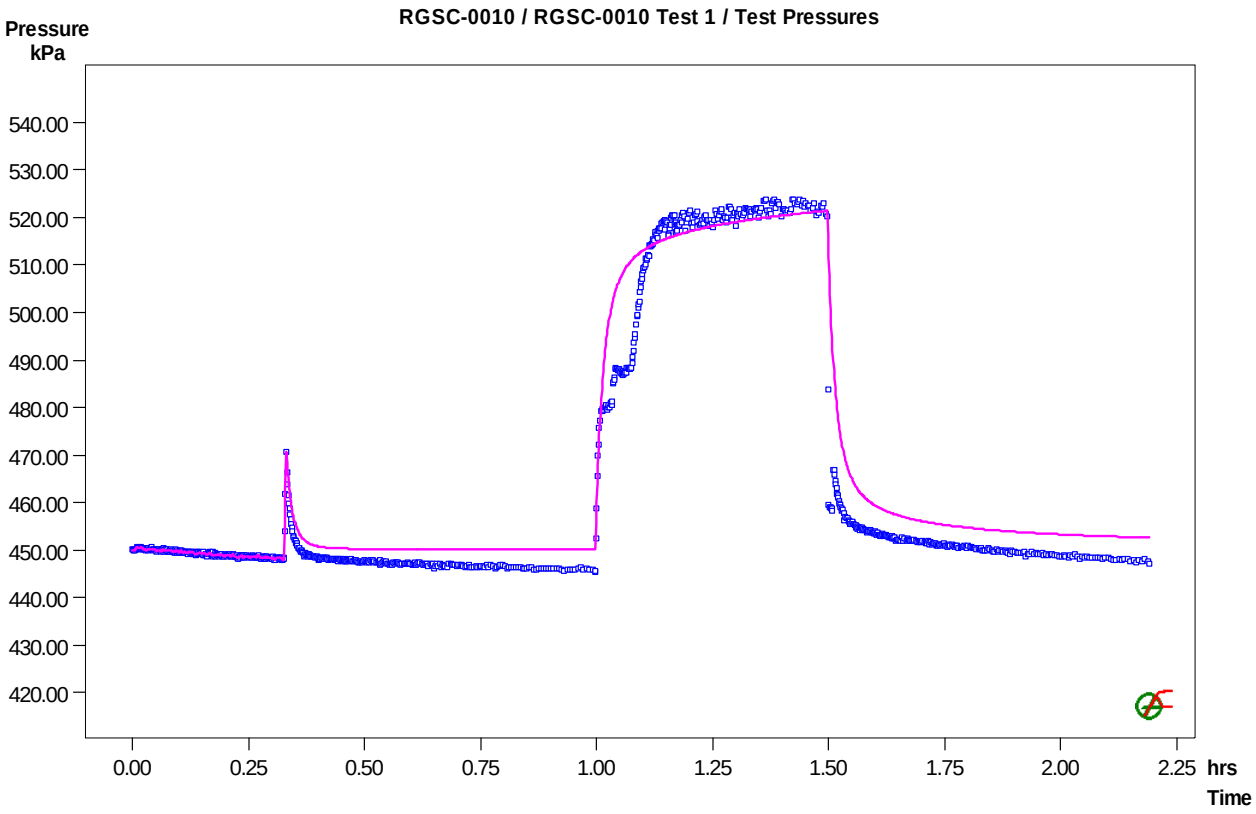
Shell Parameters:

Name	Transmissivity [m²/s]	Storativity [-]	Radius [m]	Flow Dimension [-]
Shell 1	1.0e-04	1.0e-04	- -	2.0

Sequence Parameters:

Name	Wellbore Storage [m³/Pa]	Skin [-]
Background	4.9e-07	1.0
SI	4.9e-07	1.0
SI Recovery	4.9e-07	1.0
RI	4.9e-07	1.0
RI Recovery	4.9e-07	1.0


Time
1.E-02
1.E-01
1.E+00
1.E+01
1.E+02
1.E+03
1.E+04
1.E+05
1.E+06
1.E+07 sec
1.E-11
1.E-10
1.E-09
1.E-08
1.E-07
1.E-06
1.E-05
1.E-04
1.E-03
1.E-02
m²/s
Transm.
RGSC-0010 / RGSC-0010 Test 1 / LogLog Diagnosis - Analysis_1
Pressure
kPa
RGSC-0010 / RGSC-0010 Test 1 / RI Recovery: LogLog Plot
1.E+03
1.E+02
1.E+01
1.E+00
1.E-01
1.E-02
1.E-03
1.E-02
1.E-01
1.E+00 hrs
Time


RGSC-0010 / RGSC-0010 Test 1 / Test Pressures
Pressure
kPa
540.00
530.00
520.00
510.00
500.00
490.00
480.00
470.00
460.00
450.00
440.00
430.00
420.00
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.25
hrs
Time

HYDROBENCH REPORT

Project	Riversdale		
Site	Riversdale		
Source Well	RGSC-0010		
Test Name	Test 2		
Test Date/Time	Sept19, 2104		
Interval	top: 76.43 m	bottom: 151.57 m	
Description			

Basic Data

Test Interval	75.14 m		
Porosity	0.05		
Well Radius	0.039 m	Tubing Radius	0.039 m
Inclination	0.0 deg		
Test Volume	359.046 l		
Well Type	Source		

Fluid Properties

Viscosity	0.001 Pa*s
Density	1000.0 kg/m³
Compressibility	2.0e-09 1/Pa

Sequence Definition

Name	Category	t(o) [hrs]	P(o) [kPa]	P(i) [kPa]	Rate [l/min]	C [m³/Pa]
Background	Variable Pressure	0.00000	837.84			4.9e-07
SI	dP-Event	0.24167	836.99	-22.8 *		4.9e-07
SI Recovery	Slug	0.24722	859.80	837.0		4.9e-07
RI	Constant Rate	0.75972	834.10		-3.01e+01	4.9e-07
RI Recovery	Recovery	1.25972	948.48			4.9e-07

Analysis Results

Analysis "Analysis_1"

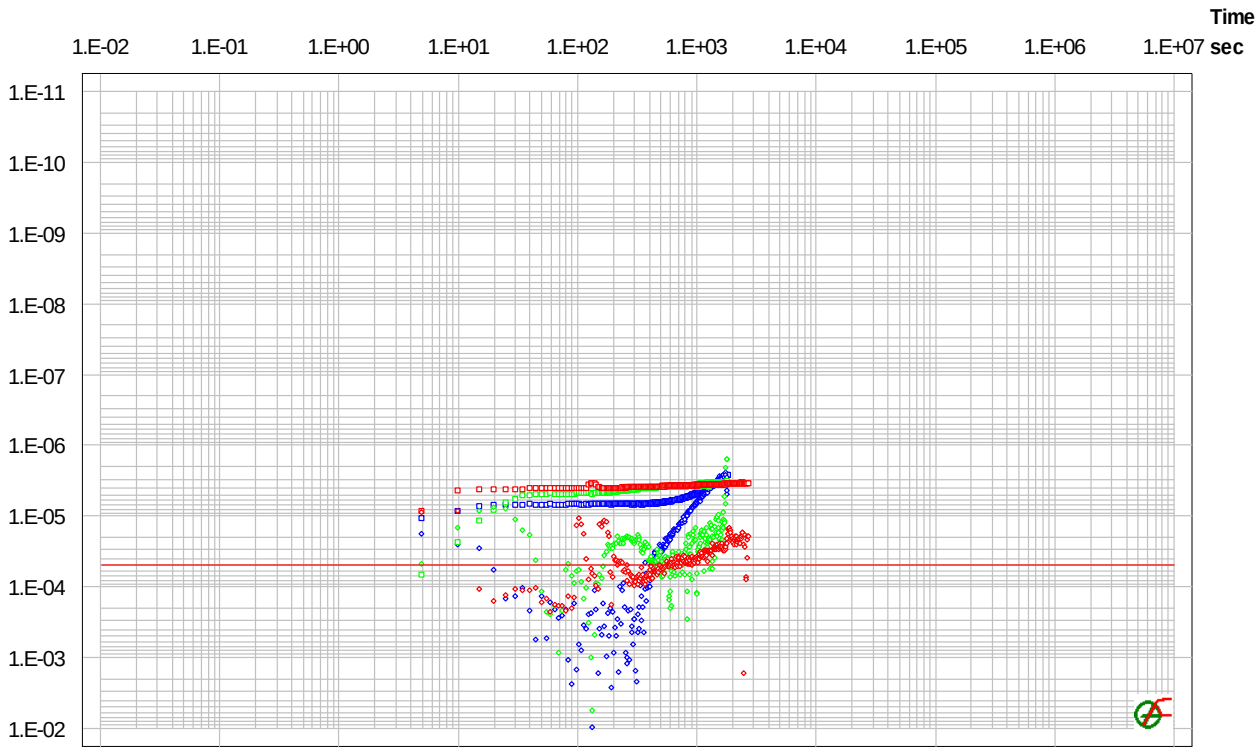
Static Pressure: 836.50 kPa

Shell Parameters:

Name	Transmissivity [m²/s]	Storativity [-]	Radius [m]	Flow Dimension [-]
Shell 1	5.0e-05	1.0e-04	- -	2.0

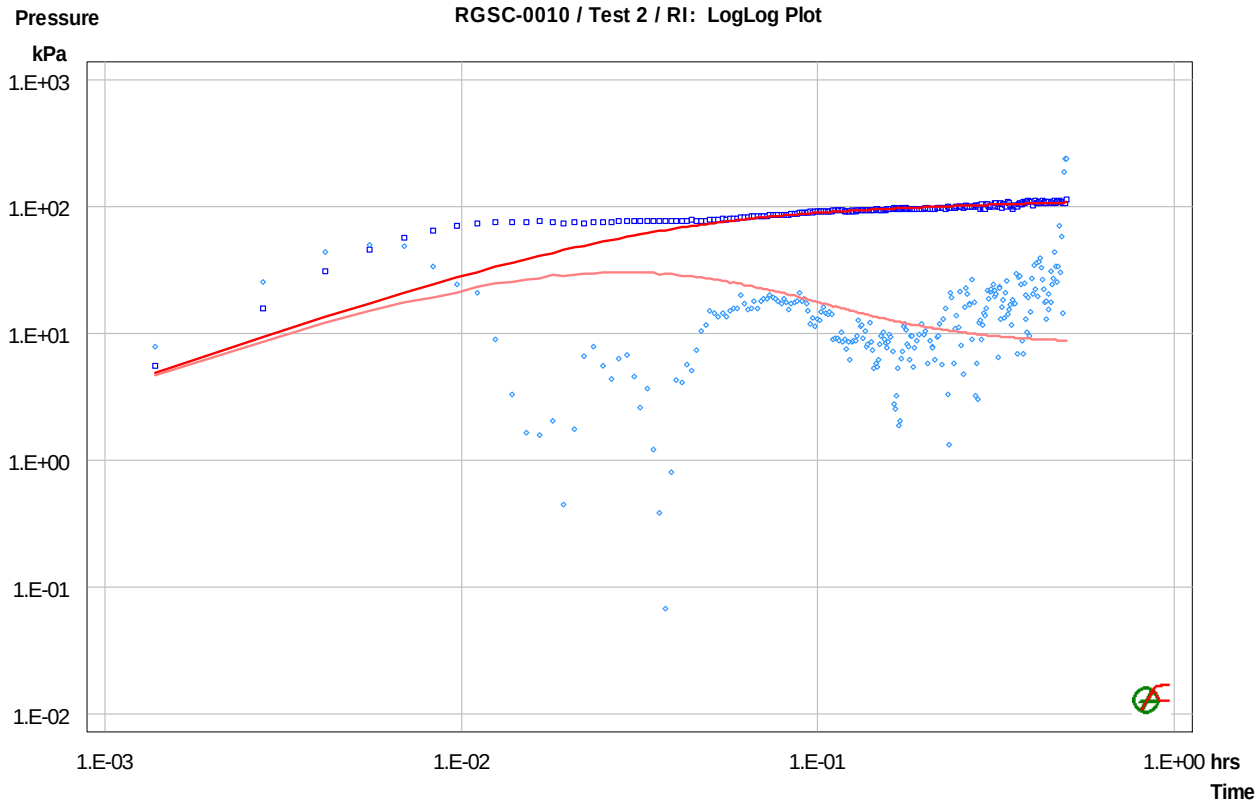
Sequence Parameters:

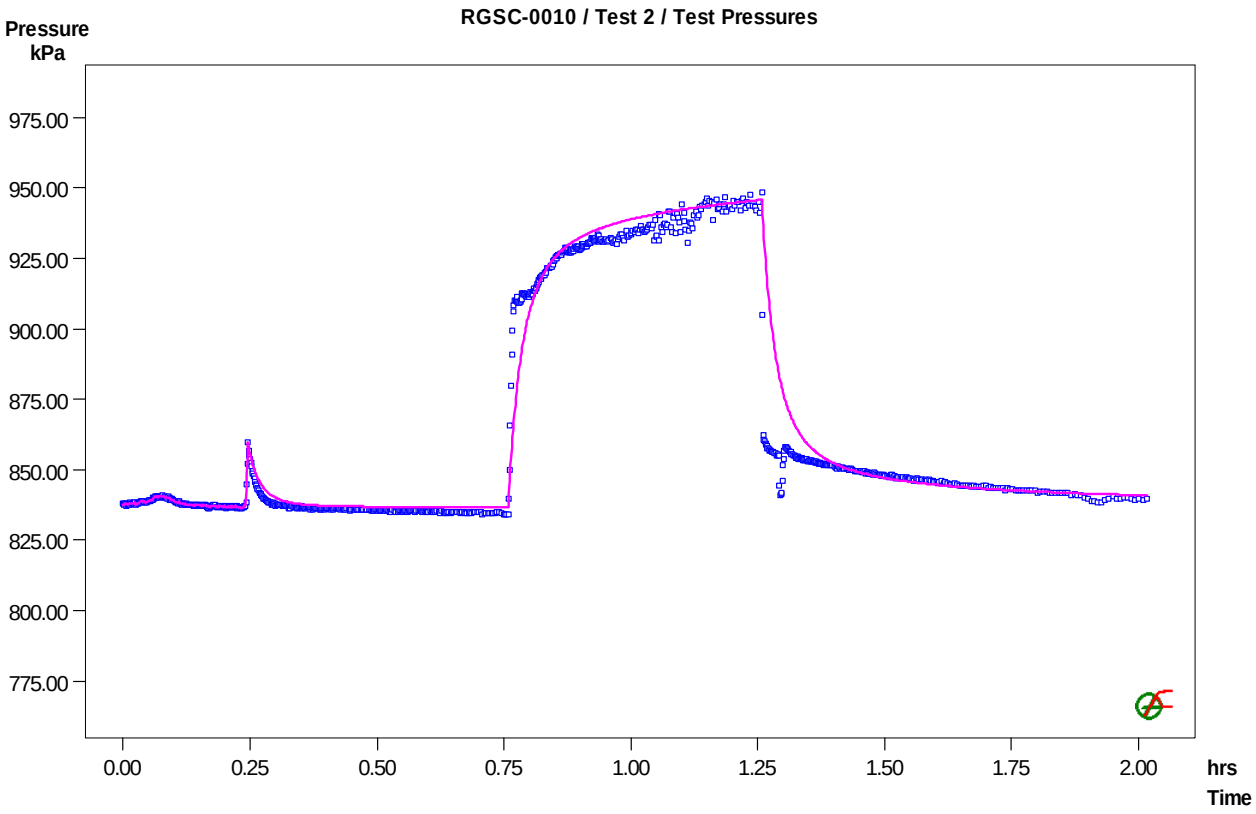
Name	Wellbore Storage [m³/Pa]	Skin [-]
Background	4.9e-07	0.0
SI	4.9e-07	0.0
SI Recovery	4.9e-07	0.0
RI	4.9e-07	0.0
RI Recovery	4.9e-07	0.0



RGSC-0010 / Test 2 / LogLog Diagnosis - Analysis_1

RGSC-0010 / Test 2 / RI: LogLog Plot

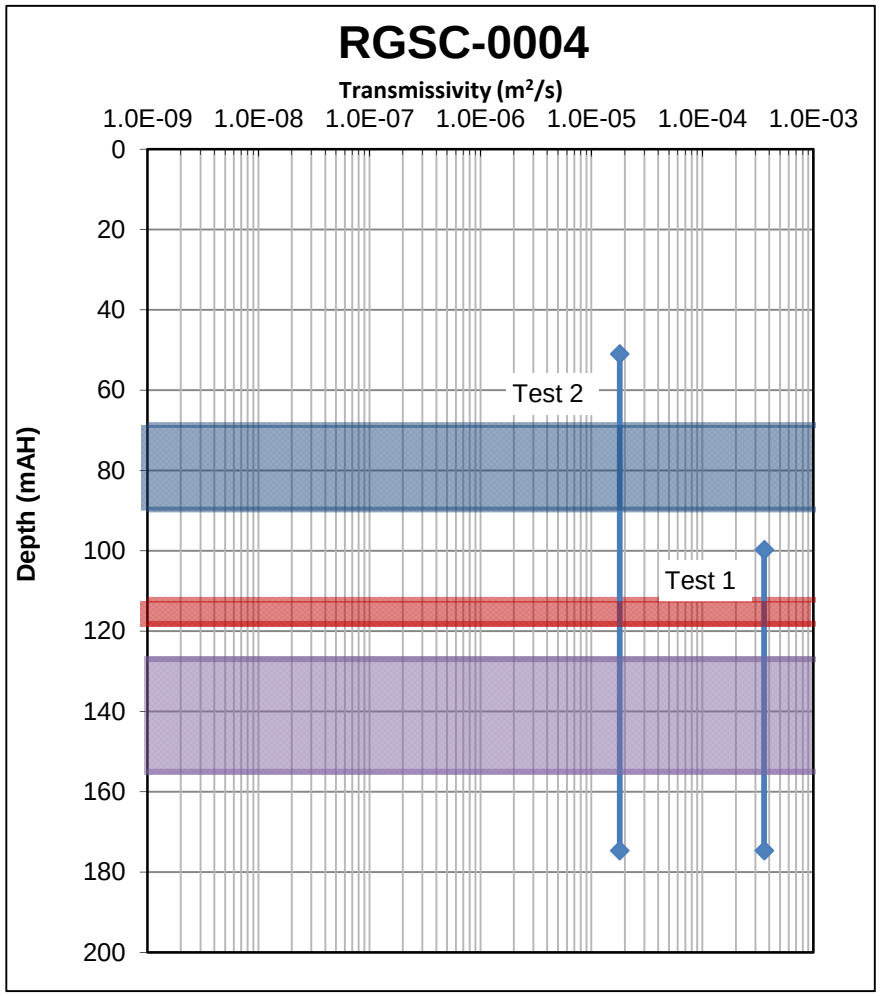


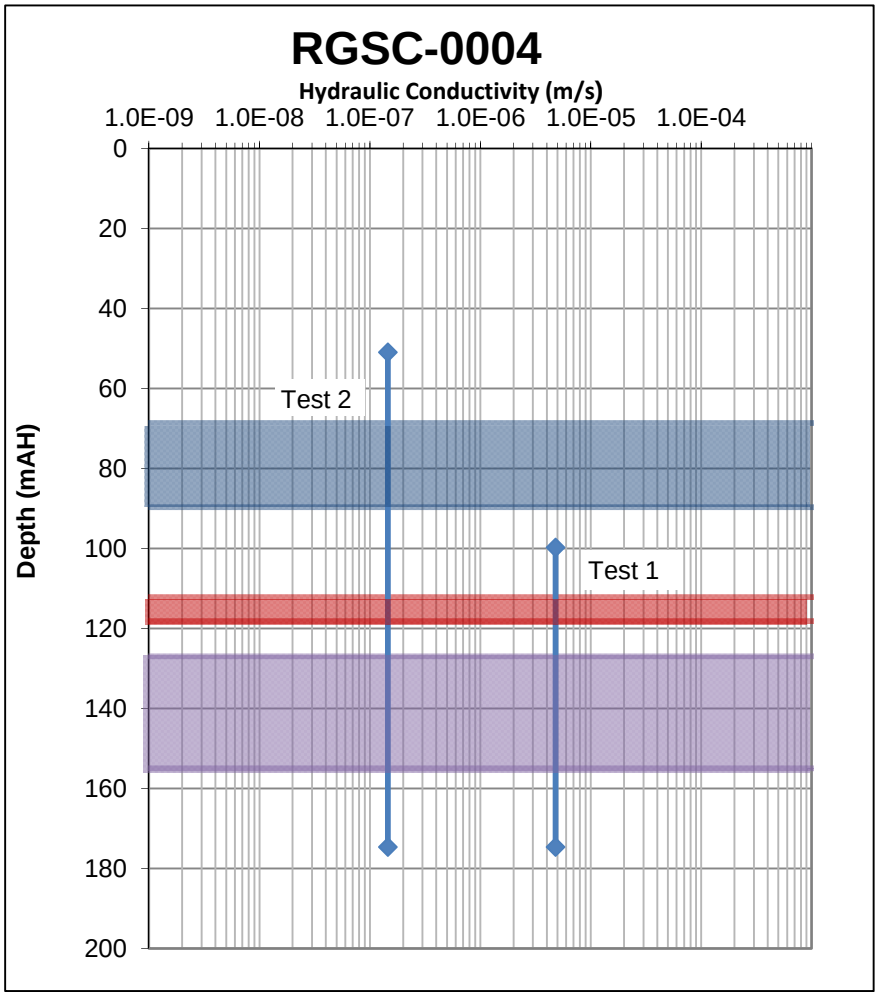

RGSC-0010 / Test 2 / Test Pressures
Pressure
kPa
975.00
950.00
925.00
900.00
875.00
850.00
825.00
800.00
775.00
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
hrs
Time

APPENDIX C

Hydraulic Conductivity Borehole Profiles

Profiles of Transmissivity and Hydraulic Conductivity





GEOLOGY LEGEND

- Coal Seam 1
- Coal Seam 2
- Coal Seam 4

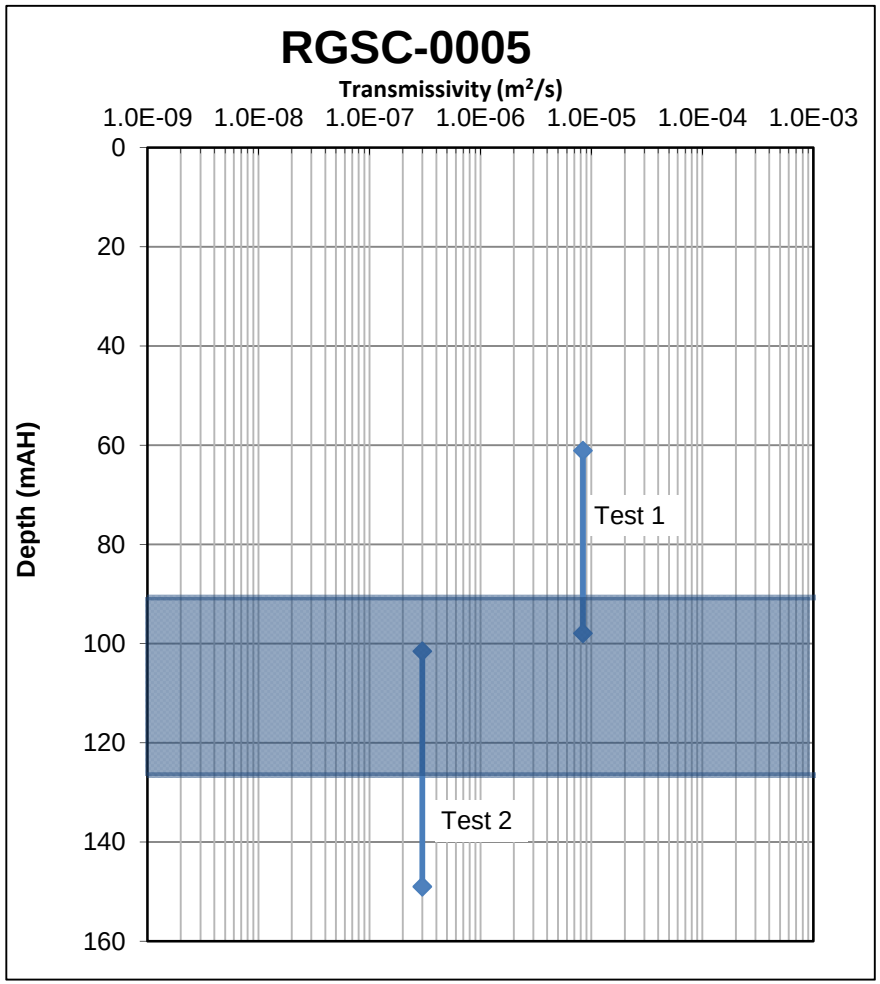
Notes

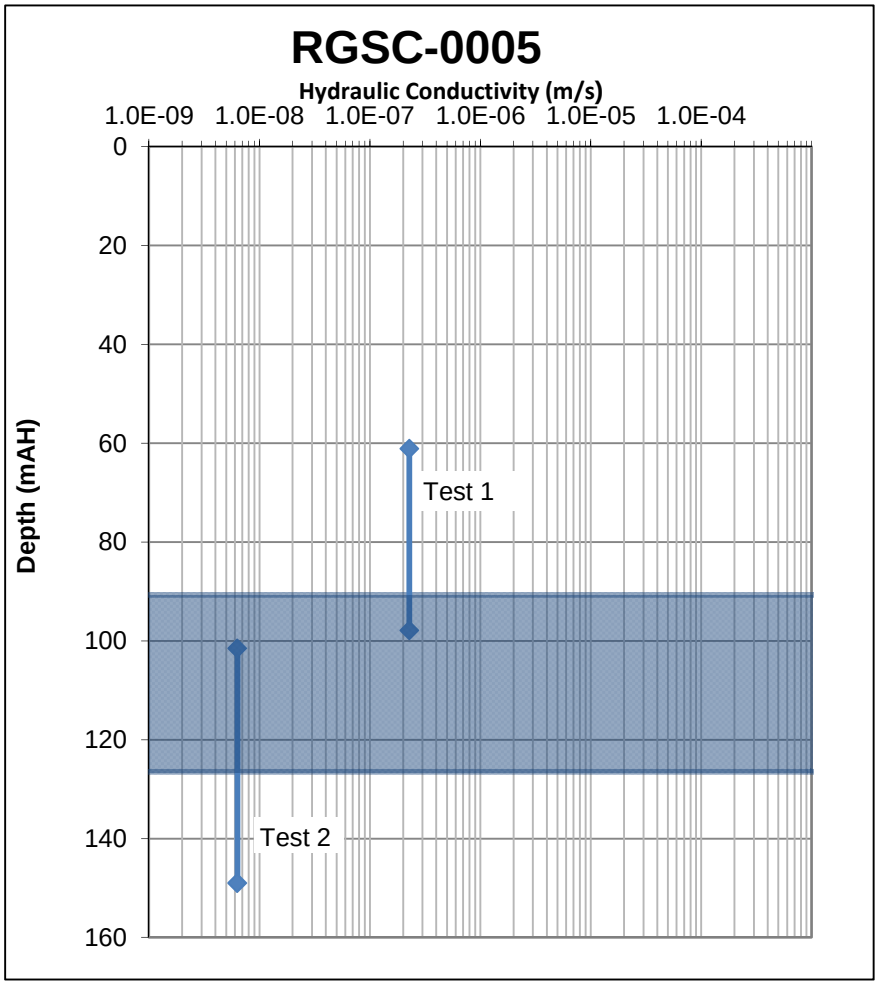
mAH = metres along hole

m/s = metres/second

m^2/s = metres squared/second

Profiles of Transmissivity and Hydraulic Conductivity





GEOLOGY LEGEND

- Coal Seam 1
- Coal Seam 2
- Coal Seam 4

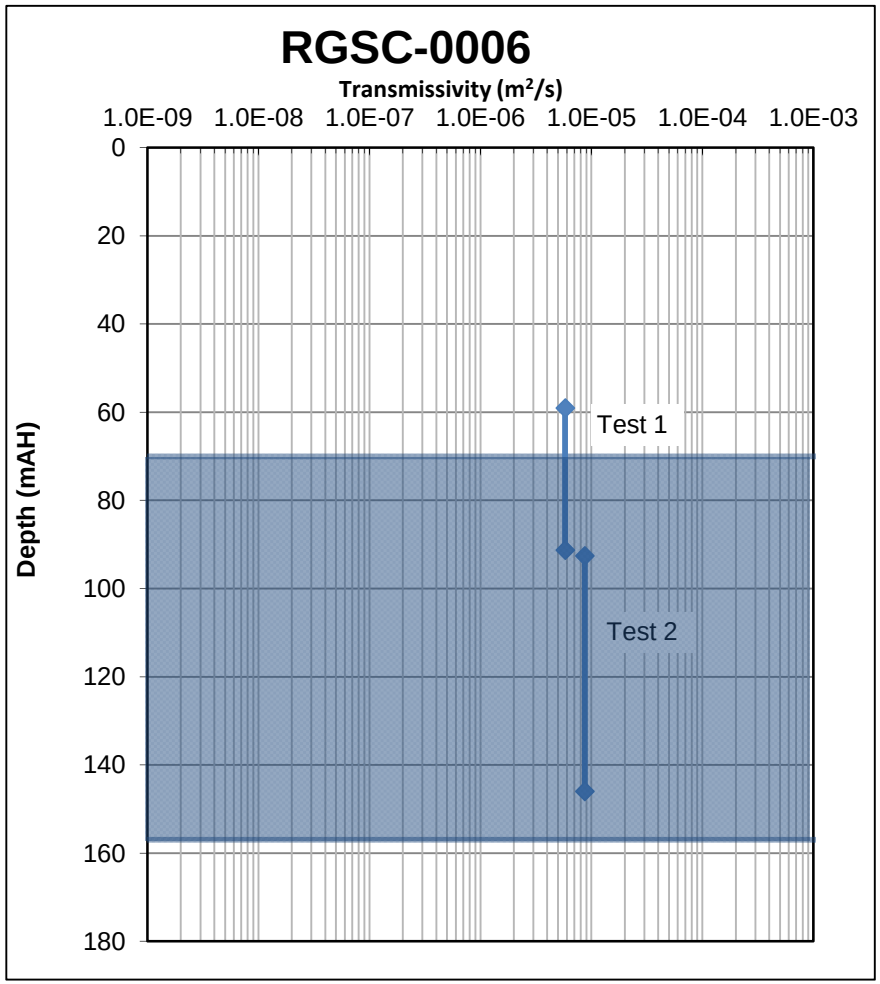
Notes

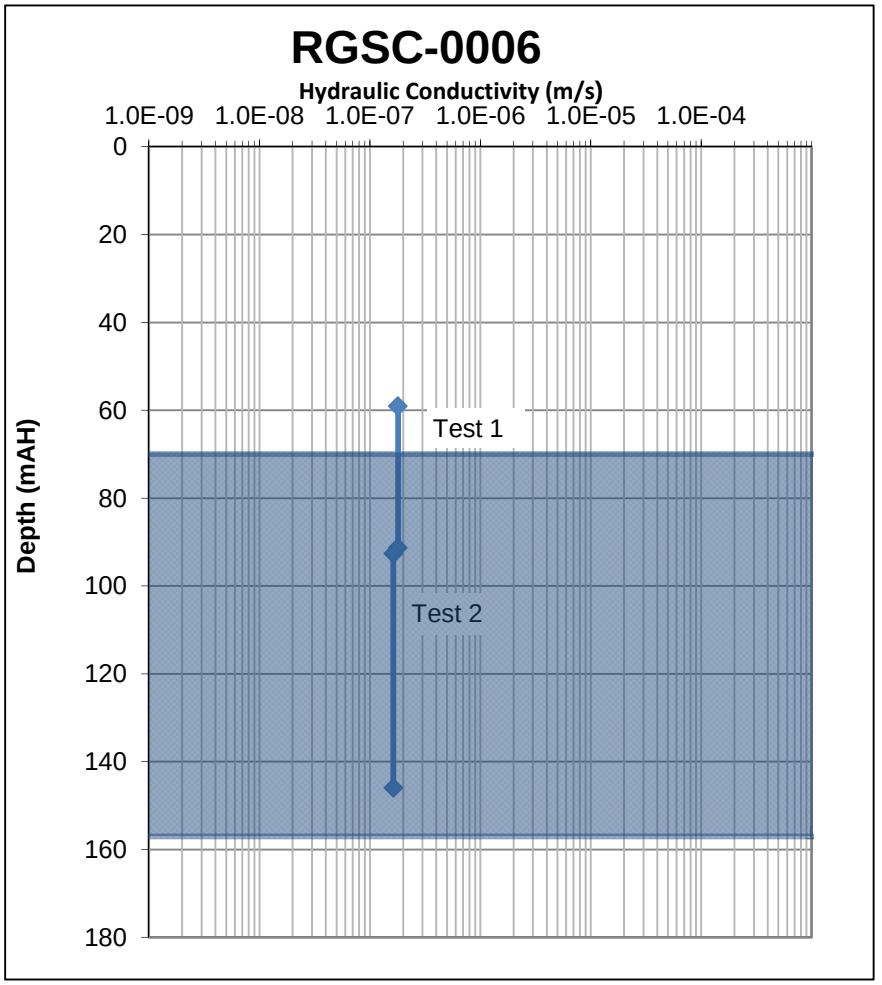
mAH = metres along hole

m/s = metres/second

m^2/s = metres squared/second

Profiles of Transmissivity and Hydraulic Conductivity





GEOLOGY LEGEND

- Coal Seam 1
- Coal Seam 2
- Coal Seam 4

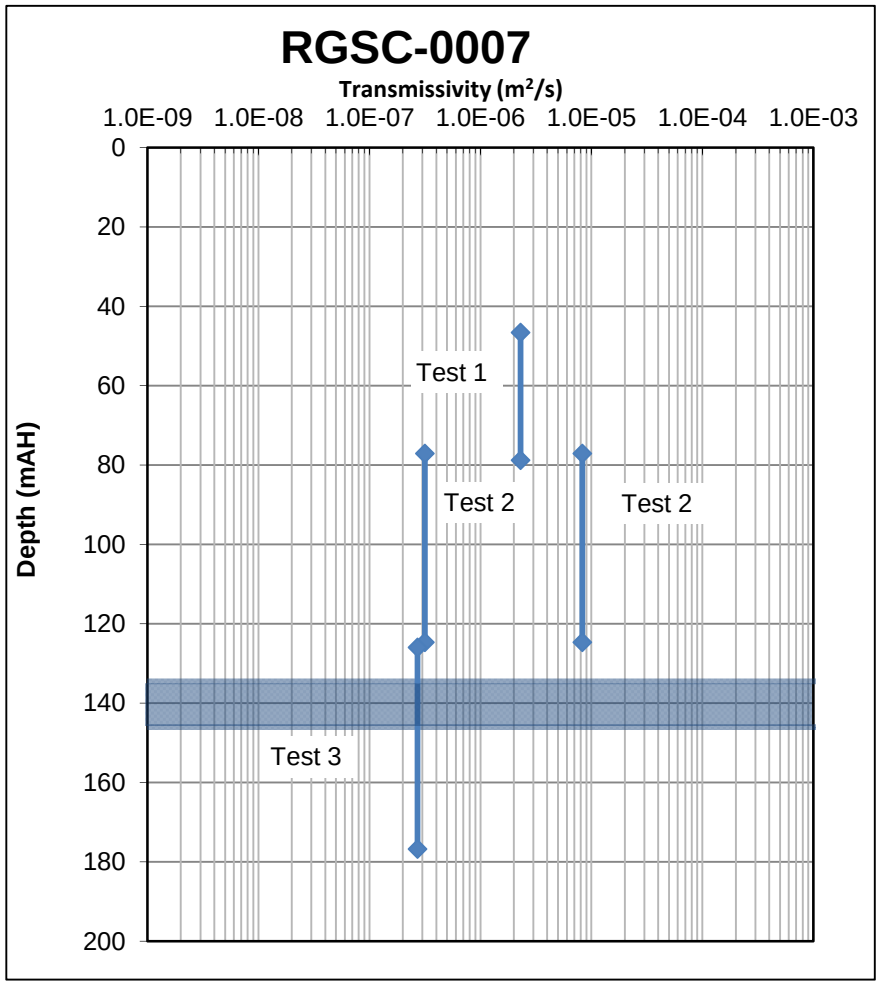
Notes

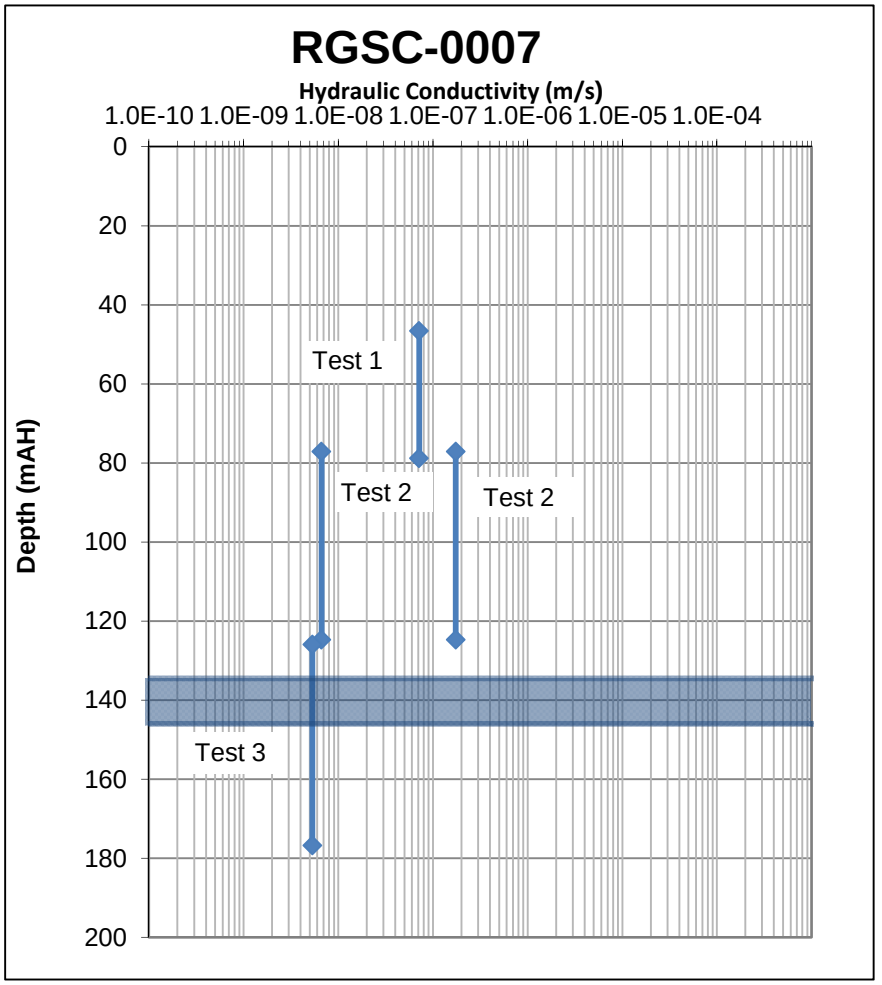
mAH = metres along hole

m/s = metres/second

m^2/s = metres squared/second

Profiles of Transmissivity and Hydraulic Conductivity





GEOLOGY LEGEND

- Coal Seam 1
- Coal Seam 2
- Coal Seam 4

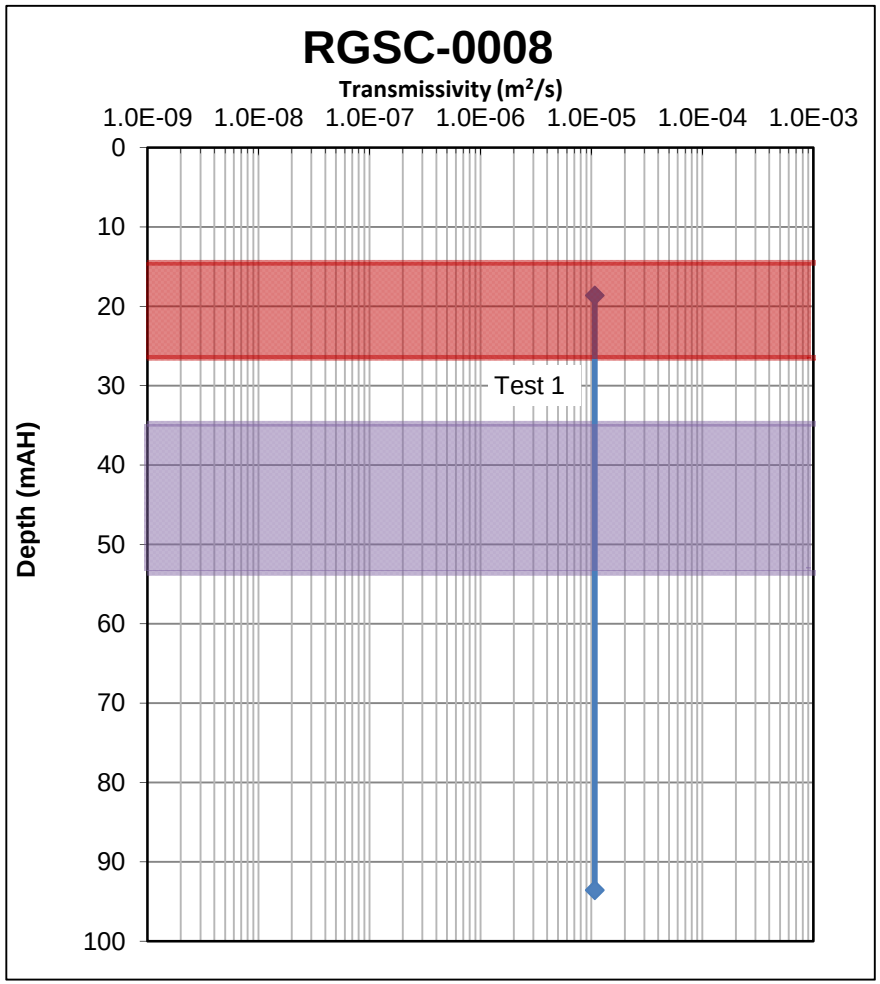
Notes

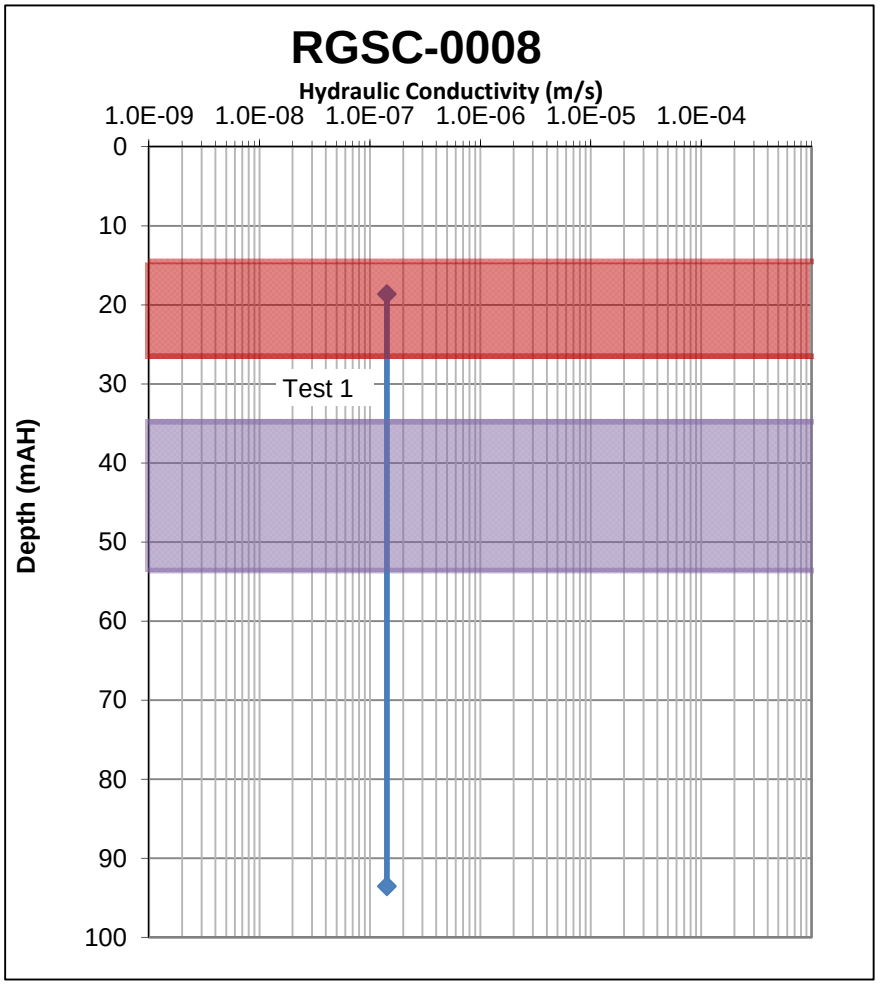
mAH = metres along hole

m/s = metres/second

m^2/s = metres squared/second

Profiles of Transmissivity and Hydraulic Conductivity





GEOLOGY LEGEND

- Coal Seam 1
- Coal Seam 2
- Coal Seam 4

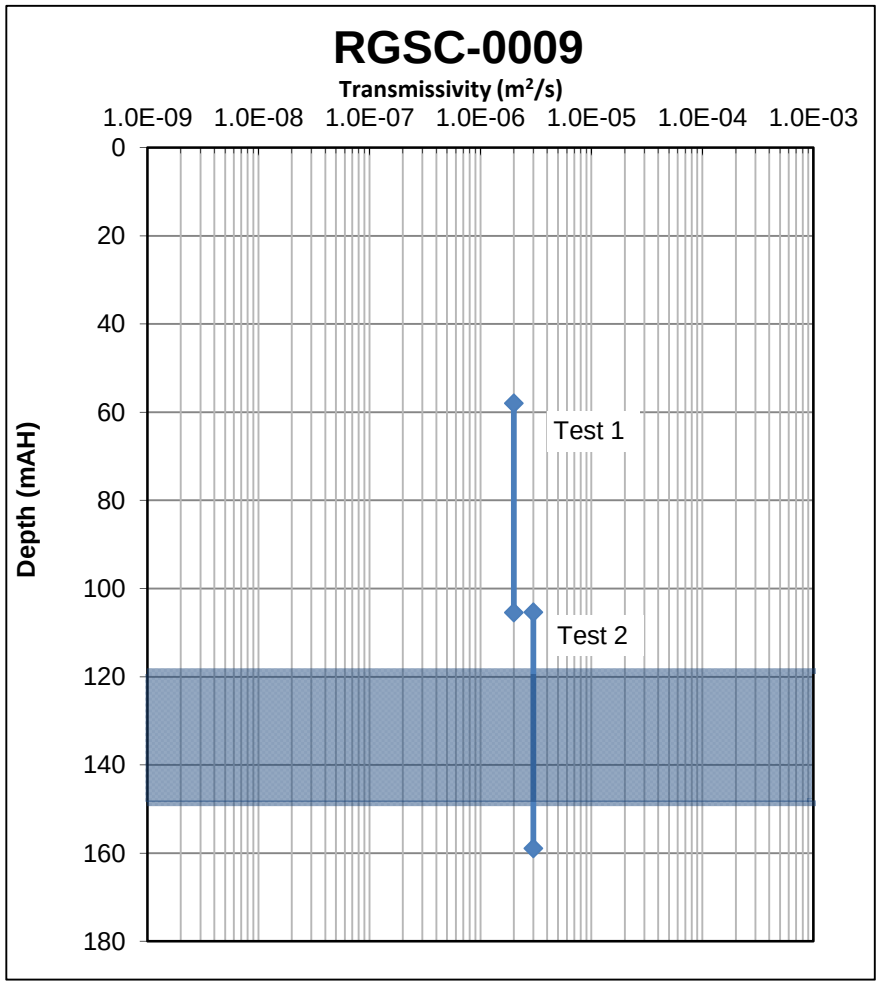
Notes

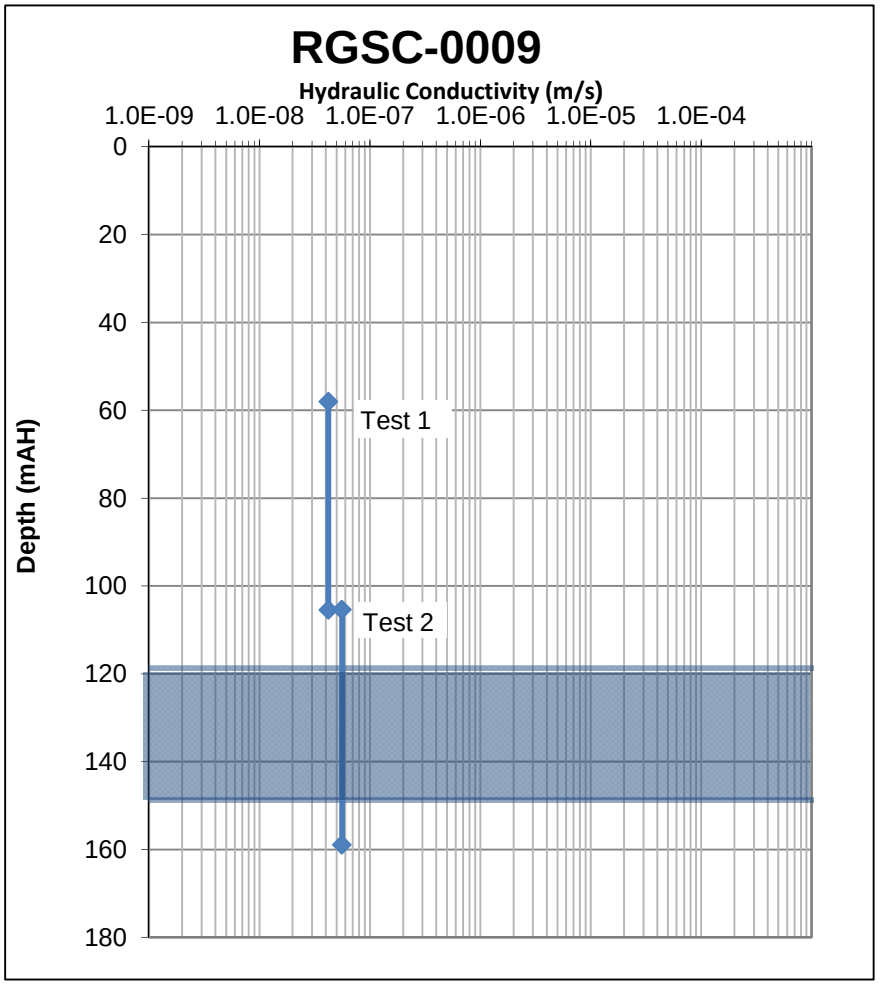
mAH = metres along hole

m/s = metres/second

m^2/s = metres squared/second

Profiles of Transmissivity and Hydraulic Conductivity





GEOLOGY LEGEND

- Coal Seam 1
- Coal Seam 2
- Coal Seam 4

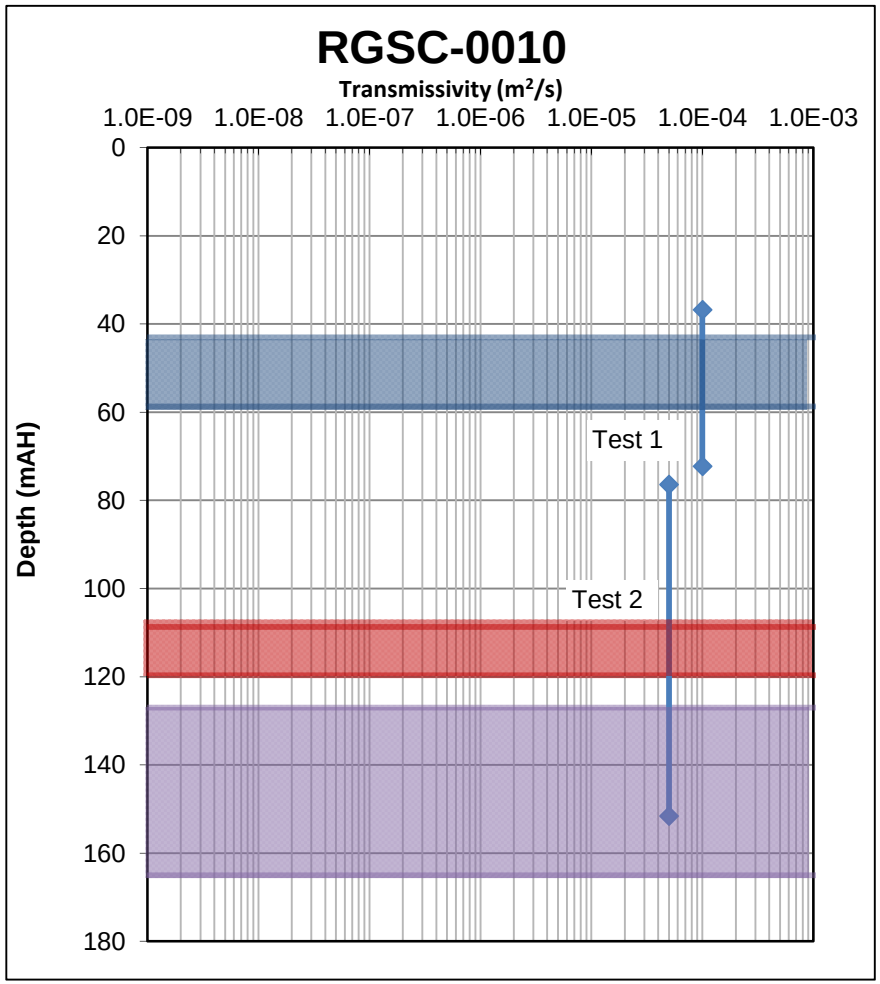
Notes

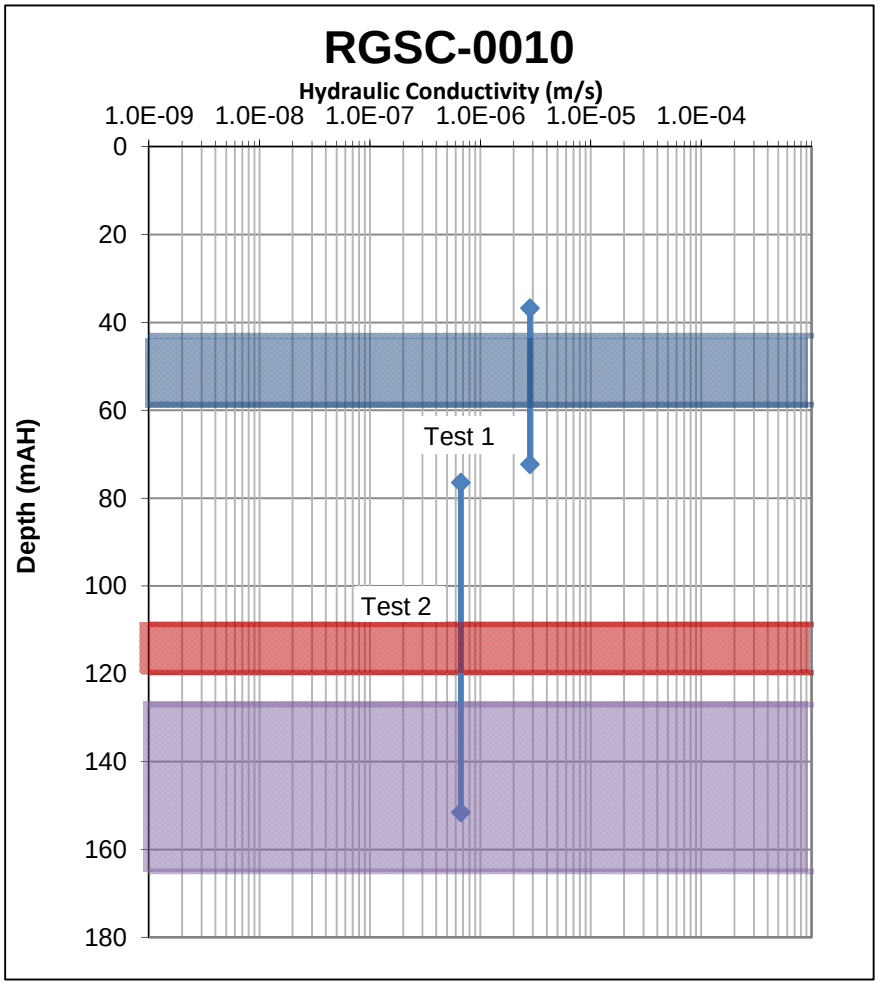
mAH = metres along hole

m/s = metres/second

m^2/s = metres squared/second

Profiles of Transmissivity and Hydraulic Conductivity





GEOLOGY LEGEND

- Coal Seam 1
- Coal Seam 2
- Coal Seam 4

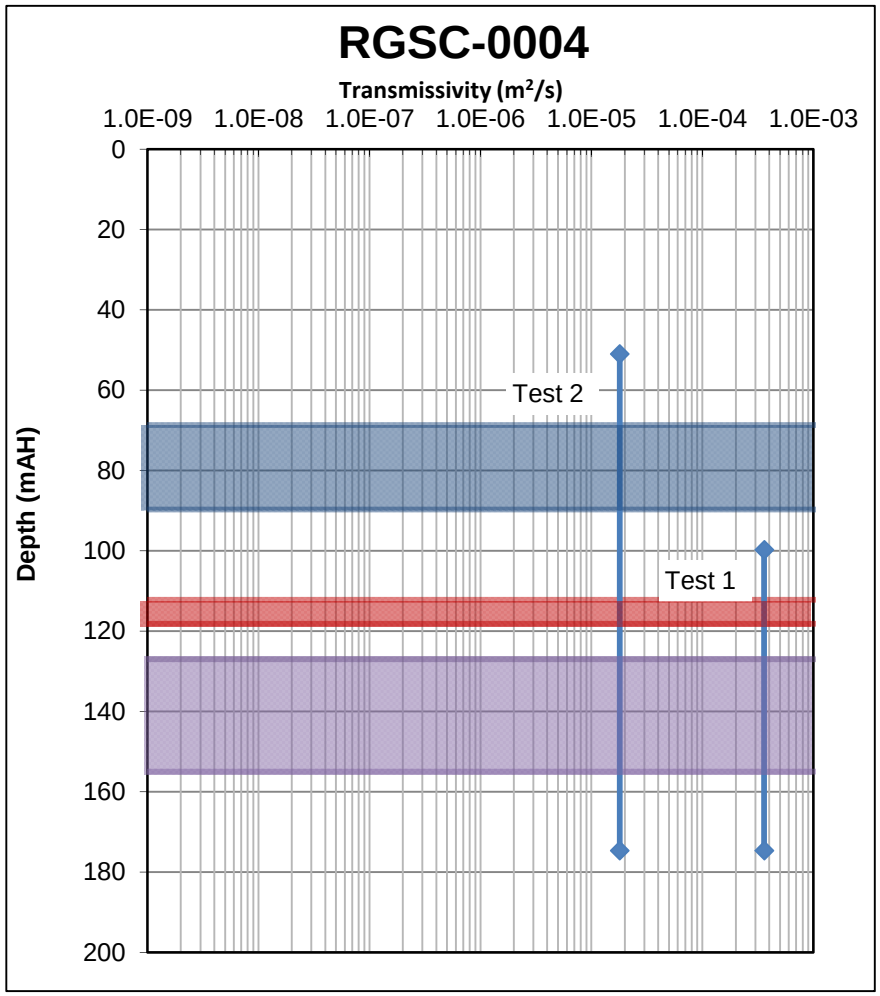
Notes

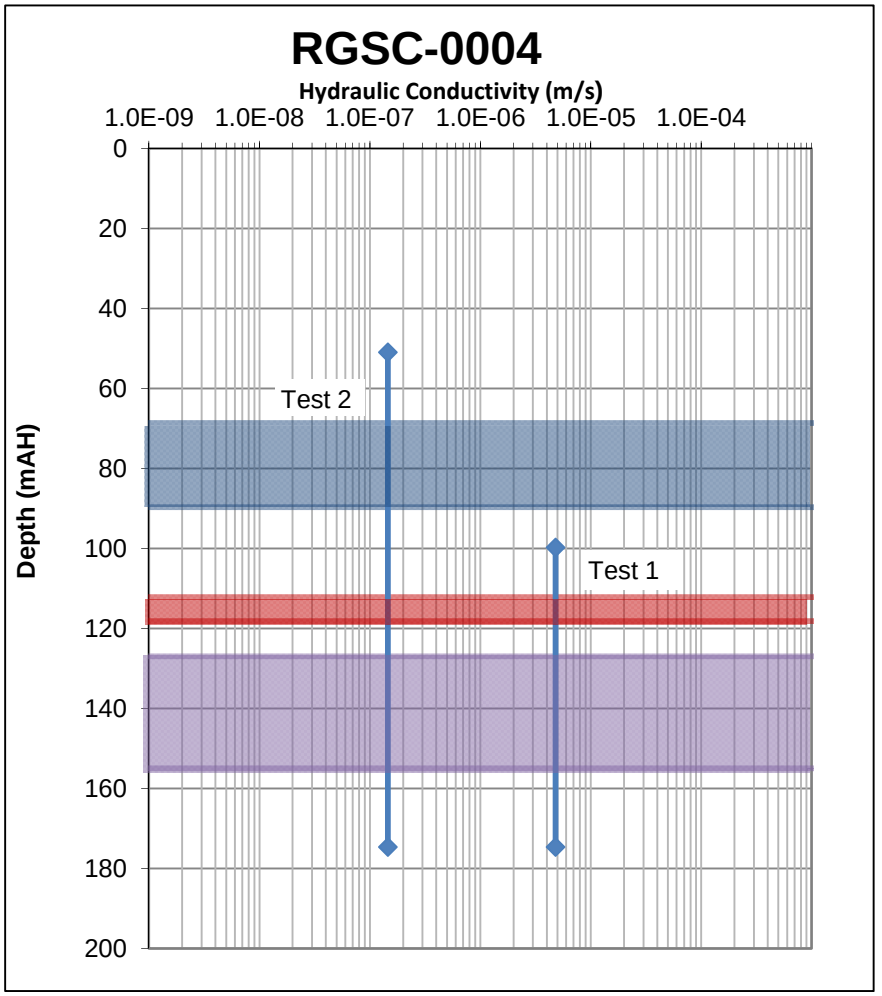
mAH = metres along hole

m/s = metres/second

m^2/s = metres squared/second

Profiles of Transmissivity and Hydraulic Conductivity





GEOLOGY LEGEND

- Coal Seam 1
- Coal Seam 2
- Coal Seam 4

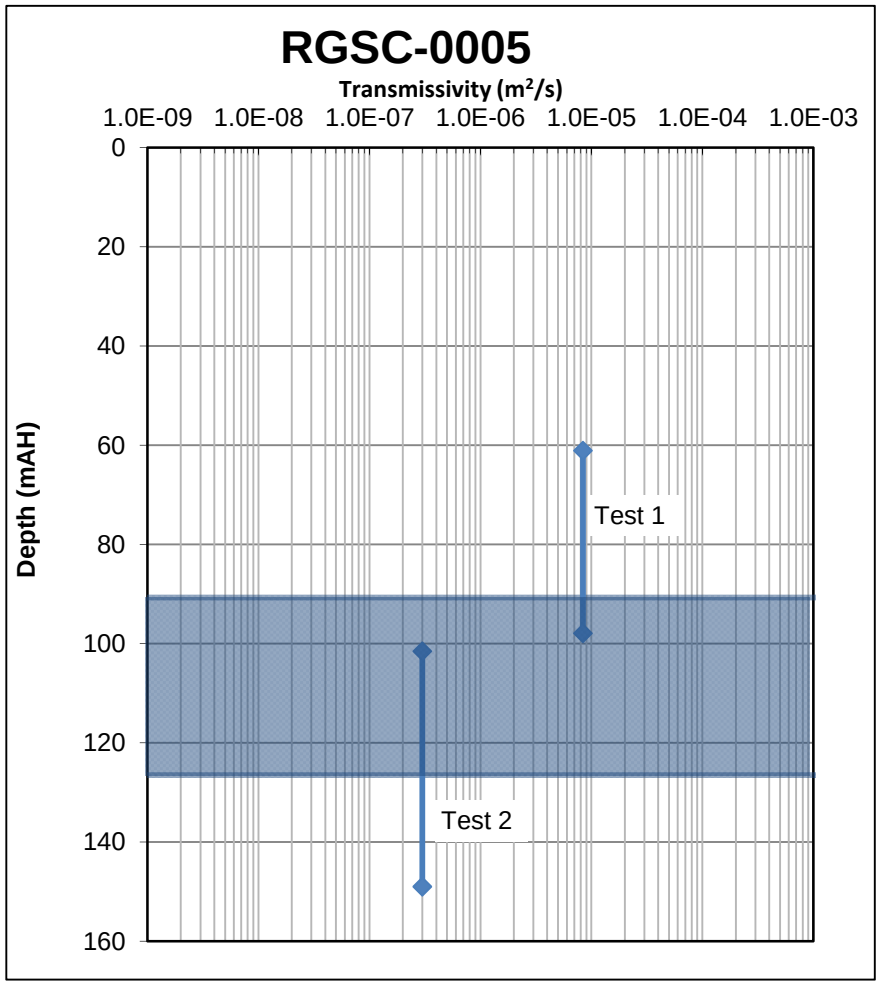
Notes

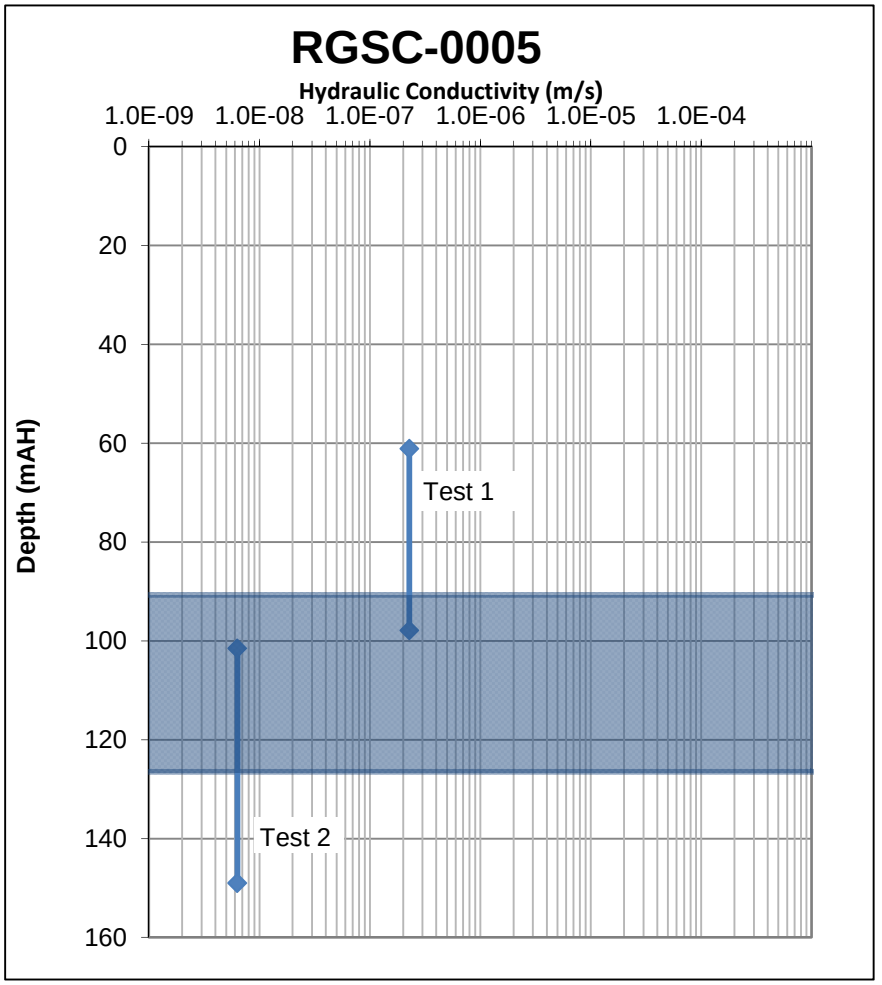
mAH = metres along hole

m/s = metres/second

m^2/s = metres squared/second

Profiles of Transmissivity and Hydraulic Conductivity





GEOLOGY LEGEND

- Coal Seam 1
- Coal Seam 2
- Coal Seam 4

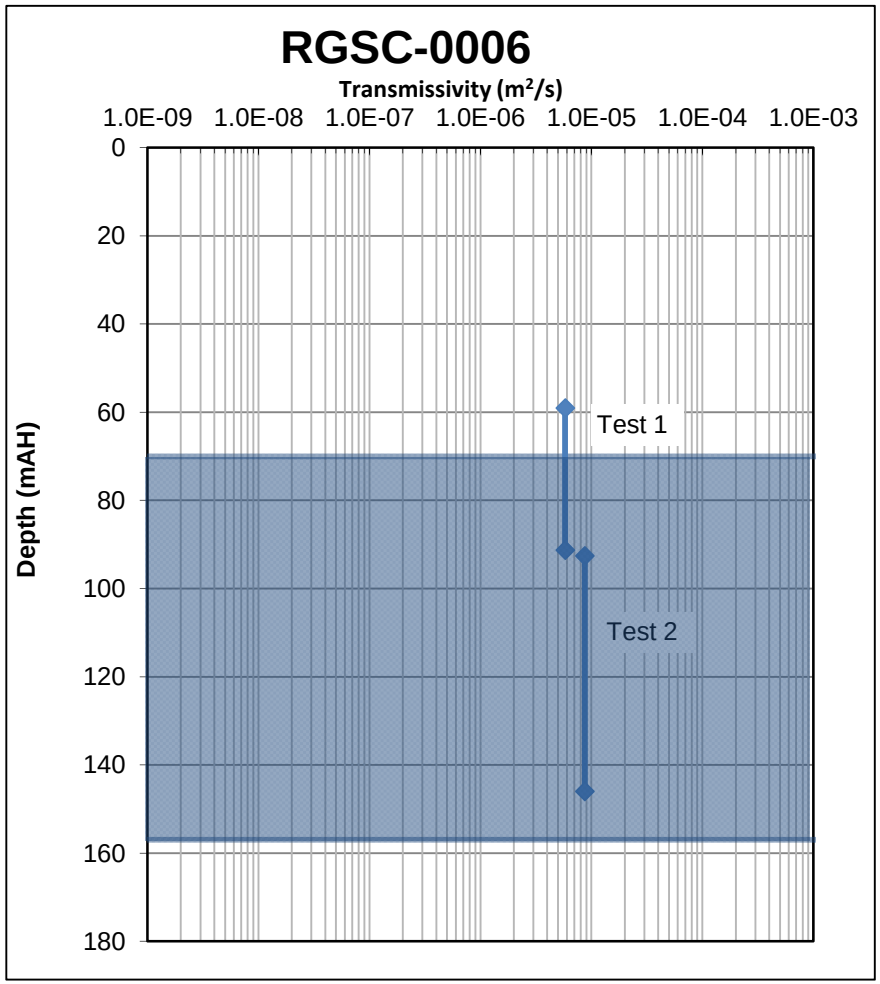
Notes

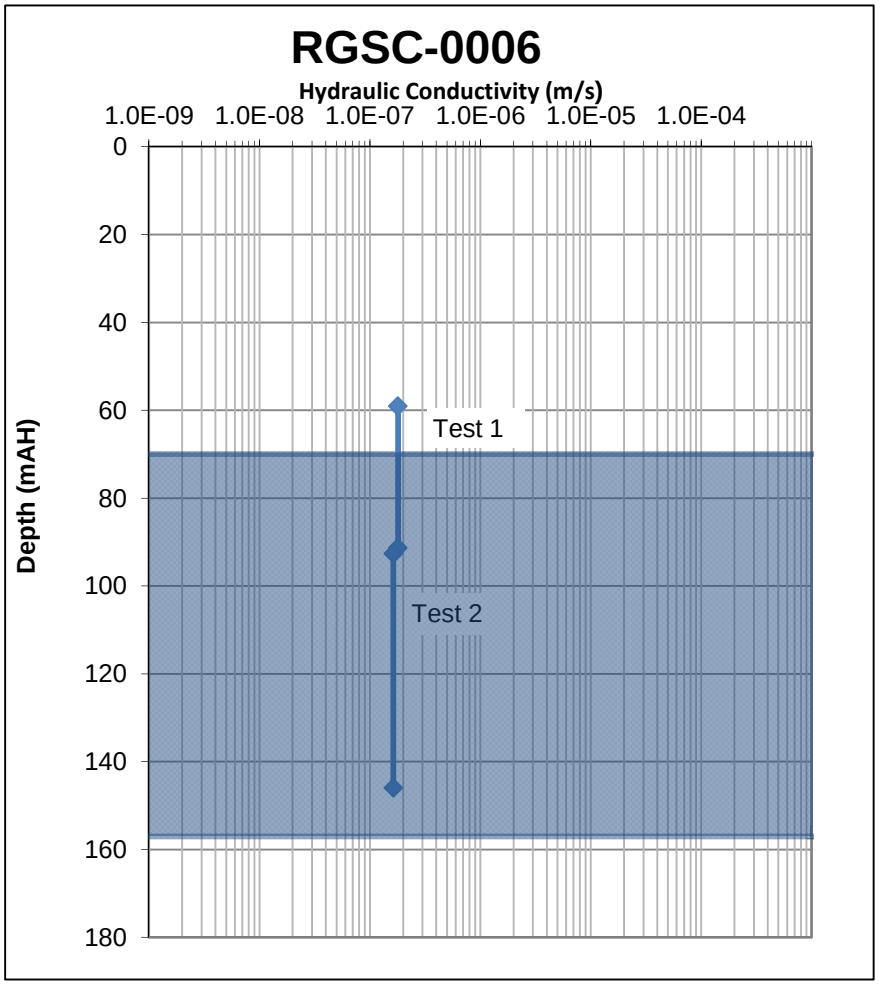
mAH = metres along hole

m/s = metres/second

m^2/s = metres squared/second

Profiles of Transmissivity and Hydraulic Conductivity





GEOLOGY LEGEND

- Coal Seam 1
- Coal Seam 2
- Coal Seam 4

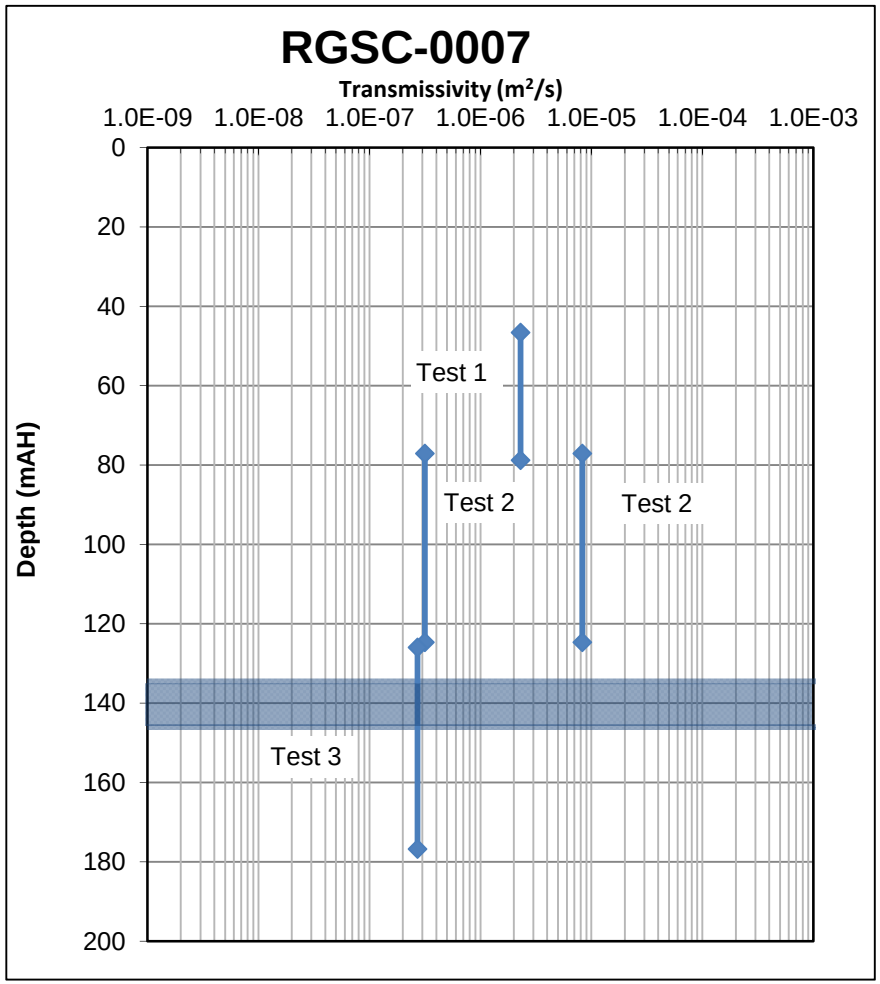
Notes

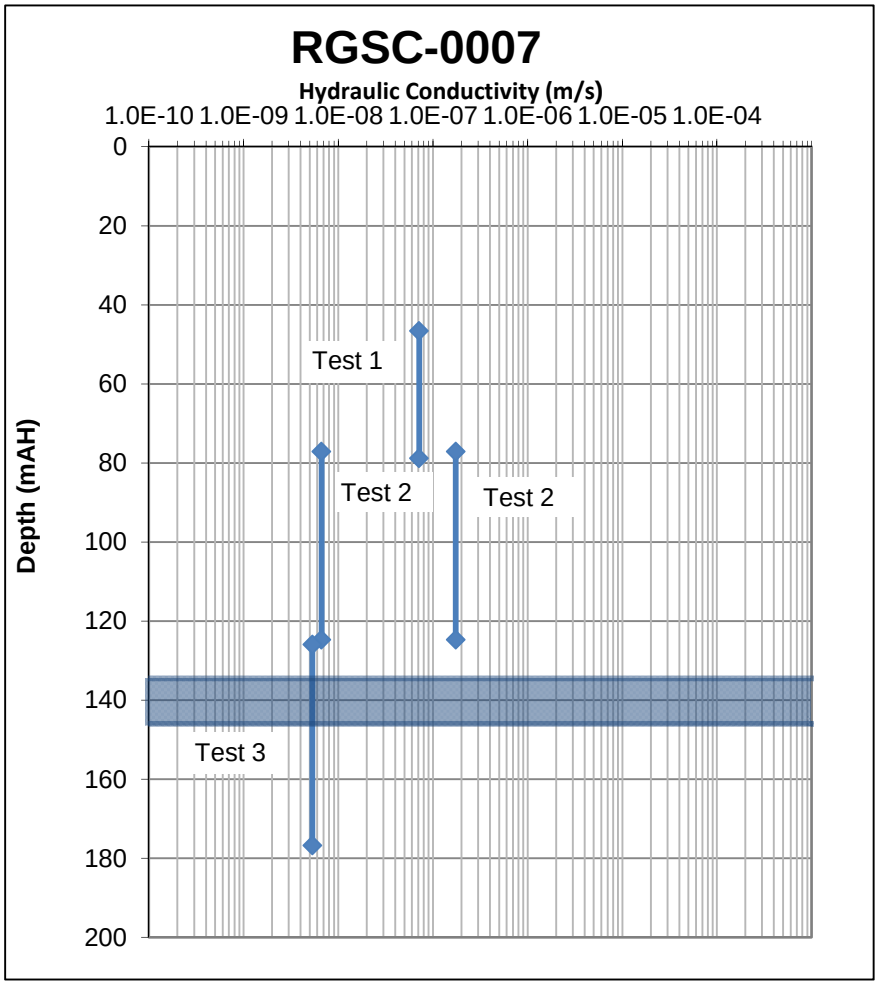
mAH = metres along hole

m/s = metres/second

m^2/s = metres squared/second

Profiles of Transmissivity and Hydraulic Conductivity





GEOLOGY LEGEND

- Coal Seam 1
- Coal Seam 2
- Coal Seam 4

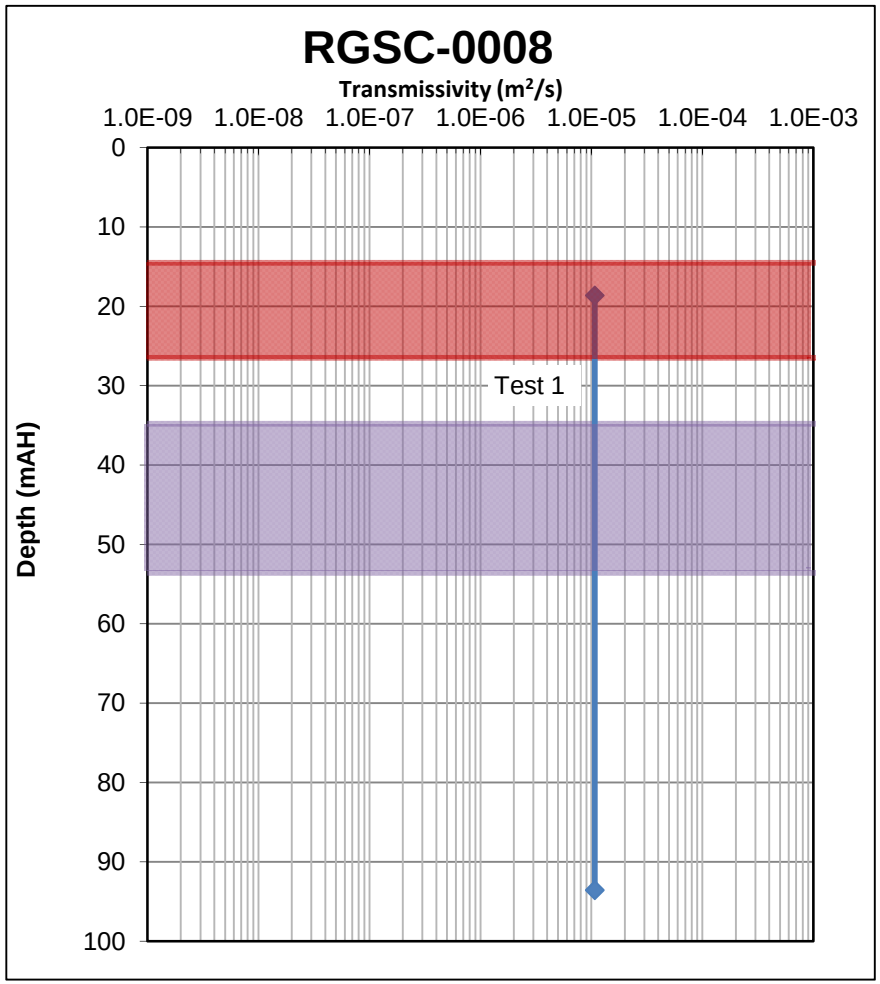
Notes

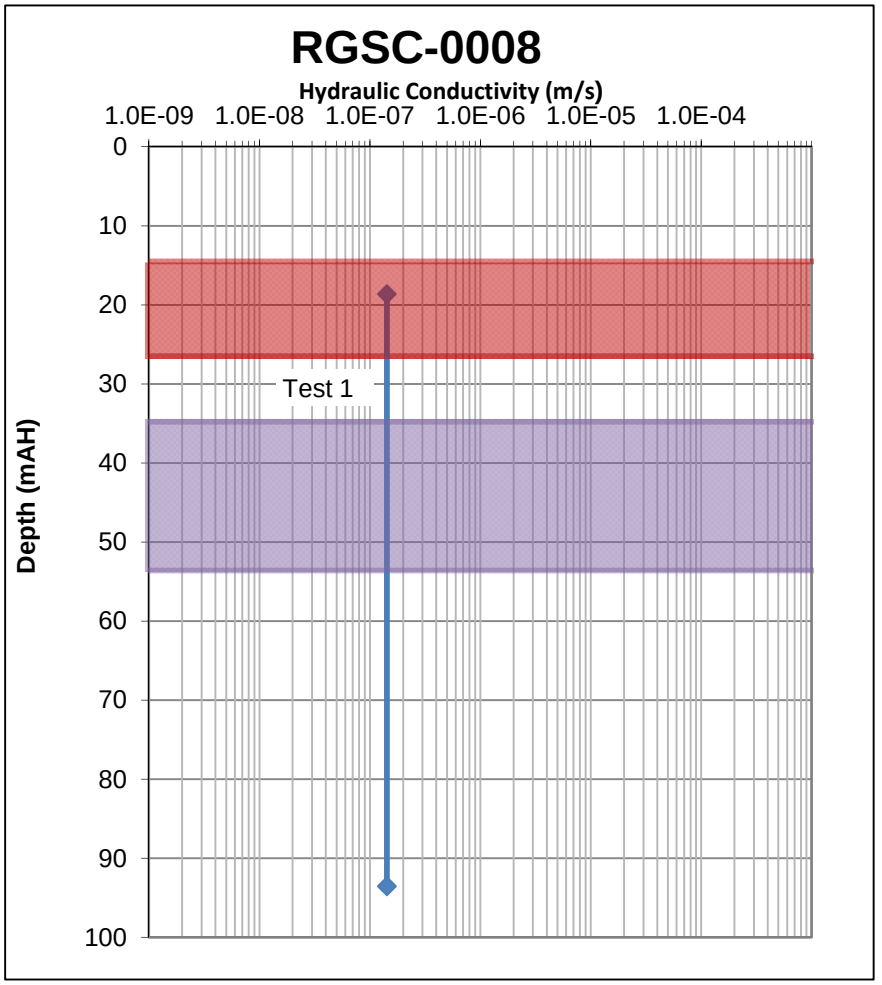
mAH = metres along hole

m/s = metres/second

m^2/s = metres squared/second

Profiles of Transmissivity and Hydraulic Conductivity





GEOLOGY LEGEND

- Coal Seam 1
- Coal Seam 2
- Coal Seam 4

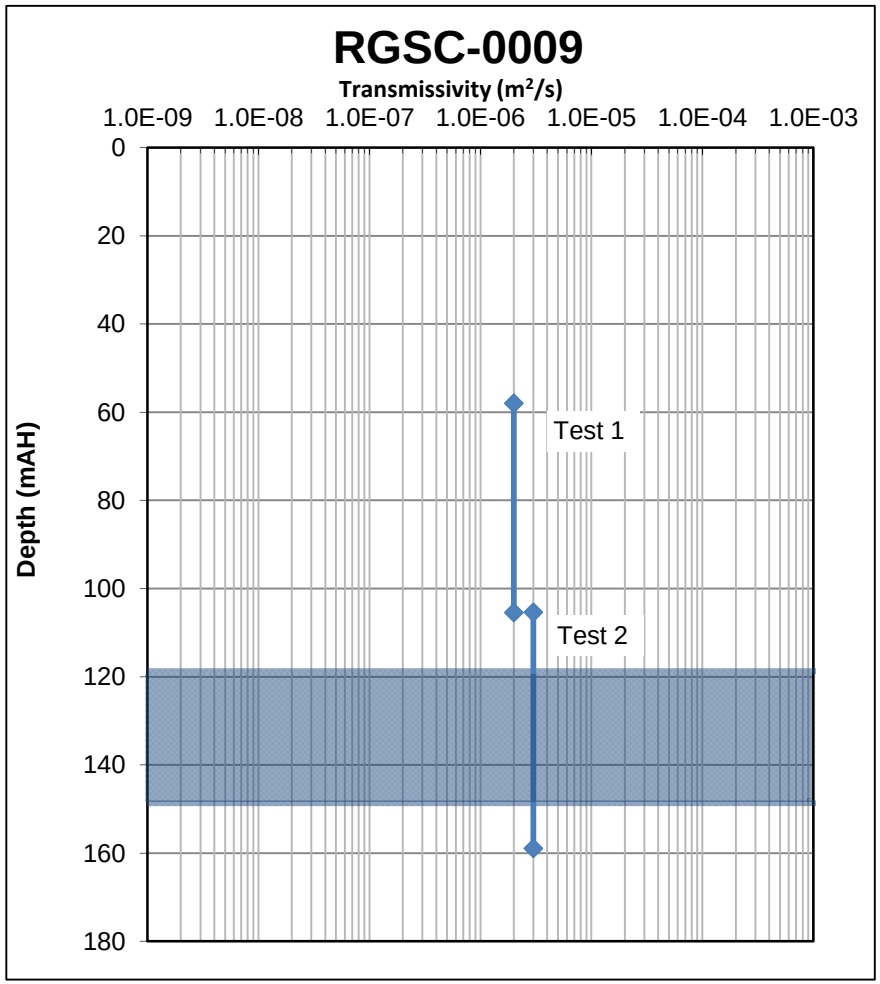
Notes

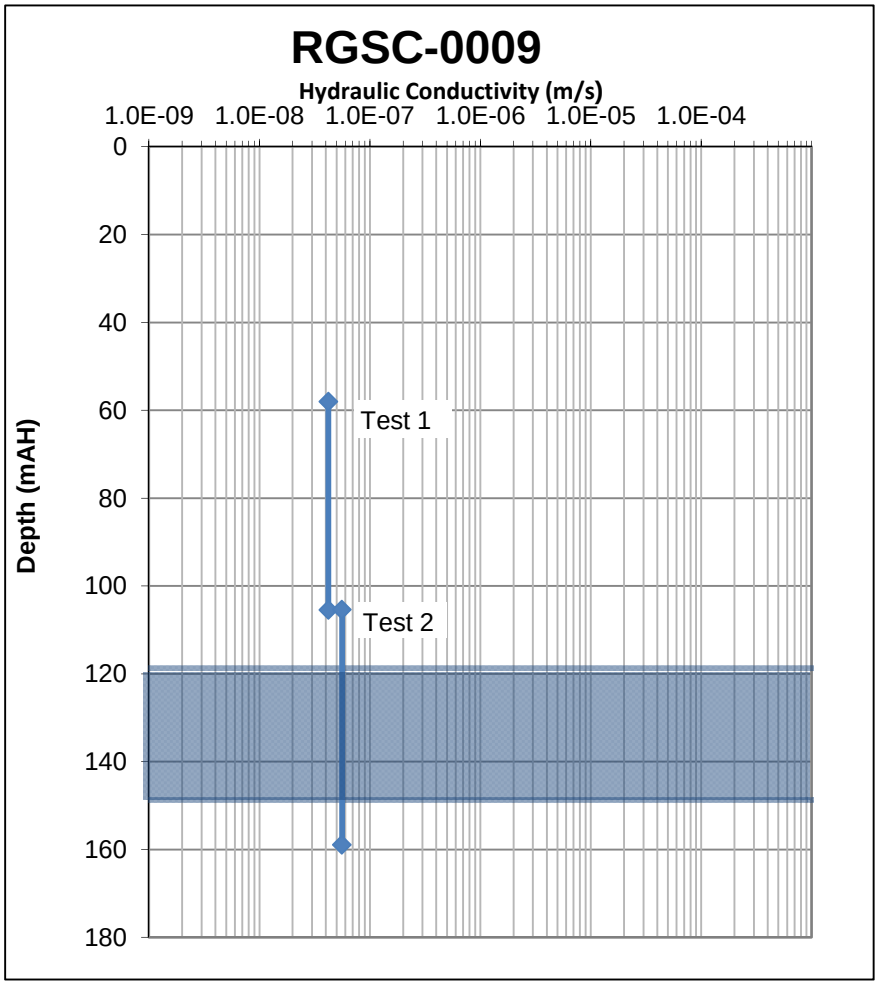
mAH = metres along hole

m/s = metres/second

m^2/s = metres squared/second

Profiles of Transmissivity and Hydraulic Conductivity





GEOLOGY LEGEND

- Coal Seam 1
- Coal Seam 2
- Coal Seam 4

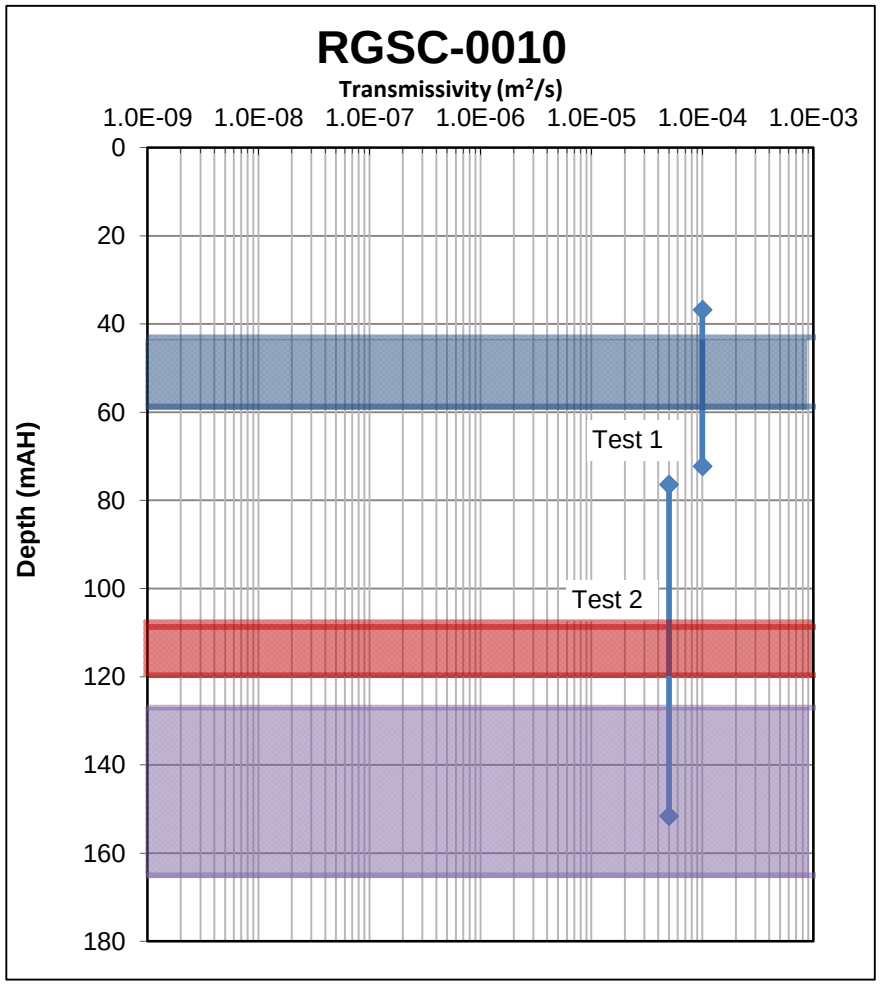
Notes

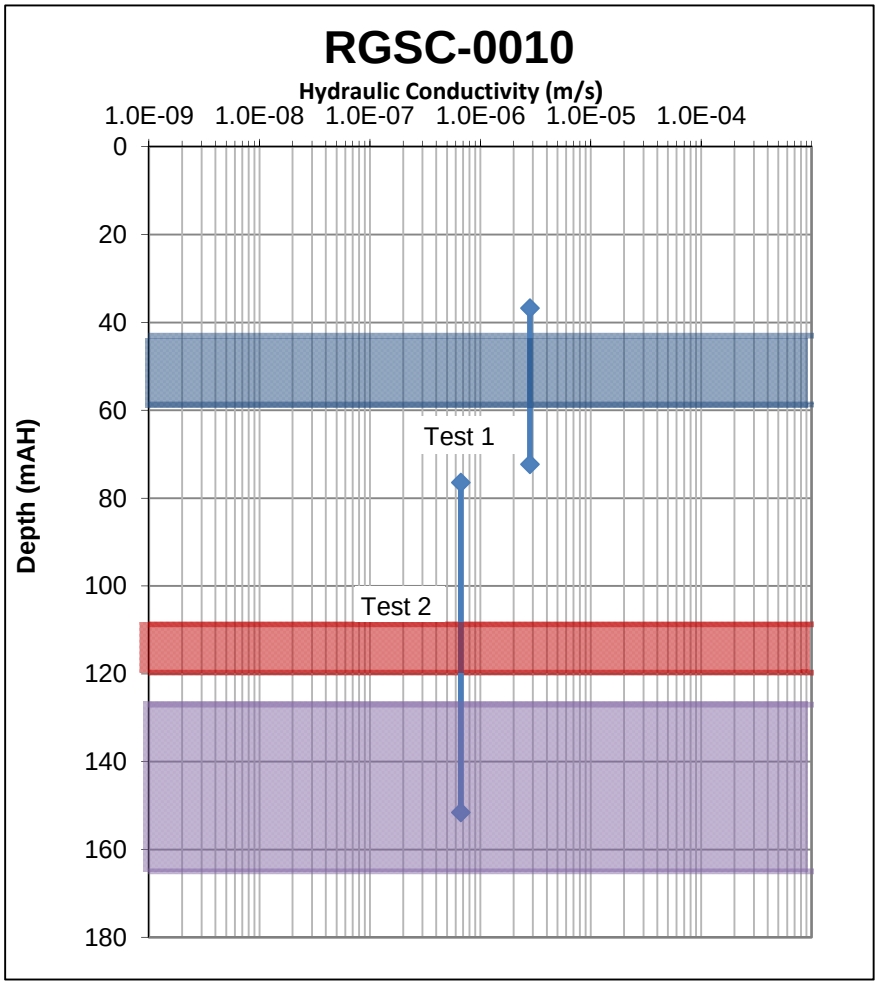
mAH = metres along hole

m/s = metres/second

m^2/s = metres squared/second

Profiles of Transmissivity and Hydraulic Conductivity





GEOLOGY LEGEND

- Coal Seam 1
- Coal Seam 2
- Coal Seam 4

Notes

mAH = metres along hole

m/s = metres/second

m^2/s = metres squared/second

APPENDIX D

Vibrating Wire Piezometer Installation Schematics

GROUTED-IN PIEZOMETER INSTALLATION

Borehole Number:
RGSC-0005

Project Number:	**1406422**
Project Name:	**Riversdale**
Location:	**Blairmore, AB**
Contractor/Rig No:	**Ewen**

Date Completed:	25-Aug-14
Personnel:	Trevor Tamburri
Weather:	Overcast, 10° C
Client Contact:	Peter Murray

Drilling and Completion Details

NAD 83 Zone 11

Collar Easting: 65118.00
Collar Northing: 5504574.00

Ground Surface Elevation: 1507.5 masl

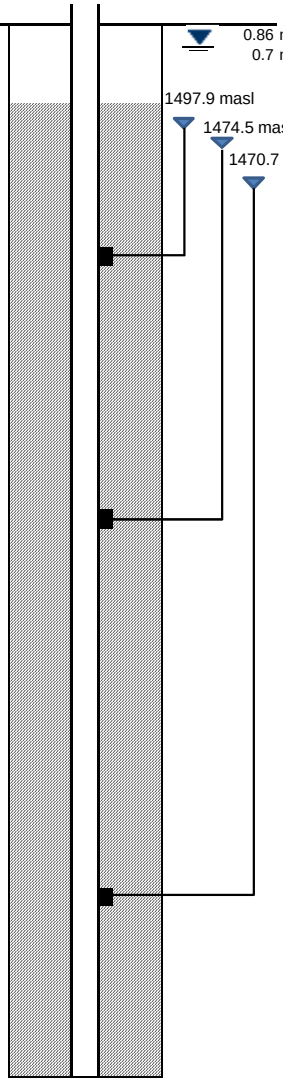
Top of Grout: 10.7 mAH, 10.1 mTVD

Borehole Diameter - HQ: *96 mm*
Inclination *70 °*
Azimuth *76 °*

Borehole Total Depth (TD) 149.0 mAH, 140.01 mTVD

Piezometer Details

Data Logger: RST Multi Channel VW Logger DT2055B



0.86 mAH, 0.7 mTVD — Water Level at end of drilling

1497.9 masl
1474.5 masl
1470.7 masl — Piezometer head elevation from September 20, 2014

Piezometer: Shallow
62.1 mAH, 58.3 mTVD, 1449.2 masl
RST Vibrating Wire Piezometer, 1.0 MPa
Serial Number: VW29689

Piezometer: Intermediate
91.5 mAH, 86.0 mTVD, 1421.5 masl
RST Vibrating Wire Piezometer, 2.0 MPa
Serial Number: VW29684

Piezometer: Deep
127.7 mAH, 120.0 mTVD, 1387.5 masl
RST Vibrating Wire Piezometer, 2.0 MPa
Serial Number: VW29682

LEGEND:

Grout — Piezometer
1 " PVC Pipe — Bentonite Chips

TVD - true vertical depth **mAH - metres along hole**

NOT TO SCALE

GROUTED-IN PIEZOMETER INSTALLATION

Borehole Number:
RGSC-0006

Project Number:	**1406422**
Project Name:	**Riversdale**
Location:	**Blairmore, AB**
Contractor/Rig No:	**Ewen**

Date Completed:	30-Aug-14
Personnel:	Trevor Tamburri
Weather:	Overcast, 10° C
Client Contact:	Peter Murray

Drilling and Completion Details

NAD 83 Zone 11

Collar Easting: 685577.00
Collar Northing: 5507161.00

Ground Surface Elevation: 1826.0 masl

Top of Grout: 0.0 mTVD

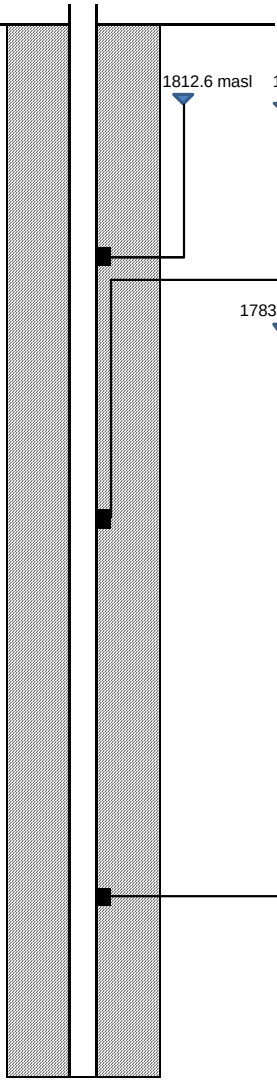
Borehole Diameter - HQ: *96 mm*
Inclination *90 °*
Azimuth *0 °*

Borehole Total Depth (TD) 161.0 mAH
161.0 mTVD

Piezometer Details

Data Logger: RST Multi Channel VW Logger DT2055B

Piezometer head elevation from September 20, 2014



Piezometer:
Shallow
RST Vibrating Wire Piezometer, 1.0 MPa
Serial Number: VW29681

Piezometer:
Intermediate
RST Vibrating Wire Piezometer, 2.0 MPa
Serial Number: VW29685

Piezometer:
Deep
RST Vibrating Wire Piezometer, 2.0 MPa
Serial Number: VW29681

LEGEND:
Grout
Piezometer
1 " PVC Pipe

TVD - true vertical depth **mAH - metres along hole**

NOT TO SCALE

GROUTED-IN PIEZOMETER INSTALLATION

Borehole Number:
RGSC-0009

Project Number:	**1406422**
Project Name:	**Riversdale**
Location:	**Blairmore, AB**
Contractor/Rig No:	**Ewen**

Date Completed:	16-Sep-14
Personnel:	Trevor Tamburri
Weather:	Overcast, 10° C
Client Contact:	Peter Murray

Drilling and Completion Details

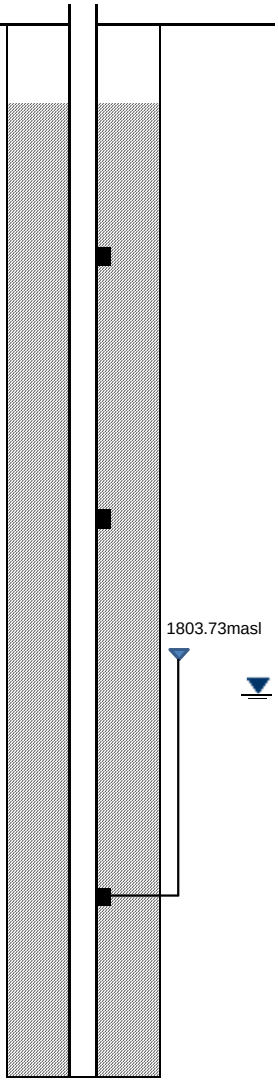
NAD 83 Zone 11

Collar Easting: 686742.00
Collar Northing: 5509160.00

Ground Surface Elevation: 1912.4 masl

Top of Grout: 13.2 mAH, 12.4 mTVD

Borehole Diameter - HQ: *96 mm*
Inclination *70 °*
Azimuth *76 °*



Borehole Total Depth (TD): 158.9 mAH, 149.34 mTVD

Piezometer Details

Data Logger: RST Multi Channel VW Logger DT2055B

Piezometer head elevation from September 20, 2014

Piezometer:
64.3 mAH, 60.4 mTVD, 1852.0 masl
Shallow
RST Vibrating Wire Piezometer, 1.0 MPa
Serial Number: VW29687

Piezometer:
99.8 mAH, 93.7 mTVD, 1818.7 masl
Intermediate
RST Vibrating Wire Piezometer, 2.0 MPa
Serial Number: VW29686

120.9 mAH, 113.6 mTVD
Water Level at end of drilling

Piezometer:
144.1 mAH, 135.4 mTVD, 1777.0 masl
Deep
RST Vibrating Wire Piezometer, 2.0 MPa
Serial Number: VW29683

LEGEND:

Grout | Piezometer
1 " PVC Pipe | Bentonite Chips

TVD - true vertical depth **mAH - metres along hole**

NOT TO SCALE

APPENDIX E

Vibrating Wire Piezometer Field Data Sheets

Vibrating Wire Piezometer Installation Report

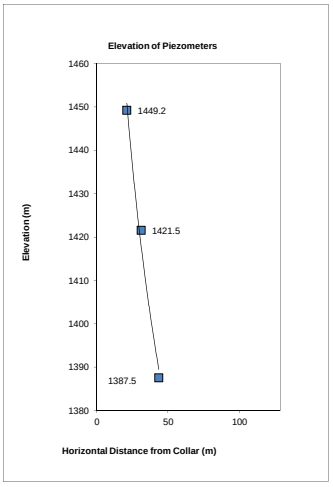
Project Name:	Riversdale-Benga Mine				
Golder File No	1406422			**Date:**	25-Aug-14
Client:	Riversdale				
Client File No.	NA				
BH ID:	RGSC-0005	**BH Size:**	HQ	**Elevation:**	1507.5
Northing:	65118.0	**Easting:**	5504574.0	**Total Length (m):**	150
Azimuth:	76	**Dip:**	70		

Groundwater Level Prior to Grouting

Depth to groundwater (mAH)	0.86
Average dip to 150 mAH	70
Groundwater Elevation (masl)	1506.7

Installation Details

VW S/N	Tip Depth	Tip Depth	Dip to piezo	Horizontal Distance from Collar (m)	Elevation of Tip (m)
	[mbgs]	[mAH]		[m]	[masl]
Shallow	58.3	62.1	70.0	21.2	1449.2
Intrt	86.0	91.5	70.0	31.3	1421.5
Deep	120.0	127.7	70.0	43.7	1387.5



Grouting/Backfill Details

Pumped 1.5 holding volumes (9 cement to 4 bentonite) through PVC until grout reached surface. Removed casing, pumped grout through open hole for a few minutes untill grout returned to surface.

Comments

Vendor Calibration Parameters (on calibration sheet)

	VW S/N	Linear Calibration Factor (C.F.)	Pressure Rating	Factory Zero Reading	Tk	
		MPa/B Unit	[MPa]	B Unit	MPa/C	
Shallow	VW29689	0.00028876	1	8877	0.00009873	All information provided on Calibration
Intermediate	VW29684	0.00058421	2	9067	0.0003230	
Deep	VW29682	0.00058643	2	8792	-0.00001515	

Initial Zero Reading (at rig prior to installation)

	VW S/N	Date	Time	B Units (at rig prior to installation)	Piezo Temp (at rig prior to installation)	Atm. Pressure (at rig prior to installation)	Source of Atm Reading
					C	[kPa]	
Shallow	VW29689	25-Aug-14	8:30	8934.00	4.8	83.193	Leveltroll
Intermediate	VW29684	25-Aug-14	8:30	9093.40	6.9	83.193	Leveltroll
Deep	VW29682	25-Aug-14	8:30	8815.00	5.5	83.193	Leveltroll

Reading After Installed Prior to Grouting

	VW S/N	Date	Time	B Units (kpa)	Piezo Temp	Atm. Pressure	Source of Atm Reading
					C	[kPa]	
Shallow	VW29689	25-Aug-14	12;52	565.19	8.7	83.193	Leveltroll
Intermediate	VW29684	25-Aug-14	12:52	836.63	7.6	83.193	Leveltroll
Deep	VW29682	25-Aug-14	12:52	1170.28	9.2	83.193	Leveltroll

Vibrating Wire Piezometer Installation Report

Project Name: Riversdale-Benga Mine
Golder File No 1406422
Client: Riversdale
Client File No. NA

Date: 30-Aug-14

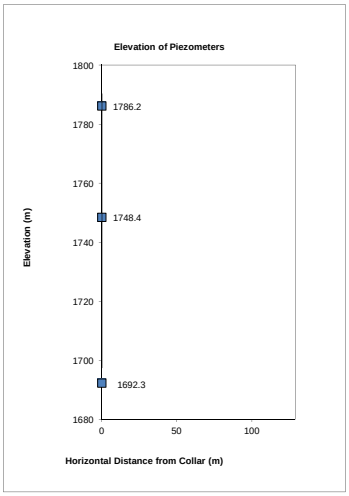
BH ID: RGSC-0006 **BH Size:** HQ **Elevation:** 1826.0
Northing: 685577.0 **Easting:** 5507161.0 **Total Length (m):** 161
Azimuth: 0 **Dip:** 90

Groundwater Level Prior to Grouting

Depth to groundwater (mAH) 16.95
Average dip to 161 mAH 90
Groundwater Elevation (masl) 1809.0

Installation Details

VW S/N	Ground Measured Along Hole Ground Level	Dip to piezo	Horizontal Distance from Collar (m)	Elevation of Tip (m)
	[mAH]		[m]	[masl]
Shallow	39.8	90.0	0.0	1786.2
Intrt	77.5	90.0	0.0	1748.4
Deep	133.7	90.0	0.0	1692.3



Grouting/Backfill Details

Pumped 1.5m3 of grout into well until pump failed. Completed grouting the following day with goodearth drilling. Grout level was at approximatly 60m, PVC pipe was lowered to this depth and grout was pumped to surface.

Comments

Vendor Calibration Parameters (on calibration sheet)

	VW S/N	Linear Calibration Factor (C.F.)	Pressure Rating	Factory Zero Reading	Tk	
		MPa/B Unit	[MPa]	B Unit	MPa/C	
Shallow	VW29688	0.00029015	1	8923	-0.00014270	All information provided on Calibration
Intermediate	VW29685	0.0005732	2	8967	0.0004694	
Deep	VW29681	0.00057086	2	8951	0.0000412	

Initial Zero Reading (at rig prior to installation)

	VW S/N	Date	Time	B Units (at rig prior to installation)	Piezo Temp (at rig prior to installation)	Atm. Pressure (at rig prior to installation)	Source of Atm Reading
					C	[kPa]	
Shallow	VW29689	29-Aug-14	1700	8997.60	12.4	79.206	Leveltroll
Intermediate	VW29684	29-Aug-14	1700	9004.10	12.9	79.206	Leveltroll
Deep	VW29682	29-Aug-14	1700	8987.40	12.9	79.206	Leveltroll

Reading After Installed Prior to Grouting

	VW S/N	Date	Time	B Units (kpa)	Piezo Temp	Atm. Pressure	Source of Atm Reading
					C	[kPa]	
Shallow	VW29689	30-Aug-14	9:50	236.25	6.7	79.206	Leveltroll
Intermediate	VW29684	30-Aug-14	9:50	609.54	7.2	79.206	Leveltroll
Deep	VW29682	30-Aug-14	9:50	1160.04	8.7	79.206	Leveltroll

Vibrating Wire Piezometer Installation Report

Project Name: Riversdale-Benga Mine
Golder File No 1406422
Client: Riversdale
Client File No. NA

Date: 16-Sep-14

BH ID: RGSC-0009
Northing: 686742.0
Azimuth: 20

BH Size: HQ
Easting: 5509160.0
Dip: 70

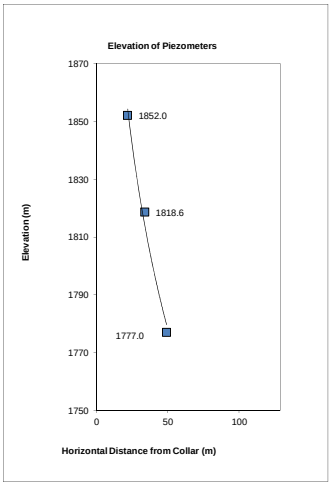
Elevation: 1912.4
Total Length (m): 158.92

Groundwater Level Prior to Grouting

Depth to groundwater (mAH) 120.9
Average dip to 161 mAH 70
Groundwater Elevation (masl) 1798.8

Installation Details

VW S/N	Ground Along Hole Ground Level	Dip to piezo	Tip Depth Below Ground Along Hole	Horizontal Distance from Collar (m)	Elevation of Tip (m)
	[mAH]		[mbgs]	[m]	[masl]
Shallow	64.3	70.0	60.4	22.0	1852.0
Intrt	99.8	70.0	93.7	34.1	1818.6
Deep	144.1	70.0	135.4	49.3	1777.0



Grouting/Backfill Details

Batch 1: 7 cement, 2 bentonite, 500L of water. Batch 2: 7 cement, 2 bentonite, 500L of water, end of batch, water started returning to surface. Batch 3: same ratios, water starts coming out of casing at 1560kpa (deep), 1576kpa (bottom piezo) grout starts to flow out of casing.

Comments

Vendor Calibration Parameters (on calibration sheet)

VW S/N	Linear Calibration Factor (C.F.) MPa/B Unit	Pressure Rating [MPa]	Factory Zero Reading B Unit	Tk MPa/C	
Shallow	VW29687	0.00028861	1	9050	0.00020290	All information provided on Calibration
Intermediate	VW29686	0.0005816	2	9019	0.0000391	
Deep	VW29683	0.00057585	2	8980	-0.000005183	

Initial Zero Reading (at rig prior to installation)

	VW S/N	Date	Time	B Units (at rig prior to installation)	Piezo Temp (at rig prior to installation) C	Atm. Pressure (at rig prior to installation) [kPa]	Source of Atm Reading
Shallow	VW29687	16-Sep-14	930am	9109.20	11.4	78.719	Leveltroll
Intermediate	VW29686	16-Sep-14	930am	9059.80	11.4	78.719	Leveltroll
Deep	VW29683	16-Sep-14	930am	9014.80	11.1	78.719	Leveltroll

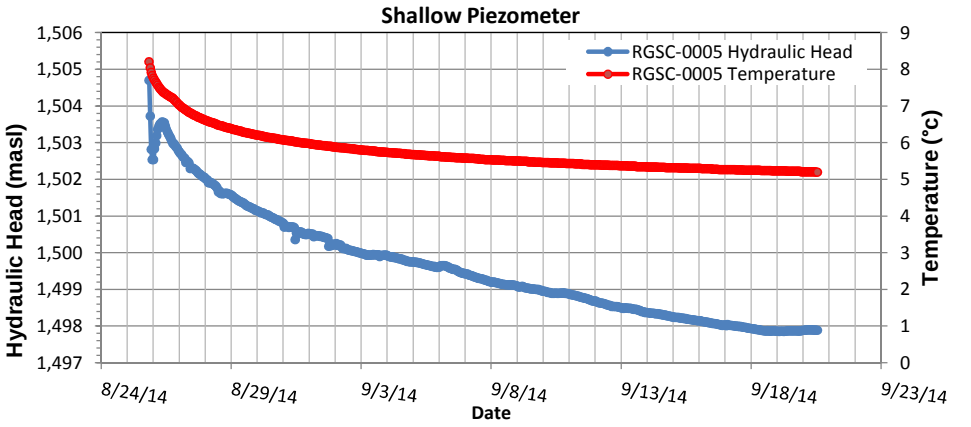
Reading After Installed Prior to Grouting

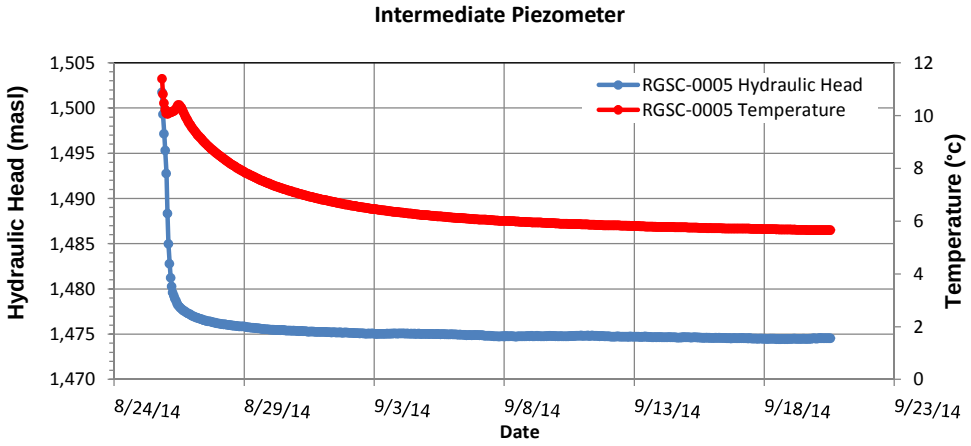
	VW S/N	Date	Time	B Units (kpa)	Piezo Temp C	Atm. Pressure [kPa]	Source of Atm Reading
Shallow	VW29687	16-Sep-14	445pm	0.45	7.2	78.719	Leveltroll
Intermediate	VW29686	16-Sep-14	445pm	1.95	6.1	78.719	Leveltroll
Deep	VW29683	16-Sep-14	445pm	214.58	6.5	78.719	Leveltroll

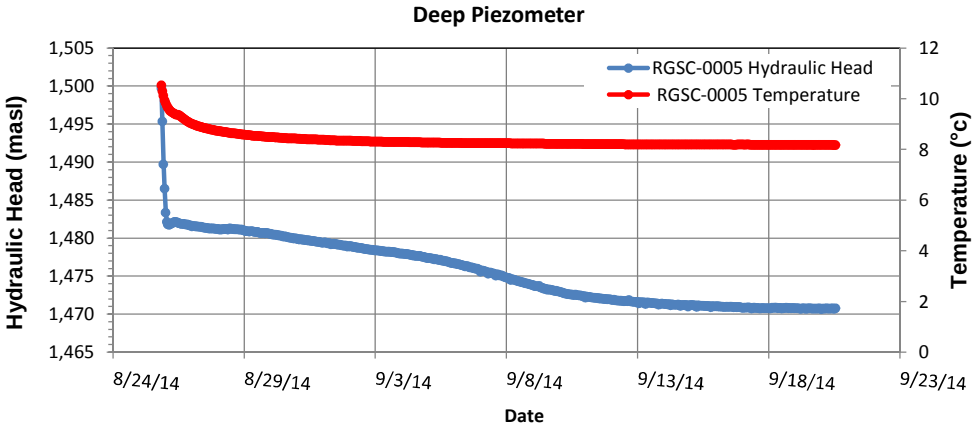
APPENDIX F

Vibrating Wire Piezometer Pressure Data Plots

Appendix F-1
Grouted-In Piezometer Measurements
RGSC-0005

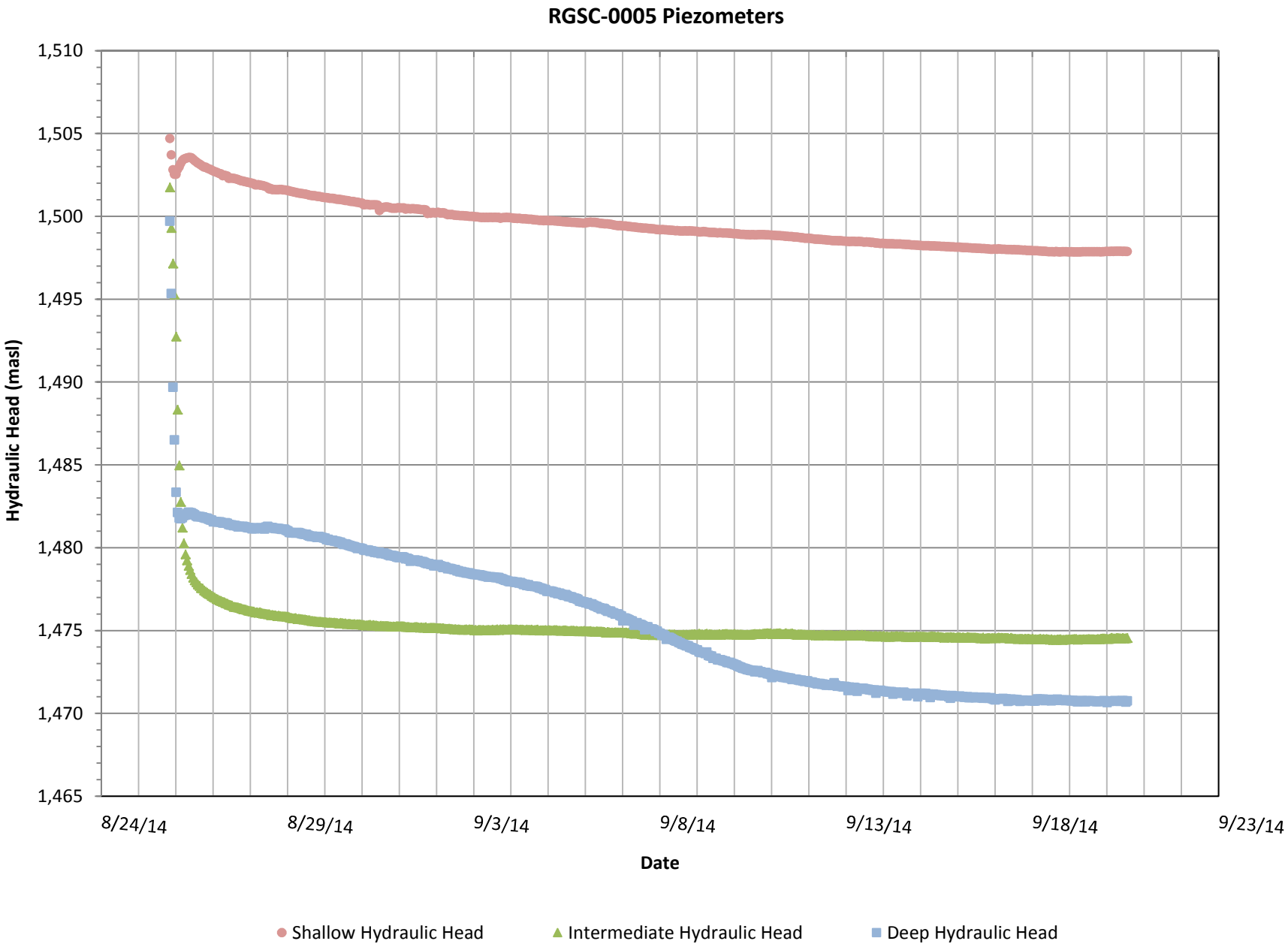






Notes:
Hydraulic Head is plotted only for piezometers located below the groundwater surface.
masl = metres above sea level

Appendix F-2



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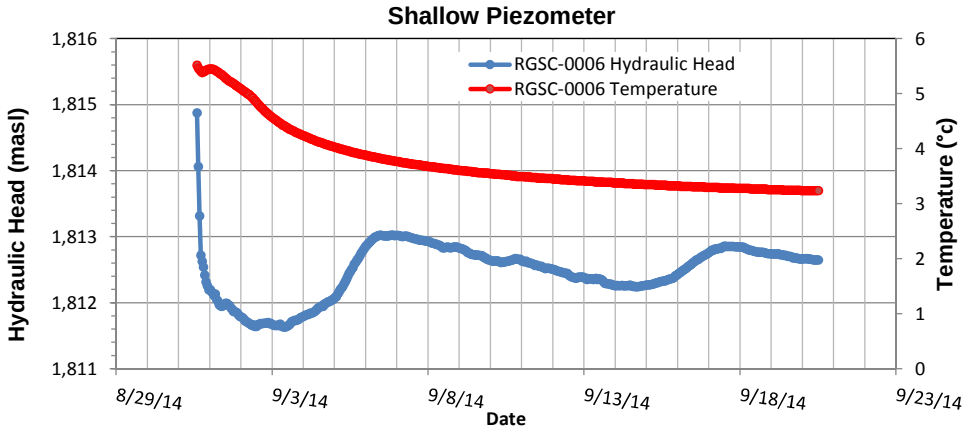
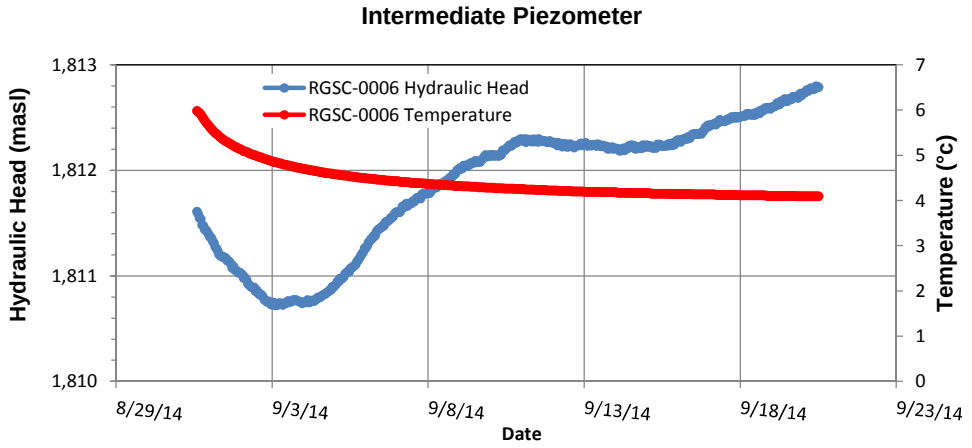
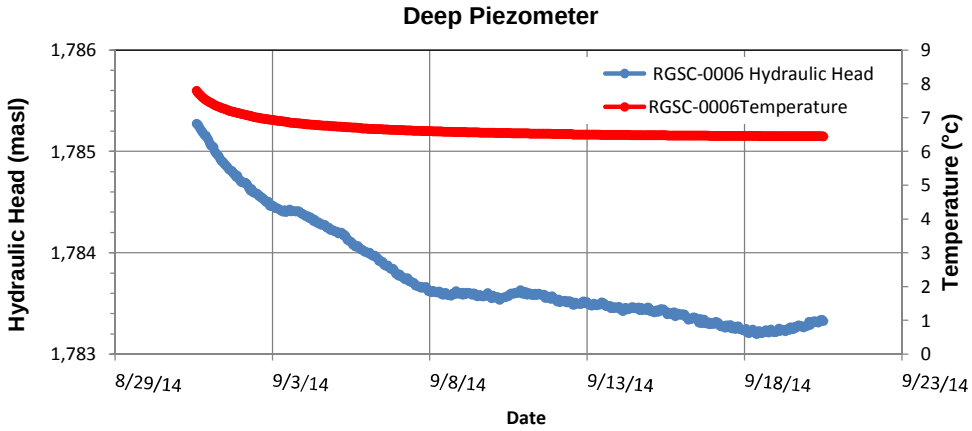
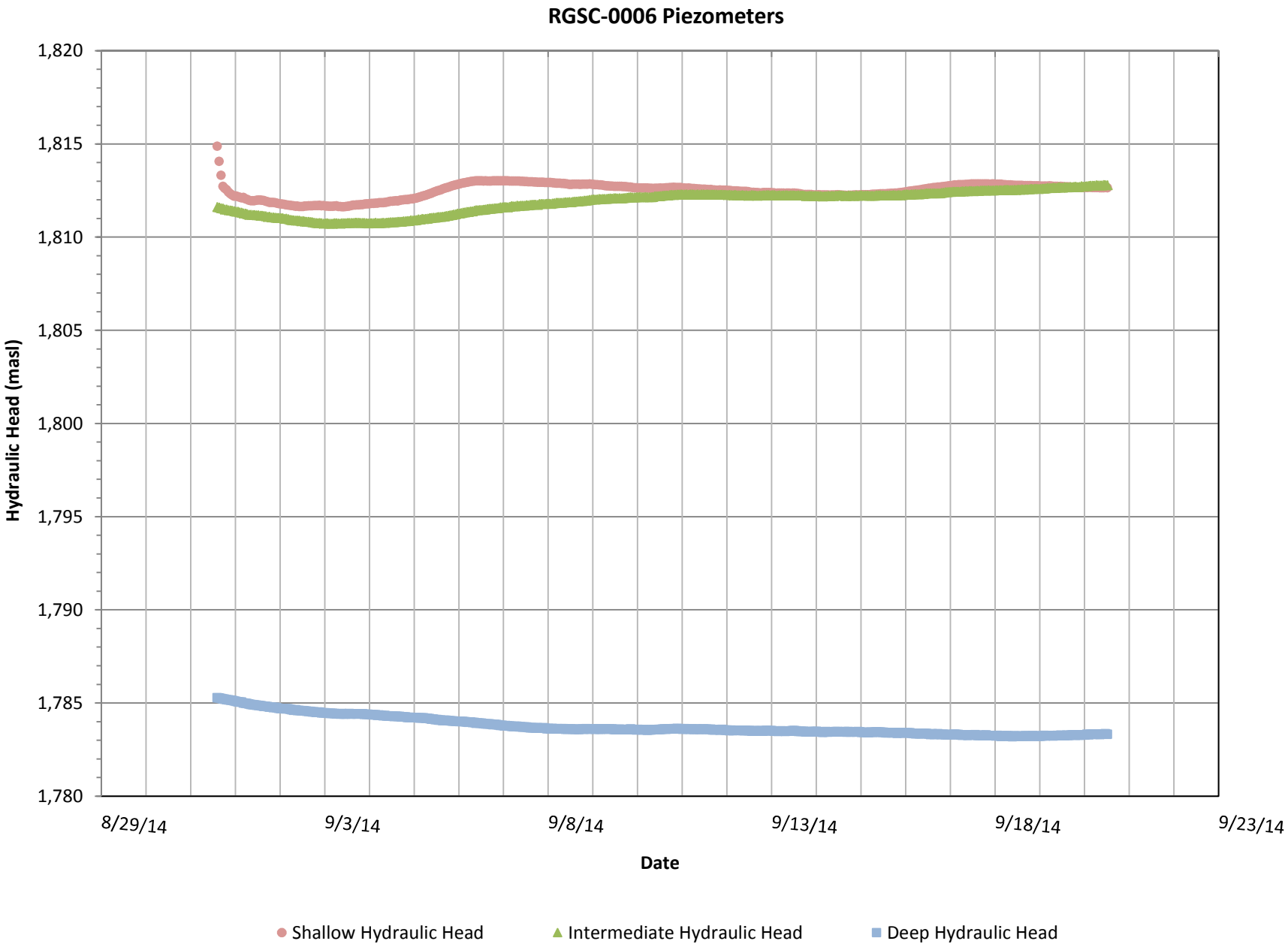
Appendix F-3
Grouted-In Piezometer Measurements
RGSC-0006







Notes:
Hydraulic Head is plotted only for piezometers located below the groundwater surface.
masl = metres above sea level



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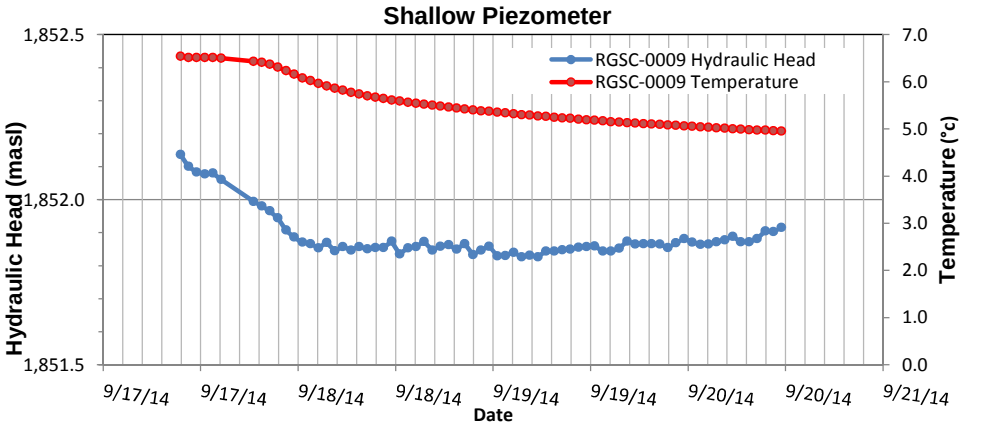
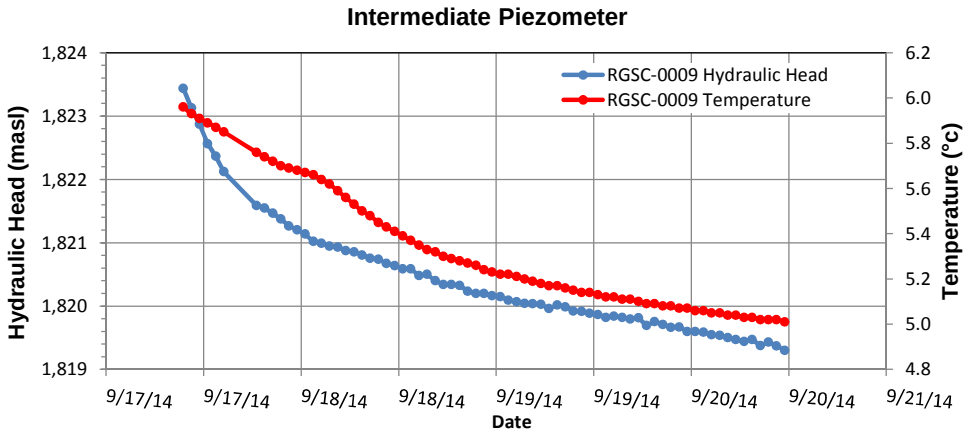
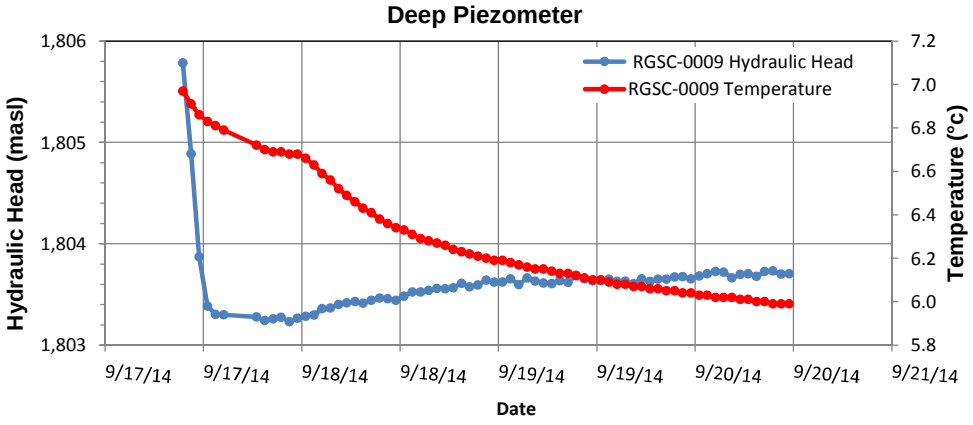
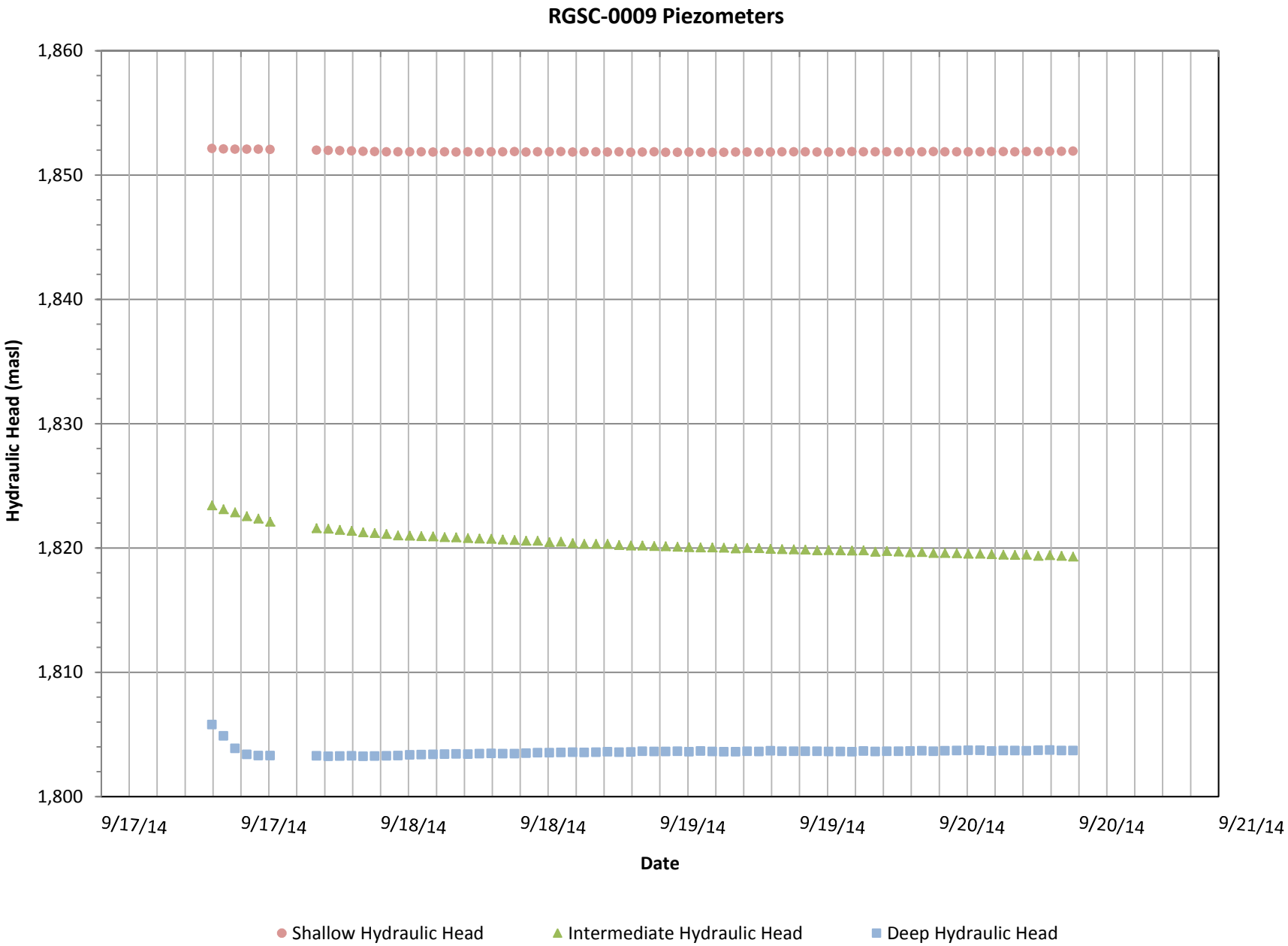
Appendix F-5
Grouted-In Piezometer Measurements
RGSC-0009







Notes:
Hydraulic Head is plotted only for piezometers located below the groundwater surface.
masl = metres above sea level



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102, 2535 - 3rd Avenue S.E.
Calgary, Alberta, T2A 7W5
Canada
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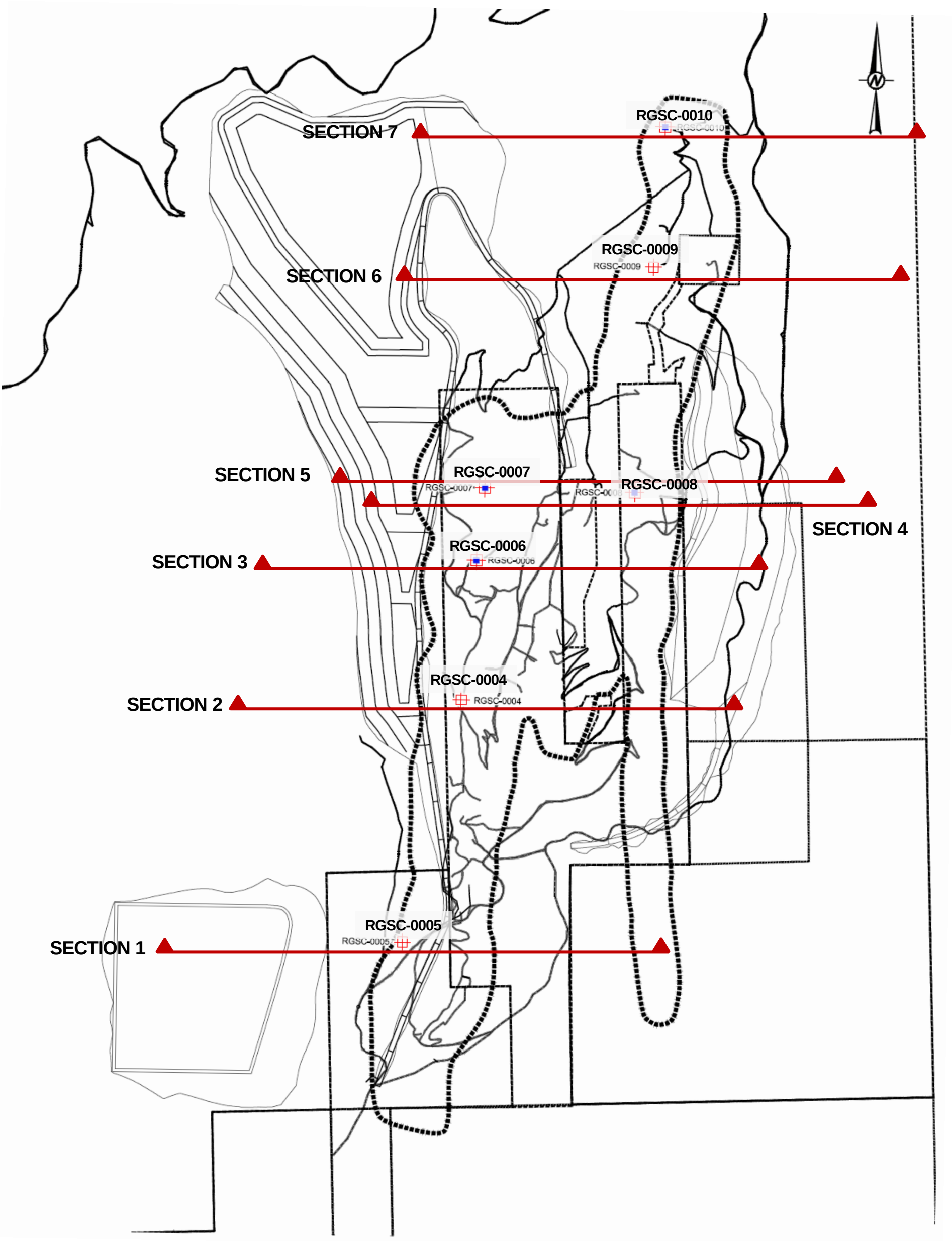
APPENDIX G

Geological Cross Sections



NOTE: MINE DESIGN SHOWN IS INDICATIVE AND NOT REPRESENTATIVE OF FEASIBILITY LEVEL PIT DESIGN

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RIVERSDALE RESOURCES LIMITED

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	YYYY-MM-DD
PREPARED	
DESIGN	
REVIEW	
APPROVED	

PROJECT
GRASSY MOUNTAIN PRELIMINARY PIT SLOPE STABILITY ASSESSMENT

TITLE
LOCATION OF GEOLOGICAL SECTIONS

PROJECT No.	Rev.	FIGURE
2850-MN-0001-0	0	G-1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B
1 in
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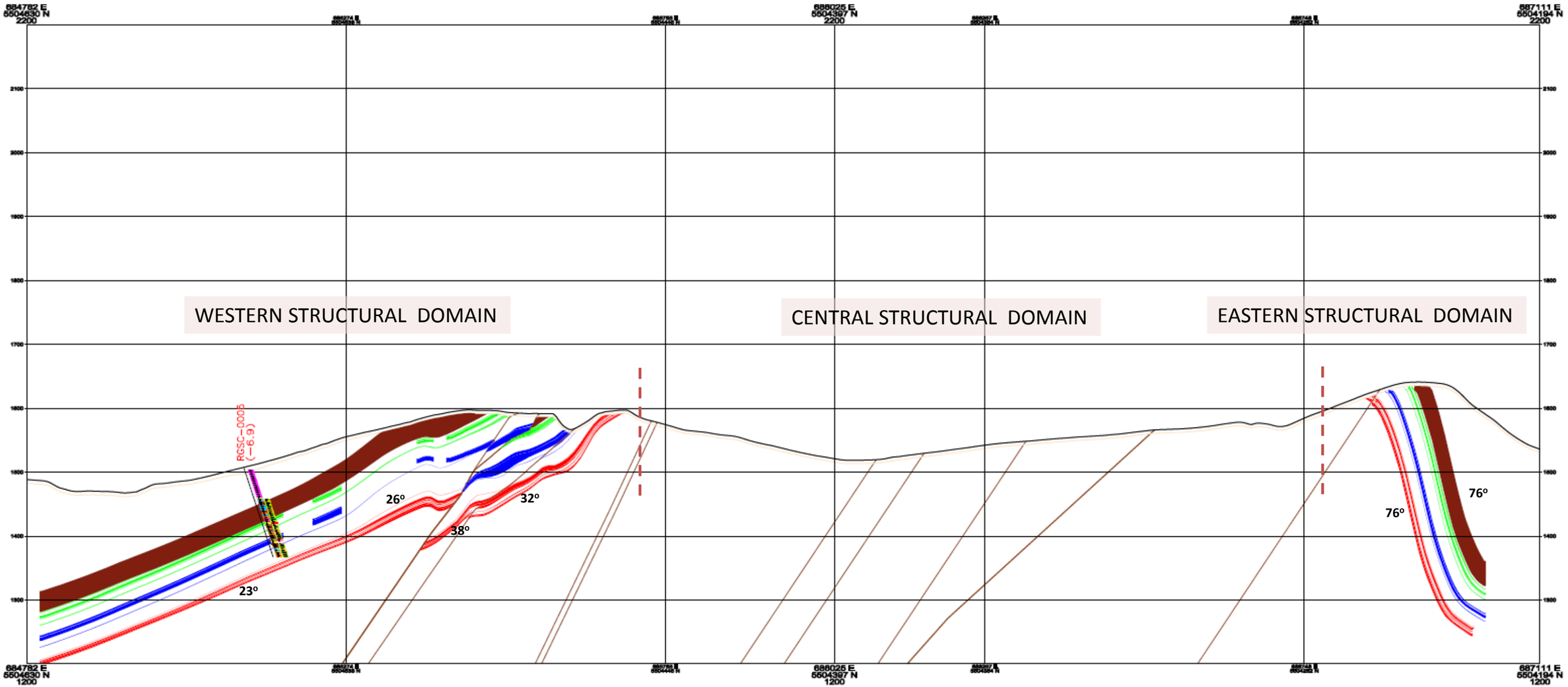

NOTE: PIT SHELL SHOWN IS INDICATIVE AND NOT REPRESENTATIVE OF FEASIBILITY LEVEL PIT DESIGN

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GRASSY MOUNTAIN PROJECT
BLAIRMORE, ALBERTA

CONSULTANT
Golder Associates

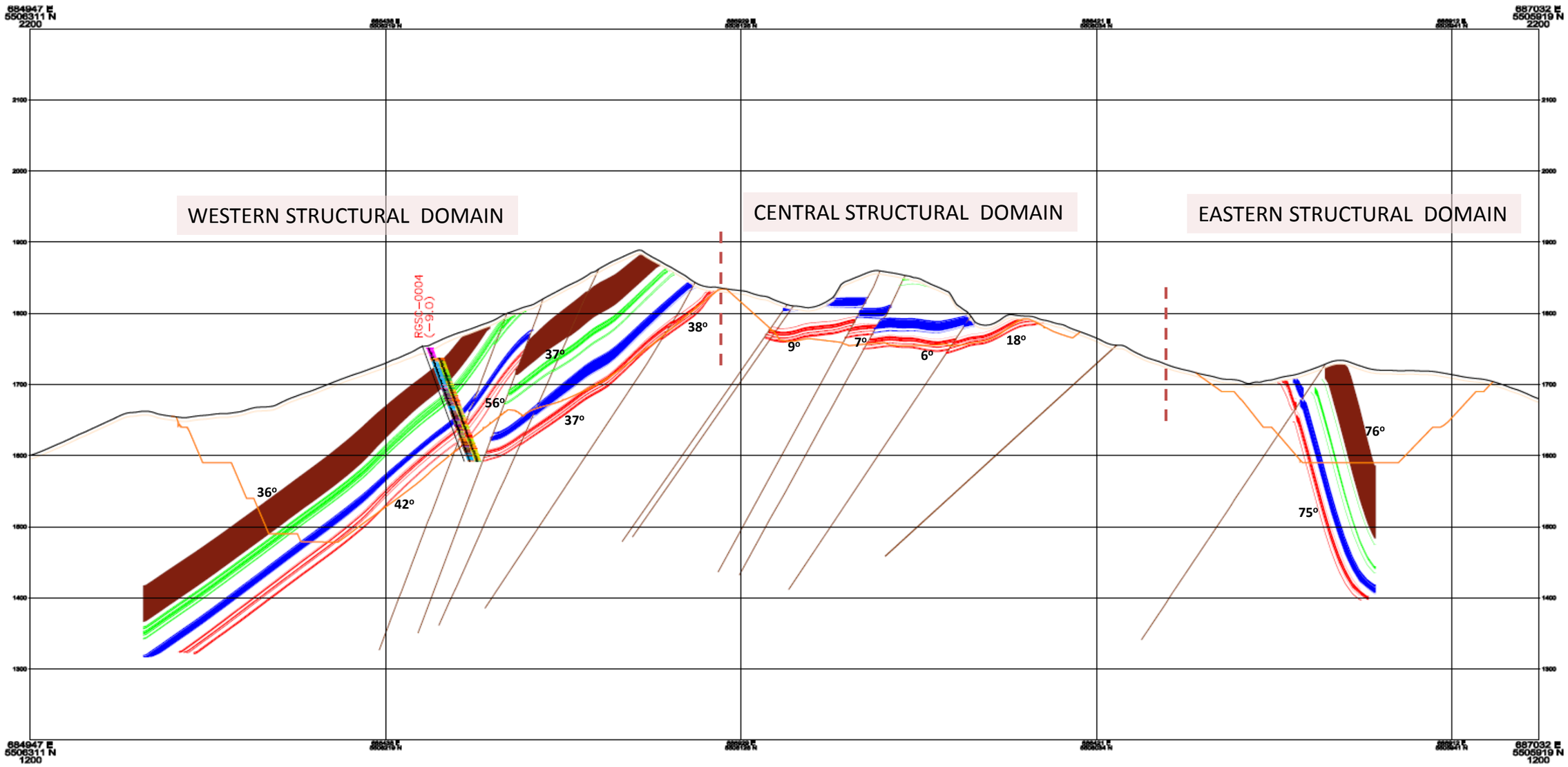
YYYY-MM-DD	2014-11-28
PREPARED	AGH
DESIGN	AGH
REVIEW	EAS
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PIT SLOPE STABILITY ANALYSIS

TITLE
GEOLOGICAL SECTION 1

PROJECT No. **2850-MN-0001-0** | Rev. **0** | FIGURE **G-2**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B



NOTE: PIT SHELL SHOWN IS INDICATIVE AND NOT REPRESENTATIVE OF FEASIBILITY LEVEL PIT DESIGN

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GRASSY MOUNTAIN PROJECT
BLAIRMORE, ALBERTA

CONSULTANT
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YYYY-MM-DD	2014-11-28
PREPARED	AGH
DESIGN	AGH
REVIEW	EAS
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PIT SLOPE STABILITY ANALYSIS

TITLE
GEOLOGICAL SECTION 2

PROJECT No.	Rev.	FIGURE
2850-MN-0001-0	**0**	**G-3**

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1 in
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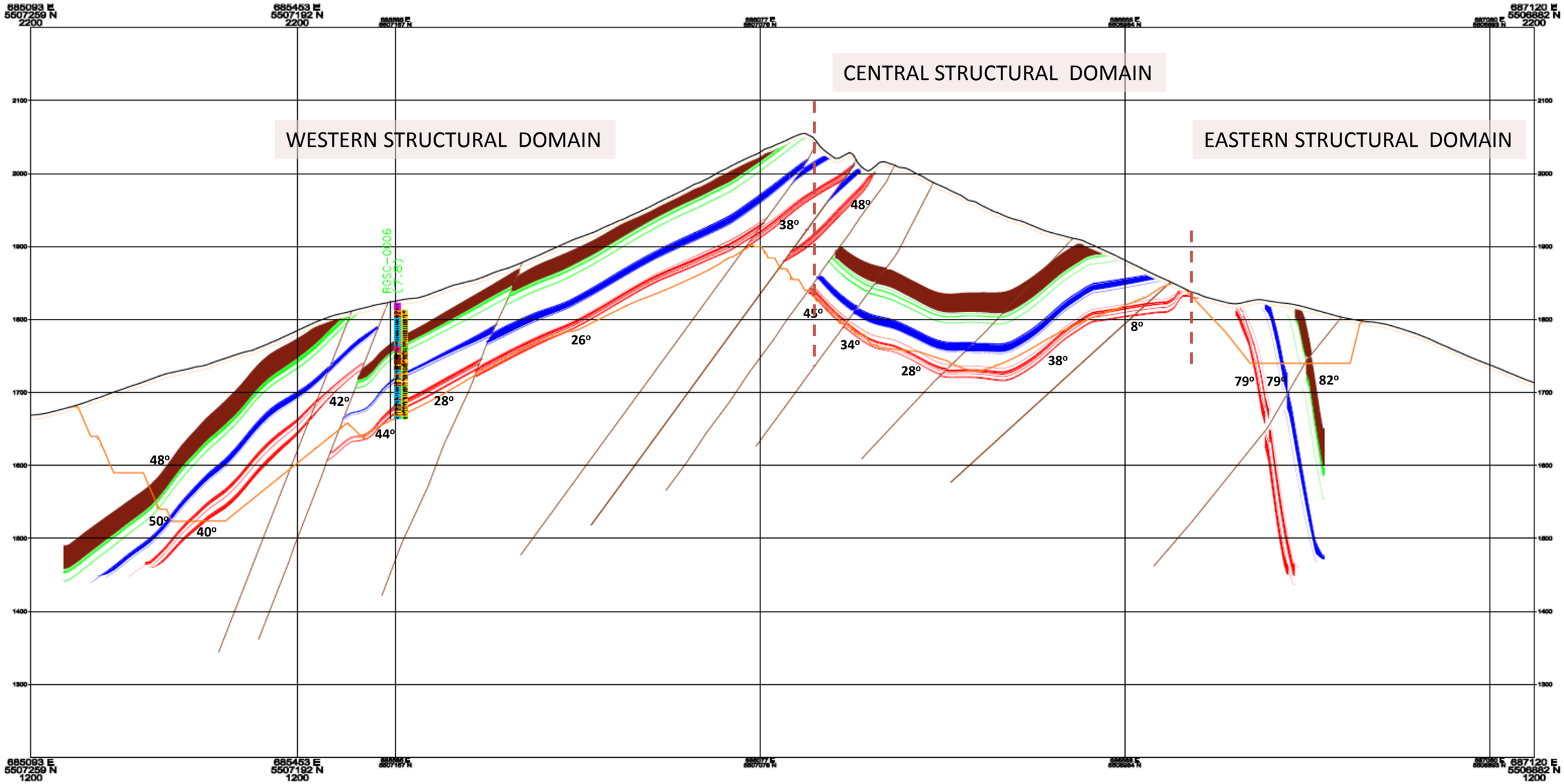

NOTE: PIT SHELL SHOWN IS INDICATIVE AND NOT REPRESENTATIVE OF FEASIBILITY LEVEL PIT DESIGN

CLIENT
RIVERSDALE RESOURCES LIMITED
GRASSY MOUNTAIN PROJECT
BLAIRMORE, ALBERTA

CONSULTANT
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YYYY-MM-DD	2014-11-28
PREPARED	AGH
DESIGN	AGH
REVIEW	EAS
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PIT SLOPE STABILITY ANALYSIS

TITLE
GEOLOGICAL SECTION 3

PROJECT No. **2850-MN-0001-0** | Rev. **0** | FIGURE **G-4**

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1 in
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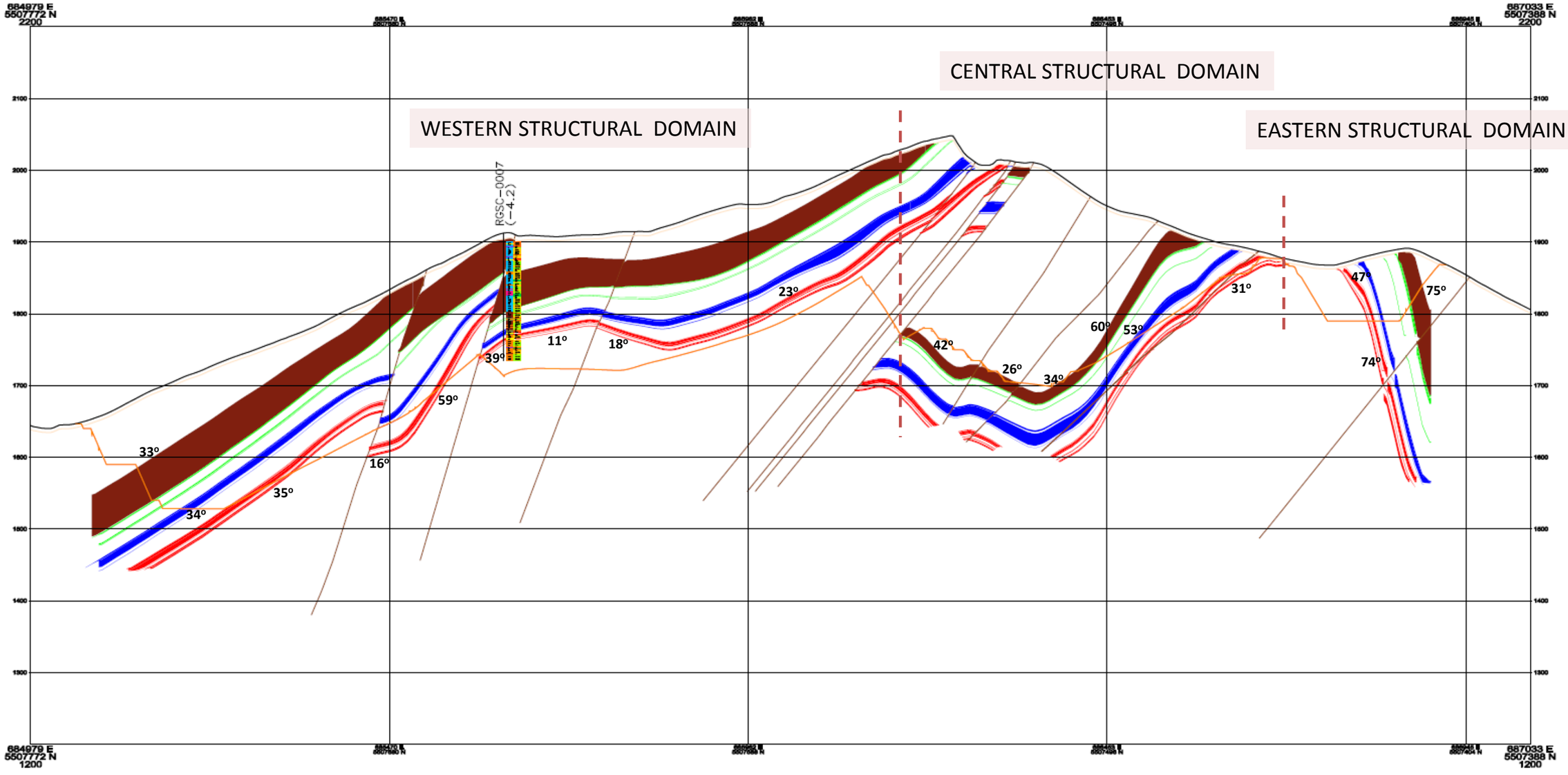

NOTE: PIT SHELL SHOWN IS INDICATIVE AND NOT REPRESENTATIVE OF FEASIBILITY LEVEL PIT DESIGN

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GRASSY MOUNTAIN PROJECT
BLAIRMORE, ALBERTA

CONSULTANT
Golder Associates

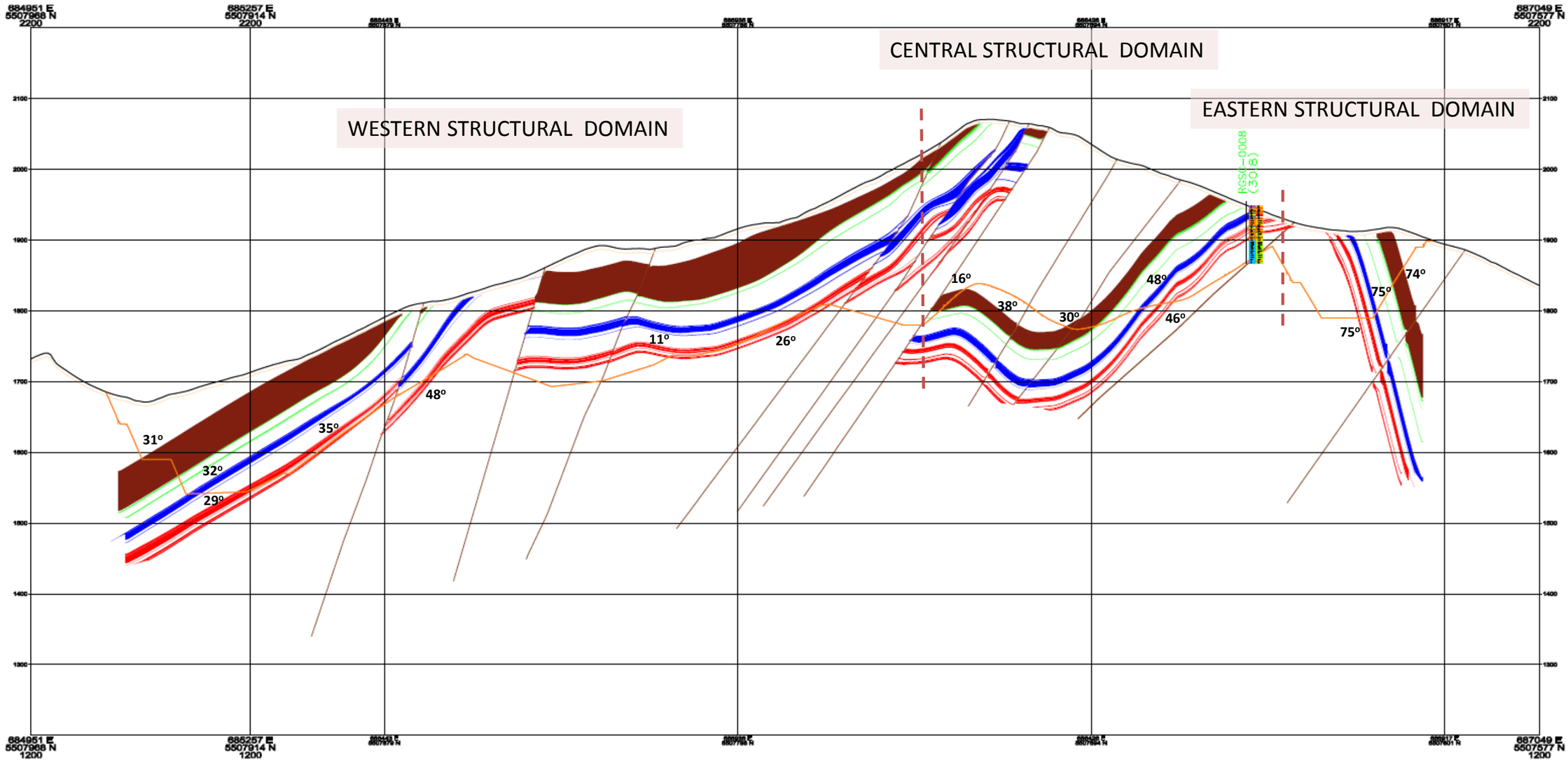
YYYY-MM-DD	2014-11-28
PREPARED	AGH
DESIGN	AGH
REVIEW	EAS
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PIT SLOPE STABILITY ANALYSIS

TITLE
GEOLOGICAL SECTION 4

PROJECT No.	Rev.	FIGURE
2850-MN-0001-0	**0**	**G-5**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B
1 in
0



NOTE: PIT SHELL SHOWN IS INDICATIVE AND NOT REPRESENTATIVE OF FEASIBILITY LEVEL PIT DESIGN

CLIENT
RIVERSDALE RESOURCES LIMITED
GRASSY MOUNTAIN PROJECT
BLAIRMORE, ALBERTA

CONSULTANT
Golder Associates

YYYY-MM-DD	2014-11-28
PREPARED	AGH
DESIGN	AGH
REVIEW	EAS
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PIT SLOPE STABILITY ANALYSIS

TITLE
GEOLOGICAL SECTION 5

PROJECT No.	Rev.	FIGURE
2850-MN-0001-0	**0**	**G-6**

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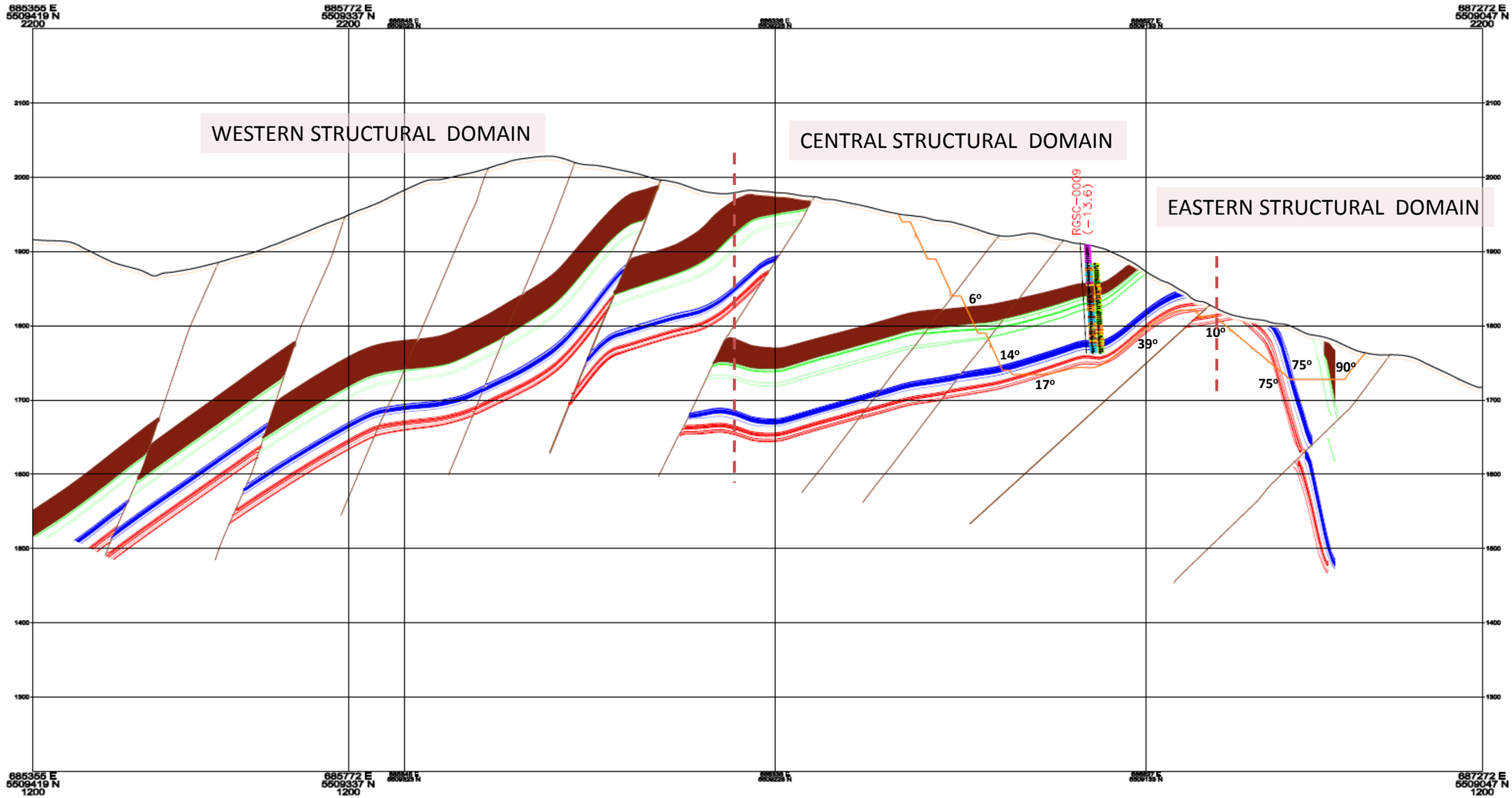

NOTE: PIT SHELL SHOWN IS INDICATIVE AND NOT REPRESENTATIVE OF FEASIBILITY LEVEL PIT DESIGN

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PROJECT
GRASSY MOUNTAIN PIT SLOPE STABILITY ANALYSIS

TITLE
GEOLOGICAL SECTION 6

PROJECT No.	Rev.	FIGURE
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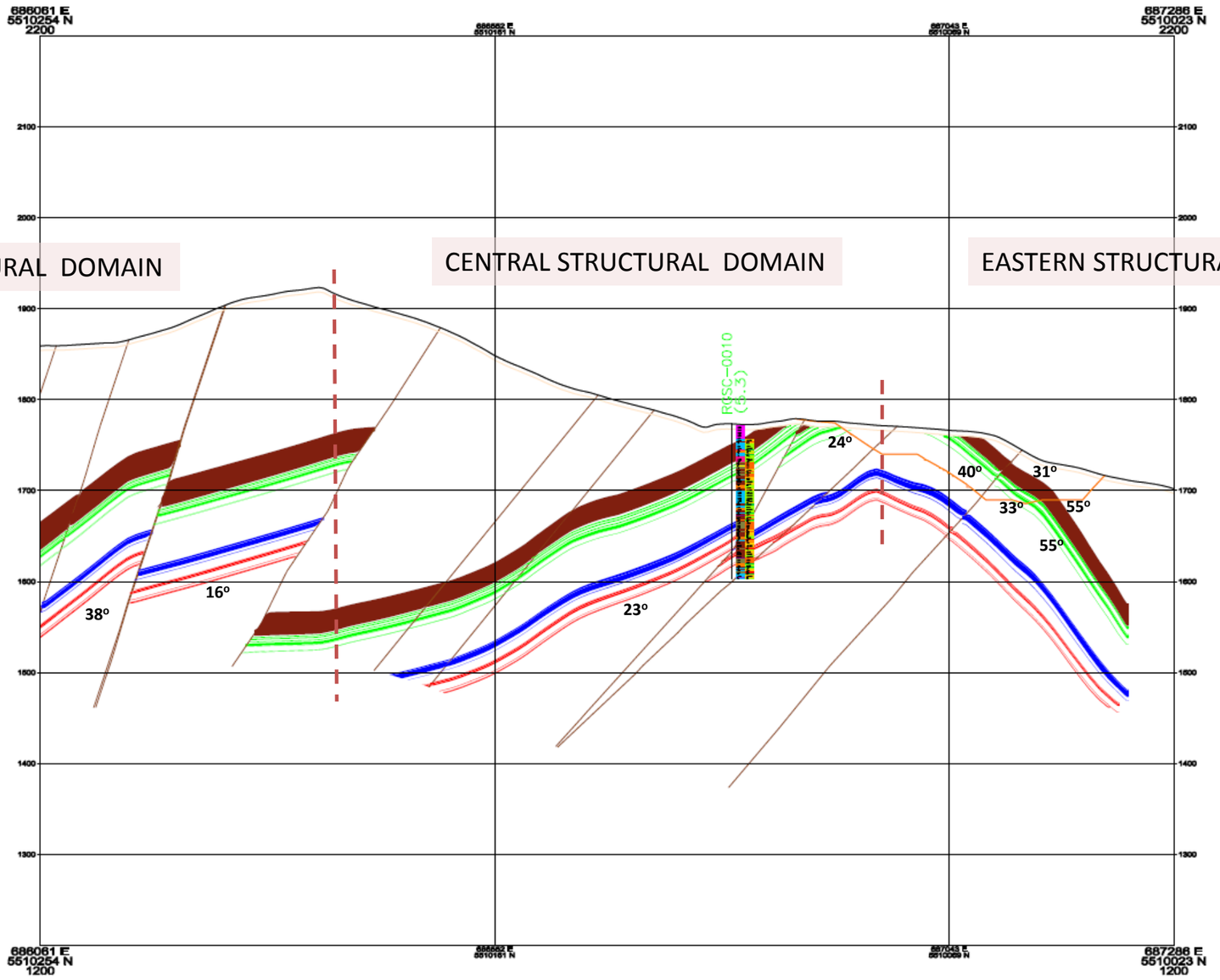

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PROJECT
GRASSY MOUNTAIN PIT SLOPE STABILITY ANALYSIS

TITLE
GEOLOGICAL SECTION 7

PROJECT No.	Rev.	FIGURE
2850-MN-0001-0	**0**	**G-8**

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APPENDIX H

Pit Slope Stability Considerations

1.0 ROCK SLOPE FAILURE MECHANISMS

Rock slope design procedures are intended to establish pit wall design criteria based on the anticipated failure modes, as determined by the analysis of the engineering geological model. In this context, instability in rock slopes can generally be classified according to two principal failure mechanisms:

- Type 1: Failures due to rock mass fabric and structural discontinuities (kinematic failures); and
- Type 2: Failures due to rock mass strength.

These mechanisms of slope failure are briefly discussed below.

1.1 Structurally Controlled Failure

1.1.1 Benched Highwall and Endwall Failure Mechanisms

Structurally controlled failure in rock occurs as the result of movement along pre-existing geological discontinuities. Three basic mechanisms of structurally controlled failure in benched highwall and endwall rock slopes are planar failures, wedge failures and toppling failures, as described below and shown schematically in Figure D-1.

Planar failures may occur when a geological discontinuity dips out of a rock slope at an angle that is shallower than the inclination of the slope and steeper than the effective angle of friction on the discontinuity. Planar failures will generally only develop to a significant extent if the strike of the geologic discontinuity is within ± 20 to 30 degrees of the strike of the rock slope.

Wedge failures may occur when two or more geological discontinuities intersect to form an unstable wedge. In order for a wedge to fail, the line of intersection of the wedge must dip out of the slope at an inclination that is shallower than the inclination of the slope face, but steeper than the effective angle of friction along the discontinuities. Wedge failures will only develop to a significant extent if the azimuth of the line of intersection is within ± 45 degrees of the dip direction of the slope face.

Toppling failures may develop when a rock mass contains multiple, parallel, steeply dipping continuous geologic structures, such as bedding surfaces or continuous joints/foliation planes, that strike nearly parallel to the strike of the face of the rock slope. Toppling failure will generally only develop when the strike of the structures is within ± 20 degrees of the azimuth of the slope face. Kinematically, the potential for toppling failure is determined by the spacing (separation), inclination, and continuity of the toppling blocks and the slope angle. Wide spacing and/or discontinuous structures will mitigate the potential for toppling while closely spaced continuous structures have the potential to develop into multi-bench, shallow-seated failures, which could result in overall wall failure.

1.1.2 Unbenched Footwall Failure Mechanisms

For the Grassy Mountain project, unbenched footwall slopes may be susceptible to the following slope instability mechanisms:

- planar or slab sliding failure;
- ploughing failure;
- bi-linear sliding failure; and
- buckling failure.

These instability mechanisms are shown schematically in Figures D-2 to D-4, and are discussed briefly in the following paragraphs.

Slab Failure

A planar or slab failure involves sliding along undercut bedding as shown in Figure D-2. The undercut bedding generally occurs as the result of stratigraphic pinch-outs or as the result of displacement along small normal faults. The dip of the footwall must exceed the friction angle of the bedding for sliding to occur.

Artificial support can be used to support undercut bedding where slope inclinations exceed bedding friction angles. However, this is typically only feasible in thickly bedded, good quality sandstone rocks.

Plough Failure

A plough failure involves sliding of the upper portion of the slope along bedding as shown in Figure D-2. The upper sliding block “rides” or “ploughs” under the lower block and causes an outward rotation of the lower block. The boundary between these blocks is normally a geologic structure that dips into the slope at an angle to the bedding, such as a stratigraphic pinch-out or thrust fault.

While thrust faults are common in the footwall slopes in the coal mines in the Elk Valley, ploughing failures are rare. Golder is aware of only two ploughing failures that have occurred on unbenched footwall slopes in the Elk Valley. In both cases, the ploughing failure occurred along a thrust fault that was exposed beneath the toe of a waste rock dump that was being advanced across the footwall slope. The waste dump provided additional driving force on the footwall that resulted in the upper portion of the footwall slope, where the dump was founded on, being driven below the lower portion of the footwall.

Footwall slopes are most susceptible to ploughing where the displacement across the thrust fault is small, and there is little to no mining step-out across the fault. Under this circumstance the lower portion of the footwall below the thrust fault is immediately in line with the upper slab, and there is no buttressing effect provided.

Bi-Linear Failure

A bi-linear failure involves sliding along bedding together with the development of an inclined failure surface at the toe of the slope, as shown in Figure D-3. The inclined failure surface may develop along a pre-existing geologic structure that dips out of the slope, such as a stratigraphic pinch-out or fault. Alternatively, in high and steep footwall slopes, the inclined failure surface may develop by shearing failure through intact rock, either by rock mass failure of thinly bedded strata or compressive strength failure of thickly bedded strata.

Bi-linear failures have not been observed at the mines in the Elk Valley, due to the following:

- higher unbenched footwall slopes excavated to date have exhibited dips of 35 degrees of less; and
- the height of the unbenched slope segments on the steeper footwall slopes been limited in order to specifically preclude the development of potential bi-linear failures.

Buckling Failure

Buckling failure involves the outward rotation of thinly bedded blocks in moderately to steeply dipping slopes under axial loading along the bedding, as shown in Figure D-4. The presence of an external disturbance such as high groundwater pressures and/or freeze-thaw action behind the blocks is required to initiate buckling.

Buckling instability is the most common form of footwall instability, and has been observed on most of the footwall slopes in the Elk Valley. It typically occurs where the footwall rocks consist of thinly bedded mudstones, or where a carbonaceous mudstone layer exists within a metre or two of the footwall. Buckling has not been observed in footwall slopes that have been excavated along the thickly bedded and competent Moose Mountain sandstone.

Buckling instability is very susceptible to groundwater pressures that develop behind the thin beds and to freeze-thaw action. Horizontal drain holes or vertical blast holes drilled into the footwalls have been successful in minimizing buckling instability in footwalls slopes. It is recommended that, at the least, shallow footwall depressurization be used on all footwall slopes that exhibit dips in excess of 25 degrees in order to minimize the potential for developing buckling failures. The exception to this is footwall slopes that are excavated along the Moose Mountain sandstone.

All structurally controlled failure modes are aggravated by water pressure within the slope, particularly toppling failures.

The magnitude and frequency of structurally controlled failures are directly related to the continuity and spacing of the structures along which sliding can occur. Rock mass structures that exhibit limited continuity, such as joints, may result in bench-scale failures that are rarely of consequence to overall slope stability, but may adversely affect access ramps or equipment installations. Conversely, larger-scale failures can occur along continuous, through-going structures, such as bedding and thrust faults. It is, therefore, these more continuous structures that are of primary concern.

1.2 Overall Rock Mass Strength Failure

In competent rock, stability is normally a function of structurally controlled failures (as previously described). However, failure through the rock mass must also be considered in very high rock slopes or in weak or heavily fractured rock masses. This overall rock mass instability mechanism is shown schematically in Figure D-5.

Rock mass failure involves the development of a failure surface that is governed by the orientation of the maximum shear stress rather than structural fabric within the rock. The failure surface can generally be of a circular nature and, in rocks with preferentially oriented structures (i.e., bedding or foliation); the failure surface may form linear segments along these potential planes of weakness.

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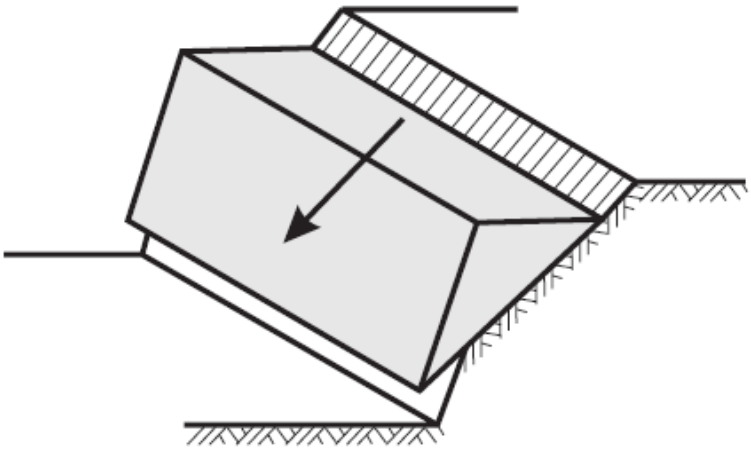
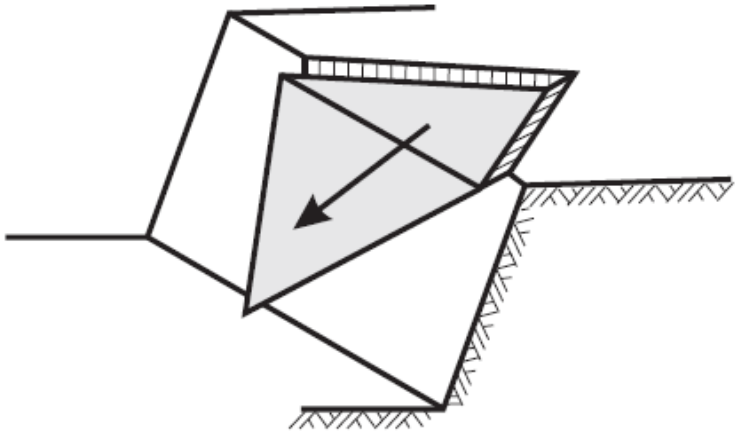
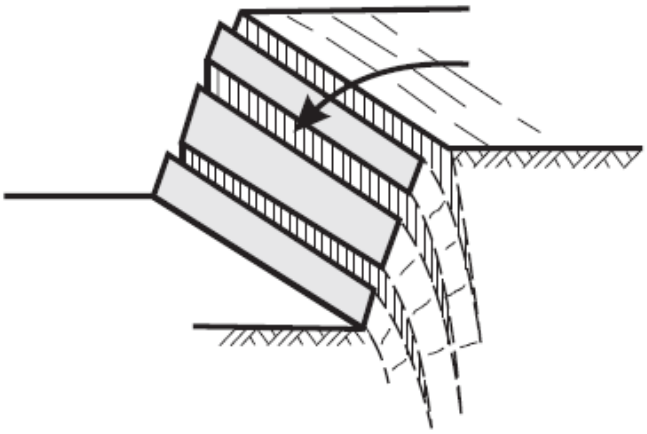


A. PLANE FAILURE ON THROUGH GOING DISCONTINUITIES



B. WEDGE FAILURE ALONG LINE OF INTERSECTION OF DISCONTINUITIES



B. TOPPLING FAILURE IN HARD ROCK WITH STEEPLY DIPPING JOINTS

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TITLE
STRUCTURALLY CONTROLLED INSTABILITY MECHANISMS IN BENCHED ROCK SLOPES

PROJECT No. **2850-MN-0001-0** | Rev. **0** | FIGURE **H-1**

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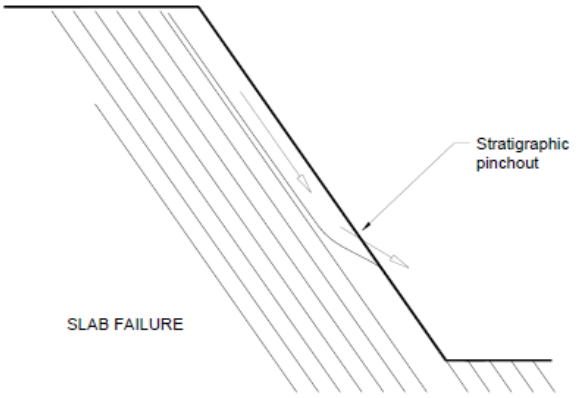
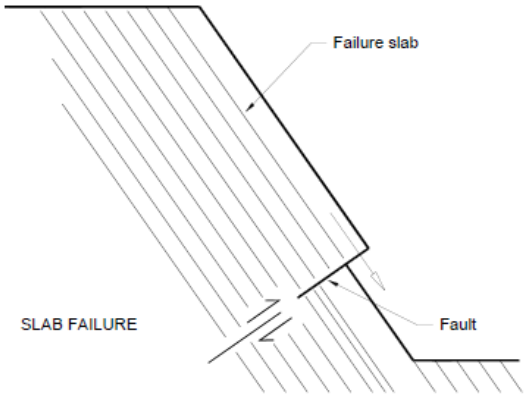
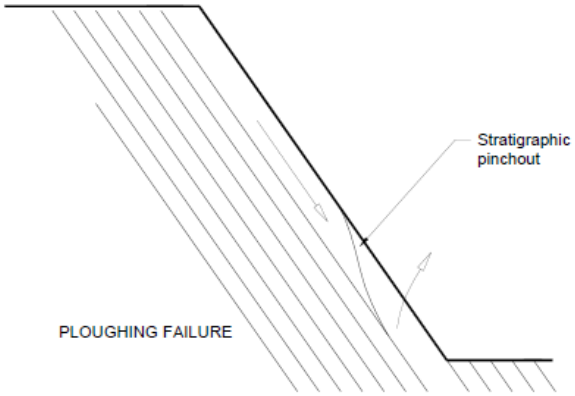
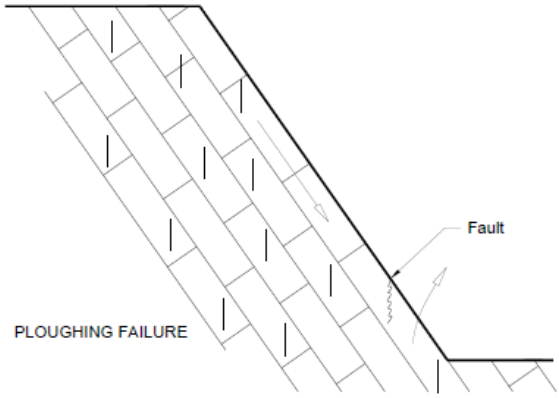
FAILURE BY STRATIGRAPHIC PINCHOUT



FAILURE BY FAULT OFFSET







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POTENTIAL FOOTWALL SLOPE FAILURE MECHANISMS

PROJECT No. **2850-MN-0001-0** | Rev. **0** | FIGURE **H-2**

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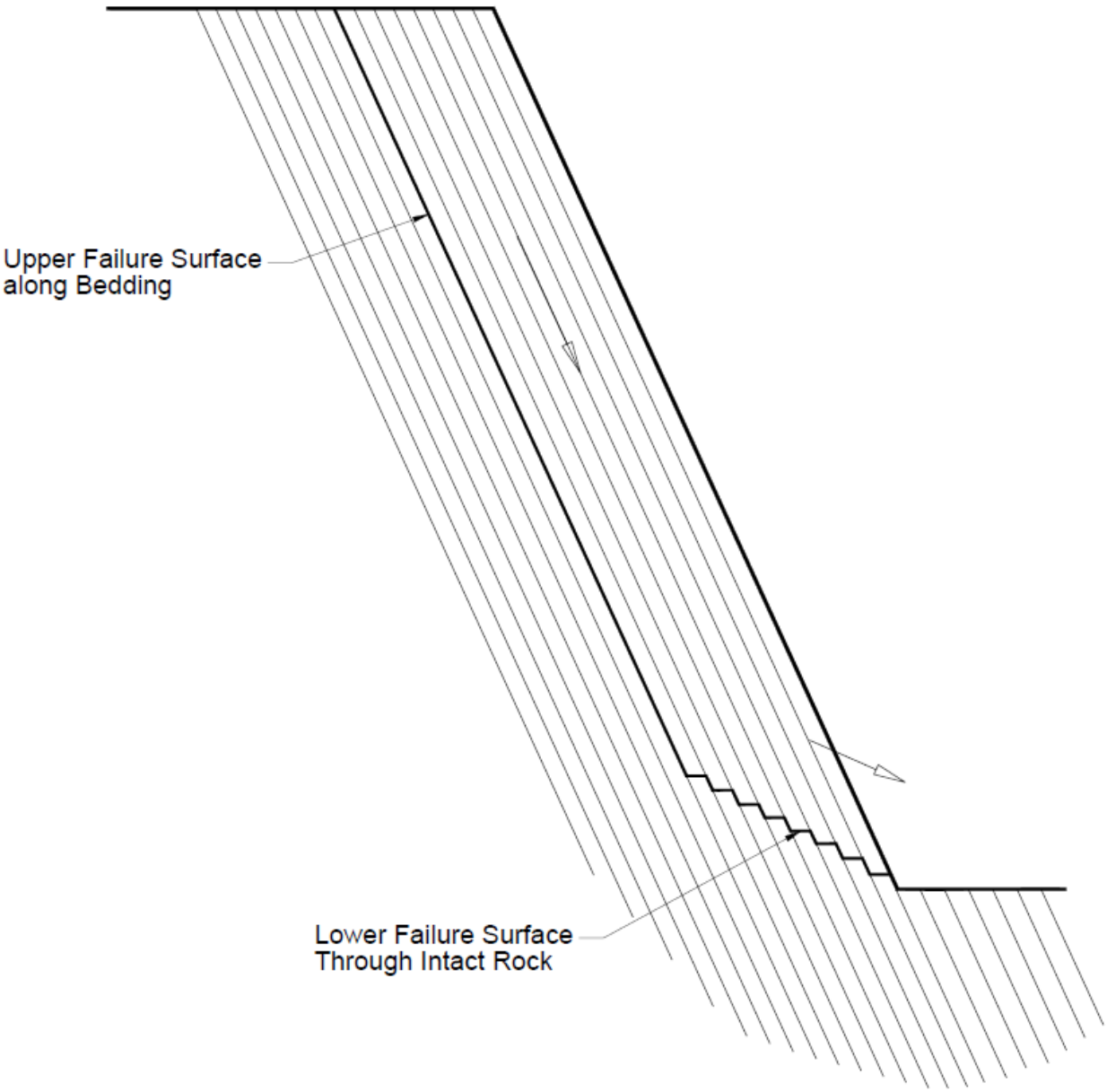

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TITLE
STRUCTURALLY CONTROLLED INSTABILITY IN UNBENCHED ROCK SLOPES – BI-LINEAR FAILURE MECHANISMS

PROJECT No. **2850-MN-0001-0** | Rev. **0** | FIGURE **H-3**

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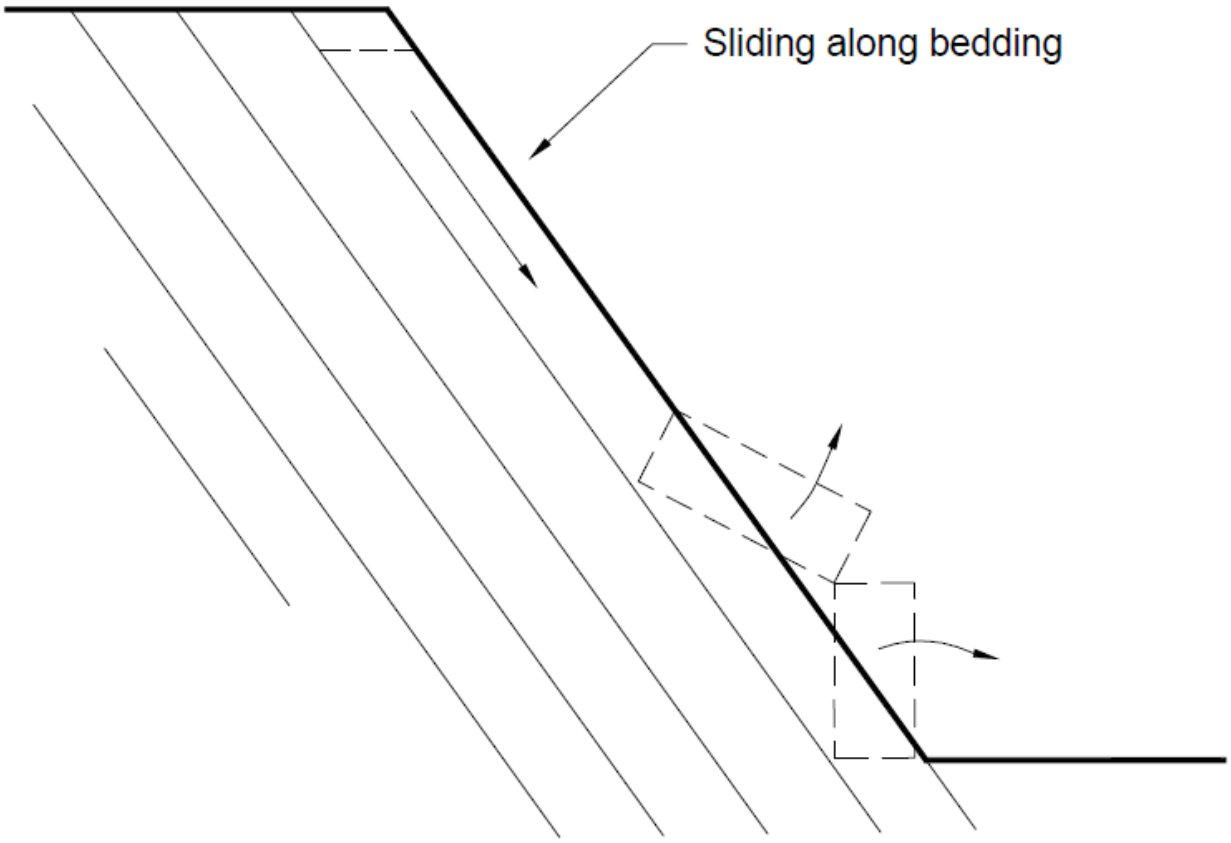

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TITLE
STRUCTURALLY CONTROLLED INSTABILITY IN UNBENCHED ROCK SLOPES – BUCKLING FAILURE MECHANISMS

PROJECT No. **2850-MN-0001-0** | Rev. **0** | FIGURE **H-4**

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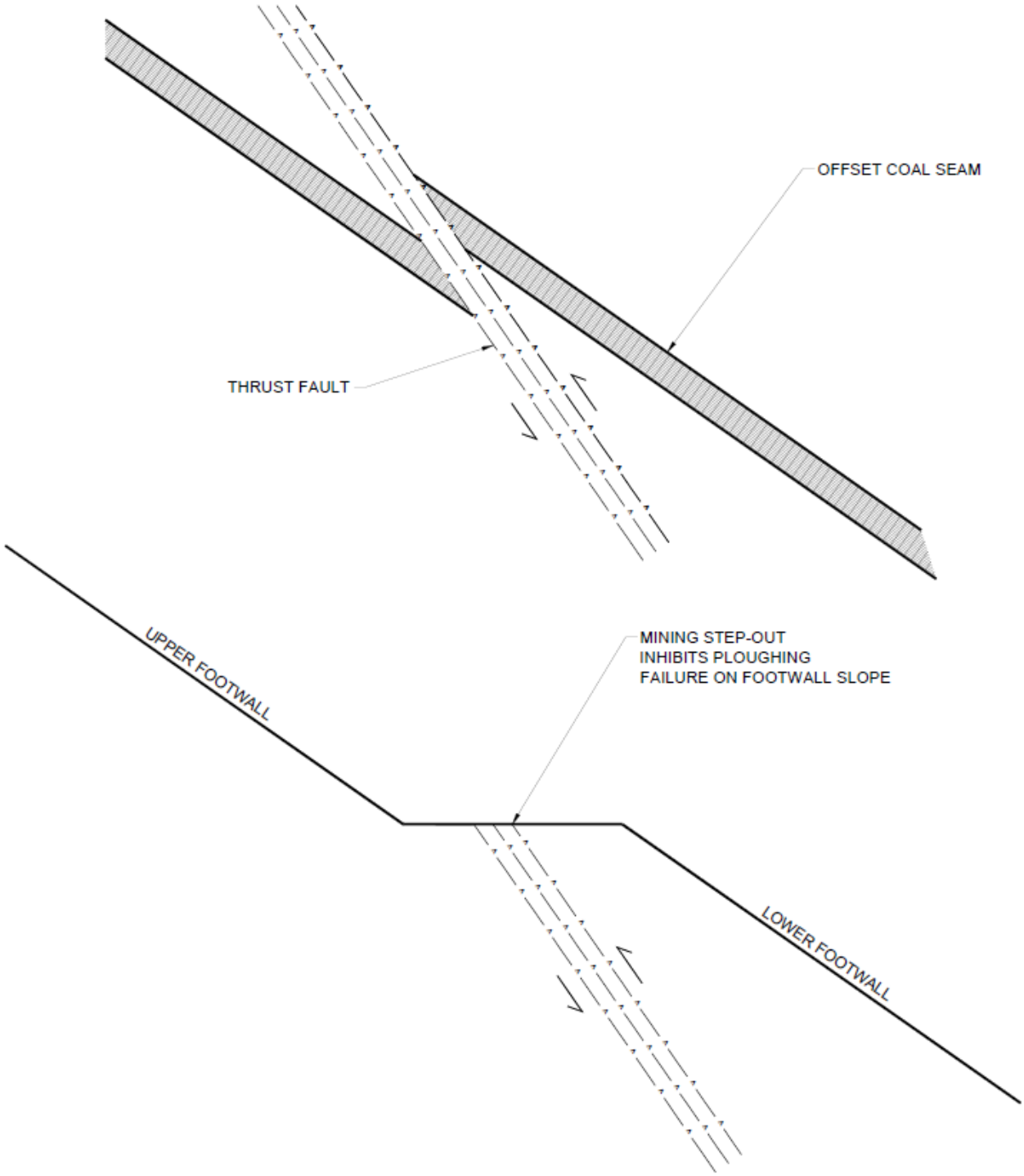

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TITLE
STRUCTURALLY CONTROLLED INSTABILITY – STEP-OUT ACROSS FOOTWALL SLOPES

PROJECT No. **2850-MN-0001-0** | Rev. **0** | FIGURE **H-5**

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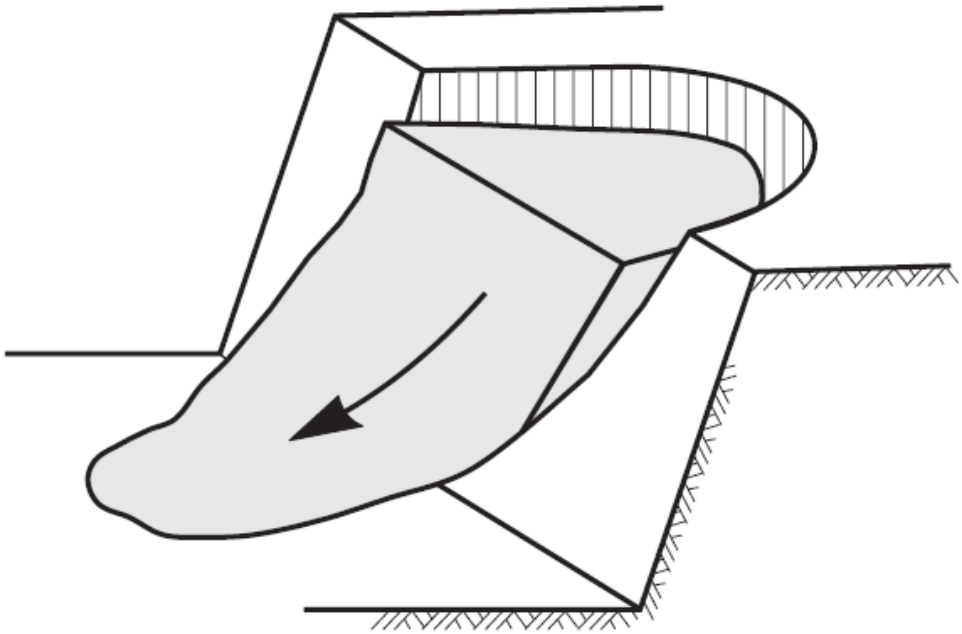

QUASI-CIRCULAR FAILURE IN WEAK OR HEAVILY FRACTURED ROCK

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TITLE
OVERALL ROCK MASS STRENGTH FAILURE MECHANISM

PROJECT No. **2850-MN-0001-0** | Rev. **0** | FIGURE **H-6**

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APPENDIX I

Pit Slope Stability Assessment

1.0 GENERIC BENCH DESIGN CRITERIA

Based on the anticipated Grassy Mountain structural geology and rock mass conditions (i.e., competency), generic bench design criteria have been developed for the highwalls and footwalls slopes. The highwall design criteria can also be applied to the design of endwall slopes. The proposed bench design criteria are predicated on the rock mass quality, bedding dip angle and the influence that the cross joints are expected to have on the bench stability. The generic bench design criteria for both 12 metre and 15 metre bench heights are presented in Tables I-1 to I-8.

The factors that are expected to control the bench scale stability of the Grassy Mountain pit walls are discussed in Section 7.0 of the main report text.

1.1 Highwall and Endwall

Bench design criteria for highwalls and endwalls where bedding dips into the slope is provided in Table I-1 to I-4.

1.1.1 Highwall – 12 Metre Bench Heights

Highwall bench design criteria for 12 metre bench heights are summarized in Table I-1 and I-2.

Table I-1: Highwall Design Criteria for Less Competent Rock (Mudstone, Shale, Coal) – 12 metre Bench Height

Bedding Dip (°)	Bench Height (m)	Bench Face Angle (°)	Bench Width (m)	Double (D) / Single (S) Bench	Inter-ramp Angle (°)	Stability Comments
5	24	70	10	D	52.0	Cross joints are steeply dipping, bench face expected to back break to joints
10	24	70	10	D	52.0	
15	24	70	10	D	52.0	
20	24	70	10	D	52.0	
25	24	65	10	D	48.6	Cross joints exhibit moderate dip, expect ravelling
30	24	65	10	D	48.6	
35	24	65	10	D	48.6	
40	12	60	8	S	38.8	Cross Joint shallower than bench face angle, expect ravelling
45	12	60	8	S	38.8	
50	12	60	8	S	38.8	
55	12	60	8	S	38.8	
60	12	60	8	S	38.8	Single benched to minimize topping along steeply dipping bedding
65	12	60	8	S	38.8	
70	12	60	8	S	38.8	
75	12	60	8	S	38.8	
80	12	60	9.5	S	36.1	
85	12	60	9.5	S	36.1	
90	12	60	9.5	S	36.1	

Table I-2: Highwall Design Criteria for More Competent Rock (Sandstone, Siltstone, Conglomerate) – 12 Metre Bench Height

Bedding Dip (°)	Bench Height (m)	Bench Face Angle (°)	Bench Width (m)	Double (D) / Single (S) Bench	Inter-ramp Angle (°)	Stability Comments
5	24	70	10	D	52.0	Cross joints are steeply dipping, bench face expected to back break to joints
10	24	70	10	D	52.0	
15	24	70	10	D	52.0	
20	24	70	10	D	52.0	
25	24	70	10	D	52.0	
30	24	65	8	D	51.4	Cross joints exhibit moderate dip, expect ravelling
35	24	65	8	D	51.4	
40	24	60	8	D	47.7	
45	12	60	8	S	38.8	Cross Joint shallower than bench face angle, expect ravelling
50	12	60	8	S	38.8	
55	12	60	8	S	38.8	
60	12	60	8	S	38.8	Single benched to minimize topping along steeply dipping bedding
65	12	60	8	S	38.8	
70	12	60	8	S	38.8	
75	12	60	8	S	38.8	
80	12	60	9.5	S	36.1	
85	12	60	9.5	S	36.1	
90	12	60	9.5	S	36.1	

1.1.2 Highwall – 15 m Bench Heights

Highwall bench design criteria for 15 metre bench heights are summarized in Table I-3 and I-4.

Table I-3: Highwall Design Criteria for Less Competent Rock (Mudstone, Shale, Coal) – 15 Metre High Bench

Bedding Dip (°)	Bench Height (m)	Bench Face Angle (°)	Bench Width (m)	Double (D) / Single (S) Bench	Inter-ramp Angle (°)	Stability Comments
5	30	70	12	D	52.6	Cross joints are steeply dipping, bench face expected to back break to joints
10	30	70	12	D	52.6	
15	30	70	12	D	52.6	
20	30	70	12	D	52.6	
25	30	65	10	D	51.4	Cross joints exhibit moderate dip, expect ravelling
30	30	65	10	D	51.4	
35	30	65	10	D	51.4	
40	15	60	10	S	38.8	Cross Joint shallower than bench face angle, expect ravelling
45	15	60	10	S	38.8	
50	15	60	10	S	38.8	
55	15	60	10	S	38.8	
60	15	60	8	S	42.0	Single benched to minimize topping along steeply dipping bedding
65	15	60	8	S	42.0	
70	15	60	8	S	42.0	
75	15	60	8	S	42.0	
80	15	60	11	S	37.3	
85	15	60	11	S	37.3	
90	15	60	11	S	37.3	

Table I-4: Highwall Design Criteria for More Competent Rock (Sandstone, Siltstone, Conglomerate) – 15 Metre High Bench

Bedding Dip (°)	Bench Height (m)	Bench Face Angle (°)	Bench Width (m)	Double (D) Single (S) bench	Inter-ramp Angle (°)	Stability Comments
5	30	70	12	D	52.6	Cross joints are steeply dipping, bench face expected to back break to joints
10	30	70	12	D	52.6	
15	30	70	12	D	52.6	
20	30	70	12	D	52.6	
25	30	70	12	D	52.6	
30	30	65	10	D	51.4	Cross joints exhibit moderate dip, expect ravelling
35	30	65	10	D	51.4	
40	30	60	10	D	47.7	
45	15	60	8	S	42.0	Cross Joint shallower than bench face angle, expect ravelling
50	15	60	8	S	42.0	
55	15	60	8	S	42.0	
60	15	60	8	S	42.0	Single benched to minimize topping along steeply dipping bedding
65	15	60	8	S	42.0	
70	15	60	8	S	42.0	
75	15	60	8	S	42.0	
80	15	60	11	S	37.3	
85	15	60	11	S	37.3	
90	15	60	11	S	37.3	

1.2 Footwall

Bench design criteria for highwalls where *bedding dips out of* the *slope* is provided in Table I-5 to I-8.

1.2.1 Footwall – 12 m Bench Heights

Footwall bench design criteria for 12 metre bench heights are summarized in Table I-5 and I-6.

Table I-5: Footwall Design Criteria for Less Competent Rock (Mudstone, Shale, Coal) – 12 Metre High Bench

Bedding Dip (°)	Bench Height (m)	Bench Face Angle (°)	Bench Width (m)	Inter-ramp Angle (°)	Stability Comments
5	Benching not required. Footwall slope to follow bedding.				Benching not required. Footwall slope to follow bedding.
10					
15					
20					
25					
30					
35					
40	24	40	8	33.3	Multiple Benching permitted provided that bedding is not undercut
45	24	45	8	36.9	
50	24	50	8	40.5	
55	24	55	8	44.1	
60	24	60	8	47.7	
65	24	65	12	46.0	Multiple Benching permitted provided that bedding is not undercut
70	24	70	12	49.2	
75	24	70	12	49.2	
80	12	70	8	44.1	Single benched configuration to minimize topping failure mechanisms along steeply dipping bedding
85	12	70	8	44.1	
90	12	70	8	44.1	

Table I-6: Footwall Design Criteria for More Competent Rock (Sandstone, Siltstone, Conglomerate) – 12 Metre High Bench

Bedding Dip (°)	Bench Height (m)	Bench Face Angle (°)	Bench Width (m)	Inter-ramp Angle (°)	Stability Comments
5	Benching not required. Footwall slope to follow bedding.				Benching not required. Footwall slope to follow bedding.
10					
15					
20					
25					
30					
35					
40	36	40	8	35.3	Multiple Benching permitted provided that bedding is not undercut
45	36	45	8	39.3	
50	36	50	8	43.3	
55	36	55	8	47.3	
60	24	60	10	45.2	Multiple Benching permitted provided that bedding is not undercut
65	24	65	10	48.6	
70	24	70	12	49.2	
75	24	70	12	49.2	
80	12	70	8	44.1	Single benched configuration to minimize topping failure mechanisms along steeply dipping bedding
85	12	70	8	44.1	
90	12	70	8	44.1	

1.2.2 Footwall – 15 m Bench Heights

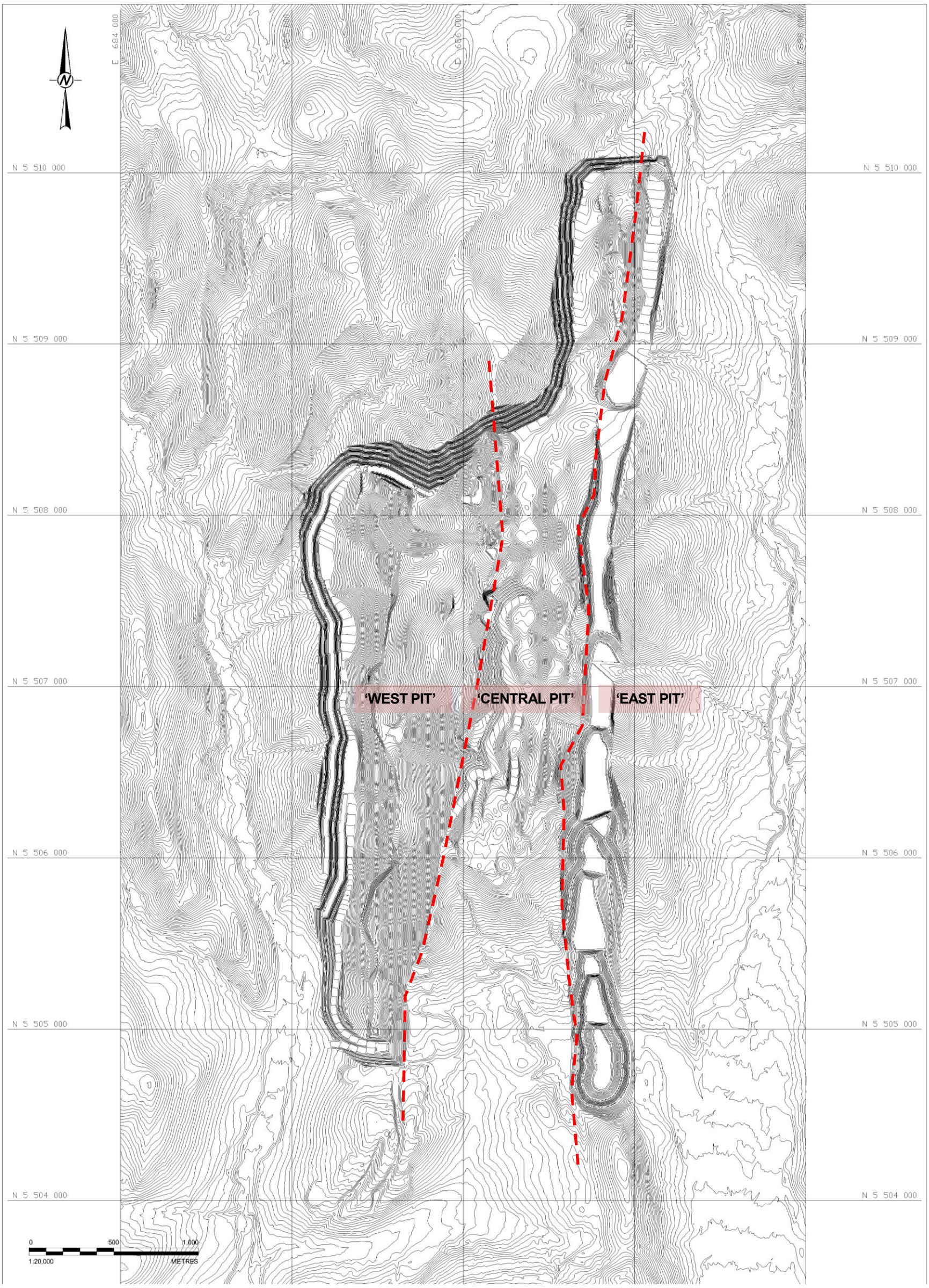
Footwall bench design criteria for 15 metre bench heights are summarized in Table I-7 and I-8.

Table I-7: Footwall Design Criteria for Less Competent Rock (Mudstone, Shale, Coal) – 15 Metre High Bench

Bedding Dip (°)	Bench Height (m)	Bench Face Angle (°)	Bench Width (m)	Inter-ramp Angle (°)	Stability Comments
5	Benching not required. Footwall slope to follow bedding.				Benching not required. Footwall slope to follow bedding.
10					
15					
20					
25					
30					
35					
40	30	40	8	34.4	Multiple Benching permitted provided that bedding is not undercut
45	30	45	8	38.3	
50	30	50	8	42.1	
55	30	55	8	46.0	
60	30	60	8	49.8	
65	30	65	12	49.1	Multiple Benching permitted provided that bedding is not undercut
70	30	70	12	52.6	
75	30	70	12	52.6	
80	15	70	8	48.1	Single benched configuration to minimize topping failure mechanisms along steeply dipping bedding
85	15	70	8	48.1	
90	15	70	8	48.1	

Table I-8: Footwall Design Criteria for More Competent Rock (Sandstone, Siltstone, Conglomerate) – 15 Metre High bench

Bedding Dip (°)	Bench Height (m)	Bench Face Angle (°)	Bench Width (m)	Inter-ramp Angle (°)	Stability Comments
5	Benching not required. Footwall slope to follow bedding.				Benching not required. Footwall slope to follow bedding.
10					
15					
20					
25					
30					
35					
40	45	40	8	36.1	Multiple Benching permitted provided that bedding is not undercut
45	45	45	8	40.3	
50	45	50	8	44.5	
55	45	55	8	48.7	
60	30	60	10	47.7	Multiple Benching permitted provided that bedding is not undercut
65	30	65	10	51.4	
70	30	70	12	52.6	
75	30	70	12	52.6	
80	15	70	8	48.1	Single benched configuration to minimize topping failure mechanisms along steeply dipping bedding
85	15	70	8	48.1	
90	15	70	8	48.1	



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PROJECT
GRASSY MOUNTAIN PRELIMINARY PIT SLOPE STABILITY ASSESSMENT

TITLE
INDICATIVE PIT NAMES

PROJECT No.	Rev.	FIGURE
2850-MN-0001-0	**0**	**I-1**

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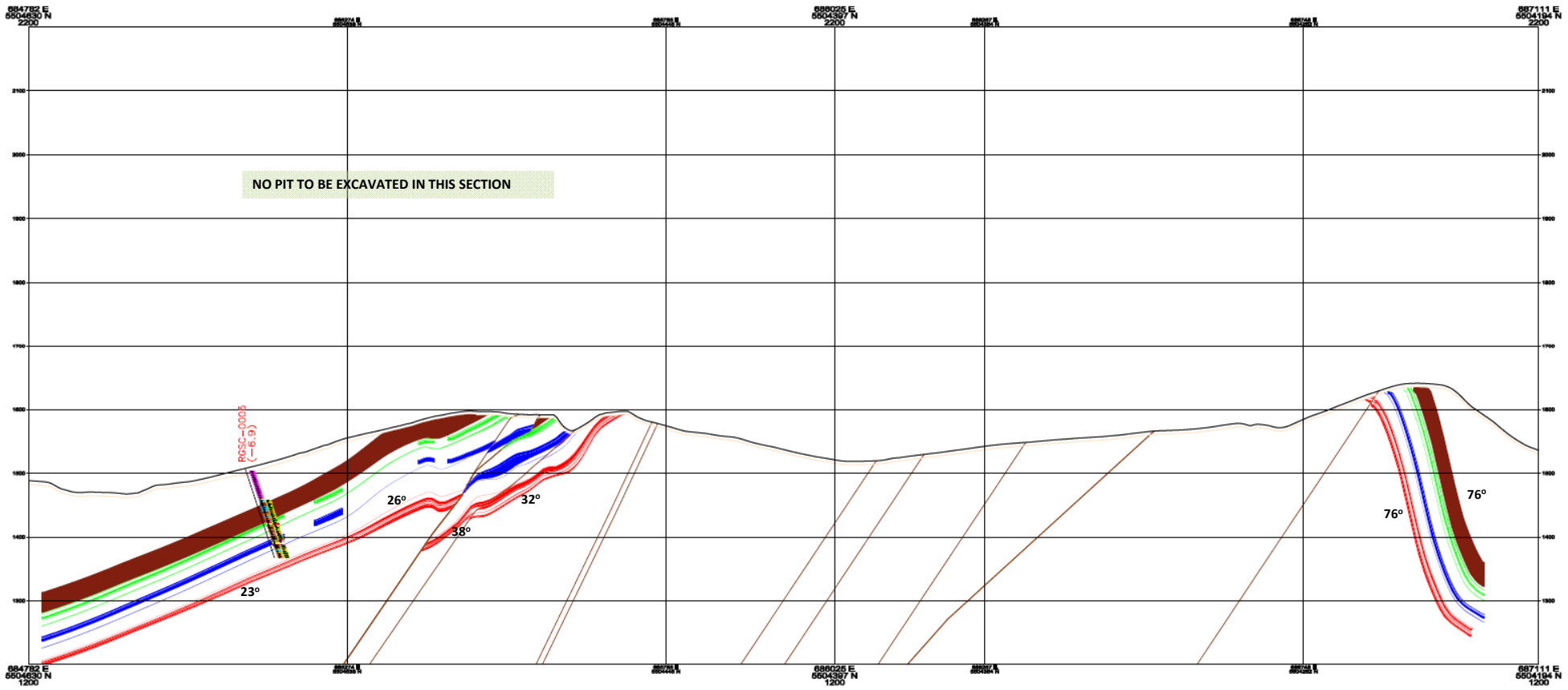

NOTE: PIT SHELL SHOWN IS INDICATIVE AND NOT REPRESENTATIVE OF FEASIBILITY LEVEL PIT DESIGN

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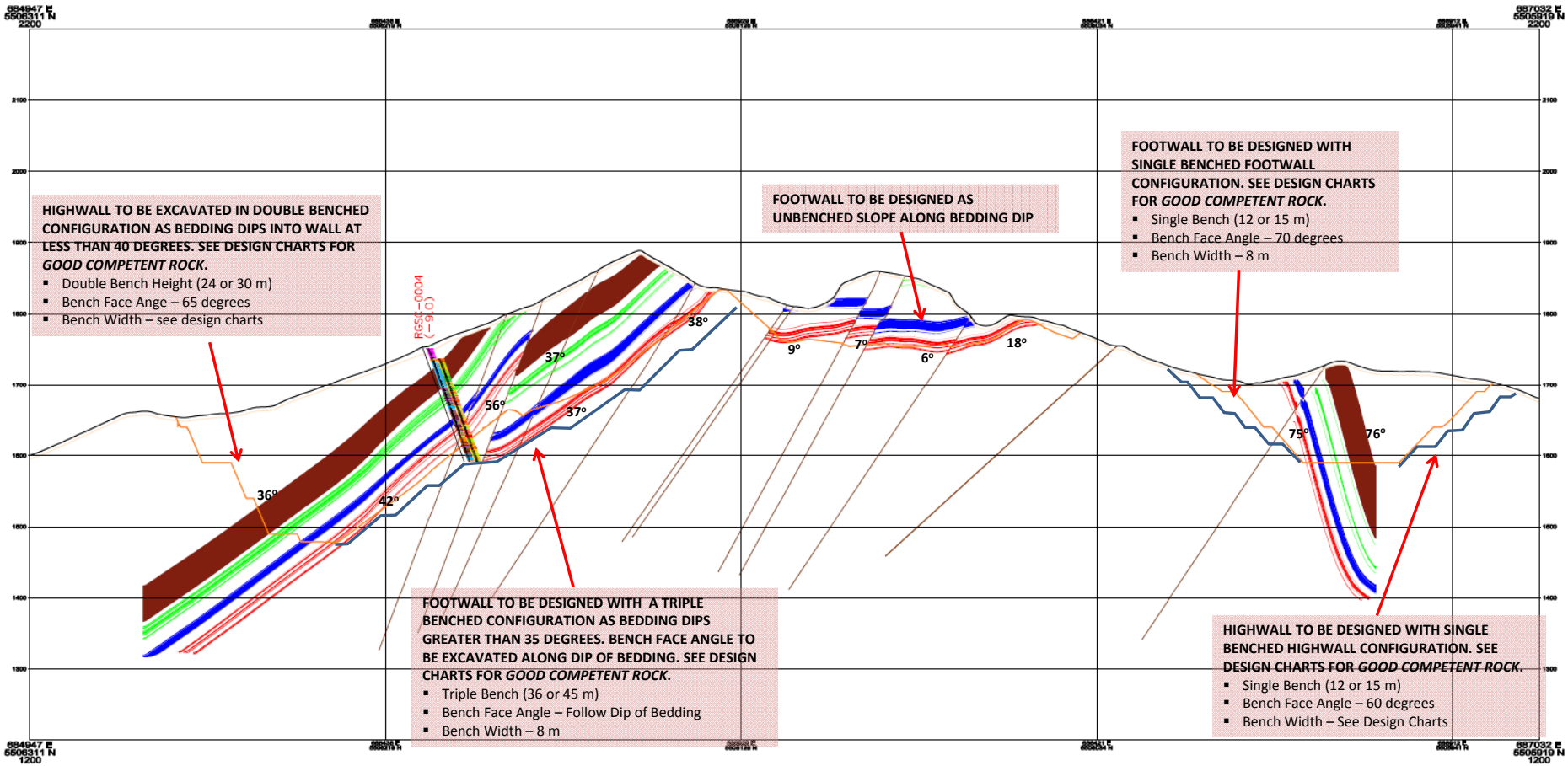
PROJECT
GRASSY MOUNTAIN PRELIMINARY PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 1 GEOLOGICAL SECTION – PIT SLOPE RECOMMENDATIONS

PROJECT No.	Rev.	FIGURE
2850-MN-0001-0	**0**	**I-2**



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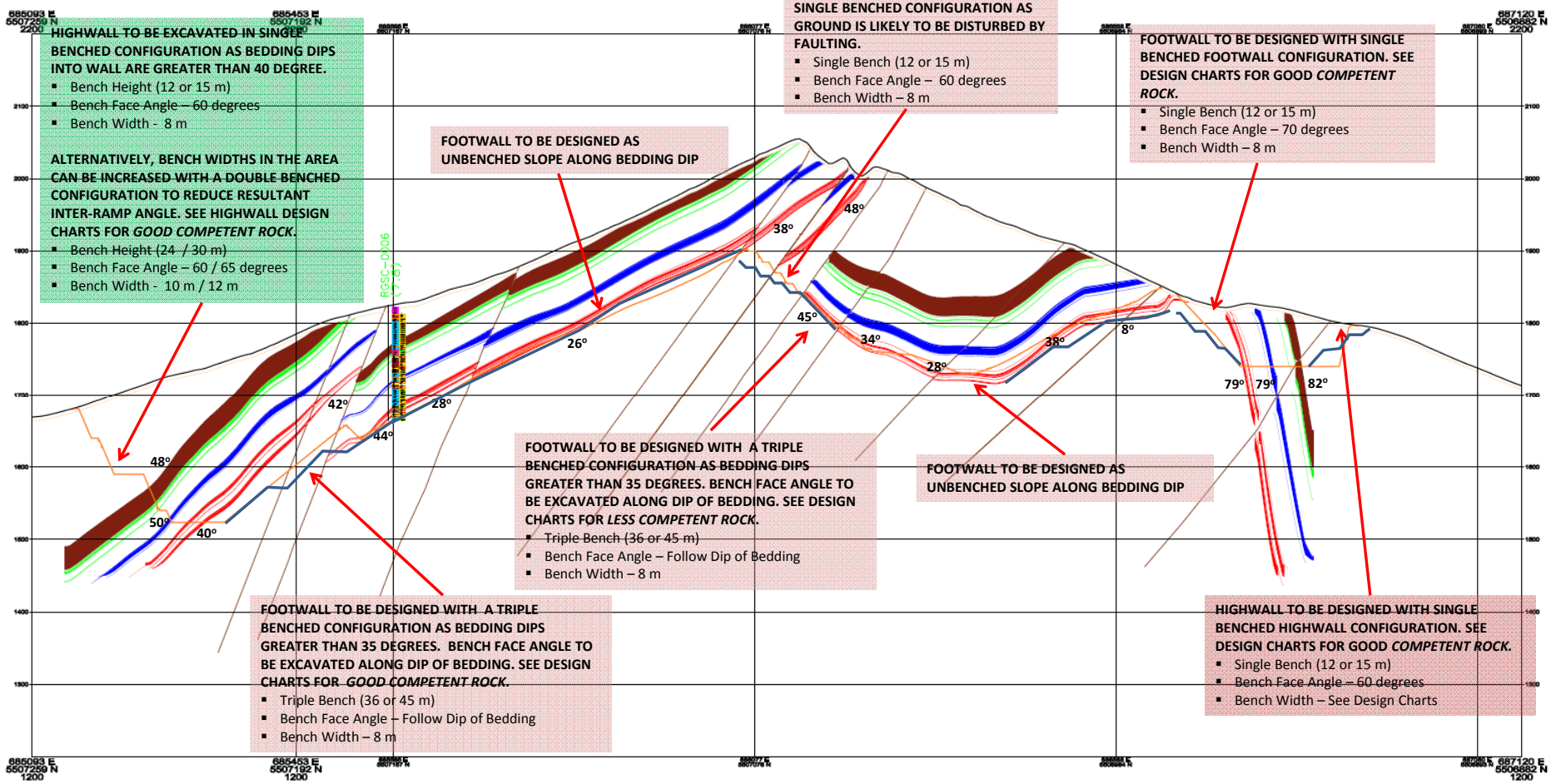
PROJECT
GRASSY MOUNTAIN PRELIMINARY PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 2 GEOLOGICAL SECTION – PIT SLOPE RECOMMENDATIONS

PROJECT No.	Rev.	FIGURE
2850-MN-0001-0	0	I-3



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PROJECT
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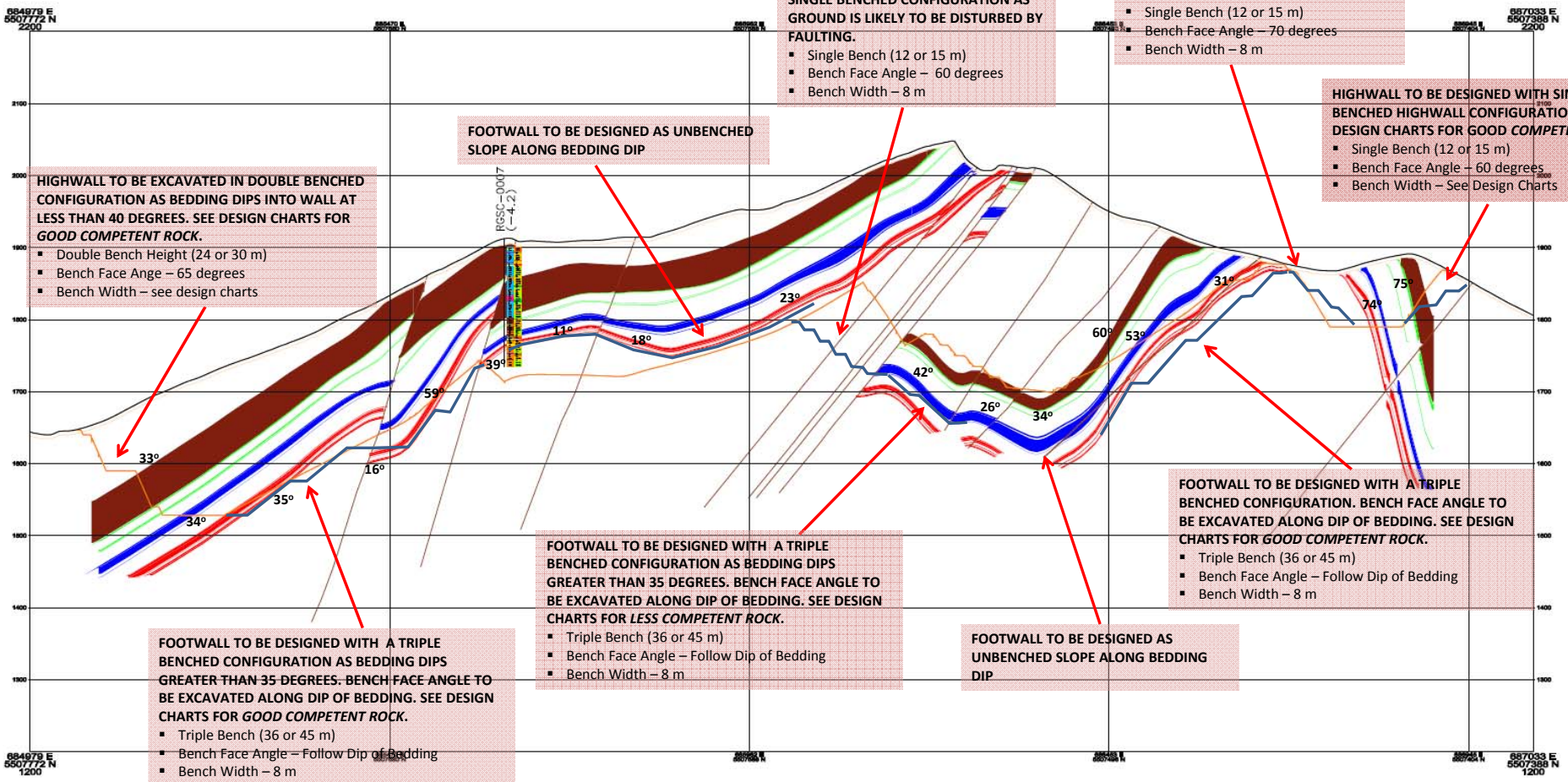
TITLE
SECTION 3 GEOLOGICAL SECTION – PIT SLOPE RECOMMENDATIONS

PROJECT No.	Rev.	FIGURE
2850-MN-0001-0	0	I-4



HIGHWALL TO BE EXCAVATED IN DOUBLE BENCHED CONFIGURATION AS BEDDING DIPS INTO WALL AT LESS THAN 40 DEGREES. SEE DESIGN CHARTS FOR *GOOD COMPETENT ROCK*.

- Double Bench Height (24 or 30 m)
- Bench Face Ange – 65 degrees
- Bench Width – see design charts

FOOTWALL TO BE DESIGNED AS UNBENCHED SLOPE ALONG BEDDING DIP

HIGHWALL TO BE DESIGNED WITH A SINGLE BENCHED CONFIGURATION AS GROUND IS LIKELY TO BE DISTURBED BY FAULTING.

- Single Bench (12 or 15 m)
- Bench Face Angle – 60 degrees
- Bench Width – 8 m

FOOTWALL TO BE DESIGNED WITH SINGLE BENCHED FOOTWALL CONFIGURATION. SEE DESIGN CHARTS FOR GOOD *COMPETENT ROCK*.

- Single Bench (12 or 15 m)
- Bench Face Angle – 70 degrees
- Bench Width – 8 m

HIGHWALL TO BE DESIGNED WITH SINGLE BENCHED HIGHWALL CONFIGURATION. SEE DESIGN CHARTS FOR GOOD *COMPETENT ROCK*.

- Single Bench (12 or 15 m)
- Bench Face Angle – 60 degrees
- Bench Width – See Design Charts

FOOTWALL TO BE DESIGNED WITH A TRIPLE BENCHED CONFIGURATION AS BEDDING DIPS GREATER THAN 35 DEGREES. BENCH FACE ANGLE TO BE EXCAVATED ALONG DIP OF BEDDING. SEE DESIGN CHARTS FOR *GOOD COMPETENT ROCK*.

- Triple Bench (36 or 45 m)
- Bench Face Angle – Follow Dip of Bedding
- Bench Width – 8 m

FOOTWALL TO BE DESIGNED WITH A TRIPLE BENCHED CONFIGURATION AS BEDDING DIPS GREATER THAN 35 DEGREES. BENCH FACE ANGLE TO BE EXCAVATED ALONG DIP OF BEDDING. SEE DESIGN CHARTS FOR *LESS COMPETENT ROCK*.

- Triple Bench (36 or 45 m)
- Bench Face Angle – Follow Dip of Bedding
- Bench Width – 8 m

FOOTWALL TO BE DESIGNED AS UNBENCHED SLOPE ALONG BEDDING DIP

FOOTWALL TO BE DESIGNED WITH A TRIPLE BENCHED CONFIGURATION. BENCH FACE ANGLE TO BE EXCAVATED ALONG DIP OF BEDDING. SEE DESIGN CHARTS FOR *GOOD COMPETENT ROCK*.

- Triple Bench (36 or 45 m)
- Bench Face Angle – Follow Dip of Bedding
- Bench Width – 8 m

NOTE: PIT SHELL SHOWN IS INDICATIVE AND NOT REPRESENTATIVE OF FEASIBILITY LEVEL PIT DESIGN

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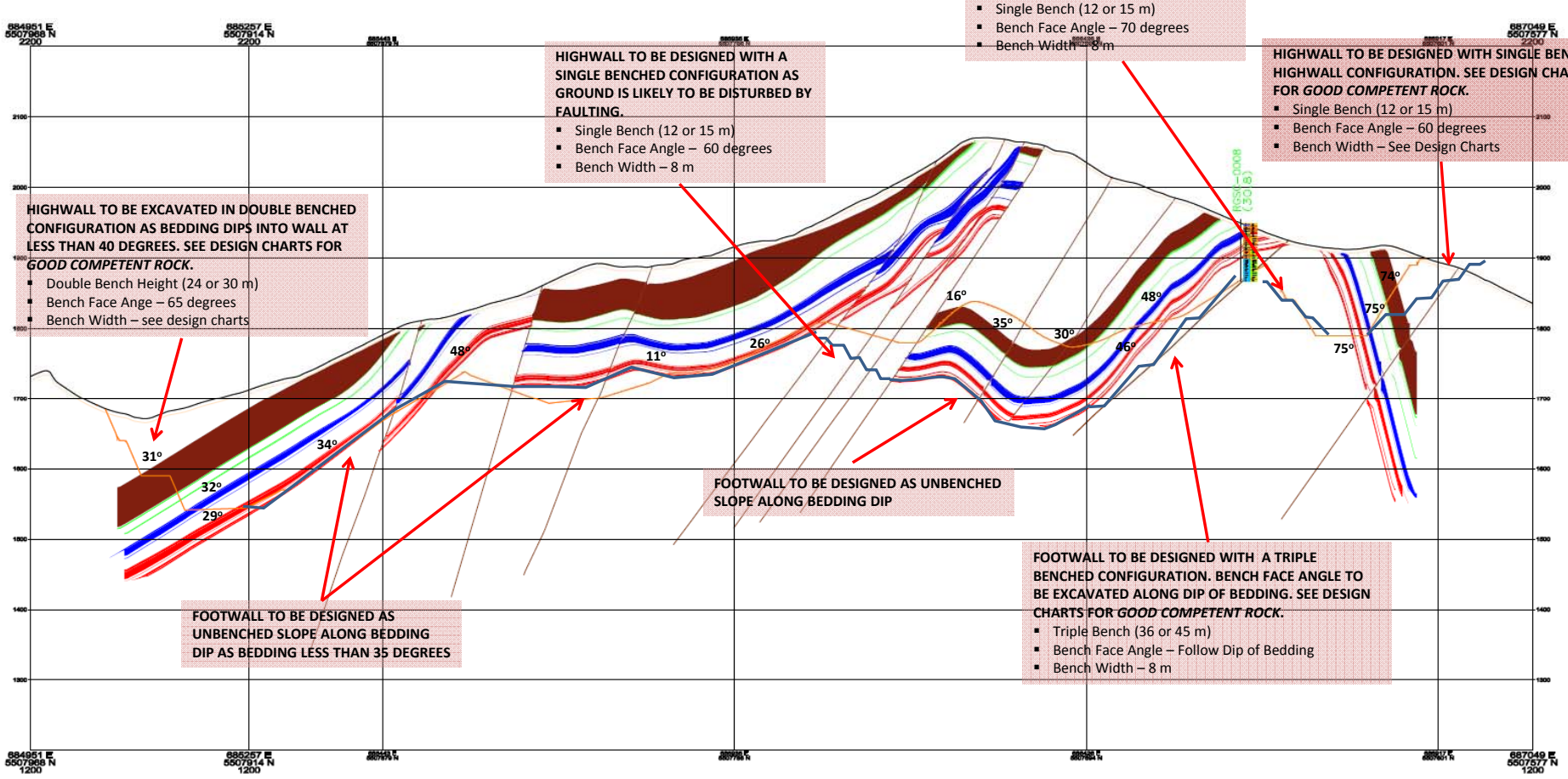
PROJECT
GRASSY MOUNTAIN PRELIMINARY PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 4 GEOLOGICAL SECTION – PIT SLOPE RECOMMENDATIONS

PROJECT No.	Rev.	FIGURE
2850-MN-0001-0	**0**	**I-5**



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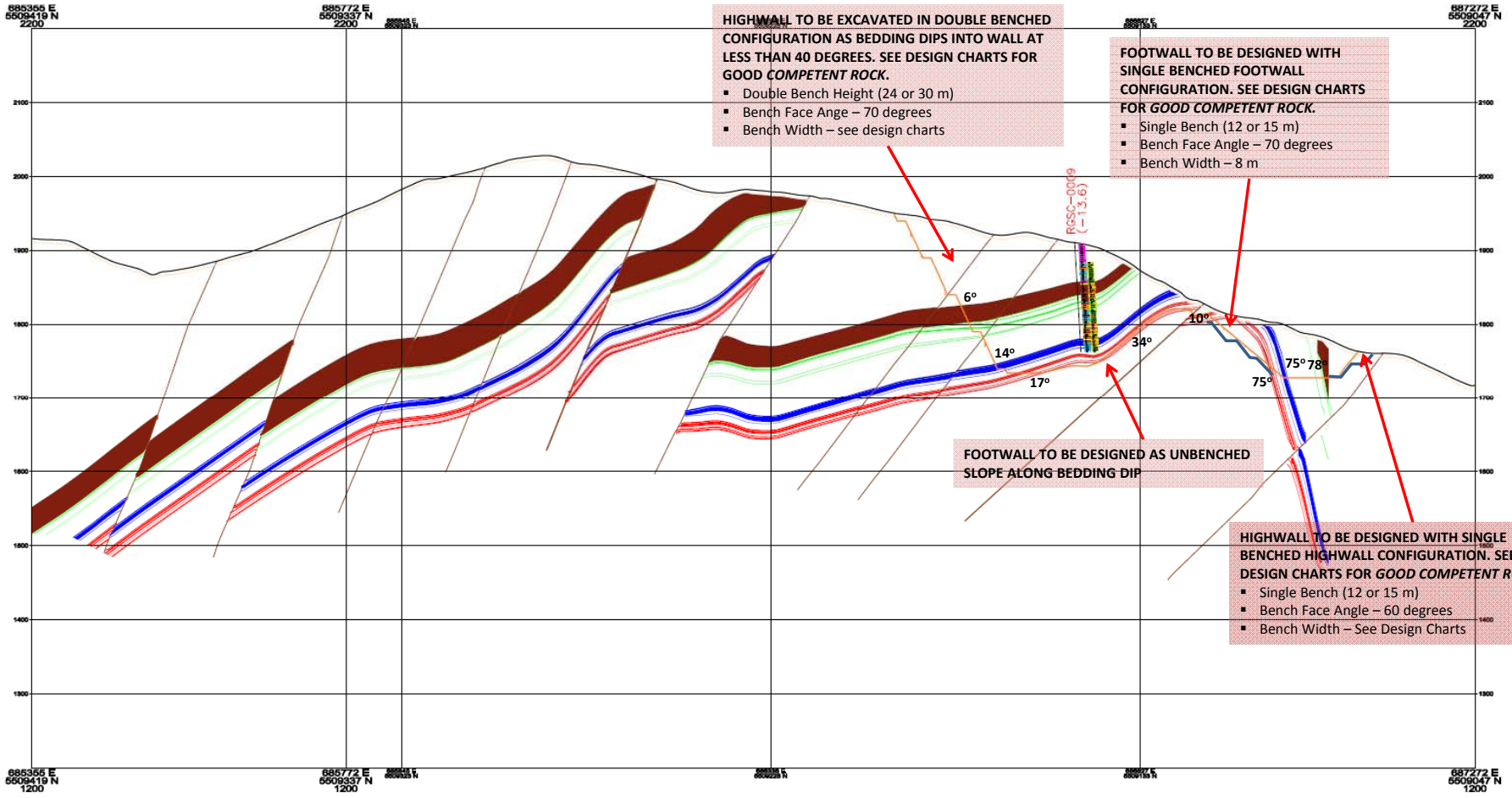
PROJECT
GRASSY MOUNTAIN PRELIMINARY PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 5 GEOLOGICAL SECTION – PIT SLOPE RECOMMENDATIONS

PROJECT No.	Rev.	FIGURE
2850-MN-0001-0	**0**	**I-6**



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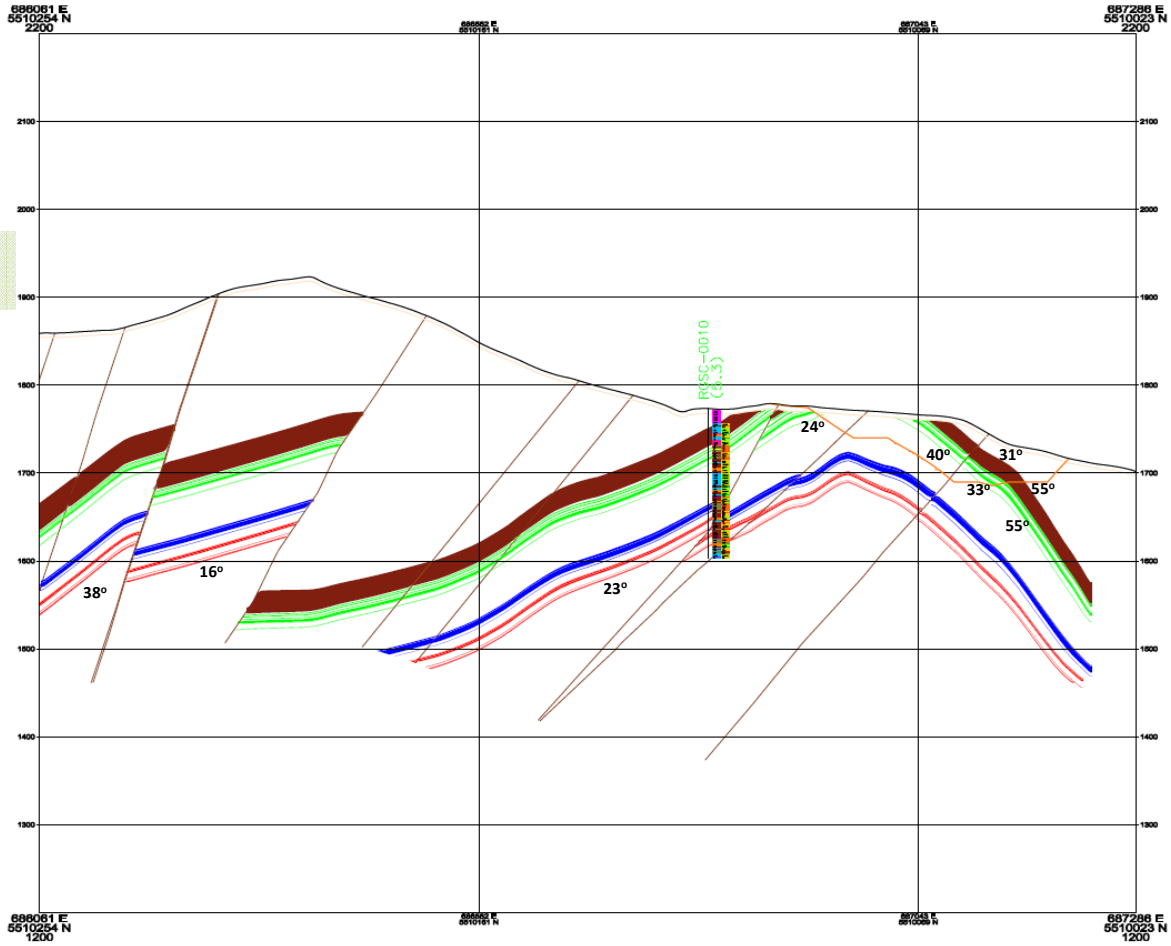
PROJECT
GRASSY MOUNTAIN PRELIMINARY PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 6 GEOLOGICAL SECTION – PIT SLOPE RECOMMENDATIONS

PROJECT No.	Rev.	FIGURE
2850-MN-0001-0	**0**	**I-7**

SECTION CUT OBLIQUE TO PIT WALLS, NOT REPRESENTATIVE. SEE NEXT SECTION TO THE SOUTH (BOREHOLE RSGC-0009)



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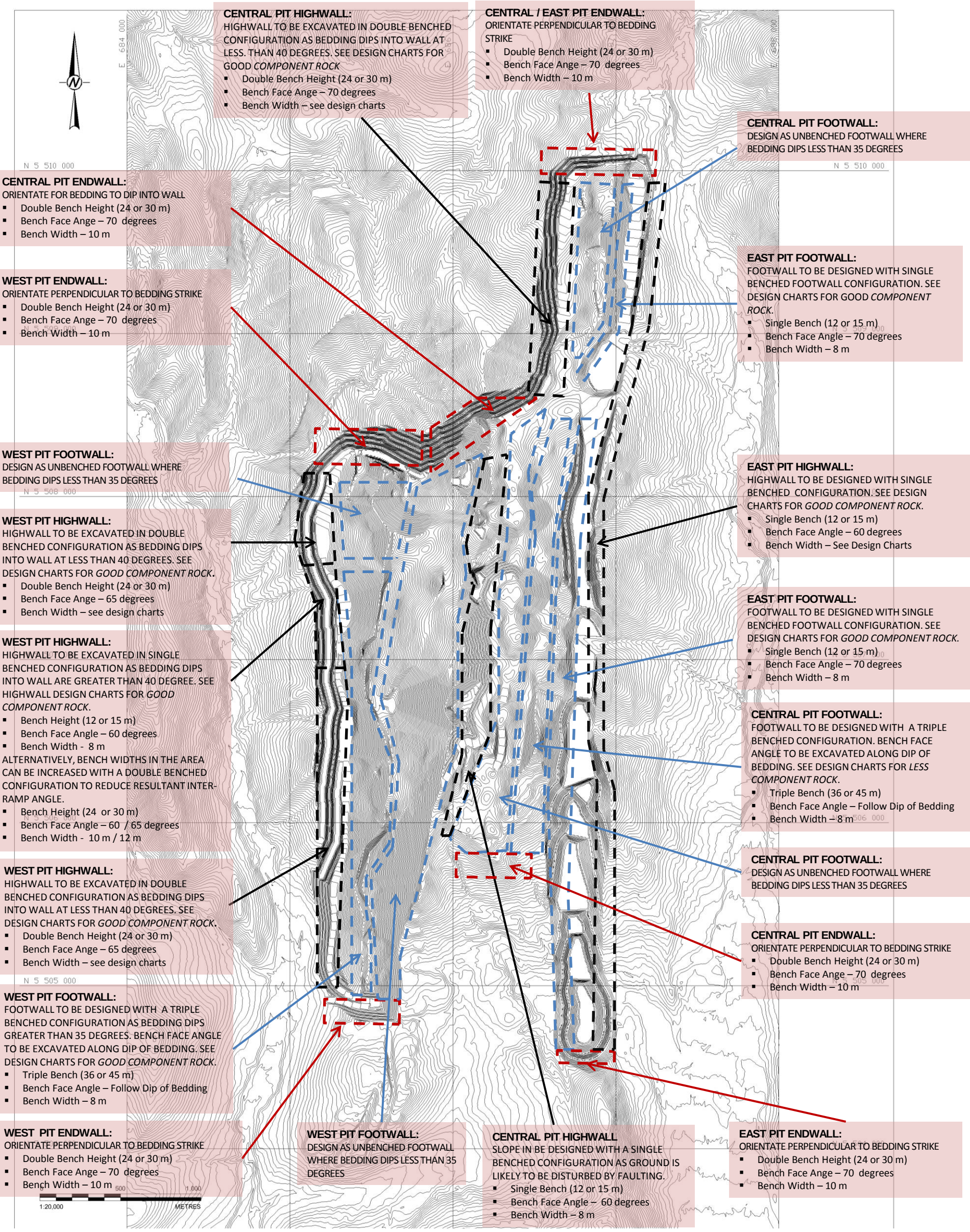
PROJECT
GRASSY MOUNTAIN PRELIMINARY PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 7 GEOLOGICAL SECTION – PIT SLOPE RECOMMENDATIONS

PROJECT No.	Rev.	FIGURE
2850-MN-0001-0	**0**	**I-8**



CENTRAL PIT HIGHWALL:
HIGHWALL TO BE EXCAVATED IN DOUBLE BENCHED CONFIGURATION AS BEDDING DIPS INTO WALL AT LESS. THAN 40 DEGREES. SEE DESIGN CHARTS FOR GOOD *COMPONENT ROCK*
- Double Bench Height (24 or 30 m)
- Bench Face Ange – 70 degrees
- Bench Width – see design charts

CENTRAL / EAST PIT ENDWALL:
ORIENTATE PERPENDICULAR TO BEDDING STRIKE
- Double Bench Height (24 or 30 m)
- Bench Face Ange – 70 degrees
- Bench Width – 10 m

CENTRAL PIT FOOTWALL:
DESIGN AS UNBENCHED FOOTWALL WHERE BEDDING DIPS LESS THAN 35 DEGREES

CENTRAL PIT ENDWALL:
ORIENTATE FOR BEDDING TO DIP INTO WALL
- Double Bench Height (24 or 30 m)
- Bench Face Ange – 70 degrees
- Bench Width – 10 m

EAST PIT FOOTWALL:
FOOTWALL TO BE DESIGNED WITH SINGLE BENCHED FOOTWALL CONFIGURATION. SEE DESIGN CHARTS FOR GOOD *COMPONENT ROCK*.
- Single Bench (12 or 15 m)
- Bench Face Angle – 70 degrees
- Bench Width – 8 m

WEST PIT ENDWALL:
ORIENTATE PERPENDICULAR TO BEDDING STRIKE
- Double Bench Height (24 or 30 m)
- Bench Face Ange – 70 degrees
- Bench Width – 10 m

WEST PIT FOOTWALL:
DESIGN AS UNBENCHED FOOTWALL WHERE BEDDING DIPS LESS THAN 35 DEGREES

EAST PIT HIGHWALL:
HIGHWALL TO BE DESIGNED WITH SINGLE BENCHED CONFIGURATION. SEE DESIGN CHARTS FOR *GOOD COMPONENT ROCK*.
- Single Bench (12 or 15 m)
- Bench Face Angle – 60 degrees
- Bench Width – See Design Charts

WEST PIT HIGHWALL:
HIGHWALL TO BE EXCAVATED IN DOUBLE BENCHED CONFIGURATION AS BEDDING DIPS INTO WALL AT LESS THAN 40 DEGREES. SEE DESIGN CHARTS FOR *GOOD COMPONENT ROCK*.
- Double Bench Height (24 or 30 m)
- Bench Face Ange – 65 degrees
- Bench Width – see design charts

EAST PIT FOOTWALL:
FOOTWALL TO BE DESIGNED WITH SINGLE BENCHED FOOTWALL CONFIGURATION. SEE DESIGN CHARTS FOR *GOOD COMPONENT ROCK*.
- Single Bench (12 or 15 m)
- Bench Face Angle – 70 degrees
- Bench Width – 8 m

WEST PIT HIGHWALL:
HIGHWALL TO BE EXCAVATED IN SINGLE BENCHED CONFIGURATION AS BEDDING DIPS INTO WALL ARE GREATER THAN 40 DEGREE. SEE HIGHWALL DESIGN CHARTS FOR *GOOD COMPONENT ROCK*.
- Bench Height (12 or 15 m)
- Bench Face Angle – 60 degrees
- Bench Width - 8 m

ALTERNATIVELY, BENCH WIDTHS IN THE AREA CAN BE INCREASED WITH A DOUBLE BENCHED CONFIGURATION TO REDUCE RESULTANT INTER-RAMP ANGLE.
- Bench Height (24 or 30 m)
- Bench Face Angle – 60 / 65 degrees
- Bench Width - 10 m / 12 m

CENTRAL PIT FOOTWALL:
FOOTWALL TO BE DESIGNED WITH A TRIPLE BENCHED CONFIGURATION. BENCH FACE ANGLE TO BE EXCAVATED ALONG DIP OF BEDDING. SEE DESIGN CHARTS FOR *LESS COMPONENT ROCK*.
- Triple Bench (36 or 45 m)
- Bench Face Angle – Follow Dip of Bedding
- Bench Width – 8 m

WEST PIT HIGHWALL:
HIGHWALL TO BE EXCAVATED IN DOUBLE BENCHED CONFIGURATION AS BEDDING DIPS INTO WALL AT LESS THAN 40 DEGREES. SEE DESIGN CHARTS FOR *GOOD COMPONENT ROCK*.
- Double Bench Height (24 or 30 m)
- Bench Face Ange – 65 degrees
- Bench Width – see design charts

CENTRAL PIT FOOTWALL:
DESIGN AS UNBENCHED FOOTWALL WHERE BEDDING DIPS LESS THAN 35 DEGREES

CENTRAL PIT ENDWALL:
ORIENTATE PERPENDICULAR TO BEDDING STRIKE
- Double Bench Height (24 or 30 m)
- Bench Face Ange – 70 degrees
- Bench Width – 10 m

WEST PIT FOOTWALL:
FOOTWALL TO BE DESIGNED WITH A TRIPLE BENCHED CONFIGURATION AS BEDDING DIPS GREATER THAN 35 DEGREES. BENCH FACE ANGLE TO BE EXCAVATED ALONG DIP OF BEDDING. SEE DESIGN CHARTS FOR *GOOD COMPONENT ROCK*.
- Triple Bench (36 or 45 m)
- Bench Face Angle – Follow Dip of Bedding
- Bench Width – 8 m

WEST PIT ENDWALL:
ORIENTATE PERPENDICULAR TO BEDDING STRIKE
- Double Bench Height (24 or 30 m)
- Bench Face Ange – 70 degrees
- Bench Width – 10 m

WEST PIT FOOTWALL:
DESIGN AS UNBENCHED FOOTWALL WHERE BEDDING DIPS LESS THAN 35 DEGREES

CENTRAL PIT HIGHWALL
SLOPE IN BE DESIGNED WITH A SINGLE BENCHED CONFIGURATION AS GROUND IS LIKELY TO BE DISTURBED BY FAULTING.
- Single Bench (12 or 15 m)
- Bench Face Angle – 60 degrees
- Bench Width – 8 m

EAST PIT ENDWALL:
ORIENTATE PERPENDICULAR TO BEDDING STRIKE
- Double Bench Height (24 or 30 m)
- Bench Face Ange – 70 degrees
- Bench Width – 10 m

NOTE:
REFER TO GEOLOGICAL SECTIONS (FIGURE I-1 TO I-7) TO SUPPLEMENT ABOVE RECOMMENDATIONS

LEGEND:
- **INDICATIVE FOOTWALL**
- **INDICATIVE HIGHWALL**
- **INDICATIVE ENDWALL**

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GRASSY MOUNTAIN PRELIMINARY PIT SLOPE STABILITY ASSESSMENT

TITLE
PRELIMINARY RECOMMENDED PIT SLOPE DESIGN PARAMETERS

PROJECT No.	Rev.	FIGURE
2850-MN-0001-0	**0**	**G-9**

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Appendix 9c

Mini Pit Geotechnical Investigation and Pit Slope Stability Assessment (Golder, July 2016)

July 7, 2016

RIVERSDALE RESOURCES LIMITED

Grassy Mountain Mini Pit Geotechnical Investigation and Pit Slope Stability Assessment

Submitted to:
Riversdale Resources Limited
PO Box 660
12331 20th Avenue
Blairmore, Alberta
T0K 0E0

Attention: Mr. Mike Youl

REPORT

Reference Number: 1654139-003-R-Rev0-5000

Distribution:

1 Electronic Copy - Riversdale Resources Limited
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Table of Contents

1.0 INTRODUCTION 1

2.0 SITE GEOLOGICAL SETTING 2

2.1 Geology 2

2.2 Structural Geology 2

3.0 PROPOSED MINI PIT DESIGN 4

4.0 2016 FIELD INVESTIGATION 5

5.0 ENGINEERING GEOLOGY MODEL 6

6.0 PIT SLOPE STABILITY ASSESSMENT 7

6.1 Overburden 7

6.2 Bedrock Kinematic Bench Scale Stability 7

6.2.1 Highwall Slope 7

6.2.2 Endwall Slope 9

6.2.3 Footwall Slope 9

6.3 Overall Pit Slope Stability Analysis 10

6.3.1 Overall Slope Stability Analyses Material and Groundwater Properties 10

6.3.2 Highwall Slope Stability Analyses Results 11

6.3.3 Footwall Slope Stability Analyses Results 11

7.0 SUMMARY OF RECOMMENDED SLOPE DESIGNS 13

8.0 SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS 15

9.0 CLOSURE 16

REFERENCES 17

STUDY LIMITATIONS 18

TABLES

Table 1: Proposed Mini Pit Dimensions 4

Table 2: Summary of Geotechnical Drilling Program 5

Table 3: Weathered/Faulted Zone in Blairmore Group 8

Table 4: Summary of Slope Stability Results for Section 480 through the Highwall 11

Table 5: Summary of Slope Stability Results for Section 750 through the Unbenched Footwall 11

Table 6: Summary of Slope Stability Results for Section 840 through the Unbenched Footwall....12

Table 7: Weathered/Faulted Zone in Blairmore Group....13

FIGURES

Figure 1: Mini Pit Plan View of Proposed Ultimate Pit Topography....19

Figure 2: Mini Pit 2016 Drillhole and Cross-Section Locations....20

Figure 3: Geologic Section RGSC-0011 and RGSC-0013....21

Figure 4: Geologic Section RGSC-0012....22

APPENDICES

APPENDIX A
Geological Cross-Sections

APPENDIX B
Field Investigations

APPENDIX C
Rock Core Photos

APPENDIX D
Point Load and Laboratory Resting Results

APPENDIX E
Downhole Drillhole Plots

APPENDIX F
Structural Orientation Data

APPENDIX G
Overall Pit Slope Stability Analyses

APPENDIX H
Recommended Conceptual Footwall Slope Design

1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Riversdale Resources Limited (Riversdale) to carry out geotechnical field investigations and pit slope stability assessments for the proposed Mini Pit, at the Grassy Mountain Project located near Blairmore, Alberta. The Mini Pit forms the southern-most end of the proposed Grassy Mountain ultimate open pit development, and is located adjacent to proposed critical mine infrastructure.

Golder have previously carried out geotechnical field investigations in 2014 and completed pit slope stability assessments in 2015. The results of this work included pit slope design criteria which was used in the development of the feasibility level Grassy Mountain pit design (Golder 2015). Following the completion of the feasibility study, Riversdale have carried out optimization studies which have resulted in the enlargement of the south-end of the mine development, known as the Mini Pit. The previously proposed slope heights in this area were in the 50 metre to 75 metre (m) range. The currently proposed Mini Pit slope heights are in the 65 m to 200 m range.

Riversdale have requested Golder to carry out a slope stability assessment of the Mini Pit walls to confirm the overall stability condition and to evaluate the performance of the proposed unbenched footwall slope. The highwall slope that will be excavated along the west side of the pit is considered critical to the current pit design due to location of the mine infrastructure behind the crest of the wall, and the high consequence related to an instability in the highwall.

This report presents:

- a description of the geology of the Grassy Mtn. deposit;
- a description of the proposed Mini Pit;
- a description of the geotechnical field investigations;
- a discussion of the engineering geology of the deposit in the area of the proposed Mini Pit;
- the results of the kinematic and overall slope stability assessments; and
- recommendations regarding the highwall, south endwall, and footwall slope designs.

The field investigation and stability assessment work has been carried out in general accordance with the Golder proposal, referenced P1654139-001-P-Rev1 and dated April 12, 2016.

2.0 SITE GEOLOGICAL SETTING

2.1 Geology

The interpreted geological model was received from Riversdale in electronic cross-section format (AutoCAD) on April 6, 2016. The cross-sections were oriented approximately northwest-southeast and are included in Appendix A.

The Grassy Mountain Project site is located in southwest Alberta, within the Rocky Mountain foreland fold and thrust belt. The coal that will be mined from the Grassy Mountain development is located within the coal-bearing Mist Mountain Formation, which is part of the Jurassic to Cretaceous Kootenay Group sedimentary sequence.

The Mist Mountain Formation typically consists of interbedded mudstones, siltstones, and sandstones, with inter-bedded, thick, bituminous coal seams. Individual seams vary from less than 1 m to more than 4 m in thickness. The mudstones generally occur as thin beds immediately adjacent to the coal seams. These beds normally grade to thicker siltstone and sandstone beds within a few metres of the coal seams, and the majority of the rocks in the sedimentary sequence consist of competent siltstones and sandstones.

The Mist Mountain Formation is unconformably overlain by the thickly-bedded Cadomin conglomerate, situated at the base of the Blairmore Group. The contact between the Mist Mountain Formation and the Cadomin conglomerate represents an erosional angular unconformity responsible for the removal of the upper half of the Mist Mountain Formation (Norris 1994, Monahan 2000). Despite the erosional unconformity, the Mist Mountain Formation and Blairmore Group exhibit similar bedding dips. Above the Cadomin conglomerate, the Blairmore Group comprises gradationally deposited sandstone, siltstone, and mudstones of the Gladstone formation.

The Mist Mountain Formation overlies the upper member of the Morrissey Formation. The upper member is Moose Mountain sandstone. The Moose Mountain Member is mainly composed of massive-bedded sandstone, but can contain thin beds of mudstone, shale and bituminous coal. Below the Moose Mountain Member is the Weary Ridge Member which has not been geotechnically drilled at the Grassy Mountain site. The Morrissey Formation is underlain by the Fernie Formation marine shales.

2.2 Structural Geology

In general, the strata at Grassy Mountain strikes north-south, and is variably folded along a series of easterly verging folds. The deposit is situated within a succession of generally west-dipping, north to south trending thrust faults (Norris 1994). The Grassy Mountain project site lies between the Livingstone Thrust Fault and another regionally continuous fault, the Coleman Thrust Fault, which is located to the west (Norwest 2013). Two major site-wide continuous west-dipping thrust faults; the McConnell and Turtle Mountain Thrusts intersect the Mist Mountain Formation. According to Norris (1994) there are three structural domains within the deposit. The domains, located from west to east, are briefly described below:

- **Western Structural Domain:** Sedimentary strata generally dip at 25 to 30 degrees towards the west at the southern end of Domain 1, increasing to 40 to 60 degrees at the northern end. The McConnell Thrust Fault forms the eastern boundary of the outcropping Mist Mountain in this domain.

- **Central Structural Domain:** Sedimentary strata generally dip at 25 to 35 degrees towards the west-north west, increasing to about 50 degrees dip angle at the northern end of the Domain. The Turtle Mountain Thrust Fault separates the Central Domain from the Eastern Domain.
- **Eastern Structural Domain:** Sedimentary strata generally dip at 60 to 70 degrees towards the east. This domain is characterised by an overturned anticline fold. The Turtle Mountain Thrust Fault defines the western boundary of this domain and is replaced by major folds in the north.

3.0 PROPOSED MINI PIT DESIGN

Riversdale engaged Deswik Mining Consultants (Australia) Pty Ltd. (Deswik) to carry out an optimization of the feasibility pit design. Deswik provided Golder with the proposed Grassy Mountain Mini Pit design via email on May 16, 2016.

The proposed ultimate pit will be excavated along the south side of the Western Structural Domain, and is shown in Figure 1. Geological cross-sections including the Deswik Mini Pit design were provided by Riversdale and are presented in Appendix A. The cross-section locations are shown on Figure 2.

The Deswik Mini Pit design includes pit wall heights between 65 and 200 m height. Previously, the pit wall heights in the south end of the development were in the 50 to 75 m range. The proposed minimum set-back from the highwall crest to the mine infrastructure is 50 m. The dimensions of the Mini Pit design are summarized in Table 1.

Table 1: Proposed Mini Pit Dimensions

Pit Wall	Maximum Crest Elevation (m)	Maximum Wall Height (m)	Bench Height (m)	Bench Face Angle (degrees)	Catch Bench Width (m)
Highwall	1,545	160	30	60 to 65	15
Endwall	1,535	40	30	60 to 65	15
Footwall	1,605	235	45	Follows bedding dip	10

4.0 2016 FIELD INVESTIGATION

A field investigation was carried out to assess the geotechnical conditions in the area of the proposed Mini Pit. Golder provided supervision of the field investigation activities from May 15 to 27, 2016. The field investigation consisted of the following activities:

- drilling of three HQ-3, diamond cored geotechnical holes;
- geotechnical data collection including the description of structural discontinuities;
- field assessment of rock strength and point load strength testing;
- collection of rock core samples for laboratory strength testing; and
- acoustic televiewer (ATV) surveys in the three diamond cored drillholes.

The locations of the drillholes are shown in plan in Figure 2, and in cross-section in Figures 3 and 4. A summary of the drilling program is provided in Table 2. The locations of the drillholes were chosen to target representative geotechnical conditions within proposed Mini Pit highwall and footwall slopes.

Table 2: Summary of Geotechnical Drilling Program

Drillhole	Date Completed	Target	Easting (m)	Northing (m)	Elevation (m)	Length (m)	Inclination (°)	Azimuth (°)
RGSC-0011	May 19, 2016	Footwall	685504	5504648	1563	156.41	-90	0
RGSC-0012	May 24, 2016	Highwall	685218	5504610	1527	139.72	-90	0
RGSC-0013	May 27, 2016	Footwall	685567	5504637	1568	127.40	-90	0

The field investigation methodology and results are presented in Appendix B. The site engineering geology model is described in Section 5.0. Core photos are presented in Appendix C. The results of Point Load Testing completed on site and laboratory testing completed on select samples are presented in Appendix D. Downhole plots of the geotechnical drillhole logging data and RMR calculations are presented in Appendix E. Structural data interpretation is presented in Appendix F.

5.0 ENGINEERING GEOLOGY MODEL

The results of the field investigations, data compilation and analyses, and the laboratory testing are described and discussed in Appendix B, and in the subsequent supporting Appendices C to F. The engineering geology model that has been derived from these data is descried below.

The extents of the Mini Pit are likely within the Western Structural Domain (described in Section 2.2) based on the geological sections provided by Riversdale. The sedimentary strata within this domain generally dip moderately to steeply towards the west. The continuous, steeply west dipping thrust faults are shown to offset the coal seams, with a maximum offset of approximately 25 m.

Drillhole RGSC-0012 was drilled through the highwall of the Mini Pit (see Figure 2) and a large weathered and faulted zone was encountered from approximately 10 to 40 m in the Blairmore Group above the Cadomin conglomerate. This corresponds with a large portion of lost core in drillhole RGSC-0005, drilled during Golder's previous field investigation in 2014 (Golder 2015). This zone of the Blairmore Group could impact the stability of the highwall upper slopes. The structural data collected by the ATV indicate that bedding is moderately dipping (20 to 35 degrees) towards the west. This is in agreement with the geological interpretation proposed by Riversdale in the area of the Mini Pit highwall.

Drillhole RGSC-0011 and RGSC-0013 were drilled to intersection the footwall of the Mini Pit. Based on discussions between Golder and Deswik, mining operations will mine back to the competent Moose Mountain Formation below Seam 004 in the footwall (see sections in Appendix A). The structural data collected by Golder and from the ATV in drillhole RGSC-0013 indicate that the Moose Mountain bedding generally dips from approximately 35 to 50 degrees towards the west-northwest. This is in good agreement with the geological interpretation proposed by Riversdale in the area of the Mini Pit footwall.

After reviewing the geological interpretation by Riversdale, geotechnical drilling completed by Golder, and ATV interpretation by ASIMS (Acoustic Scanner and Sonic Log Interpretation), geotechnical characterization has been performed by Golder to assess the stability performance of the Mini Pit design. The intact rock and rock mass ratings of the rock types encountered in the Mini Pit are generally in agreement with the findings of Golder (2015). Based on the updated interpretation of the geological and structural model, Golder has proceeded with applying the geotechnical characterization to the pit slope stability assessment discussed in Section 6.0.

6.0 PIT SLOPE STABILITY ASSESSMENT

The Grassy Mountain slope stability assessment of the Mini Pit described in the following subsections is based on the following:

- results of the 2014 Grassy Mountain field investigation and stability assessment (Golder 2015);
- results of the 2016 Mini Pit field investigation;
- Riversdale geology and fault structure interpretation;
- Grassy Mountain engineering geology; and
- the Deswik Mini Pit design.

Pit slope stability considerations were previously described in detail in Golder (2015).

6.1 Overburden

Overburden thicknesses in the area of the Mini Pit range from 5 to 15 m as seen in drillholes RGSC-0011 to RGSC-0013. These soils are expected to consist of competent glacial till that is overlain by a thin and variable thickness layer of colluvium. A thin layer of top soils may or may not be present at the higher elevations and on the steeper natural slopes.

Slopes of the Mini Pit excavated in soil and extremely weak rocks are susceptible to circular type failure mechanisms through the intact soil or rock. Slopes excavated in these materials are typically designed at a 2 Horizontal: 1 Vertical profile to provide long-term stable slopes and reduce the consequence of failure.

6.2 Bedrock Kinematic Bench Scale Stability

The bench scale stability of the highwall, endwall and footwall slopes of the Mini Pit will be predominantly controlled by the orientation and persistence of geologic structures. The geologic structures that will control the Mini Pit slope stability are the continuous faults and bedding surfaces and the discontinuous, systematic joints sets. The geology model indicates that there are a number of steep thrust faults interpreted to intercept the Mini Pit. The results of the field investigations indicate that areas of localised poor rock mass quality are encountered in the coal and adjacent to interpreted fault structures.

6.2.1 Highwall Slope

Two east facing highwall slopes will be excavated along the west side of the pit. The upper slope will be separated from the lower slope by a thrust fault off set of the coal seams. The upper highwall slope that will be excavated along the west side of the Mini Pit will be excavated in rocks of the Blairmore Group and Mist Mountain Formation. The lower highwall will be excavated in the Mist Mountain rocks. The current design configuration has a bench face angle of 60 to 65 degrees with a double bench design, and an inter-ramp slope angle of approximately 45 degrees. Deswik have used a highwall design that is generally in accordance with the previous recommendations outlined in Golder (2015).

The geological model and televiewer data from drillhole RGSC-0012 indicate that bedding in the area of the highwall dips between 10 and 35 degrees to the west-northwest, and into the highwall. The westerly dipping bedding will be favorably oriented with respect to the highwall slope, and instability along the bedding is not expected to occur.

The southeast-northwest trending and steeply dipping JS2 cross joints will be oriented near perpendicular to the highwall. The southeast dipping JS1 joint set will dip toward the east at an inclination of 55 to 70 degrees, with an average dip of approximately 70 degrees. These joints will be undercut in the bench face, and bench scale planar failure will occur along the undercut joints. The perpendicular JS2 cross joints will act as release structures for these planar failures. The bench face will have a tendency to break back to an angle that is slightly steeper than the average JS1 joint dip. Bench face angles on the order of 60 to 65 degrees should be achievable.

The results of the geotechnical logging from drillholes RGSC-0005 and RGSC-0012 generally indicate that there is an approximately 30 m thick zone of the Blairmore Group that is largely weathered and faulted in the upper portion of the highwall (described in Section 5.0). The faulting is due to a westerly dipping thrust fault that will be exposed in the upper part of the highwall slope. Below this zone, the rock quality in the Blairmore Group and the underlying Mist Mountain Formation improves to good quality, competent rock.

It is recommended that a shallower design bench configuration be used in the weathered and the faulted rocks in the upper portion of the upper highwall. A steeper bench configuration can be used below the thrust fault exposure. The approximate elevation of the thrust fault exposure along the highwall is summarized in Table 3.

Table 3: Weathered/Faulted Zone in Blairmore Group

Section	Weathered/Faulted Zone Elevation (m)[(1)]	Thickness (m)
0060	No faulted zone in highwall	N/A
0120	1528 to 1536	8
0300	1509 to 1532	23
0480	1490 to 1532	42
0660	1470 to 1502	32
0750	1465 to 1497	32
0840	1468 to 1493	25
1020	1468 to 1493	25

1) Elevations based on geological sections provided by Riversdale Resources Limited (Appendix A).

The following design bench configurations is recommended for the upper portion of the highwall slope that will be excavated in the weathered and thrust faulted Blairmore rocks, above the approximate lowest elevation for each cross-section in Table 3.

Bench Height:	30 m (double bench)
Bench Face Angle:	60 degrees
Catch-bench Width:	12 m
Inter-ramp Angle:	45.7 degrees

The following design bench configurations is recommended for the lower portion of the upper highwall slope and the lower highwall slope that will be excavated in the competent Mist Mountain Rocks, below the approximate lowest elevations for each cross-section in Table 3.

Bench Height:	30 m (double bench)
Bench Face Angle:	65 degrees
Catch-bench Width:	12 m
Inter-ramp Angle:	49.1 degrees

6.2.2 Endwall Slope

A small, north-northeast facing endwall slope will be excavated at the south end of the Mini Pit. The geologic model indicates that the endwall located along the south side of the Mini Pit will be excavated in rocks of the Blairmore Group and Mist Mountain Formation. Deswik have used an endwall design that is generally in accordance with the previous recommendations outlined in Golder (2015). The configuration has a bench face angle of 60 to 65 degrees with a double bench design.

The results of the logging from geotechnical drillholes generally indicate that rock quality within the Blairmore Group and Mist Mountain Formation improves with depth, and to be good quality, competent rock.

The endwall is to be oriented perpendicular to the bedding dip direction, and will face toward approximately 020° azimuth. It will be important to ensure that the endwall is excavated perpendicular to bedding to prevent planar sliding along undercut bedding if the endwall is oriented at an oblique angle such that bedding dips out of the slope.

The north-south striking JS1 joint set will dip toward the east at a moderate to steep inclination, and will be oriented near perpendicular to the wall. If the wall is oriented at an oblique angle to the bedding strike, and faces toward the northeast, the easterly dipping joints will be undercut in the bench face, and planar sliding can occur along the joints, with lateral release along the northerly dipping JS2 joints. The most favorable endwall stability conditions will be achieved with the endwall oriented perpendicular to the bedding strike.

The JS2 cross joints are expected to dip toward the north at a steep inclination. The individual bench faces will break back to the joints, and bench face angles on the order of 70 degrees should be achievable.

The following design bench configurations is recommended for the south endwall.

Bench Height:	30 m (double bench)
Bench Face Angle:	70 degrees
Catch-bench Width:	12 m
Inter-ramp Angle:	52.6 degrees

6.2.3 Footwall Slope

The geological model indicates that the footwall located along the east side of the Mini Pit will be excavated in rocks of the Moose Mountain member of the Morrissey Formation. Deswik have used a benched footwall design that is generally in accordance with the recommendations outlined in Golder (2015).

The geological model and televiewer data from drillholes RGSC-0011 and RGSC-0013 indicate that bedding in the Moose Mountain dips between 35 and 50 to the west-northwest, with some small, steeper segments. The results of the geotechnical characterization of the rock mass below the footwall generally indicate that rock quality within the Moose Mountain to be good quality, competent rock.

Due to the steep bedding dips, the unbenched and benched segments of the footwall slopes should follow the bedding, and bedding should not be undercut. The overall stability of the proposed footwall slope, and the need for catchment to control rock fall on the plus 200 m high slope is discussed in Section 6.3.3.

6.3 Overall Pit Slope Stability Analysis

Limit equilibrium stability assessments were carried out for large-scale rock mass failure for the proposed Mini Pit slopes. The stability analyses were performed deterministically using the two-dimensional limit equilibrium analysis software SLIDE (Version 6.0) (Rocscience). The GLE (General Limit Equilibrium) – Morgenstern-Price method of slices was used to calculate the Factors of Safety. This limit equilibrium method satisfies both force and moment equilibrium. The analyses considered two potential failure mechanisms:

- circular failure through the rock mass in both the highwall and footwall; and
- bi-linear failure in the footwall slope, involving the failure of rock mass in the toe of the slope with sliding along the bedding surfaces in the upper portion of the footwall slope.

The geological cross-sections provided by Riversdale were selected for the stability analyses. Section 480 was selected for the highwall and Sections 750 and 840 were selected for the footwall (Appendix A). Section 750 is considered a typical section through the footwall of the Mini Pit and Section 840 is considered a critical section through the footwall as the pit design in this area is steeper. No stability assessment was carried out on the south endwall slope, as this slope will only 3 to 4 benches high.

Given, the close proximity of the Mini Pit highwall to the proposed infrastructure, the consequence of failure can be considered high, which requires design Factors of Safety of 1.5 for overall stability for the highwall. The consequence of the failure for the proposed footwall is considered to be medium, which corresponds to an acceptance overall stability Factor of Safety of 1.3. See Appendix G for a more detailed description of the acceptability criteria.

6.3.1 Overall Slope Stability Analyses Material and Groundwater Properties

The strength parameters and the groundwater conditions that have been used in the slope stability analyses are summarized in Section 2.0 and 3.0 in Appendix G. The highwall and footwall stability analyses were carried out for dry conditions and for an r_u of 0.1. Experience with existing coal mines in the Rocky Mountains indicates that highwall and endwall slopes drain well along the continuous bedding that is exposed in the slopes. Piezometers indicate that the slopes drain as they are mined, and that low groundwater pressures in the slopes.

The continuous bedding strikes parallel to the footwall slopes, and the footwall will not drain as readily across the bedding. However, drainage does occur along the discontinuous cross joints. In general, it is common practice to install shallow drain holes in high and steep footwall slopes to minimize the likelihood of developing buckling or ploughing type failures, and this is discussed further in Section 6.3.3.

6.3.2 Highwall Slope Stability Analyses Results

The results of stability analyses indicate adequate stability conditions along the highwall in Section 480 in the Mini Pit and are presented in Table 4.

Table 4: Summary of Slope Stability Results for Section 480 through the Highwall

Stability Section	Case	Failure Surface	Groundwater Conditions	Factor of Safety	Figure No. in Appendix G
Section 480	Overall	Circular	r_u = 0.1	2.07	G-1
			Dry	2.27	G-2
	Upper Benches		r_u = 0.1	0.50	G-3
			Dry	0.60	G-4

The results of the overall slope stability analyses indicate that the overall slope, from toe to crest, is expected to exhibit factors of Safety in excess of 1.5 for the assumed ground water conditions.

The results of the stability analyses indicate that the upper portion of the slope within the weathered and thrust faulted Blairmore group is not expected to exhibit adequate Factors of Safety for a typical highwall slope, in excess of 1.3. The analyses indicate that bench scale instability can be expected to occur in the weathered and faulted Blairmore. However, Figure G-3 shows all surfaces that exhibit a Factor of Safety less than 1.5. These surfaces extend approximately 34.5 m behind the crest of the wall. Consequently, the proposed critical infrastructure minimum set-back distance of 50 m is considered to be appropriate.

6.3.3 Footwall Slope Stability Analyses Results

The results of overall stability analyses for the unbenched footwall in Section 750 in the Mini Pit are presented in Table 5.

Table 5: Summary of Slope Stability Results for Section 750 through the Unbenched Footwall

Stability Section	Failure Surface	Groundwater Conditions	Factor of Safety	Figure No. in Appendix G
Section 750	Circular	r_u = 0.1	5.94	G-5
		Dry	6.29	G-6
	Bi-Linear	r_u = 0.1	1.38	G-7
		Dry	1.55	G-8

The results of overall stability analyses for the unbenched footwall in Section 840 in the Mini Pit are presented in Table 6.

Table 6: Summary of Slope Stability Results for Section 840 through the Unbenched Footwall

Stability Section	Failure Surface	Groundwater Conditions	Factor of Safety	Figure No. in Appendix G
Section 840	Circular	r_u = 0.1	5.92	G-9
		Dry	6.25	G-10
	Bi-Linear	r_u = 0.1	1.51	G-11
		Dry	1.53	G-12

The results of the footwall slope stability analyses indicate that an unbenched footwall slope is expected to exhibit adequate stability with respect to deep-seated circular failure, and to bi-linear failure that involves sliding along the bedding behind the slope and failure through the rock mass in the toe of the slope. This is largely due to the high strength of the Moose Mountain sandstone rocks that will form the footwall slope.

However, the high, unbenched footwall slope will also be susceptible to:

- Buckling failures where there are anticline-shaped rolls in the footwall.
- Ploughing failure where thrust faults are exposed in the footwall.

The proposed footwall slope contains unfavorable roll and thrust faults that dip steeper than the footwall. In order to minimize the likelihood of developing buckling and/or ploughing it is recommended that the footwall slope be benched above the footwall rolls. Moreover, in order to provide adequate rock fall protection, it is recommended that the footwall slope be benched where the bedding dip exceeds approximately 35 degrees.

In view of the above considerations, it is recommended that the following benched configuration be used on the portions of the footwall slope where the bedding dip exceeds 35 degrees.

Bench Height:	45 m (triple bench)
Bench Face Angle:	Follows bedding dip, and does not undercut bedding
Catch-bench Width:	8 m
Inter-ramp Angle:	Variable, depending on bedding dip

An unbenched configuration can be used where the bedding dip is less than 35 degrees.

Benched and unbenched footwalls should be excavated with a bench face angle that follows the bedding dip to reduce the probability of undercutting bedding surfaces.

According to the geologic sections, there is a small layer of Mist Mountain mudstone rocks between the base of the lowest coal seam and the top of the Moose Mountain sandstone. This layer should be mined out, and only Moose Mountain or Morrissey sandstones should be left in the footwall slope.

The conceptual application of the recommended footwall slope configuration to the proposed footwall slope is shown on the geologic cross-sections in Appendix H. Consistent conceptual catch-bench elevations have been used between the cross-sections. However, the actual catch-bench elevations can be adjusted to match the proposed mine bench elevations.

7.0 SUMMARY OF RECOMMENDED SLOPE DESIGNS

The recommended slope designs for the highwall, south endwall and footwall slopes are summarized below.

Summary of Highwall Recommended Slope Design

The following design bench configurations is recommended for the upper portion of the highwall slope that will be excavated in the weathered and thrust faulted Blairmore rocks, above the approximate lowest elevation for each cross-section in Table 7 below.

Bench Height:	30 m (double bench)
Bench Face Angle:	60 degrees
Catch-bench Width:	12 m
Inter-ramp Angle:	47 degrees

The following design bench configurations is recommended for the lower portion of the upper highwall slope and the lower highwall slope that will be excavated in the competent Mist Mountain Rocks, below the approximate lowest elevations for each cross-section in Table 7 below.

Bench Height:	30 m (double bench)
Bench Face Angle:	65 degrees
Catch-bench Width:	12 m
Inter-ramp Angle:	49.1 degrees

Table 7: Weathered/Faulted Zone in Blairmore Group

Section	Weathered/Faulted Zone Elevation (m)[(1)]	Thickness (m)
0060	No faulted zone in highwall	N/A
0120	1528 to 1536	8
0300	1509 to 1532	23
0480	1490 to 1532	42
0660	1470 to 1502	32
0750	1465 to 1497	32
0840	1468 to 1493	25
1020	1468 to 1493	25

1) Elevations based on geological sections provided by Riversdale Resources Limited (Appendix A).

Summary of South Endwall Recommended Slope Design

Bench Height:	30 m (double bench)
Bench Face Angle:	70 degrees
Catch-bench Width:	12 m
Inter-ramp Angle:	52.6 degrees

Summary of Footwall Recommended Slope Design

It is recommended that the following benched configuration be used on the portions of the footwall slope where the bedding dip exceeds 35 degrees.

Bench Height:	45 m (triple bench)
Bench Face Angle:	Follows bedding dip, and does not undercut bedding
Catch-bench Width:	8 m
Inter-ramp Angle:	Variable, depending on bedding dip

An unbenched configuration can be used where the bedding dip is less than 35 degrees.

8.0 SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

Based on the recommendations made in Golder (2015) and the findings of the 2016 pit slope stability assessment, the following is a summary of recommendations for the Mini Pit design:

- It is recommended that critical infrastructure be set back a minimum of 50 meters from the crest of the highwall slope, based on the highwall slope stability analyses results.
- It is recommended that the upper portions of the footwall slope be benched to reduce the likelihood of developing buckling and ploughing failure, and rockfall hazards.
- The three geotechnical holes drilled in 2016 (RGSC-0011 to RGSC-0013) address some of the information gaps noted for the overall pit development to the north of the Mini Pit (Golder 2015). It is expected that on-going resource delineation drilling will be required due to some geological uncertainty in the deepest areas of the pit. Mining in these areas occurs 8 to 10 years into the mine life. The additional deep geotechnical holes recommended for these areas by Golder (2015) are to be part of the overall on-going site management of slope stability, and will augment information gained during stability performance monitoring. In addition, an observational pit slope design approach should be adhered to during pit excavation to include mapping and stability performance monitoring, as subsurface geology is exposed during mining.

9.0 CLOSURE

This report should be read in conjunction with the Study Limitations which is appended at the end of the report. The reader's attention is specifically drawn to this information, as it is essential that it be followed for the proper use and interpretation of this report.

We trust this report satisfies your current requirements. If you have any questions or require further assistance, please do not hesitate to contact the undersigned.

GOLDER ASSOCIATES LTD.

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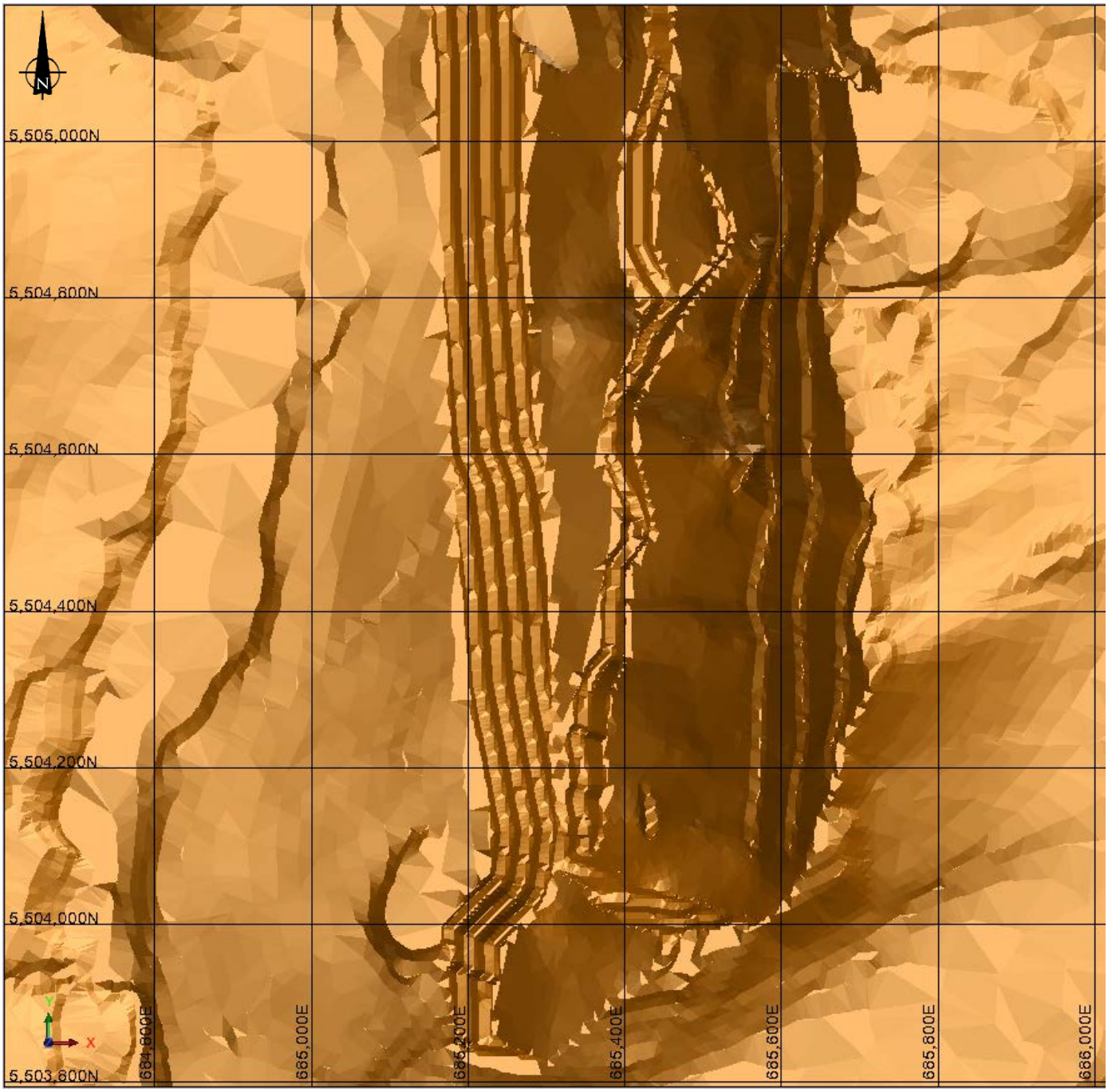

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CLIENT
RIVERSDALE RESOURCES LIMITED

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-06-14
PREPARED	SMR
DESIGN	SMR
REVIEW	AVC
APPROVED	AVC

TITLE
MINI PIT
PLAN VIEW OF PROPOSED ULTIMATE PIT TOPOGRAPHY

PROJECT No.	PHASE	Rev.	FIGURE
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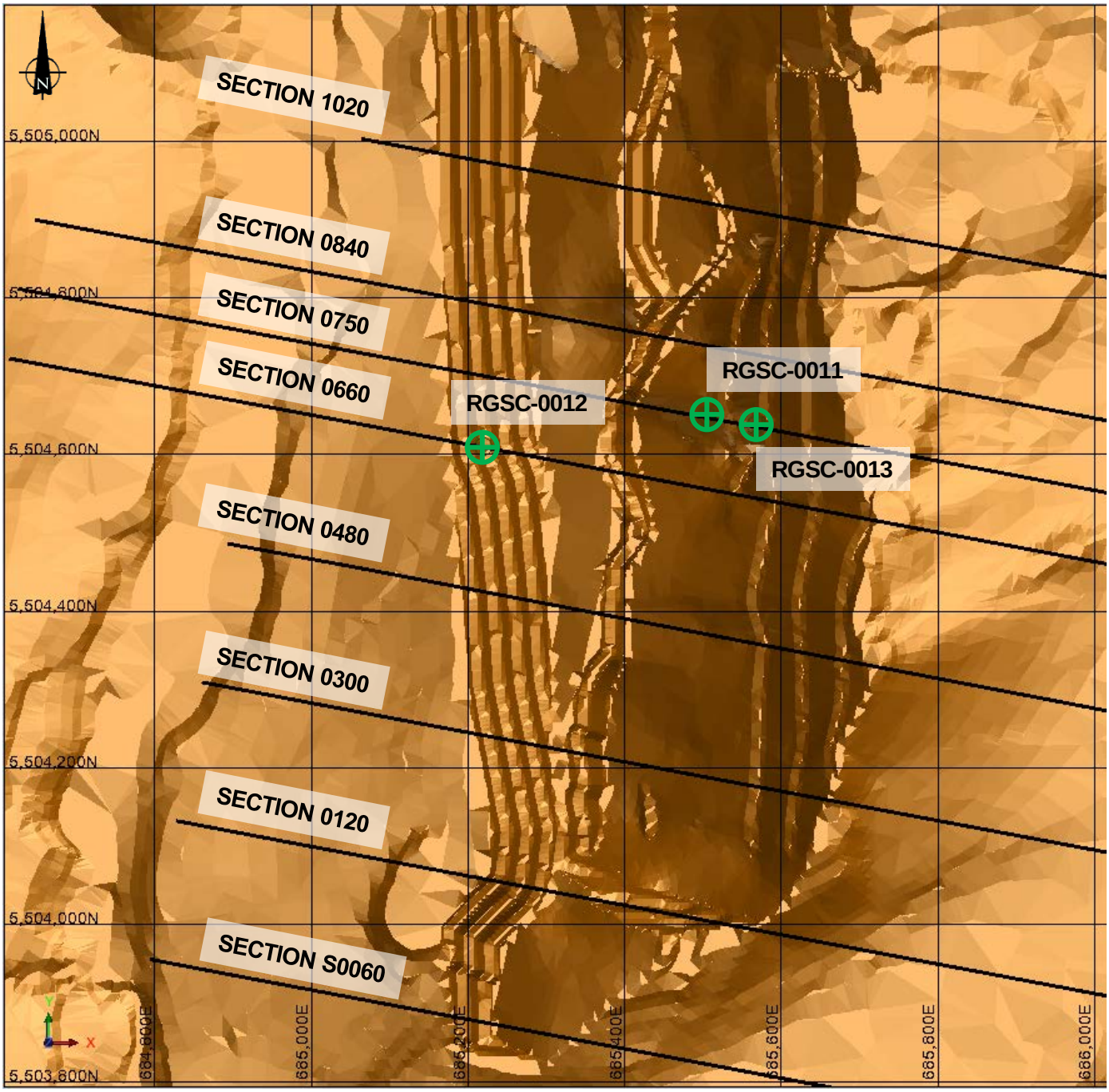

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2. DRILLHOLES SURVEYED DURING MAY 2016 FIELD INVESTIGATION.
3. GEOLOGICAL CROSS SECTIONS PROVIDED BY RIVERSDALE RESOURCES LIMITED ON JUNE 23, 2016.

CLIENT
RIVERSDALE RESOURCES LIMITED

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-06-14
PREPARED	SMR
DESIGN	SMR
REVIEW	AVC
APPROVED	AVC

TITLE
MINI PIT
2016 DRILLHOLE AND CROSS SECTION LOCATIONS

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**2**

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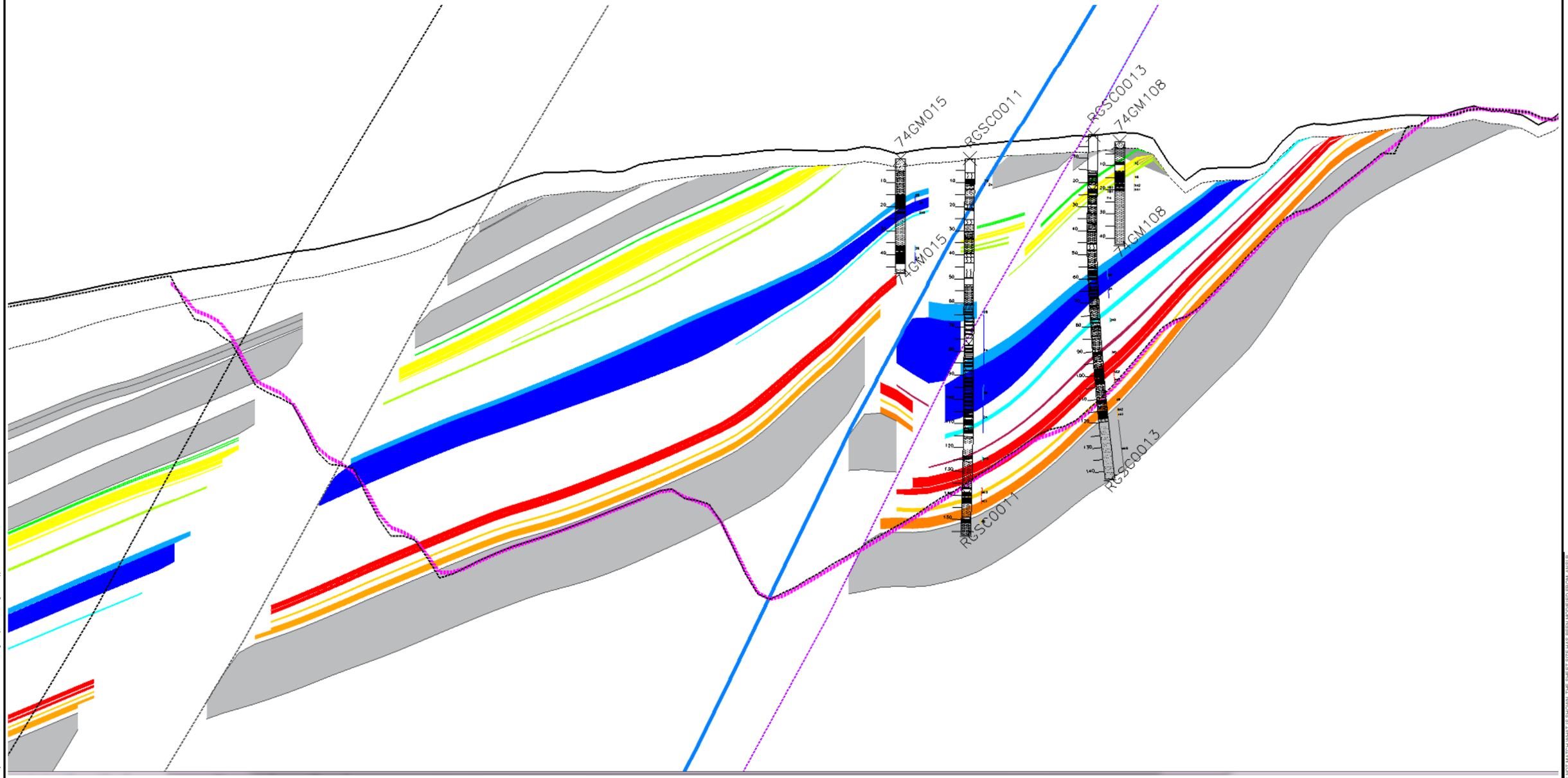

REFERENCE

1. GEOLOGICAL SECTIONS WITH 2016 DRILLHOLES PROVIDED BY RIVERSDALE RESOURCES LIMITED JUNE 7, 2016.

CLIENT
RIVERSDALE RESOURCE LIMITED

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-06-17
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

TITLE
GEOLOGICAL SECTION
RGSC-0011 AND RGSC-0013

PROJECT No.	PHASE	REV	FIGURE
1654139	**5000**	**0**	**3**

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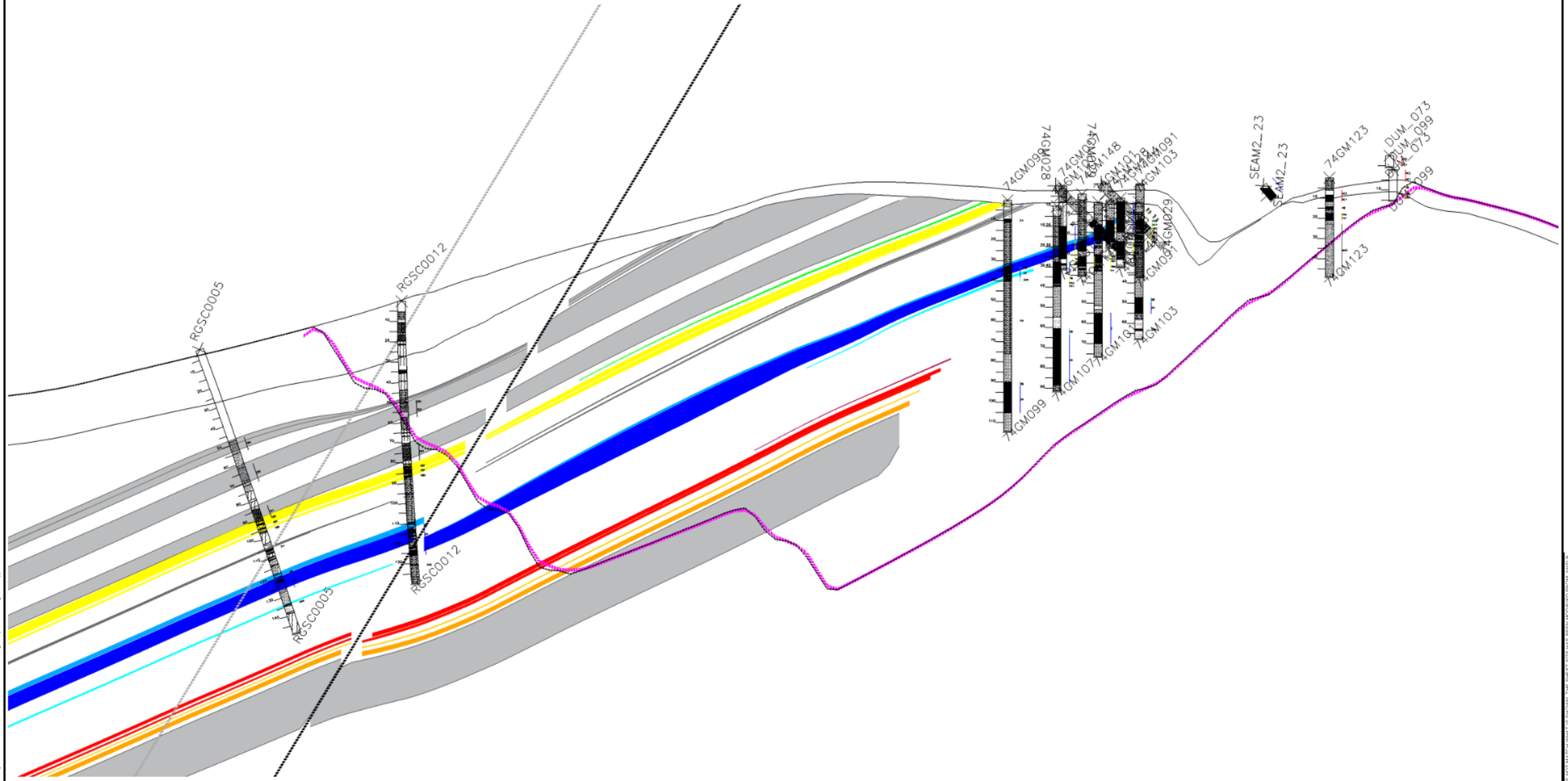

REFERENCE

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CONSULTANT
Golder Associates

YYYY-MM-DD	2016-06-17
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

TITLE
GEOLOGICAL SECTION
RGSC-0012

PROJECT No.	PHASE	REV	FIGURE
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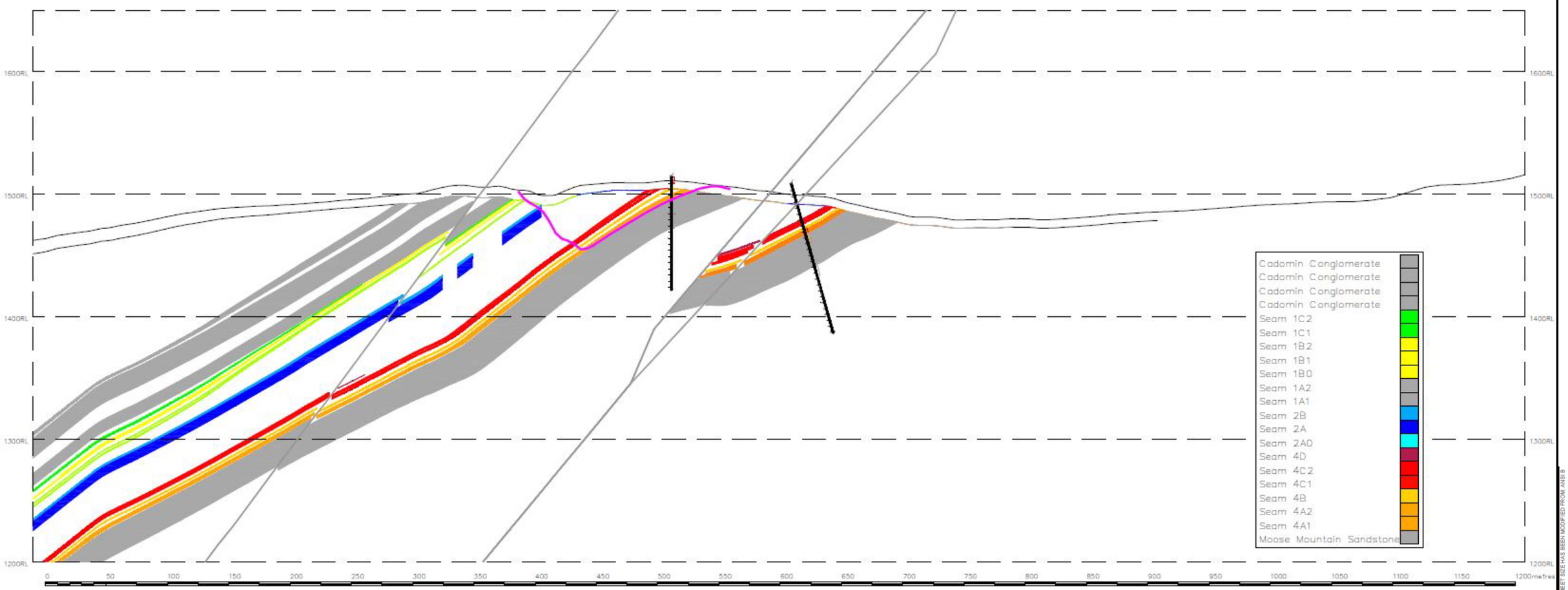
APPENDIX A

Geological Cross-Sections



REFERENCE

1. GEOLOGICAL SECTIONS PROVIDED BY RIVERSDALE RESOURCES LIMITED APRIL 6, 2016.

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RIVERSDALE RESOURCE LIMITED

CONSULTANT
Golder Associates

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PREPARED	SMR
DESIGN	SMR
REVIEW	AVC
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

TITLE
GEOLOGICAL SECTION 1
SECTION 0060

PROJECT No.	PHASE	Rev.	FIGURE
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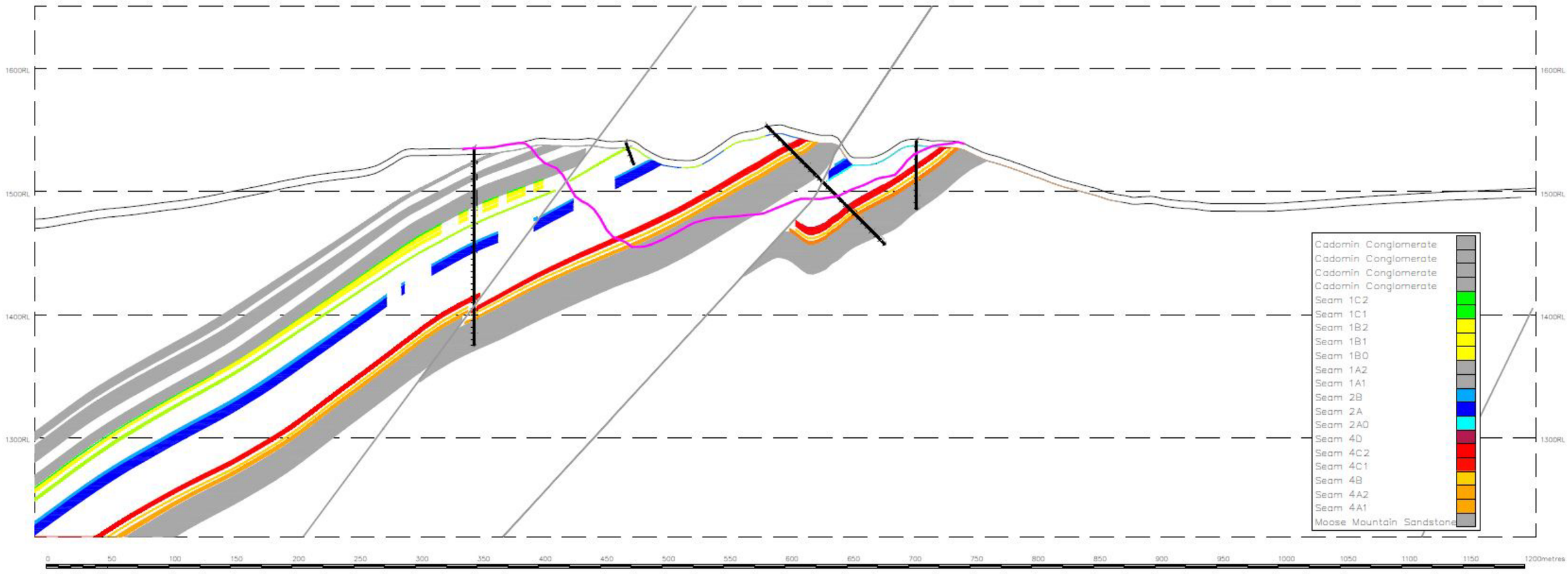

REFERENCE

1. GEOLOGICAL SECTIONS PROVIDED BY RIVERSDALE RESOURCES LIMITED APRIL 6, 2016.

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RIVERSDALE RESOURCE LIMITED

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-06-17
PREPARED	SMR
DESIGN	SMR
REVIEW	AVC
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

TITLE
GEOLOGICAL SECTION 2
SECTION 0120

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**A-2**

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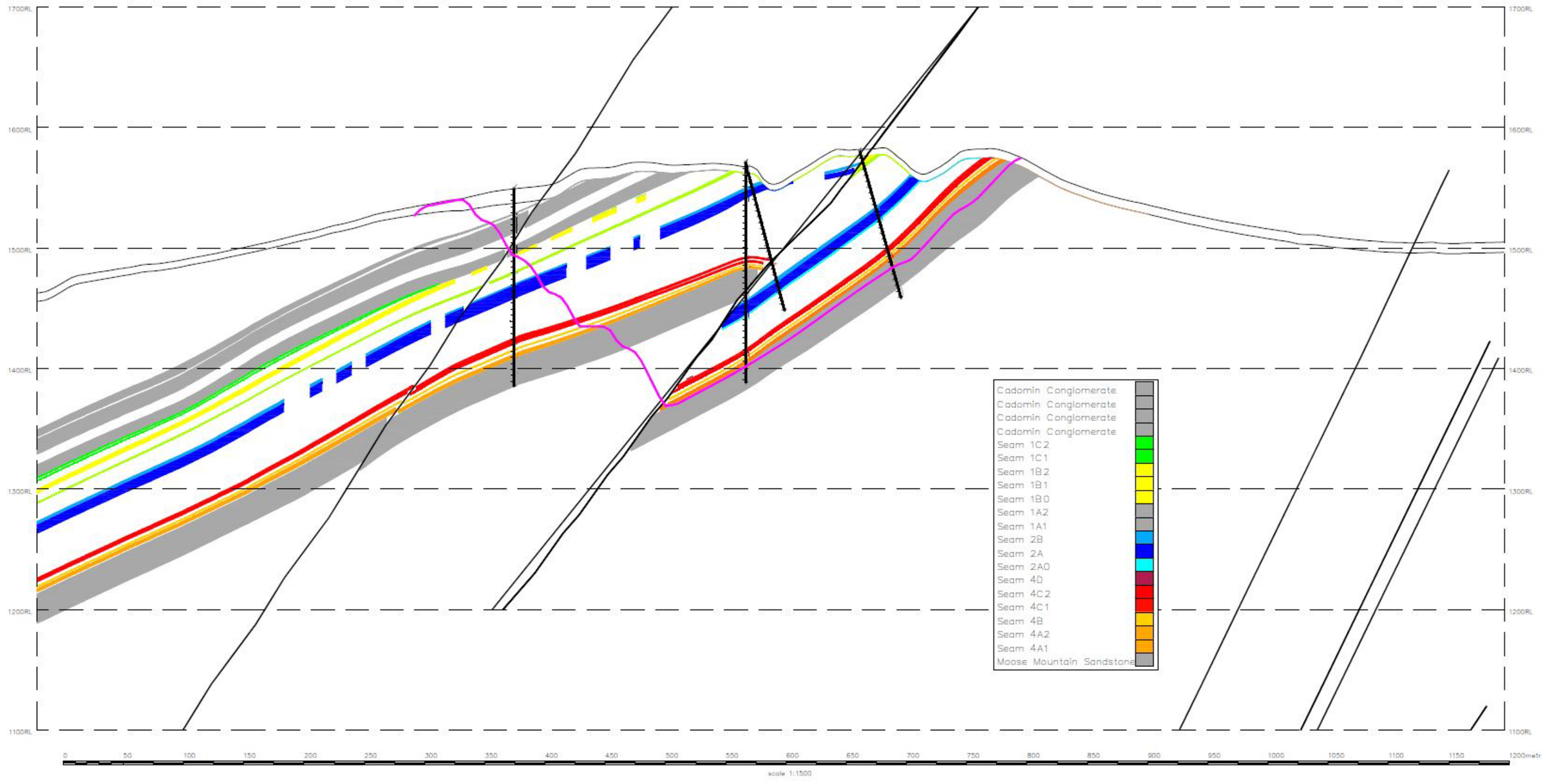

REFERENCE

1. GEOLOGICAL SECTIONS PROVIDED BY RIVERSDALE RESOURCES LIMITED APRIL 6, 2016.

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RIVERSDALE RESOURCE LIMITED

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-06-17
PREPARED	SMR
DESIGN	SMR
REVIEW	AVC
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

TITLE
GEOLOGICAL SECTION 3
SECTION 0300

PROJECT No.	PHASE	Rev.	FIGURE
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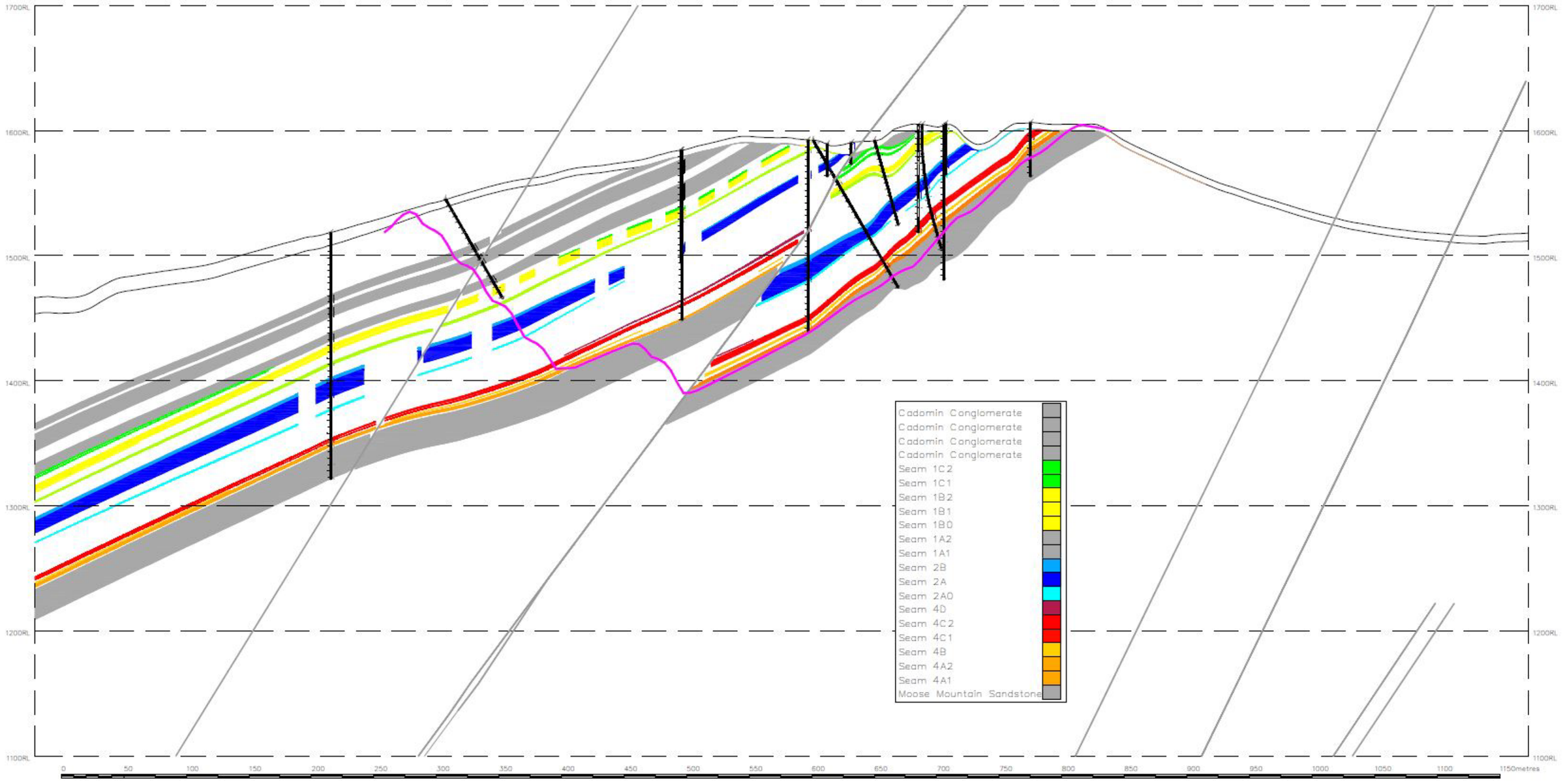

REFERENCE

1. GEOLOGICAL SECTIONS PROVIDED BY RIVERSDALE RESOURCES LIMITED APRIL 6, 2016.

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Golder Associates

YYYY-MM-DD	2016-06-17
PREPARED	SMR
DESIGN	SMR
REVIEW	AVC
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

TITLE
GEOLOGICAL SECTION 4
SECTION 0480

PROJECT No.	PHASE	Rev.	FIGURE
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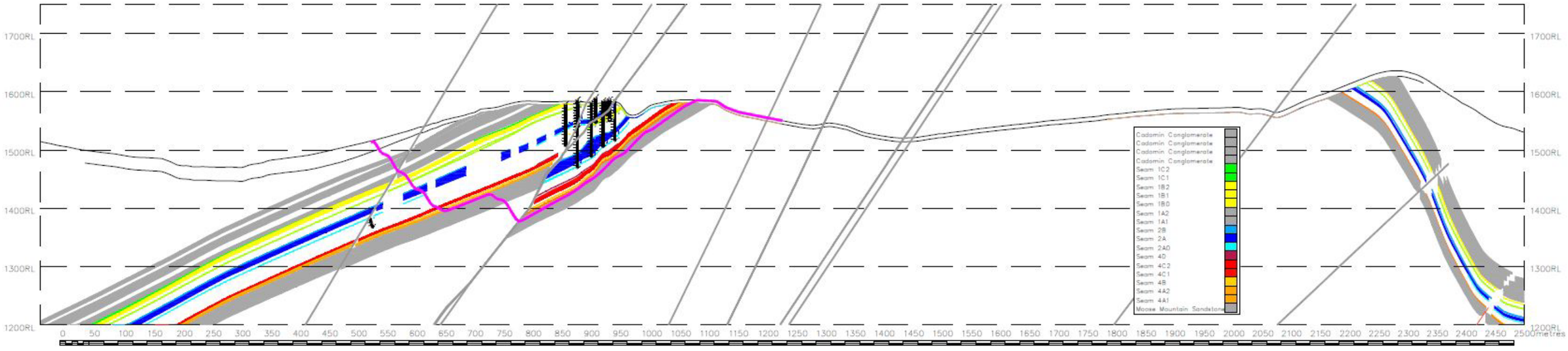

REFERENCE

1. GEOLOGICAL SECTIONS PROVIDED BY RIVERSDALE RESOURCES LIMITED APRIL 6, 2016.

CLIENT
RIVERSDALE RESOURCE LIMITED

CONSULTANT
Golder Associates

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

TITLE
GEOLOGICAL SECTION 5
SECTION 0660

YYYY-MM-DD	2016-06-17
PREPARED	SMR
DESIGN	SMR
REVIEW	AVC
APPROVED	AVC

PROJECT No.	PHASE	Rev.	FIGURE
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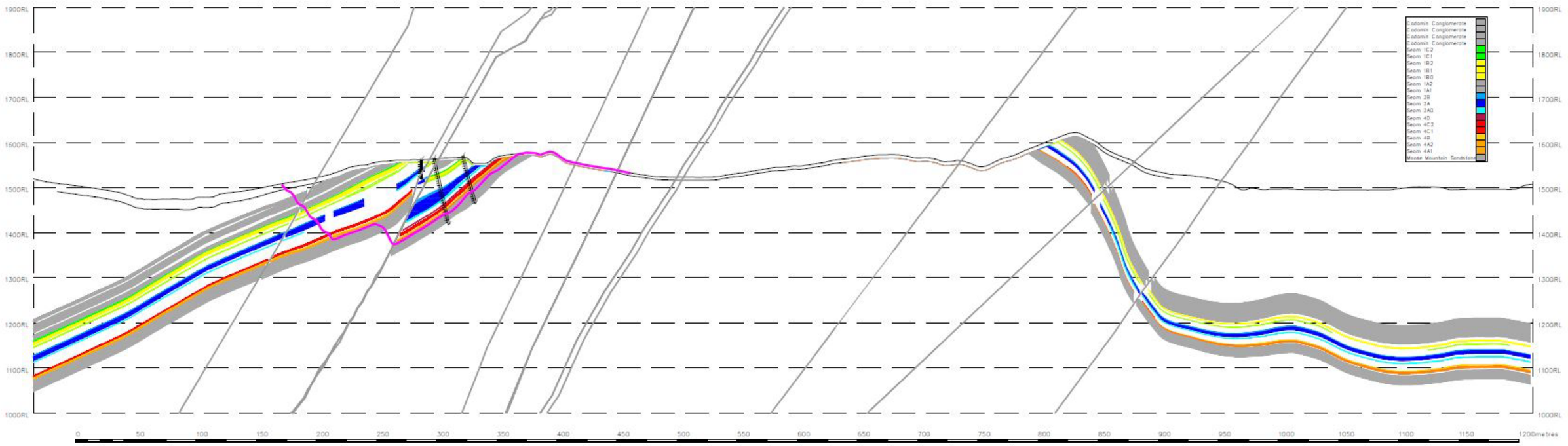

REFERENCE

1. GEOLOGICAL SECTIONS PROVIDED BY RIVERSDALE RESOURCES LIMITED APRIL 6, 2016.

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CONSULTANT
Golder Associates

YYYY-MM-DD	2016-06-17
PREPARED	SMR
DESIGN	SMR
REVIEW	AVC
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

TITLE
GEOLOGICAL SECTION 6
SECTION 0750

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**A-6**

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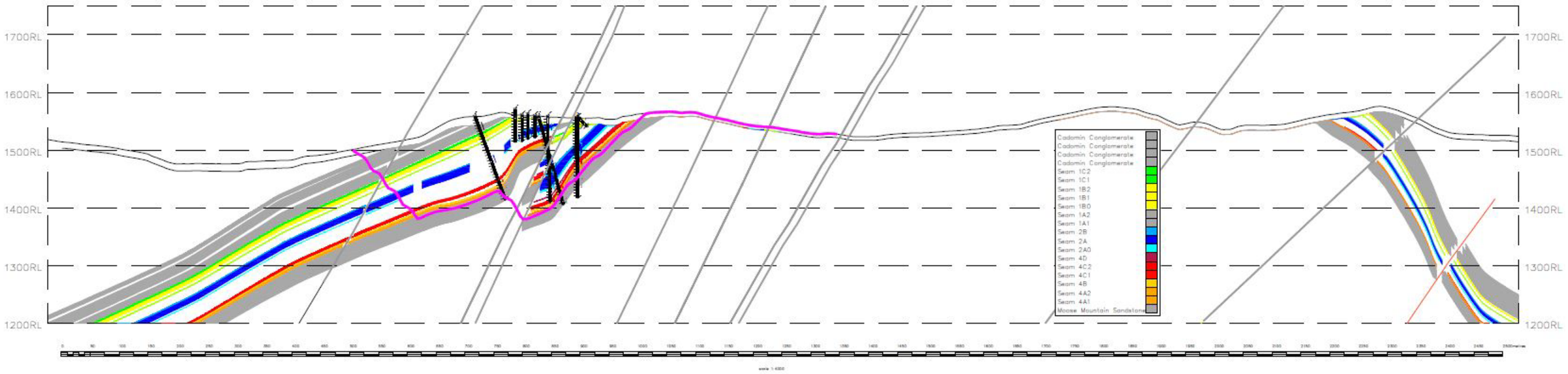

REFERENCE

1. GEOLOGICAL SECTIONS PROVIDED BY RIVERSDALE RESOURCES LIMITED APRIL 6, 2016.

CLIENT
RIVERSDALE RESOURCE LIMITED

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-06-17
PREPARED	SMR
DESIGN	SMR
REVIEW	AVC
APPROVED	AVC

TITLE
GEOLOGICAL SECTION 7
SECTION 0840

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**A-7**

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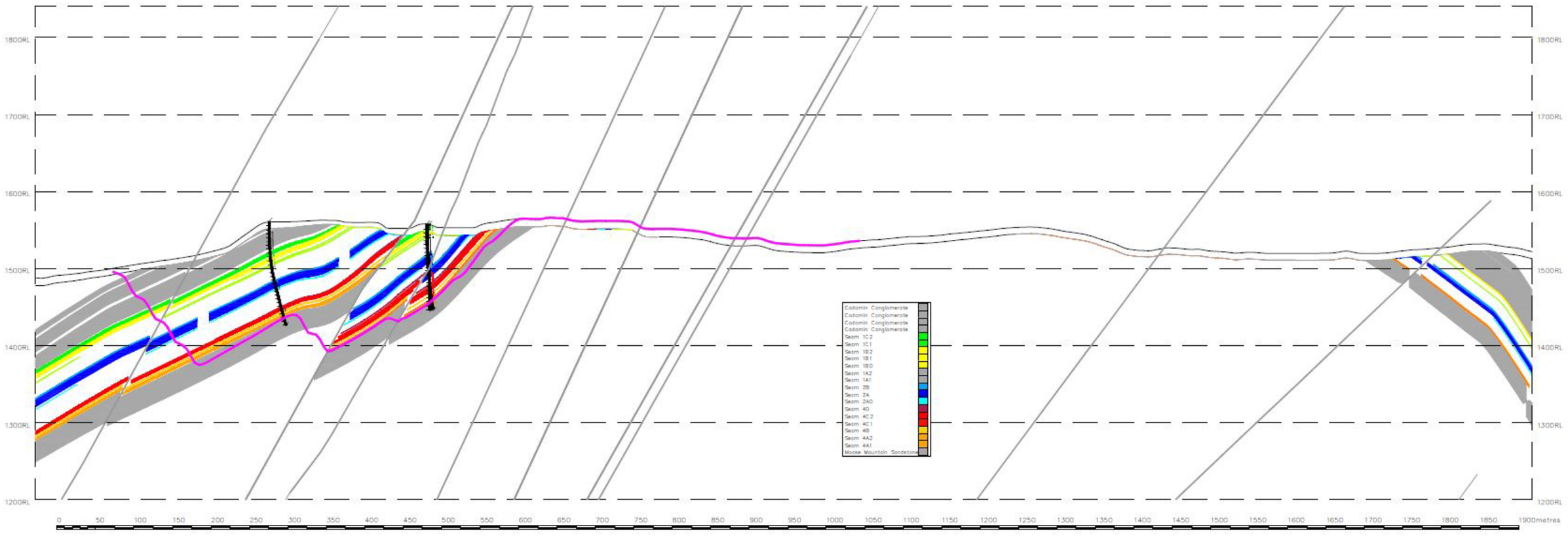

REFERENCE

1. GEOLOGICAL SECTIONS PROVIDED BY RIVERSDALE RESOURCES LIMITED APRIL 6, 2016.

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RIVERSDALE RESOURCE LIMITED

CONSULTANT
Golder Associates

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PREPARED	SMR
DESIGN	SMR
REVIEW	AVC
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

TITLE
GEOLOGICAL SECTION 8
SECTION 1020

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**A-8**

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APPENDIX B

Field Investigations

1.0 2016 FIELD INVESTIGATION

The following sections present the methodology and the results of the 2016 Mini Pit geotechnical field investigations carried out by Golder personnel from May 15 to 27, 2016.

1.1 Methodology

Detailed geotechnical core logging was carried out at the drill site by personnel from Golder's Vancouver office. Geotechnical logging was undertaken in accordance with Golder's *Geotechnical Core Logging Guidelines* that were developed specifically for the Grassy Mountain Project. The descriptive terms and standards used by Golder to describe the geotechnical characteristics of the recovered rock are broadly consistent with terminology recommended by the American Society for Testing and Materials (ASTM), and the International Society for Rock Mechanics (Brown 1981).

Core photos of the three drillholes are provided in Appendix C.

Point Load Testing (PLT) was carried out by Golder personnel after the core was logged and photographed. PLTs were carried out on representative rock types, generally at 3 to 4 m depth intervals. The raw PLT data is presented in Appendix D.

Rock core samples for laboratory testing were collected by Golder personnel, and the samples were shipped to Golder's Burnaby, British Columbia laboratory. Unconfined Compressive Strength (UCS) testing and direct shear testing were carried out on the samples. Table B-1 lists the samples selected for laboratory testing, and details of the testing is presented in Appendix D.

Table B-1: Geotechnical Rock Sample Laboratory Testing Program

Borehole ID	Sample ID	Depth From (mah)	Depth To (mah)	UCS Testing	Direct Shear Testing
RGSC-0011	6	151.57	151.80	X	
RGSC-0012	8	41.19	41.45	X	
RGSC-0012	11	90.52	90.85	X	
RGSC-0012	13	128.51	128.85	X	
RGSC-0013	17	105.21	105.54	X	
RGSC-0013	18	126.64	126.96	X	
RGSC-0012	10	55.35	55.62		X
RGSC-0013	15	49.90	50.22		X

Downhole plots of the geotechnical borehole logging data and rock mass quality results are presented in Appendix E.

Downhole geophysical surveys were conducted in all three boreholes by Century Wireline Services Ltd. (Century). Century carried out the following downhole geophysical logging methods:

- Borehole deviation (azimuth and tilt);
- Caliper;
- Fluid resistivity;
- Gamma;
- Neutron density;
- Formation Dip Meter; and
- Acoustic televiewer (ATV) surveys.

2.0 GRASSY MOUNTAIN ENGINEERING GEOLOGY

The site engineering geology model derived from the results of the field investigations, the field investigations carried out by Golder in 2014 (Golder 2015), and previous experience at other open pit coal mines located nearby in the Elk Valley is discussed in the following subsections.

2.1 Intact Rock Strength

Intact rock strength data was collected during the field investigation as follows:

- field estimates of intact rock strength collected during core logging;
- Laboratory Uniaxial Compressive Strength (UCS) on selected rock core samples; and
- field point load testing on rock core samples.

2.1.1 Field Estimate of Intact Rock Strength

During the 2016 field investigation, approximately 433.50 m of rock core from the Grassy Mountain Project was geotechnically logged. Field estimates of intact rock strength were collected by Golder personnel during geotechnical core logging, using the International Society of Rock Mechanics (ISRM) methods (Brown 1981). Field estimates of intact rock strength are summarized in Table B-2.

Table B-2: Summary of ISRM Intact Rock Strength Estimates (Brown 1981)

Grade	Description	Field Identification	Approximate Range of Uniaxial Compressive Strength (MPa)
R0	Extremely weak rock	Indented by thumbnail.	0.25 to 1.0
R1	Very weak rock	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife.	1.0 to 5.0
R2	Weak rock	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer.	5.0 to 25
R3	Medium strong rock	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer.	25 to 50
R4	Strong rock	Specimen requires more than one blow of geological hammer to fracture it.	50 to 100
R5	Very strong rock	Specimen requires many blows of geological hammer to fracture it.	100 to 250
R6	Extremely strong rock	Specimen can only be chipped with geological hammer.	>250

A histogram of the field estimates of intact rock strength by geological formation is presented in Plate B-1 below.

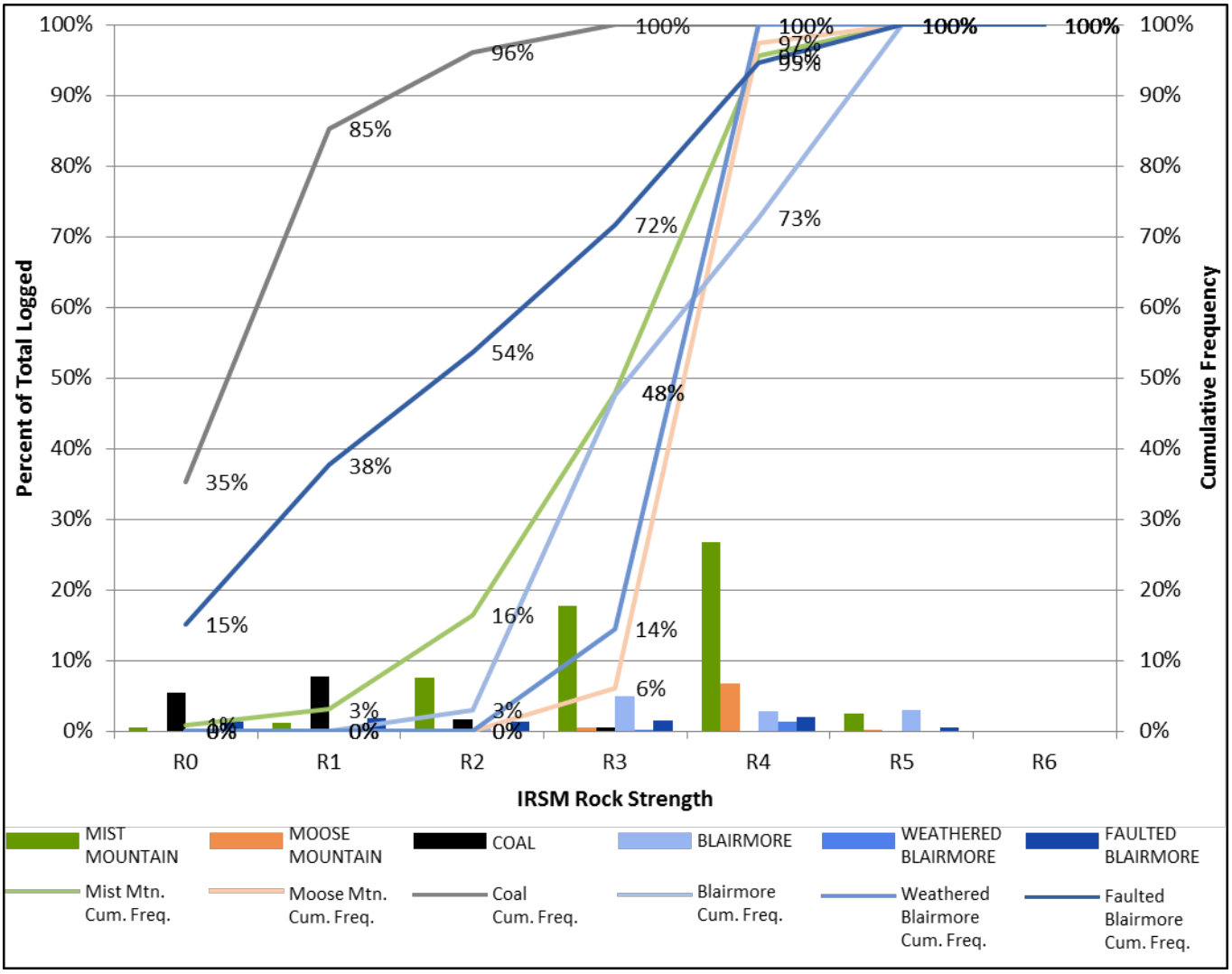

Plate B-1: Distribution of Logged ISRM Estimated Field Strength by Geological Formation

The following observations have been made with respect to the field strength estimate data:

- The average logged rock strength for coal of the Mist Mountain Formation typically ranges from R0 (extremely weak rock) to R3 (medium strong rock). Approximately 85% of the coal was logged as less than R1 and 15% logged as R2 and R3. The average estimated rock strength the coal is R1 (very weak).
- The average logged strength of all rock types of the Mist Mountain Formation is R4 (strong rock). However, 84% of the rocks logged are estimated as R3 (strong rock) or better. The weak rock (R0 to R2) component accounts for 16% of the Mist Mountain, and is considered representative of the carbonaceous mudstone and finely bedded siltstone. The strong rock (R3 to R5) component is representative of the more massive siltstones and sandstones.

- The average logged strength of the Blairmore Group is R3 (medium strong rock), however, over 50% of the rocks logged in this group are R4 (strong rock) and higher in strength. The average logged strength of the weathered Blairmore Group is R4 (strong rock), 86% of the rock was logged as R4 with the remaining 14% logged as R3. The average logged strength of the faulted Blairmore Group is R2, almost half of the faulted Blairmore Group was logged as either R1 or R4.
- The average strength of the Moose Mountain is R4.

2.1.2 Point Load Testing

Point Load Testing (PLT) was carried out by Golder personnel on rock core samples collected from boreholes RGSC-0011 to RGSC-0013. A total of 189 tests were performed, of which 161 were valid tests. Tests were considered invalid if the sample did not break cleanly and entirely through the intact sample at failure. A test was deemed invalid under any of the following conditions:

- fragments of rock chipped off the sample (chipping);
- the platens of the point load tester dug into the weak sample (punching);
- the sample slipped out of the centre of the platens (slipping); or
- the test could not be completed because the rock strength exceeded the point load tester gauge range.

If a sample broke along a pre-existing discontinuity such as a healed joint or along foliation, it was considered invalid if the break did not occur through the entire sample. It is common practice to exclude invalid test results from the statistical analysis.

A summary of the valid PLT results is summarized in Table B-3 and

Table B-4, and the raw data is presented in Appendix D.

Table B-3: Summary of Diametral Point Load Strength Index Results

Point Load Strength ($Is_{(50)}$ MPa)		Diametral Point Load Test					
		Mist Mountain	Moose Mountain	Coal	Blairmore	Faulted Blairmore	Weathered Blairmore
Range	Maximum	6.73	9.56	0.82	6.73	6.19	6.45
	Minimum	0.28	1.50	0.12	0.58	0.86	4.22
Average		2.75	4.01	0.29	1.11	1.80	1.11
Median		2.67	2.65	0.55	5.33	2.19	5.33
Standard Deviation		1.31	2.90	0.29	1.11	1.80	1.11

Table B-4: Summary of Diametral Point Load Strength Index Results

Point Load Strength ($Is_{(50)}$ MPa)		Axial Point Load Test					
		Mist Mountain	Moose Mountain	Coal	Blairmore	Faulted Blairmore	Weathered Blairmore
Range	Maximum	18.92	9.91	4.97	11.36	2.61	9.66
	Minimum	1.30	6.02	4.97	1.31	1.74	5.68
Average		5.63	7.34	4.97	3.80	2.17	8.19
Median		4.87	7.28	4.97	3.49	2.17	9.22
Standard Deviation		3.60	1.38	0.00	2.16	0.43	1.78

2.1.3 Intact Rock Strength Laboratory Testing – Unconfined Compressive Strength

A total of 6 UCS tests were performed on rock core samples collected by Golder during the 2016 field investigation. These tests were carried out according to ASTM D7012-10 *Standard Test Method for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures* Method C: Uniaxial Compressive Strength of Intact Rock Core Specimens. The laboratory test results are summarized in Table B-5, and the UCS test data sheets are included in Appendix D.

Table B-5: Summary of UCS Laboratory Testing Results

Borehole ID	Depth From (mah)[1]	Depth To (mah)[1]	Length (m)	Rock Type[2]	Formation	Wet Density (kg/m^3)	Stress (MPa)	Failure Mode	
								Type[3]	Degree
RGSC-0011	151.57	151.80	0.23	Mudstone	Mist Mountain	2601	20.1	5	35
RGSC-0012	41.19	41.45	0.26	Siltstone	Blairmore	2622	37.0	6	-
	90.52	90.85	0.33	Mudstone	Mist Mountain	2631	46.8	1/6	-
	128.51	128.85	0.34	Mudstone	Mist Mountain	2596	37.9	1	-
RGSC-0013	105.21	105.54	0.33	Mudstone	Mist Mountain	2593	41.4	6/5	28
	126.64	126.96	0.32	Sandstone	Moose Mountain	2606	65.6	1	-

1) mah = meters along hole, relative to ground surface.

2) Rock type logged by Golder personnel during sample collection.

3) Codes for failure mode as follows: 1 – simple extension; 2 – multiple extension; 3 – multiple fracturing; 4 – multiple shear; 5 – single shear; 6 – spalling; 7 – other.

Due to the limited UCS sample set, it is difficult to determine an accurate UCS-Point Load Strength (Is_{50} MPa) correlation for the rocks at Grassy Mountain. In addition, due to the heterogeneous nature of the sedimentary rock, a large number of UCS and point load tests would have to be carried out on each rock type to establish a reliable UCS-Point Load Strength correlation. This is not considered to be necessary. Rather, the point load strength results provide a continuous record of estimated intact rock strength along the length of the borehole, as shown in the Downhole Borehole Plots (Appendix E). The combined UCS and Point Load Strength testing demonstrate that the rocks at the Grassy Mountain project can be classified as weak to medium strong rock rocks, and exhibit similar intact rock mass strengths to the rock exposed at the other coal mines in the nearby Elk Valley.

2.2 Discontinuity Characterization Data

2.2.1 Joint Condition Rating Data

The joint condition rating (JCR) is a parameter used in the RMR_{76} rock mass classification system (Bieniawski 1976) to describe the small-scale surface characteristics of open discontinuities, based on visual estimates of the discontinuity surface roughness and wall rock alteration. A discrete numeric rating of 0, 6, 12, 20, or 25 is assigned based on the evaluation of the shape and the roughness of the discontinuity, as shown in Table B-6.

Table B-6: Rating Guide for Joint Condition Rating

Condition of Joints	Rating
Soft gouge >5 mm thick, or joints open >5 mm; continuous joints	0
Slickensided surfaces, or gouge <5 mm thick, or joints open 1–5 mm; continuous joints	6
Slightly rough surfaces, separation <1 mm, soft joint wall rock	12
Slightly rough surfaces, separation <1 mm, hard joint wall rock	20
Very rough surfaces, not continuous, no separation, hard joint wall rock	25

Source: Modified from Bieniawski 1976.

> = greater than; < = less than; mm = millimetre.

Golder personnel collected JCR data for individual discontinuities, and also estimated an average JCR for each geotechnical interval logged. The interval JCR was assigned based on the most representative joint conditions observed in the interval.

The discontinuity JCR data do not take into account intervals of lost core or very weak rock, where features were not able to be logged the JCR was assigned 0. In other words, the feature JCR data only represents the quality of features that were able to be observed and logged. It has been assumed that lost core intervals encountered very weak rocks that would contain weak rock and weak discontinuities that exhibit a low JCR value. The logged JCR values for the geotechnical intervals by lithology are summarised in Plate B-2.

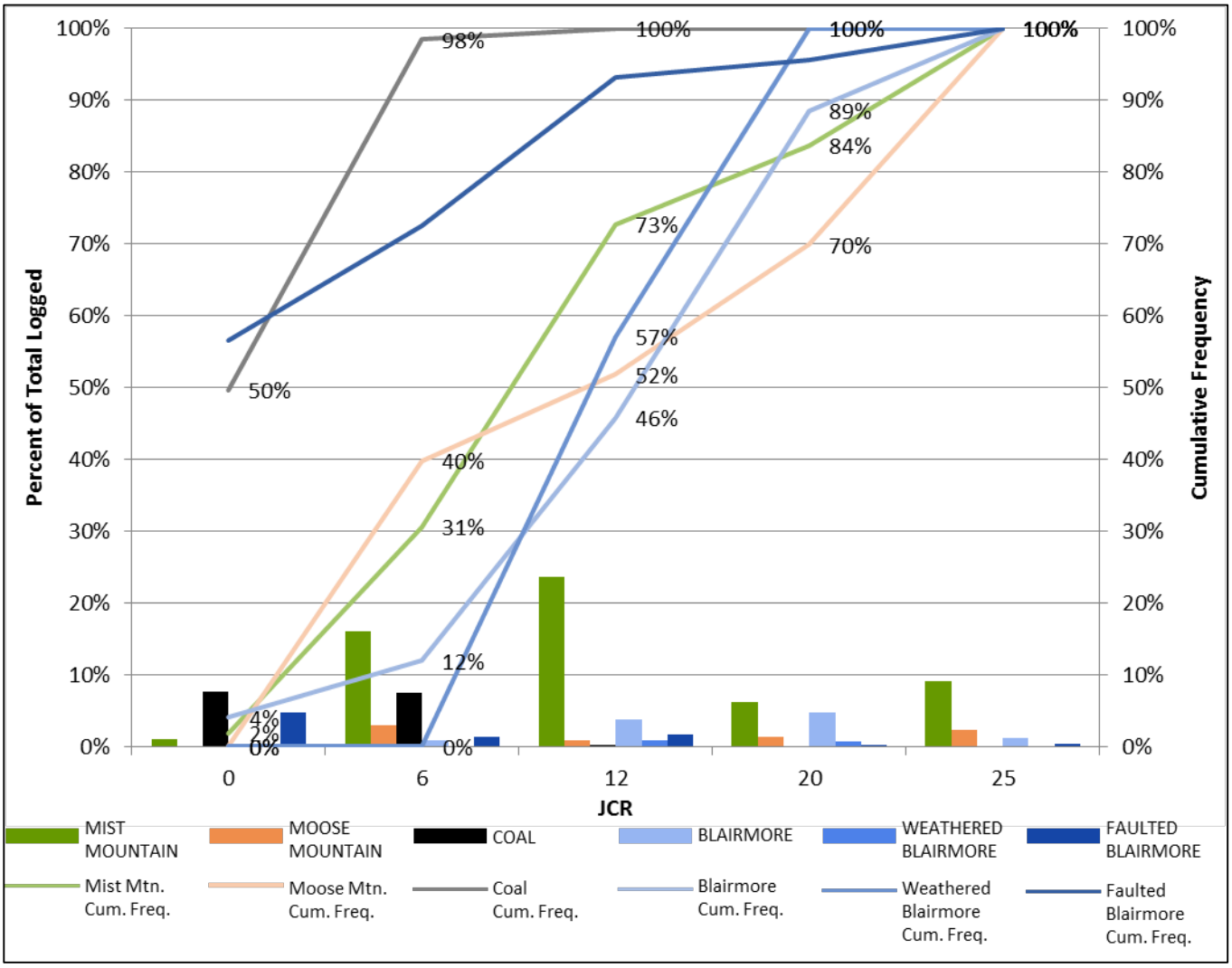

Plate B-2: Distribution of Geotechnical Interval Joint Condition Rating (JCR) Values by Geological Formation

The following observations have been made with respect to the interval JCR data:

- The coal of the Mist Mountain was generally assigned an interval JCR value of 0 or 6. 50% of the coal was assigned an interval JCR value of 0, and 49% was assigned a value of 6.
- The average interval JCR logged in the Mist Mountain formation rocks is 12, in the Moose Mountain is 6, in the Blairmore Group is 20, and in the weathered and faulted Blairmore Group is 0.
- Interval JCR values of 12 and 20 were logged for approximately 53% of the Mist Mountain formation rocks. 31% was logged with an interval JCR of 0 or 6. 16% was logged with an interval JCR of 25.
- An Interval JCR value of 6 was logged for approximately 40% of the Moose Mountain. 12% was logged as 12; 18% logged as 20; and 30% as a JCR of 25.

- An Interval JCR value of 20 was logged for approximately 43% of the Blairmore Group. 11% logged as 25; 34% logged as 12; 8% was logged as 6; and 4% as a 0.
- The weathered Blairmore Group has 48% core logged as a JCR of 0; 14% logged as 6; 26% logged as 12; and the remaining 13% as 20 and 25.
- The faulted Blairmore Group has 57% core logged as a JCR of 0; 16% logged as 6; 21% logged as 12; the remaining 7% was logged as 20 and 25.

2.2.2 Direct Shear Testing of Discontinuities

A total of two discontinuities were selected for direct shear testing, with three tests performed on each sample. These tests were carried out according to ASTM D5607-08 *Standard Test Method for Performing Laboratory Direct Shear Strength Tests of Rock Specimens Under Constant Normal Force*. Details on the samples selected for testing are summarized in Table B-7. The results of the tests, as well as plots of the direct shear data, are included in Appendix D.

Table B-7: Summary of Direct Shear Laboratory Testing

Borehole ID	Depth From (mah)[1]	Depth To (mah)[1]	Length (m)	Feature Type	Feature Angle (deg.)	Peak Test		Residual Test	Rock Type[2,3]
						Normal Stress (kPa)	Peak Shear Stress (kPa)	Normal Stress (kPa)	
RGSC-0012	55.35	55.62	0.28	Joint	62	200	680	100	SST
								200	
								300	
RGSC-0013	49.90	50.22	0.32	Joint	47	200	170	100	MST
								200	
								300	

1) mah = meters along hole, relative to ground surface.

2) Rock type logged by Golder personnel during sample collection.

3) SST = Sandstone; MST = Mudstone.

2.3 Rock Mass Quality

An assessment of the overall quality of the rocks that will be exposed at the proposed Mini Pit has been prepared using the Rock Mass Rating (RMR^{76}) rock mass classification system (Bieniawski 1976), based on the data collected from the 2016 geotechnical drilling investigation.

The RMR_{76} classification system ranks the following five geotechnical parameters:

- *R1* = rating for the strength of intact rock material (rating = 0 to 15).
- *R2* = rating for drill core quality, Rock Quality Designation, RQD (rating = 3 to 20).
- *R3* = rating for spacing of joints (rating = 5 to 30).

- *R4* = rating for condition of joints, JCR (rating = 0 to 25).
- *R5* = rating for groundwater (rating = 0 to 10).

The overall rock mass quality is determined by summing the individual rankings as follows.

$$RMR_{76} = R1 + R2 + R3 + R4 + R5$$

The rock mass classes as a function of rock mass ratings are summarized in Table B-8.

Table B-8: Rock Mass Rating System (Bieniawski, 1976)

RMR_{76} Rating	Rock Mass Class	Legend
81 to 100	Class I – Very Good Rock	
61 to 80	Class II – Good Rock	
41 to 60	Class III – Fair Rock	
21 to 40	Class IV – Poor Rock	
20 or less	Class V – Very Poor Rock	

As per industry practice, a groundwater rating of 10 (i.e., dry conditions) has been assumed for the rock mass classification, as the groundwater conditions have been added directly to the limit equilibrium slope stability analyses.

The four geotechnical parameters logged and the resulting RMR_{76} for each geotechnical interval are shown in the borehole plots presented in Appendix E.

The following rules have been applied for RMR_{76} calculations:

- RMR_{76} classification parameters are not assigned to overburden materials.
- RQD values for soil and weak rock (R0 and R1 rock strengths) are assigned 0%. This is consistent with standard industry practice, where RQD is considered to apply to sound and competent rock.
- JCR values for soil and weak rock (i.e., soft joint wall conditions) are assigned a maximum value of 12.

A JCR value for broken core was assigned based on the representative surface characteristics of the fractured rock pieces within the interval.

Plate B-3 presents the RMR_{76} frequency histogram for all core logged.

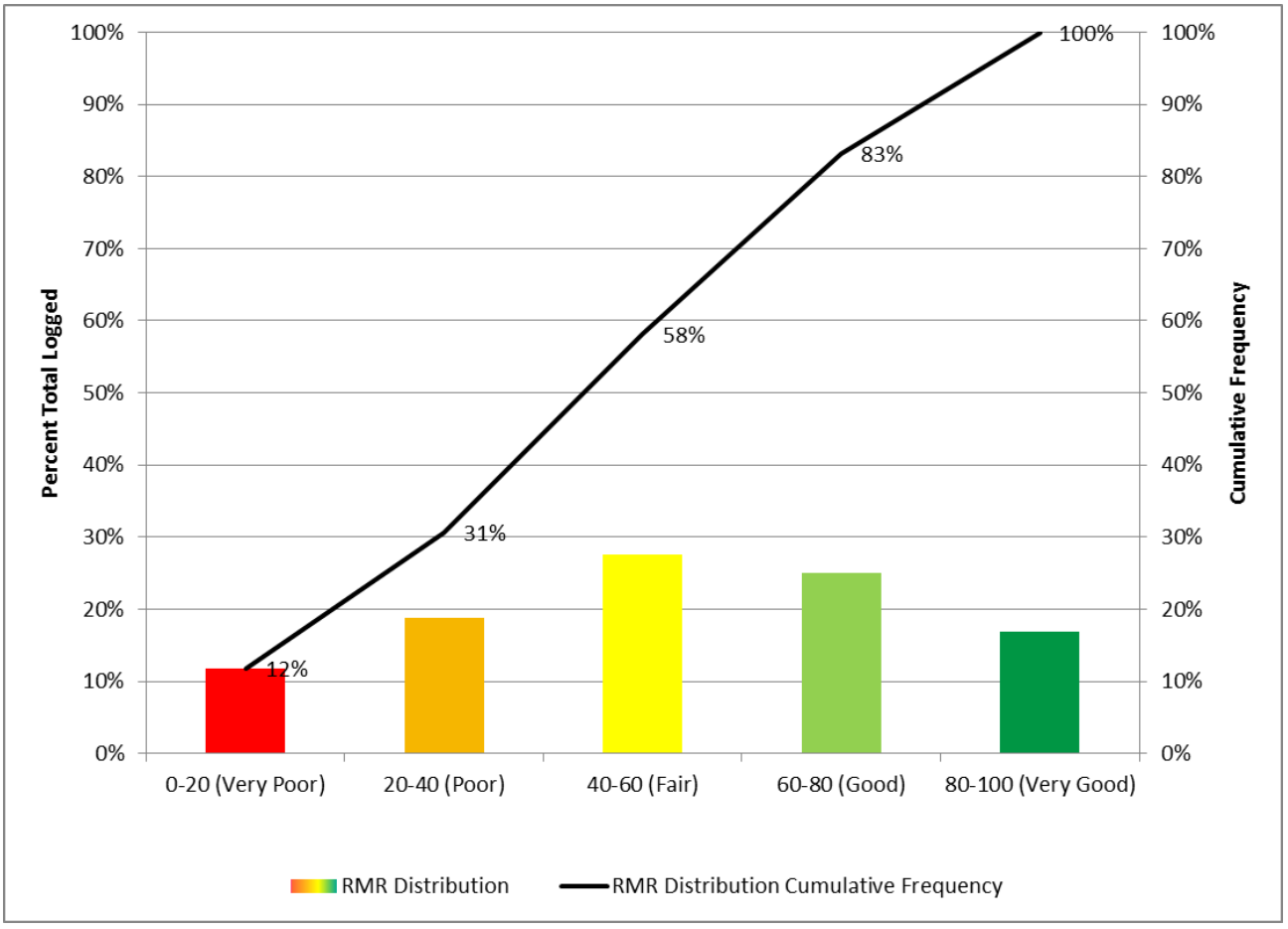

Plate B-3: RMR_{76} Distribution - All Borehole Data

The rock mass quality data have been divided based on the geological formations encountered at Grassy Mountain. The average RMR_{76} values were determined using a weighted average based on the variable geotechnical interval lengths, and are summarized in Table B-9.

Table B-9: Summary of Weighted RMR_{76} Classification Values

Dataset	Geological Formation	RMR_{76}[(a)] (Weighted Average)	Rock Mass Classification (RMR_{76})
All Boreholes	Mist Mountain [(b)]	55	Fair Rock
	Moose Mountain	69	Good Rock
	Mist Mountain – Coal	10	Very Poor Rock
	Blairmore Group	65	Good Rock
	Weathered Blairmore Group	51	Fair Rock
	Faulted Blairmore Group	36	Poor Rock
	All Data	**48**	**Fair Rock**

(a) RMR_{76} values were determined using a weighted average based on the variable geotechnical interval lengths.

(b) Mist Mountain Formation includes all rock types (mudstone, carbonaceous mudstone, and siltstone) with the exception of the coal data.

2.4 Structural Orientation Data

As part of the 2016 geotechnical investigation, orientation data was collected for geological discontinuities by Century. ASIMS (Acoustic Scanner and Sonic Log Interpretation) interpreted the raw televiewer images and oriented the data to Mine Grid North. Pertinent geological features (i.e. bedding, joints, and faults) were picked from the ATV logs and the processed structural orientation data were provided to Golder.

Lower hemisphere, equal area stereographic projections of the geological orientation data have been produced using the Rocscience software, Dips (Version 6.0). The stereographic projections and downhole plots are presented in Appendix F. The observed structures are discussed in the following sections.

2.4.1 Bedding, Cross Joint Structures and Faults

The bedding features in the sedimentary strata in the Rocky Mountains have been observed to be continuous over hundreds of meters. The bedding at the Grassy Mountain deposit typically strikes north-northeast-south-southwest Bedding spacing varies by rock type, and varies from a few cm in the mudstones to a few metres in the thickly bedded Moose Mountain sandstone.

Sedimentary strata also typically contain to prominent cross-joint sets. One set typically strikes parallel or near parallel to bedding strike, and dips orthogonal to the bedding. The second set typically strikes perpendicular to the strike of the bedding and orthogonal to the first joint set. These cross-joint sets and bedding define an orthogonal fracture pattern, in that both joint sets are mutually perpendicular and are oriented perpendicular to the bedding.

For the sake of clarity Golder commonly refers to these joins as the JS1 and JS2 joint sets, respectively, where the JS1 joint set strikes parallel to the strike of the bedding and the JS2 set strikes perpendicular to the strike of the bedding. A schematic of these typical structures in folded sedimentary rocks is shown in Plate B-4.

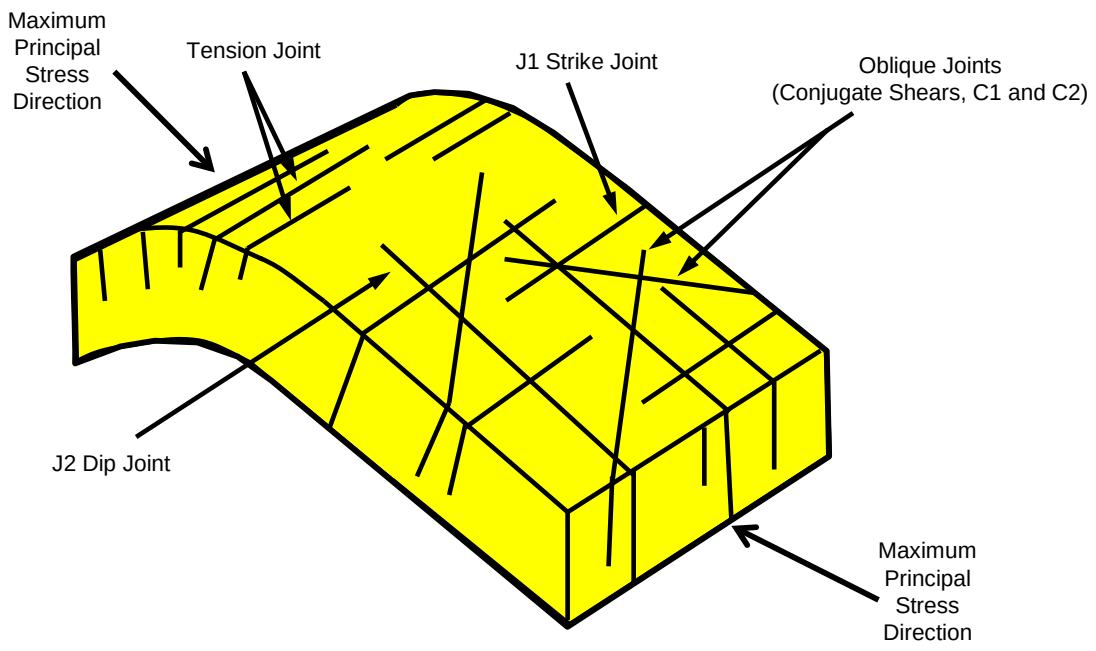

Plate B-4: Typical Structure in Folded Sedimentary Rocks

The deposit also contains westerly dipping thrust faults, and westerly dipping faults that re sub-parallel to the bedding are observed in the televiewer data. Other faults that are sub-parallel to the cross joints are also observed in the televiewer data. In outcrop, these structures are often observed as late stage normal faults that are sub-parallel to the cross joints.

2.4.2 Borehole Structural Data Interpretation

2.4.2.1 RGSC-0011

Borehole RGSC-0011 is located in the lower portion of the proposed footwall slope that will be excavated along the east side of the Mini Pit. Data collected from the ATV surveys indicate that the bedding dips at 10 to 55 degrees towards the west-northwest at 270° to 290° azimuth (Figure F-2). Some easterly dipping bedding is also observed, and this may represent folding adjacent to thrust faults.

Faults that dip toward the west-northwest at a dip angle that is slightly steeper than the bedding are also observed. This is consistent with the dip of the thrust faults and the structural geology interpretation (Figure F-3).

The stereographic projection also shows a cluster of steep,-west dipping joint surfaces and a lesser concentration of steep, easterly dipping joints. The easterly concentration agrees with the expected orientation of the JS1 cross joints (Figure F-4). JS1 joint set is evident in the stereographic projection and is oriented near parallel to bedding strike, dipping at approximately 55 to 80 degrees towards the east southeast (80° to 110° azimuth). The westerly dipping joints may be due to the folded easterly dipping bedding, minor thrust faults or sub-parallel faults that were logged as joint sets, or some steep, folded westerly bedding that were logged as joints.

Only a few of the JS2 joint sets appear to have been captured in this ATV data, and these exhibit a steep, east-northeast dip. This low concentration is likely due to the fact that these joints are sub-parallel to the borehole inclination, and are within the orientation blind spot of the borehole.

Several faults were interpreted from the ATV data. There is a cluster of faults which follow the same dip direction as the major bedding set concentration. These faults dip steeply from 55 to 80 degrees toward the west-northwest (270° to 300° azimuth). This generally agrees with the fault interpretation provided by Riversdale which indicates that the majority of the faulting dips steeply towards the west. These observed structures are likely major and minor thrust faults.

2.4.2.2 RGSC-0012

Borehole RGSC-0012 is located just behind the proposed highwall slope that will be along the west side of the Mini Pit. Data collected from the ATV surveys indicate that the bedding dips at a shallow angle (10 to 35 degrees) to the west (260° to 280° azimuth) (Figure F-6).

There is a cluster of faults dipping steeply (60 to 80 degrees) to the southeast (120° to 160° azimuth) (Figure F-7). These are likely normal faults that are sub-parallel to the cross joints. There are a few westerly dipping faults that correlate with the thrust faults.

Based on the downhole plot (Figure F-14) these faults appears to be in the Faulted Blairmore Group at a downhole depth of approximately 40 to 60 meters. There is a large joint set that follows the dip and dip direction of these faults in the competent Blairmore Group below the weathered and faulted zone.

There is a large concentration of joints that correlate with the east-southeasterly dipping JS1 cross joints, and a lesser concentration that correlates with the north-northeasterly dipping JS2 joints.

2.4.2.3 RGSC-0013

Borehole RGSC-0013 is located in the upper portion of the proposed footwall slope that will be excavated along the east side of the Mini Pit. Data collected from the ATV surveys indicate that the bedding has two separate clusters, one has a moderate dip (40 to 62 degrees) to the west-northwest (270° to 300° azimuth), and the second has a moderate to steep dip (60 to 80 degrees) to the west (260° to 270° azimuth). Based on the downhole plot (Figure F-15) the change in bedding orientation is most likely due to some faulting in the area.

Steep, westerly dipping faults that correlate with the thrust faults are observed.

The stereographic projection shows a cluster of steeply-west dipping joint surfaces which may be indicative of steeper bedding surfaces, the thrust faults, or variable JS1 joint orientations due to folded bedding (Figure F-12). JS1 joint set is evident in the stereographic projection and is oriented near parallel to bedding strike, steeply dipping at approximately 70 to 80 degrees towards the east (85° to 105° azimuth). Weak concentrations of the JS2 cross joints are also observed.

APPENDIX C

Rock Core Photos

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0011
5.91 – 14.91 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-1**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A

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PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0011
14.91 – 20.69 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-2**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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0 1m

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PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0011
20.69 – 26.68 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-3**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0011
26.68 – 32.35 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-4**

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PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0011
32.35 – 38.01 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-5**

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0 1m

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PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0011
38.01 – 44.27 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-6**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A

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PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0011
44.27 – 49.91 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-7**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A

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PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0011
49.91 – 55.33 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-8**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0011
55.33 – 60.82 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-9**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A

0 1m

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PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0011
60.82 – 75.19 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-10**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A

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PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0011
75.19 – 87.76 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-11**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A

0 1m

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0011
87.76 – 100.17 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-12**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0011
100.17 – 114.43 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-13**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0011
114.43 – 120.13 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-14**

Path: \golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0011
120.13 – 125.61 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-15**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0011
125.61 – 131.86 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-16**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT

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PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0011
131.86 – 137.29 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-17**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A

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MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0011
137.29 – 145.77 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-18**

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TITLE
RGSC-0011
145.77 – 152.81 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-19**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A

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MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0011
152.81 – 156.41 m (EOH)
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-20**

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MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
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TITLE
RGSC-0012
5.19 – 7.62 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-21**

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
7.62 – 10.52 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-22**

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0 1in

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MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
10.52 – 13.56 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-23**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A

0 1m

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
13.56 – 15.93 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-24**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
15.93 – 18.43 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-25**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
18.43 – 20.86 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-26**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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0 1in

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
20.86 – 22.68 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-27**

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
22.68 – 24.73 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-28**

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
24.73 – 26.68 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-29**

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
26.68 – 28.76 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-30**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
28.76 – 30.62 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-31**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
30.62 – 32.30 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-32**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
32.30 – 33.97 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-33**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
33.97 – 35.89 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-34**

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0 1m

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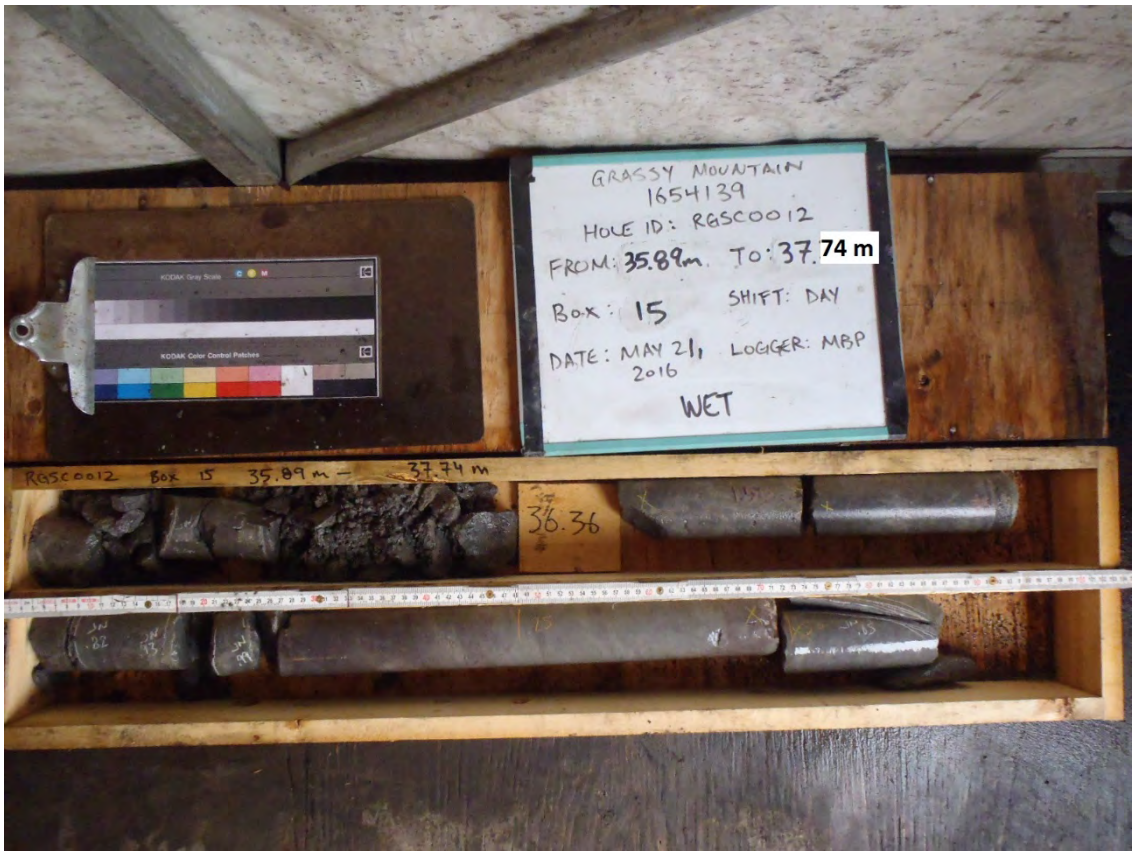

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MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
35.89 – 37.74 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-35**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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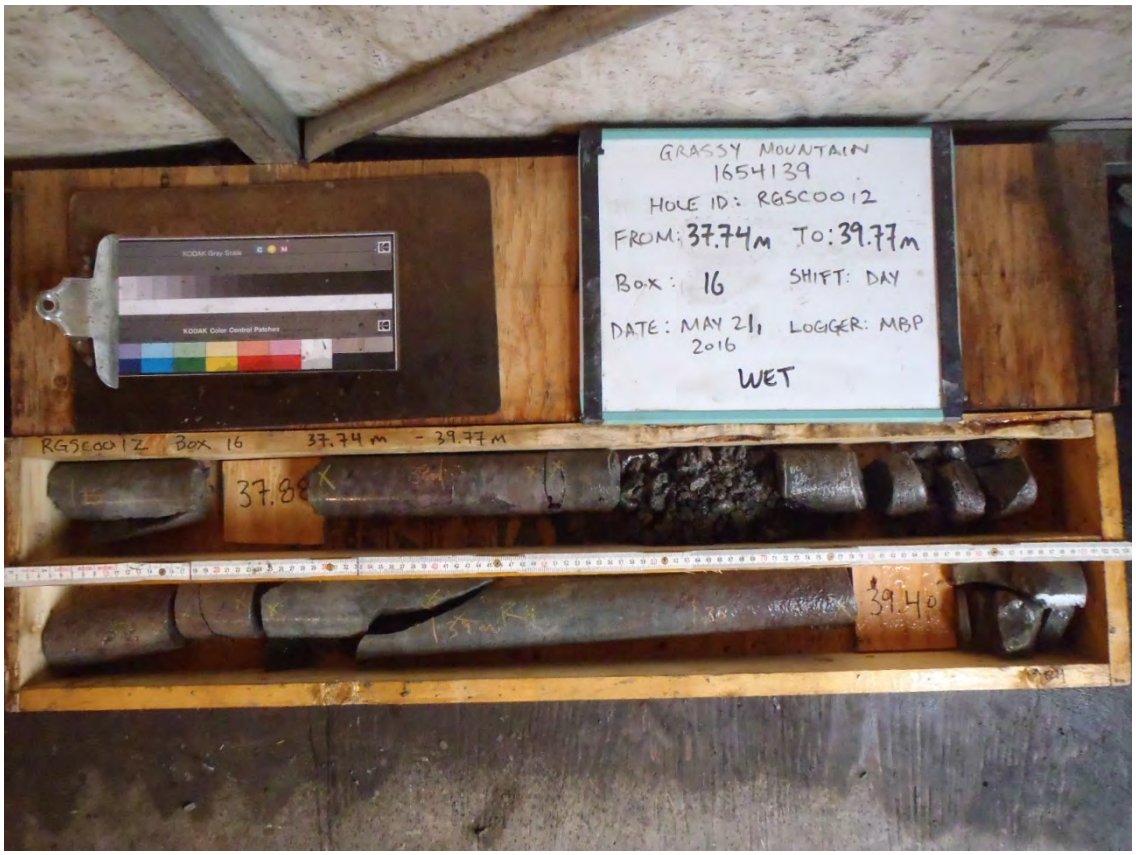
0 1in



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PROJECT
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MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
37.74 – 39.77 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-36**

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
39.77 – 41.47 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-37**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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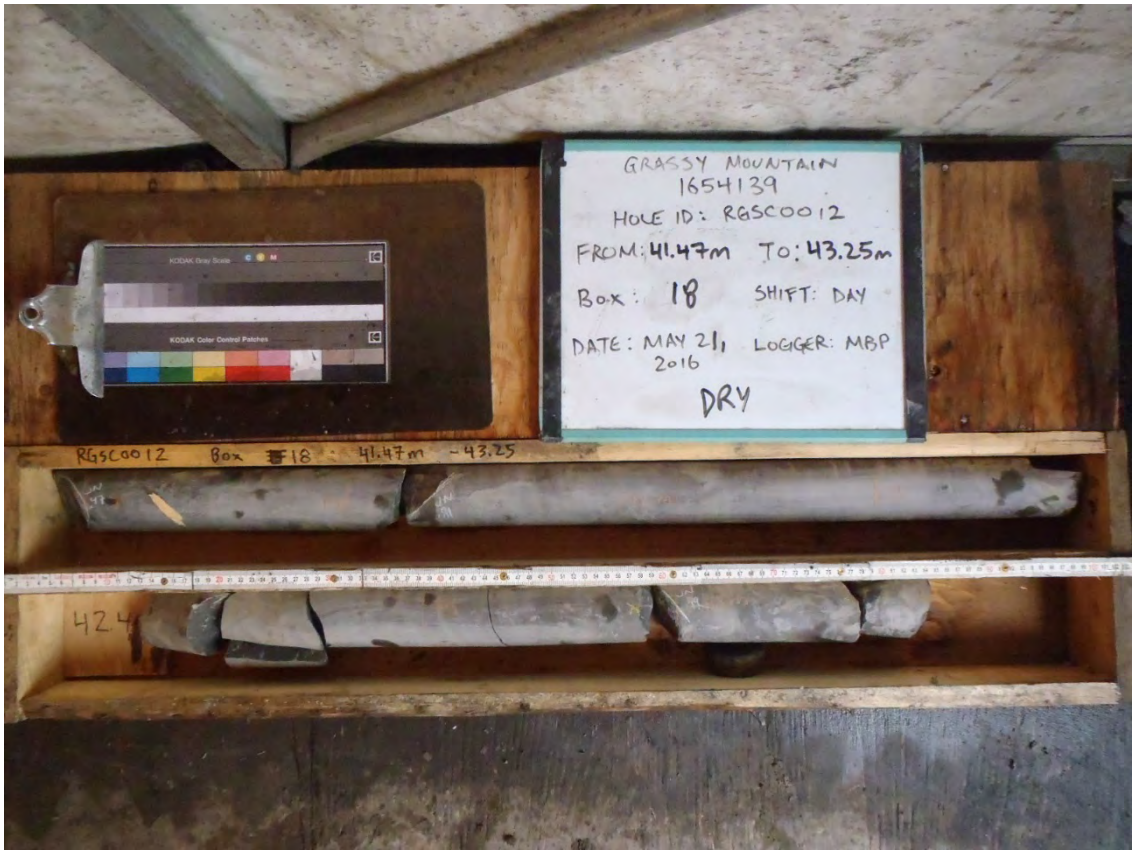
0 1in



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PROJECT
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MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
41.47 – 43.25 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-38**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
43.25 – 45.07 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-39**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
45.07 – 47.00 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-40**

Path: \golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
47.00 – 48.79 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-41**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
0 1m

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
48.79 – 51.36 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-42**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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RIVERSDALE RESOURCES LIMITED

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
51.36 – 53.08 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-43**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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RIVERSDALE RESOURCES LIMITED

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
53.08 – 54.71 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-44**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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RIVERSDALE RESOURCES LIMITED

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
54.71 – 56.50 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-45**

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GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
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APPROVED	AVC

TITLE
RGSC-0012
56.50 – 58.11 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-46**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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DESIGN	AGH
REVIEW	AVC
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TITLE
RGSC-0012
58.11 – 60.42 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-47**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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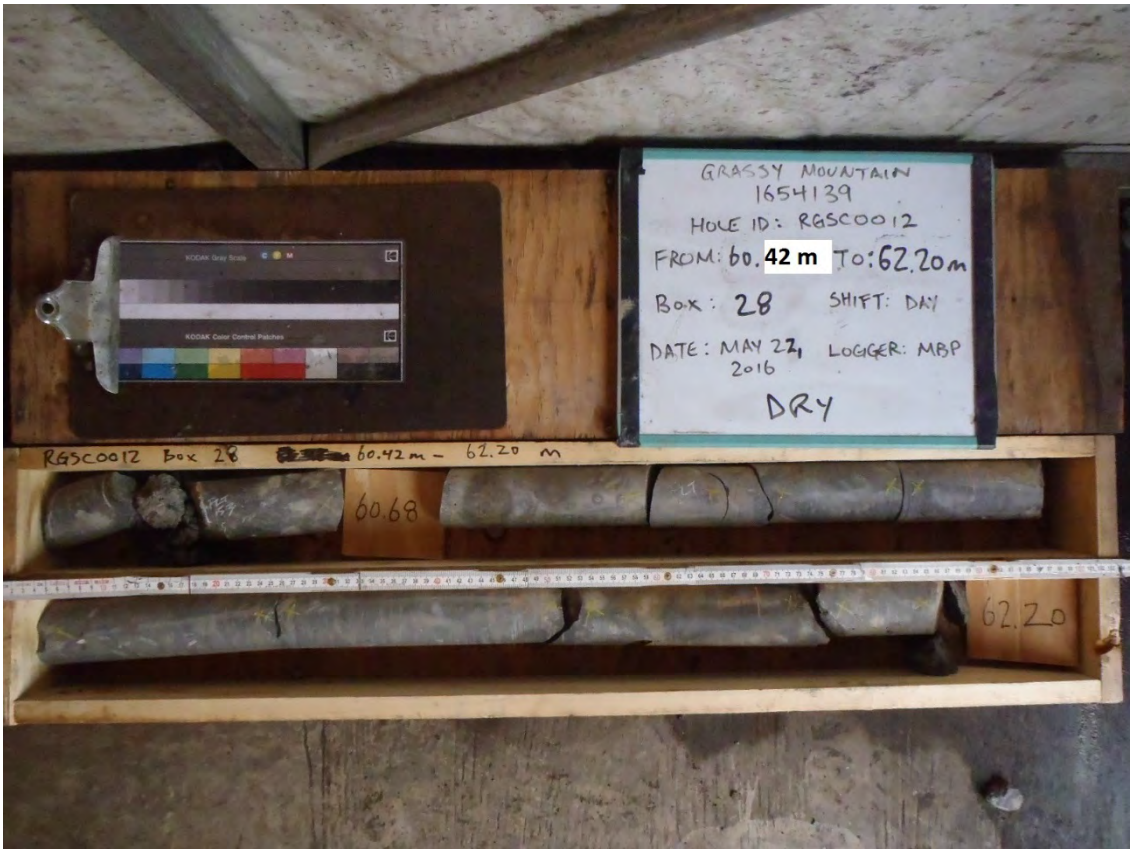

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MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
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TITLE
RGSC-0012
60.42 – 62.20 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-48**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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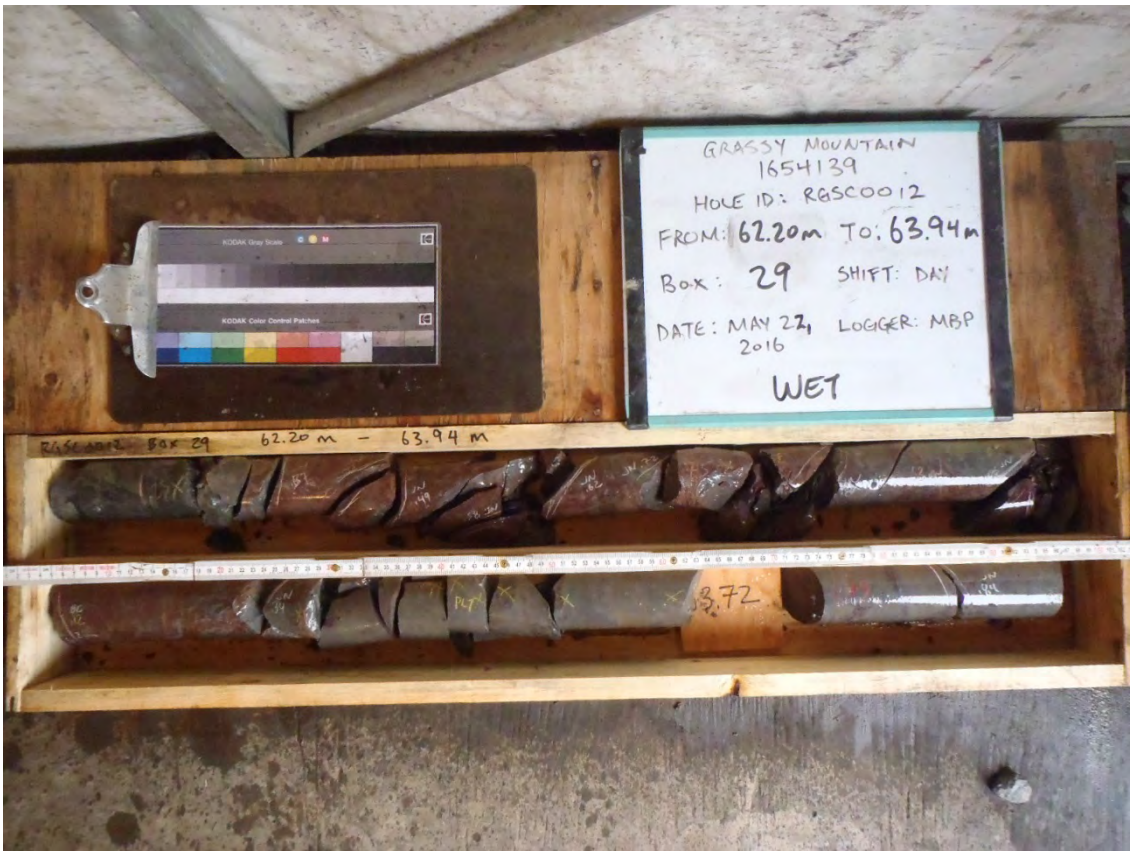

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MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
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TITLE
RGSC-0012
62.20 – 63.94 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-49**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
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TITLE
RGSC-0012
63.94 – 66.03 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-50**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
67.95 – 69.68 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-51**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
69.68 – 71.65 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-52**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
71.65 – 73.46 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-53**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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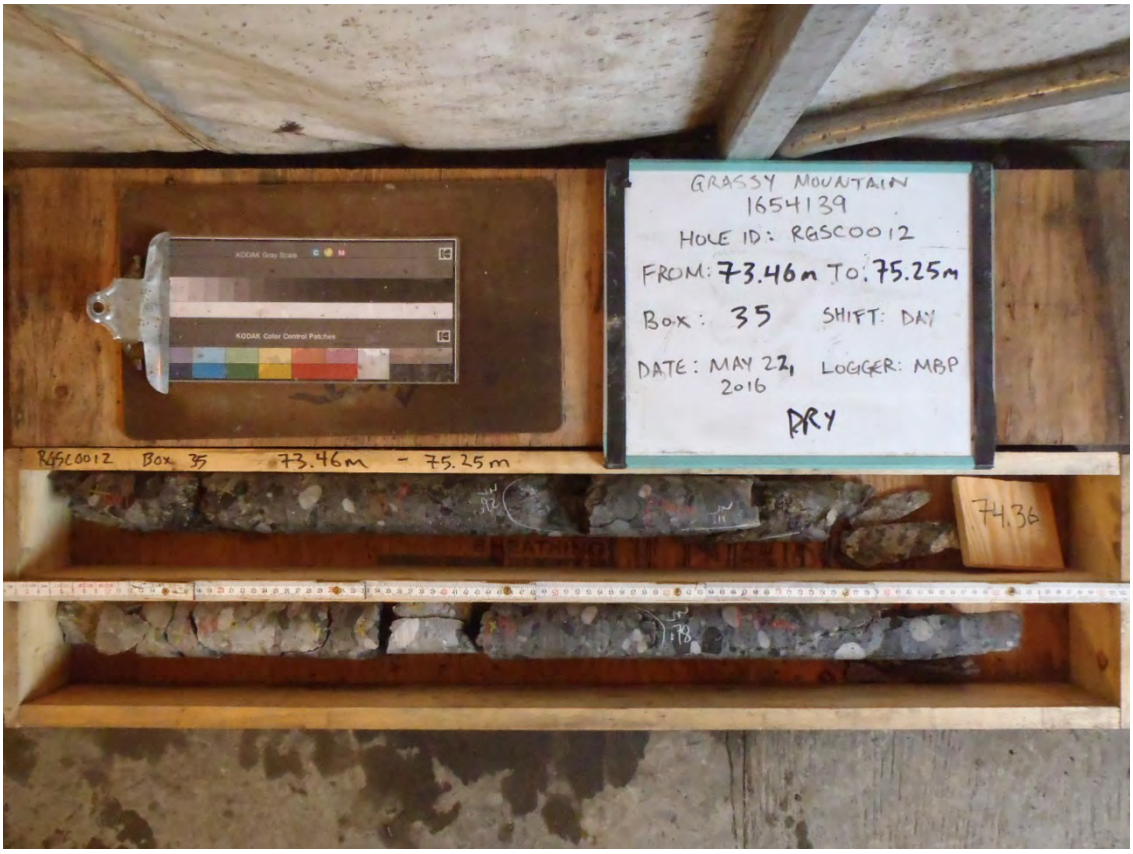

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MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
73.46 – 75.25 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-54**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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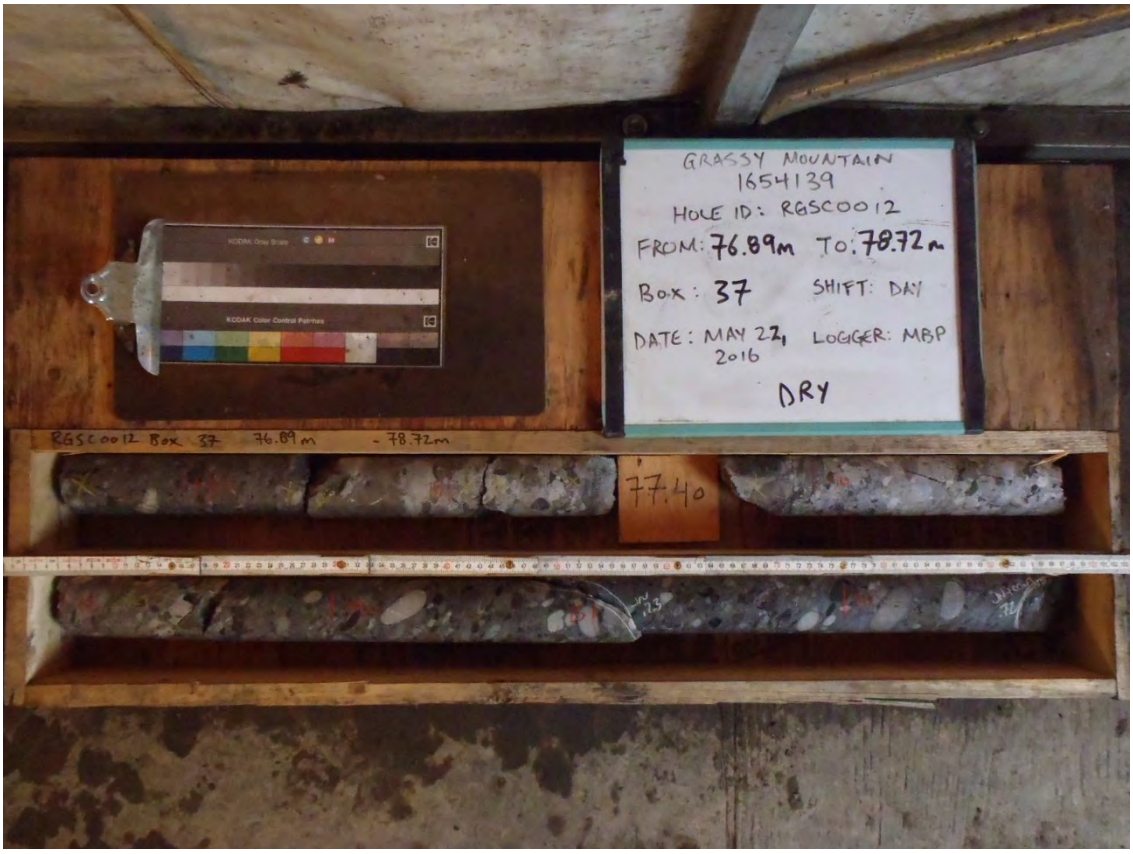

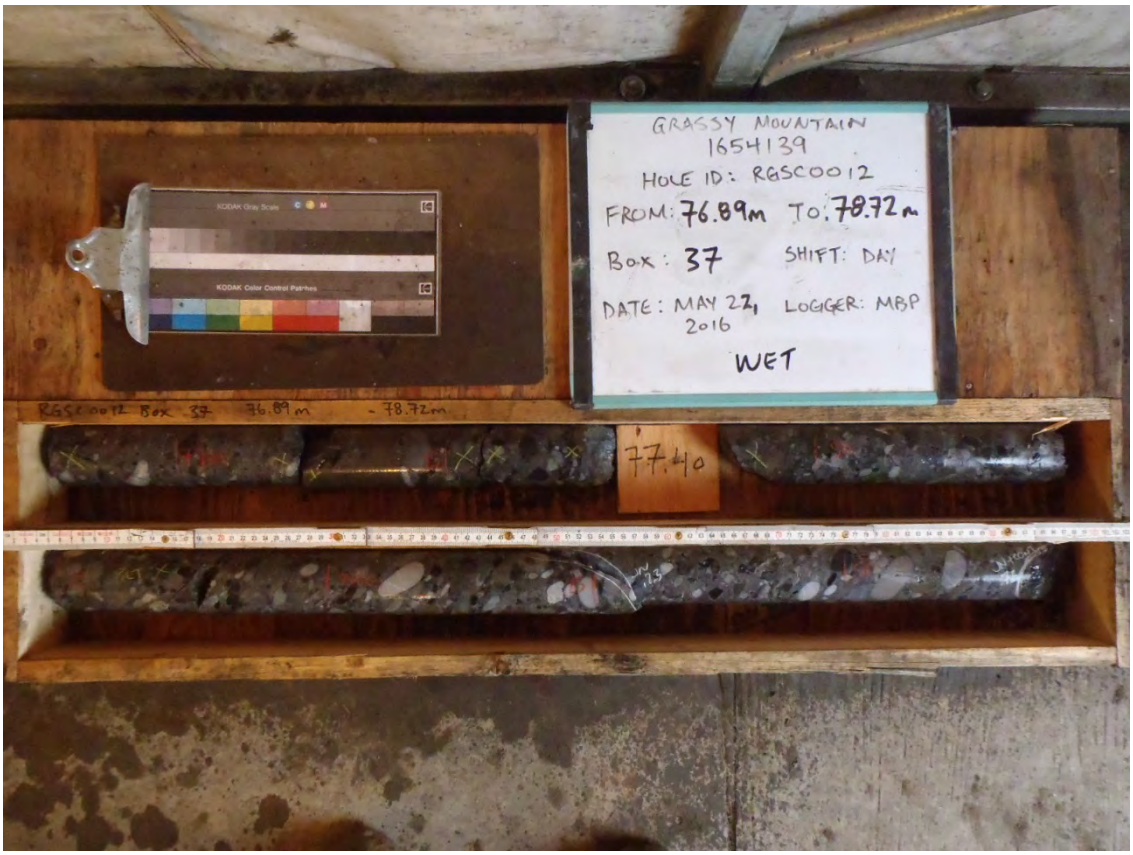

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
76.89 – 78.72 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-55**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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PROJECT
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MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
78.72 – 80.44 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-56**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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PROJECT
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MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
80.44 – 83.02 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-57**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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0 1in

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
83.02 – 85.37 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-58**

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
85.37 – 87.95 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-59**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
87.95 – 90.03 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-60**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
90.03 – 91.87 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-61**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
91.87 – 93.98 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-62**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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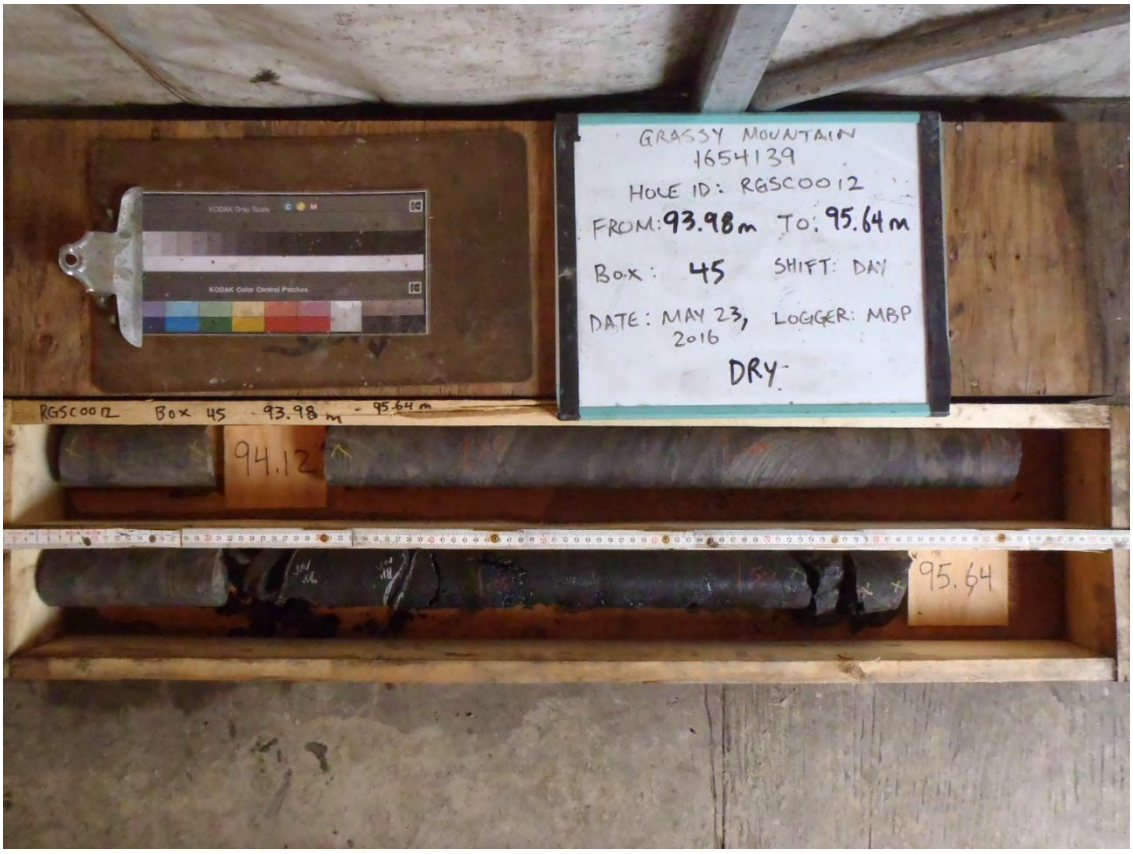

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
93.98 – 95.64 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-63**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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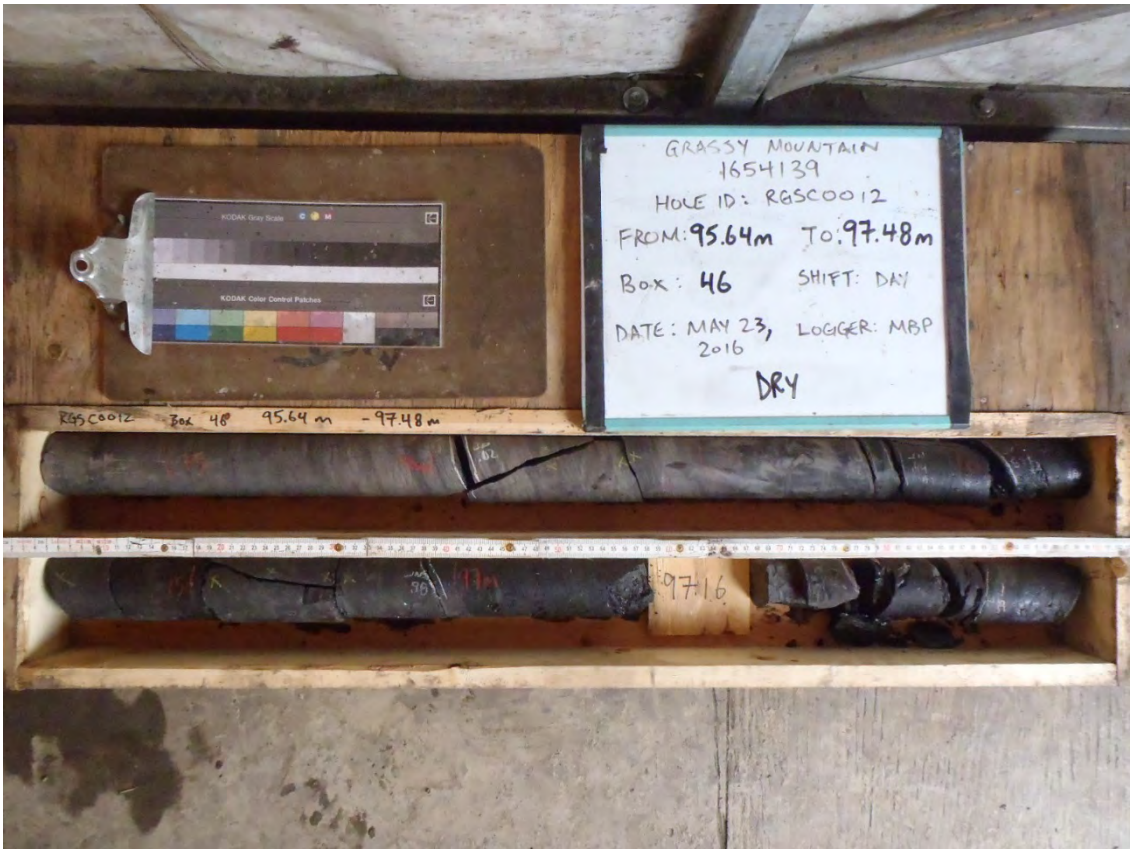

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PROJECT
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MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
95.64 – 97.48 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-64**

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
97.48 – 99.25 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-65**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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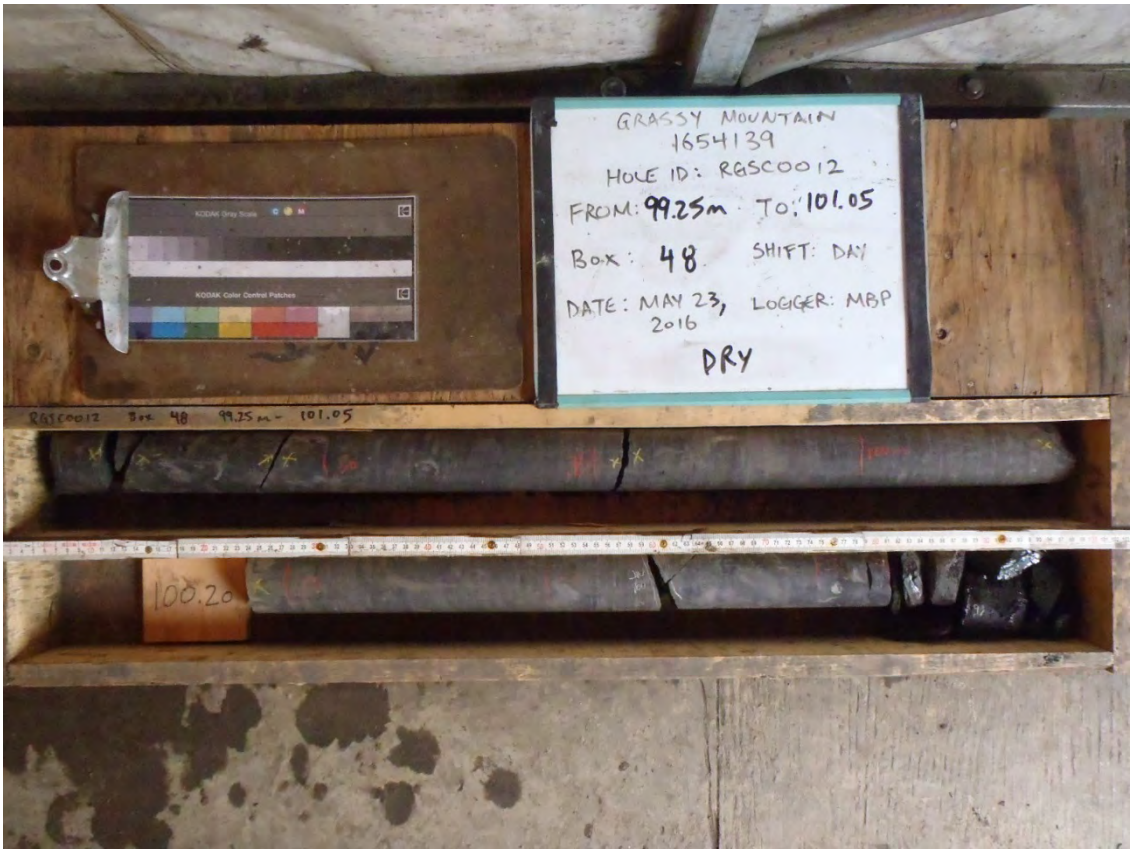

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
99.25 – 101.05 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-66**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
101.05 – 102.85 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-67**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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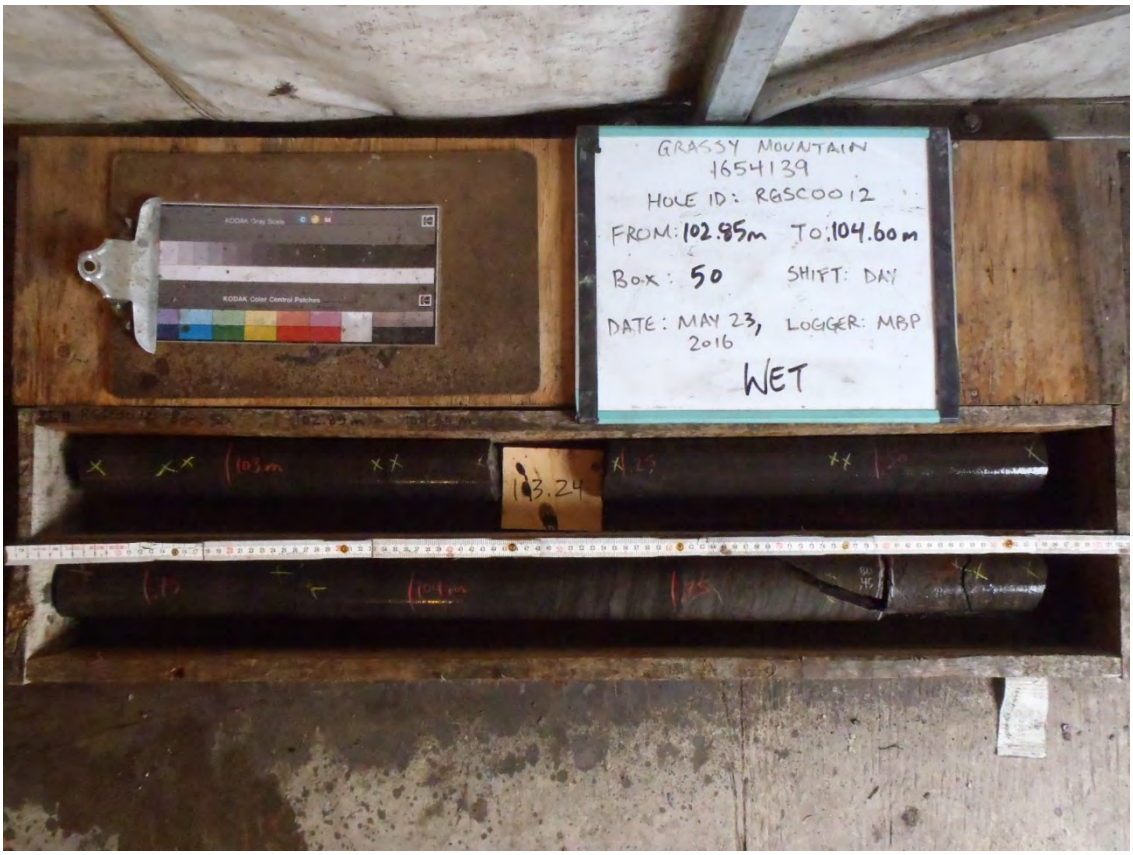

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
102.85 – 104.60 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-68**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
104.60 – 106.28 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-69**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
106.28 – 108.03 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-70**

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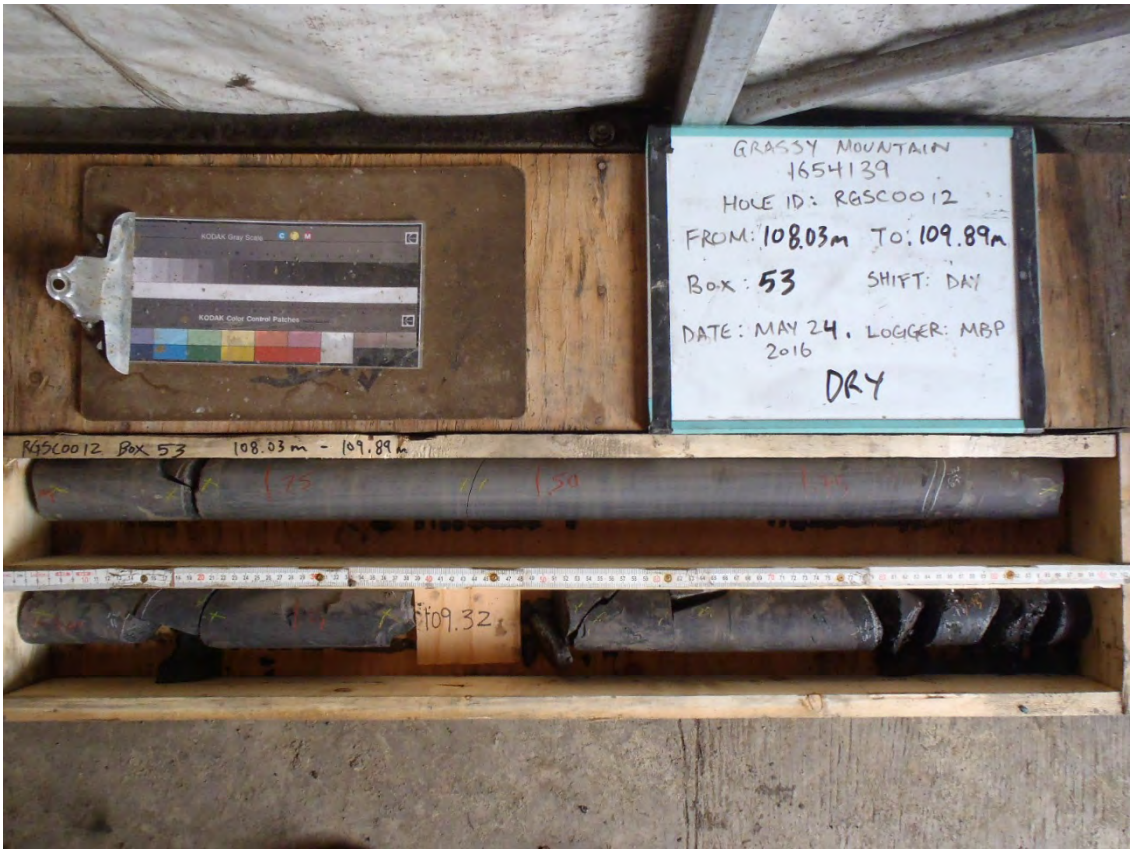

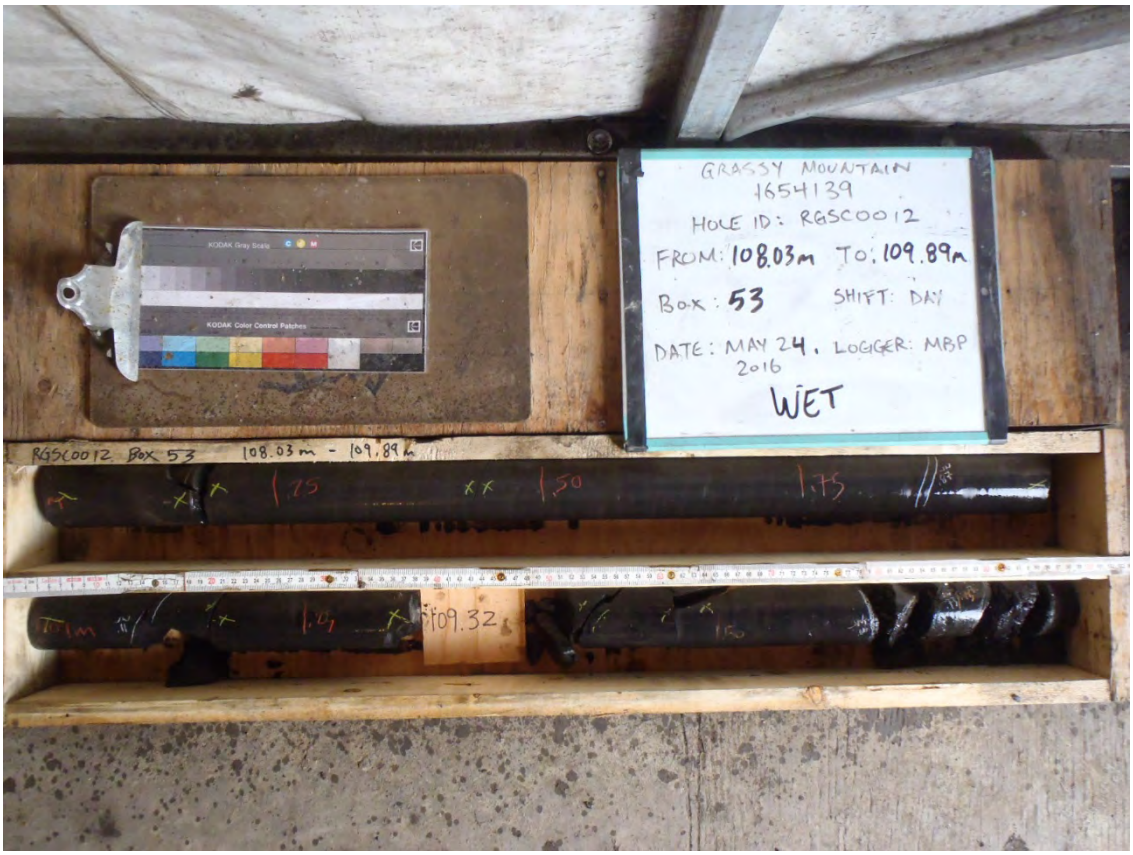

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PROJECT
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MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
108.03 – 109.89 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-71**

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PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
109.89 – 115.40 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-72**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
115.40 – 120.51 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-73**

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MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
120.51 – 123.94 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-74**

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
123.94 – 127.02 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-75**

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
127.02 – 129.71 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-76**

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
129.71 – 132.76 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-77**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
132.76 – 135.50 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-78**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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Golder Associates

YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
135.50 – 138.20 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-79**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07. Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0012
138.20 – 139.72 m (EOH)
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-80**

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
15.15 – 19.44 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-81**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
19.44 – 26.10 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-82**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
26.10 – 29.58 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-83**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
29.58 – 32.30 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-84**

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
32.30 – 35.55 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-85**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
35.55 – 39.08 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-86**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
39.08 – 42.24 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-87**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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0 1in

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PROJECT
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MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
42.24 – 45.13 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-88**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
45.13 – 48.04 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-89**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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PROJECT
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MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
48.04 – 50.85 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-90**

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0 1m

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
50.85 – 53.56m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-91**

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RIVERSDALE RESOURCES LIMITED

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
53.56 – 56.55 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-92**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
56.55 – 64.64 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-93**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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0 1m

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT

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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
64.64 – 69.01 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-94**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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0 1m

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
69.01 – 72.36 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-95**

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RIVERSDALE RESOURCES LIMITED

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
72.36 – 75.04 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-96**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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0 1m

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
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YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
75.04 – 80.17 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-97**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
80.17 – 83.28 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-98**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
83.28 – 86.43 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-99**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-31
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
86.43 – 89.36 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-100**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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PREPARED	AGH
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REVIEW	AVC
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TITLE
RGSC-0013
89.36 – 92.44 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-101**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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0 1in

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PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
92.44 – 95.59 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-102**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
95.59 – 99.26 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-103**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
99.26 – 102.26 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-104**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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0 1in

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PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
102.26 – 105.54 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-105**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
105.54 – 108.62 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-106**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
108.62 – 111.78 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-107**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A

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DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
111.78 – 114.80 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-108**

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0 1in

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TITLE
RGSC-0013
114.80 – 118.29 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-109**

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0 1m

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TITLE
RGSC-0013
118.29 – 121.17 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-110**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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TITLE
RGSC-0013
121.17 – 123.91 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-111**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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PREPARED	AGH
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REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
123.91 – 126.64 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-112**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
126.64 – 134.96 m
DRY/WET

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-113**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx
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PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013
134.96 – 142.56 m
WET/DRY

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**C-114**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix C - Core Photos | File Name: Appendix C - Core Photos.pptx

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APPENDIX D

Point Load and Laboratory Resting Results

AXIAL POINT LOAD TESTING

Golder Associates

POINT LOAD STRENGTH INDEX TEST

Reference
ASTM D5731 - 08

Client	Riversdale Resources Limited	Project No	1654139
Project	Grassy Mountain	Test Date	01-May-16
Location	RGSC0011, RGCS0012, RGSC0013	Tested By	Michael Pak

Axial Test

Test #	Borehole	Depth	D	W	Guage Reading	Load P	$D_e^2=4WD/\pi$	$I_s = P/D_e^2$	$F = (D_e/50)^{0.45}$	$I_{s(50)}$	Type	Direction	Remarks
	No.	m	mm	mm	kN	MN	mm^2	MPa		MPa			
1	RGSC0011	15.12	45.00	63.00	7.63	0.00763	2025.0	3.77	0.954	**3.59**	a		Failed along weak plane
2	RGSC0011	19.94	40.00	63.00	13.14	0.01314	1600.0	8.22	0.904	**7.43**	a		Valid - Intact rock
3	RGSC0011	25.03	40.00	63.00	4.10	0.00410	1600.0	2.56	0.904	**2.32**	a		Valid - Intact rock
4	RGSC0011	27.9	40.00	63.00	8.12	0.00812	1600.0	5.08	0.904	**4.59**	a		Valid - Intact rock
5	RGSC0011	29.51	20.00	63.00	6.52	0.00652	400.0	16.30	0.662	**10.79**	a		Valid - Intact rock
6	RGSC0011	29.53	20.00	63.00	11.43	0.01143	400.0	28.58	0.662	**18.92**	a		Valid - Intact rock
7	RGSC0011	32.61	40.00	63.00	2.93	0.00293	1600.0	1.83	0.904	**1.66**	a		Valid - Intact rock
8	RGSC0011	36.52	40.00	63.00	3.10	0.00310	1600.0	1.94	0.904	**1.75**	a		Valid - Intact rock
9	RGSC0011	53.5	40.00	63.00	9.54	0.00954	1600.0	5.97	0.904	**5.40**	a		Valid - Intact rock
10	RGSC0011	53.48	40.00	63.00	11.90	0.01190	1600.0	7.44	0.904	**6.73**	a		Valid - Intact rock
11	RGSC0011	52.16	50.00	63.00	11.69	0.01169	2500.0	4.68	1.000	**4.68**	a		Valid - Intact rock
12	RGSC0011	66.62	50.00	63.00	12.41	0.01241	2500.0	4.97	1.000	**4.97**	a		Valid - Intact rock
13	RGSC0011	116.83	40.00	63.00	8.97	0.00897	1600.0	5.61	0.904	**5.07**	a		Valid - Intact rock
14	RGSC0011	130.83	50.00	63.00	7.15	0.00715	2500.0	2.86	1.000	**2.86**	a		Valid - Intact rock
15	RGSC0011	60.8	30.00	63.00	1.60	0.00160	900.0	1.78	0.795	**1.41**	a		Invalid - Chipped.
1	RGSC0012	6.82	80.00	63.00	29.43	0.02943	6400.0	4.60	1.236	**5.68**	a		Valid - Intact rock
2	RGSC0012	9.32	40.00	63.00	17.08	0.01708	1600.0	10.68	0.904	**9.66**	a		Valid - Intact rock
3	RGSC0012	9.36	40.00	63.00	16.31	0.01631	1600.0	10.19	0.904	**9.22**	a		Valid - Intact rock
4	RGSC0012	26.88	40.00	63.00	3.08	0.00308	1600.0	1.93	0.904	**1.74**	a		Valid - Intact rock
5	RGSC0012	32.11	50.00	63.00	6.52	0.00652	2500.0	2.61	1.000	**2.61**	a		Valid - Intact rock
6	RGSC0012	40.38	50.00	63.00	9.49	0.00949	2500.0	3.80	1.000	**3.80**	a		Valid - Intact rock
7	RGSC0012	40.43	50.00	63.00	6.70	0.00670	2500.0	2.68	1.000	**2.68**	a		Valid - Intact rock
8	RGSC0012	42.51	50.00	63.00	8.99	0.00899	2500.0	3.60	1.000	**3.60**	a		Valid - Intact rock
9	RGSC0012	42.57	60.00	63.00	11.83	0.01183	3600.0	3.29	1.086	**3.57**	a		Valid - Intact rock
10	RGSC0012	43.48	40.00	63.00	6.61	0.00661	1600.0	4.13	0.904	**3.73**	a		Valid - Intact rock
11	RGSC0012	46.22	70.00	63.00	12.97	0.01297	4900.0	2.65	1.163	**3.08**	a		Valid - Intact rock
12	RGSC0012	47.28	30.00	63.00	12.87	0.01287	900.0	14.30	0.795	**11.36**	a		Valid - Intact rock
13	RGSC0012	47.34	50.00	63.00	12.37	0.01237	2500.0	4.95	1.000	**4.95**	a		Valid - Intact rock
14	RGSC0012	61.02	40.00	63.00	7.01	0.00701	1600.0	4.38	0.904	**3.96**	a		Valid - Intact rock

15	RGSC0012	63.42	40.00	63.00	5.28	0.00528	1600.0	3.30	0.904	**2.99**	a	Valid - Intact rock
16	RGSC0012	63.48	40.00	63.00	6.17	0.00617	1600.0	3.86	0.904	**3.49**	a	Valid - Intact rock
17	RGSC0012	63.52	40.00	63.00	5.36	0.00536	1600.0	3.35	0.904	**3.03**	a	Valid - Intact rock
18	RGSC0012	63.56	40.00	63.00	4.72	0.00472	1600.0	2.95	0.904	**2.67**	a	Valid - Intact rock
19	RGSC0012	64.46	40.00	63.00	2.31	0.00231	1600.0	1.44	0.904	**1.31**	a	Valid - Intact rock
20	RGSC0012	69.21	50.00	63.00	5.83	0.00583	2500.0	2.33	1.000	**2.33**	a	Invalid - Chipping
21	RGSC0012	68.62	50.00	63.00	6.96	0.00696	2500.0	2.78	1.000	**2.78**	a	Valid - Intact rock
22	RGSC0012	79.53	50.00	63.00	9.49	0.00949	2500.0	3.79	1.000	**3.79**	a	Valid - Intact rock
23	RGSC0012	79.60	70.00	63.00	11.49	0.01149	4900.0	2.34	1.163	**2.73**	a	Invalid - Chipping
24	RGSC0012	80.87	40.00	63.00	3.74	0.00374	1600.0	2.34	0.904	**2.11**	a	Valid - Intact rock
25	RGSC0012	80.92	40.00	63.00	3.94	0.00394	1600.0	2.46	0.904	**2.23**	a	Valid - Intact rock
26	RGSC0012	89.35	30.00	63.00	3.62	0.00362	900.0	4.02	0.795	**3.19**	a	Valid - Intact rock
27	RGSC0012	89.40	50.00	63.00	7.58	0.00758	2500.0	3.03	1.000	**3.03**	a	Valid - Intact rock
28	RGSC0012	90.46	40.00	63.00	5.61	0.00561	1600.0	3.51	0.904	**3.17**	a	Valid - Intact rock
29	RGSC0012	93.46	50.00	63.00	18.26	0.01826	2500.0	7.30	1.000	**7.30**	a	Valid - Intact rock
30	RGSC0012	93.51	50.00	63.00	14.17	0.01417	2500.0	5.67	1.000	**5.67**	a	Valid - Intact rock
31	RGSC0012	94.25	50.00	63.00	23.57	0.02357	2500.0	9.43	1.000	**9.43**	a	Valid - Intact rock
32	RGSC0012	97.41	50.00	63.00	13.88	0.01388	2500.0	5.55	1.000	**5.55**	a	Invalid - Chipping
33	RGSC0012	97.47	50.00	63.00	15.87	0.01587	2500.0	6.35	1.000	**6.35**	a	Valid - Intact rock
34	RGSC0012	101.76	40.00	63.00	18.80	0.01880	1600.0	11.75	0.904	**10.63**	a	Valid - Intact rock
35	RGSC0012	107.34	50.00	63.00	8.10	0.00810	2500.0	3.24	1.000	**3.24**	a	Valid - Intact rock
36	RGSC0012	107.39	50.00	63.00	10.39	0.01039	2500.0	4.15	1.000	**4.15**	a	Valid - Intact rock
37	RGSC0012	119.49	60.00	63.00	7.33	0.00733	3600.0	2.04	1.086	**2.21**	a	Valid - Intact rock
38	RGSC0012	119.55	60.00	63.00	4.32	0.00432	3600.0	1.20	1.086	**1.30**	a	Valid - Intact rock
39	RGSC0012	128.45	50.00	63.00	5.59	0.00559	2500.0	2.24	1.000	**2.24**	a	Valid - Intact rock
40	RGSC0012	128.48	40.00	63.00	4.84	0.00484	1600.0	3.02	0.904	**2.73**	a	Valid - Intact rock
41	RGSC0012	134.76	50.00	63.00	11.56	0.01156	2500.0	4.62	1.000	**4.62**	a	Valid - Intact rock
42	RGSC0012	134.82	60.00	63.00	7.80	0.00780	3600.0	2.17	1.086	**2.35**	a	Invalid - Chipping
43	RGSC0012	139.45	50.00	63.00	8.98	0.00898	2500.0	3.59	1.000	**3.59**	a	Valid - Intact rock
44	RGSC0012	139.47	50.00	63.00	14.18	0.01418	2500.0	5.67	1.000	**5.67**	a	Valid - Intact rock
1	RGSC0013	26.90	40.00	63.00	9.68	0.00968	1600.0	6.05	0.904	**5.47**	a	Invalid - Chipping
2	RGSC0013	31.12	40.00	63.00	16.30	0.01630	1600.0	10.19	0.904	**9.21**	a	Valid - Intact rock
3	RGSC0013	31.16	40.00	63.00	11.48	0.01148	1600.0	7.18	0.904	**6.49**	a	Invalid - Chipping
4	RGSC0013	35.9	50.00	63.00	5.92	0.00592	2500.0	2.37	1.000	**2.37**	a	Invalid - Chipping
5	RGSC0013	35.95	50.00	63.00	13.80	0.01380	2500.0	5.52	1.000	**5.52**	a	Valid - Intact rock
6	RGSC0013	40.22	50.00	63.00	6.60	0.00660	2500.0	2.64	1.000	**2.64**	a	Valid - Intact rock
7	RGSC0013	40.27	50.00	63.00	2.62	0.00262	2500.0	1.05	1.000	**1.05**	a	Invalid - Chipping
8	RGSC0013	42.76	30.00	63.00	15.78	0.01578	900.0	17.53	0.795	**13.93**	a	Valid - Intact rock
9	RGSC0013	42.81	45.00	63.00	24.37	0.02437	2025.0	12.03	0.954	**11.48**	a	Valid - Intact rock
10	RGSC0013	51.95	40.00	63.00	13.90	0.01390	1600.0	8.69	0.904	**7.86**	a	Valid - Intact rock
11	RGSC0013	52	50.00	63.00	6.25	0.00625	2500.0	2.50	1.000	**2.50**	a	Valid - May have broke along weak plane.
12	RGSC0013	54.02	40.00	63.00	15.31	0.01531	1600.0	9.57	0.904	**8.65**	a	Valid - Intact rock
13	RGSC0013	54.06	40.00	63.00	12.62	0.01262	1600.0	7.89	0.904	**7.13**	a	Valid - Intact rock
14	RGSC0013	74.34	40.00	63.00	14.12	0.01412	1600.0	8.82	0.904	**7.98**	a	Valid - Intact rock

15	RGSC0013	74.38	40.00	63.00	14.74	0.01474	1600.0	9.22	0.904	**8.33**	a	Valid - Intact rock
16	RGSC0013	75.83	50.00	63.00	25.16	0.02516	2500.0	10.06	1.000	**10.06**	a	Valid - Intact rock
17	RGSC0013	75.87	50.00	63.00	20.28	0.02028	2500.0	8.11	1.000	**8.11**	a	Invalid - Chipping
18	RGSC0013	96.02	40.00	63.00	4.03	0.00403	1600.0	2.52	0.904	**2.28**	a	Valid - Intact rock
19	RGSC0013	92.14	40.00	63.00	3.08	0.00308	1600.0	1.93	0.904	**1.74**	a	Valid - Intact rock
20	RGSC0013	106.79	40.00	63.00	9.85	0.00985	1600.0	6.16	0.904	**5.57**	a	Valid - Intact rock
21	RGSC0013	108.81	40.00	63.00	11.11	0.01111	1600.0	6.94	0.904	**6.28**	a	Valid - Intact rock
22	RGSC0013	119.26	50.00	63.00	15.58	0.01558	2500.0	6.23	1.000	**6.23**	a	Valid - Intact rock
23	RGSC0013	119.30	40.00	63.00	10.65	0.01065	1600.0	6.66	0.904	**6.02**	a	Valid - Intact rock
24	RGSC0013	125.51	40.00	63.00	12.88	0.01288	1600.0	8.05	0.904	**7.28**	a	Valid - Intact rock
25	RGSC0013	127.05	40.00	63.00	17.53	0.01753	1600.0	10.96	0.904	**9.91**	a	Valid - Intact rock
26	RGSC0013	126.98	40.00	63.00	12.87	0.01287	1600.0	8.04	0.904	**7.28**	a	Valid - Intact rock

$I_{s(50)}$ ***= Size Corrected Point Load Strength***

$I_{s(50)} = FI_s$

I_s = Uncorrected Point Load Strength

$I_s = P/D_e^2$

F = Size Correction Factor

$F = (D_e/50)^{0.45}$

D_e = equivalent core diameter (mm)

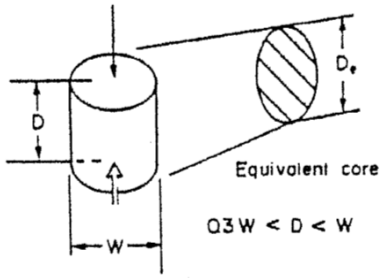
$D_e^2 = 4/\pi * D * W = (mm^2)$

Direction

\\ = parallel

p = perpendicular to planes of weakness

Axial Test



Tested By	Date :	Checked By	Date :

DIAMETRAL POINT LOAD TESTING

Golder Associates

POINT LOAD STRENGTH INDEX TEST

Reference: ASTM D5731 - 08

Client: Riversdale Resources Limited
Project: Grassy Mountain
Location: RGSC0011, RGCS0012, RGSC0013

Project No: 1654139
Test Date: May-16
Tested By: Michael Pak

Diametral Test

Test #	Borehole	Depth	D	L	Guage Reading	Load P	$D_e^2 = D^2$	$I_s = P/D_e^2$	$F = (D_e/50)^{0.45}$	$I_{s(50)}$	Type	Direction	Remarks
	No.	m	mm	mm	kN	MN	mm^2	MPa		MPa			
1	RGSC0011	15.15	63.00	85.00	9.77	0.00977	3969.0	2.46	1.110	**2.73**	d		Valid - Intact Rock
2	RGSC0011	19.96	63.00	100.00	6.70	0.00670	3969.0	1.69	1.110	**1.87**	d		Valid - Intact Rock
3	RGSC0011	24.99	63.00	100.00	3.03	0.00303	3969.0	0.76	1.110	**0.85**	d		Invalid - Broke through weak plane
4	RGSC0011	27.83	63.00	80.00	9.51	0.00951	3969.0	2.40	1.110	**2.66**	d		Valid - Intact Rock
5	RGSC0011	29.53	63.00	60.00	13.41	0.01341	3969.0	3.38	1.110	**3.75**	d		Valid - Intact rock
6	RGSC0011	29.95	63.00	40.00	2.37	0.00237	3969.0	0.60	1.110	**0.66**	d		Failed along weak plane
7	RGSC0011	44.79	63.00	80.00	12.99	0.01299	3969.0	3.27	1.110	**3.63**	d		Failed along weak plane
8	RGSC0011	32.62	63.00	80.00	2.12	0.00212	3969.0	0.53	1.110	**0.59**	d		Valid - Intact rock
9	RGSC0011	36.54	63.00	80.00	5.40	0.00540	3969.0	1.36	1.110	**1.51**	d		Valid - Intact rock
10	RGSC0011	48.11	63.00	80.00	11.01	0.01101	3969.0	2.77	1.110	**3.08**	d		Valid - Intact rock
11	RGSC0011	53.48	63.00	80.00	9.92	0.00992	3969.0	2.50	1.110	**2.77**	d		Valid - Intact rock
12	RGSC0011	49.69	63.00	120.00	7.50	0.00750	3969.0	1.89	1.110	**2.10**	d		Valid - Intact rock
13	RGSC0011	51.61	63.00	80.00	4.48	0.00448	3969.0	1.13	1.110	**1.25**	d		Invalid - Broke through weak plane
14	RGSC0011	55.66	63.00	80.00	7.30	0.00730	3969.0	1.84	1.110	**2.04**	d		Valid - Intact rock
15	RGSC0011	59.54	63.00	100.00	3.68	0.00368	3969.0	0.93	1.110	**1.03**	d		Invalid - Broke through weak plane
16	RGSC0011	116.85	63.00	80.00	7.04	0.00704	3969.0	1.77	1.110	**1.97**	d		Valid - Intact rock
17	RGSC0011	130.86	63.00	100.00	9.02	0.00902	3969.0	2.27	1.110	**2.52**	d		Valid - Intact rock
18	RGSC0011	132.6	63.00	120.00	12.27	0.01227	3969.0	3.09	1.110	**3.43**	d		Valid - Intact rock
19	RGSC0011	107.92	63.00	100.00	1.04	0.00104	3969.0	0.26	1.110	**0.29**	d		Invalid - Broke through weak plane
20	RGSC0011	103.23	63.00	110.00	2.92	0.00292	3969.0	0.74	1.110	**0.82**	d		Valid - Intact rock
21	RGSC0011	134.51	63.00	160.00	11.13	0.01113	3969.0	2.80	1.110	**3.11**	d		Valid - Intact rock
22	RGSC0011	137.25	63.00	100.00	7.45	0.00745	3969.0	1.88	1.110	**2.08**	d		Valid - Intact rock
23	RGSC0011	128.19	63.00	130.00	21.75	0.02175	3969.0	5.48	1.110	**6.08**	d		Valid - Intact rock
24	RGSC0011	123.35	63.00	80.00	1.08	0.00108	3969.0	0.27	1.110	**0.30**	d		Invalid - Broke through weak plane
25	RGSC0011	149.08	63.00	140.00	9.59	0.00959	3969.0	2.42	1.110	**2.68**	d		Valid - Intact rock
26	RGSC0011	154.76	63.00	100.00	2.74	0.00274	3969.0	0.69	1.110	**0.76**	d		Valid - Intact rock
1	RGSC0012	6.84	63.00	100.00	23.06	0.02306	3969.0	5.81	1.110	**6.45**	d		Valid - Intact rock
2	RGSC0012	9.34	63.00	80.00	15.10	0.01510	3969.0	3.80	1.110	**4.22**	d		Valid - Intact rock
3	RGSC0012	20.39	63.00	80.00	3.23	0.00323	3969.0	0.81	1.110	**0.90**	d		Invalid - Broke along weakplane
4	RGSC0012	27.19	63.00	100.00	3.06	0.00306	3969.0	0.77	1.110	**0.86**	d		Valid - Intact rock
5	RGSC0012	29.02	63.00	100.00	4.10	0.00410	3969.0	1.03	1.110	**1.15**	d		Valid - Intact rock

6	RGSC0012	32.14	63.00	140.00	7.51	0.00751	3969.0	1.89	1.110	**2.10**	d	Valid - Intact rock
7	RGSC0012	33.95	63.00	100.00	18.53	0.01853	3969.0	4.67	1.110	**5.18**	d	Valid - Intact rock
8	RGSC0012	35.06	63.00	160.00	2.01	0.00201	3969.0	0.51	1.110	**0.56**	d	Invalid - Broke along weakplane
9	RGSC0012	36.87	63.00	110.00	0.63	0.00063	3969.0	0.16	1.110	**0.18**	d	Invalid - Broke along weakplane
10	RGSC0012	37.2	63.00	100.00	22.14	0.02214	3969.0	5.58	1.110	**6.19**	d	Valid - Intact rock
11	RGSC0012	38.79	63.00	60.00	6.65	0.00665	3969.0	1.68	1.110	**1.86**	d	Valid - Intact rock
12	RGSC0012	40.1	63.00	100.00	3.68	0.00368	3969.0	0.93	1.110	**1.03**	d	Invalid - Broke along weakplane
13	RGSC0012	40.4	63.00	100.00	7.10	0.00710	3969.0	1.79	1.110	**1.99**	d	Valid - Intact rock
14	RGSC0012	42.54	63.00	140.00	6.87	0.00687	3969.0	1.73	1.110	**1.92**	d	Valid - Intact rock
15	RGSC0012	43.46	63.00	80.00	6.57	0.00657	3969.0	1.66	1.110	**1.84**	d	Valid - Intact rock
16	RGSC0012	43.54	63.00	80.00	8.76	0.00876	3969.0	2.21	1.110	**2.45**	d	Valid - Intact rock
17	RGSC0012	44.01	63.00	110.00	7.60	0.00760	3969.0	1.91	1.110	**2.12**	d	Valid - Intact rock
18	RGSC0012	46.2	63.00	100.00	11.26	0.01126	3969.0	2.84	1.110	**3.15**	d	Valid - Intact rock
19	RGSC0012	47.3	63.00	80.00	24.06	0.02406	3969.0	6.06	1.110	**6.73**	d	Valid - Intact rock
20	RGSC0012	54.34	63.00	160.00	4.36	0.00436	3969.0	1.10	1.110	**1.22**	d	Invalid - Broke along weakplane
21	RGSC0012	55.68	63.00	90.00	23.98	0.02398	3969.0	6.04	1.110	**6.70**	d	Valid - Intact rock
22	RGSC0012	60.37	63.00	100.00	4.47	0.00447	3969.0	1.13	1.110	**1.25**	d	Valid - Intact rock
23	RGSC0012	61	63.00	90.00	5.96	0.00596	3969.0	1.50	1.110	**1.67**	d	Valid - Intact rock
24	RGSC0012	63.45	63.00	100.00	4.67	0.00467	3969.0	1.18	1.110	**1.31**	d	Valid - Intact rock
25	RGSC0012	63.54	63.00	80.00	2.09	0.00209	3969.0	0.53	1.110	**0.59**	d	Valid - Intact rock
26	RGSC0012	64.48	63.00	80.00	2.06	0.00206	3969.0	0.52	1.110	**0.58**	d	Valid - Intact rock
27	RGSC0012	67.56	63.00	80.00	9.08	0.00908	3969.0	2.29	1.110	**2.54**	d	Valid - Intact rock
28	RGSC0012	67.65	63.00	80.00	6.45	0.00645	3969.0	1.63	1.110	**1.80**	d	Valid - Intact rock
29	RGSC0012	69.25	63.00	110.00	6.61	0.00661	3969.0	1.66	1.110	**1.85**	d	Valid - Intact Bedding
30	RGSC0012	70.51	63.00	140.00	13.04	0.01304	3969.0	3.29	1.110	**3.65**	d	Valid - Intact rock
31	RGSC0012	72.54	63.00	80.00	5.29	0.00529	3969.0	1.33	1.110	**1.48**	d	Invalid - Broke along weakplane
32	RGSC0012	71.94	63.00	70.00	8.07	0.00807	3969.0	2.03	1.110	**2.26**	d	Valid - Intact rock
33	RGSC0012	72.13	63.00	70.00	23.96	0.02396	3969.0	6.04	1.110	**6.70**	d	Valid - Intact rock
34	RGSC0012	74.53	63.00	90.00	15.57	0.01557	3969.0	3.92	1.110	**4.35**	d	Valid but might have broke along on microdefect
35	RGSC0012	74.44	63.00	70.00	13.77	0.01377	3969.0	3.47	1.110	**3.85**	d	Valid but might have broke along on microdefect
36	RGSC0012	76.85	63.00	100.00	11.20	0.01120	3969.0	2.82	1.110	**3.13**	d	Valid but might have broke along on microdefect
37	RGSC0012	77.82	63.00	170.00	5.09	0.00509	3969.0	1.28	1.110	**1.42**	d	Invalid - Broke along weakplane
38	RGSC0012	79.76	63.00	130.00	3.43	0.00343	3969.0	0.86	1.110	**0.96**	d	Invalid - Broke along weakplane
39	RGSC0012	80.89	63.00	80.00	1.97	0.00197	3969.0	0.50	1.110	**0.55**	d	Valid - Intact rock
40	RGSC0012	86.09	63.00	90.00	1.21	0.00121	3969.0	0.30	1.110	**0.34**	d	Valid but might have broke along on microdefect
41	RGSC0012	89.38	63.00	90.00	6.36	0.00636	3969.0	1.60	1.110	**1.78**	d	Valid - Intact rock
42	RGSC0012	90.58	63.00	65.00	2.21	0.00221	3969.0	0.56	1.110	**0.62**	d	Valid but might have broke along on microdefect
43	RGSC0012	93.48	63.00	100.00	6.06	0.00606	3969.0	1.53	1.110	**1.69**	d	Valid - Intact rock
44	RGSC0012	94.27	63.00	100.00	13.33	0.01333	3969.0	3.36	1.110	**3.73**	d	Valid - Intact rock
45	RGSC0012	97.44	63.00	100.00	9.79	0.00979	3969.0	2.47	1.110	**2.74**	d	Valid - Intact rock
46	RGSC0012	101.73	63.00	120.00	7.30	0.00730	3969.0	1.84	1.110	**2.04**	d	Valid - Intact rock
47	RGSC0012	107.35	63.00	100.00	6.35	0.00635	3969.0	1.60	1.110	**1.78**	d	Valid - Intact rock
48	RGSC0012	119.52	63.00	120.00	7.20	0.00720	3969.0	1.81	1.110	**2.01**	d	Valid - Intact rock
49	RGSC0012	128.48	63.00	110.00	4.69	0.00469	3969.0	1.18	1.110	**1.31**	d	Valid - Intact rock
50	RGSC0012	134.79	63.00	120.00	10.08	0.01008	3969.0	2.54	1.110	**2.82**	d	Valid - Intact rock
51	RGSC0012	139.47	63.00	100.00	10.12	0.01012	3969.0	2.55	1.110	**2.83**	d	Valid - Intact rock

1	RGSC0013	20.35	63.00	110.00	0.99	0.00099	3969.0	0.25	1.110	**0.28**	d	Valid - Intact rock
2	RGSC0013	26.88	63.00	80.00	7.00	0.00700	3969.0	1.76	1.110	**1.96**	d	Valid - Intact rock
3	RGSC0013	31.14	63.00	80.00	13.00	0.01300	3969.0	3.28	1.110	**3.63**	d	Valid - Intact rock
4	RGSC0013	35.92	63.00	100.00	8.67	0.00867	3969.0	2.19	1.110	**2.42**	d	Valid - Intact rock
5	RGSC0013	40.25	63.00	100.00	5.94	0.00594	3969.0	1.50	1.110	**1.66**	d	Valid - Intact rock
6	RGSC0013	42.79	63.00	90.00	19.23	0.01923	3969.0	4.85	1.110	**5.38**	d	Valid - Intact rock
7	RGSC0013	47.43	63.00	80.00	16.51	0.01651	3969.0	4.16	1.110	**4.62**	d	Valid - Intact rock
8	RGSC0013	48.97	63.00	100.00	15.80	0.01580	3969.0	3.98	1.110	**4.42**	d	Valid - Intact rock
9	RGSC0013	51.97	63.00	90.00	15.66	0.01566	3969.0	3.95	1.110	**4.38**	d	Valid - Intact rock
10	RGSC0013	54.04	63.00	80.00	11.64	0.01164	3969.0	2.93	1.110	**3.25**	d	Valid - Intact rock
11	RGSC0013	74.36	63.00	80.00	11.59	0.01159	3969.0	2.92	1.110	**3.24**	d	Valid - Intact rock
12	RGSC0013	75.85	63.00	100.00	24.07	0.02407	3969.0	6.06	1.110	**6.73**	d	Valid - Intact rock
13	RGSC0013	82.98	63.00	130.00	14.24	0.01424	3969.0	3.59	1.110	**3.98**	d	Valid - Intact rock
14	RGSC0013	85.25	63.00	130.00	7.95	0.00795	3969.0	2.00	1.110	**2.22**	d	Valid - Bedding.
15	RGSC0013	87.49	63.00	70.00	13.81	0.01381	3969.0	3.48	1.110	**3.86**	d	Valid - Intact rock
16	RGSC0013	92.84	63.00	80.00	5.99	0.00599	3969.0	1.51	1.110	**1.67**	d	Invalid - Chipping
17	RGSC0013	102.6	63.00	80.00	0.43	0.00043	3969.0	0.11	1.110	**0.12**	d	Valid - Intact rock
18	RGSC0013	105.68	63.00	60.00	9.00	0.00900	3969.0	2.27	1.110	**2.52**	d	Valid - Intact rock
19	RGSC0013	106.81	63.00	60.00	9.41	0.00941	3969.0	2.37	1.110	**2.63**	d	Valid - Intact rock
20	RGSC0013	108.83	63.00	80.00	11.02	0.01102	3969.0	2.78	1.110	**3.08**	d	Valid - Intact rock
21	RGSC0013	105.04	63.00	60.00	11.00	0.01100	3969.0	2.77	1.110	**3.08**	d	Valid - Intact rock
22	RGSC0013	114.61	63.00	90.00	34.18	0.03418	3969.0	8.61	1.110	**9.56**	d	Valid - Intact rock
23	RGSC0013	119.28	63.00	90.00	9.48	0.00948	3969.0	2.39	1.110	**2.65**	d	Valid - Intact rock
24	RGSC0013	123.05	63.00	100.00	8.03	0.00803	3969.0	2.02	1.110	**2.24**	d	Valid - Intact rock
25	RGSC0013	124.13	63.00	80.00	5.21	0.00521	3969.0	1.31	1.110	**1.46**	d	Invalid - Broke along weak plane
26	RGSC0013	125.51	63.00	60.00	5.38	0.00538	3969.0	1.36	1.110	**1.50**	d	Valid - Intact rock
27	RGSC0013	127.03	63.00	70.00	14.69	0.01469	3969.0	3.70	1.110	**4.11**	d	Valid - Intact rock

$I_{s(50)}$ ***= Size Corrected Point Load Strength***

$I_{s(50)} = FI_s$

I_s = Uncorrected Point Load Strength

$I_s = P/D_e^2$

F = Size Correction Factor

$F = (D_e/50)^{0.45}$

D_e = equivalent core diameter (mm)

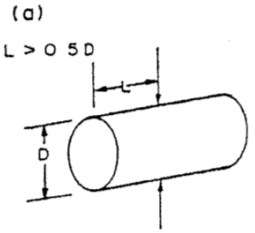
$D_e^2 = D^2$ (mm^2)

Direction

\\ = parallel

p = perpendicular to planes of weakness

Diametral Test



Tested By	Date :	Checked By	Date :

Laboratory Determination of Uniaxial Compressive Strength of Intact Rock Core Specimens.

Summary of Test Results

ASTM D7012 Method C

Project No.: 1654139/2000/2500
Project: Mini-Pit Stability Assessment
Location: Grassy Mountain
Client: Riversdale Resources
Lab ID No: 203

Failure Modes

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

Note: (deg) measured from core axis

No.	Borehole #	Sample #	Depth (m)	Dia (mm)	Ht (mm)	Area (cm^2)	Volume (cm^3)	Mass (g)	Wet Density (kg/m^3)	Moisture (%)	Dry Density (kg/m^3)	Maximum Load (kN)	Stress σ_u (MPa)	Rock Type	Failure Mode	
															Type	(deg)
1	RGSC0011	6	151.57-151.80	60.70	123.22	28.94	356.57	927.30	2601	1.08	2573	58.10	20.1	MST	5	35
2	RGSC0012	7	26.68-26.96	Sample broke during preparation												
3	RGSC0012	11	90.52-90.85	60.74	123.41	28.98	357.59	941.00	2631	0.88	2608	135.50	46.8	MST	1/6	
4	RGSC0012	13	128.51-128.85	60.56	124.47	28.80	358.53	930.90	2596	1.06	2569	109.10	37.9	MST	1	
5	RGSC0013	17	105.21-105.54	60.65	125.05	28.89	361.27	936.80	2593	1.13	2564	119.60	41.4	MST	6/5	28
6	RGSC0013	18	126.64-126.96	60.57	126.38	28.81	364.15	949.10	2606	0.57	2591	189.00	65.6	SST	1	
7	RGSC0012	8	41.19-41.45	61.18	124.85	29.40	367.03	962.40	2622	1.07	2594	108.90	37.0	SLT/MST	6	

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E. Kostyukov	June 7, 2016	L.Perrey	June 8,2016
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates Ltd.
300, 3811 North Fraser Way, Burnaby, British Columbia, Canada V5J 5J2
Tel: 604-412-6899 Fax: 604-412-6816 www.golder.com

Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1654139/2000/2500	**Borehole:**	RGSC0011
Project:	Mini-Pit Stability Assessment	**Sample Number:**	6
Location:	Grassy Mountain	**Depth (m):**	151.57-151.80
Client:	Riversdale Resources	**Lab ID No:**	203

Testing Results

Max Load (kN)	**58.10**
Stress σ_u (MPa)	**20.1**
Pace Rate (kN/s)	0.50
Lithology	MST

Sample Measurements

Diameter	(mm)	60.70
Height	(mm)	123.22
Area	(cm²)	28.94
Volume	(cm³)	356.57
Mass	(g)	927.30
Moisture Content	(%)	1.08
Wet Density	(kg/m³)	2601
Dry Density	(kg/m³)	2573

BEFORE TEST

Failure Mode

Type: **5**

Degrees:* **35**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

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E. Kostyukov	June 7, 2016	L.Perrey	June 8,2016
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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

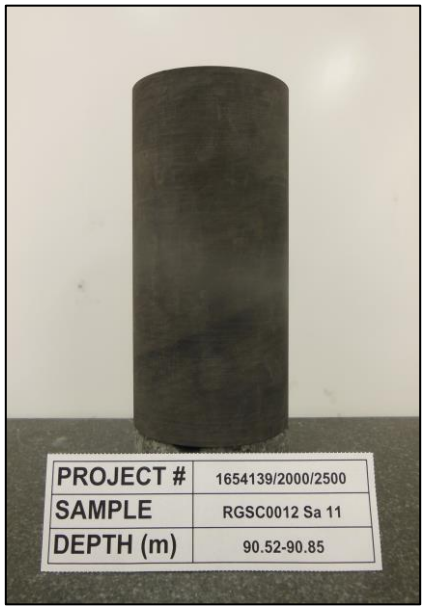
Project No.:	1654139/2000/2500	**Borehole:**	RGSC0012
Project:	Mini-Pit Stability Assessment	**Sample Number:**	11
Location:	Grassy Mountain	**Depth (m):**	90.52-90.85
Client:	Riversdale Resources	**Lab ID No:**	203

Testing Results

Max Load (kN)	**135.50**
Stress σ_u (MPa)	**46.8**
Pace Rate (kN/s)	0.50
Lithology	MST

Sample Measurements

Diameter	(mm)	60.74
Height	(mm)	123.41
Area	(cm^2)	28.98
Volume	(cm^3)	357.59
Mass	(g)	941.00
Moisture Content	(%)	0.88
Wet Density	(kg/m^3)	2631
Dry Density	(kg/m^3)	2608



BEFORE TEST

Failure Mode

Type: **1/6**

Degrees:*

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1654139/2000/2500	**Borehole:**	RGSC0012
Project:	Mini-Pit Stability Assessment	**Sample Number:**	13
Location:	Grassy Mountain	**Depth (m):**	128.51-128.85
Client:	Riversdale Resources	**Lab ID No:**	203

Testing Results		Sample Measurements	
Max Load (kN)	**109.10**	Diameter (mm)	60.56
Stress σ_u (MPa)	**37.9**	Height (mm)	124.47
Pace Rate (kN/s)	0.50	Area (cm^2)	28.80
Lithology	MST	Volume (cm^3)	358.53
		Mass (g)	930.90
		Moisture Content (%)	1.06
		Wet Density (kg/m^3)	2596
		Dry Density (kg/m^3)	2569

BEFORE TEST

Failure Mode		Notes
Type:	**1**	- Water content as received
Degrees:*		**Mode:**
		(1) Simple Extension
* Degrees measured with respect to core axis.		(2) Multiple Extension
		(3) Multiple Fracturing
		(4) Multiple Shear
		(5) Single Shear
The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.		(6) Spalling
		(7) Other

AFTER TEST

Comments

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E. Kostyukov	June 7, 2016	L.Perrey	June 8,2016
TESTED BY	DATE	CHECKED BY	DATE

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1654139/2000/2500	**Borehole:**	RGSC0013
Project:	Mini-Pit Stability Assessment	**Sample Number:**	17
Location:	Grassy Mountain	**Depth (m):**	105.21-105.54
Client:	Riversdale Resources	**Lab ID No:**	203

Testing Results

Max Load (kN)	**119.60**
Stress σ_u (MPa)	**41.4**
Pace Rate (kN/s)	0.50
Lithology	MST

Sample Measurements

Diameter	(mm)	60.65
Height	(mm)	125.05
Area	(cm^2)	28.89
Volume	(cm^3)	361.27
Mass	(g)	936.80
Moisture Content	(%)	1.13
Wet Density	(kg/m^3)	2593
Dry Density	(kg/m^3)	2564

BEFORE TEST

Failure Mode

Type: **6/5**

Degrees:* **28**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

Comments

AFTER TEST

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1654139/2000/2500	**Borehole:**	RGSC0013
Project:	Mini-Pit Stability Assessment	**Sample Number:**	18
Location:	Grassy Mountain	**Depth (m):**	126.64-126.96
Client:	Riversdale Resources	**Lab ID No:**	203

Testing Results

Max Load (kN)	**189.00**
Stress σ_u (MPa)	**65.6**
Pace Rate (kN/s)	0.50
Lithology	MST

Sample Measurements

Diameter	(mm)	60.57
Height	(mm)	126.38
Area	(cm^2)	28.81
Volume	(cm^3)	364.15
Mass	(g)	949.10
Moisture Content	(%)	0.57
Wet Density	(kg/m^3)	2606
Dry Density	(kg/m^3)	2591

BEFORE TEST

Failure Mode

Type: **1**

Degrees:*

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

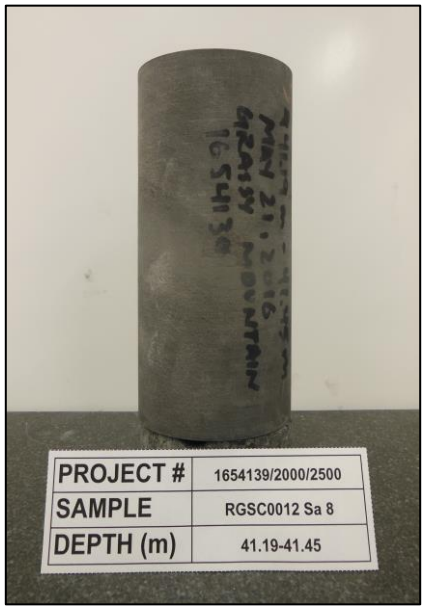
Project No.:	1654139/2000/2500	**Borehole:**	RGSC0012
Project:	Mini-Pit Stability Assessment	**Sample Number:**	8
Location:	Grassy Mountain	**Depth (m):**	41.19-41.45
Client:	Riversdale Resources	**Lab ID No:**	203

Testing Results

Max Load (kN)	**108.90**
Stress σ_u (MPa)	**37.0**
Pace Rate (kN/s)	0.50
Lithology	SLT/MST

Sample Measurements

Diameter	(mm)	61.18
Height	(mm)	124.85
Area	(cm^2)	29.40
Volume	(cm^3)	367.03
Mass	(g)	962.40
Moisture Content	(%)	1.07
Wet Density	(kg/m^3)	2622
Dry Density	(kg/m^3)	2594



BEFORE TEST

Failure Mode

Type: **6**

Degrees:*

* Degrees measured with respect to core axis.

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Notes

- Water content as received

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

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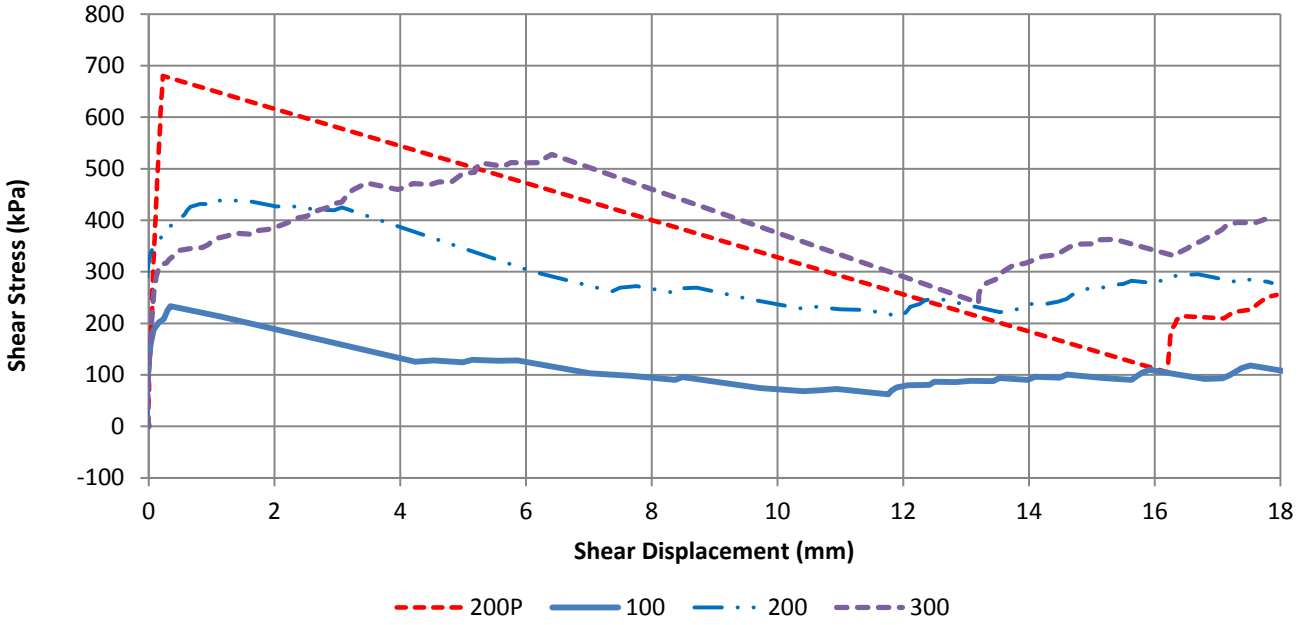
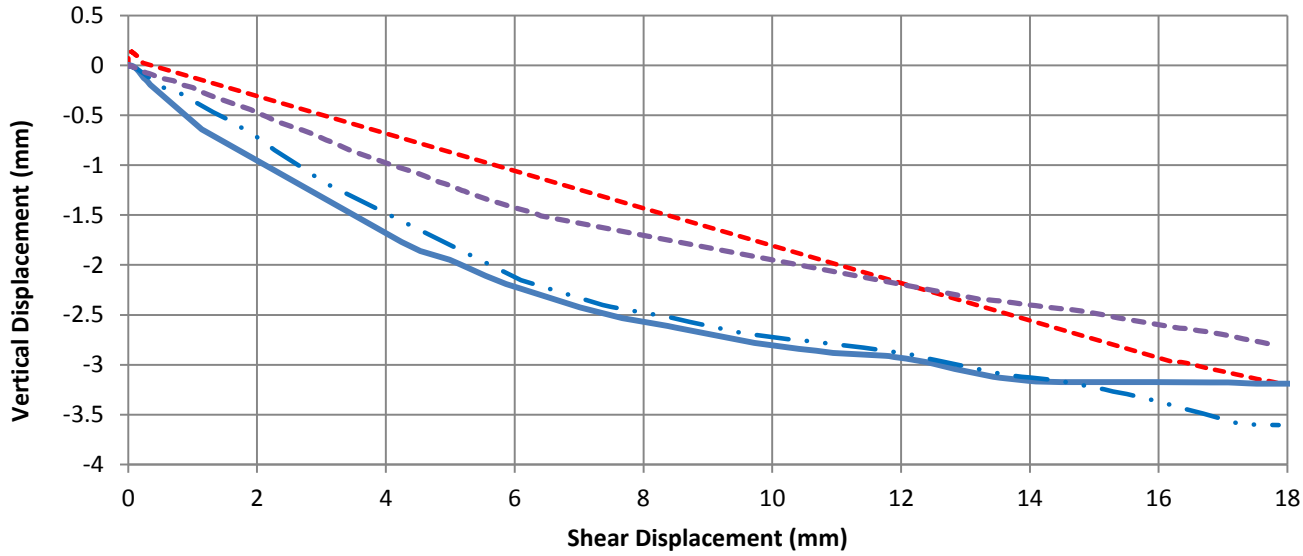
Direct Shear Strength Testing Under Constant Normal Force

ASTM D5607

Project No.:	1654139/2000/2500	**Sample No.:**	RGSC 0012
Project:	MINI PIT STABILITY ASSESSMENT	**Test ID:**	10
Location:	GRASSY MOUNTAIN	**Depth (m):**	55.35-55.62
Client:	RIVERSIDE RESOURCES	**Lab ID No:**	203

Test Condition:	Open	**Moisture Condition:**	As-received
Lithology:	Sedimentary	**Sample Geometry**	Elliptical
Discontinuity Orientation	62°	**Joint Roughness Coefficient**	10-12
		Encapsulating Material	Capping Compound





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TESTED BY	DATE	CHECKED BY	DATE

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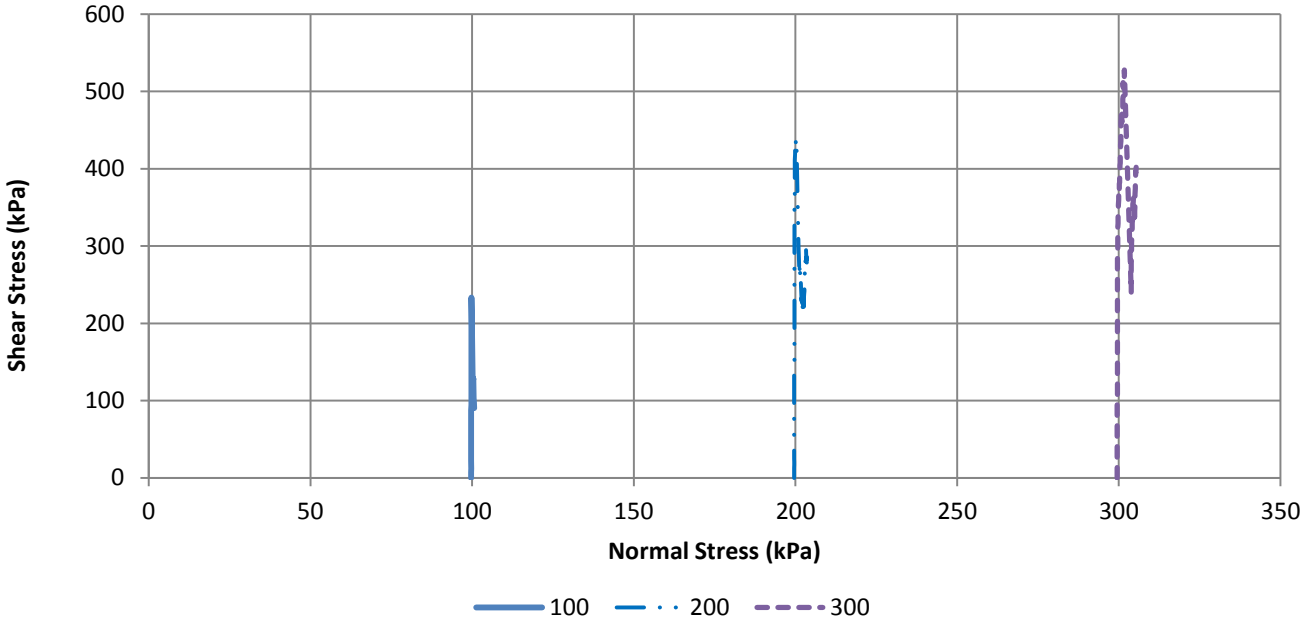
Direct Shear Strength Testing Under Constant Normal Force

ASTM D5607

Project No.:	1654139/2000/2500	**Sample No.:**	RGSC 0012
Project:	MINI PIT STABILITY ASSESSMENT	**Test ID:**	10
Location:	GRASSY MOUNTAIN	**Depth (m):**	55.35-55.62
Client:	RIVERSIDE RESOURCES	**Lab ID No:**	203

Test Condition:	Open	**Moisture Condition:**	As-received
Lithology:	Sedimentary	**Sample Geometry**	Elliptical
Discontinuity Orientation	62°	**Joint Roughness Coefficient**	10-12
		Encapsulating Material	Capping Compound



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Direct Shear Strength Testing Under Constant Normal Force

ASTM D5607

Project No.:	1654139/2000/2500	**Sample No.:**	RGSC 0012
Project:	MINI PIT STABILITY ASSESSMENT	**Test ID:**	10
Location:	GRASSY MOUNTAIN	**Depth (m):**	55.35-55.62
Client:	RIVERSIDE RESOURCES	**Lab ID No:**	203

Before Shear

After Shear

The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

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Direct Shear Strength Testing Under Constant Normal Force

ASTM D5607

Project No.:	1654139/2000/2500	**Sample No.:**	RGSC 0012
Project:	MINI PIT STABILITY ASSESSMENT	**Test ID:**	10
Location:	GRASSY MOUNTAIN	**Depth (m):**	55.35-55.62
Client:	RIVERSIDE RESOURCES	**Lab ID No:**	203

PEAK + RESIDUAL		RESIDUAL 1		RESIDUAL 2		RESIDUAL 3	
σn Stress, kPa	200	σn Stress, kPa	100	σn Stress, kPa	200	σn Stress, kPa	300

Horz Disp mm	Shear Stress kPa	Vert Disp mm	Horz Disp mm	Shear Stress kPa	Vert Disp mm	Horz Disp mm	Shear Stress kPa	Vert Disp mm	Horz Disp mm	Shear Stress kPa	Vert Disp mm
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	-0.07	0.00	0.00	0.37	0.00	0.00	-0.12	0.00	0.00	-0.10	0.00
0.00	0.52	0.00	0.00	3.61	0.00	0.00	1.30	0.00	0.00	1.46	0.00
0.00	2.14	0.00	-0.01	7.52	0.00	-0.01	3.78	0.00	0.00	3.91	0.00
0.00	4.25	0.00	-0.01	12.01	0.00	-0.01	6.71	0.00	-0.01	6.67	0.00
-0.01	6.61	0.00	-0.02	22.03	0.00	-0.01	9.94	0.00	-0.01	9.77	0.00
-0.01	9.15	0.00	-0.03	27.25	0.00	-0.02	13.30	0.00	-0.01	12.96	0.00
-0.01	11.79	0.00	-0.03	32.61	0.00	-0.02	16.92	0.00	-0.02	16.41	0.00
-0.01	14.63	0.00	-0.03	38.12	0.00	-0.03	20.87	0.00	-0.02	19.98	0.00
-0.01	17.49	0.00	-0.03	43.65	0.00	-0.03	24.55	0.00	-0.02	23.70	0.00
-0.01	20.53	0.00	-0.03	49.32	0.00	-0.03	28.82	0.00	-0.02	27.51	0.00
-0.01	23.78	0.00	-0.03	55.31	0.00	-0.04	33.18	0.00	-0.02	31.65	0.00
-0.01	27.10	0.00	-0.03	61.36	0.00	-0.04	37.75	0.00	-0.02	36.03	0.00
-0.01	30.56	0.00	-0.02	67.77	0.00	-0.04	42.32	0.00	-0.02	40.67	0.00
-0.01	34.25	0.00	-0.02	73.99	0.00	-0.04	47.16	0.00	-0.02	45.41	0.00
-0.01	38.32	0.00	-0.02	80.65	0.00	-0.04	52.04	0.00	-0.01	50.35	0.00
0.00	42.29	0.00	-0.02	87.35	0.00	-0.05	57.28	0.00	-0.01	55.42	0.00
0.00	46.66	0.00	-0.02	94.29	0.00	-0.05	62.60	0.00	-0.01	60.62	0.00
0.00	51.19	0.00	-0.01	101.19	0.00	-0.05	68.43	0.00	-0.01	66.04	0.00
0.00	55.92	0.00	-0.01	108.14	0.00	-0.05	74.43	0.00	-0.01	71.50	0.00
0.00	60.95	0.00	0.00	115.54	0.00	-0.05	80.58	0.00	-0.01	77.24	0.00
0.00	66.16	0.00	0.00	122.81	0.00	-0.05	86.81	0.00	-0.01	82.90	0.00
0.00	71.41	0.00	0.01	130.73	0.00	-0.05	93.16	0.00	-0.01	88.95	0.00
0.01	76.86	0.00	0.01	138.68	0.00	-0.05	99.81	0.00	-0.01	94.85	0.00
0.01	82.51	0.00	0.02	146.44	0.00	-0.05	106.68	0.00	-0.01	101.01	0.00
0.00	88.28	0.00	0.03	154.41	0.00	-0.05	113.76	0.00	0.00	107.24	0.00
0.00	94.51	0.14	0.03	162.90	0.00	-0.05	120.55	0.00	0.00	113.64	0.00
0.00	100.81	0.14	0.05	171.23	0.00	-0.05	127.86	0.00	0.00	120.48	0.00
0.00	107.30	0.14	0.06	178.89	0.00	-0.05	135.48	0.00	0.00	127.39	0.00

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Direct Shear Strength Testing Under Constant Normal Force

ASTM D5607

Project No.:	1654139/2000/2500	**Sample No.:**	RGSC 0012
Project:	MINI PIT STABILITY ASSESSMENT	**Test ID:**	10
Location:	GRASSY MOUNTAIN	**Depth (m):**	55.35-55.62
Client:	RIVERSIDE RESOURCES	**Lab ID No:**	203

PEAK + RESIDUAL		RESIDUAL 1		RESIDUAL 2		RESIDUAL 3	
σn Stress, kPa	200	σn Stress, kPa	100	σn Stress, kPa	200	σn Stress, kPa	300

Horz Disp mm	Shear Stress kPa	Vert Disp mm	Horz Disp mm	Shear Stress kPa	Vert Disp mm	Horz Disp mm	Shear Stress kPa	Vert Disp mm	Horz Disp mm	Shear Stress kPa	Vert Disp mm
0.01	113.65	0.14	0.08	186.96	-0.01	-0.05	142.70	0.00	0.01	134.39	0.00
0.01	120.16	0.14	0.12	194.67	-0.03	-0.05	149.98	0.00	0.01	141.68	0.00
0.01	126.75	0.14	0.16	202.33	-0.06	-0.05	157.66	0.00	0.01	148.96	0.00
0.02	133.05	0.14	0.24	208.40	-0.13	-0.05	165.96	0.00	0.02	156.47	0.00
0.02	139.68	0.14	0.27	216.86	-0.14	-0.05	173.77	0.00	0.02	164.04	-0.01
0.02	146.48	0.14	0.30	225.17	-0.16	-0.05	181.99	0.00	0.03	171.79	-0.01
0.03	153.51	0.14	0.34	233.36	-0.20	-0.05	190.17	0.00	0.03	179.08	-0.01
0.03	160.36	0.14	1.14	213.37	-0.64	-0.05	198.60	0.00	0.04	186.77	-0.01
0.03	167.34	0.14	4.24	125.76	-1.77	-0.05	207.19	0.00	0.04	194.39	-0.01
0.03	174.57	0.14	4.53	128.05	-1.86	-0.05	215.61	0.00	0.05	202.26	-0.01
0.04	182.04	0.14	4.99	124.13	-1.95	-0.04	224.79	0.00	0.05	210.34	-0.01
0.04	189.60	0.14	5.15	129.46	-1.99	-0.04	233.93	0.00	0.06	218.25	-0.01
0.04	197.27	0.14	5.55	127.43	-2.11	-0.04	242.91	0.00	0.06	226.30	-0.01
0.04	205.03	0.14	5.86	128.31	-2.19	-0.04	251.92	0.00	0.07	234.69	-0.01
0.05	212.82	0.14	7.02	103.30	-2.43	-0.04	261.37	0.00	0.07	242.46	-0.01
0.05	220.92	0.14	7.67	98.28	-2.53	-0.03	270.68	0.00	0.08	250.59	-0.01
0.06	228.75	0.14	8.38	90.22	-2.61	-0.03	279.54	0.00	0.08	258.90	-0.02
0.06	237.21	0.14	8.49	95.88	-2.63	-0.03	288.71	0.00	0.09	267.01	-0.02
0.05	246.06	0.14	9.72	74.47	-2.78	-0.02	297.24	0.00	0.10	275.30	-0.02
0.05	254.43	0.14	10.41	68.10	-2.84	-0.01	305.76	0.00	0.11	283.28	-0.02
0.06	263.21	0.14	10.68	70.07	-2.86	-0.01	314.45	0.00	0.12	291.63	-0.03
0.06	272.34	0.13	10.94	72.65	-2.88	0.00	322.67	0.00	0.14	299.29	-0.04
0.06	281.01	0.13	11.76	62.57	-2.91	0.02	331.08	-0.01	0.16	306.65	-0.04
0.07	290.31	0.13	11.82	69.55	-2.91	0.04	339.76	-0.01	0.19	313.61	-0.05
0.07	300.09	0.13	11.90	75.93	-2.92	0.08	348.03	-0.02	0.28	317.45	-0.07
0.07	309.01	0.13	12.08	79.95	-2.94	0.15	354.94	-0.04	0.32	324.08	-0.08
0.08	318.54	0.13	12.42	80.41	-2.98	0.18	363.44	-0.05	0.38	329.46	-0.09
0.08	328.12	0.13	12.50	86.54	-2.99	0.22	370.56	-0.08	0.44	335.46	-0.11
0.08	337.38	0.12	12.83	86.05	-3.04	0.26	378.65	-0.09	0.49	341.40	-0.13

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L.Perrey	June 10,2016	E. Kostyukov	June 15, 2016
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates Ltd.
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Tel: 604-412-6899 Fax: 604-412-6816 www.golder.com

Direct Shear Strength Testing Under Constant Normal Force

ASTM D5607

Project No.:	1654139/2000/2500	**Sample No.:**	RGSC 0012
Project:	MINI PIT STABILITY ASSESSMENT	**Test ID:**	10
Location:	GRASSY MOUNTAIN	**Depth (m):**	55.35-55.62
Client:	RIVERSIDE RESOURCES	**Lab ID No:**	203

PEAK + RESIDUAL			RESIDUAL 1			RESIDUAL 2			RESIDUAL 3		
σn Stress,	kPa	200	σn Stress,	kPa	100	σn Stress,	kPa	200	σn Stress,	kPa	300
Horz Disp	Shear Stress	Vert Disp	Horz Disp	Shear Stress	Vert Disp	Horz Disp	Shear Stress	Vert Disp	Horz Disp	Shear Stress	Vert Disp
mm	kPa	mm	mm	kPa	mm	mm	kPa	mm	mm	kPa	mm
0.09	346.78	0.12	13.07	88.47	-3.07	0.30	386.30	-0.11	0.70	345.75	-0.15
0.09	356.57	0.12	13.43	87.95	-3.12	0.38	391.65	-0.15	0.85	347.09	-0.20
0.09	366.37	0.12	13.53	93.86	-3.13	0.43	399.04	-0.18	0.95	353.15	-0.21
0.10	376.18	0.12	13.98	90.35	-3.16	0.51	404.58	-0.21	1.00	359.86	-0.22
0.10	385.50	0.11	14.09	96.28	-3.17	0.57	411.18	-0.23	1.09	365.36	-0.25
0.10	395.34	0.11	14.49	94.52	-3.17	0.61	419.08	-0.24	1.25	369.81	-0.29
0.11	404.96	0.11	14.61	100.48	-3.17	0.67	426.15	-0.25	1.36	374.92	-0.32
0.11	414.96	0.11	15.18	93.68	-3.17	0.82	431.41	-0.28	1.66	372.70	-0.39
0.11	424.73	0.11	15.63	90.31	-3.17	1.03	430.81	-0.36	1.73	380.23	-0.41
0.12	435.20	0.10	15.72	97.51	-3.17	1.09	438.26	-0.39	1.90	382.60	-0.44
0.12	446.15	0.10	15.80	104.14	-3.18	1.32	438.19	-0.47	2.04	387.19	-0.48
0.13	456.88	0.10	15.91	109.62	-3.17	1.57	437.70	-0.55	2.16	392.94	-0.51
0.13	467.99	0.10	16.80	91.98	-3.18	2.03	426.69	-0.73	2.26	398.29	-0.55
0.14	478.91	0.09	17.08	93.18	-3.18	2.27	427.36	-0.85	2.36	404.17	-0.57
0.14	489.73	0.09	17.20	99.49	-3.18	2.66	420.49	-1.01	2.52	407.78	-0.61
0.15	501.04	0.09	17.29	106.61	-3.18	2.95	419.47	-1.13	2.59	414.59	-0.63
0.15	511.96	0.09	17.39	113.58	-3.19	3.07	425.25	-1.19	2.71	419.83	-0.65
0.15	523.19	0.08	17.52	118.24	-3.19	6.10	300.58	-2.15	2.83	424.54	-0.68
0.16	534.71	0.08	18.45	99.63	-3.19	7.36	262.12	-2.40	2.92	431.50	-0.70
0.16	545.85	0.08	18.58	104.43	-3.19	7.50	268.98	-2.42	3.07	435.50	-0.75
0.17	556.94	0.08				7.76	272.27	-2.45	3.13	444.16	-0.76
0.17	568.40	0.07				8.38	259.08	-2.52	3.18	452.94	-0.77
0.18	579.24	0.07				8.47	267.73	-2.53	3.26	459.77	-0.80
0.18	589.88	0.07				8.72	268.90	-2.57	3.36	465.57	-0.83
0.19	601.64	0.06				9.54	247.07	-2.68	3.46	472.44	-0.86
0.19	612.95	0.06				10.36	228.82	-2.75	3.96	459.81	-0.97
0.20	623.92	0.05				10.57	232.98	-2.76	4.10	464.75	-1.00
0.20	635.44	0.05				11.00	226.98	-2.80	4.20	471.21	-1.02
0.21	646.82	0.05				11.41	226.15	-2.83	4.48	469.45	-1.08

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L.Perrey	June 10,2016	E. Kostyukov	June 15, 2016
TESTED BY	DATE	CHECKED BY	DATE

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Direct Shear Strength Testing Under Constant Normal Force

ASTM D5607

Project No.:	1654139/2000/2500	**Sample No.:**	RGSC 0012
Project:	MINI PIT STABILITY ASSESSMENT	**Test ID:**	10
Location:	GRASSY MOUNTAIN	**Depth (m):**	55.35-55.62
Client:	RIVERSIDE RESOURCES	**Lab ID No:**	203

PEAK + RESIDUAL			RESIDUAL 1			RESIDUAL 2			RESIDUAL 3		
σn Stress,	kPa	200	σn Stress,	kPa	100	σn Stress,	kPa	200	σn Stress,	kPa	300
Horz Disp	Shear Stress	Vert Disp	Horz Disp	Shear Stress	Vert Disp	Horz Disp	Shear Stress	Vert Disp	Horz Disp	Shear Stress	Vert Disp
mm	kPa	mm	mm	kPa	mm	mm	kPa	mm	mm	kPa	mm
0.21	658.05	0.04				11.97	213.45	-2.88	4.61	474.48	-1.11
0.22	669.24	0.03				12.06	223.13	-2.89	4.83	475.78	-1.17
0.23	680.17	0.03				12.11	231.90	-2.89	4.91	483.42	-1.18
16.21	104.92	-2.97				12.26	237.54	-2.91	5.00	490.55	-1.20
16.21	116.39	-2.97				12.35	245.12	-2.93	5.18	493.24	-1.25
16.22	126.19	-2.97				12.54	248.28	-2.96	5.22	503.20	-1.26
16.22	135.30	-2.97				13.54	221.52	-3.09	5.28	511.42	-1.27
16.23	144.22	-2.97				13.76	224.71	-3.11	5.64	504.58	-1.36
16.23	153.19	-2.97				13.87	231.08	-3.12	5.76	511.88	-1.38
16.24	162.10	-2.97				13.99	237.34	-3.13	5.98	511.63	-1.42
16.25	170.75	-2.97				14.27	237.54	-3.15	6.24	512.21	-1.47
16.26	179.83	-2.97				14.46	241.63	-3.16	6.31	520.94	-1.48
16.27	189.00	-2.97				14.60	247.31	-3.18	6.41	527.80	-1.51
16.32	197.66	-2.97				14.68	255.24	-3.19	13.20	239.82	-2.34
16.35	206.90	-2.97				14.80	261.32	-3.20	13.20	256.85	-2.34
16.43	214.02	-2.98				14.92	267.03	-3.22	13.24	268.84	-2.34
16.76	212.28	-3.03				15.15	268.58	-3.25	13.33	278.24	-2.35
17.10	209.52	-3.08				15.29	273.95	-3.27	13.47	285.16	-2.36
17.20	217.23	-3.09				15.50	276.41	-3.29	13.53	295.22	-2.36
17.31	222.80	-3.11				15.63	282.54	-3.31	13.63	304.04	-2.37
17.53	226.57	-3.14				16.02	277.61	-3.37	13.75	312.19	-2.38
17.61	234.92	-3.15				16.13	284.73	-3.39	13.94	316.87	-2.40
17.70	242.77	-3.16				16.25	290.86	-3.41	14.09	323.14	-2.41
17.79	250.68	-3.17				16.46	293.84	-3.45	14.23	330.14	-2.42
17.94	255.43	-3.20				16.69	295.12	-3.49	14.44	332.91	-2.43
						17.25	281.58	-3.59	14.54	340.49	-2.44
						17.40	286.43	-3.60	14.65	348.05	-2.45
						17.79	280.51	-3.60	14.79	353.97	-2.46
						17.86	278.55	-3.60	15.05	354.26	-2.49

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L.Perrey	June 10,2016	E. Kostyukov	June 15, 2016
TESTED BY	DATE	CHECKED BY	DATE

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Tel: 604-412-6899 Fax: 604-412-6816 www.golder.com

Direct Shear Strength Testing Under Constant Normal Force

ASTM D5607

Project No.:	1654139/2000/2500	**Sample No.:**	RGSC 0012
Project:	MINI PIT STABILITY ASSESSMENT	**Test ID:**	10
Location:	GRASSY MOUNTAIN	**Depth (m):**	55.35-55.62
Client:	RIVERSIDE RESOURCES	**Lab ID No:**	203

PEAK + RESIDUAL			RESIDUAL 1			RESIDUAL 2			RESIDUAL 3		
σn Stress, kPa		200	σn Stress, kPa		100	σn Stress, kPa		200	σn Stress, kPa		300
Horz Disp mm	Shear Stress kPa	Vert Disp mm	Horz Disp mm	Shear Stress kPa	Vert Disp mm	Horz Disp mm	Shear Stress kPa	Vert Disp mm	Horz Disp mm	Shear Stress kPa	Vert Disp mm
									15.13	362.58	-2.50
									15.37	362.92	-2.53
									16.33	330.55	-2.63
									16.41	338.51	-2.64
									16.52	345.31	-2.65
									16.62	353.41	-2.66
									16.74	360.09	-2.67
									16.85	367.00	-2.68
									16.97	374.43	-2.69
									17.07	381.97	-2.71
									17.14	390.56	-2.72
									17.31	395.90	-2.74
									17.60	395.41	-2.78
									17.75	401.84	-2.80

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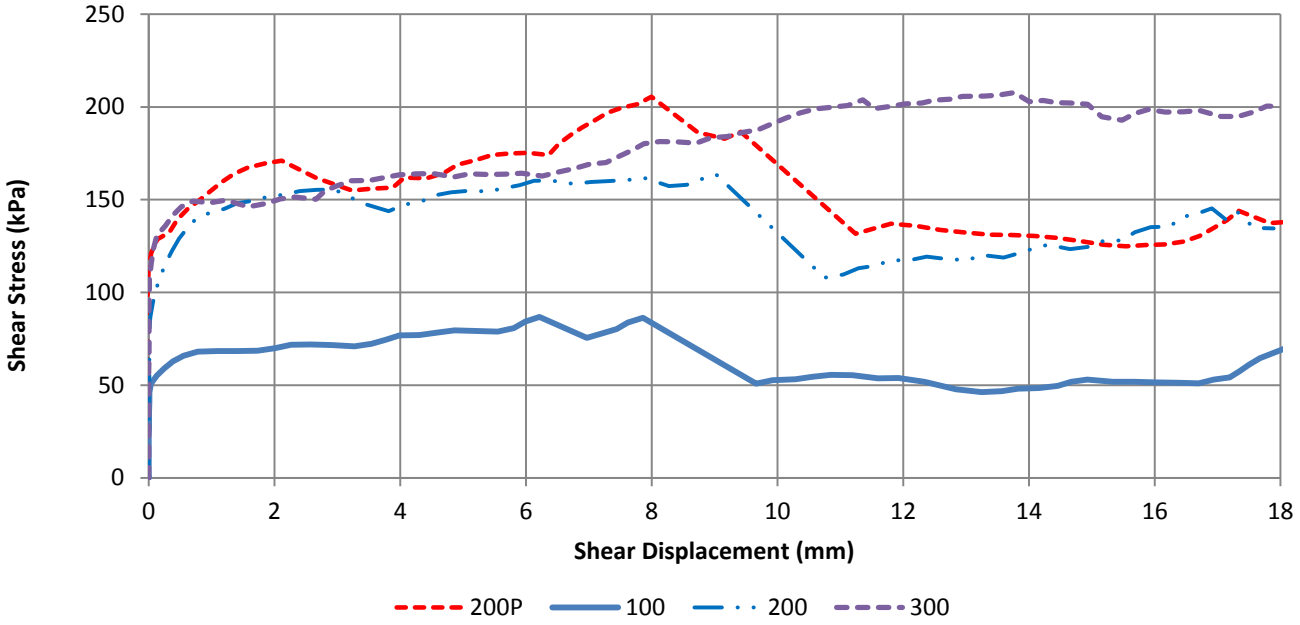
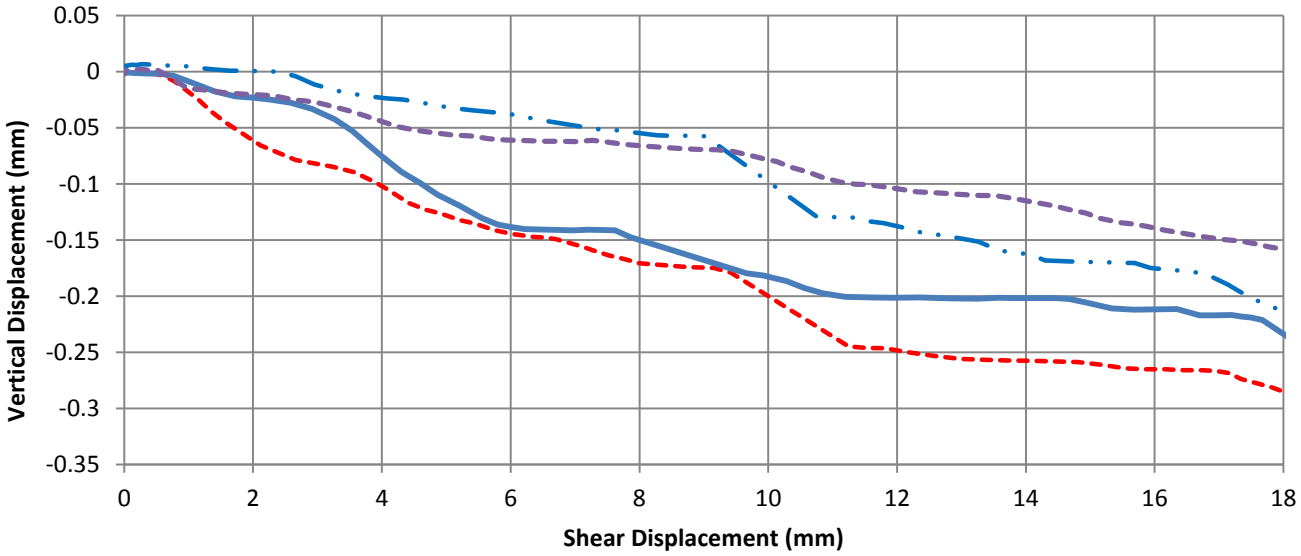
Direct Shear Strength Testing Under Constant Normal Force

ASTM D5607

Project No.:	1654139/2000/2500	**Sample No.:**	RGSC 0013
Project:	MINI PIT STABILITY ASSESSMENT	**Test ID:**	15
Location:	GRASSY MOUNTAIN	**Depth (m):**	49.9-50.22
Client:	RIVERSIDE RESOURCES	**Lab ID No:**	203

Test Condition:	Open	**Moisture Condition:**	As-received
Lithology:	Sedimentary	**Sample Geometry**	Elliptical
Discontinuity Orientation	47°	**Joint Roughness Coefficient**	4-6
		Encapsulating Material	Capping Compound





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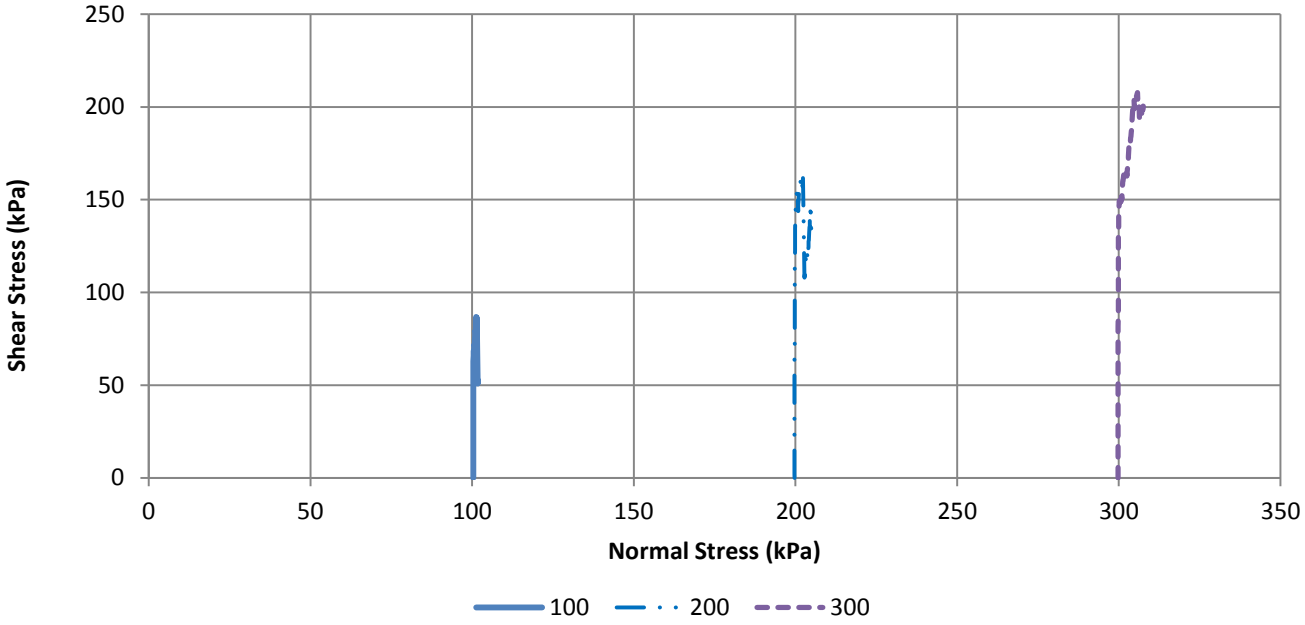
Direct Shear Strength Testing Under Constant Normal Force

ASTM D5607

Project No.:	1654139/2000/2500	**Sample No.:**	RGSC 0013
Project:	MINI PIT STABILITY ASSESSMENT	**Test ID:**	15
Location:	GRASSY MOUNTAIN	**Depth (m):**	49.9-50.22
Client:	RIVERSIDE RESOURCES	**Lab ID No:**	203

Test Condition:	Open	**Moisture Condition:**	As-received
Lithology:	Sedimentary	**Sample Geometry**	Elliptical
Discontinuity Orientation	47°	**Joint Roughness Coefficient**	4-6
		Encapsulating Material	Capping Compound



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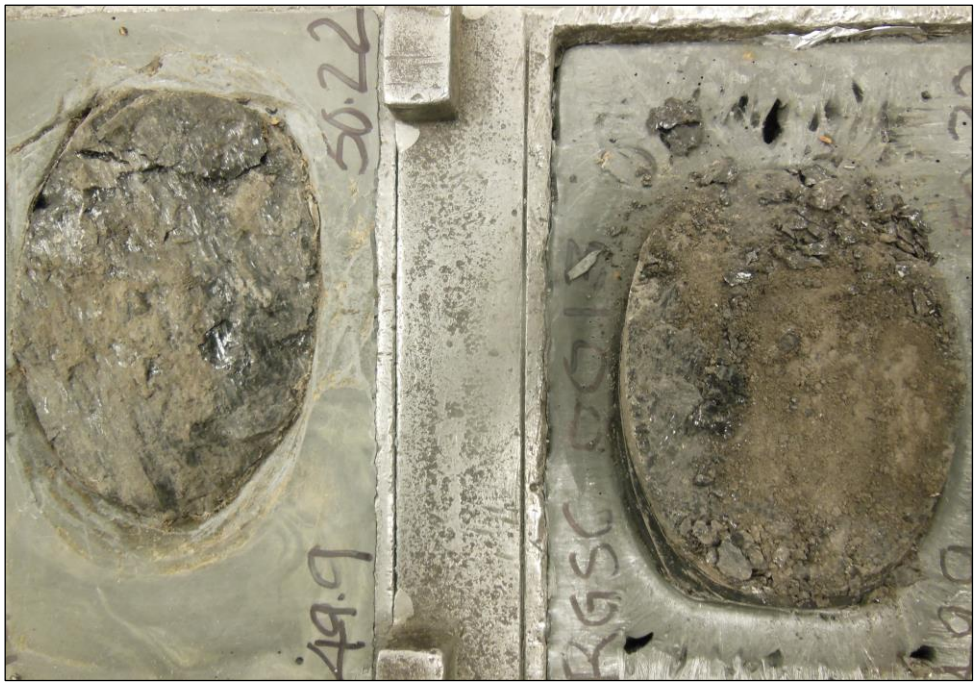
ASTM D5607

Project No.:	1654139/2000/2500	**Sample No.:**	RGSC 0013
Project:	MINI PIT STABILITY ASSESSMENT	**Test ID:**	15
Location:	GRASSY MOUNTAIN	**Depth (m):**	49.9-50.22
Client:	RIVERSIDE RESOURCES	**Lab ID No:**	203

Before Shear



After Shear

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Direct Shear Strength Testing Under Constant Normal Force

ASTM D5607

Project No.:	1654139/2000/2500	**Sample No.:**	RGSC 0013
Project:	MINI PIT STABILITY ASSESSMENT	**Test ID:**	15
Location:	GRASSY MOUNTAIN	**Depth (m):**	49.9-50.22
Client:	RIVERSIDE RESOURCES	**Lab ID No:**	203

PEAK + RESIDUAL		RESIDUAL 1		RESIDUAL 2		RESIDUAL 3	
σn Stress, kPa	200	σn Stress, kPa	100	σn Stress, kPa	200	σn Stress, kPa	300

Horz Disp mm	Shear Stress kPa	Vert Disp mm	Horz Disp mm	Shear Stress kPa	Vert Disp mm	Horz Disp mm	Shear Stress kPa	Vert Disp mm	Horz Disp mm	Shear Stress kPa	Vert Disp mm
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	1.32	0.00	0.00	0.24	0.00	0.00	2.02	0.00	0.00	0.43	0.00
0.00	5.52	0.00	0.00	1.66	0.00	0.00	7.83	0.00	0.00	4.81	0.00
-0.01	10.40	0.00	0.00	4.34	0.00	0.00	14.88	0.00	0.00	10.26	0.00
-0.01	15.39	0.00	0.00	7.71	0.00	0.00	22.15	0.00	0.00	16.14	0.00
-0.01	20.63	0.00	0.00	11.12	0.00	0.00	29.79	0.00	0.00	22.31	0.00
-0.02	26.37	0.00	0.00	14.65	0.00	0.01	37.73	0.00	0.00	29.18	0.00
-0.02	32.59	0.00	0.00	18.48	0.00	0.01	46.14	0.00	0.00	35.85	0.00
-0.02	39.22	0.00	0.00	22.33	0.00	0.01	54.79	0.00	0.00	42.80	0.00
-0.02	46.20	0.00	0.00	26.65	0.00	0.01	63.34	0.00	0.00	50.10	0.00
-0.02	53.35	0.00	0.00	30.93	0.00	0.01	71.06	0.00	0.00	57.51	0.00
-0.02	60.93	0.00	0.00	35.50	0.00	0.01	79.18	0.00	0.00	65.00	0.00
-0.03	68.95	0.00	0.01	40.68	0.00	0.02	86.54	0.01	0.00	73.15	0.00
-0.03	77.01	0.00	0.01	45.86	0.00	0.06	94.27	0.01	0.01	81.71	0.00
-0.03	85.46	0.00	0.03	50.82	0.00	0.11	101.53	0.01	0.01	89.92	0.00
-0.02	94.52	0.00	0.13	55.28	0.00	0.18	108.52	0.01	0.01	98.56	0.00
-0.02	103.73	0.00	0.25	59.16	0.00	0.27	115.76	0.01	0.01	107.09	0.00
0.00	112.97	0.00	0.39	62.81	0.00	0.37	122.63	0.01	0.04	115.64	0.00
0.04	121.38	0.00	0.55	65.88	0.00	0.48	129.12	0.01	0.08	123.48	0.00
0.13	128.59	0.00	0.78	68.03	0.00	0.61	134.56	0.01	0.13	130.85	0.00
0.33	132.49	0.00	1.09	68.34	-0.01	0.76	139.90	0.01	0.26	135.80	0.00
0.46	139.24	0.00	1.40	68.46	-0.02	0.97	142.97	0.00	0.38	141.47	0.00
0.61	144.76	0.00	1.73	68.61	-0.02	1.20	145.04	0.00	0.52	146.16	0.00
0.80	149.50	-0.01	2.00	69.97	-0.02	1.40	147.96	0.00	0.70	149.15	0.00
0.98	154.57	-0.02	2.26	71.72	-0.02	1.64	149.43	0.00	0.98	148.39	-0.02
1.16	159.49	-0.03	2.58	72.01	-0.03	1.90	151.63	0.00	1.22	149.75	-0.02
1.36	163.88	-0.04	2.92	71.68	-0.03	2.17	152.71	0.00	1.59	146.24	-0.02
1.58	167.34	-0.05	3.27	70.89	-0.04	2.40	154.63	0.00	1.88	148.06	-0.02
1.84	169.48	-0.06	3.54	72.24	-0.05	2.67	155.33	0.00	2.09	150.45	-0.02

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L.Perrey	June 10,2016	E. Kostyukov	June 15, 2016
TESTED BY	DATE	CHECKED BY	DATE

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Direct Shear Strength Testing Under Constant Normal Force

ASTM D5607

Project No.:	1654139/2000/2500	**Sample No.:**	RGSC 0013
Project:	MINI PIT STABILITY ASSESSMENT	**Test ID:**	15
Location:	GRASSY MOUNTAIN	**Depth (m):**	49.9-50.22
Client:	RIVERSIDE RESOURCES	**Lab ID No:**	203

PEAK + RESIDUAL		RESIDUAL 1		RESIDUAL 2		RESIDUAL 3	
σn Stress, kPa	200	σn Stress, kPa	100	σn Stress, kPa	200	σn Stress, kPa	300

Horz Disp mm	Shear Stress kPa	Vert Disp mm	Horz Disp mm	Shear Stress kPa	Vert Disp mm	Horz Disp mm	Shear Stress kPa	Vert Disp mm	Horz Disp mm	Shear Stress kPa	Vert Disp mm
2.11	171.06	-0.07	3.77	74.48	-0.06	2.95	155.38	-0.01	2.32	151.38	-0.02
2.66	161.80	-0.08	3.99	76.91	-0.07	3.42	147.91	-0.02	2.66	150.22	-0.03
3.23	155.01	-0.08	4.31	77.10	-0.09	3.81	143.77	-0.02	2.80	154.87	-0.03
3.56	155.94	-0.09	4.59	78.44	-0.10	4.06	147.28	-0.02	2.98	157.32	-0.03
3.88	156.55	-0.10	4.86	79.63	-0.11	4.32	148.88	-0.02	3.22	160.20	-0.03
4.07	161.97	-0.10	5.20	79.20	-0.12	4.57	152.40	-0.03	3.51	160.44	-0.04
4.42	161.59	-0.12	5.55	78.87	-0.13	4.81	153.87	-0.03	3.74	161.86	-0.04
4.69	164.30	-0.12	5.81	80.82	-0.14	5.09	154.72	-0.03	3.98	163.35	-0.04
4.91	168.88	-0.13	5.99	84.30	-0.14	5.40	154.43	-0.03	4.26	163.86	-0.05
5.20	171.34	-0.13	6.21	86.78	-0.14	5.64	156.10	-0.04	4.52	164.15	-0.05
5.45	173.99	-0.14	6.97	75.55	-0.14	5.90	157.89	-0.04	4.86	162.19	-0.05
5.74	174.87	-0.14	7.21	77.92	-0.14	6.13	160.20	-0.04	5.10	163.84	-0.06
6.04	175.20	-0.14	7.44	80.25	-0.14	6.42	160.16	-0.04	5.38	163.64	-0.06
6.36	174.13	-0.15	7.62	83.76	-0.14	6.76	158.51	-0.05	5.66	163.83	-0.06
6.53	180.08	-0.15	7.86	86.31	-0.15	7.03	159.46	-0.05	5.93	164.28	-0.06
6.70	184.72	-0.15	9.66	50.89	-0.18	7.31	160.09	-0.05	6.26	162.66	-0.06
6.89	188.96	-0.15	9.92	52.62	-0.18	7.60	160.56	-0.05	6.52	164.94	-0.06
7.10	192.85	-0.16	10.28	53.16	-0.19	7.88	161.75	-0.05	6.77	166.86	-0.06
7.30	196.89	-0.16	10.56	54.51	-0.19	8.28	157.36	-0.06	7.01	169.12	-0.06
7.53	199.57	-0.16	10.85	55.63	-0.20	8.55	158.07	-0.06	7.27	170.01	-0.06
7.77	201.44	-0.17	11.19	55.39	-0.20	8.79	161.05	-0.06	7.48	173.33	-0.06
8.00	205.47	-0.17	11.60	53.67	-0.20	9.02	163.64	-0.06	7.69	176.57	-0.06
8.74	186.31	-0.17	11.93	53.88	-0.20	10.75	108.02	-0.13	7.87	180.06	-0.07
9.16	182.84	-0.17	12.34	51.82	-0.20	11.05	109.72	-0.13	8.13	181.27	-0.07
9.42	186.65	-0.18	12.84	47.78	-0.20	11.29	113.00	-0.13	8.40	181.08	-0.07
11.24	131.56	-0.24	13.25	46.24	-0.20	11.55	114.33	-0.13	8.71	180.43	-0.07
11.52	134.37	-0.25	13.57	46.76	-0.20	11.79	117.21	-0.13	8.94	183.31	-0.07
11.81	137.00	-0.25	13.83	48.12	-0.20	12.11	117.41	-0.14	9.20	183.95	-0.07
12.21	135.79	-0.25	14.17	48.42	-0.20	12.38	119.25	-0.14	9.44	186.28	-0.07

The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

L.Perrey	June 10,2016	E. Kostyukov	June 15, 2016
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates Ltd.
300, 3811 North Fraser Way, Burnaby, British Columbia, Canada V5J 5J2
Tel: 604-412-6899 Fax: 604-412-6816 www.golder.com

Direct Shear Strength Testing Under Constant Normal Force

ASTM D5607

Project No.:	1654139/2000/2500	**Sample No.:**	RGSC 0013
Project:	MINI PIT STABILITY ASSESSMENT	**Test ID:**	15
Location:	GRASSY MOUNTAIN	**Depth (m):**	49.9-50.22
Client:	RIVERSIDE RESOURCES	**Lab ID No:**	203

PEAK + RESIDUAL			RESIDUAL 1			RESIDUAL 2			RESIDUAL 3		
σn Stress,	kPa	200	σn Stress,	kPa	100	σn Stress,	kPa	200	σn Stress,	kPa	300
Horz Disp	Shear Stress	Vert Disp	Horz Disp	Shear Stress	Vert Disp	Horz Disp	Shear Stress	Vert Disp	Horz Disp	Shear Stress	Vert Disp
mm	kPa	mm	mm	kPa	mm	mm	kPa	mm	mm	kPa	mm
12.59	133.66	-0.25	14.46	49.61	-0.20	12.70	117.93	-0.15	9.70	187.69	-0.07
12.99	132.38	-0.26	14.67	51.86	-0.20	13.02	117.51	-0.15	9.92	190.97	-0.08
13.38	131.10	-0.26	14.93	53.09	-0.21	13.26	120.11	-0.15	10.14	193.96	-0.08
13.72	130.95	-0.26	15.34	51.78	-0.21	13.60	118.71	-0.16	10.36	196.73	-0.09
14.08	130.44	-0.26	15.68	51.90	-0.21	13.84	121.17	-0.16	10.60	198.87	-0.09
14.43	129.37	-0.26	16.02	51.55	-0.21	14.07	123.62	-0.16	10.84	199.75	-0.09
14.81	127.80	-0.26	16.34	51.31	-0.21	14.30	125.68	-0.17	11.12	200.83	-0.10
15.19	125.75	-0.26	16.70	50.95	-0.22	14.65	123.28	-0.17	11.36	203.88	-0.10
15.54	124.91	-0.26	16.94	52.96	-0.22	14.93	124.52	-0.17	11.54	199.01	-0.10
15.85	125.60	-0.27	17.20	54.24	-0.22	15.17	127.56	-0.17	11.79	200.18	-0.10
16.16	125.95	-0.27	17.35	57.57	-0.22	15.48	128.03	-0.17	12.03	201.66	-0.10
16.46	127.47	-0.27	17.50	60.93	-0.22	15.69	132.50	-0.17	12.30	202.10	-0.11
16.71	130.50	-0.27	17.67	64.46	-0.22	15.93	135.11	-0.17	12.49	203.70	-0.11
16.94	134.65	-0.27	18.12	70.46	-0.24	16.24	135.58	-0.18	12.74	204.20	-0.11
17.15	138.98	-0.27				16.43	140.61	-0.18	12.94	205.67	-0.11
17.34	143.95	-0.27				16.68	142.39	-0.18	13.29	205.84	-0.11
17.83	137.38	-0.28				16.91	145.28	-0.18	13.51	206.34	-0.11
18.13	138.00	-0.29				17.14	139.09	-0.19	13.77	207.72	-0.11
						17.32	143.25	-0.20	14.01	202.81	-0.12
						17.58	134.84	-0.20	14.23	203.44	-0.12
						17.89	134.49	-0.21	14.44	202.29	-0.12
									14.65	202.17	-0.12
									14.93	201.39	-0.13
									15.16	194.62	-0.13
									15.48	192.83	-0.13
									15.68	196.43	-0.14
									15.89	198.63	-0.14
									16.17	197.26	-0.14
									16.46	197.47	-0.14

The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

L.Perrey	June 10,2016	E. Kostyukov	June 15, 2016
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates Ltd.
300, 3811 North Fraser Way, Burnaby, British Columbia, Canada V5J 5J2
Tel: 604-412-6899 Fax: 604-412-6816 www.golder.com

Direct Shear Strength Testing Under Constant Normal Force

ASTM D5607

Project No.:	1654139/2000/2500	**Sample No.:**	RGSC 0013
Project:	MINI PIT STABILITY ASSESSMENT	**Test ID:**	15
Location:	GRASSY MOUNTAIN	**Depth (m):**	49.9-50.22
Client:	RIVERSIDE RESOURCES	**Lab ID No:**	203

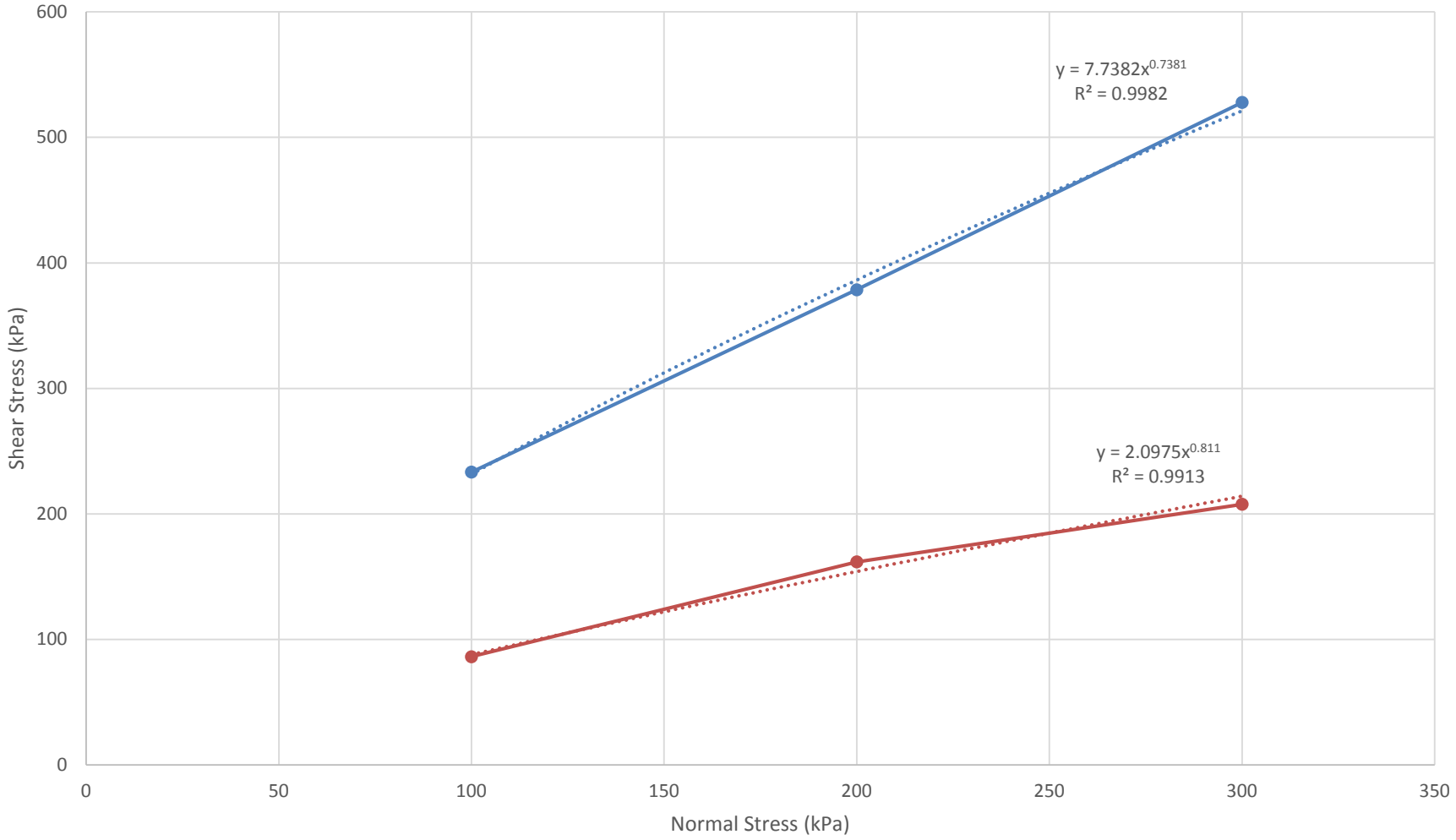
PEAK + RESIDUAL			RESIDUAL 1			RESIDUAL 2			RESIDUAL 3		
σn Stress, kPa		200	σn Stress, kPa		100	σn Stress, kPa		200	σn Stress, kPa		300
Horz Disp mm	Shear Stress kPa	Vert Disp mm	Horz Disp mm	Shear Stress kPa	Vert Disp mm	Horz Disp mm	Shear Stress kPa	Vert Disp mm	Horz Disp mm	Shear Stress kPa	Vert Disp mm
									16.71	198.08	-0.15
									17.05	194.88	-0.15
									17.33	194.80	-0.15
									17.57	197.25	-0.15
									17.78	200.41	-0.16
									17.99	200.31	-0.16

The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

L.Perrey	June 10,2016	E. Kostyukov	June 15, 2016
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates Ltd.
300, 3811 North Fraser Way, Burnaby, British Columbia, Canada V5J 5J2
Tel: 604-412-6899 Fax: 604-412-6816 www.golder.com

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix D - Point Load and Laboratory Testing Results\Source | File Name: D- 6 Direct Shear Testing Graph.pptx



CLIENT
RIVERSDALE RESOURCES LIMITED

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-06-22
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
DIRECT SHEAR TESTING
POWER CURVE

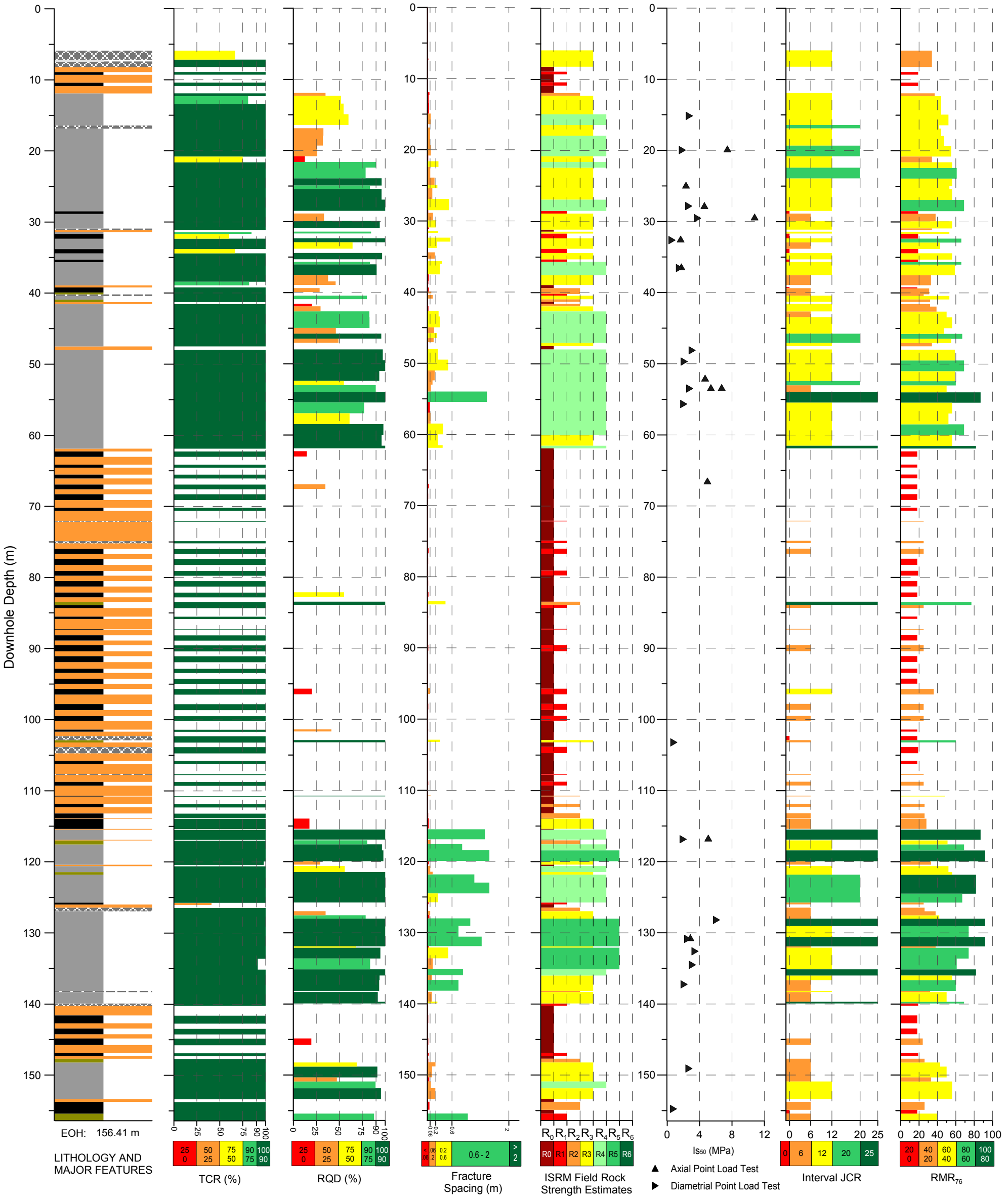
PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**D-1**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A

APPENDIX E

Downhole Drillhole Plots

Northing (m):	5504648.0	Azimuth:	000°	Borehole ID:	RGSC-0011
Easting (m):	685504.0	Inclination:	-90°		
Elevation (m.a.s.l.):	1563.0	Length (m):	156.41		



LITHOLOGY

- Coal
- Carbonaceous Mudstone
- Mudstone
- Siltstone
- Sandstone
- Conglomerate

MAJOR FEATURES

- Fault
- Lost Core
- Broken Core

Rev. 0

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

CLIENT
RIVERSDALE RESOURCE LIMITED

TITLE
GEOTECHNICAL SUMMARY LOG
RGSC-0011

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-06-03
PREPARED	DAM
CAD	SMR
CHECK	AVC
REVIEW	AVC

PROJECT No.: 1654139
PHASE: 5000

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

Northing (m):	5504610.0	Azimuth:	000°	Borehole ID:	RGSC-0012
Easting (m):	685218.0	Inclination:	-90°		
Elevation (m.a.s.l.):	1527.0	Length (m):	139.72		

LITHOLOGY

- Coal
- Carbonaceous Mudstone
- Mudstone
- Siltstone
- Sandstone
- Conglomerate

MAJOR FEATURES

- Fault
- Lost Core
- Broken Core

Rev. 0

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

CLIENT
RIVERSDALE RESOURCE LIMITED

TITLE
GEOTECHNICAL SUMMARY LOG
RGSC-0012

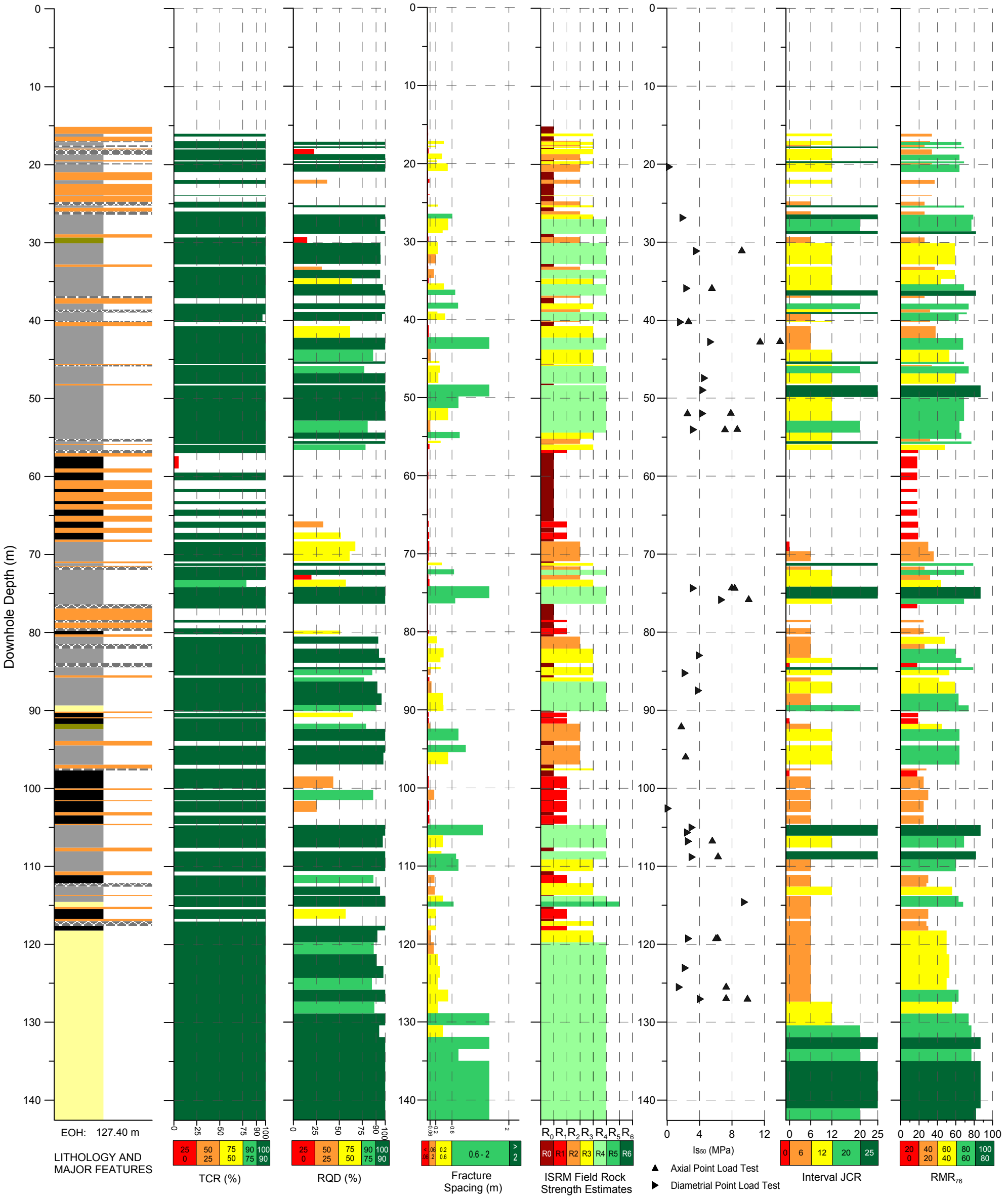
CONSULTANT
Golder Associates

YYYY-MM-DD	2016-06-03
PREPARED	DAM
CAD	SMR
CHECK	AVC
REVIEW	AVC

PROJECT No. 1654139
PHASE 5000

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

Northing (m):	5504637.0	Azimuth:	000°	Borehole ID:	RGSC-0013
Easting (m):	685567.0	Inclination:	-90°		
Elevation (m.a.s.l.):	1568.0	Length (m):	127.40		



LITHOLOGY

- Coal
- Carbonaceous Mudstone
- Mudstone
- Siltstone
- Sandstone
- Conglomerate

MAJOR FEATURES

- Fault
- Lost Core
- Broken Core

Rev. 0

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

CLIENT
RIVERSDALE RESOURCE LIMITED

TITLE
GEOTECHNICAL SUMMARY LOG
RGSC-0013

CONSULTANT
Golder Associates

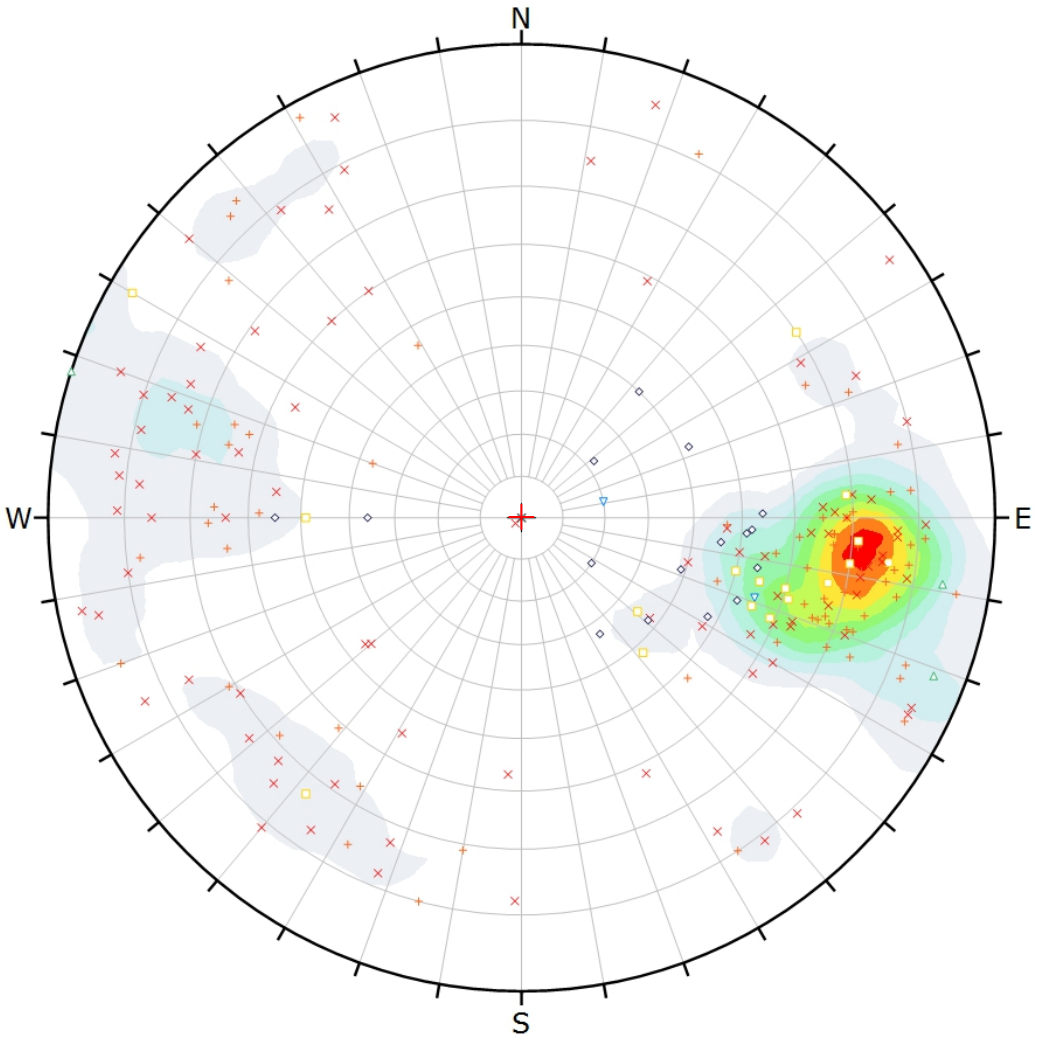
YYYY-MM-DD	2016-06-03
PREPARED	DAM
CAD	SMR
CHECK	AVC
REVIEW	AVC

PROJECT No. 1654139
PHASE 5000

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

APPENDIX F

Structural Orientation Data



Symbol	FEATURE TYPE	Quantity
◇	Bedding	16
×	Closed/ infilled joint	89
△	Discontinuous joint	3
+	Open joint	71
▽	Other feature	2
□	Possible fault	17

Color	Density Concentrations
	0.00 - 1.50
	1.50 - 3.00
	3.00 - 4.50
	4.50 - 6.00
	6.00 - 7.50
	7.50 - 9.00
	9.00 - 10.50
	10.50 - 12.00
	12.00 - 13.50
	13.50 - 15.00

Maximum Density	14.39%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	198 (198 Entries)
Hemisphere	Lower
Projection	Equal Angle

RGSC-0011 BOREHOLE TREND & PLUNGE
90º INCLINATION TOWARDS 000º AZIMUTH

NOTES

1. THE TELEVIEWER INTERPRETATION DATA WAS PROVIDED TO GOLDER BY ASIMS (ACOUSTIC SCANNER AND SONIC LOG INTERPRETATION).
2. STEREOGRAPHIC PROJECTIONS TO MINE GRID NORTH.
3. STEREOGRAPHIC PLOTS PREPARED USING ROCSCIENCE DIPS VERSION 6.0.

CLIENT
RIVERSDALE RESOURCES LIMITED

CONSULTANT
Golder Associates

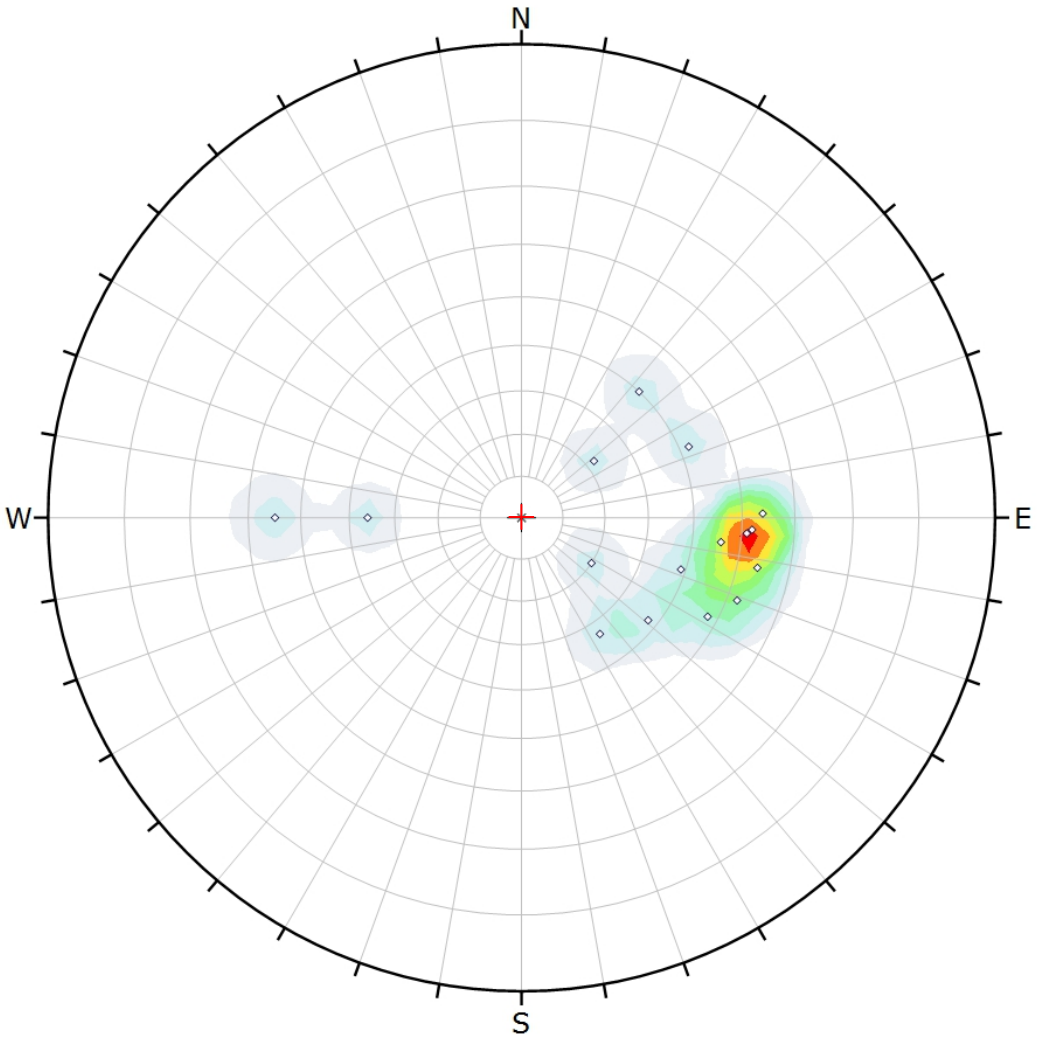
YYYY-MM-DD	2016-06-16
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

TITLE
STEREOGRAPHIC PROJECTION – RGSC-0011
SYMBOLIC POLE PLOT OF ALL FEATURES

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**F-1**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0



Symbol	FEATURE TYPE	Quantity
◇	Bedding	16

Color	Density Concentrations
	0.00 - 2.90
	2.90 - 5.80
	5.80 - 8.70
	8.70 - 11.60
	11.60 - 14.50
	14.50 - 17.40
	17.40 - 20.30
	20.30 - 23.20
	23.20 - 26.10
	26.10 - 29.00

Maximum Density	28.10%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	16 (16 Entries)
Hemisphere	Lower
Projection	Equal Angle

RGSC-0011 BOREHOLE TREND & PLUNGE
90º INCLINATION TOWARDS 000º AZIMUTH

NOTES

1. THE TELEVIEWER INTERPRETATION DATA WAS PROVIDED TO GOLDER BY ASIMS (ACOUSTIC SCANNER AND SONIC LOG INTERPRETATION).
2. STEREOGRAPHIC PROJECTIONS TO MINE GRID NORTH.
3. STEREOGRAPHIC PLOTS PREPARED USING ROCSCIENCE DIPS VERSION 6.0.

CLIENT
RIVERSDALE RESOURCES LIMITED

CONSULTANT
Golder Associates

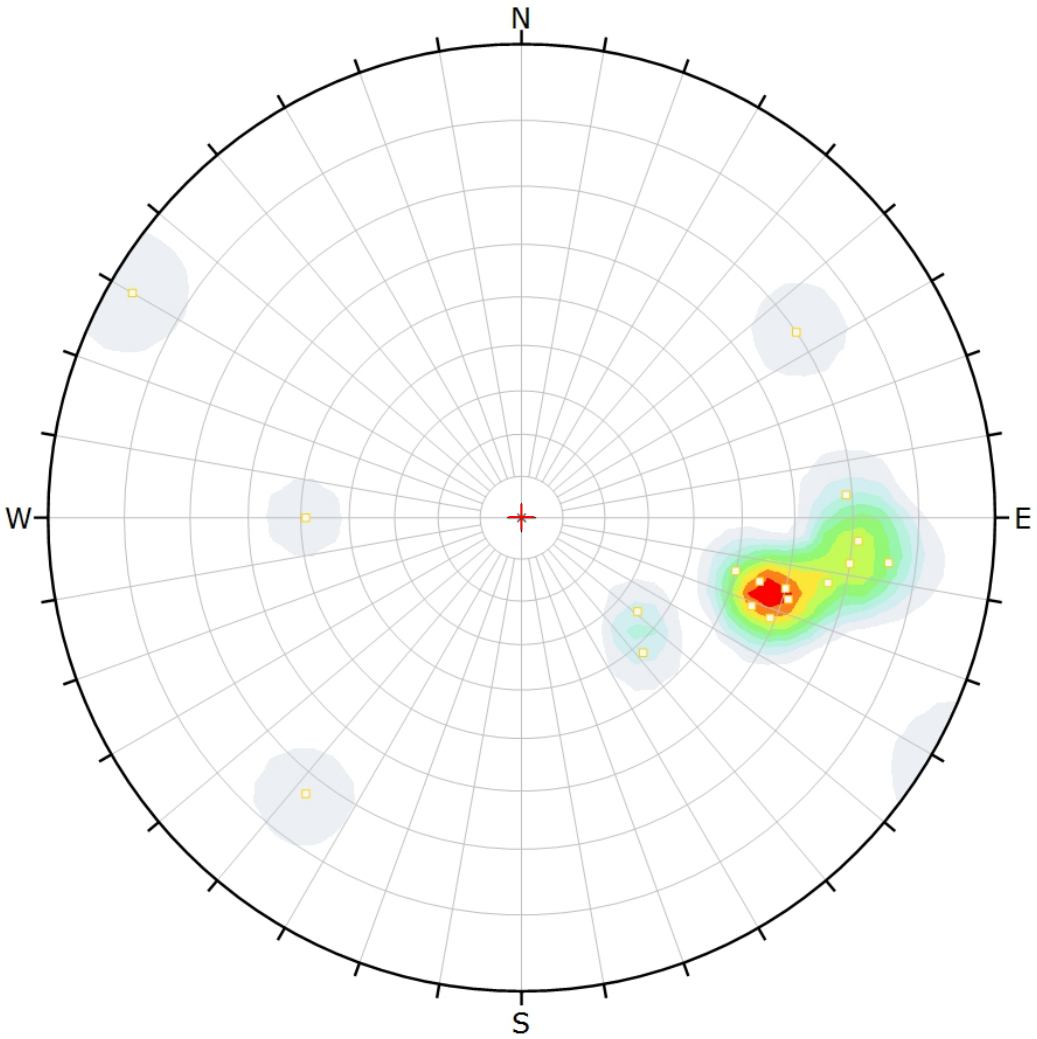
YYYY-MM-DD	2016-06-16
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

TITLE
STEREOGRAPHIC PROJECTION – RGSC-0011
SYMBOLIC POLE PLOT OF BEDDING

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**F-2**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0



Symbol	FEATURE TYPE	Quantity
□	Possible fault	17

Color	Density Concentrations
	0.00 - 3.20
	3.20 - 6.40
	6.40 - 9.60
	9.60 - 12.80
	12.80 - 16.00
	16.00 - 19.20
	19.20 - 22.40
	22.40 - 25.60
	25.60 - 28.80
	28.80 - 32.00

Maximum Density	31.79%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	17 (17 Entries)
Hemisphere	Lower
Projection	Equal Angle

RGSC-0011 BOREHOLE TREND & PLUNGE
90º INCLINATION TOWARDS 000º AZIMUTH

NOTES

1. THE TELEVIEWER INTERPRETATION DATA WAS PROVIDED TO GOLDER BY ASIMS (ACOUSTIC SCANNER AND SONIC LOG INTERPRETATION).
2. STEREOGRAPHIC PROJECTIONS TO MINE GRID NORTH.
3. STEREOGRAPHIC PLOTS PREPARED USING ROCSCIENCE DIPS VERSION 6.0.

CLIENT
RIVERSDALE RESOURCES LIMITED

CONSULTANT
Golder Associates

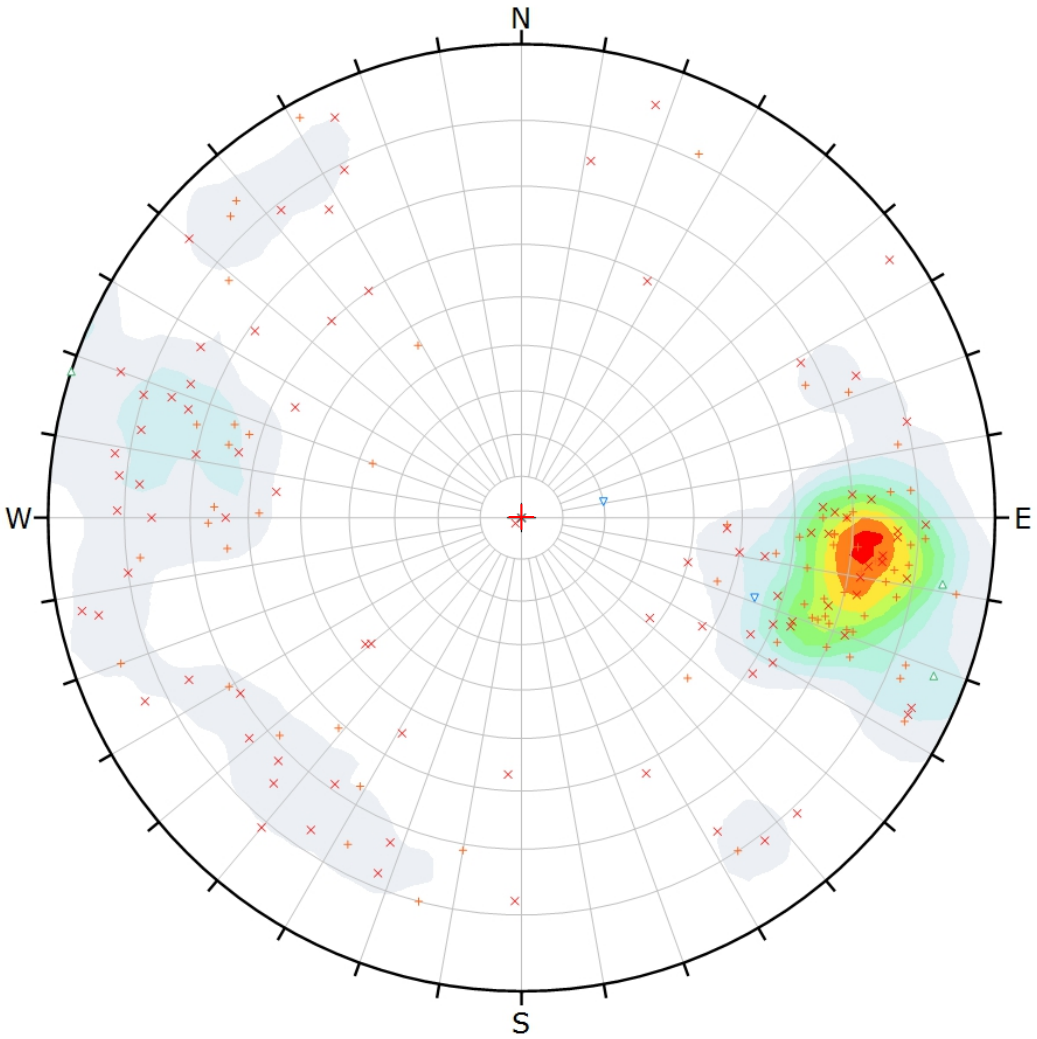
YYYY-MM-DD	2016-06-16
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

TITLE
STEREOGRAPHIC PROJECTION – RGSC-0011
SYMBOLIC POLE PLOT OF FAULTS

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**F-3**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0



Symbol	FEATURE TYPE	Quantity
×	Closed/ infilled joint	89
△	Discontinuous joint	3
+	Open joint	71
▽	Other feature	2

Color	Density Concentrations
	0.00 - 1.60
	1.60 - 3.20
	3.20 - 4.80
	4.80 - 6.40
	6.40 - 8.00
	8.00 - 9.60
	9.60 - 11.20
	11.20 - 12.80
	12.80 - 14.40
	14.40 - 16.00

Maximum Density	15.06%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	165 (165 Entries)
Hemisphere	Lower
Projection	Equal Angle

\+ RGSC-0011 BOREHOLE TREND & PLUNGE
90º INCLINATION TOWARDS 000º AZIMUTH

NOTES

1. THE TELEVIEWER INTERPRETATION DATA WAS PROVIDED TO GOLDER BY ASIMS (ACOUSTIC SCANNER AND SONIC LOG INTERPRETATION).
2. STEREOGRAPHIC PROJECTIONS TO MINE GRID NORTH.
3. STEREOGRAPHIC PLOTS PREPARED USING ROCSCIENCE DIPS VERSION 6.0.

CLIENT
RIVERSDALE RESOURCES LIMITED

CONSULTANT
Golder Associates

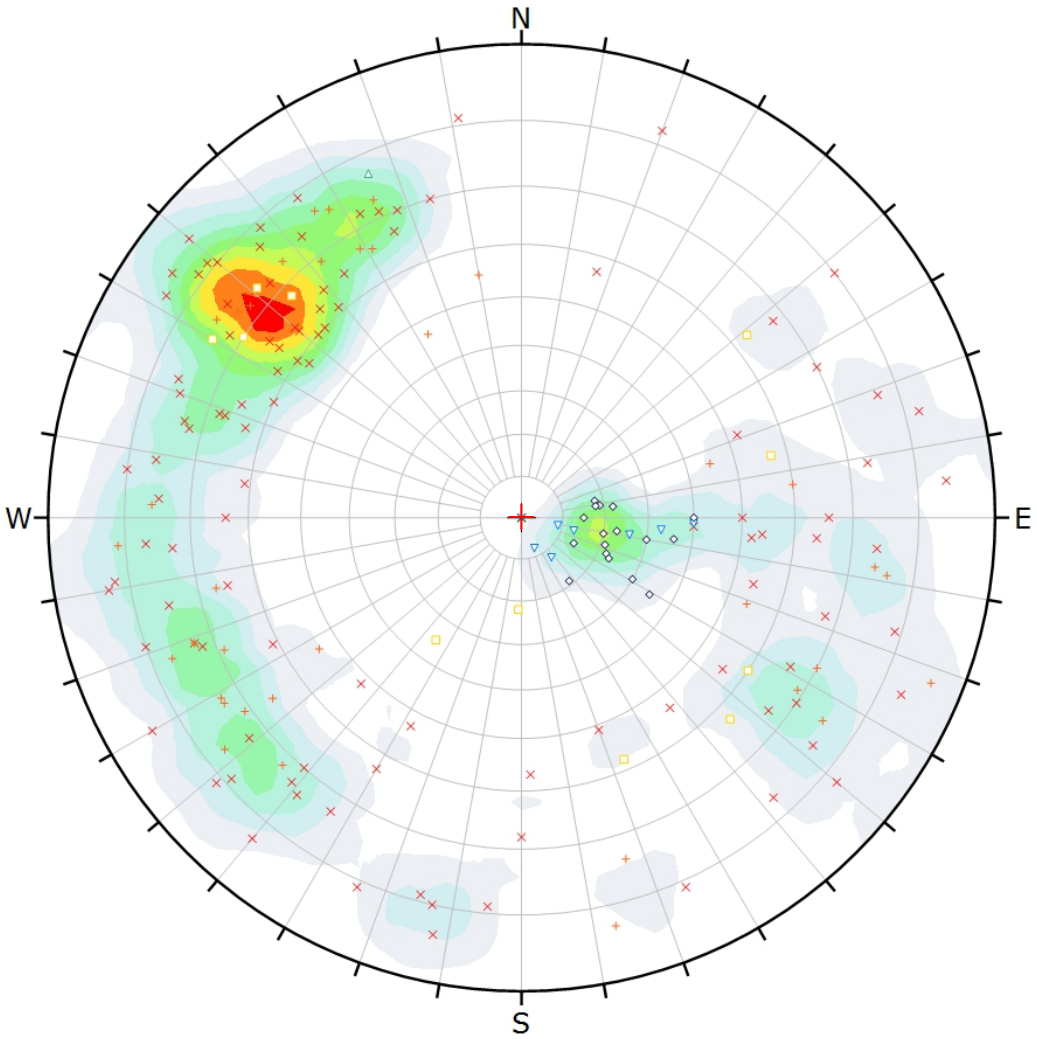
YYYY-MM-DD	2016-06-16
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

TITLE
STEREOGRAPHIC PROJECTION – RGSC-0011
SYMBOLIC POLE PLOT OF JOINTS

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**F-4**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0



Symbol	FEATURE TYPE	Quantity
◇	Bedding	17
×	Closed/ infilled joint	108
△	Discontinuous joint	1
+	Open joint	36
▽	Other feature	7
□	Possible fault	11

Color	Density Concentrations
	0.00 - 0.85
	0.85 - 1.70
	1.70 - 2.55
	2.55 - 3.40
	3.40 - 4.25
	4.25 - 5.10
	5.10 - 5.95
	5.95 - 6.80
	6.80 - 7.65
	7.65 - 8.50

Maximum Density	8.01%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	180 (180 Entries)
Hemisphere	Lower
Projection	Equal Angle

RGSC-0012 BOREHOLE TREND & PLUNGE
90º INCLINATION TOWARDS 000º AZIMUTH

NOTES

1. THE TELEVIEWER INTERPRETATION DATA WAS PROVIDED TO GOLDER BY ASIMS (ACOUSTIC SCANNER AND SONIC LOG INTERPRETATION).
2. STEREOGRAPHIC PROJECTIONS TO MINE GRID NORTH.
3. STEREOGRAPHIC PLOTS PREPARED USING ROCSCIENCE DIPS VERSION 6.0.

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Golder Associates

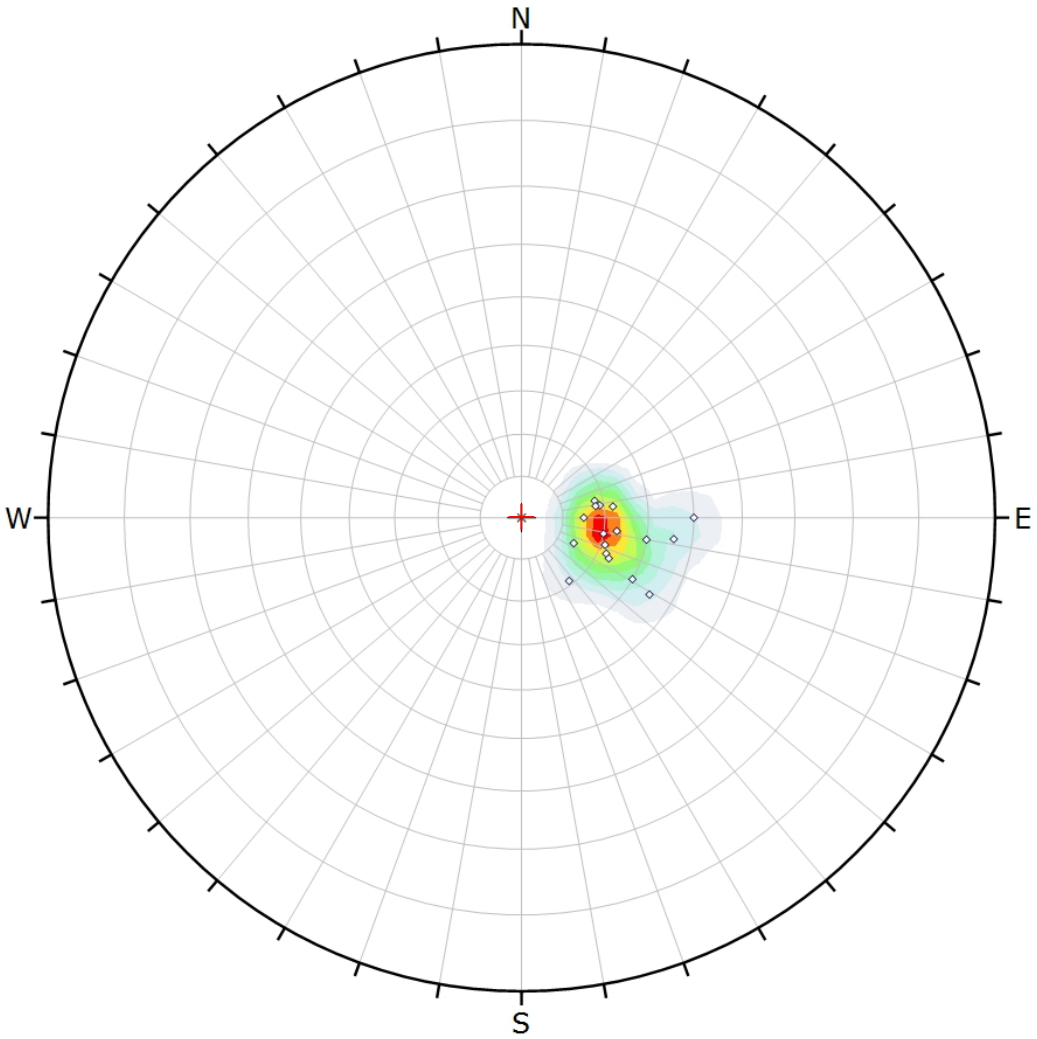
YYYY-MM-DD	2016-06-16
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

TITLE
STEREOGRAPHIC PROJECTION – RGSC-0012
SYMBOLIC POLE PLOT OF ALL FEATURES

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**F-5**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: A/B/A
1 in
0



Symbol	FEATURE TYPE	Quantity
◇	Bedding	17

Color	Density Concentrations
	0.00 - 5.10
	5.10 - 10.20
	10.20 - 15.30
	15.30 - 20.40
	20.40 - 25.50
	25.50 - 30.60
	30.60 - 35.70
	35.70 - 40.80
	40.80 - 45.90
	45.90 - 51.00

Maximum Density	50.06%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	17 (17 Entries)
Hemisphere	Lower
Projection	Equal Angle

RGSC-0012 BOREHOLE TREND & PLUNGE
90º INCLINATION TOWARDS 000º AZIMUTH

NOTES

1. THE TELEVIEWER INTERPRETATION DATA WAS PROVIDED TO GOLDER BY ASIMS (ACOUSTIC SCANNER AND SONIC LOG INTERPRETATION).
2. STEREOGRAPHIC PROJECTIONS TO MINE GRID NORTH.
3. STEREOGRAPHIC PLOTS PREPARED USING ROCSCIENCE DIPS VERSION 6.0.

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YYYY-MM-DD	2016-06-16
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

TITLE
STEREOGRAPHIC PROJECTION – RGSC-0012
SYMBOLIC POLE PLOT OF BEDDING

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**F-6**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
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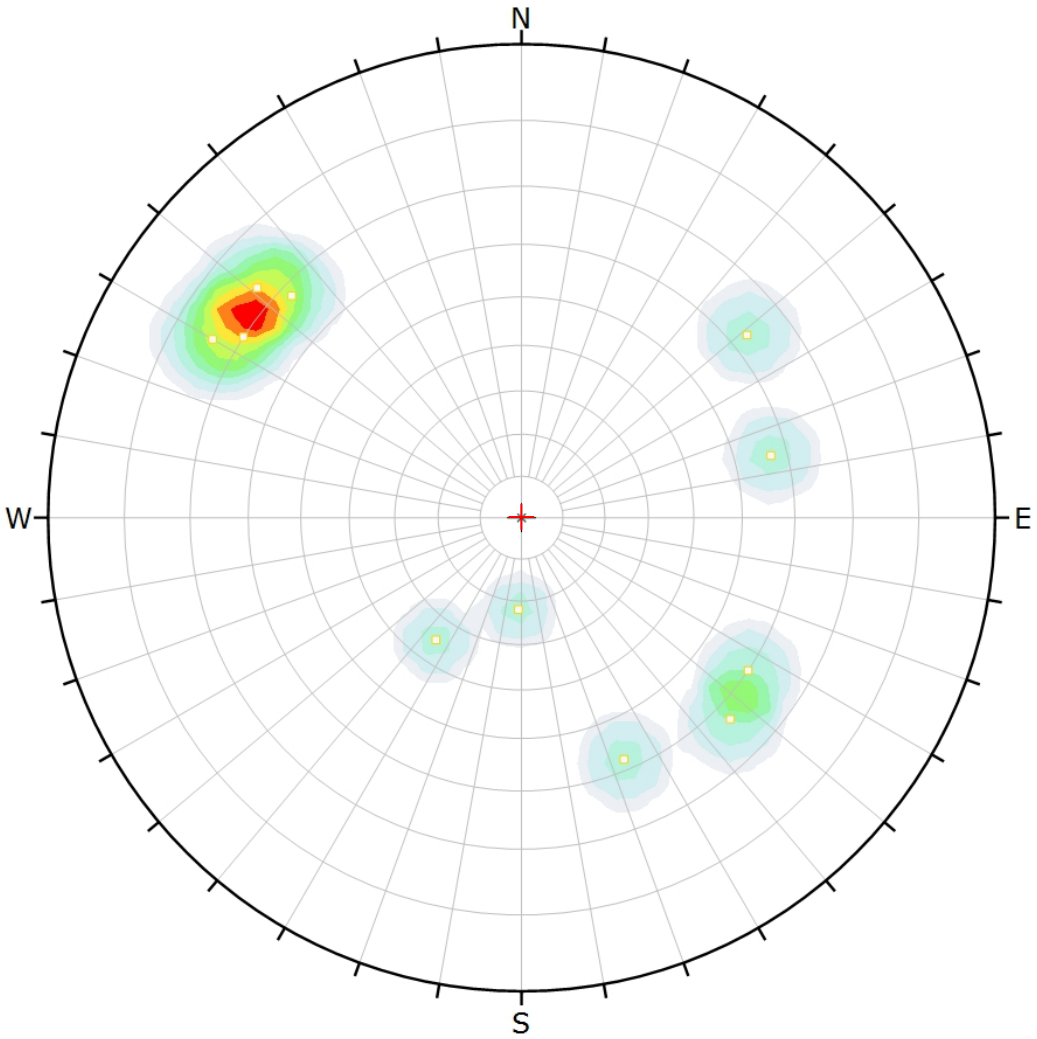

Symbol	FEATURE TYPE	Quantity
□	Possible fault	11

Color	Density Concentrations
	0.00 - 2.80
	2.80 - 5.60
	5.60 - 8.40
	8.40 - 11.20
	11.20 - 14.00
	14.00 - 16.80
	16.80 - 19.60
	19.60 - 22.40
	22.40 - 25.20
	25.20 - 28.00

Maximum Density	27.32%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	11 (11 Entries)
Hemisphere	Lower
Projection	Equal Angle

RGSC-0012 BOREHOLE TREND & PLUNGE
90º INCLINATION TOWARDS 000º AZIMUTH

NOTES

1. THE TELEVIEWER INTERPRETATION DATA WAS PROVIDED TO GOLDER BY ASIMS (ACOUSTIC SCANNER AND SONIC LOG INTERPRETATION).
2. STEREOGRAPHIC PROJECTIONS TO MINE GRID NORTH.
3. STEREOGRAPHIC PLOTS PREPARED USING ROCSCIENCE DIPS VERSION 6.0.

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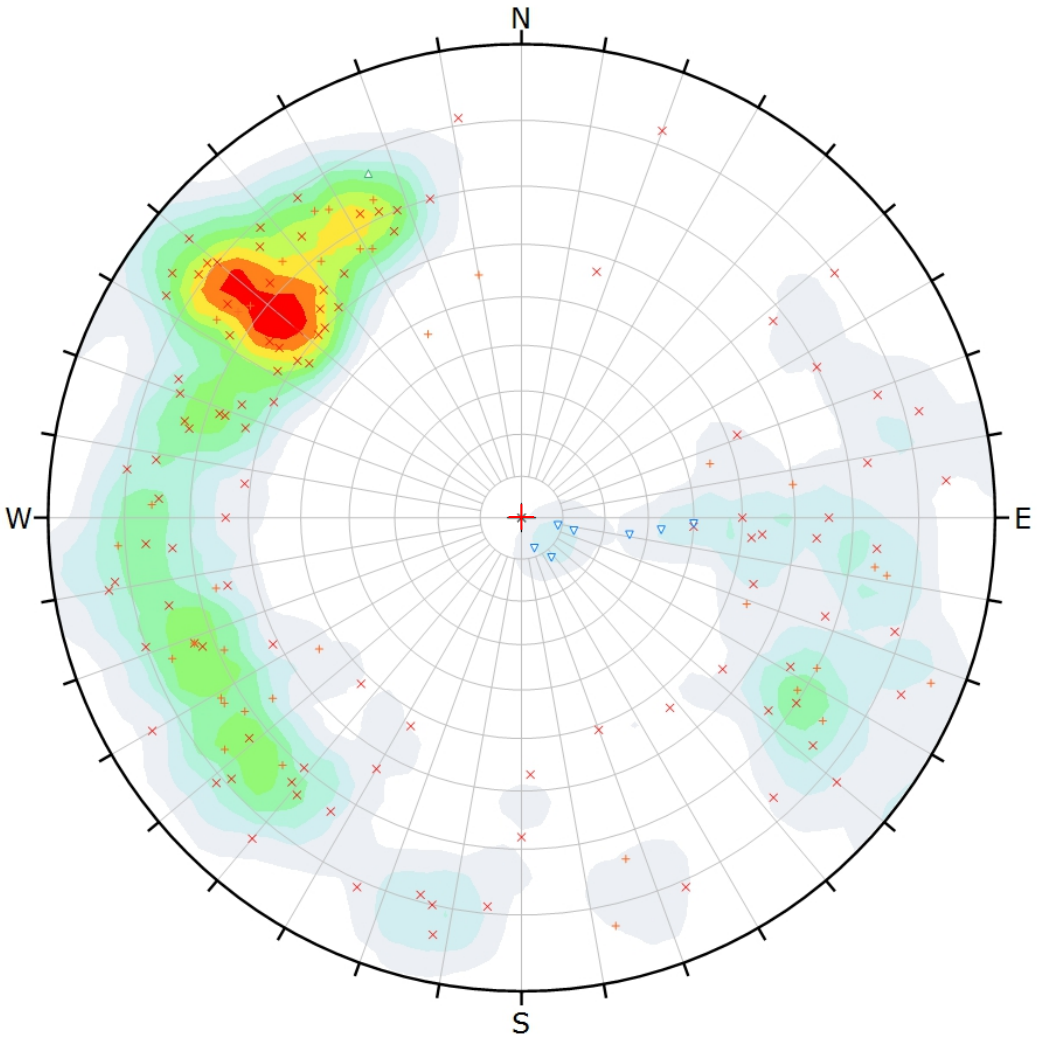
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

TITLE
STEREOGRAPHIC PROJECTION – RGSC-0012
SYMBOLIC POLE PLOT OF FAULTS

PROJECT No.	PHASE	Rev.	FIGURE
1654139	5000	0	F-7

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0



Symbol	FEATURE TYPE	Quantity
×	Closed/ infilled joint	108
△	Discontinuous joint	1
+	Open joint	36
▽	Other feature	7

Color	Density Concentrations
	0.00 - 0.80
	0.80 - 1.60
	1.60 - 2.40
	2.40 - 3.20
	3.20 - 4.00
	4.00 - 4.80
	4.80 - 5.60
	5.60 - 6.40
	6.40 - 7.20
	7.20 - 8.00

Maximum Density	7.89%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	152 (152 Entries)
Hemisphere	Lower
Projection	Equal Angle

\+ RGSC-0012 BOREHOLE TREND & PLUNGE
90º INCLINATION TOWARDS 000º AZIMUTH

NOTES

1. THE TELEVIEWER INTERPRETATION DATA WAS PROVIDED TO GOLDER BY ASIMS (ACOUSTIC SCANNER AND SONIC LOG INTERPRETATION).
2. STEREOGRAPHIC PROJECTIONS TO MINE GRID NORTH.
3. STEREOGRAPHIC PLOTS PREPARED USING ROCSCIENCE DIPS VERSION 6.0.

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-06-16
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
STEREOGRAPHIC PROJECTION – RGSC-0012
SYMBOLIC POLE PLOT OF JOINTS

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**F-8**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
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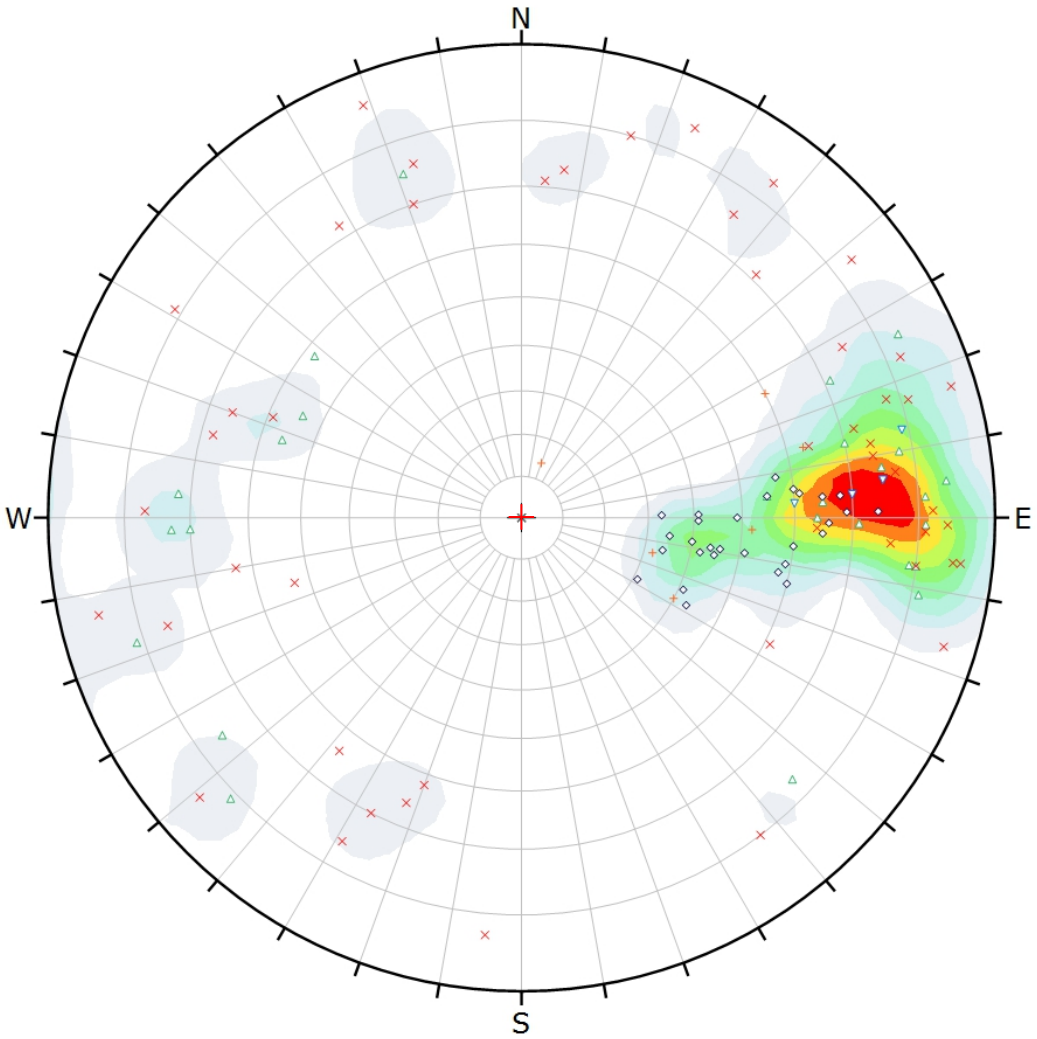

Symbol	FEATURE TYPE	Quantity
◇	Bedding	29
×	Closed/ infilled joint	52
△	Open joint	26
+	Other feature	6
▽	Possible fault	4

Color	Density Concentrations
	0.00 - 1.40
	1.40 - 2.80
	2.80 - 4.20
	4.20 - 5.60
	5.60 - 7.00
	7.00 - 8.40
	8.40 - 9.80
	9.80 - 11.20
	11.20 - 12.60
	12.60 - 14.00

Maximum Density	13.90%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	117 (117 Entries)
Hemisphere	Lower
Projection	Equal Angle

RGSC-0013 BOREHOLE TREND & PLUNGE
90º INCLINATION TOWARDS 000º AZIMUTH

NOTES

1. THE TELEVIEWER INTERPRETATION DATA WAS PROVIDED TO GOLDER BY ASIMS (ACOUSTIC SCANNER AND SONIC LOG INTERPRETATION).
2. STEREOGRAPHIC PROJECTIONS TO MINE GRID NORTH.
3. STEREOGRAPHIC PLOTS PREPARED USING ROCSCIENCE DIPS VERSION 6.0.

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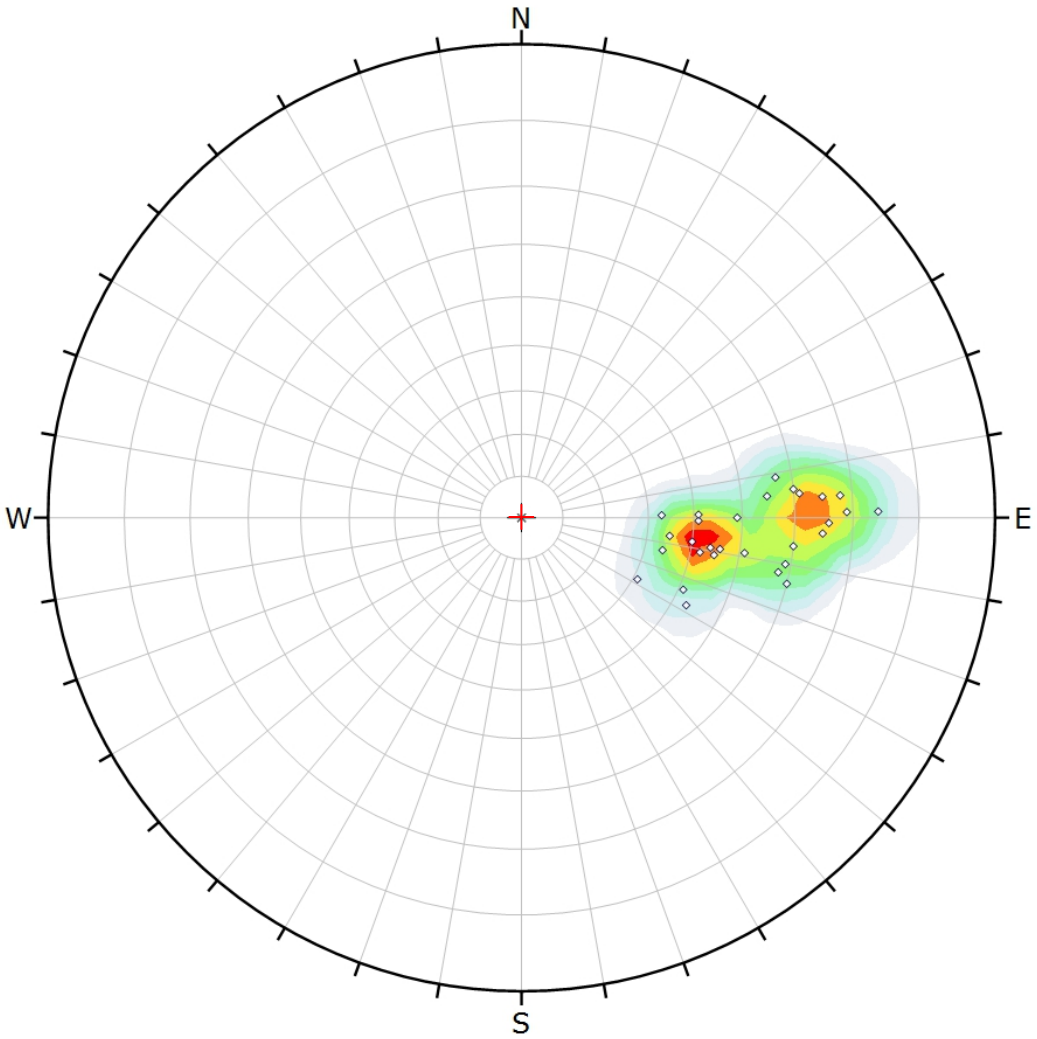
REVIEW	AVC
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

TITLE
STEREOGRAPHIC PROJECTION – RGSC-0013
SYMBOLIC POLE PLOT OF ALL FEATURES

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**F-9**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
0



Symbol	FEATURE TYPE	Quantity
◇	Bedding	29

Color	Density Concentrations
	0.00 - 3.00
	3.00 - 6.00
	6.00 - 9.00
	9.00 - 12.00
	12.00 - 15.00
	15.00 - 18.00
	18.00 - 21.00
	21.00 - 24.00
	24.00 - 27.00
	27.00 - 30.00

Maximum Density	29.44%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	29 (29 Entries)
Hemisphere	Lower
Projection	Equal Angle

RGSC-0013 BOREHOLE TREND & PLUNGE
90º INCLINATION TOWARDS 000º AZIMUTH

NOTES

1. THE TELEVIEWER INTERPRETATION DATA WAS PROVIDED TO GOLDER BY ASIMS (ACOUSTIC SCANNER AND SONIC LOG INTERPRETATION).
2. STEREOGRAPHIC PROJECTIONS TO MINE GRID NORTH.
3. STEREOGRAPHIC PLOTS PREPARED USING ROCSCIENCE DIPS VERSION 6.0.

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

TITLE
STEREOGRAPHIC PROJECTION – RGSC-0013
SYMBOLIC POLE PLOT OF BEDDING

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**F-10**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
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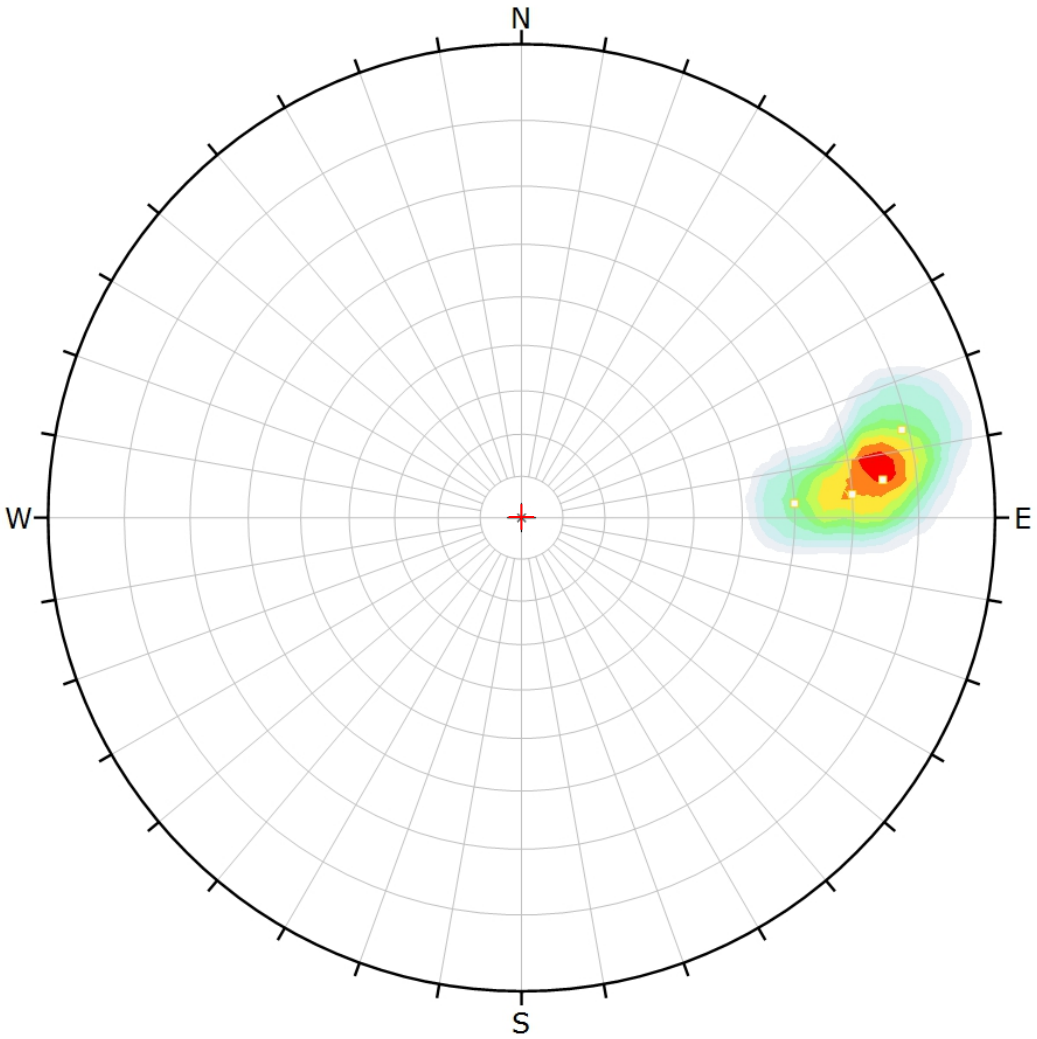

Symbol	FEATURE TYPE	Quantity
□	Possible fault	4

Color	Density Concentrations
	0.00 - 6.30
	6.30 - 12.60
	12.60 - 18.90
	18.90 - 25.20
	25.20 - 31.50
	31.50 - 37.80
	37.80 - 44.10
	44.10 - 50.40
	50.40 - 56.70
	56.70 - 63.00

Maximum Density	62.86%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	4 (4 Entries)
Hemisphere	Lower
Projection	Equal Angle

RGSC-0013 BOREHOLE TREND & PLUNGE
90º INCLINATION TOWARDS 000º AZIMUTH

NOTES

1. THE TELEVIEWER INTERPRETATION DATA WAS PROVIDED TO GOLDER BY ASIMS (ACOUSTIC SCANNER AND SONIC LOG INTERPRETATION).
2. STEREOGRAPHIC PROJECTIONS TO MINE GRID NORTH.
3. STEREOGRAPHIC PLOTS PREPARED USING ROCSCIENCE DIPS VERSION 6.0.

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PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

TITLE
STEREOGRAPHIC PROJECTION – RGSC-0013
SYMBOLIC POLE PLOT OF FAULTS

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**F-11**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
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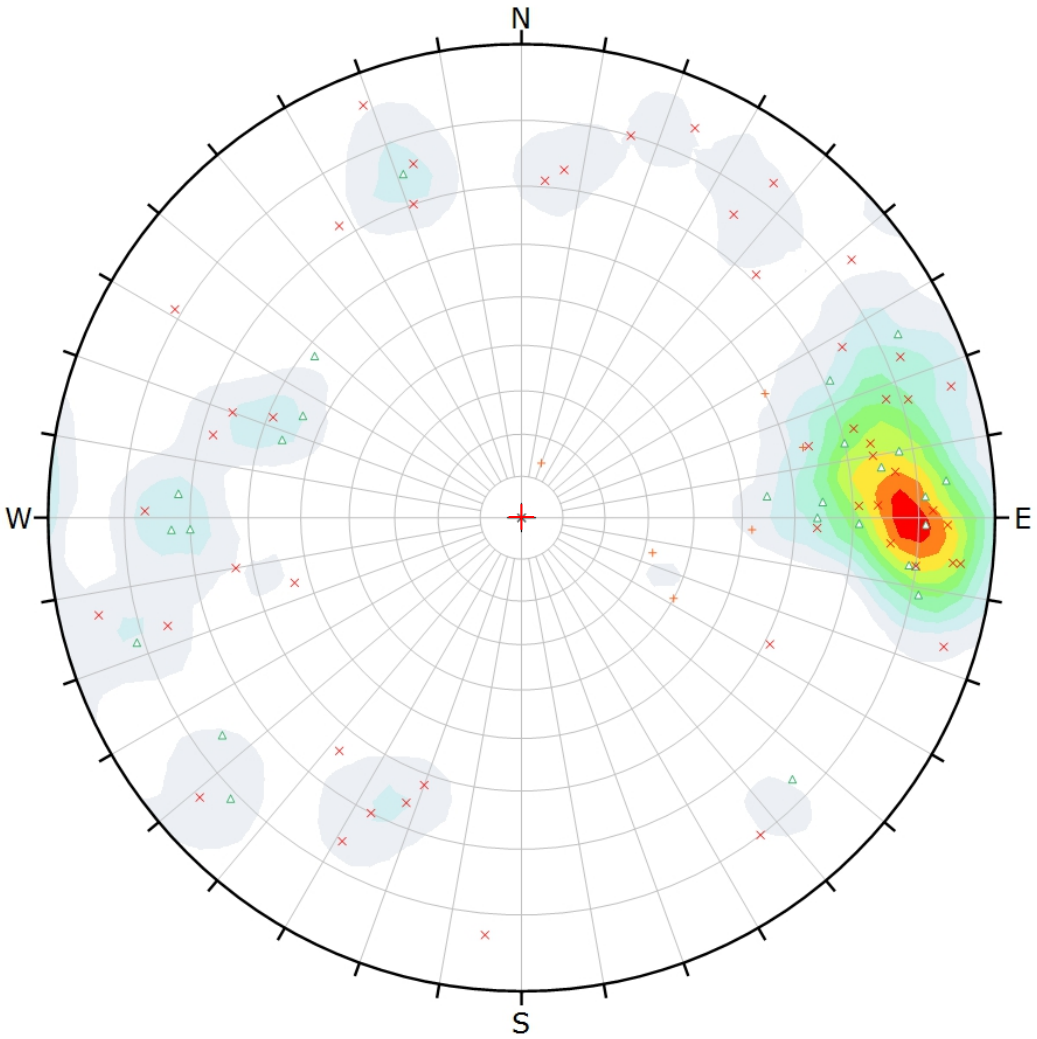

Symbol	FEATURE TYPE	Quantity
×	Closed/ infilled joint	52
△	Open joint	26
+	Other feature	6

Color	Density Concentrations
	0.00 - 1.60
	1.60 - 3.20
	3.20 - 4.80
	4.80 - 6.40
	6.40 - 8.00
	8.00 - 9.60
	9.60 - 11.20
	11.20 - 12.80
	12.80 - 14.40
	14.40 - 16.00

Maximum Density	15.41%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	84 (84 Entries)
Hemisphere	Lower
Projection	Equal Angle

\+ RGSC-0013 BOREHOLE TREND & PLUNGE
90º INCLINATION TOWARDS 000º AZIMUTH

NOTES

1. THE TELEVIEWER INTERPRETATION DATA WAS PROVIDED TO GOLDER BY ASIMS (ACOUSTIC SCANNER AND SONIC LOG INTERPRETATION).
2. STEREOGRAPHIC PROJECTIONS TO MINE GRID NORTH.
3. STEREOGRAPHIC PLOTS PREPARED USING ROCSCIENCE DIPS VERSION 6.0.

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Golder Associates

YYYY-MM-DD	2016-06-16
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

TITLE
STEREOGRAPHIC PROJECTION – RGSC-0013
SYMBOLIC POLE PLOT OF JOINTS

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**F-12**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
1 in
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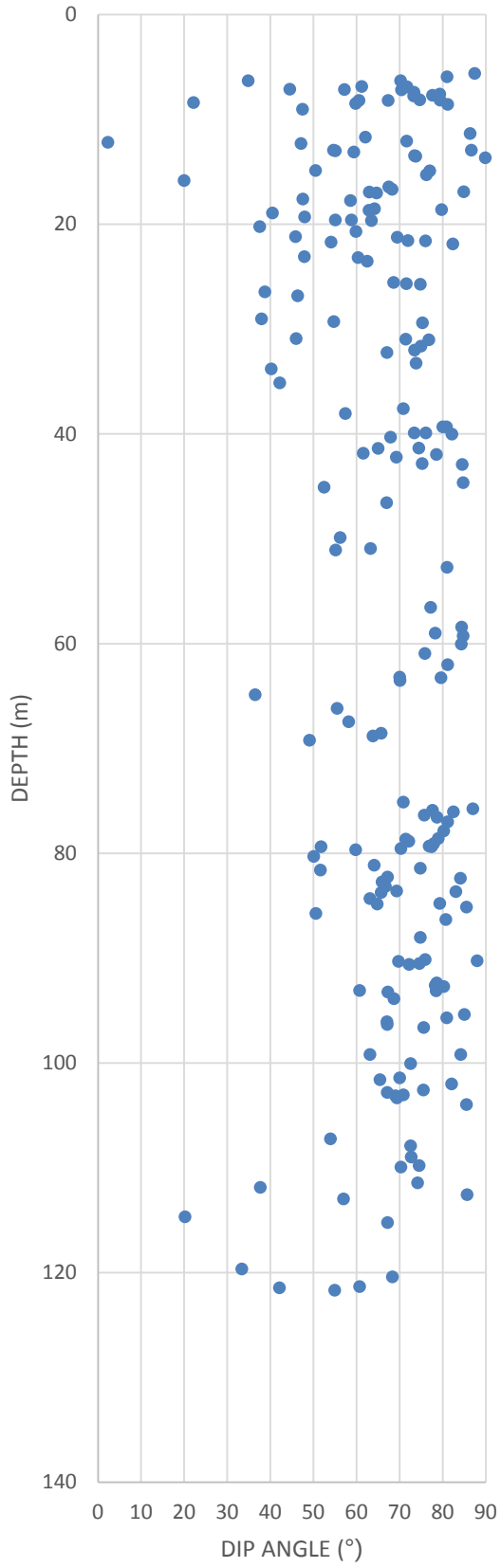
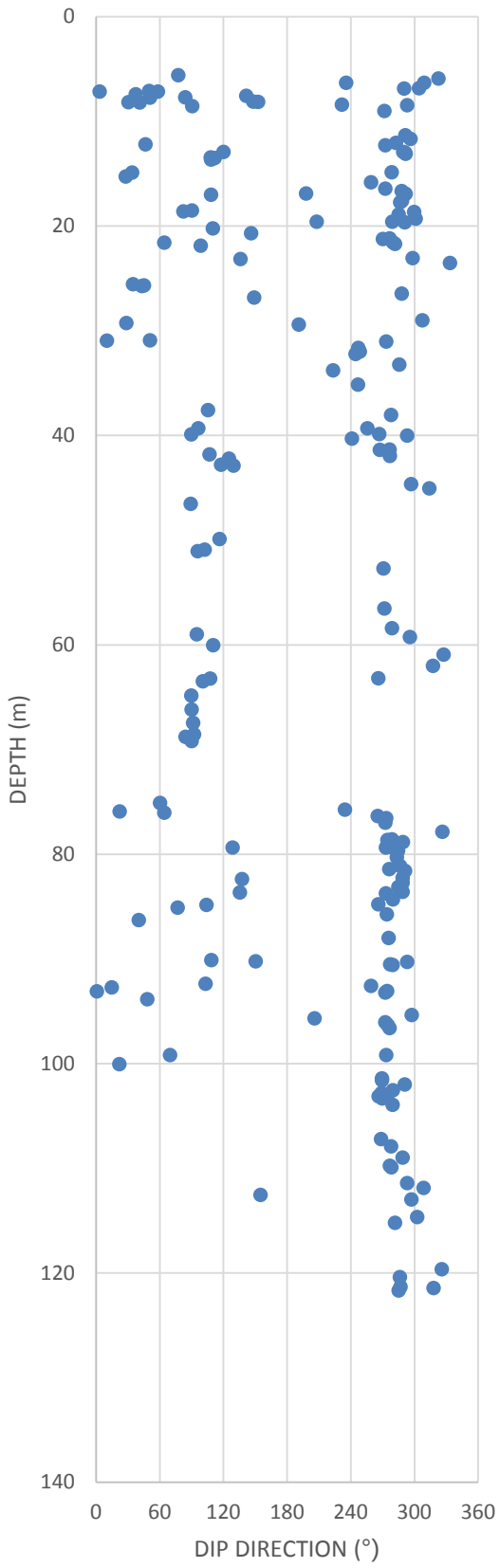
DIP ANGLE VS DEPTH



DIP DIRECTION VS DEPTH



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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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Golder Associates

YYYY-MM-DD	2016-06-16
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

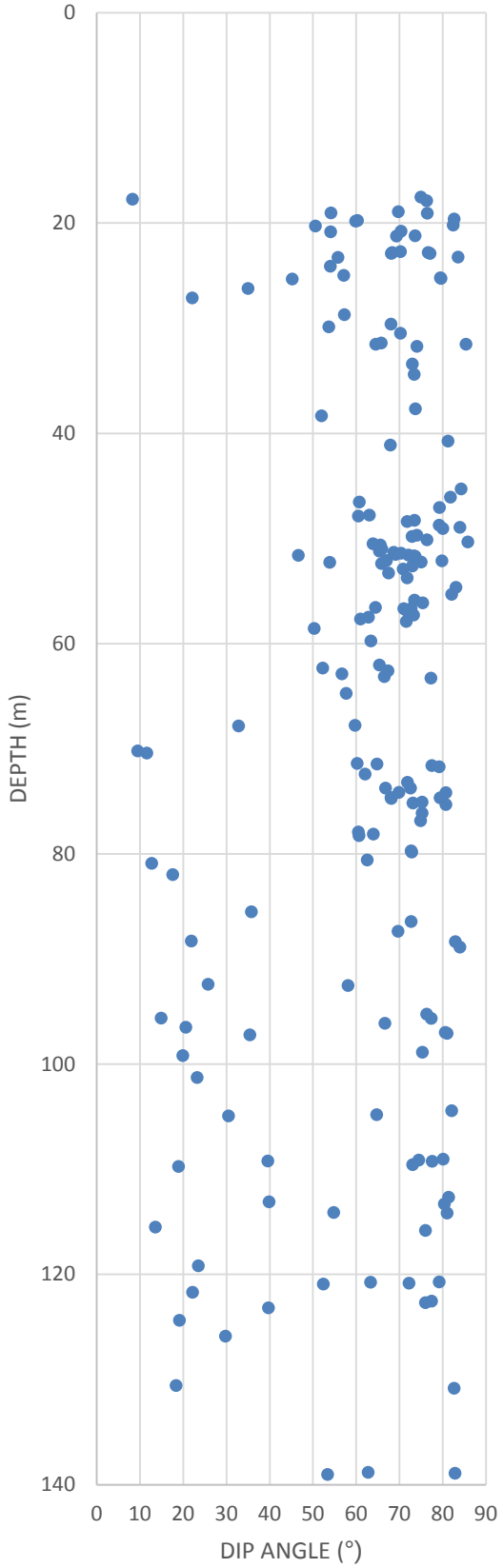
TITLE
RGSC-0011 DOWHOLE ORIENTATION PLOTS
ACOUSTIC TELEVIEWER PICKS

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**F- 13**

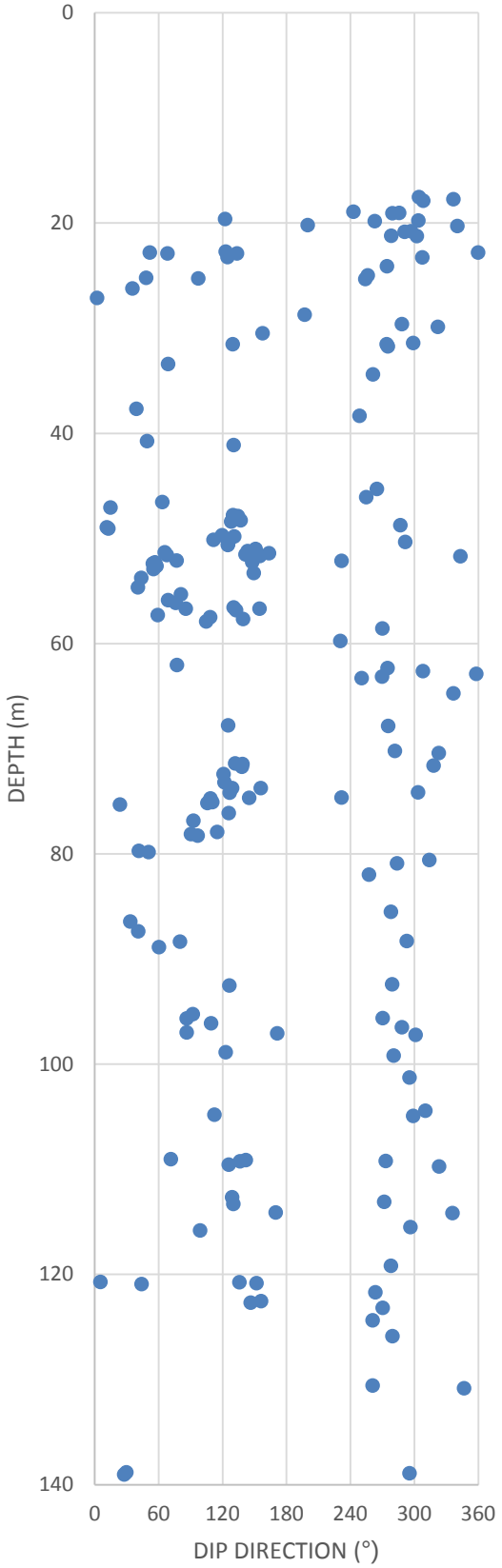
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix F - Structural Orientation Data\ File Name: F-2 Downhole Plots.rptx

DIP ANGLE VS DEPTH



DIP DIRECTION VS DEPTH



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MINI PIT – PIT SLOPE STABILITY ASSESSMENT

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Golder Associates

YYYY-MM-DD	2016-06-16
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

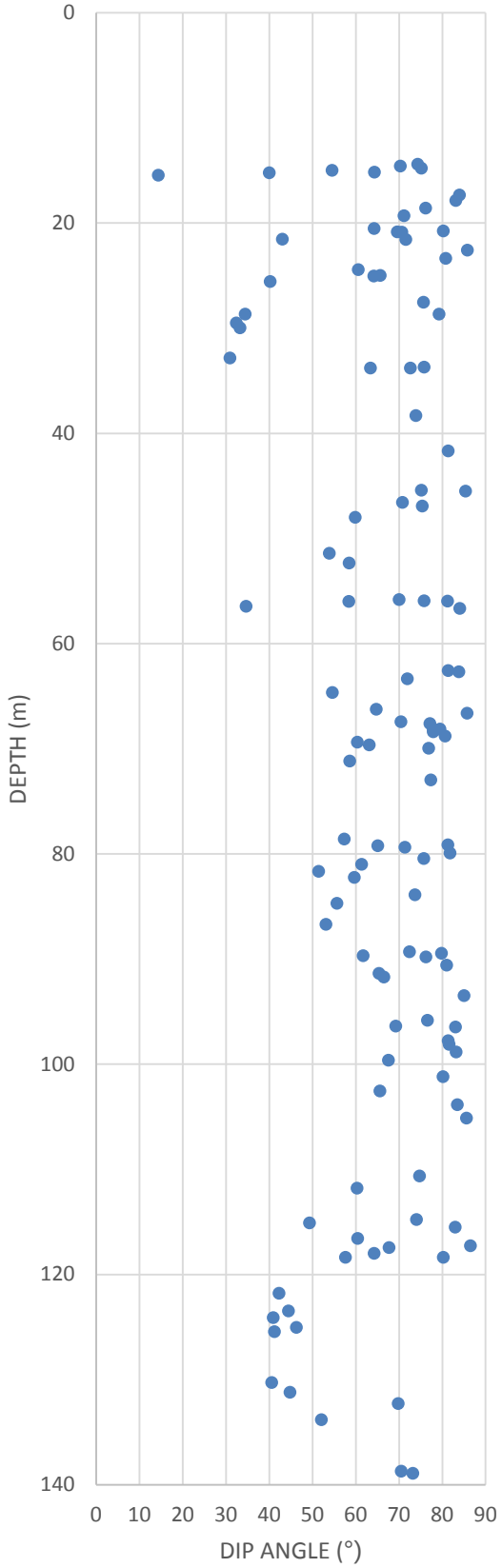
TITLE
RGSC-0012 DOWHOLE ORIENTATION PLOTS
ACOUSTIC TELEVIEWER PICKS

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**F- 14**

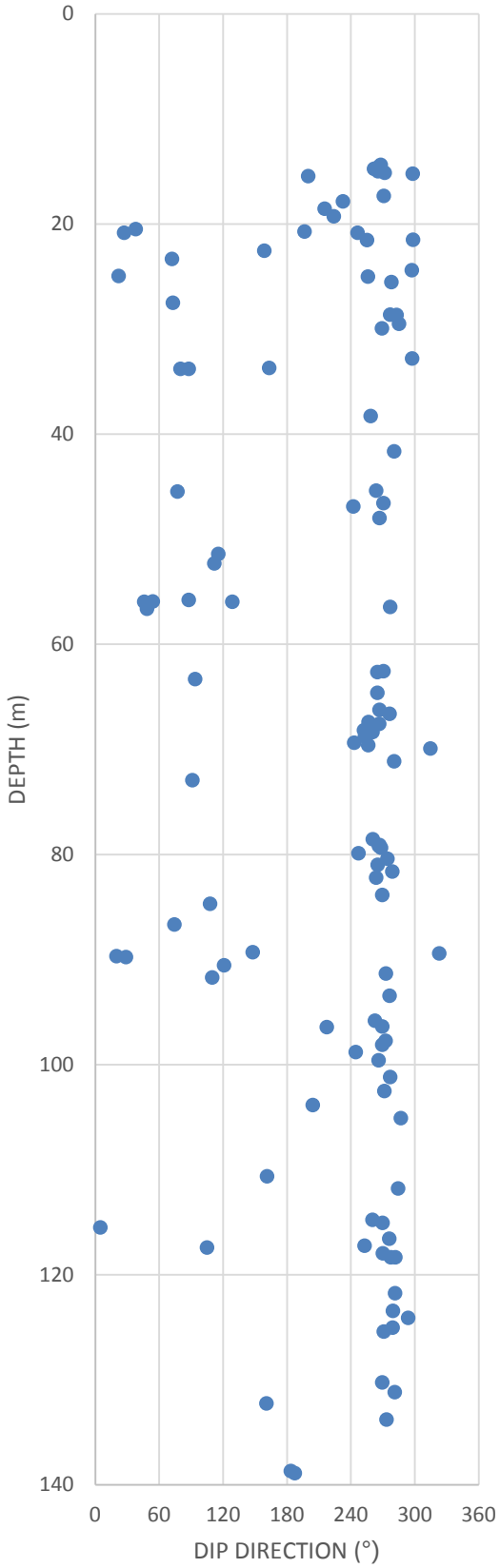
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix F - Structural Orientation Data\ File Name: F-2 Downhole Plots.pptx

DIP ANGLE VS DEPTH



DIP DIRECTION VS DEPTH



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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT – PIT SLOPE STABILITY ASSESSMENT

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-06-16
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
RGSC-0013 DOWHOLE ORIENTATION PLOTS
ACOUSTIC TELEVIEWER PICKS

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**F- 15**

Path: \\golder.gds\gal\burnaby\Active\2016\3 Proj\1654139 Riversdale_Mini Pit_Grassy Mtn\07 Deliverables\1654139-003-R-Rev0-5000\Appendices\Appendix F - Structural Orientation Data\ File Name: F-2 Downhole Plots.pptx

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
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APPENDIX G

Overall Pit Slope Stability Analyses

1.0 OVERALL SLOPE STABILITY ANALYSIS

Limit equilibrium stability assessments were carried out for large-scale rock mass failure for the proposed Mini Pit slopes. The stability analyses were performed deterministically using the two-dimensional limit equilibrium analysis software SLIDE (Version 6.0) (Rocscience). The GLE (General Limit Equilibrium) – Morgenstern-Price method of slices was used to calculate the Factors of Safety. This limit equilibrium method satisfies both force and moment equilibrium. The analyses considered two potential failure mechanisms:

- Circular failure through the rock mass in both the highwall and footwall; and
- Bi-linear failure initiating in intact rock and sliding along the bedding surfaces in the footwall.

Geological sections provided by Riversdale were selected for the stability analyses. Section 480 was selected for the highwall and Sections 750 and 840 were selected for the footwall (Appendix A). Section 750 is considered a typical section through the footwall of the Mini Pit and Section 840 is considered a critical section through the footwall as the pit design in this area is steeper. No stability assessment was carried out on the endwall slopes as the design is considered adequate and generally follows Golder recommendations (Golder 2015). These analyses were performed to confirm that the proposed Mini Pit wall design will exhibit a Factor of Safety greater than the minimum acceptance criteria described in Section 1.1.

1.1 Acceptability Criteria

Typical Factor of Safety acceptance criteria values for large open pit slopes are summarized in Table G-1 (Read and Stacey 2009).

Table G-1: Typical Factor of Safety and Probability of Failure Acceptance Criteria Values

Slope Scale	Consequence of Failure(1)	Acceptance Criteria
		Minimum FoS(2)
Bench	Low to high	1.1
Inter-ramp	Low	1.15 – 1.2
	Medium	1.2
	High	1.2 – 1.3
Overall	Low	1.2 – 1.3
	Medium	1.3
	High	1.3 – 1.5

1) Consequence of failure semi-quantitatively evaluated.

2) FoS = factor of safety.

Given, the close proximity of the Mini Pit highwall to the proposed infrastructure, the consequence of failure can be considered high. Based on the criteria presented in Table G-1, design Factors of Safety of 1.3 to 1.5 for overall stability are considered to be appropriate for the highwall. The consequence of the failure for the proposed footwall is considered to be medium, which corresponds to an acceptance overall stability Factor of Safety of 1.3.

2.0 MATERIAL PROPERTIES

2.1 Rock Mass Strength Parameters

The strength of a rock mass, and consequently its response to loading, is controlled by the following:

- the strength of the intact rock;
- the degree of fracturing of the rock mass; and
- the nature of the fracture surfaces.

The overall strength of a rock mass is usually characterized using the results of laboratory testing and/or by various rock mass classification methods on the basis of core logging data or surface mapping data.

The rock mass strengths used for the slope stability analyses presented in this report were determined using the Generalized Hoek-Brown failure criterion (Hoek 2002), which is based on the following parameters:

- GSI, the Geological Strength Index, which is considered equivalent to RMR_{76}, and describes the overall character and quality of a given rock mass.
- σ_{ci}, the uniaxial compressive strength (UCS) of the intact rock mass, which is typically determined from UCS testing and/or field strength estimates.
- Intact m (m_i), an empirical material constant for the intact rock.
- Disturbance factor (D), which is related to the degree of disturbance in the rock mass by blast damage and stress relaxation.

GSI has been determined using average values of RMR_{76} from geotechnical core logging (Appendix B). The intact rock strength has been determined using the results of UCS testing from Golder (2015), 2016 lab testing (Appendix D), and field strength estimates from core logging. The m_i values are based on the combined results of the UCS testing and experience of similar rock formations.

Table G-2 presents a summary of the rock mass strength parameters for each of the major rock formations considered for the Mini Pit.

Table G-2: Summary of Hoek-Brown Rock Mass Strength Parameters

Rock Formation	Unit Weight[(b)] (kN/m^3)	UCS (MPa)	GSI (RMR_{76})	m_i	Disturbance Factor
Mist Mountain Formation [(a)]	25	42.4	55	9	0 / 0.7
Moose Mountain Member	26	96.0	69	9	0 / 0.7
Blairmore Group	26	71.8	65	17	0 / 0.7
Faulted Blairmore Group	26	4.0	36	7	0 / 0.7
Weathered Blairmore Group	26	15.0	51	7	0 / 0.7
Weary Ridge Member	26	100.0	72	9	0 / 0.7

1) Representative of all rocks types in the Mist Mountain formation expect coal
2) Unit weight based on the average unit weight from the UCS test samples.
3) A Disturbance Factor (D) of 0.7 was applied to a zone behind the pit wall with a thickness 30 meters into the pit wall (Hoek and Karzulovic 2000), assuming that good blasting practices will be used. Beyond this zone, a D of 0 was applied.

Parameters for the Weary Ridge Member were adopted from nearby sites in the Elk Valley that have encountered this rock type as this Weary Ridge Member has not been drilled at Grassy Mountain.

Mohr Coulomb strength parameters were also considered for the Mini Pit and are described below in Table G-3.

Table G-3: Summary of Mohr Coulomb Strength Parameters

Material	Unit Weight (kN/m^3)	Cohesion (kN/m^2)	Friction Angle (degrees)
Overburden	19	0	30
Coal	16	100	30
Faults	26	0	25
Bedding	26	0	30

The overburden parameters are assumed from commonly observed foundation conditions in the area. The coal strength parameters are derived from laboratory testing and field observations while logging the coal. The geological model indicates the presence of thrust faulting within the Mini Pit area. The thrust faults tend to have smooth and polished fault surfaces due flexural slip. The data and observations indicate that smooth, polished and slickensided surfaces can be expected to be relatively common along the fault surfaces, therefore a low friction angle was assumed. The bedding shear strength used for the analyses is derived from geotechnical logging of discontinuity surface characteristics in the 2014 and 2016 field investigations and an understanding of the structural and tectonic history of the area.

2.2 Anisotropy in Geological Formations

The rock mass fabric defined by bedding, joints and faults results in an anisotropic rock mass, with weaker strengths associated with potential shearing along the bedding surfaces. This condition is accounted for in the limit-equilibrium slope stability analysis models by using an anisotropic strength function, where the shear strength for a failure surface along the bedding is defined by the bedding strength parameters applied within the range of discontinuity orientations, and where Hoek-Brown rock mass strength is assigned for a failure surface through the rock mass.

The orientations over which the bedding strengths are applied in the anisotropic models are defined by the range of bedding dip angles for the borehole located nearest to each cross section and interpretation of the geological model provided by Riversdale.

2.3 Summary of Parameters for Highwall and Footwall

A summary of the parameters used in the highwall stability assessments is show below in Table G-4.

Table G-4: Material Properties used in Highwall Limit Equilibrium Analyses

Material Type		Unit Weight (kN/m^3)	Mohr Coulomb		Generalized Hoek-Brown			
			Cohesion (kPa)	Friction Angle (degrees)	UCS (MPa)	GSI	m_i	D
Mist Mountain Formation Host Rock	Rock Mass	26	-	-	42.4	55	9	0 / 0.7
	Bedding Anisotropy		0	30	-	-	-	-
Moose Mountain Member Host Rock	Rock Mass	26	-	-	96.0	69	9	0 / 0.7
	Bedding Anisotropy		0	30	-	-	-	-
Coal		16	100	30	-	-	-	-
Blairmore Group		26	-	-	71.8	65	17	0 / 0.7
Faulted Blairmore Group		26	-	-	4.0	36	7	0 / 0.7
Weathered Blairmore Group		26	-	-	15.0	51	7	0 / 0.7
Weary Ridge Member Host Rock	Rock Mass	26	-	-	100.0	72	9	0 / 0.7
	Bedding Anisotropy		0	30	-	-	-	-
Overburden		19	0	30	-	-	-	-
Fault		26	0	25	-	-	-	-

A summary of the parameters used in the footwall stability assessments is shown below in Table G-5.

Table G-5: Material Properties used in Footwall Limit Equilibrium Analyses

Material Type		Unit Weight (kN/m³)	Mohr Coulomb		Generalized Hoek-Brown			
			Cohesion (kPa)	Friction Angle (degrees)	UCS (MPa)	GSI	m_i	D
Moose Mountain Member Host Rock	Rock Mass	26	-	-	96.0	69	9	0 / 0.7
	Bedding Anisotropy		0	30	-	-	-	-
Weary Ridge Member Host Rock	Rock Mass	26	-	-	100.0	72	9	0 / 0.7
	Bedding Anisotropy		0	30	-	-	-	-
Overburden		19	0	30	-	-	-	-
Fault		26	0	25	-	-	-	-

3.0 GROUNDWATER CONDITIONS

The groundwater pressures that will exist in the Mini Pit walls have been modelled using the r_u method. The design r_u values used in the slope stability analysis are based on the hydrogeological data collected in 2014 (Golder 2015) and are presented in Table G-6.

Table G-6: Summary of Groudwater Conditions for Mini Pit

Groundwater Condition	Design r_u
Dry	0
Naturally Dewatered	0.1

4.0 STABILITY ANALYSES RESULTS

4.1 Highwall Slope Stability Analyses Results

The results of stability analyses indicate adequate stability conditions along the highwall in Section 480 in the Mini Pit and are presented in Table G-7.

Table G-7: Summary of Slope Stability Results for Section 480 through the Highwall

Stability Section	Case	Failure Surface	Groundwater Conditions	Factor of Safety	Figure No. in Appendix G
Section 480	Overall	Circular	r_u = 0.1	2.07	G-1
			Dry	2.27	G-2
	Upper Benches		r_u = 0.1	0.5	G-3
			Dry	0.6	G-4

4.2 Unbenched Footwall Slope Stability Analyses Results

The results of overall stability analyses for the unbenched footwall in Section 750 in the Mini Pit are presented in Table G-8.

Table G-8: Summary of Slope Stability Results for Section 750 through the Unbenched Footwall

Stability Section	Failure Surface	Groundwater Conditions	Factor of Safety	Figure No. in Appendix G
Section 750	Circular	r_u = 0.1	5.94	G-5
		Dry	6.29	G-6
	Bi-Linear	r_u = 0.1	1.38	G-7
		Dry	1.55	G-8

The results of overall stability analyses for the unbenched footwall in Section 840 in the Mini Pit are presented in Table G-9.

Table G-9: Summary of Slope Stability Results for Section 840 through the Unbenched Footwall

Stability Section	Failure Surface	Groundwater Conditions	Factor of Safety	Figure No. in Appendix G
Section 840	Circular	r_u = 0.1	5.92	G-9
		Dry	6.25	G-10
	Bi-Linear	r_u = 0.1	1.51	G-11
		Dry	1.53	G-12

4.3 Discussion of Stability Analyses Results

The highwall stability analyses indicate that adequate stability conditions are to be expected for rock mass strength failure of the overall slope and upper bench scale. The upper bench scale stability results indicate that maintaining infrastructure at a minimum of 50 meters from the crest of the highwall is recommended.

The footwall stability analyses indicate that adequate stability conditions are met for bilinear failure through the rock mass in an unbenched configuration. It is considered best practice to maintain some form of benching to avoid rockfall and buckling. In addition, there are number of rolls in the bedding in the Moose Mountain Formation which has the potential to buckle. It is recommended that a number of 8 meter wide catch-benches be used on the footwall slope to provide catchment and to off load the buckling potential.

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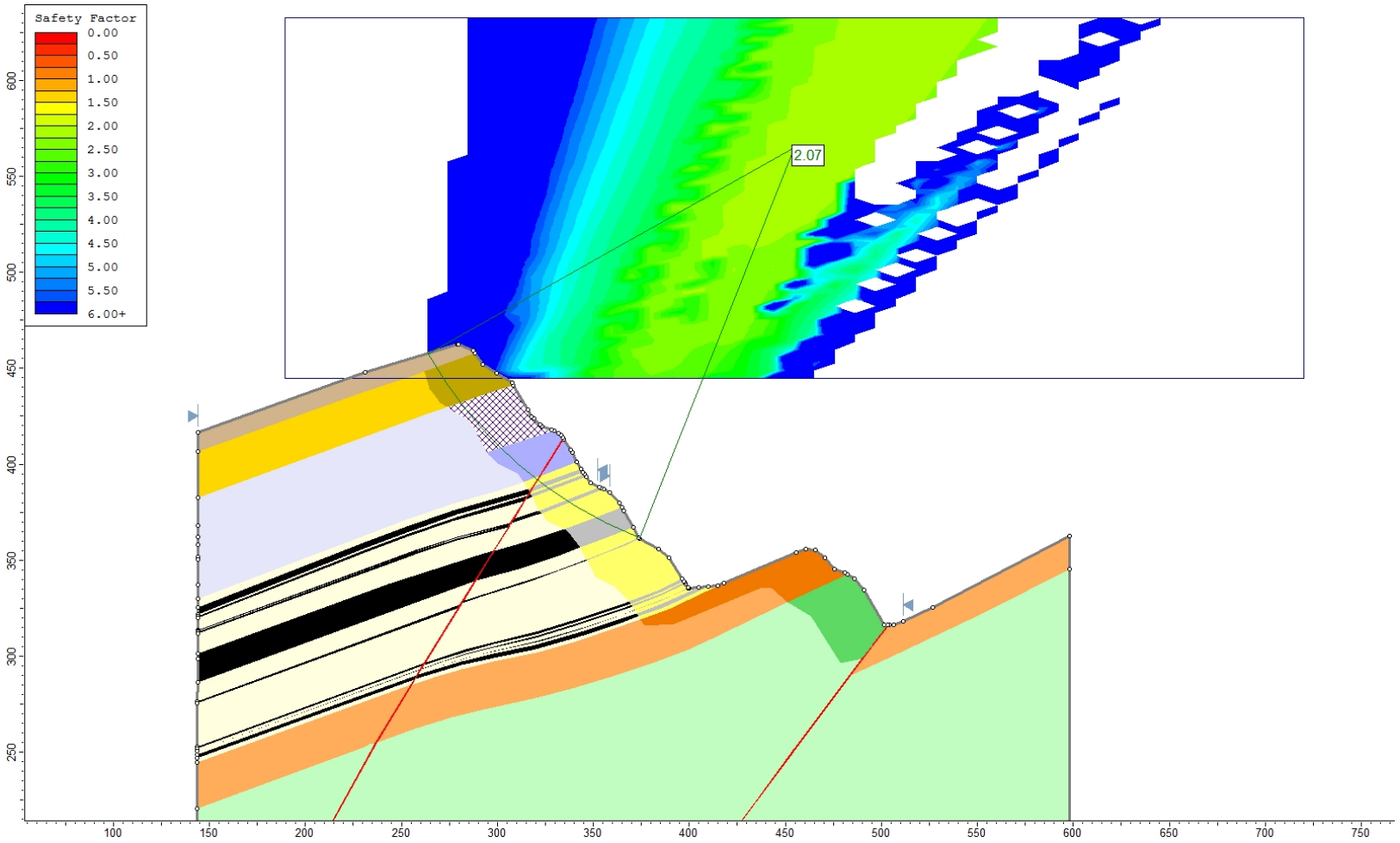

NOTES

1. STABILITY MODELS PREPARED USING ROCSCIENCE SLIDE VERSION 6.0.
2. FACTORS OF SAFETY CALCULATED USING THE GLE/MORGENSTERN-PRICE METHOD OF SLICES.

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Golder Associates

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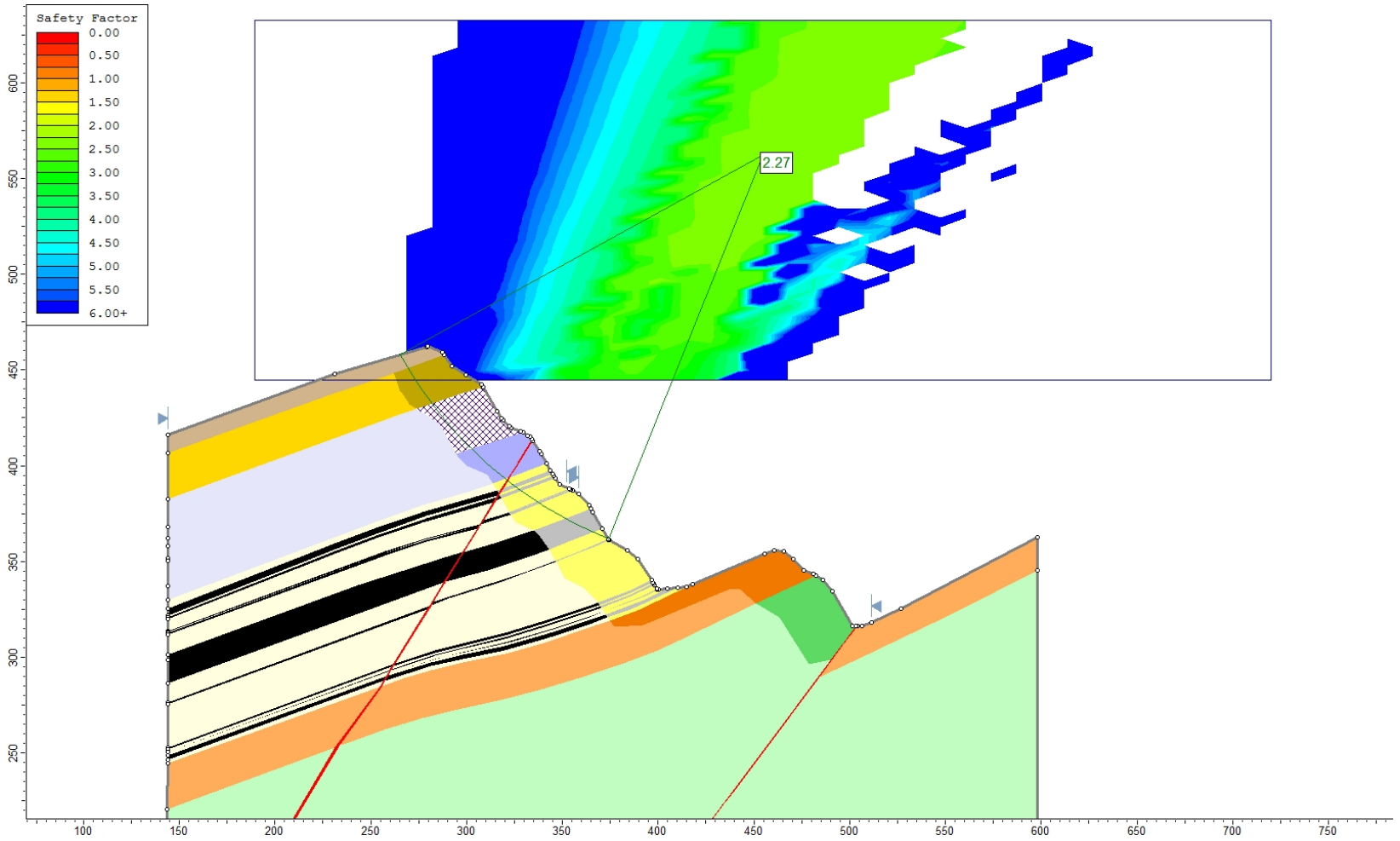
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 480 - HIGHWALL
OVERALL SLOPE FAILURE – CIRCULAR
Ru = 0.1

PROJECT No.	PHASE	Rev.	FIGURE
1654139	5000	0	G-1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A



NOTES

1. STABILITY MODELS PREPARED USING ROCSCIENCE SLIDE VERSION 6.0.

2. FACTORS OF SAFETY CALCULATED USING THE GLE/MORGENSTERN-PRICE METHOD OF SLICES.

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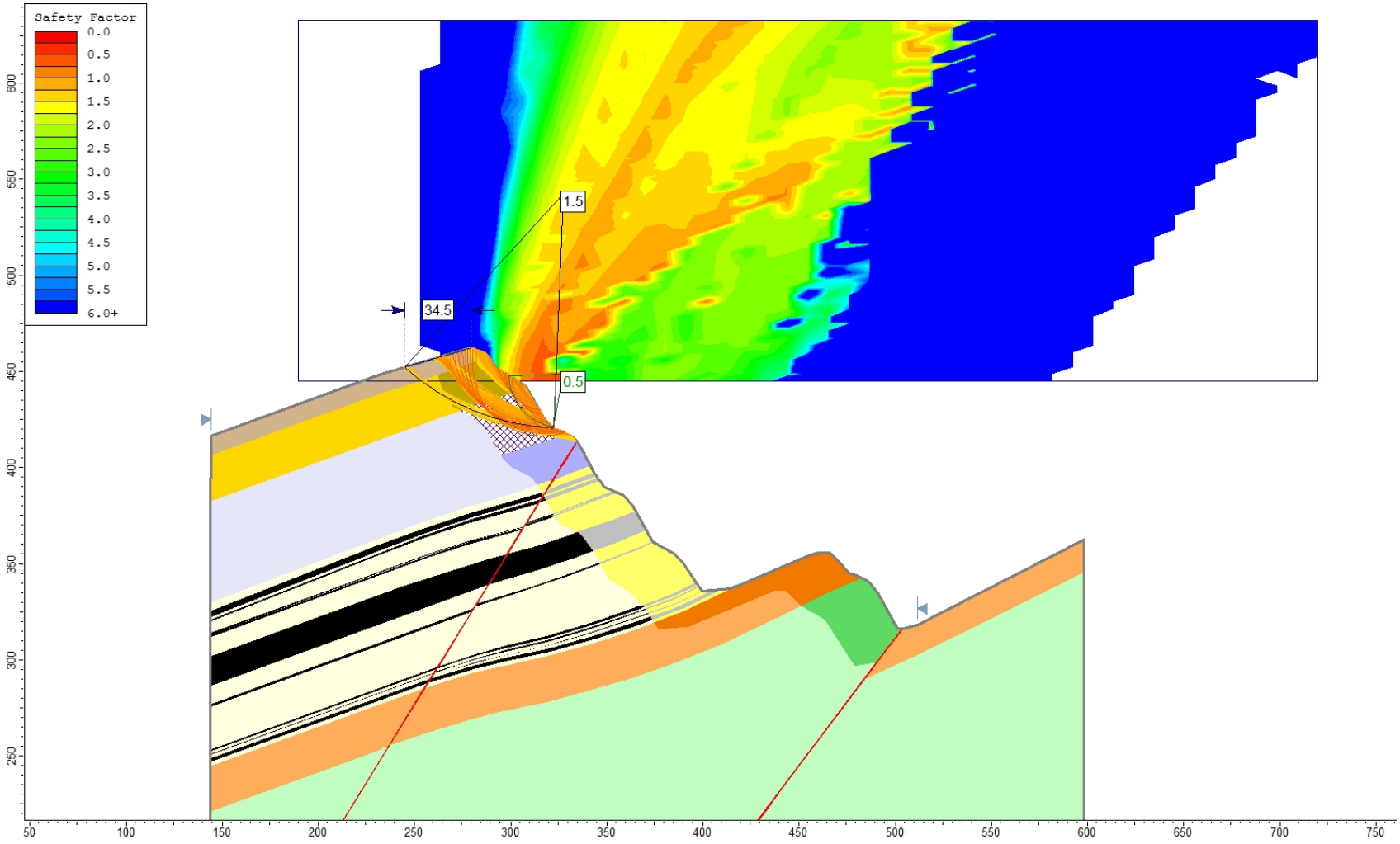
PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 480 - HIGHWALL
OVERALL SLOPE FAILURE – CIRCULAR
Ru = 0

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**G-2**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A



NOTES

1. STABILITY MODELS PREPARED USING ROCSCIENCE SLIDE VERSION 6.0.

2. FACTORS OF SAFETY CALCULATED USING THE GLE/MORGENSTERN-PRICE METHOD OF SLICES.

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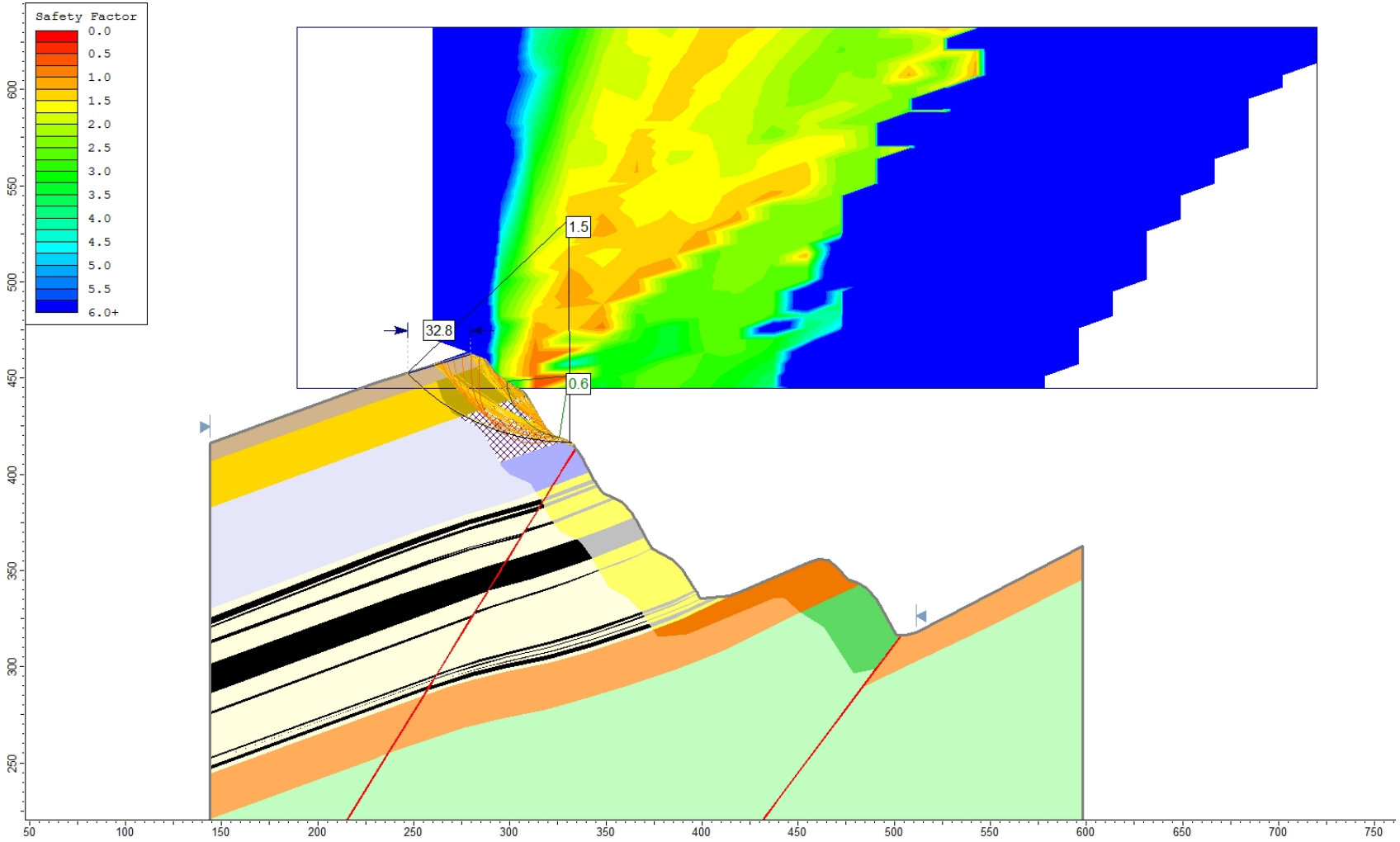
PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 480 - HIGHWALL
SHALLOW SLOPE FAILURE – CIRCULAR
Ru = 0.1

PROJECT No.	PHASE	Rev.	FIGURE
1654139	5000	0	G-3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A



NOTES

1. STABILITY MODELS PREPARED USING ROCSCIENCE SLIDE VERSION 6.0.

2. FACTORS OF SAFETY CALCULATED USING THE GLE/MORGENSTERN-PRICE METHOD OF SLICES.

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GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 480 - HIGHWALL
SHALLOW SLOPE FAILURE – CIRCULAR
Ru = 0

PROJECT No.	PHASE	Rev.	FIGURE
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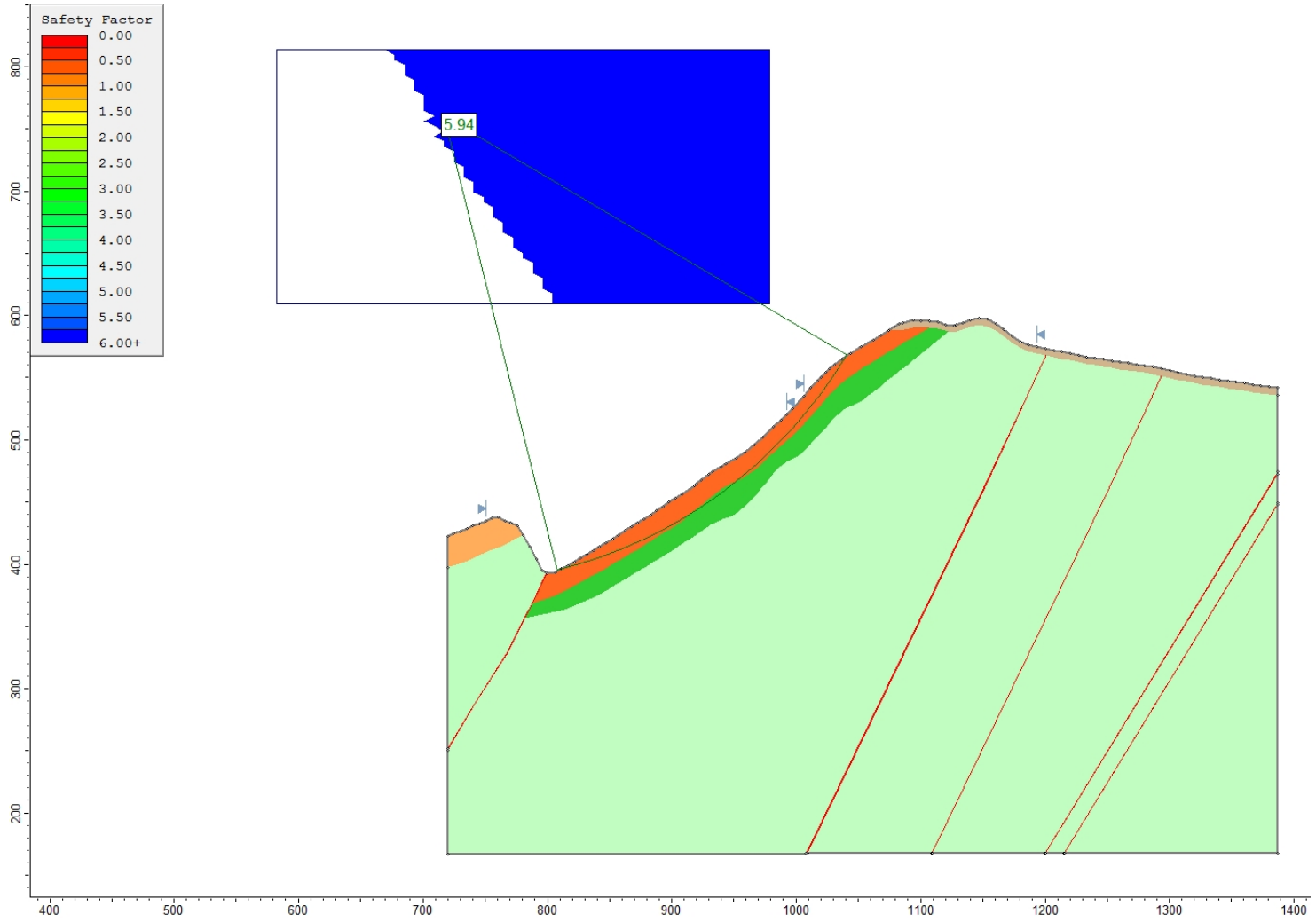

NOTES

1. STABILITY MODELS PREPARED USING ROCSCIENCE SLIDE VERSION 6.0.

2. FACTORS OF SAFETY CALCULATED USING THE GLE/MORGENSTERN-PRICE METHOD OF SLICES.

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PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

TITLE
SECTION 750 – FOOTWALL UNBENCHED
OVERALL SLOPE FAILURE – CIRCULAR
Ru = 0.1

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**G-5**

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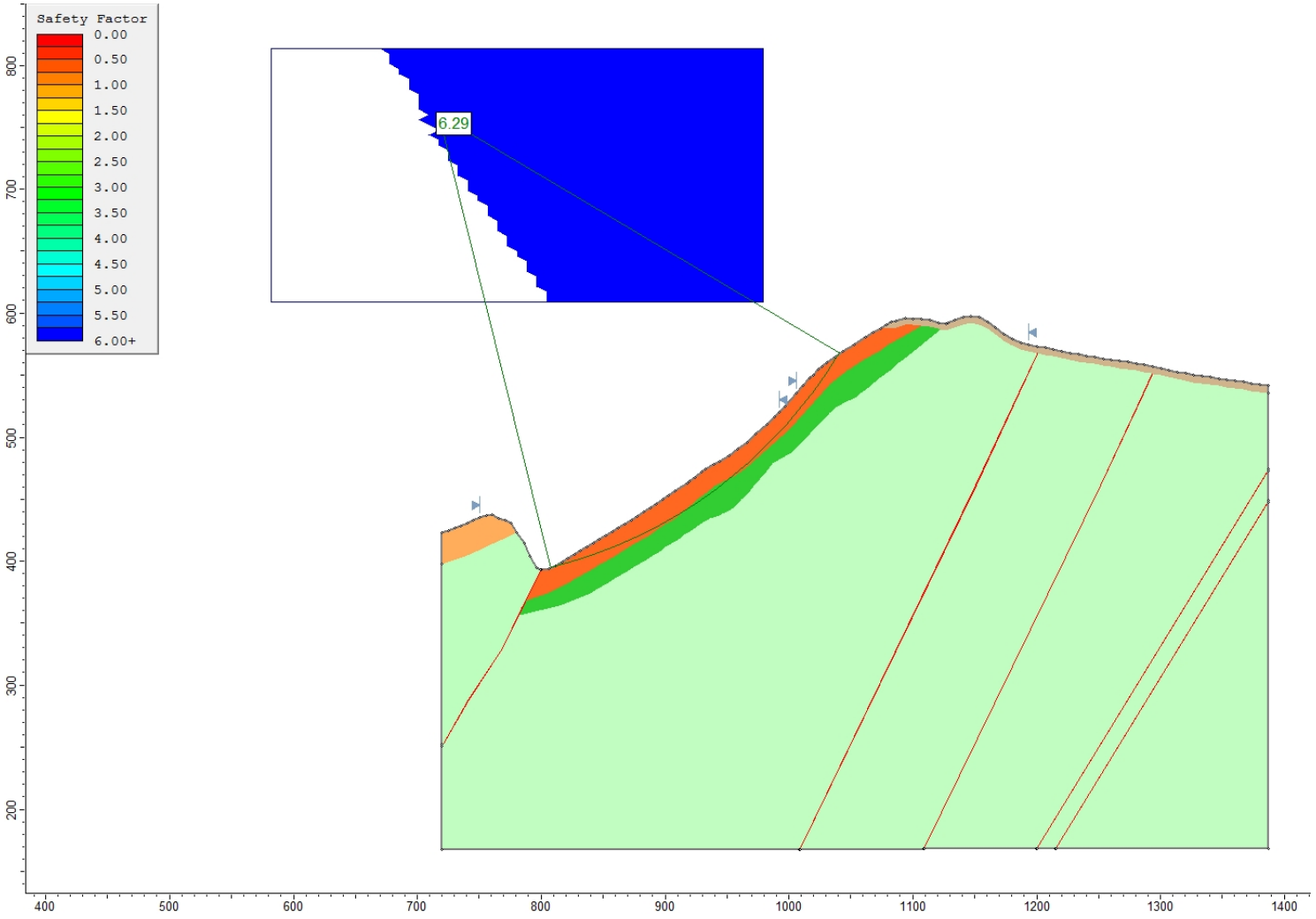

NOTES

1. STABILITY MODELS PREPARED USING ROCSCIENCE SLIDE VERSION 6.0.

2. FACTORS OF SAFETY CALCULATED USING THE GLE/MORGENSTERN-PRICE METHOD OF SLICES.

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GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 750 – FOOTWALL UNBENCHED
OVERALL SLOPE FAILURE – CIRCULAR
Ru = 0

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**G-6**

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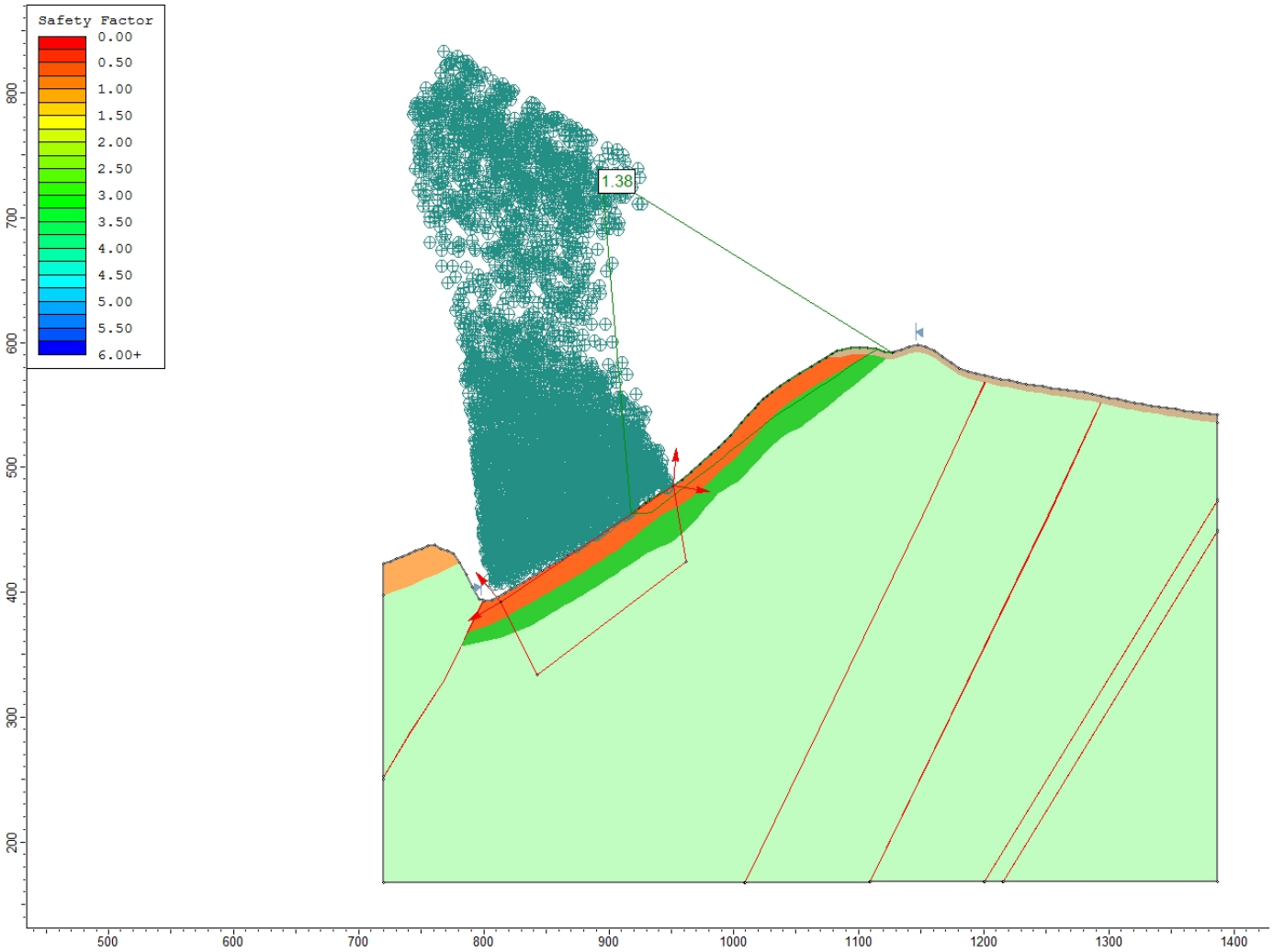

NOTES

1. STABILITY MODELS PREPARED USING ROCSCIENCE SLIDE VERSION 6.0.

2. FACTORS OF SAFETY CALCULATED USING THE GLE/MORGENSTERN-PRICE METHOD OF SLICES.

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MINI PIT - PIT SLOPE STABILITY ASSESSMENT

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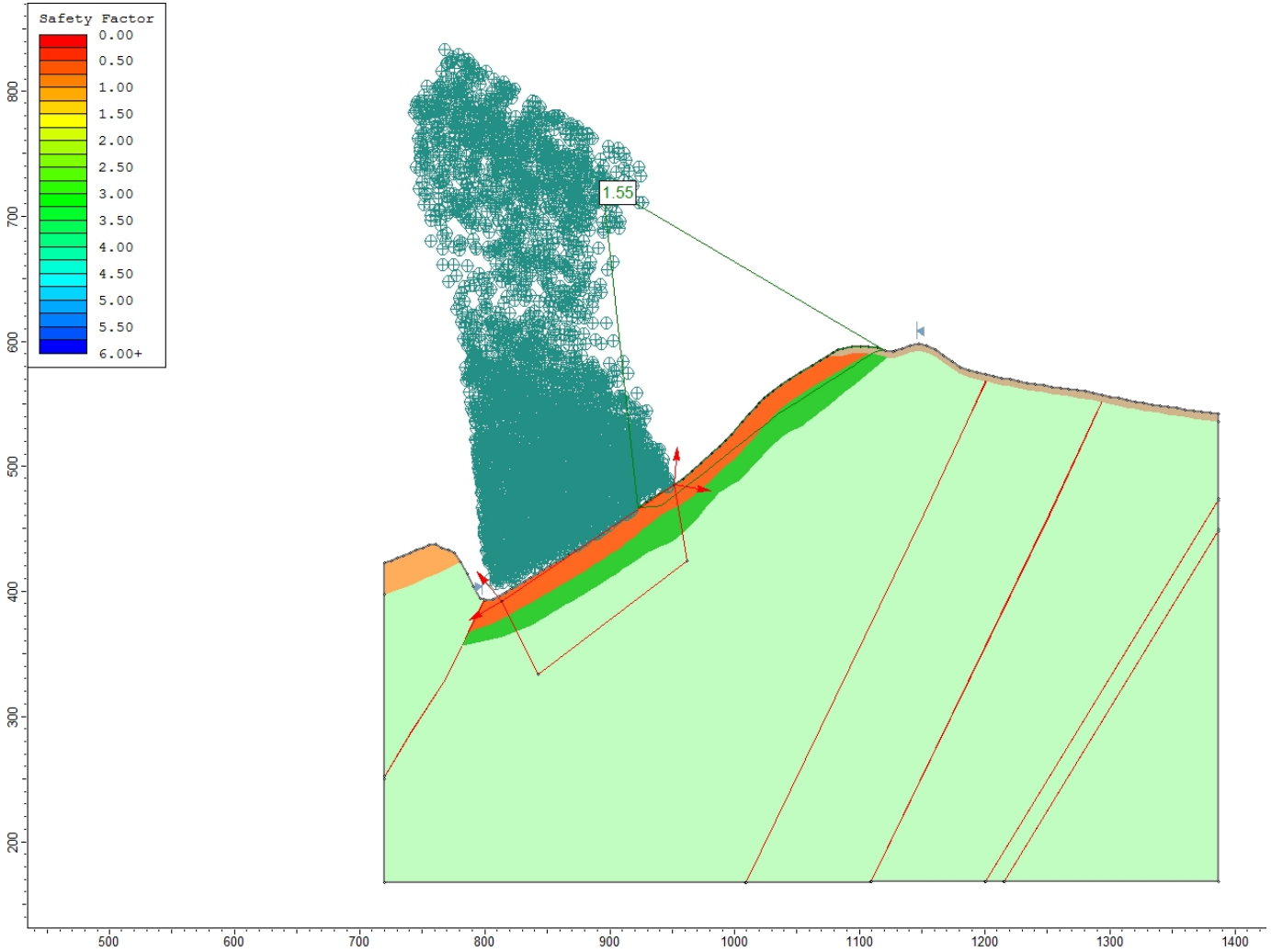
APPROVED	AVC

TITLE
SECTION 750 – FOOTWALL UNBENCHED
OVERALL SLOPE FAILURE – BILINEAR
Ru = 0.1

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**G-7**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A



NOTES

1. STABILITY MODELS PREPARED USING ROCSCIENCE SLIDE VERSION 6.0.

2. FACTORS OF SAFETY CALCULATED USING THE GLE/MORGENSTERN-PRICE METHOD OF SLICES.

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GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 750 – FOOTWALL UNBENCHED OVERALL SLOPE FAILURE – BILINEAR
Ru = 0

PROJECT No.	PHASE	Rev.	FIGURE
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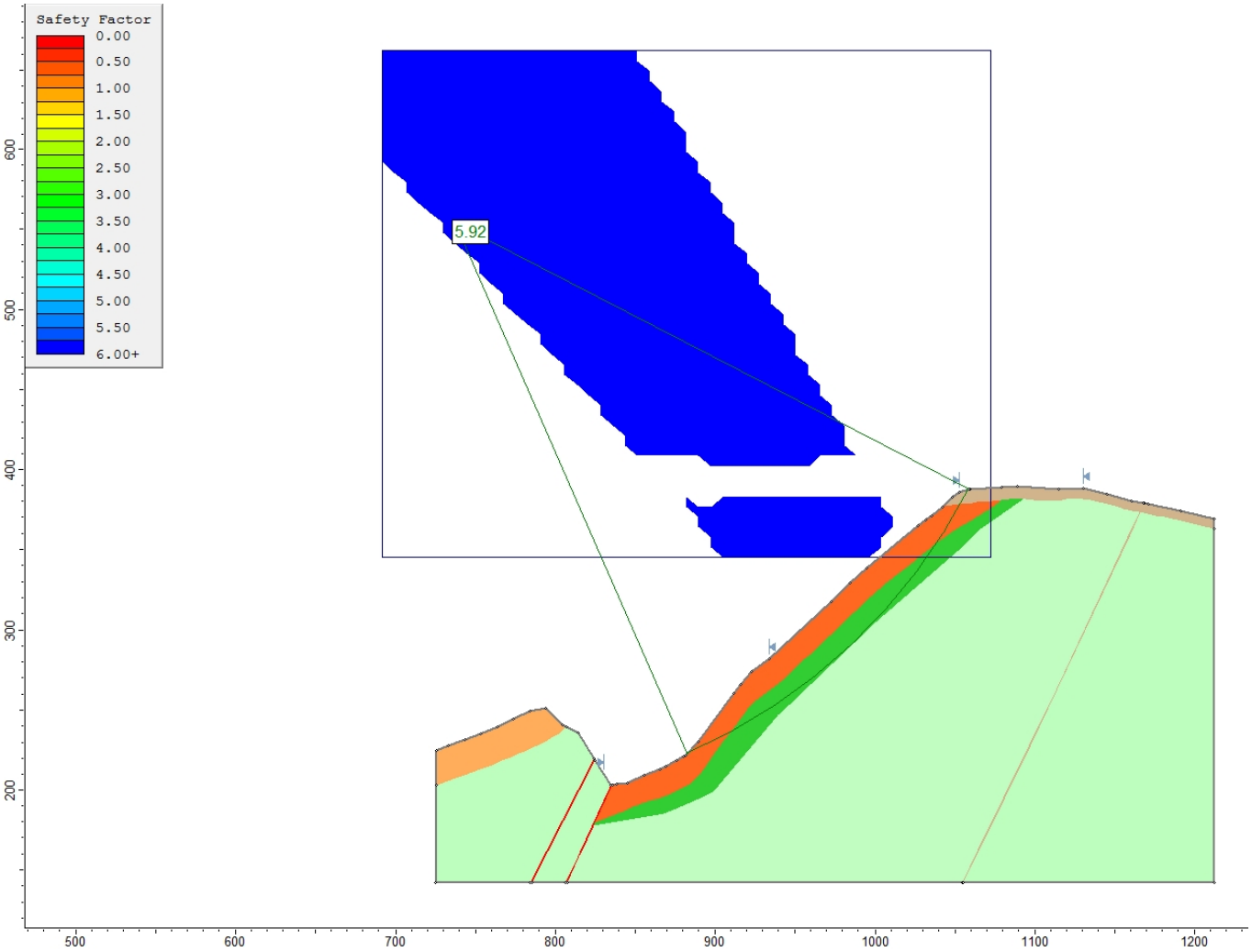

NOTES

1. STABILITY MODELS PREPARED USING ROCSCIENCE SLIDE VERSION 6.0.

2. FACTORS OF SAFETY CALCULATED USING THE GLE/MORGENSTERN-PRICE METHOD OF SLICES.

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 840– FOOTWALL UNBENCHED OVERALL SLOPE FAILURE - CIRCULAR
Ru = 0.1

PROJECT No.	PHASE	Rev.	FIGURE
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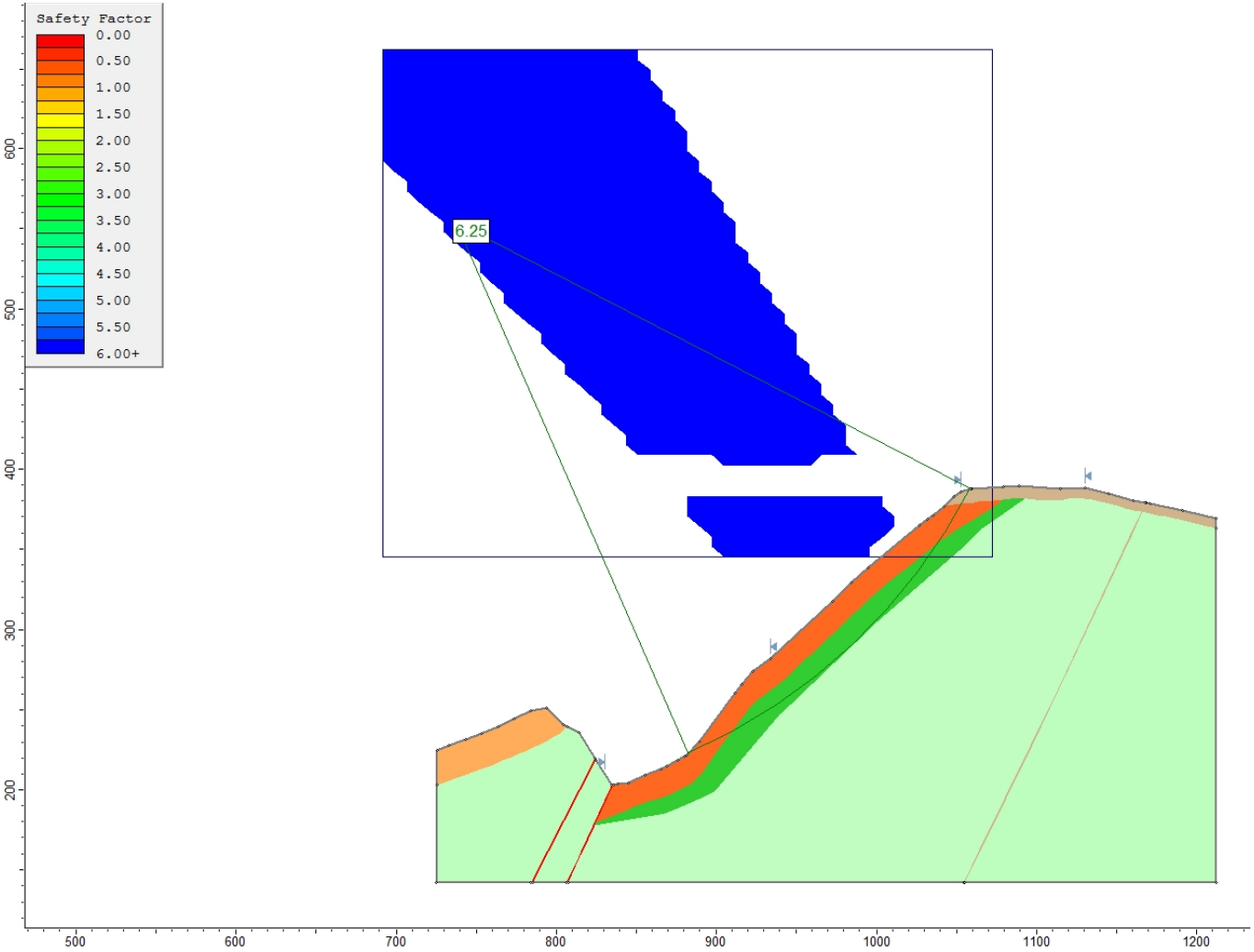
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A



NOTES

1. STABILITY MODELS PREPARED USING ROCSCIENCE SLIDE VERSION 6.0.

2. FACTORS OF SAFETY CALCULATED USING THE GLE/MORGENSTERN-PRICE METHOD OF SLICES.

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PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 840– FOOTWALL UNBENCHED OVERALL SLOPE FAILURE - CIRCULAR
Ru = 0

PROJECT No.	PHASE	Rev.	FIGURE
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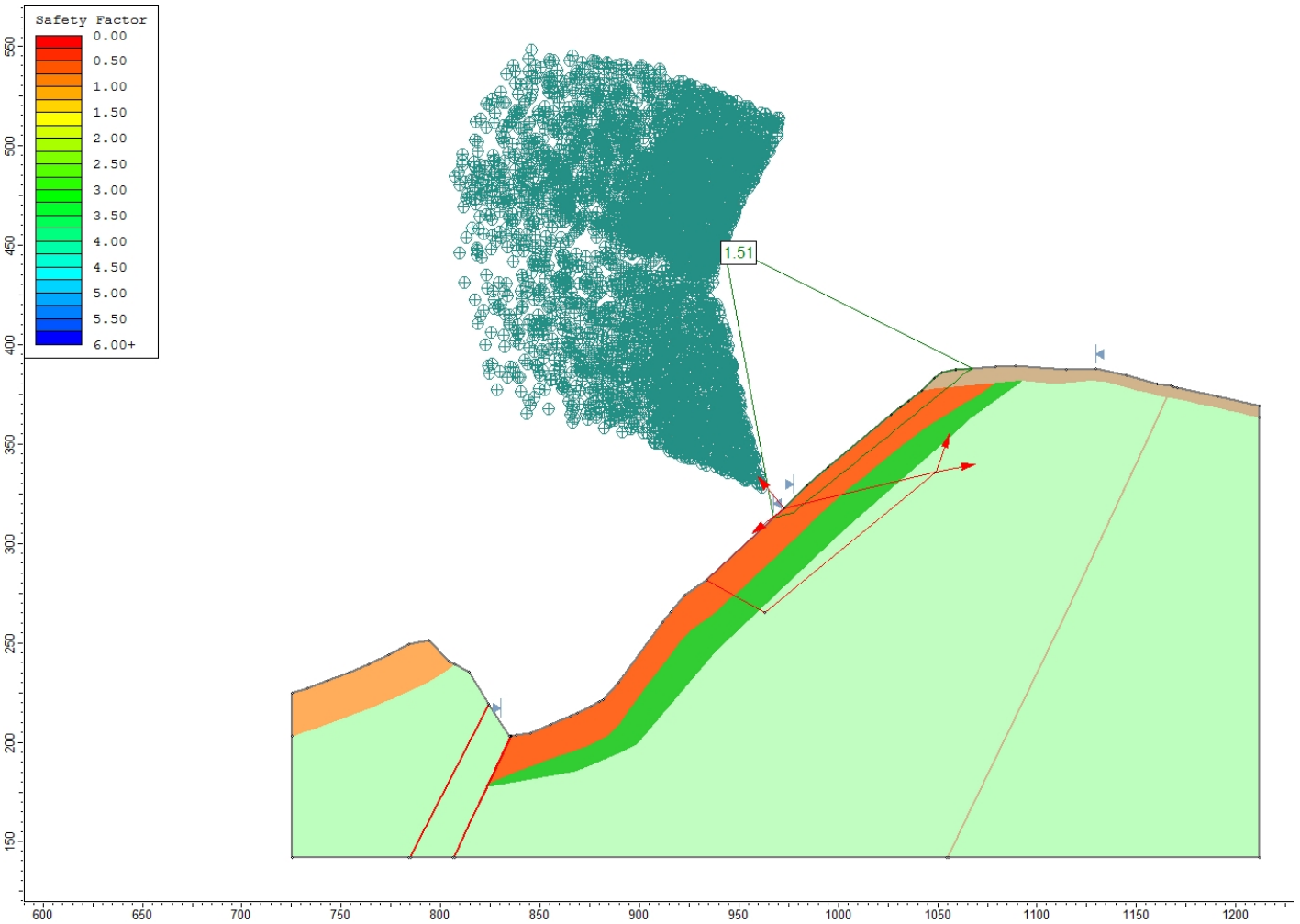
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A



NOTES

1. STABILITY MODELS PREPARED USING ROCSCIENCE SLIDE VERSION 6.0.

2. FACTORS OF SAFETY CALCULATED USING THE GLE/MORGENSTERN-PRICE METHOD OF SLICES.

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PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 840– FOOTWALL UNBENCHED OVERALL SLOPE FAILURE - BILINEAR
Ru = 0.1

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**G-11**

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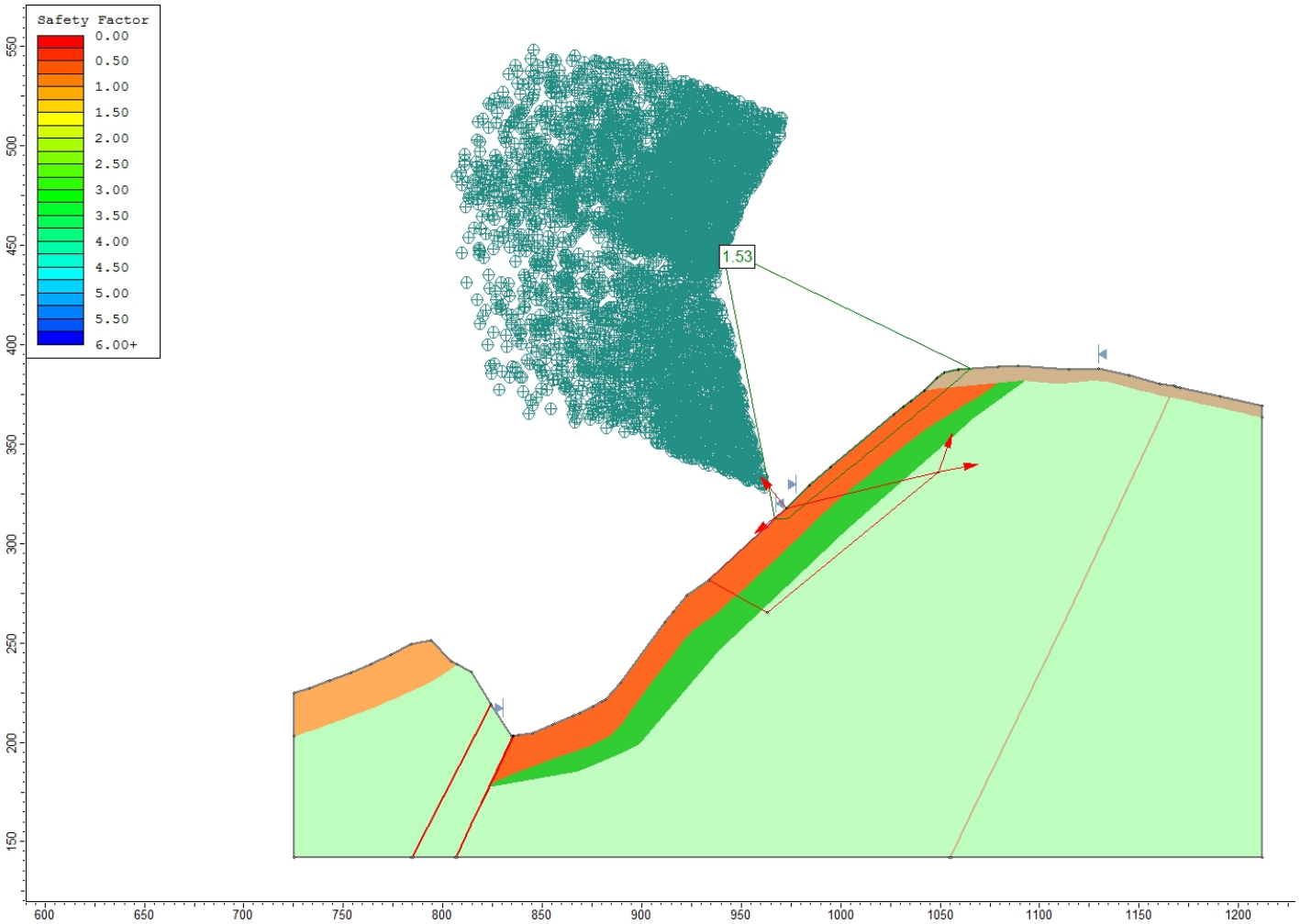

NOTES

1. STABILITY MODELS PREPARED USING ROCSCIENCE SLIDE VERSION 6.0.

2. FACTORS OF SAFETY CALCULATED USING THE GLE/MORGENSTERN-PRICE METHOD OF SLICES.

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RIVERSDALE RESOURCES LIMITED

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YYYY-MM-DD	2016-05-30
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 840– FOOTWALL UNBENCHED OVERALL SLOPE FAILURE - BILINEAR
Ru = 0

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**G-12**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A

APPENDIX H

Recommended Conceptual Footwall Slope Design

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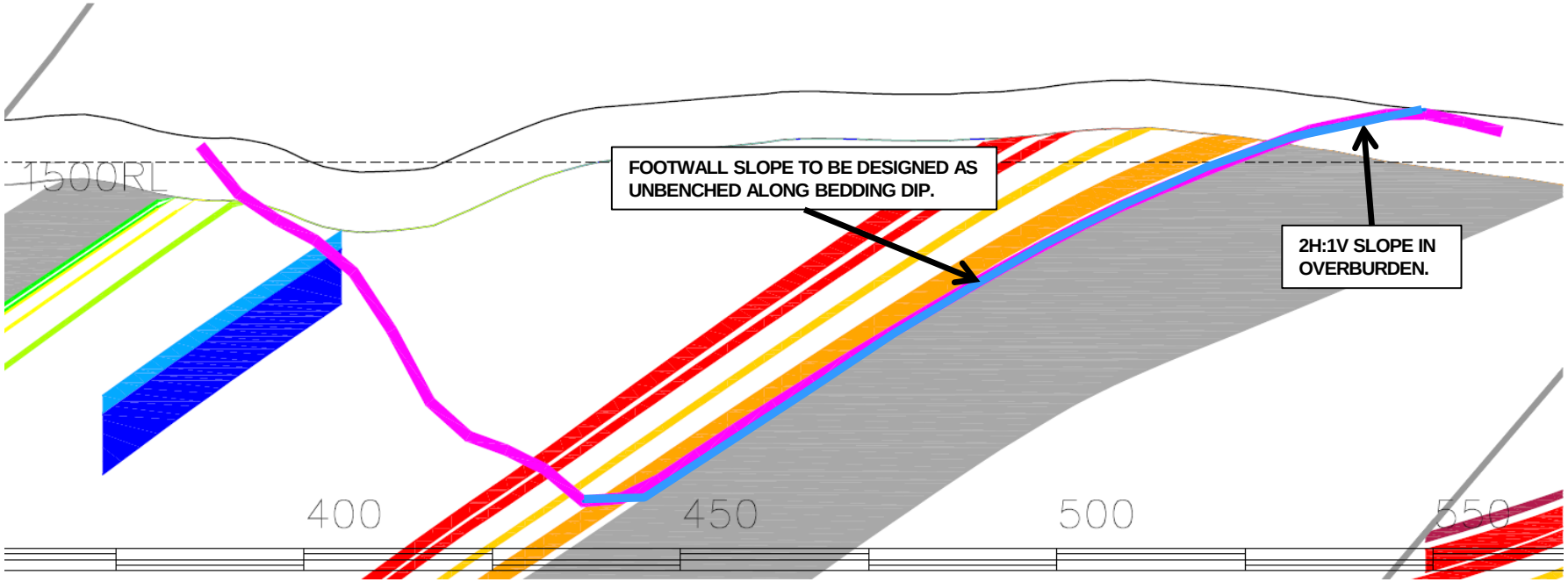

REFERENCES

1. SECTIONS PROVIDED BY RIVERSDALE RESOURCES LIMITED APRIL 6, 2016.

LEGEND

DESWIK MINI PIT DESIGN

GOLDER RECOMMENDED DESIGN

CLIENT
RIVERSDALE RESOURCES LIMITED

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-06-28
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 0060
RECOMMENDED MINI PIT FOOTWALL DESIGN

PROJECT No.	PHASE	Rev.	FIGURE
1654139	5000	0	H-1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A

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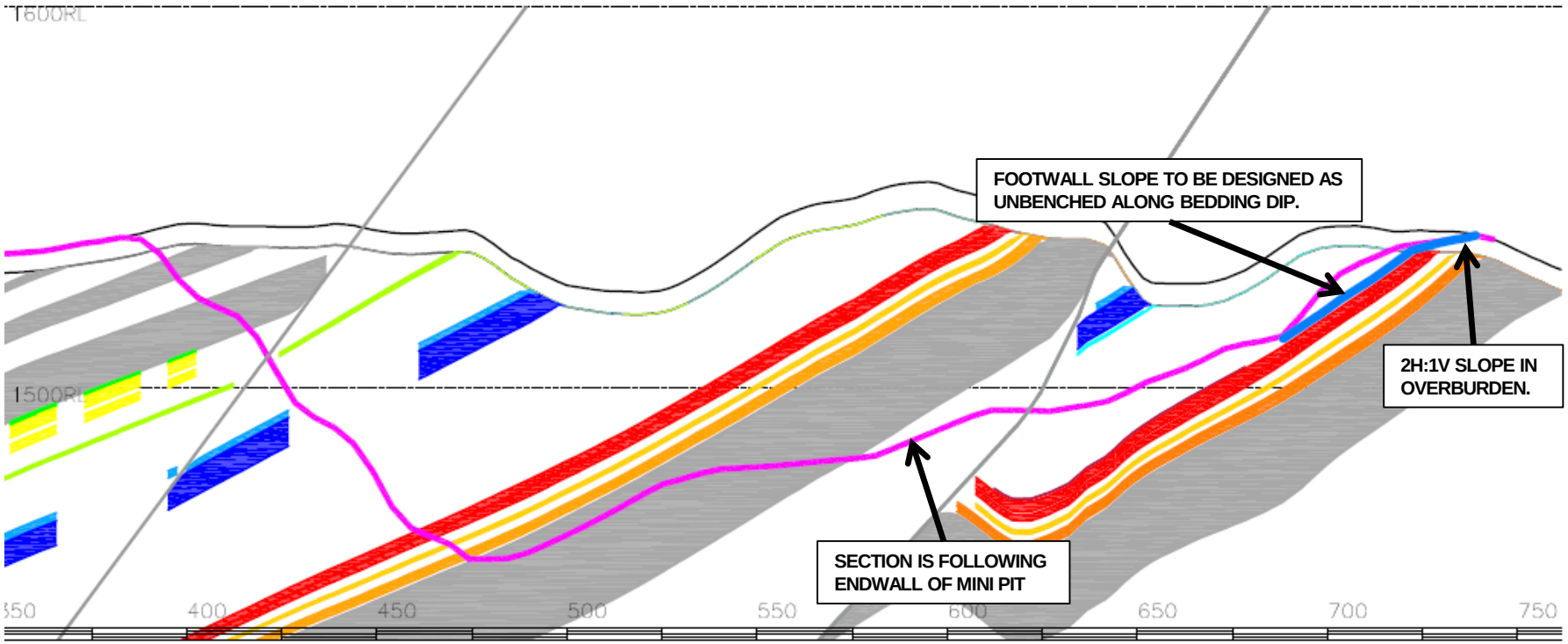

REFERENCES

1. SECTIONS PROVIDED BY RIVERSDALE RESOURCES LIMITED APRIL 6, 2016.

LEGEND

DESWIK MINI PIT DESIGN

GOLDER RECOMMENDED DESIGN

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YYYY-MM-DD	2016-06-28
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 0120
RECOMMENDED MINI PIT FOOTWALL DESIGN

PROJECT No.	PHASE	Rev.	FIGURE
1654139	5000	0	H-2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A

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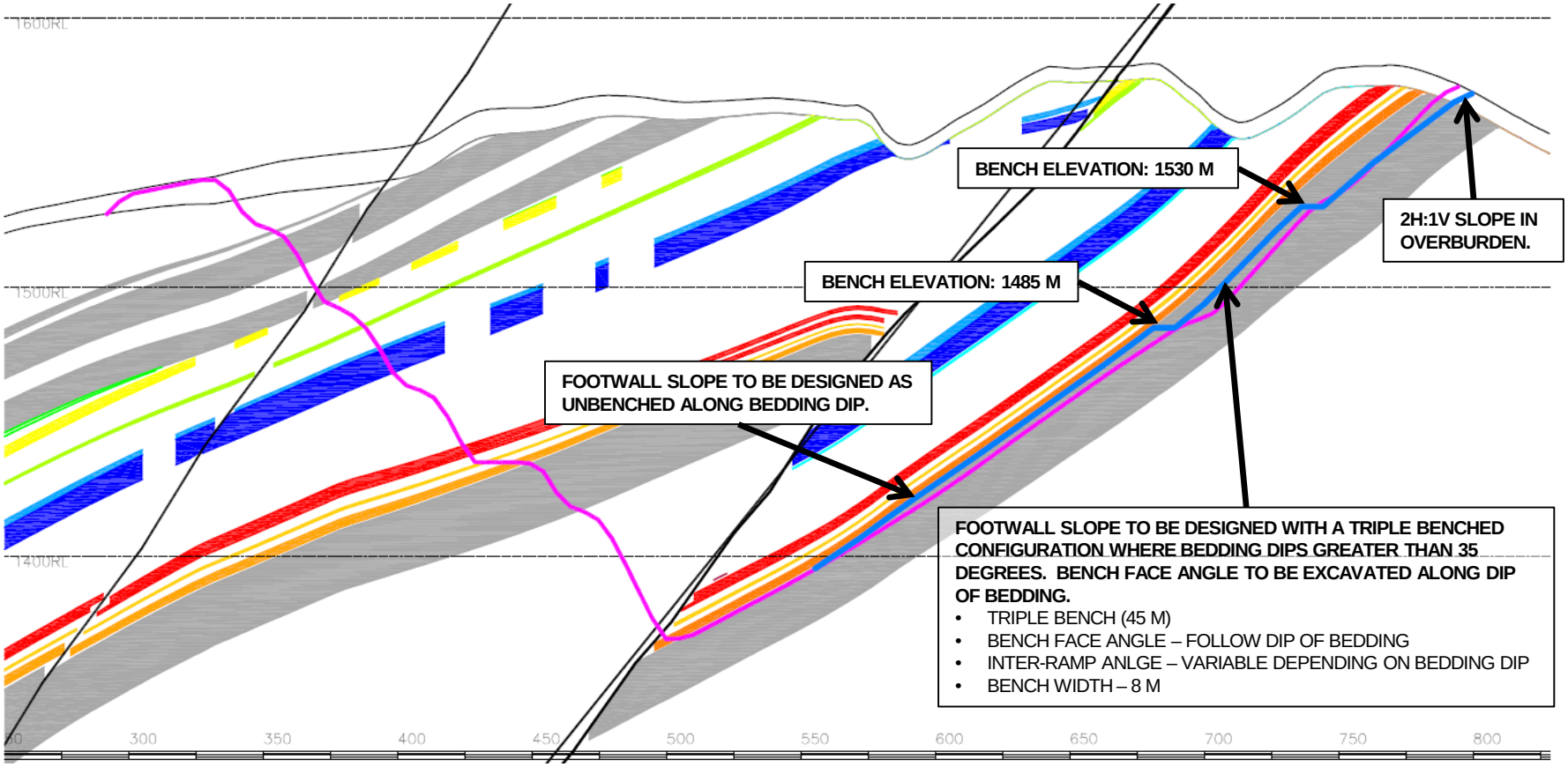


REFERENCES

1. SECTIONS PROVIDED BY RIVERSDALE RESOURCES LIMITED APRIL 6, 2016.

LEGEND

DESWIK MINI PIT DESIGN

GOLDER RECOMMENDED DESIGN

CLIENT
RIVERSDALE RESOURCES LIMITED

CONSULTANT
Golder Associates

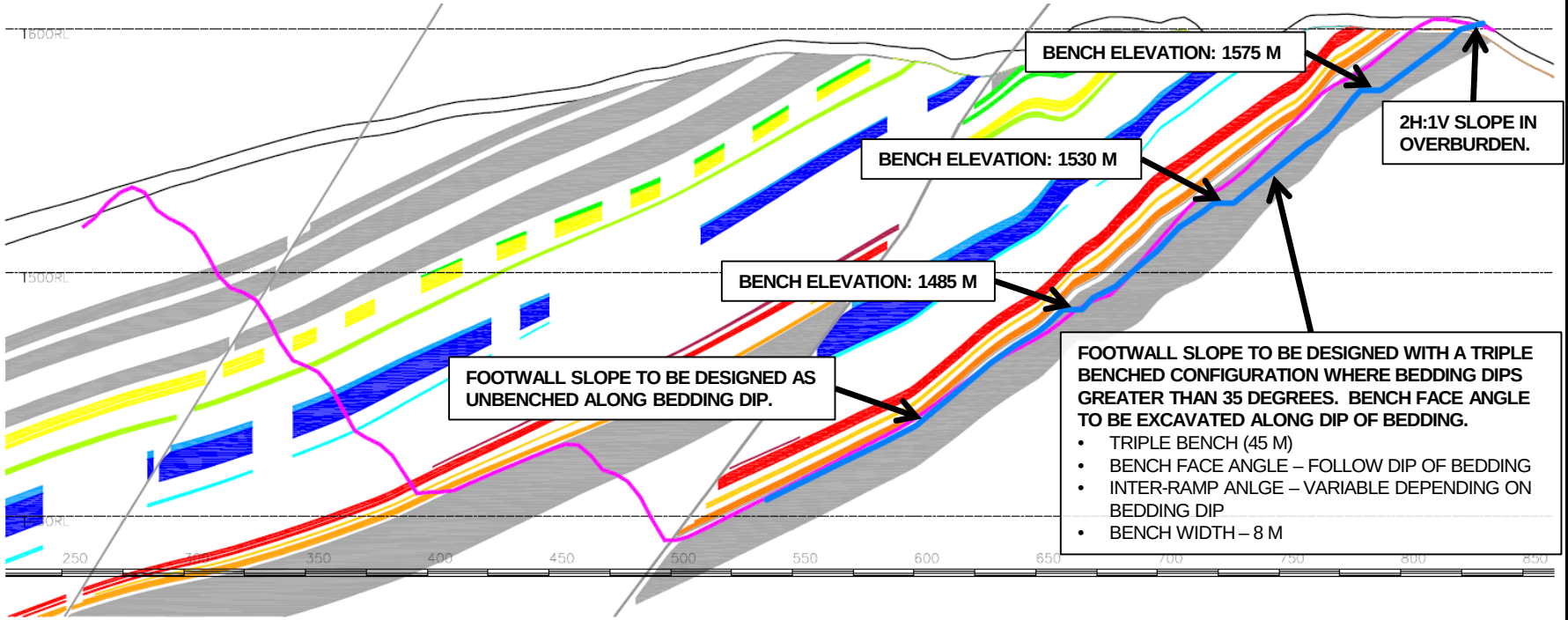
YYYY-MM-DD	2016-06-28
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 0300
RECOMMENDED MINI PIT FOOTWALL DESIGN

PROJECT No.	PHASE	Rev.	FIGURE
1654139	5000	0	H-3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A



REFERENCES

1. SECTIONS PROVIDED BY RIVERSDALE RESOURCES LIMITED APRIL 6, 2016.

LEGEND

DESWIK MINI PIT DESIGN

GOLDER RECOMMENDED DESIGN

CLIENT
RIVERSDALE RESOURCES LIMITED

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-06-28
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 0480
RECOMMENDED MINI PIT FOOTWALL DESIGN

PROJECT No.	PHASE	Rev.	FIGURE
1654139	5000	0	H-4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A

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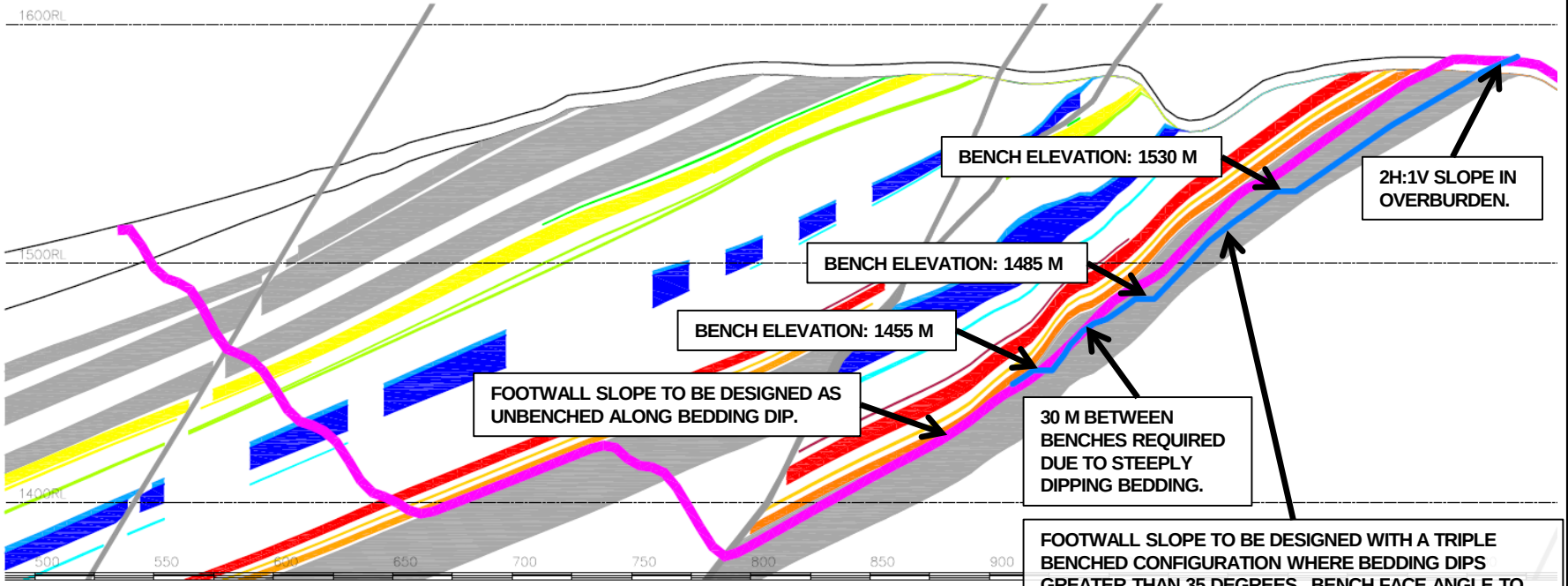

FOOTWALL SLOPE TO BE DESIGNED WITH A TRIPLE BENCHED CONFIGURATION WHERE BEDDING DIPS GREATER THAN 35 DEGREES. BENCH FACE ANGLE TO BE EXCAVATED ALONG DIP OF BEDDING.

- TRIPLE BENCH (45 M)
- BENCH FACE ANGLE – FOLLOW DIP OF BEDDING
- INTER-RAMP ANLGE – VARIABLE DEPENDING ON BEDDING DIP
- BENCH WIDTH – 8 M

REFERENCES

1. SECTIONS PROVIDED BY RIVERSDALE RESOURCES LIMITED APRIL 6, 2016.

LEGEND

DESWIK MINI PIT DESIGN

GOLDER RECOMMENDED DESIGN

CLIENT
RIVERSDALE RESOURCES LIMITED

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-06-28
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 0660
RECOMMENDED MINI PIT FOOTWALL DESIGN

PROJECT No.	PHASE	Rev.	FIGURE
1654139	5000	0	H-5

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A

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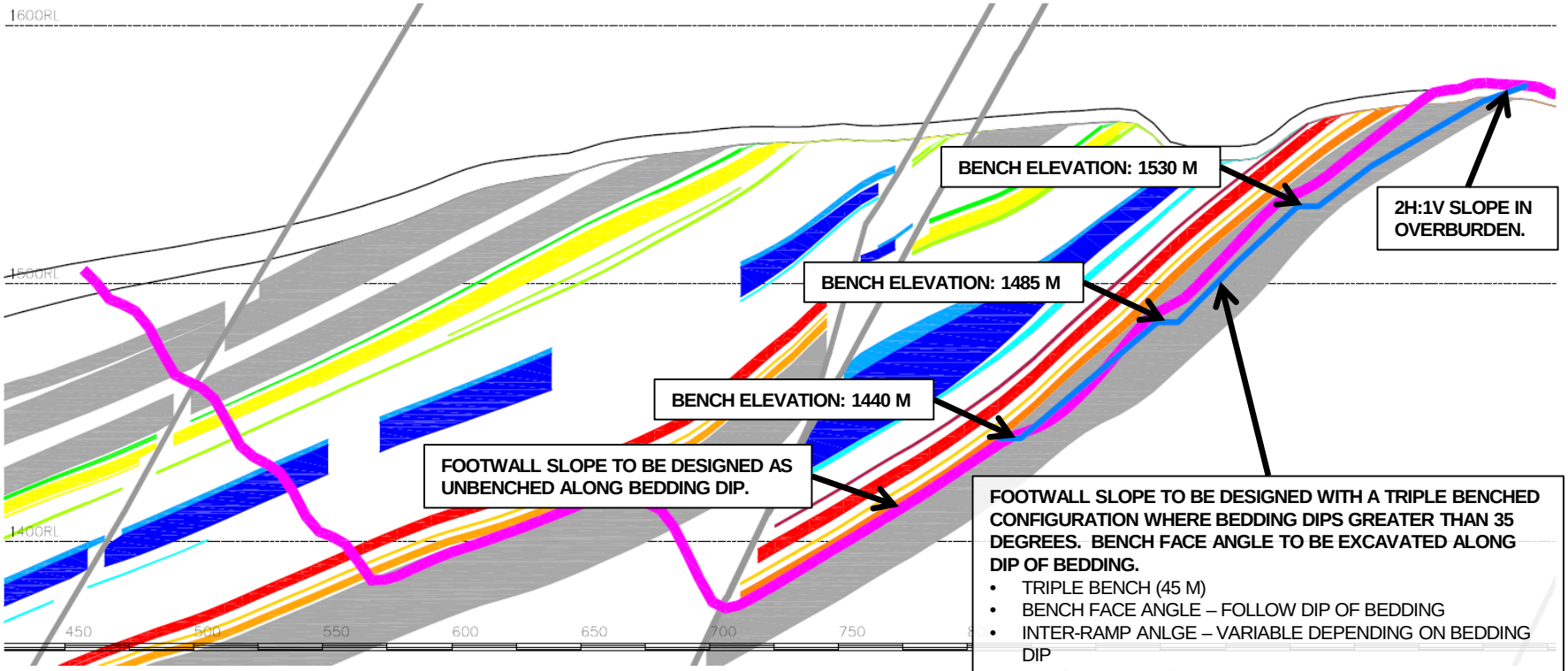

REFERENCES

1. SECTIONS PROVIDED BY RIVERSDALE RESOURCES LIMITED APRIL 6, 2016.

LEGEND

DESWIK MINI PIT DESIGN

GOLDER RECOMMENDED DESIGN

CLIENT
RIVERSDALE RESOURCES LIMITED

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-06-28
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 0750
RECOMMENDED MINI PIT FOOTWALL DESIGN

PROJECT No.	PHASE	Rev.	FIGURE
1654139	5000	0	H-6

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A

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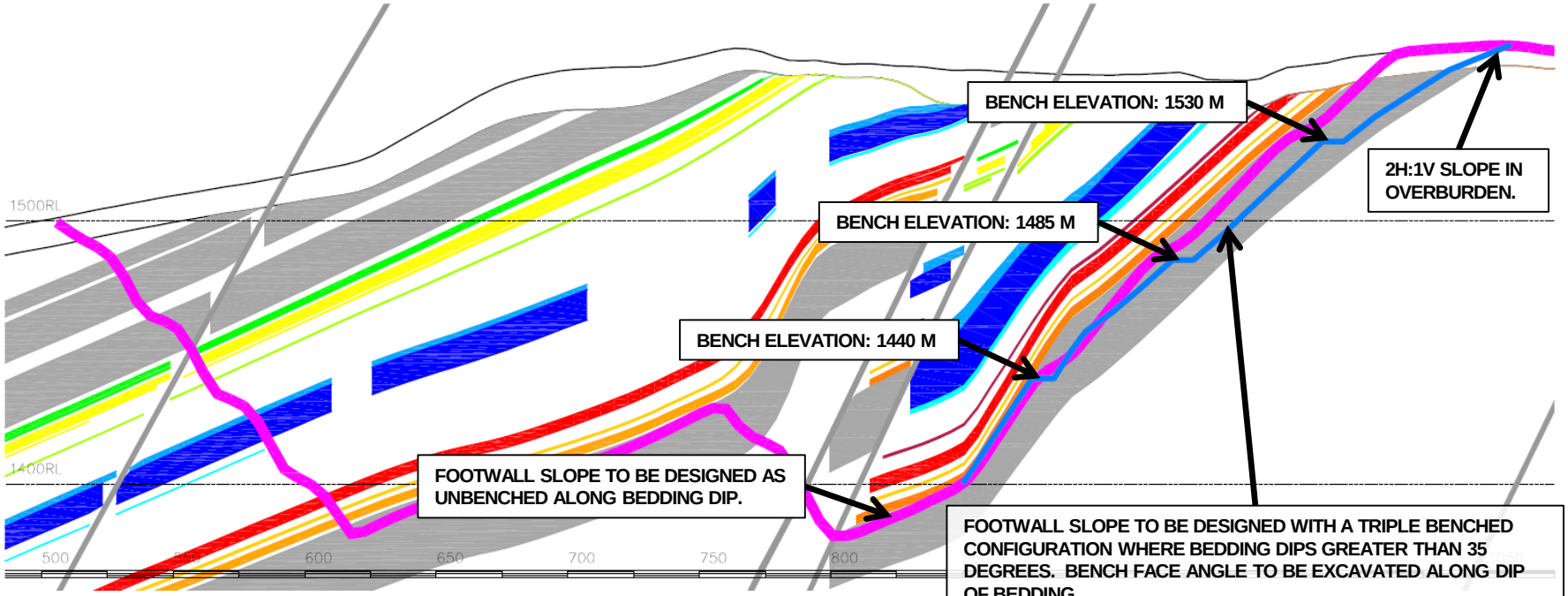

FOOTWALL SLOPE TO BE DESIGNED WITH A TRIPLE BENCHED CONFIGURATION WHERE BEDDING DIPS GREATER THAN 35 DEGREES. BENCH FACE ANGLE TO BE EXCAVATED ALONG DIP OF BEDDING.

- TRIPLE BENCH (45 M)
- BENCH FACE ANGLE – FOLLOW DIP OF BEDDING
- INTER-RAMP ANLGE – VARIABLE DEPENDING ON BEDDING DIP
- BENCH WIDTH – 8 M

REFERENCES

1. SECTIONS PROVIDED BY RIVERSDALE RESOURCES LIMITED APRIL 6, 2016.

LEGEND

DESWIK MINI PIT DESIGN

GOLDER RECOMMENDED DESIGN

CLIENT
RIVERSDALE RESOURCES LIMITED

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-06-28
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 0840
RECOMMENDED MINI PIT FOOTWALL DESIGN

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**H-7**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A
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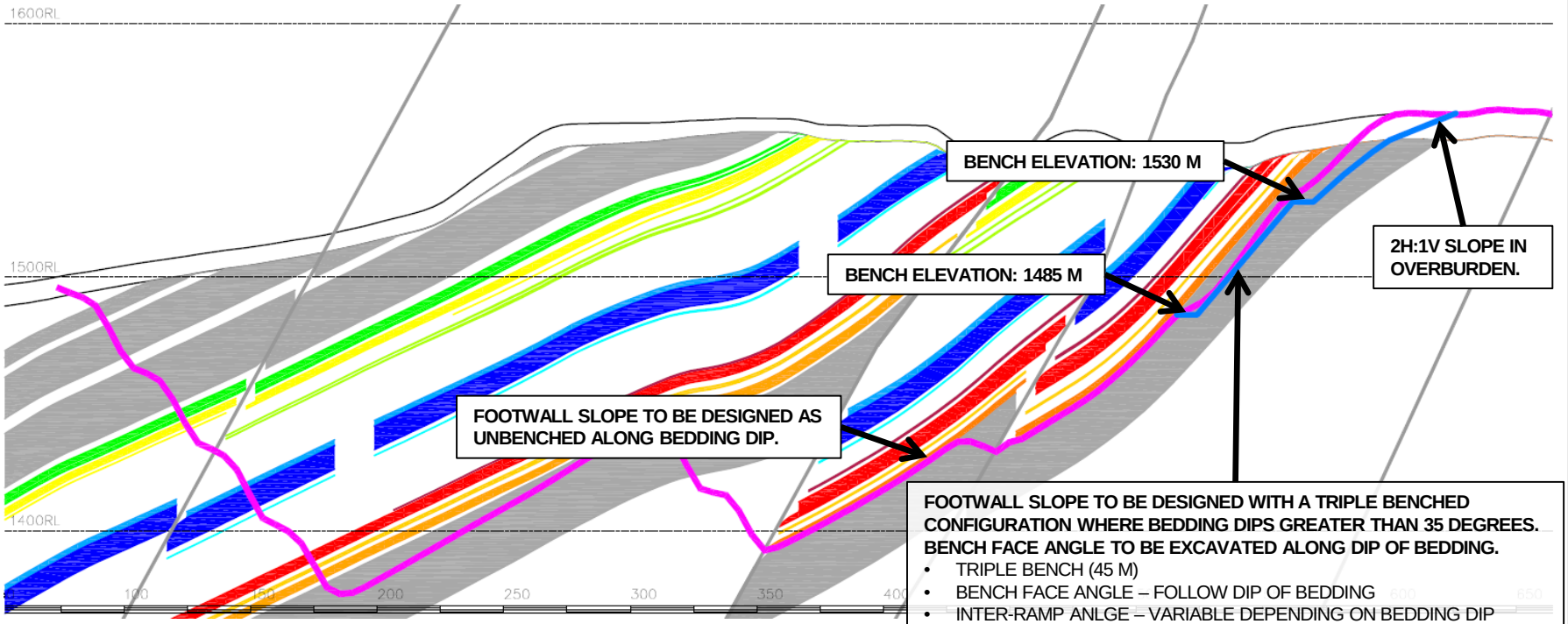

REFERENCES

1. SECTIONS PROVIDED BY RIVERSDALE RESOURCES LIMITED APRIL 6, 2016.

LEGEND

DESWIK MINI PIT DESIGN

GOLDER RECOMMENDED DESIGN

CLIENT
RIVERSDALE RESOURCES LIMITED

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-06-28
PREPARED	AGH
DESIGN	AGH
REVIEW	AVC
APPROVED	AVC

PROJECT
GRASSY MOUNTAIN PROJECT
MINI PIT - PIT SLOPE STABILITY ASSESSMENT

TITLE
SECTION 1020
RECOMMENDED MINI PIT FOOTWALL DESIGN

PROJECT No.	PHASE	Rev.	FIGURE
1654139	**5000**	**0**	**H-8**

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Golder Associates

Appendix 9d

Geotechnical Site Investigation of Waste Storage Dumps and Water Impoundment Structures (Terracon, July 2016)

TERRACON GEOTECHNIQUE

400, 800 – 5 Avenue SW
Calgary, Alberta T2P 3T6
PH: 403 266-1150
FX: 403 233-0841
www.terracon.ca

July 12, 2016 PROJECT NO. 163585

Benga Mining Limited
12331 – 20th Ave
PO Box 660
Blairmore, Alberta
T0K 0E0

ATTENTION: Mr. Michael Youl and Mr. Jim McQuaid

Dear Mr. Youl and Mr. McQuaid:

SUBJECT: GEOTECHNICAL SITE INVESTIGATION OF WASTE STORAGE DUMPS AND WATER IMPOUNDMENT STRUCTURES AT GRASSY MOUNTAIN COAL PROJECT

1.0 INTRODUCTION

Benga Mining Limited (Benga) retained Terracon Geotechnique Ltd. (TGL) to complete a geotechnical site investigation for selected infrastructure for the Grassy Mountain Coal Project (the Project). In order to support license applications, further investigations were required for earth structures that were either modified in design or were not previously accessible during earlier field work. This report summarizes the findings from field investigations and laboratory programs, and provides comments on and recommendations for the design of the Raw Water Pond, South East Surge Pond, East Sediment Pond and South Waste Dump.

1.1 Project Site Description and History

The Project is located approximately 150 km southwest of Calgary, in the Crowsnest Pass region of Alberta, about 7 km north of the community of Blairmore. A site specific drawing is included in Figure 1 in Appendix A for general information purposes. A modest selection of 4 photographs are collected in Appendix B to illustrate the field conditions.

The Project area of approximately 1582 ha has moderate to steep mountainous topography, with elevations from 1406 masl to 2090 masl, and variable montane and subalpine mixed

vegetation. The Project comprises a surface metallurgical coal mine, rock disposal areas, and a coal handling and preparation plant with associated infrastructure.

An Engineering Feasibility Study for the Project was completed in 2015, with a supplemental geotechnical program completed in 2015. Areas previously investigated included the Raw Water Pond and South Waste Dump. The design of the South Waste Dump has been revised since the previous investigations to include a north portion and a south portion separated by an existing powerline. The relevant historical geotechnical reports were reviewed and the subsurface conditions, design parameters and recommendations referenced in this investigation in order to fully utilize all available information sources.

1.2 Purpose

The purpose of this report is to provide a description and characterization of subsurface stratigraphic profiles, relevant soil physical properties, groundwater levels and the soil-bedrock contact conditions at the specific sites.

This study also required an examination of the slope stability conditions of the proposed structures at these sites, in light of the foundation conditions as described in this field survey. Static and pseudo-static analyses were also included in the slope stability modeling exercises.

2.0 FIELD INVESTIGATION AND LABORATORY TESTING

2.1 Scope of Work and Methodology

The primary objective of this site investigation was to explore and define the subsurface conditions and to discuss, as necessary, 4 specific structures (South Waste Dump, Raw Water Pond, South East Surge Pond and East Sediment Pond) including development considerations.

The scope of work included: (1) drilling of 12 geotechnical test holes at designated locations; (2) conducting in-situ soil testing, performing soil descriptions of the borehole samples, and collecting grab, split spoon, Shelby tube and core samples; (3) installation of 2 standpipe piezometers; and (4) data compilation and analyses, geological and groundwater interpretation, and reporting while focusing on the characterization of subsurface conditions for stable slope designs of the structures of interest. Specific deliverables include:

- Description of field investigation activities;
- Plan of borings;
- Borehole geological logs, groundwater table;
- Description of site conditions;

- Discussion of local geologic concerns;
- Discussion of laboratory testing regime and results; selection of representative shear strength parameters and other relevant factors relating to shear strength determination;
- Stable slope recommendations for South Waste Dump;
- Stable slope recommendations for Raw Water Pond dam;
- Stable slope recommendations for South East Surge Pond dam; and
- Stable slope recommendations for East Sediment Pond dam.

The methodology employed throughout is industry standard and includes field exploration and testing, followed by data analyses and interpretations. Figure 2 in Appendix A presents the site plan, including borehole locations and structure locations.

2.2 Health and Safety Protocols

Prior to the start of field work, TGL completed a Safe Work Plan (SWP) coherent with the site and task specifics. This safety plan included specific Job Hazard Analyses and Controls and Emergency procedures. Site specific orientation/training for the field crew was conducted by Benga prior entering the Project site.

The proposed borehole locations, flagged by Benga, were determined to be at a safe working distance from any obstacles, including underground and overhead utilities and structures. All work was conducted according to Alberta Occupational Health & Safety Code. Field Level Risk Assessments and Coordination Meetings were completed at the beginning of shifts and at any change of the work environment.

Access to the field investigation sites required commute on a radio controlled road. The borehole locations were accessible by the drilling equipment, by foot and/or ATV, provided on site by Benga. The field work was completed with the Benga's logistical support and without incident.

2.3 Drilling Program

Benga had the drilling locations surveyed, scanned, and flagged prior to the field personnel arrival on site. As needed, the field personnel and the drilling equipment were escorted to the drilling sites by a Benga representative. A selection of photographs is presented in Appendix B to illustrate general field conditions and equipment.

The field drilling program was carried out from May 11, 2016 to May 15, 2016. Ten geotechnical, 2.3 m to 10.7 m deep auger boreholes were completed by Val's Drilling, using a track mounted drill rig, equipped with continuous flight solid and hollow stem augers, ODEX and HQ coring equipment. Two holes were drilled by hand, at inaccessible by drilling equipment locations.

Two standpipe piezometers were installed:

- MW16-13-11 (in borehole GT16-11) at the East Sediment Pond footprint; and
- MW16-14-03 (in borehole GT16-07) at the South Waste Dump area.

These standpipes remained at the end of the field program as permanent groundwater observation wells. However, MW16-14-13 lies within the dump footprint and will eventually be buried by dump waste rock.

Drilling, in-situ testing, soil sampling, standpipe installation and borehole backfilling processes were supervised and directed by a TGL field consultant.

During drilling, solid and hollow stem augers as well as ODEX equipment were utilized in order to manage the subsurface conditions, soil sampling, in-situ testing and standpipe installation. HQ coring was also employed to retrieve bedrock core samples. Bedrock coring was completed to confirm the bedrock lithology and therefore bedrock core intervals were short.

Continuous geotechnical soil description of the subsurface materials was conducted for all the 12 drilling locations. Borehole as-built data are summarized in Table 2.1. Borehole logs, including subsurface material descriptions, in-situ test data, sample intervals and sample types, and standpipe installation details, are presented in Appendix C. Groundwater table elevations, where identified, are presented on the borehole logs.

Table 2.1: Borehole As-built Data

Borehole ID	Easting* [m]	Northing* [m]	Collar Elevation** [masl]	Borehole Depth [m]	Depth to Bedrock [m]	Borehole Location
GT16-01	685585.00	5503808.42	1480.00	9.14	7.62	Raw Water Pond
GT16-02	685586.87	5503635.48	1493.35	7.62	4.57	Raw Water Pond
GT16-03	686235.49	5503610.61	1562.51	3.05	0.61	South Waste Dump
GT16-04	686120.14	5502813.87	1717.14	0.46	0.46	South Waste Dump
GT16-05	686668.14	5502928.82	1738.55	0.76	0.76	South Waste Dump
GT16-06	686726.85	5503577.69	1591.71	2.29	0.76	South Waste Dump
GT16-07	686616.85	5504450.64	1554.29	6.10	3.05	South Waste Dump
GT16-08	687304.90	5504478.29	1499.74	7.62	6.86	South - East Surge Pond
GT16-09	687344.87	5504670.28	1504.35	10.06	9.45	South - East Surge Pond
GT16-10	687615.85	5506197.18	1574.00	4.27	-	East Sediment Pond
GT16-11	687765.52	5506181.92	1570.00	10.67	9.14	East Sediment Pond
GT16-12	687732.60	5506379.47	1574.65	4.57	3.35	East Sediment Pond

Total soil footage: 46.63 m
Total rock footage: 19.98 m

* Borehole co-ordinates are UTM NAD 83 ZONE 11 N and are recorded with a hand held device

** Borehole collar elevations are inferred from original topography digital data, provided by Benga

" – " Indicates that bedrock was not encountered

The site investigation strategy was devised in the context of a montane geomorphological model in a heavily glaciated terrain which leaves no weathered bedrock. The surficial soils profile is the product of a residual glacial debris modified by recent physical weathering, mass wasting runoff and local fluvial activity. As such, the soil bedrock interface is sharp and distinct and the bedrock is relatively fresh and unweathered. The field exploration findings including the soil profiles were consistent with this genetic model.

2.4 In-Situ Testing and Sampling

2.4.1 Soil

Detailed soil descriptions, together with sampling, SPT, Atterberg Limits and groundwater levels are recorded systematically on the borehole logs in Appendix C. Standard Penetration Tests (SPTs) were conducted as a means to measure and correlate soil resistance to penetration

through the blow count N values. The SPTs were conducted at designated depths, to capture the in-situ properties of the soil profile. Field vane shear testing was not viewed as necessary given the soil textures that were intersected.

A total of 79 soil samples were collected during the drilling program, including 32 grab, 46 split spoon and 1 Shelby tube sample, for laboratory tests.

Disturbed split spoon samples were obtained at regular (1.5 m) intervals. Supplemental grab samples from the auger flights were also collected to better define subsurface material properties. Relatively "undisturbed" thin-walled Shelby sample was retrieved at GT16-01, from 2.29 m bgs to 2.44 m bgs.

Collected soil samples were visually examined and described in accordance with the general practice. All grab and SPT samples were double bagged, labeled and stored for further laboratory examination and testing. The Shelby tube sample was sealed in the field, labeled and also stored for testing.

Identified surficial materials range from clay and silt through sand to gravel glacial till with occasional cobbles, boulders and bedrock fragments. Silty clay layers/beds were encountered at six locations: GT16-01, GT16-02, GT16-06, GT16-07, GT16-10, and GT16-11, at depths from 0.0 m to 4.6 m bgs. Silt was identified at GT16-01, GT16-02, GT16-03, GT16-07, GT16-10, and GT16-12, at depths from 0.0 m to 7.6 m bgs. Sand pockets/interbeds were found at GT16-04, GT16-05, GT16-08, GT16-09, and GT16-12 from the surface to 9.5 m bgs. Gravel was found in GT16-08, GT16-09, GT16-10 and GT16-11 from 0.0 m to 9.0 m bgs.

The field investigation suggests variable spatial distribution of the identified surficial materials.

2.4.2 Bedrock

Bedrock intersections are described in the borehole logs in Appendix C. To define the bedrock properties, within the targeted structure footprints, core samples from five boreholes (GT16-01, GT16-02, GT16-03, GT16-06 and GT16-07), with 63.5 mm diameter, were retrieved using HQ diamond drilling equipment.

After reaching suspected bedrock, suggested by the auger drilling/SPT refusals, 1.5 m coring flight was advanced, to confirm if the actual bedrock has been reached and to collect core samples for strength laboratory tests. The bedrock core was logged in the field and sampled. Representative (with at least 2.5/1 length/diameter ratio) intact core sections were selected, double bagged, labeled and stored for testing. Samples of disintegrated core were also collected for reference.

The bedrock, encountered at GT16-03, GT16-06 and GT16-07, is defined as hard, massive, predominantly fine grained sandstone. The bedrock at GT16-01 and GT16-02 is defined as hard, fractured siltstone.

2.5 Laboratory Testing

A laboratory testing program was initiated soon after completion of the field program. Based on the locations and conditions of the soil and rock samples, selected samples were delivered to Golder Associates Ltd. (Golder) laboratory in Calgary for laboratory tests, assigned by TGL.

The completed laboratory tests included: moisture content analyses, particle size distribution analyses, plasticity analyses, direct shear and triaxial compression tests. Table 2.2 lists the type and number of laboratory tests performed for this site investigation. Limited undisturbed (Shelby tube) samples were collected due to the limited presence of cohesive materials. One silty clay (cohesive) horizon, which was encountered at the Raw Water Pond site, was observed. This unit was 4.6 m to 7.5 m thick and the Atterberg Limits data show this horizon to be of low to medium plasticity due to the relatively low clay content and the high silt content. Based on experience, this horizon is expected to have a low pore pressure response (Ru) value. The SPT profile in boring GT16-01 shows one low density zone approximately between 1.5 m and 3.5 m depth in this horizon.

Table 2.2: Type and Number of Laboratory Tests

Type of Test/Analysis	Number of Tests/Analyses
Particle Size Distribution	6
Moisture Content	3
Plasticity	3
Direct Shear	1
Triaxial Compression	1

Individual laboratory test reports are presented in Appendix D and selected soil properties are reported in Table 6.1.

3.0 SUBSURFACE CONDITIONS

The surficial geology within the Project limits is represented by Quaternary moraine till deposits of variable thickness and composition (but generally coarse), fluvial deposits of coarse to fine sediments, and colluvium, derived from the underlying bedrock. Quaternary strata unconformably overlays the Mist Mountain Formation interstratified sandstone, siltstone,

claystone, coal and conglomerate bedrock of late Jurassic to early Cretaceous age. The surficial strata include a variety of glacial till materials, including sand, silt and clay. Minor deposits of coarser materials, associated with the glacial drift, such as pebbles, gravels and cobbles, were also encountered intermixed with the finer glacial till. Borehole locations are highlighted in Figure 2 in Appendix A. Detailed borehole logs with samples, soil descriptions, N values and index test results are shown in Appendix C.

3.1 Raw Water Pond

Two boreholes (GT16-01 and GT16-02) were drilled in the Raw Water Pond footprint. The interpreted soil stratigraphy and subsurface conditions are as follows:

Topsoil: Represented by brown – black, organic, moist to damp, low plastic silt – clay mixture, with some fine to coarse grained sand and some gravel. The inferred maximum thickness of this layer was 0.13 m at GT16-01. Topsoil samples were not collected.

Silt to Silty Clay: This layer of interbedded grey - dark grey silt and silty clay is characterized with soft consistency, medium plasticity and natural water content of 20% to 35%. The layer contains some fine to coarse grained sand lenses/laminae and occasional angular siltstone fragments. Inferred thicknesses of the layer are 7.5 m at GT16-01 and 4.6 m at GT16-02. The N values in GT16-01 in this unit varies from 2 to 22, with the lower values occurring at the top of this horizon at depths of 1.5 m to 2.5 m. The N values in GT16-02 are significantly higher.

In previous field investigations, clayey gravel and sand to clayey sand were encountered below the organic topsoil and the silt to silty clay was not encountered. In our view these types of soils are classic mixed soils with a larger grain size range and are representative of glacial debris sediments.

Bedrock: Hard, fractured, well indurated, dark grey siltstone bedrock was intersected at 7.6 m below ground surface (bgs) at GT16-01 and at 4.6 m bgs at GT16-02.

3.2 South East Surge Pond

Two boreholes (GT16-08 and GT16-09) were drilled in the South East Surge Pond location. The interpreted soil stratigraphy and subsurface conditions are as follows:

Topsoil: Represented by buff-grey, soft to medium stiff, dry, low plastic silt – clay mixture, with occasional fine to coarse grained sand and occasional gravel. The inferred thickness of this layer was 0.05 m at both borehole locations. Topsoil samples were not collected.

Gravel and Silty Sand: Interbedded, on metre scale, sand and gravel represents the subsoil lithology across the South East Surge Pond area. Loose to very dense, dry to wet, subrounded to subangular, sandy to silty gravel beds were inferred at 0.05 m bgs to 6.10 m bgs at GT16-08; from 0.05 m bgs to 3.05 m bgs and from 4.6 m bgs to 8.1 m bgs at GT16-09. Beds of dense to very dense, moist to wet, very fine to coarse grained, silty sand, with trace to some gravel and trace clay, were inferred at 6.1 m bgs to 6.9 m bgs at GT16-08; at 3.05 m bgs to 4.6 m bgs and at 8.1 m bgs to 9.45 m bgs at GT16-09.

Bedrock: Hard, cemented, fine grained, light grey sandstone bedrock was encountered at 6.9 m bgs at GT16-08 and at 9.45m bgs at GT16-09.

3.3 East Sediment Pond

Three boreholes (GT16-10, GT16-11 and GT16-12) were drilled in the East Sediment Pond footprint. The interpreted soil stratigraphy and subsurface conditions are as follows:

Topsoil: The topsoil layer at the east sediment pond location has maximum thickness of 0.13 m at GT16-10. This layer comprises low plastic, soft to stiff, dry to moist, brown – grey, organic silt and clay mixture with trace to occasional fine to coarse grained sand and trace gravel.

Silt and Silty Clay: Layer of interbedded silt and silty clay was interpreted at 0.13 m bgs to 2.0 m bgs at GT16-10; at 0.02 m bgs to 1.5 m bgs at GT16-11 and from 1.22 m bgs to 3.35 m bgs at GT16-12. Inferred from the SPT blow count numbers and laboratory testing, the silt and the silty clay are low plastic, very stiff to hard. The measured natural water content was 10%. The layer has occasional to common sand and gravel.

Sand: Loose, dry, homogeneous, very fine grained sand, with some coarse grained sand and trace gravel, was encountered below the topsoil (0.08 m bgs to 1.22 m bgs) at GT16-12.

Gravel: Dense to very dense, dry to moist, silty to clayey gravel, was logged at 2.0 m bgs to 4.3 m bgs at GT16-10 and at 1.5 m bgs to 9.14 m bgs at GT16-11.

Bedrock: Hard, fine grained, light grey to grey sandstone bedrock was inferred at 9.14 m bgs at GT16-11 and at 3.35 m bgs at GT16-12. The soil-bedrock contact is a clear and sharp boundary surface with no bedrock weathering evident.

3.4 South Waste Dump

Five boreholes were drilled in the south waste dump footprint: GT16-03, GT16-04, GT16-05, GT16-06 and GT16-07. Two of the boreholes (GT16-04 and GT16-05) were drilled by hand, due to the drilling locations' limited access. Observed subsurface lithology and conditions are as follows:

Topsoil: Low plastic, stiff, dry to moist silt and clay mixture with occasional fine to coarse grained sand was encountered at all five drilling locations. The maximum thickness (0.13 m) of the topsoil was measured at GT16-07. No topsoil samples were collected.

Silt and Silty Clay: Beds of silt and silty clay were inferred at 0.05 m bgs to 0.6 m bgs at GT16-03; at 0.05 m bgs to 0.8 m bgs at GT16-06 and from 0.13 m bgs to 1.22 m bgs at GT16-07. SPT blow count numbers and laboratory testing suggest that the silt and the silty clay are low plastic, very stiff to hard. The layer has occasional zones of sand and gravel. Silty clay was encountered in previous investigations in only one borehole.

Sand and Sandy Silt: Loose, dry to moist, homogeneous, fine grained sand and clayey sand, with trace to occasional gravel, was logged at 0.08 m bgs to 0.46 m bgs at GT16-04 and at 0.08 m bgs to 0.76 m bgs at GT16-05. Low plastic, loose, dry sandy silt with some gravel was recorded at 1.22 m bgs to 3.05 m bgs at GT16-07.

Bedrock: Hard, partially fractured, fine grained, light to dark grey sandstone bedrock was encountered at 3.05 m bgs at GT16-03, at 0.46 m bgs at GT16-04, at 0.76 m bgs at GT16-05, at 0.76 m bgs at GT16-06, and at 3.05 m bgs at GT16-07.

4.0 TOPSOIL CONDITIONS

Topsoil encountered during drilling was relatively thin (0 to 13 cm thick). Due to the organic materials and low strength characteristics, it is recommended that the topsoil be stripped in any construction areas. The topsoil should be stockpiled for use during reclamation.

5.0 GROUNDWATER CONDITIONS

5.1 Raw Water Pond

Groundwater: Groundwater was measured at 2.13 m bgs at GT16-01. No groundwater was encountered at the location of GT16-02 (7.62 m total depth). Previous investigations encountered groundwater at 3.3 m bgs in one borehole and did not encounter groundwater in a second, much shallower borehole. The groundwater table system is at least partially perched and not necessarily related to the ground surface.

5.2 South East Surge Pond

Groundwater: Groundwater table was measured at 3.20 m bgs at GT16-08 and at 5.50 m bgs at GT16-09.

5.3 East Sediment Pond

Groundwater: No groundwater was encountered at the East Sediment Pond drilling locations. This suggests the groundwater table is at least 10.7 m below the ground surface.

5.4 South Waste Dump

Groundwater: No groundwater was encountered at the South Waste Dump drilling locations, and groundwater was only encountered in one borehole during previous investigations. This observation suggests the water table lies at least 6.1 m below the ground surface and resides in the bedrock. The overburden cover is in a drained condition.

6.0 SLOPE STABILITY ANALYSES

6.1 Methodology

Slope stability analyses were conducted using Geo-Studio International SLOPE/W software (Version 8) to determine the factor of safety against slope failure of the Raw Water Pond, South East Surge Pond, East Sediment Pond and South Waste Dump. Profiles used in the models are shown in Figure 2 in Appendix A. The Morgenstern-Price method was used in the analysis with a circular failure mode. As the failure planes are unlikely to include the bedrock, the slope stability analyses considered that material as impenetrable (failure surfaces do not penetrate the bedrock). The critical slip surface search mode was employed as well as inputting defined failure surfaces. Appendix E includes the 20 slope models analyzed.

The material properties used for slope stability analyses are presented in Table 6.1. These are based on previous geotechnical reports, visual/manual soil descriptions, field tests and laboratory testing. The soil stratigraphic colour coding in Table 6.1 matches the soil colour codes on the slope stability models presented in Appendix E.

Table 6.1: Slope/W Soil Parameter Inputs

Material	Unit Weight (kN/m^3)	Cohesion (kPa)	Friction Angle (°)
Fill	21	0	32
Gravel and Sand (medium dense to very dense)	22	0	33
Gravel and Sand (loose to medium dense)	20	0	30
Sand and Sandy Silt	17	0	27
Silt and Silty Clay (soft to stiff)	17	0	20
Silt and Silty Clay (stiff to hard)	17	0	20
Siltstone/Sandstone Bedrock	Impenetrable		

Groundwater was modeled at the ground surface for the conservative case where the soil is fully saturated. The slope stabilities were analysed with the ponds filled with water to the maximum capacity state and with the ponds empty (to model rapid drawdown state). For the Raw Water Pond (dam classification high consequence of failure), a seismic load of 0.12 g was added to confirm long term stability with a potential seismic load. A seismic load of 0.17 g was added for the South East Surge Pond and East Sediment Pond analyses, both of which carry a very high consequence of failure for dams. The South Waste Dump model utilized a seismic load of 0.12 g.

In our judgement, based on the local soil properties, groundwater conditions and the length of likely seismic events, soil liquefaction, a high Ru value and strain softening are not seen as significant risks. Therefore shear strength reduction and/or increased pore pressure occurring during seismic events are not included in the models.

The slope models are also based on the following criteria:

- The dam design provided by Benga includes upstream slopes of 2.5H:1V and downstream slopes of 3H:1V;
- The waste dump design provided by Benga includes an overall slope of 23°, with a maximum height of 200 m;
- The subsurface conditions are interpreted based on field investigations and regional geology;
- The in-situ material properties are represented by the most conservative values derived from the laboratory and field tests;

6.2 Raw Water Pond

One cross section was modelled for the Raw Water Pond dam, as shown in Figure 2 in Appendix A. This section was selected based on the greatest dam height. Profile 4 in Appendix E presents the geometry, subsurface conditions and analysis results. Table 6.2 below summarizes the analysis results for the selected pond conditions. The failure mode column reflects the structure elements that are susceptible to failure.

Table 6.2: Slope Stability Results – Profile 4

Condition	Minimum Target FoS	Minimum FoS	Failure Mode
Undrained	1.3	1.4	Foundation
Drained	1.5	1.2	Foundation
Rapid Drawdown	1.2	1.2	Foundation
Drained with Seismic	1.0	0.8	Foundation

6.3 South East Surge Pond

Two cross sections were modelled for the South East Surge Pond dam, as shown in Figure 2 in Appendix A. These sections were selected based on the dam configuration, with the greatest dam height being away from the centre of the length of the dam. Profiles 2 and 3 in Appendix E present the geometry, subsurface conditions and analysis results. Tables 6.3 and 6.4 below summarize the analysis results for the selected pond conditions.

Table 6.3: Slope Stability Results – Profile 2

Condition	Minimum Target FoS	Minimum FoS	Failure Mode
Undrained	1.3	1.6	Embankment
Drained	1.5	1.9	Embankment
Rapid Drawdown	1.2	1.4	Foundation
Drained with Seismic	1.0	1.2	Embankment

Table 6.4: Slope Stability Results – Profile 3

Condition	Minimum Target FoS	Minimum FoS	Failure Mode
Undrained	1.3	1.6	Embankment
Drained	1.5	1.9	Embankment
Rapid Drawdown	1.2	1.2	Embankment
Drained with Seismic	1.0	1.2	Foundation

6.4 East Sediment Pond

One cross section was modelled for the East Sediment Pond dam, as shown in Figure 2 in Appendix A. This section was selected based on the greatest dam height. Profile 1 in Appendix E presents the geometry, subsurface conditions and analysis results. Table 6.5 below summarizes the analysis results for the selected pond conditions.

Table 6.5: Slope Stability Results – Profile 1

Condition	Minimum Target FoS	Minimum FoS	Failure Mode
Undrained	1.3	1.4	Foundation
Drained	1.5	1.7	Foundation
Rapid Drawdown	1.2	1.2	Embankment
Drained with Seismic	1.0	1.0	Foundation

6.5 South Waste Dump

Two cross sections were modelled for the South Waste Dump, as shown in Figure 2 in Appendix A. These sections were selected based on the greatest dump height and the potential impact of dump failure on the power line that separates the north and south portions of the South Waste Dump. Profiles 5 and 6 in Appendix E present the geometry, subsurface conditions and analysis results. Tables 6.6 and 6.7 below summarize the analysis results for the selected dump conditions.

Table 6.6: Slope Stability Results – Profile 5

Condition	Minimum Target FoS	Minimum FoS	Failure Mode
Drained	1.5	1.6	Foundation
Drained with Seismic	1.1	1.1	Foundation

Table 6.7: Slope Stability Results – Profile 6

Condition	Minimum Target FoS	Minimum FoS	Failure Mode
Drained	1.5	1.6	Foundation
Drained with Seismic	1.1	1.2	Foundation

7.0 RECOMMENDATIONS

With the exception of the Raw Water Pond, the structures modelled in this report meet the minimum FoS for the corresponding dam or dump stability. It is recommended to review/revise the design of the Raw Water Pond dam in order to increase the FoS to acceptable values for both drained and seismic conditions.

As the slope stability of the South Waste Dump is sensitive to the presence of the silt and silty clay in the foundation soils, it is recommended this material be stripped prior to dump construction. In addition, constructing the dump in lifts and utilizing benches to vary the final dump profile will also give better control on the overall FoS for dump stability and may provide more practical access and slopes for reclamation.

8.0 CLOSURE

We trust this draft report meets your present requirements and appreciate any comments or questions you may have so that we may finalize the report.

Yours Sincerely,
TERRACON GEOTECHNIQUE LTD.
APEGA PERMIT NO. 3407

Partnerships IN HEALTH AND SAFETY

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ENCLOSURE

APPENDIX A

Figures

Figure 1 ..... Location Map
Figure 2 ..... 2016 Geotechnical Borehole Location Map

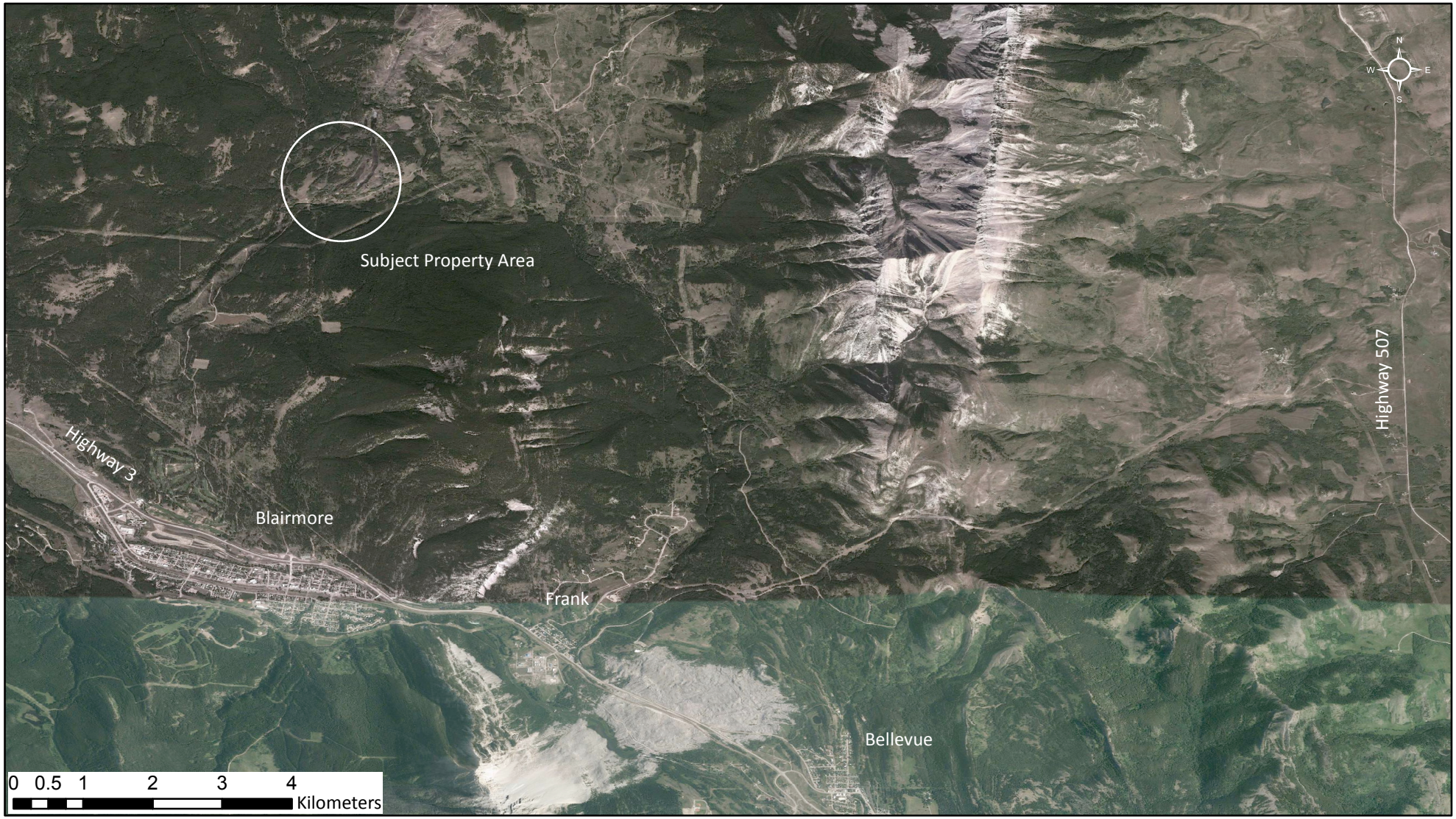
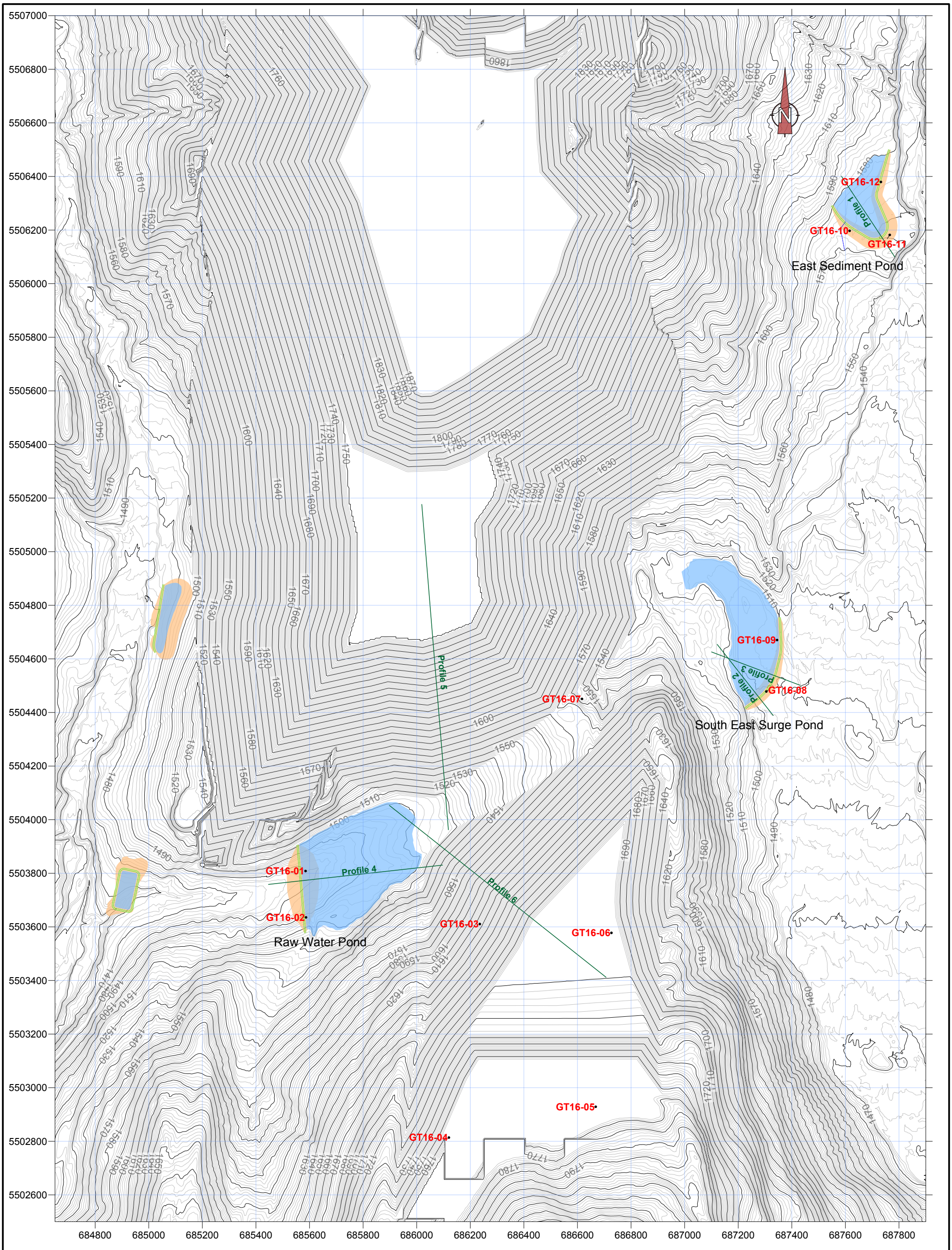


Figure 1. Location Map.

Project Number: 163585
Project Name: Benga Mining Ltd. Grassy Mountain
Drafted: KH
Date Taken: December 30, 2012
Scale: 1:80 000
Projection: WGS 1984
Source: Google Earth Pro

TERRACON GEOTECHNIQUE



Scale 1 : 13 000

0 500 1000 1500 2000

Riversdale Resources Limited
Benga Mining Limited
Grassy Mountain Project, Alberta

TERRACON GEOTECHNIQUE LTD.
CONSULTING ENGINEERS AND GEOLOGISTS

Figure 2
2016 Geotechnical Borehole Location Map

Date: June 30, 2016	Designed By: L.N.	DWG Size: custom
Scale: 1 : 13 000	Drawn By: O.G.	Sheet:
Project No.: 163585	Reviewed By: L.N.	File Name: Benga Site Plan_2

APPENDIX B

Photographs

Photograph 1 .....Drill Rig at GT16-08
Photograph 2 .....GT16-08
Photograph 3 ..... Sandstone Bedrock at GT16-08
Photograph 4 .....Standpipe

Photograph 1: Drill Rig at GT16-08

Photograph 2: GT16-08

Photograph 3: Sandstone Bedrock at GT16-08

Photograph 4: Standpipe

APPENDIX C

Borehole Logs

BOREHOLE GT16-01
BOREHOLE GT16-02
BOREHOLE GT16-03
BOREHOLE GT16-04
BOREHOLE GT16-05
BOREHOLE GT16-06
WELL GT16-07 / MW16-14-03
BOREHOLE GT16-08
BOREHOLE GT16-09
BOREHOLE GT16-06
WELL GT16-11 / MW16-13-11
BOREHOLE GT16-12

BOREHOLE GT16-01

RIVERSDALE RESOURCES

CLIENT Benga Mining Limited
PROJECT NAME Grassy Mountain Geotechnical Investigation - May 2016
PROJECT NUMBER 163585
PROJECT LOCATION Blairmore, AB

DATE STARTED 5/14/16 **COMPLETED** 5/14/16 **GROUND ELEVATION** 1480 m **HOLE SIZE** 6
DRILLING CONTRACTOR Val's Drilling
COORDINATES E 685585m N 5503808.42m
DRILLING METHOD Solid Stem Auger and HQ Coring
LOGGED BY OG **CHECKED BY** BK **GROUND WATER LEVELS:** ▽ **DURING DRILLING** 2.13 m / Elev 1477.87 m
NOTES RAW WATER POND. Switched to coring at 7.62 m depth. **AFTER DRILLING** ---

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	▲ SPT N VALUE ▲ PL MC LL ☐ ORGANIC CONTENT (%) 20 40 60 80	Facies Descriptor	GRAPHIC LOG	MATERIAL DESCRIPTION	POCKET PEN. (kPa)	WELL DIAGRAM
	AU 1						0.13 TOPSOIL: Organic silt and clay. 1479.87 Low plastic, soft , moist to damp, brown - black; some fine to coarse grained sand, some gravel (1 cm), common rootlets.		
1	SPT 2		1-2-2 (4)	▲			SILT: Dry to moist, loose, grey - dark grey; some fine to coarse grained sand, some clay, occasional angular siltstone fragments.		
	AU 3								
2	SPT 4		0-0-2 (2)	▲			1.98 1478.02		
	AU 5						SILTY CLAY: Soft, damp, medium plastic; grey; some fine grained sand lenses/laminae; occasional siltstone fragments.	▽	
	ST 6								
3	AU 7						Note the low N values from 1.5 m to 2.5 m depth.		
	SPT 8		3-2-3 (5)	▲					
	AU 9						3.81 1476.19		
4	SPT 10		8-6-9 (15)	▲			SILT: Damp to wet, loose to dense, low to medium plastic; grey - dark grey; sandy, some clay, occasional angular siltstone fragments.		
5	SPT 11		4-11-11 (22)	▲					
	AU 12								
6									
	SPT 13		3-7-13 (20)	▲					
7	AU 14								
	SPT 15		48-50/0.13	>>▲			7.62 1472.38		
8							SILTSTONE (BEDROCK): Hard, fractured, dark grey.		
	RC 16								
9									

BETA - GEOTECH W WELL AND SPT BENGA LOGS.GPJ GINT STD US LAB.GDT 7/12/16

(Continued Next Page)

BOREHOLE GT16-01

RIVERSDALE RESOURCES

CLIENT Benga Mining Limited

PROJECT NAME Grassy Mountain Geotechnical Investigation - May 2016

PROJECT NUMBER 163585

PROJECT LOCATION Blairmore, AB

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	▲ SPT N VALUE ▲ PL MC LL / ☐ ORGANIC CONTENT (%) 20 40 60 80	Facies Descriptor	GRAPHIC LOG	MATERIAL DESCRIPTION	POCKET PEN. (kPa)	WELL DIAGRAM
							9.14 1470.86 Bottom of hole at 9.14 m.		

BETA - GEOTECH W WELL AND SPT BENGA LOGS.GPJ GINT STD US LAB.GDT 7/12/16

BOREHOLE GT16-02

RIVERSDALE RESOURCES

CLIENT Benga Mining Limited
PROJECT NAME Grassy Mountain Geotechnical Investigation - May 2016
PROJECT NUMBER 163585
PROJECT LOCATION Blairmore, AB

DATE STARTED 5/14/16 **COMPLETED** 5/14/16 **GROUND ELEVATION** 1493.35 m **HOLE SIZE** 6
DRILLING CONTRACTOR Val's Drilling
COORDINATES E 685586.87m N 5503635.48m
DRILLING METHOD Solid Stem Auger and HQ Coring
LOGGED BY OG **CHECKED BY** BK **GROUND WATER LEVELS:** **DURING DRILLING** Water table not encountered
NOTES RAW WATER POND. Dry hole, switched to coring at 6.10 m depth. **AFTER DRILLING** ---

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	SPT N VALUE / PL MC LL / ORGANIC CONTENT (%)	Facies Descriptor	GRAPHIC LOG	MATERIAL DESCRIPTION	POCKET PEN. (kPa)	WELL DIAGRAM
	AU 1						SILT: Dry, loose, low plastic; grey - dark grey; sandy, trace clay, common gravel (3 cm).		
1	SPT 2		8-9-9 (18)	▲					
	AU 3								
2	SPT 4		6-6-9 (15)	▲			1.98 1491.37		
	AU 5						SILTY CLAY: Stiff, moist, low to medium plastic; grey; some fine to coarse grained sand lenses/laminae; occasional gravel (2 cm), occasional siltstone angular fragments at bottom of interval. Note high N values in this zone relative to the SPT profile in GT16-01.		
3	SPT 6		6-10-15 (25)	▲					
4	AU 7						4.57 1488.78		
	SPT 8		50/0.05	>>▲			SILTSTONE (BEDROCK): Hard, fractured, dark grey.		
5	AU 9								
6	SPT 10		50/0.02	>>▲					
7	RC 11						7.62 1485.73 Bottom of hole at 7.62 m.		

BOREHOLE GT16-03

RIVERSDALE RESOURCES

CLIENT Benga Mining Limited
PROJECT NAME Grassy Mountain Geotechnical Investigation - May 2016
PROJECT NUMBER 163585
PROJECT LOCATION Blairmore, AB

DATE STARTED 5/14/16 **COMPLETED** 5/14/16 **GROUND ELEVATION** 1562.51 m **HOLE SIZE** 6
DRILLING CONTRACTOR Val's Drilling
COORDINATES E 686235.49m N 5503610.61m
DRILLING METHOD Solid Stem Auger and HQ Coring
LOGGED BY OG **CHECKED BY** BK **GROUND WATER LEVELS:** **DURING DRILLING** Water table not encountered
NOTES SOUTH WASTE DUMP. Dry hole, switched to coring at 0.76 m depth. **AFTER DRILLING** ---

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	▲ SPT N VALUE ▲ PL MC LL ☐ ORGANIC CONTENT (%) 20 40 60 80	Facies Descriptor	GRAPHIC LOG	MATERIAL DESCRIPTION	POCKET PEN. (kPa)	WELL DIAGRAM
	AU 1						0.05 TOPSOIL: Organic silt and clay. 1562.46		
							Low plastic, stiff, dry to moist, brown-grey; occasional fine to coarse grained sand;		
							0.61 occasional rootlets. 1561.90		
	SPT 2		50/0.13	>>▲			SILT: Dry to moist, loose, low plastic; brown-grey; some fine to coarse grained sand, some clay, some angular sandstone fragments.		
1	RC 3						SANDSTONE (BEDROCK): Weathered, fine grained, grey.		
2	RC 4								
3							3.05 1559.46		
							Bottom of hole at 3.05 m.		

BETA - GEOTECH W WELL AND SPT BENGA LOGS.GPJ GINT STD US LAB.GDT 7/12/16

BOREHOLE GT16-04

RIVERSDALE RESOURCES

CLIENT Benga Mining Limited
PROJECT NAME Grassy Mountain Geotechnical Investigation - May 2016
PROJECT NUMBER 163585
PROJECT LOCATION Blairmore, AB

DATE STARTED 5/15/16 **COMPLETED** 5/15/16 **GROUND ELEVATION** 1717.14 m **HOLE SIZE** 3
DRILLING CONTRACTOR OG / MA
COORDINATES E 686120.14m N 5502813.87m
DRILLING METHOD Hand Auger
LOGGED BY OG **CHECKED BY** BK **GROUND WATER LEVELS:** **DURING DRILLING** Water table not encountered
NOTES SOUTH WASTE DUMP. Bedrock at 0.46 m depth. **AFTER DRILLING** ---

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	▲ SPT N VALUE ▲ PL MC LL ☐ ORGANIC CONTENT (%) 20 40 60 80	Facies Descriptor	GRAPHIC LOG	MATERIAL DESCRIPTION	POCKET PEN. (kPa)	WELL DIAGRAM
	GB						0.08 TOPSOIL: Organic silt and clay. 1717.06 Low plastic, stiff, dry to moist, brown-grey; occasional fine to coarse grained sand; common rootlets. 0.46 1716.68 SAND: Dry to moist, loose, fine grained, homogenous; buff; some clay, occasional gravel. SANDSTONE (BEDROCK): Hard, fine grained, light grey. Bottom of hole at 0.46 m.		

BETA - GEOTECH W WELL AND SPT BENGA LOGS.GPJ GINT STD US LAB.GDT 7/12/16

BOREHOLE GT16-05

RIVERSDALE RESOURCES

CLIENT Benga Mining Limited
PROJECT NAME Grassy Mountain Geotechnical Investigation - May 2016
PROJECT NUMBER 163585
PROJECT LOCATION Blairmore, AB

DATE STARTED 5/15/16 **COMPLETED** 5/15/16 **GROUND ELEVATION** 1738.55 m **HOLE SIZE** 3
DRILLING CONTRACTOR OG / MA
COORDINATES E 686668.14m N 5502928.82m
DRILLING METHOD Hand Auger
LOGGED BY OG **CHECKED BY** BK **GROUND WATER LEVELS:** **DURING DRILLING** Water table not encountered
NOTES SOUTH WASTE DUMP. Bedrock at 0.76 m depth. **AFTER DRILLING** ---

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	▲ SPT N VALUE ▲ PL MC LL ☐ ORGANIC CONTENT (%) 20 40 60 80	Facies Descriptor	GRAPHIC LOG	MATERIAL DESCRIPTION		POCKET PEN. (kPa)	WELL DIAGRAM
	GB 1						0.08 TOPSOIL: Organic silt and clay.	1738.47		
	GB 2						0.36 Low plastic, stiff, dry to moist, brown-grey; occasional fine to coarse grained sand; common rootlets.	1738.19		
							0.76 SAND: Moist, loose, fine grained, homogenous; buff; some clay, trace gravel.	1737.79		
							CLAYEY SAND: Moist, medium dense, fine grained; buff - grey; occasional gravel (1 cm).			
							SANDSTONE (BEDROCK): Hard, fine grained, light grey. Bottom of hole at 0.76 m.			

BETA - GEOTECH W WELL AND SPT BENGA LOGS.GPJ GINT STD US LAB.GDT 7/12/16

BOREHOLE GT16-06

RIVERSDALE RESOURCES

CLIENT Benga Mining Limited **PROJECT NAME** Grassy Mountain Geotechnical Investigation - May 2016

PROJECT NUMBER 163585 **PROJECT LOCATION** Blairmore, AB

DATE STARTED 5/14/16 **COMPLETED** 5/14/16 **GROUND ELEVATION** 1591.713 m **HOLE SIZE** 6

DRILLING CONTRACTOR Val's Drilling

COORDINATES E 686726.85m N 5503577.69m

DRILLING METHOD Solid Stem Auger and HQ Coring

LOGGED BY OG **CHECKED BY** BK **GROUND WATER LEVELS:** **DURING DRILLING** Water table not encountered

NOTES SOUTH WASTE DUMP. Dry hole, switched to coring at 0.76 m depth. **AFTER DRILLING** ---

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	▲ SPT N VALUE ▲ PL MC LL ☐ ORGANIC CONTENT (%) 20 40 60 80	Facies Descriptor	GRAPHIC LOG	MATERIAL DESCRIPTION	POCKET PEN. (kPa)	WELL DIAGRAM
	AU 1						0.05 TOPSOIL: Organic silt and clay. 1591.66 Low plastic, stiff, dry to moist, brown-grey; occasional fine to coarse grained sand; occasional rootlets.		
1	SPT 2		50/0.13	>>▲			0.76 SILTY CLAY: Soft, damp, medium plastic; buff-grey; occasional sandstone angular clasts. 1590.95 SANDSTONE (BEDROCK): Hard, fine grained, light grey.		
	RC 3								
2							2.29 1589.43 Bottom of hole at 2.29 m.		

WELL GT16-07 / MW16-14-03

RIVERSDALE RESOURCES

CLIENT Benga Mining Limited
PROJECT NAME Grassy Mountain Geotechnical Investigation - May 2016
PROJECT NUMBER 163585
PROJECT LOCATION Blairmore, AB

DATE STARTED 5/13/16 **COMPLETED** 5/14/16 **GROUND ELEVATION** 1554.29 m **HOLE SIZE** 8
DRILLING CONTRACTOR Val's Drilling
COORDINATES E 686616.85m N 5504450.64m
DRILLING METHOD Hollow Stem Auger and HQ coring
LOGGED BY OG **CHECKED BY** BK **GROUND WATER LEVELS:** **DURING DRILLING** Water table not encountered
NOTES SOUTH WASTE DUMP. Dry hole, switched to coring at 3.05 m depth. **AFTER DRILLING** ---

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	SPT N VALUE / PL MC LL / ORGANIC CONTENT (%)	Facies Descriptor	GRAPHIC LOG	MATERIAL DESCRIPTION	POCKET PEN. (kPa)	WELL DIAGRAM
-1									
0							0.00 1554.29 0.13 TOPSOIL: Organic silt and clay. 1554.16 Low plastic, soft to medium stiff, damp to wet, brown-dark grey; occasional fine to coarse grained sand; occasional rootlets.		Top cap Solid pipe: sch. 40 PVC Pipe protector
	AU 1								
1	SPT 2		5-11-18 (29)	▲			SILTY CLAY: Low plastic, soft to medium stiff, damp, grey - brown; some gravel (1 cm); occasional fine to coarse grained sand laminae/lenses.		Bentonite fill Solid pipe: sch. 40 PVC
	AU 3						1.22 1553.07		1.22 mbgs
	SPT 4		15-23-50/0.06	>>▲			SANDY SILT: Low plastic, loose, dry, grey - brown; some gravel (1 cm).		1.52 mbgs
2	AU 5								4/10 Target Filter Sand Slotted pipe: sch. 40 PVC, 010 slot size
3							3.05 1551.24		3.00 mbgs Bottom cap
	SPT 6		50/0.05	>>▲			SANDSTONE (BEDROCK): Hard, fractured, grey - dark grey.		
4	RC 7								
5									Backfill / Slough
	RC 8								
6							6.10 1548.19 Bottom of hole at 6.10 m.		6.10 mbgs

BETA - GEOTECH W WELL AND SPT BENGA LOGS.GPJ GINT STD US LAB.GDT 7/12/16

BOREHOLE GT16-08

RIVERSDALE RESOURCES

CLIENT Benga Mining Limited
PROJECT NAME Grassy Mountain Geotechnical Investigation - May 2016
PROJECT NUMBER 163585
PROJECT LOCATION Blairmore, AB

DATE STARTED 5/11/16 **COMPLETED** 5/11/16 **GROUND ELEVATION** 1499.74 m **HOLE SIZE** 8
DRILLING CONTRACTOR Val's Drilling
COORDINATES E 687304.9m N 5504478.29m
DRILLING METHOD Solid Stem Auger and Hollow Stem Auger
LOGGED BY OG **CHECKED BY** BK **GROUND WATER LEVELS:** ▽ **DURING DRILLING** 3.20 m / Elev 1496.54 m
NOTES SOUTH EAST SURGE POND. Switched to hollow stem at 3.05 m depth **AFTER DRILLING** ---

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	SPT N VALUE / PL MC LL / ORGANIC CONTENT (%)	Facies Descriptor	GRAPHIC LOG	MATERIAL DESCRIPTION	POCKET PEN. (kPa)	WELL DIAGRAM
	AU 1						0.05 TOPSOIL: Organic silt and clay. 1499.69 Low plastic, soft to medium stiff, dry, buff-grey; occasional fine to coarse grained sand, occasional gravel (1 cm), occasional rootlets.		
1	SPT 2		2-2-10 (12)				GRAVEL: Loose, dry, subrounded; sandy, some silt.		
2	SPT 3		9-21-23 (44)				1.98 1497.76		
3	AU 4						GRAVEL: Loose, damp, subrounded; silty, some fine to coarse grained sand.	▽	
	SPT 5		22-32-50 (82)				3.51 1496.23		
4							GRAVEL: Loose, wet, subrounded to subangular; sandy, common silt. Note the low N value within the gravel at ~ 5 m depth.		
5	SPT 6		3-3-2 (5)						
6							6.10 1493.64		
	SPT 7		10-12-20 (32)				SAND: Dense, wet, homogenous; very fine grained, silty, buff - grey; some coarse grained sand, trace gravel (1 cm); oxidation staining.		
7							6.86 1492.88		
							SANDSTONE (BEDROCK): Hard, fine grained, light grey.		
	SPT 8		50/0.08	>>			7.62 1492.12 Bottom of hole at 7.62 m.		

BETA - GEOTECH W WELL AND SPT BENGA LOGS.GPJ GINT STD US LAB.GDT 7/12/16

BOREHOLE GT16-09

RIVERSDALE RESOURCES

CLIENT Benga Mining Limited
PROJECT NAME Grassy Mountain Geotechnical Investigation - May 2016
PROJECT NUMBER 163585
PROJECT LOCATION Blairmore, AB

DATE STARTED 5/11/16 **COMPLETED** 5/11/16 **GROUND ELEVATION** 1504.35 m **HOLE SIZE** 8
DRILLING CONTRACTOR Val's Drilling
COORDINATES E 687344.87m N 5504670.28m
DRILLING METHOD Hollow Stem Auger
LOGGED BY OG **CHECKED BY** BK **GROUND WATER LEVELS:** ▽ **DURING DRILLING** 5.49 m / Elev 1498.86 m
NOTES SOUTH EAST SURGE POND **AFTER DRILLING** ---

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	SPT N VALUE / PL MC LL / ORGANIC CONTENT (%)	Facies Descriptor	GRAPHIC LOG	MATERIAL DESCRIPTION	POCKET PEN. (kPa)	WELL DIAGRAM
	AU 1						0.05 1504.30 TOPSOIL: Organic silt and clay. Low plastic, soft to medium stiff, dry, buff-grey; occasional fine to coarse grained sand, occasional gravel (1 cm), occasional rootlets.		
1	SPT 2		5-5-3 (8)				GRAVEL: Loose, dry to moist, subrounded to subangular; sandy, some silt, some rootlets.		
2	SPT		4-4-5 (9)						
3							3.05 1501.30		
4	SPT 3		9-10-11 (21)				SAND: Loose to dense, moist; fine to coarse grained, silty, buff - grey; some very fine grained sand lenses/laminae, some subangular to subrounded gravel (2 cm); some oxidation staining.		
5	SPT 4		29-25-17 (42)				4.57 1499.78 GRAVEL: Dense, moist to wet, subrounded; silty, grey - buff; some fine to coarse grained sand, some oxidation staining, angular sandstone clasts at bottom of interval.	▽	
6									
7	SPT 5		23-17-18 (35)						
8	SPT 6		16-26-32 (58)				8.08 1496.27		
9	AU 7						SAND: Dense, wet; fine to coarse grained, silty, buff - grey; some gravel (1 cm), trace clay, some sandstone angular clasts, some oxidation staining.		

(Continued Next Page)

BOREHOLE GT16-09

RIVERSDALE RESOURCES

CLIENT Benga Mining Limited

PROJECT NAME Grassy Mountain Geotechnical Investigation - May 2016

PROJECT NUMBER 163585

PROJECT LOCATION Blairmore, AB

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	▲ SPT N VALUE ▲ PL MC LL; ☐ ORGANIC CONTENT (%) 20 40 60 80	Facies Descriptor	GRAPHIC LOG	MATERIAL DESCRIPTION	POCKET PEN. (kPa)	WELL DIAGRAM
	SPT 8		31-42-50/0.08	>>▲			9.45 1494.90 SANDSTONE (BEDROCK): Hard, fine grained, light grey.		
10	SPT		50/0.08	>>▲			10.06 1494.29 Bottom of hole at 10.06 m.		

BETA - GEOTECH W WELL AND SPT BENGA LOGS.GPJ GINT STD US LAB.GDT 7/12/16

BOREHOLE GT16-10

RIVERSDALE RESOURCES

CLIENT Benga Mining Limited
PROJECT NAME Grassy Mountain Geotechnical Investigation - May 2016
PROJECT NUMBER 163585
PROJECT LOCATION Blairmore, AB

DATE STARTED 5/12/16 **COMPLETED** 5/12/16 **GROUND ELEVATION** 1574 m **HOLE SIZE** 8
DRILLING CONTRACTOR Val's Drilling
COORDINATES E 687615.85m N 5506197.18m
DRILLING METHOD Solid Stem Auger and Hollow Stem Auger
LOGGED BY OG **CHECKED BY** BK **GROUND WATER LEVELS:** **DURING DRILLING** Water table not encountered
NOTES EAST SEDIMENT POND. Switched to hollow stem at 3.05 m depth. **AFTER DRILLING** ---

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	SPT N VALUE / PL MC LL / ORGANIC CONTENT (%)	Facies Descriptor	GRAPHIC LOG	MATERIAL DESCRIPTION	POCKET PEN. (kPa)	WELL DIAGRAM
	AU 1						0.13 TOPSOIL: Organic silt and clay. 1573.87 Low plastic, soft , moist, brown - grey; some fine to coarse grained sand, some gravel (1 cm), common rootlets.		
1	SPT 2		4-16-21 (37)				SILT: Dry to moist, loose, low plastic; brown-buff to grey; some fine to coarse grained sand, some clay, some gravel (3 cm). 1.22 1572.78		
	AU 3						SILTY CLAY: Stiff, moist, medium plastic; buff-grey; occasional gravel (3 cm), some very fine to coarse grained sand lenses.		
2	SPT 4		8-10-14 (24)				1.98 1572.02		
	AU 5						GRAVEL: Dry, dense; grey - buff; silty, some fine to coarse grained sand, trace clay.		
3	SPT 6		16-22-24 (46)						
4	SPT 7		10-14-14 (28)				4.27 1569.73 Bottom of hole at 4.27 m.		

BETA - GEOTECH W WELL AND SPT BENGA LOGS.GPJ GINT STD US LAB.GDT 7/12/16

WELL GT16-11 / MW16-13-11

RIVERSDALE RESOURCES

CLIENT Benga Mining Limited
PROJECT NAME Grassy Mountain Geotechnical Investigation - May 2016
PROJECT NUMBER 163585
PROJECT LOCATION Blairmore, AB

DATE STARTED 5/12/16 **COMPLETED** 5/13/16 **GROUND ELEVATION** 1570.0 m **HOLE SIZE** 8
DRILLING CONTRACTOR Val's Drilling
COORDINATES E 687765.52m N 5506181.92m
DRILLING METHOD Solid Stem Auger and Hollow Stem Auger
LOGGED BY OG **CHECKED BY** BK **GROUND WATER LEVELS:** **DURING DRILLING** Water table not encountered
NOTES EAST SEDIMENT POND. Switched from solid to hollow stem at 3.05 m depth. **AFTER DRILLING** ---

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	SPT N VALUE / PL MC LL / ORGANIC CONTENT (%)	Facies Descriptor	GRAPHIC LOG	MATERIAL DESCRIPTION	POCKET PEN. (kPa)
0	AU 1						0.00 / 1570.00 0.02 / 1569.98 TOPSOIL: Organic silt and clay. Low plastic, medium stiff to stiff, dry to moist, grey - brown; occasional fine to coarse grained sand; occasional rootlets.	
1	SPT 2		30-40-6 (46)				SILTY CLAY: Low to medium plastic, soft to medium stiff, moist to wet, grey - buff; some gravel (4 cm) and subangular rock fragments; occasional fine to coarse grained sand laminae/lenses.	
	AU 3						1.52 / 1568.48 CLAYEY GRAVEL: Very dense/hard, moist, grey-buff; some fine to coarse grained sand;	
2	SPT 4		9-9-27 (36)				1.98 / 1568.02 occasional very fine grained sand and silt.	
	AU 5						SILTY GRAVEL: Loose to dense, dry to moist, grey; some fine to coarse grained sand; some angular rock clasts; occasional clay lumps.	
3								
	SPT 6		8-24-30 (54)					
4								
	SPT 7		12-30-50/0.06	>>				
5								
6								
	SPT 8		19-19-14 (33)					
7								
	SPT		50					

WELL DIAGRAM: Top cap; Solid pipe: sch. 40 PVC; Pipe protector; Backfill; Solid pipe: sch. 40 PVC; Bentonite fill; 7.01 mbgs; 15.82 mbgs

BETA - GEOTECH W WELL AND SPT BENGA LOGS.GPJ GINT STD US LAB.GDT 7/12/16

(Continued Next Page)

WELL GT16-11 / MW16-13-11

RIVERSDALE RESOURCES

CLIENT Benga Mining Limited

PROJECT NAME Grassy Mountain Geotechnical Investigation - May 2016

PROJECT NUMBER 163585

PROJECT LOCATION Blairmore, AB

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	▲ SPT N VALUE ▲ PL MC LL; ☐ ORGANIC CONTENT (%) 20 40 60 80	Facies Descriptor	GRAPHIC LOG	MATERIAL DESCRIPTION	POCKET PEN. (kPa)	WELL DIAGRAM
8	9						SILTY GRAVEL: Loose to dense, dry to moist, grey; some fine to coarse grained sand; some angular rock clasts; occasional clay lumps. *(continued)*		4/10 Target Filter Sand; Slotted pipe: sch. 40 PVC, 010 slot size
9	SPT 10		50/0.02	>>▲			9.14 1560.86 SANDSTONE (BEDROCK): Hard, grey.		
10	SPT 11		50/0.05	>>▲			10.67 1559.33 Bottom of hole at 10.67 m.		10.31 mbgs Bottom cap; 10.67 mbgs

BETA - GEOTECH W WELL AND SPT BENGA LOGS.GPJ GINT STD US LAB.GDT 7/12/16

BOREHOLE GT16-12

RIVERSDALE RESOURCES

CLIENT Benga Mining Limited
PROJECT NAME Grassy Mountain Geotechnical Investigation - May 2016
PROJECT NUMBER 163585
PROJECT LOCATION Blairmore, AB

DATE STARTED 5/12/16 **COMPLETED** 5/12/16 **GROUND ELEVATION** 1574.65 m **HOLE SIZE** 6
DRILLING CONTRACTOR Val's Drilling
COORDINATES E 687732.6m N 5506379.47m
DRILLING METHOD Solid Stem Auger
LOGGED BY OG **CHECKED BY** BK **GROUND WATER LEVELS:** **DURING DRILLING** Water table not encountered
NOTES EAST SEDIMENT POND **AFTER DRILLING** ---

DEPTH (m)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	SPT N VALUE / PL MC LL / ORGANIC CONTENT (%)	Facies Descriptor	GRAPHIC LOG	MATERIAL DESCRIPTION	POCKET PEN. (kPa)	WELL DIAGRAM
	AU 1						0.08 TOPSOIL: Organic silt and clay. 1574.57 Low plastic, soft , moist, brown; trace fine to coarse grained sand, trace gravel (1 cm), common rootlets.		
1	SPT		2-3-3 (6)				SAND: Loose, dry, homogenous; very fine grained, silty, buff - grey; some coarse grained sand, trace gravel (1 cm). 1.22 1573.43		
2	SPT 2		3-2-2 (4)				SILT: Moist to wet, medium stiff, low to medium plastic; some fine to coarse grained sand, trace clay, trace gravel (2 cm), abundant sandstone angular clasts at bottom of interval.		
3	AU 3								
	SPT 4		18-50/0.03	>>			3.35 1571.30 SANDSTONE (BEDROCK): Hard, fine grained, light grey.		
4							4.57 1570.08 Bottom of hole at 4.57 m.		

BETA - GEOTECH W WELL AND SPT BENGA LOGS.GPJ GINT STD US LAB.GDT 7/12/16

APPENDIX D

Laboratory Test Results

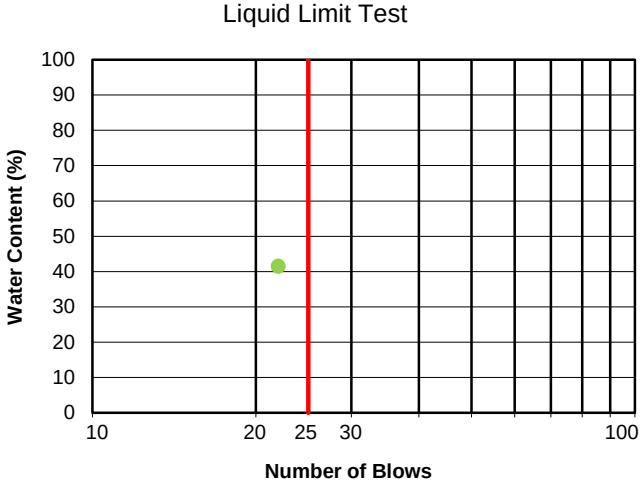
Atterberg Limits ..... Sample GT16-01
Particle Size Analysis of Soil ..... Sample GT16-01
Triaxial Compression Test - Consolidated Undrained Summary ..... 1 of 1
Triaxial Compression Test - Consolidated Undrained Summary ..... 2 of 2
Triaxial Compression Test - Consolidated Undrained Photographs
Particle Size Analysis of Soil ..... Sample GT16-11
Atterberg Limits ..... Sample GT16-11
Particle Size Analysis of Soil ..... Sample GT16-11
Particle Size Analysis of Soil ..... Sample GT16-09
Particle Size Analysis of Soil ..... Sample GT16-08
Particle Size Analysis of Soil ..... Sample GT16-07
Direct Shear Test ..... Borehole GT16-016
Atterberg Limits ..... Sample GT16-01
General Lab Testing Summary

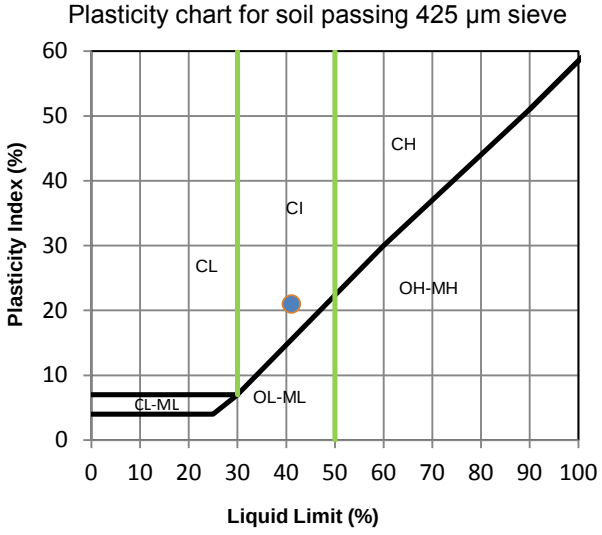
Atterberg Limits (ASTM D 4318)

Project No.:	1412422	Phase:	5000
Short Title:	Terracon/ Lab Testing/ CGY - May 2016	Lab No.:	B831-08
Tested By:	DS	Date:	18-May-16

Borehole: - Sample No.: GT16-01 Depth: 7.5-8.0 ft

Liquid Limit Determination:			Natural Water Content:		
Number of Blows	22	22	As Received Water Content (%)		33.0%
Blow Correction Factor	0.99	0.99	**Plastic Limit Determination:**		
Mass of wet sample + tare (g)	34.88	37.69	Mass of wet sample + tare (g)	25.50	21.69
Mass of dry sample + tare (g)	31.45	34.49	Mass of dry sample + tare (g)	23.76	19.85
Mass of tare (g)	23.18	26.80	Mass of tare (g)	15.24	10.81
Weight of Water (g)	3.43	3.2	Weight of Water (g)	1.74	1.84
Weight of dry soil (g)	8.27	7.69	Weight of dry soil (g)	8.52	9.04
Water Content (%)	41.5	41.6	Water Content (%)	20.42	20.35
Liquid Limit	41.0	41.0	Average Water Content (%)		20.39





Liquid Limit =	41	%
Plastic Limit =	20	%
Plasticity Index =	21	

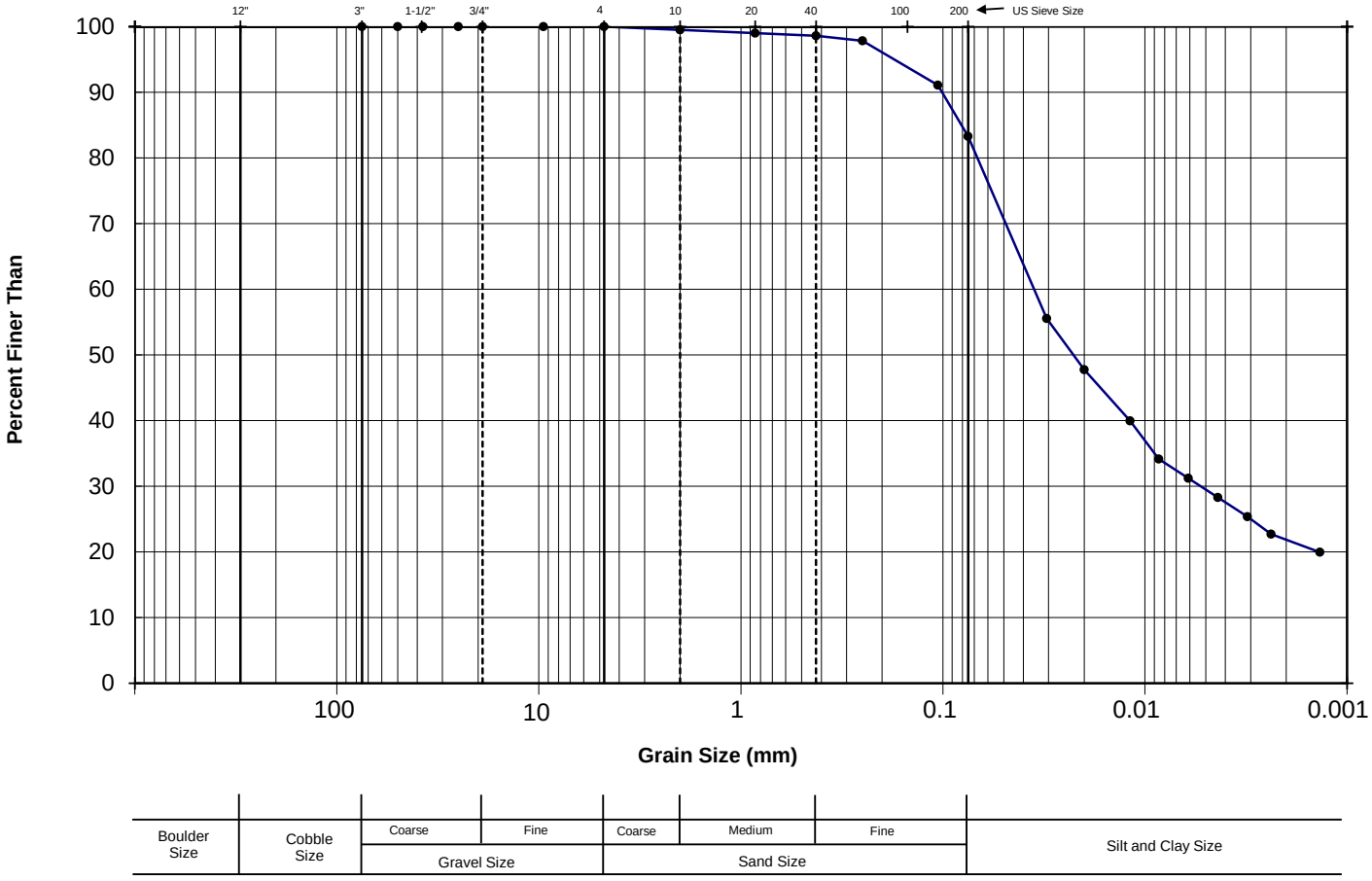
Comments:

Reviewed:

Project No.:	1412422.5000	Lab No.:	B831-08
Project Title:	Terracon/ Lab Testing/ CGY - May 2016		
Borehole:	-	Sample No.:	GT16-01
Depth:	7.5-8.0 ft		
Date Tested:	25-May-16	By:	DS

Particle Size Analysis of Soil

(ASTM D422)



Diameter of Sieve (mm)	Percent Passing (%)
75.0	100.0
50.0	100.0
37.5	100.0
25.0	100.0
19.0	100.0
9.5	100.0
4.75	100.0
2.0	99.5
0.850	99.0
0.425	98.6
0.250	97.8
0.106	91.1
0.075	83.3
0.031	55.6
0.020	47.8
0.012	40.0
0.009	34.1
0.006	31.2
0.004	28.3
0.003	25.4
0.002	22.7
0.001	19.9

Comments:

Reviewed:

TRIAXIAL COMPRESSION TEST-CONSOLIDATED UNDRAINED SUMMARY

(ASTM D4767-04)

Project Identification

Project #	1412422	Phase:	-
Project Title:	Terracon/Lab Testing/Calgary		
Tested By:	DJH	Date:	8-Jun-16

Initial Sample Parameters

Lab Number	B831-08a	B831-08a	B831-08a
Location ID	6T16-01	6T16-01	6T16-01
Sample Number	-	-	-
Depth (ft)	7.5-8	7.5-8	7.5-8
Sample Type	Undisturbed	Undisturbed	Undisturbed
Initial Diameter (cm)	7.24	7.24	7.24
Initial Height (cm)	14.17	14.17	14.17
Initial Mass (g)	916.24	916.24	916.24
Initial Moisture Content (%)	28.77	-	-
Initial Void Ratio	1.17	-	-
Wet Density (kg/m3)	1570	-	-
Dry Density (kg/m3)	1219	-	-
Sample Description	(Cl) sandy SILTY CLAY, medium plasticity; brown; cohesive; w>PL, firm.		

Test Parameters

Cell Pressure (kPa)	640	780	930
Pore Pressure (kPa)	300	300	300
Effective Stress (kPa)	340	480	630
"B" Parameter	98	98	98
Consolidation Volume Change (%)	16.87	18.68	20.10
Consolidated Diameter (cm)	6.83	6.80	6.79
Consolidated Height (cm)	13.23	13.07	12.88
Final Moisture Content (%)	-	-	25.55
Final Void Ratio	-	-	0.677

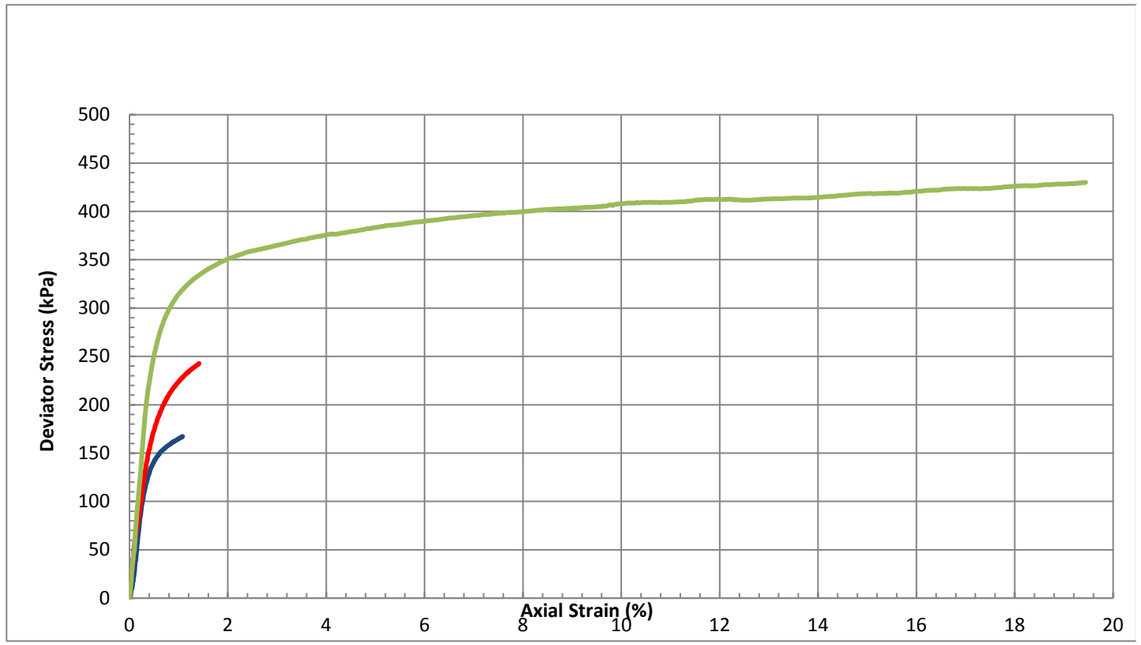
Comments/Observations

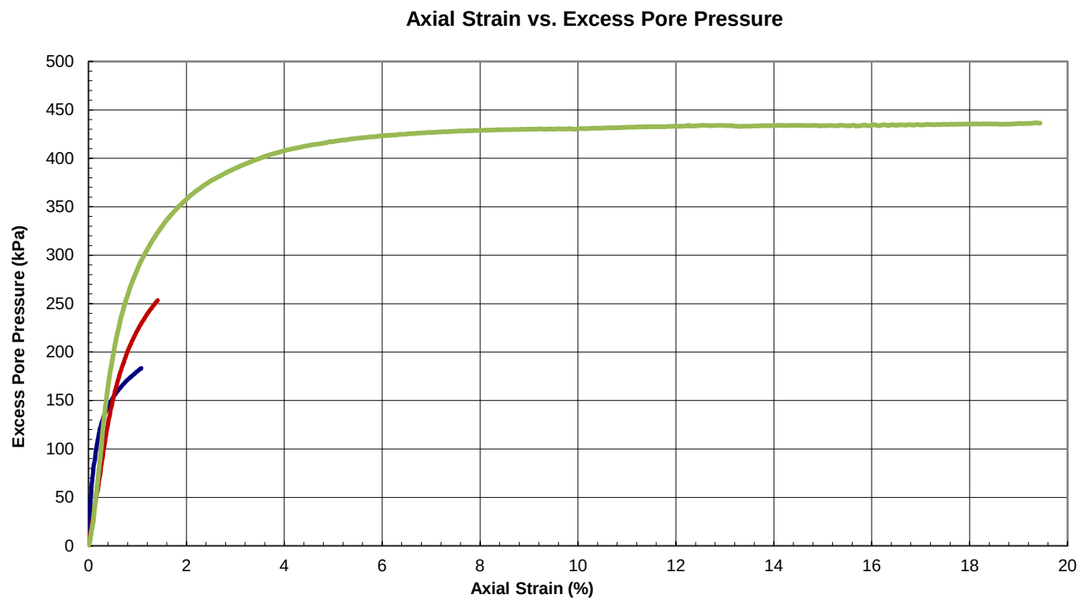
The testing services reported herein have been performed in accordance with the indicated recognized standard, or in accordance with local industry practice. This report is for the sole use of the designated client. This report constitutes a testing service only and does not represent any results interpretation or opinion regarding specification compliance or material suitability. Engineering interpretation can be provided by Golder Associates Ltd. upon request.

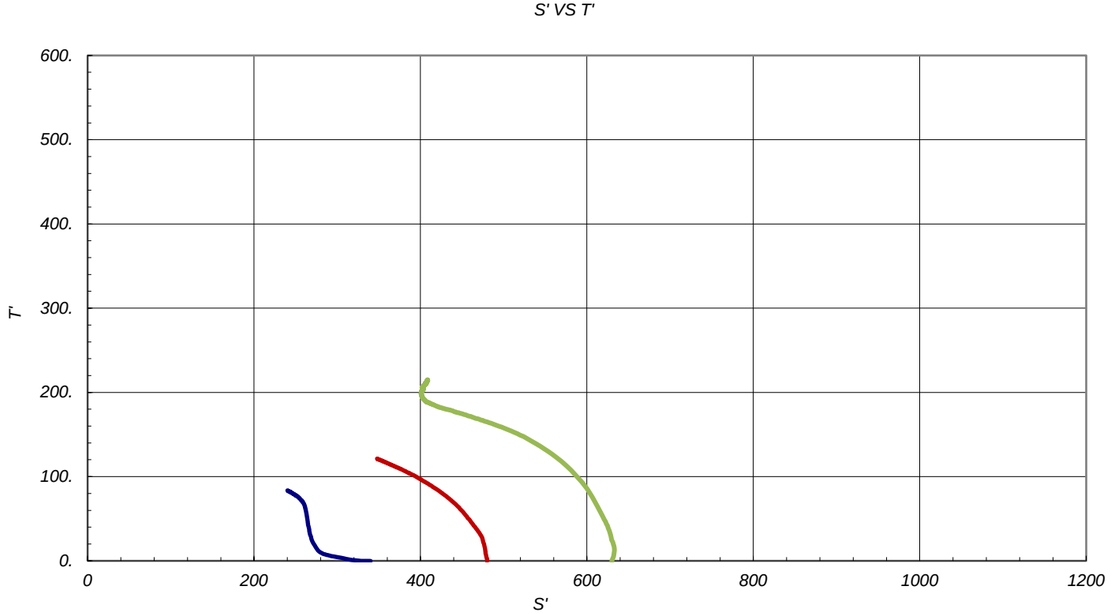
Bay 7, 820 - 28th Street NE
Calgary, AB

Reviewed: _____

TRIAXIAL COMPRESSION TEST-CONSOLIDATED UNDRAINED SUMMARY
(ASTM D4767-04)







Project Number	1412422		
Short Title	Terracon/Lab Testing/Calgary		
Location ID	6T16-01	6T16-01	6T16-01
Sample Number	-	-	-
Depth (ft)	7.5-8	7.5-8	7.5-8
Graph Line Style			
Effective Stress (kPa)	340	480	630
B Pressure Parameter	98	98	98
intitial Moisture Content (%)	28.77	-	-
Initial Void Ratio	1.17	-	-
Intial Wet Density (kg/m^3)	1570	-	-
Intial Dry Density (kg/m^3)	1219	-	
Final Moisture Content (%)	-	-	25.55
Final Void Ratio	-	-	0.68

The testing services reported herein have been performed in accordance with the indicated recognized standard, or in accordance with local industry practice. This report is for the sole use of the designated client. This report constitutes a testing service only and does not represent any results interpretation or opinion regarding specification compliance or material suitability. Engineering interpretation can be provided by Golder Associates Ltd. upon request.

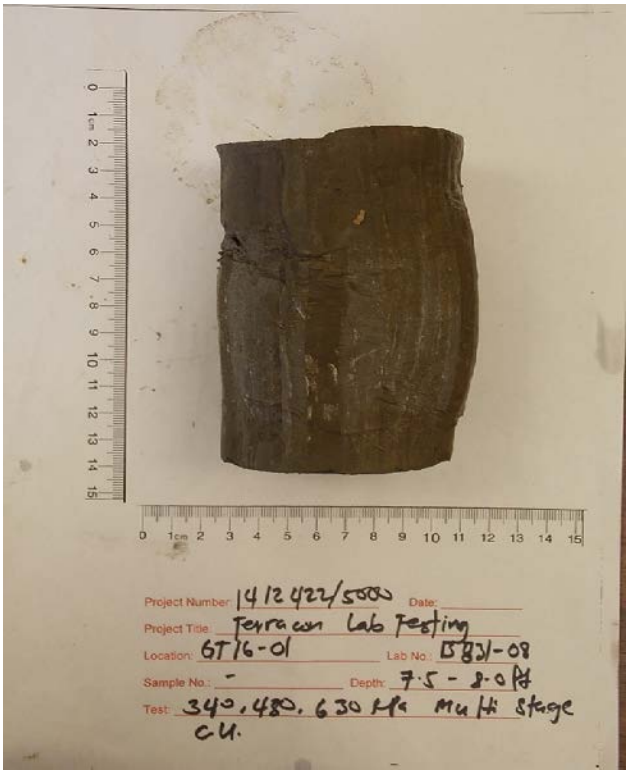
TRIAXIAL COMPRESSION TEST-CONSOLIDATED UNDRAINED PHOTOGRAPHS

(ASTM D4767-04)

Project Identification

Project #	1412422	Phase: -
Project Title:	Terracon/Lab Testing/Calgary	
Tested By:	FC	Date: 8-Jun-16

	Pretest	Posttest
Lab Number:	B831-08a	
Location ID.:	6T16-01	
Sample No.:	-	
Depth (ft):	7.5-8	
Effective Stress:	340, 480, 630 kPa	

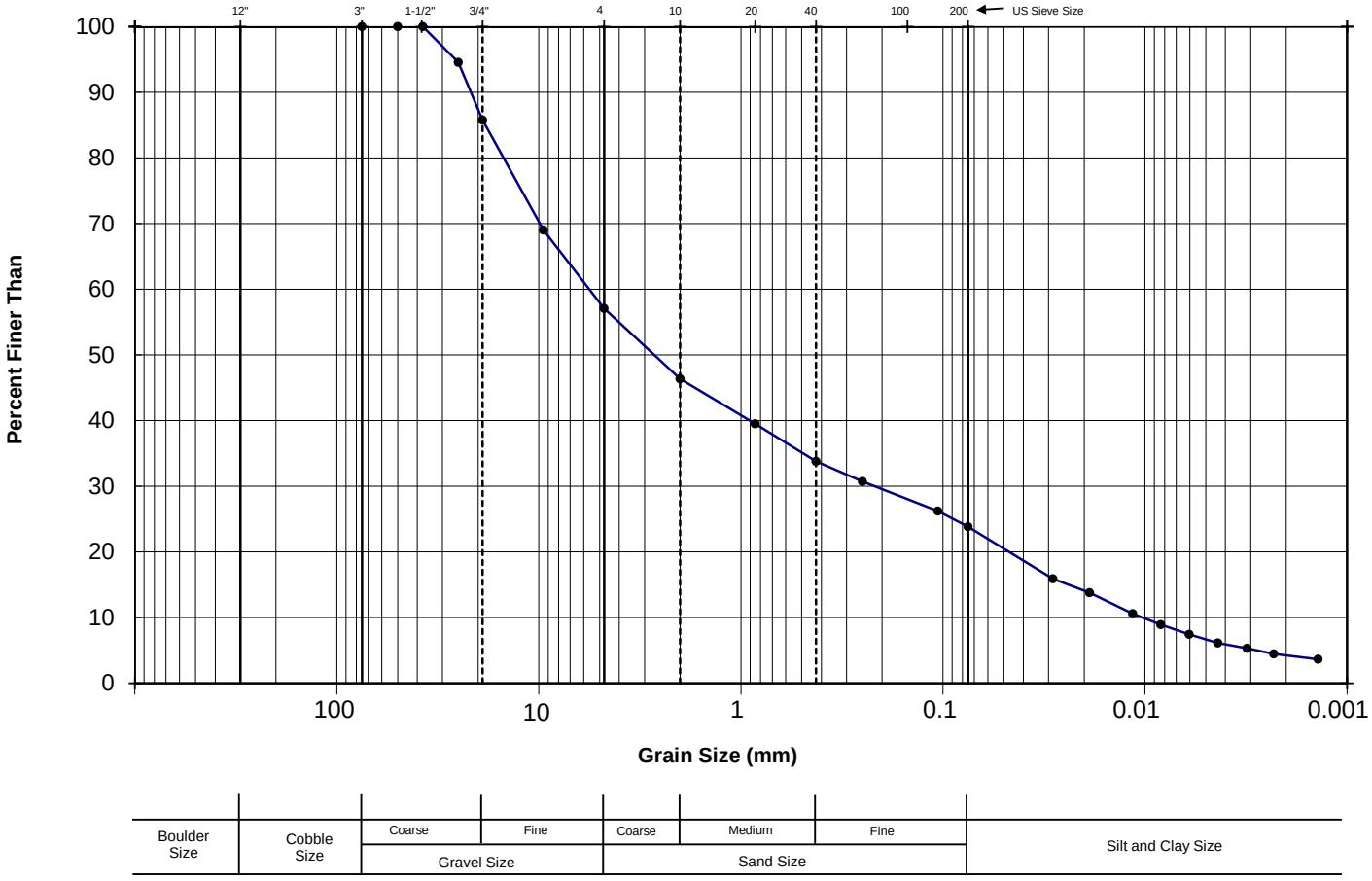


The testing services reported herein have been performed in accordance with the indicated recognized standard, or in accordance with local industry practice. This report is for the sole use of the designated client. This report constitutes a testing service only and does not represent any results interpretation or opinion regarding specification compliance or material suitability. Engineering interpretation can be provided by Golder Associates Ltd. upon request.

Project No.:	1412422.5000	Lab No.:	B831-07
Project Title:	Terracon/ Lab Testing/ CGY - May 2016		
Borehole:	-	Sample No.:	GT16-11
Depth:	6.5-10.0 ft		
Date Tested:	18-May-16	By:	DS

Particle Size Analysis of Soil

(ASTM D422)



Diameter of Sieve (mm)	Percent Passing (%)
75.0	100.0
50.0	100.0
37.5	100.0
25.0	94.5
19.0	85.8
9.5	69.0
4.75	57.1
2.0	46.3
0.850	39.5
0.425	33.8
0.250	30.7
0.106	26.2
0.075	23.8
0.029	15.9
0.019	13.8
0.011	10.6
0.008	8.9
0.006	7.4
0.004	6.2
0.003	5.3
0.002	4.5
0.001	3.6

Comments:

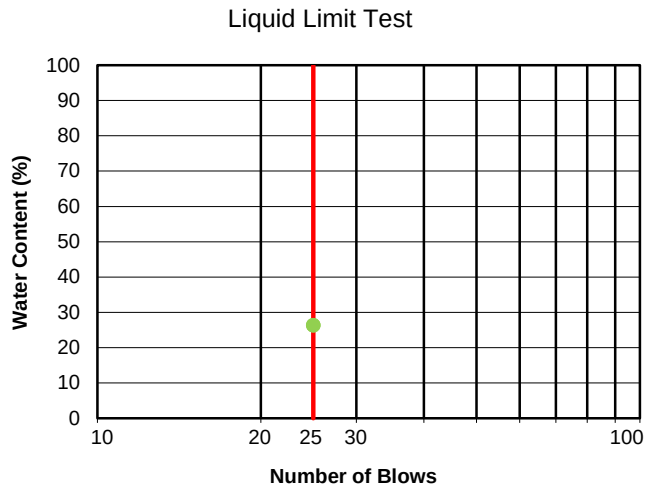
Reviewed:

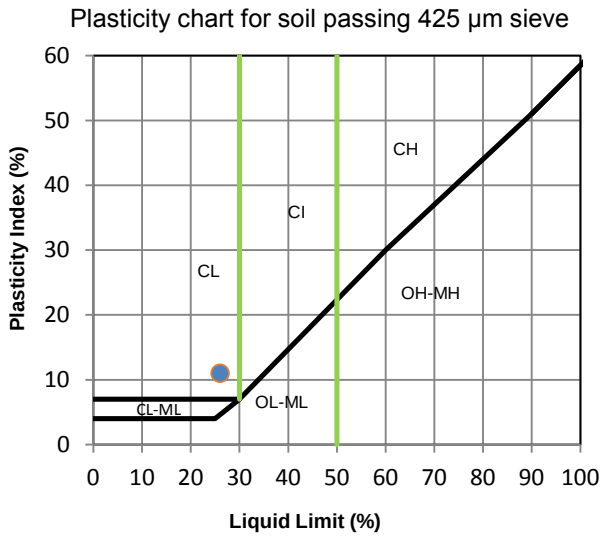
Atterberg Limits (ASTM D 4318)

Project No.:	1412422	Phase:	5000
Short Title:	Terracon/ Lab Testing/ CGY - May 2016	Lab No.:	B831-06
Tested By:	DS	Date:	18-May-16

Borehole: - Sample No.: GT16-11 Depth: 4.0-5.0 ft

Liquid Limit Determination:			Natural Water Content:		
Number of Blows	25	25	As Received Water Content (%)		10.4%
Blow Correction Factor	1.00	1.00	**Plastic Limit Determination:**		
Mass of wet sample + tare (g)	30.55	36.27	Mass of wet sample + tare (g)	19.13	20.95
Mass of dry sample + tare (g)	28.22	33.82	Mass of dry sample + tare (g)	17.89	19.60
Mass of tare (g)	19.38	24.54	Mass of tare (g)	9.81	10.66
Weight of Water (g)	2.33	2.45	Weight of Water (g)	1.24	1.35
Weight of dry soil (g)	8.84	9.28	Weight of dry soil (g)	8.08	8.94
Water Content (%)	26.4	26.4	Water Content (%)	15.35	15.10
Liquid Limit	26.0	26.0	Average Water Content (%)		15.22





Liquid Limit =	26	%
Plastic Limit =	15	%
Plasticity Index =	11	

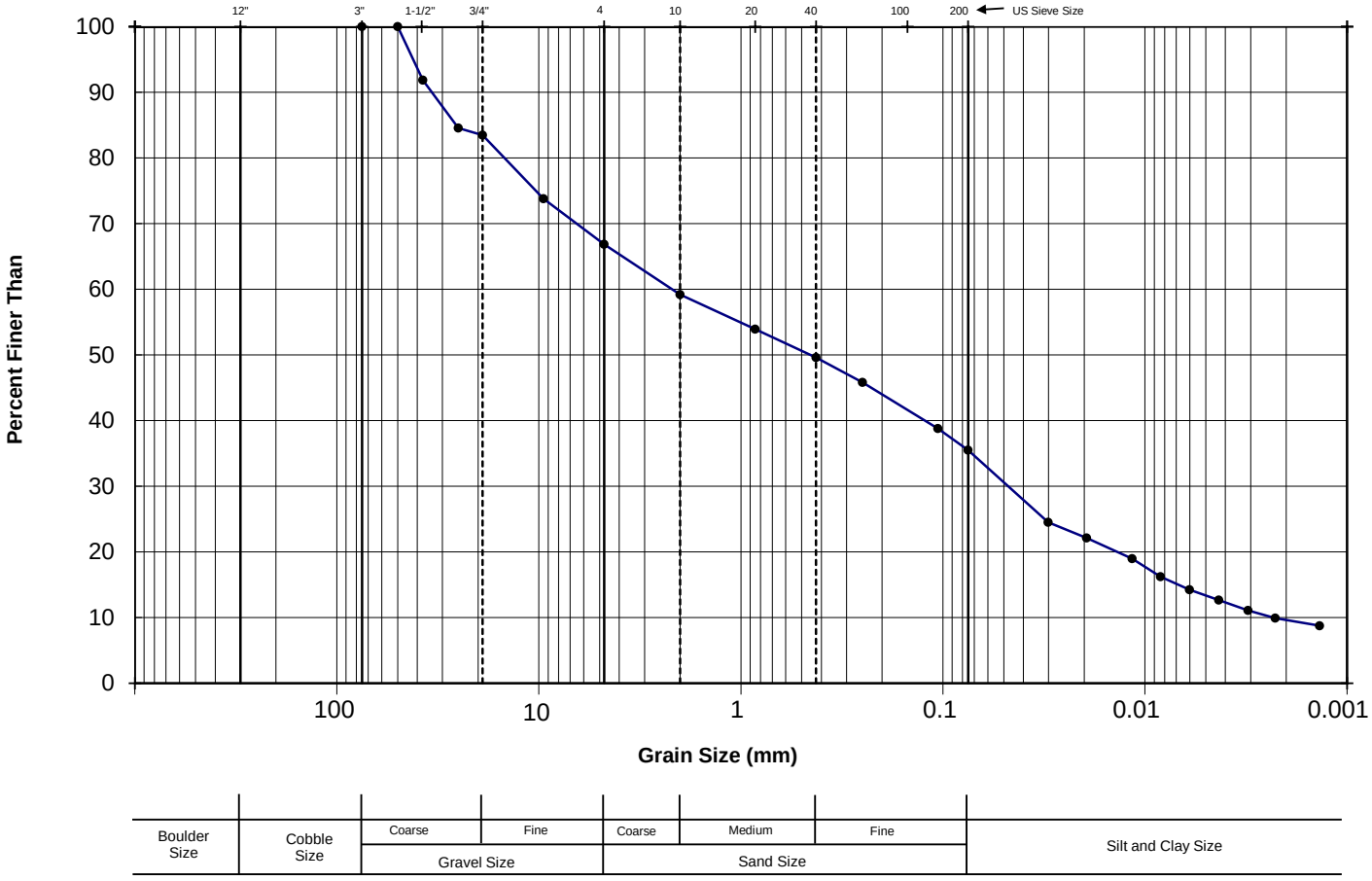
Comments:

Reviewed:

Project No.:	1412422.5000	Lab No.:	B831-06
Project Title:	Terracon/ Lab Testing/ CGY - May 2016		
Borehole:	-	Sample No.:	GT16-11
Depth:	4.0-5.0 ft		
Date Tested:	18-May-16	By:	DS

Particle Size Analysis of Soil

(ASTM D422)



Diameter of Sieve (mm)	Percent Passing (%)
75.0	100.0
50.0	100.0
37.5	91.8
25.0	84.5
19.0	83.5
9.5	73.8
4.75	66.9
2.0	59.2
0.850	53.9
0.425	49.6
0.250	45.8
0.106	38.8
0.075	35.5
0.030	24.5
0.019	22.1
0.012	19.0
0.008	16.2
0.006	14.2
0.004	12.7
0.003	11.1
0.002	9.9
0.001	8.8

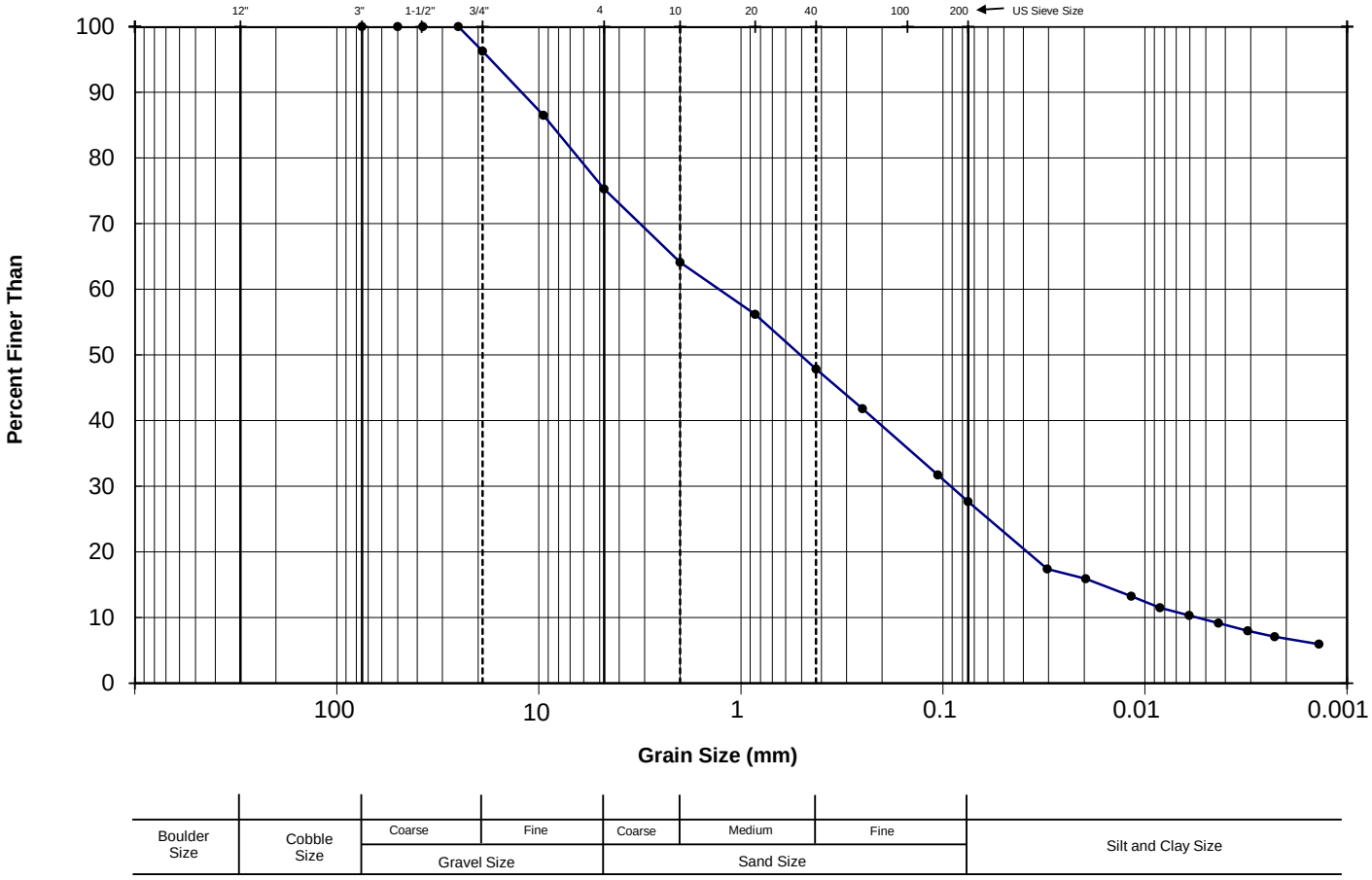
Comments:

Reviewed:

Project No.:	1412422.5000	Lab No.:	B831-05
Project Title:	Terracon/ Lab Testing/ CGY - May 2016		
Borehole:	-	Sample No.:	GT16-09
Depth:	10.0-11.5 ft		
Date Tested:	18-May-16	By:	DS

Particle Size Analysis of Soil

(ASTM D422)



Diameter of Sieve (mm)	Percent Passing (%)
75.0	100.0
50.0	100.0
37.5	100.0
25.0	100.0
19.0	96.3
9.5	86.5
4.75	75.3
2.0	64.1
0.850	56.2
0.425	47.9
0.250	41.8
0.106	31.7
0.075	27.6
0.030	17.4
0.020	15.9
0.012	13.3
0.008	11.5
0.006	10.3
0.004	9.1
0.003	8.0
0.002	7.1
0.001	5.9

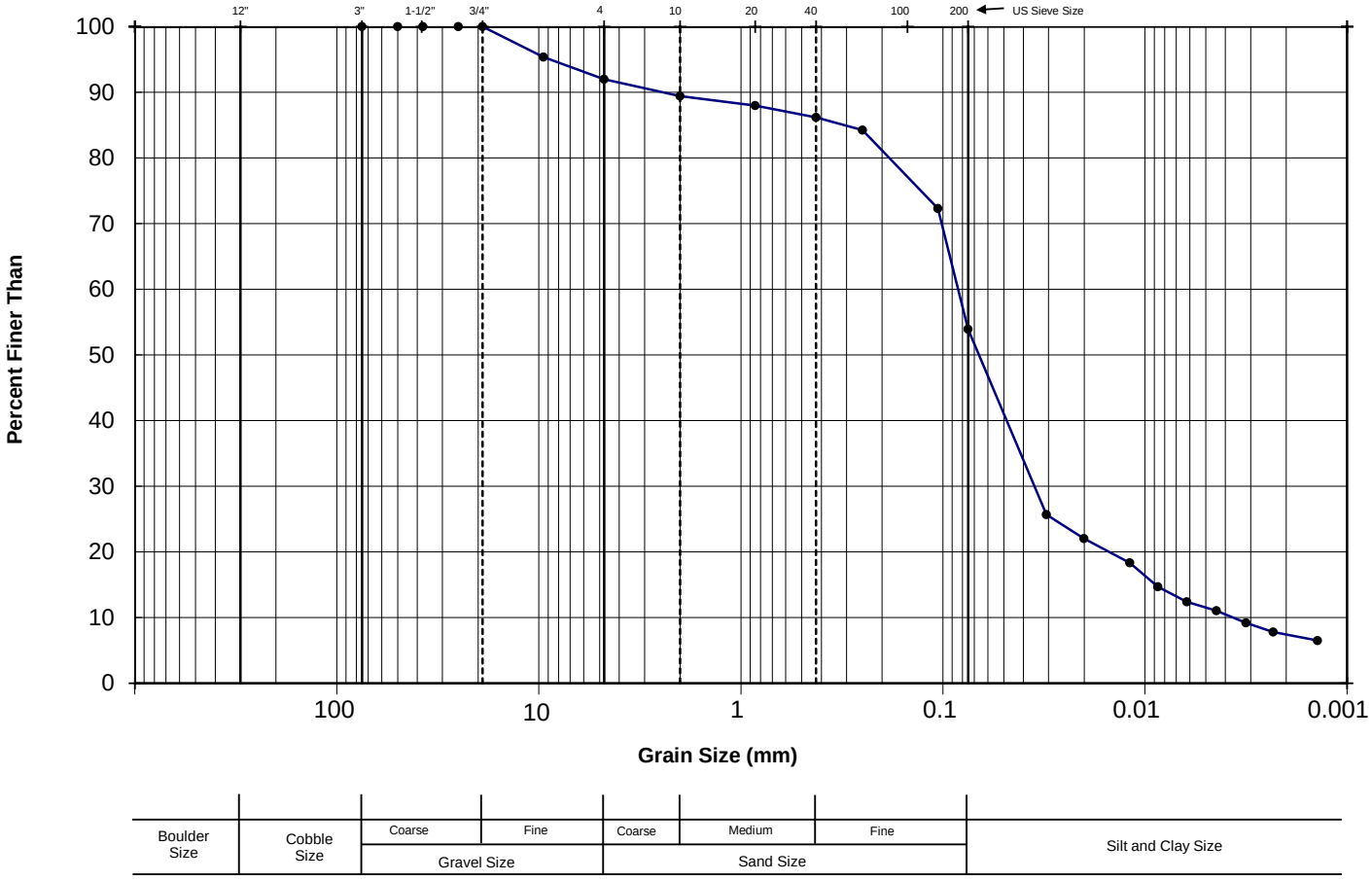
Comments:

Reviewed:

Project No.:	1412422.5000	Lab No.:	B831-04
Project Title:	Terracon/ Lab Testing/ CGY - May 2016		
Borehole:	-	Sample No.:	GT16-08
Depth:	20.0-21.5 ft		
Date Tested:	18-May-16	By:	DS

Particle Size Analysis of Soil

(ASTM D422)



Diameter of Sieve (mm)	Percent Passing (%)
75.0	100.0
50.0	100.0
37.5	100.0
25.0	100.0
19.0	100.0
9.5	95.4
4.75	92.0
2.0	89.4
0.850	88.0
0.425	86.2
0.250	84.2
0.106	72.3
0.075	53.9
0.031	25.7
0.020	22.0
0.012	18.4
0.009	14.7
0.006	12.4
0.004	11.0
0.003	9.2
0.002	7.8
0.001	6.5

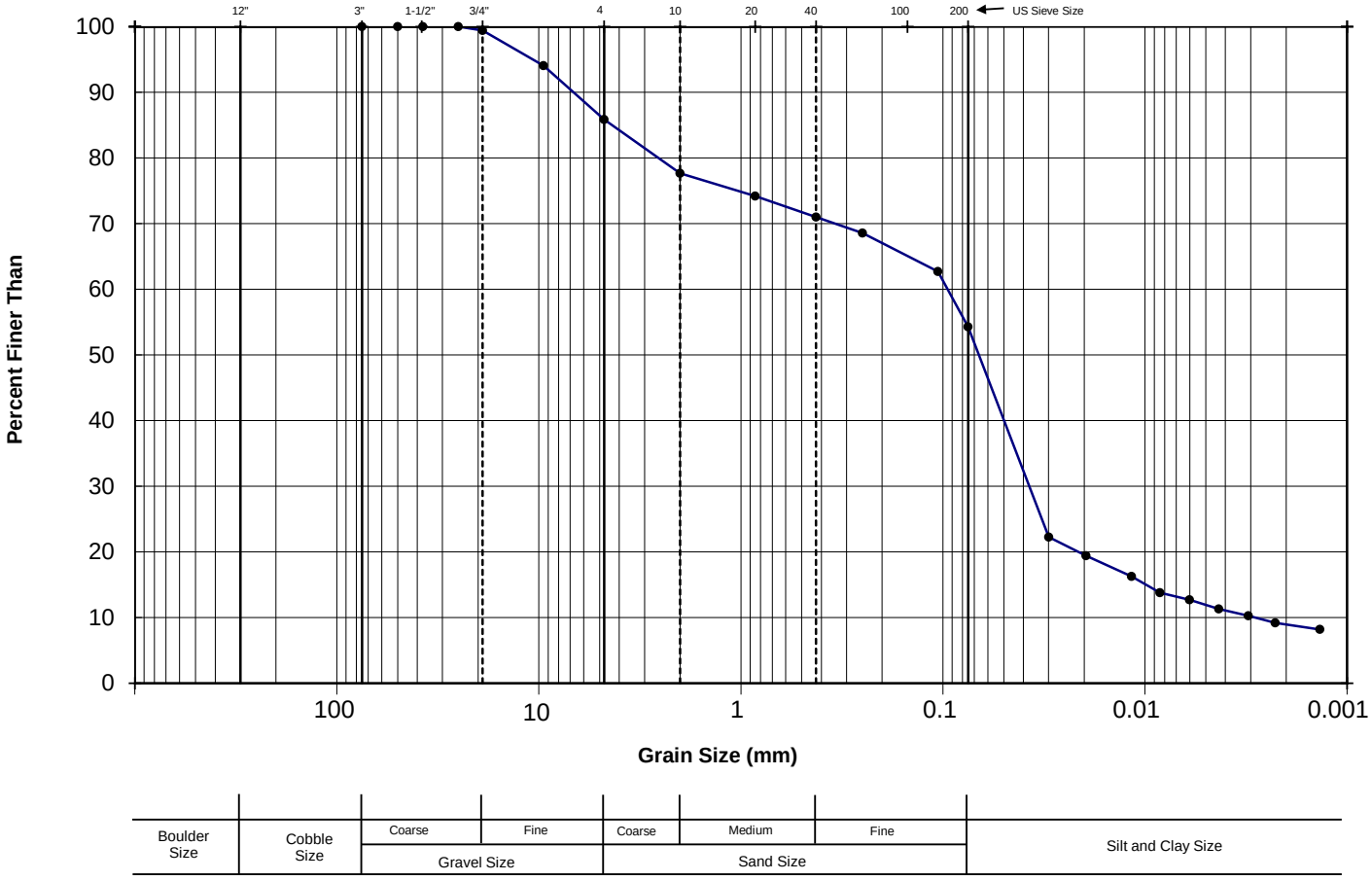
Comments:

Reviewed:

Project No.:	1412422.5000	Lab No.:	B831-03
Project Title:	Terracon/ Lab Testing/ CGY - May 2016		
Borehole:	-	Sample No.:	GT16-07
Depth:	4.0-5.0 ft		
Date Tested:	18-May-16	By:	DS

Particle Size Analysis of Soil

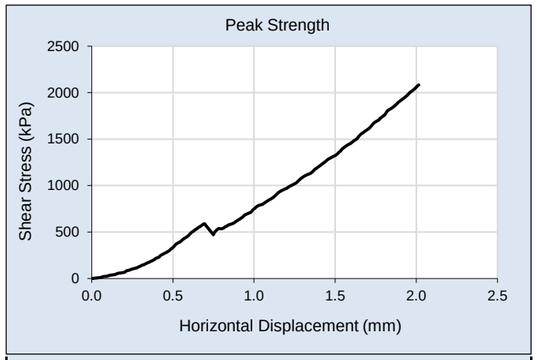
(ASTM D422)



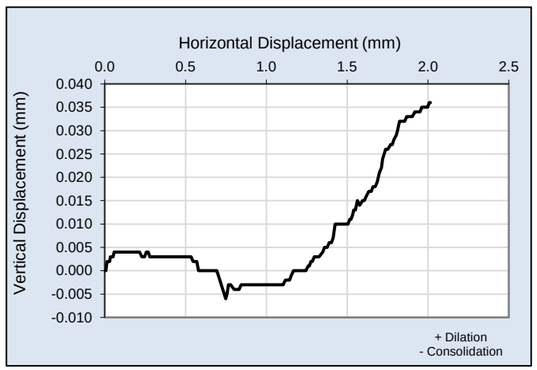
Diameter of Sieve (mm)	Percent Passing (%)
75.0	100.0
50.0	100.0
37.5	100.0
25.0	100.0
19.0	99.4
9.5	94.1
4.75	85.8
2.0	77.6
0.850	74.2
0.425	71.0
0.250	68.5
0.106	62.7
0.075	54.3
0.030	22.3
0.020	19.4
0.012	16.3
0.008	13.8
0.006	12.7
0.004	11.3
0.003	10.3
0.002	9.2
0.001	8.2

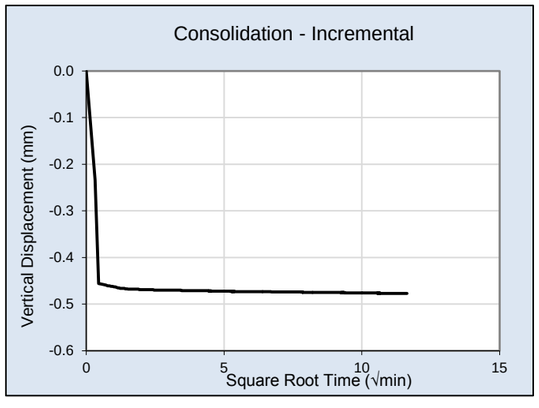
Comments:

Reviewed:



Normal Load σ', kPa	**2150**	Shear Rate, mm/min	0.0727





Consolidation Test Results

T90	2.89	min
T50	0.68	min
Shear Rate	0.1185	mm/min
Delta H	-0.48	mm

Sample Identification

Project No.	1412422	Borehole	GT16-06
Client	Terracon Geotechnique Lt	Sample	-
Project	Terracon/Lab Testing/CGY		
Location	-	Depth	2.5-7.5 ft

Initial - Sample Dimensions

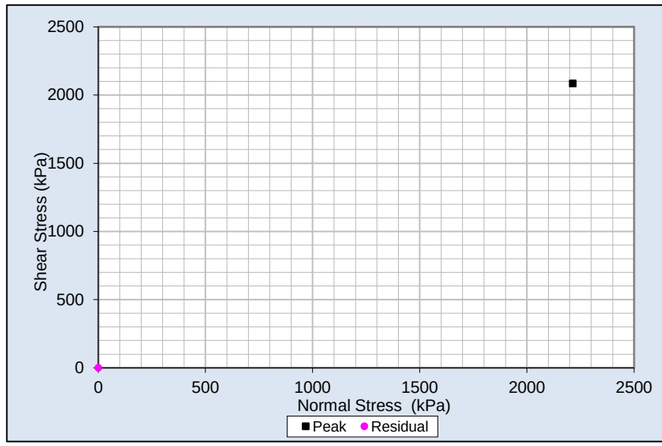
Trial Number	1
Shear Box Geometry	Circle
Diameter, mm	61.10
Depth, mm	26.49
Area, cm^2	29.32
Volume, cm^3	77.66

Weight Volume Relationships

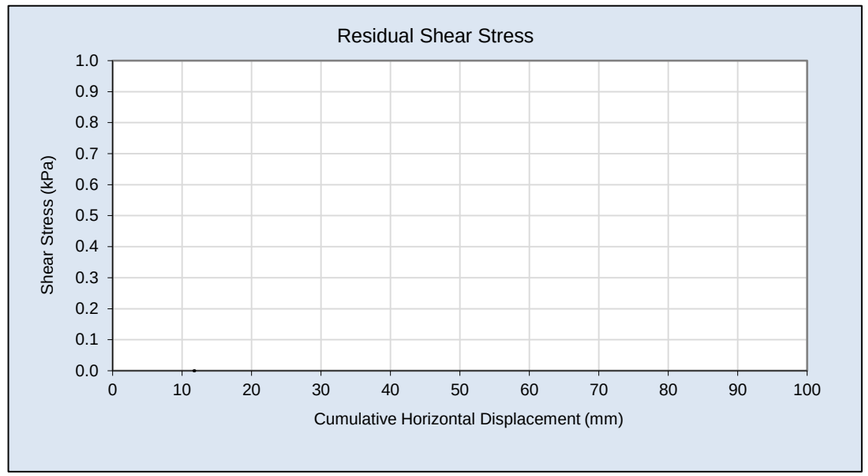
Test No.		**B831-02**	
Sample Type		Undisturbed	
Initial Wet Wt, g		202.46	
Initial Dry Wt, g		202.46	
Initial Water Content, %		0.00	(assumed)
Final Water Content, %		0.00	(assumed)
Initial γ_{dry}, kg/m^3		2607	
Final γ_{dry}, kg/m^3	(after consolidation)	-	
Specific Gravity	(assumed)	3.00	
Initial Void Ratio, e		0.151	

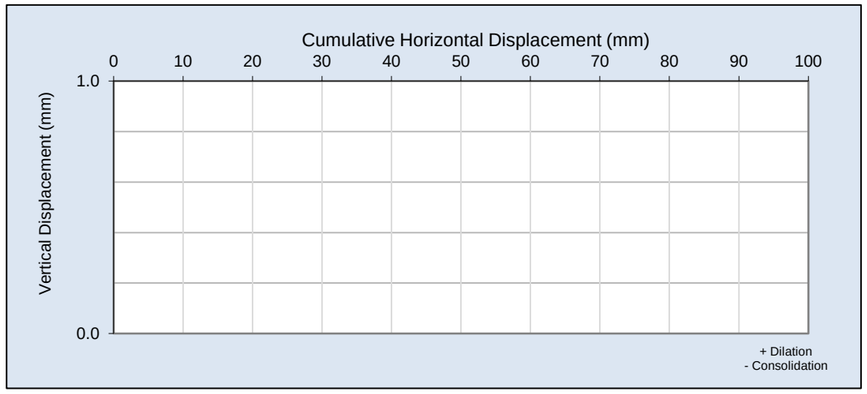
Test Results (Area Corrected)

Displacement at Failure, mm	2.015
Normal Stress Reached, kPa	2214
Shear Stress Reached, kPa	2084
Displacement at Residual, mm	n/a
Residual Normal Stress, kPa	n/a
Residual Shear Stress, kPa	n/a
Shear rate for Residual Stress, mm/min	n/a



Comments:
We were unable to reach Peak of this material as it exceeded the machine maximum shear load capacity.
Sample description: Rock core - Limestone





Index Test Results

Water Content (%)	-
Liquid Limit (%)	-
Plastic Limit (%)	-
Plasticity Index	-

Equipment - DS-KWSOIL s/n: 547

Axial LPT Serial #	4024-ch3
Normal Load Cell Serial #	4024-ch4
Shear Load Cell Serial #	4024-ch1
Vertical LPT Serial #	4024-ch2

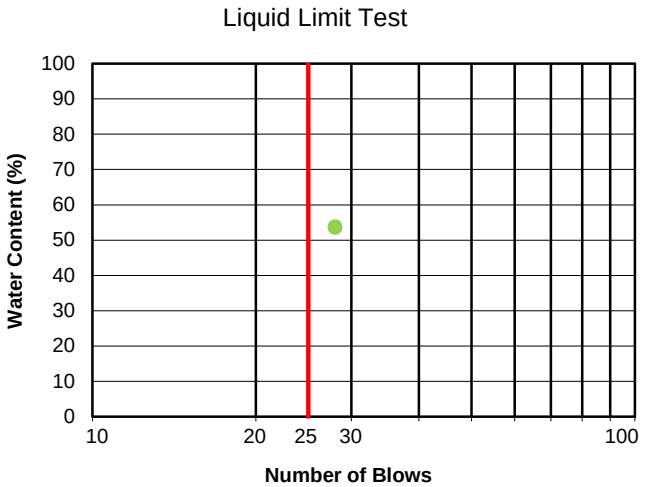
Client: Terracon Geotechnique Ltd.	Terracon/Lab Testing/CGY
Golder Associates	DIRECT SHEAR TEST Borehole GT16-06 Sample -
PROJECT: 1412422.5000	Check: FC Review:

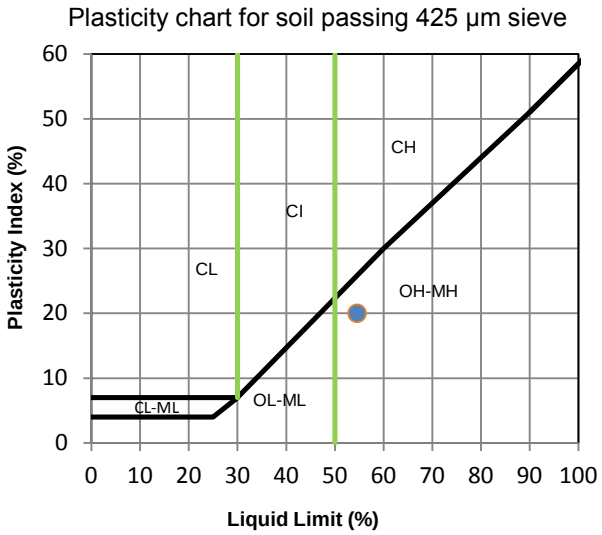
Atterberg Limits (ASTM D 4318)

Project No.:	1412422	Phase:	5000
Short Title:	Terracon/ Lab Testing/ CGY - May 2016	Lab No.:	B831-01
Tested By:	DS	Date:	18-May-16

Borehole: - Sample No.: GT16-01 Depth: 4.0-5.0 ft

Liquid Limit Determination:			Natural Water Content:		
Number of Blows	28	28	As Received Water Content (%)		33.0%
Blow Correction Factor	1.01	1.01	**Plastic Limit Determination:**		
Mass of wet sample + tare (g)	35.97	40.82	Mass of wet sample + tare (g)	21.17	19.89
Mass of dry sample + tare (g)	31.88	36.45	Mass of dry sample + tare (g)	18.52	17.57
Mass of tare (g)	24.28	28.29	Mass of tare (g)	11.06	10.84
Weight of Water (g)	4.09	4.37	Weight of Water (g)	2.65	2.32
Weight of dry soil (g)	7.6	8.16	Weight of dry soil (g)	7.46	6.73
Water Content (%)	53.8	53.6	Water Content (%)	35.52	34.47
Liquid Limit	55.0	54.0	Average Water Content (%)		35.00





Liquid Limit =	55	%
Plastic Limit =	35	%
Plasticity Index =	20	

Comments:

Reviewed:

General Lab Testing Summary

Project No.:	1412422	Phase:	5000
Short Title:	Terracon/ Lab Testing/ CGY - May 2016	Lab No.:	B831
Tested By:	DS	Date:	04-May-16

Sample Identification				Laboratory Test Results					
Sample No.	Depth (ft)		Lab No.	Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	SPMDD (kg/m^3)	Optimum w (%)
	from	to							
GT16-01	4.0	5.0	B831-01	33.0	55	35	20		
GT16-06	2.5	7.5	B831-02						
GT16-07	4.0	5.0	B831-03						
GT16-08	20.0	21.5	B831-04						
GT16-09	10.0	11.5	B831-05						
GT16-11	4.0	5.0	B831-06	10.4	26	15	11		
GT16-11	6.5	10.0	B831-07						
GT16-01	7.5	8.0	B831-08	33.0	41	20	21		
GT16-12			B831-09						

Reviewed By: _____

APPENDIX E

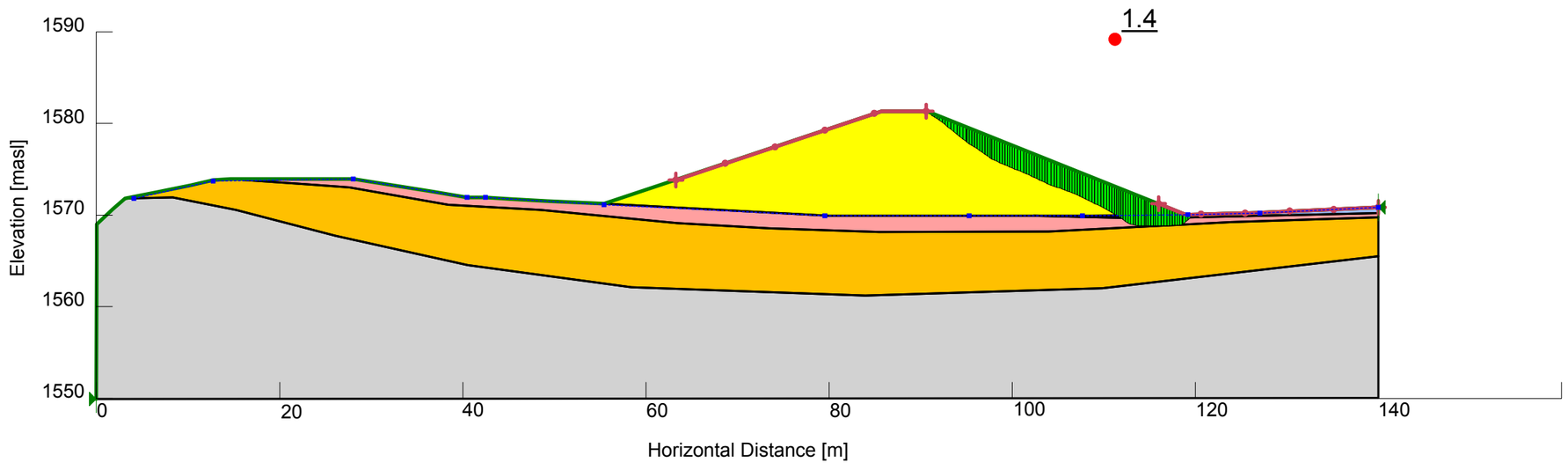
Slope Stability Models

Profile 1: East Sediment Pond Undrained Condition
Profile 1: East Sediment Pond Rapid Drawdown Condition
Profile 1: East Sediment Pond Drained Condition
Profile 1: East Sediment Pond Seismic Condition
Profile 2: South East Surge Pond Undrained Condition
Profile 2: South East Surge Pond Rapid Drawdown Condition
Profile 2: South East Surge Pond Drained Condition
Profile 2: South East Surge Pond Seismic Condition
Profile 3: South East Surge Pond Undrained Condition
Profile 3: South East Surge Pond Rapid Drawdown Condition
Profile 3: South East Surge Pond Drained Condition
Profile 3: South East Surge Pond Seismic Condition
Profile 4: Raw Water Pond Undrained Condition
Profile 4: Raw Water Pond Rapid Drawdown Condition
Profile 4: Raw water Pond Drained Condition
Profile 4: Raw Water Pond Seismic Condition
Profile 5: South Waste Dump Drained Condition
Profile 5: South Waste Dump Seismic Condition
Profile 6: South Waste Dump Drained Condition
Profile 6: South Waste Dump Seismic Condition

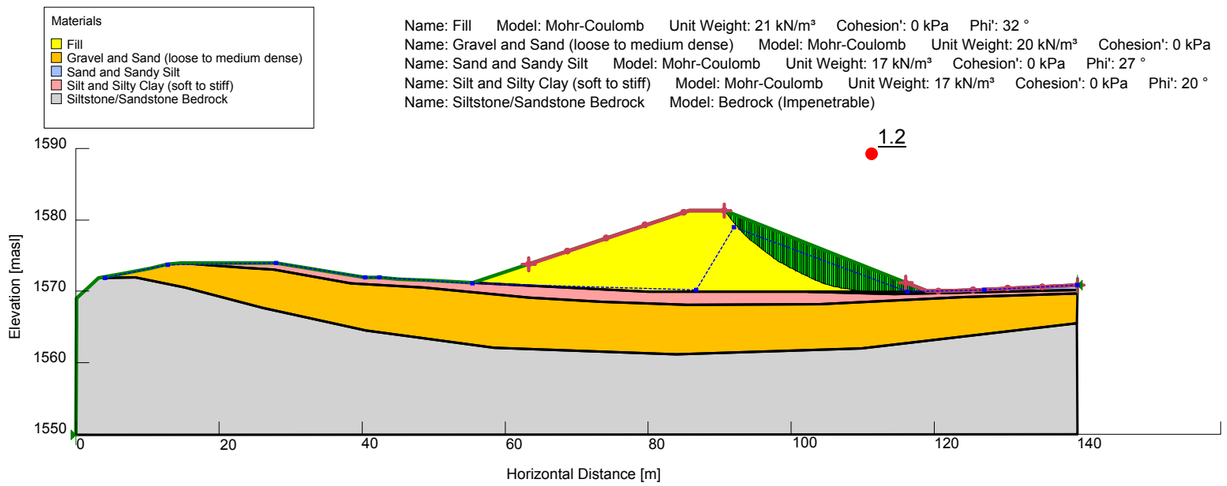
Materials

- Fill
- Gravel and Sand (loose to medium dense)
- Sand and Sandy Silt
- Silt and Silty Clay (soft to stiff)
- Siltstone/Sandstone Bedrock

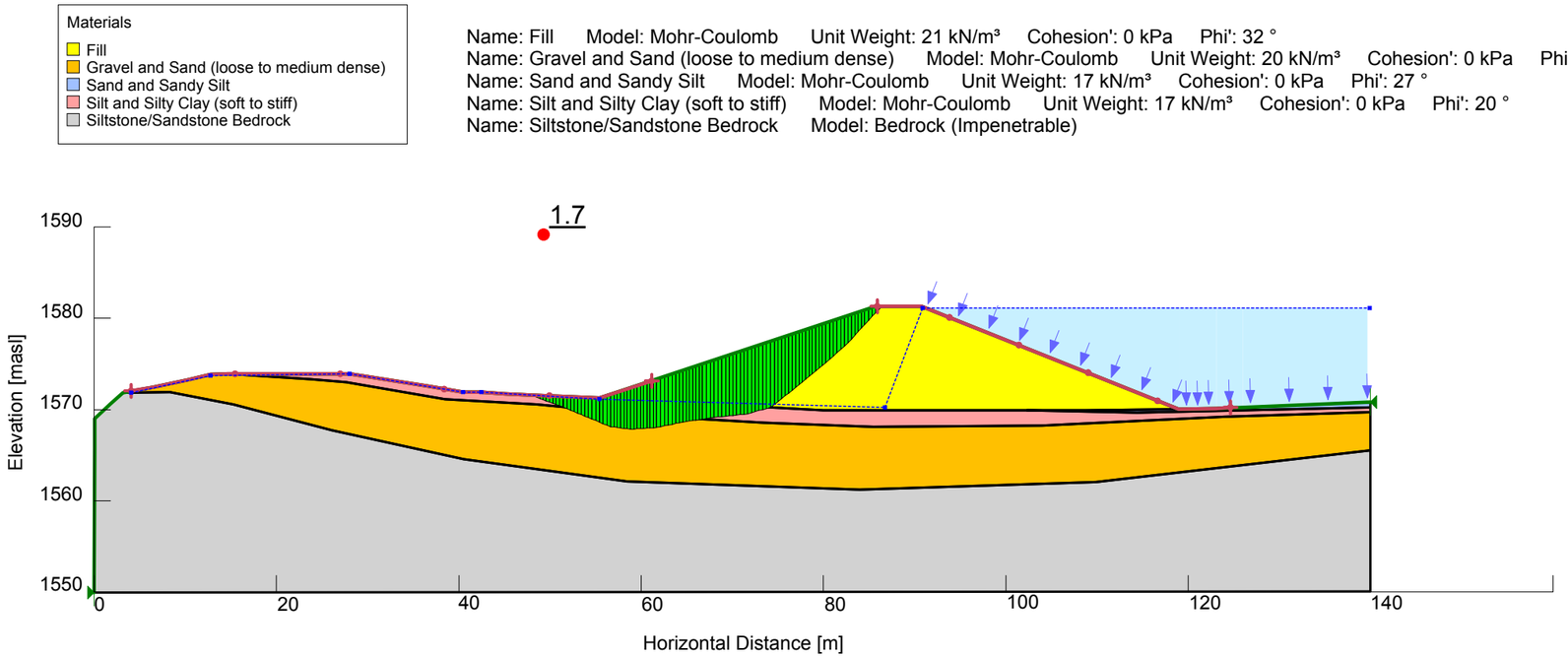
Name: Fill Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion': 0 kPa Phi': 32 °
Name: Gravel and Sand (loose to medium dense) Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Sand and Sandy Silt Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion': 0 kPa Phi': 27 °
Name: Silt and Silty Clay (soft to stiff) Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion': 0 kPa Phi': 20 °
Name: Siltstone/Sandstone Bedrock Model: Bedrock (Impenetrable)



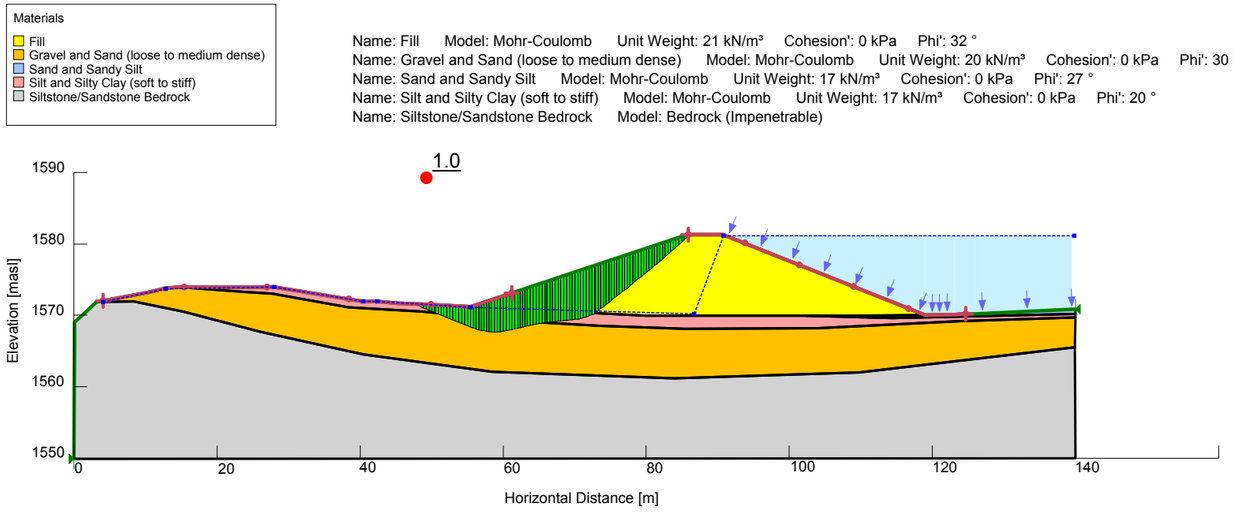
Profile 1: East Sediment Pond
Undrained Condition



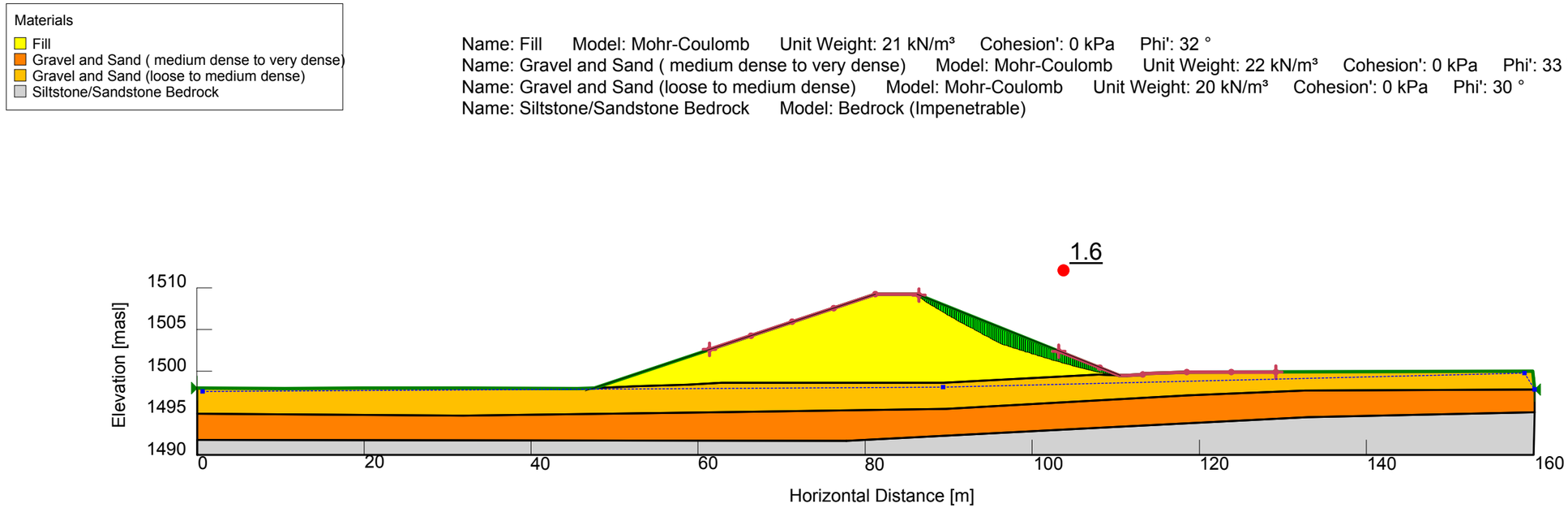
Profile 1: East Sediment Pond
Rapid Drawdown Condition



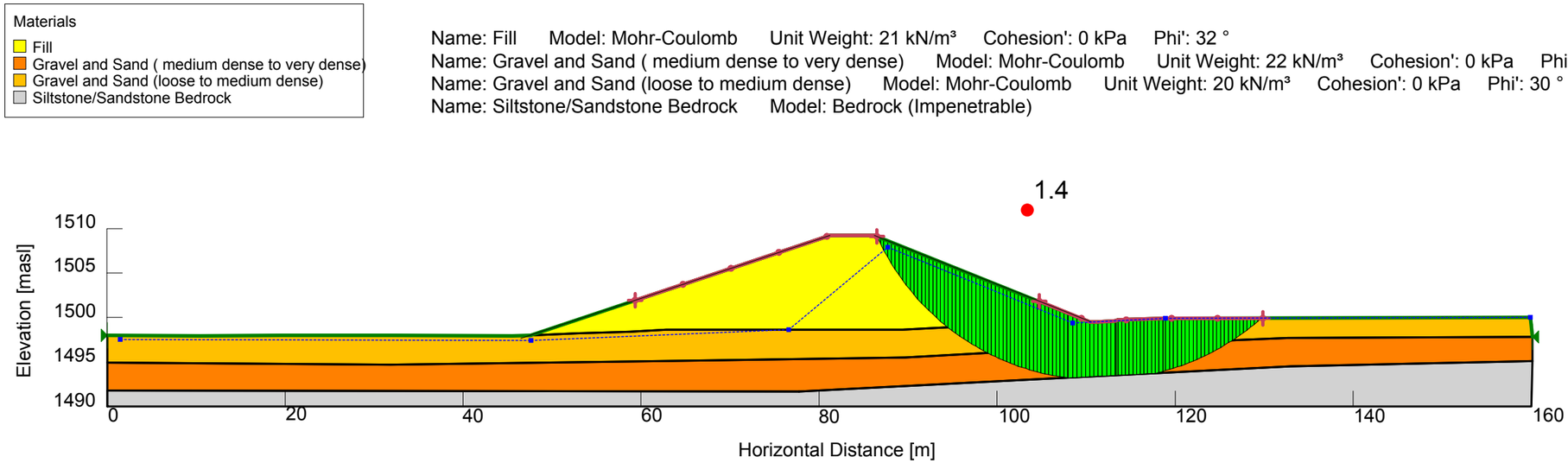
Profile 1: East Sediment Pond
Drained Condition



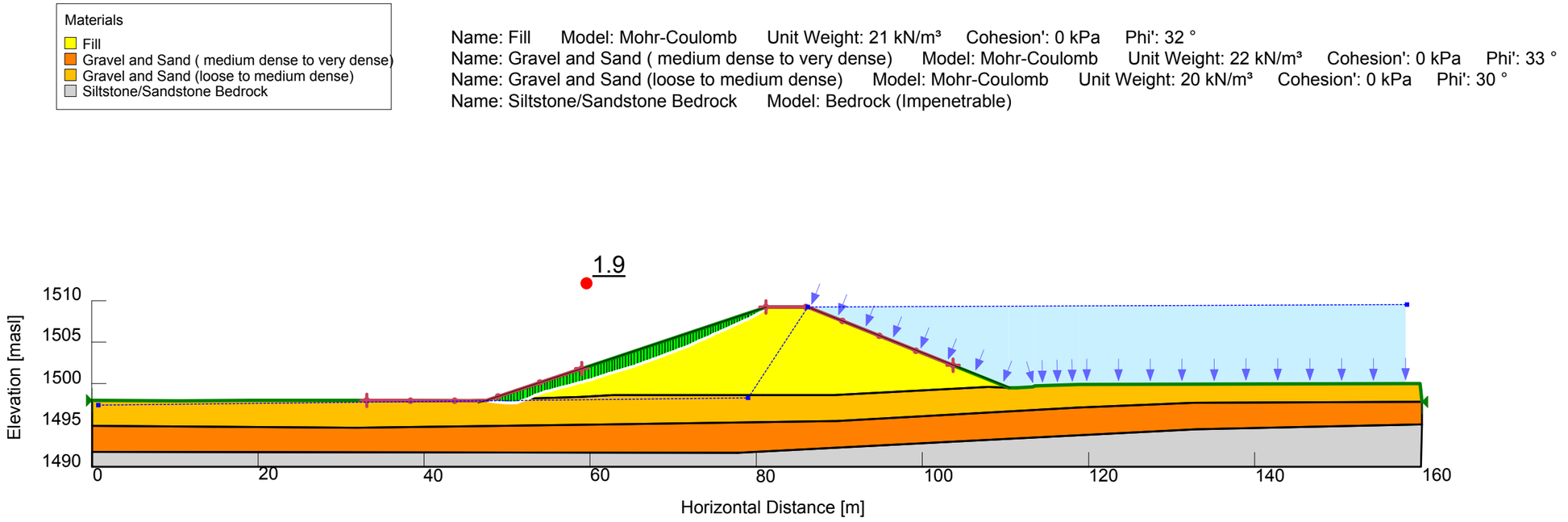
Profile 1: East Sediment Pond
Seismic Condition



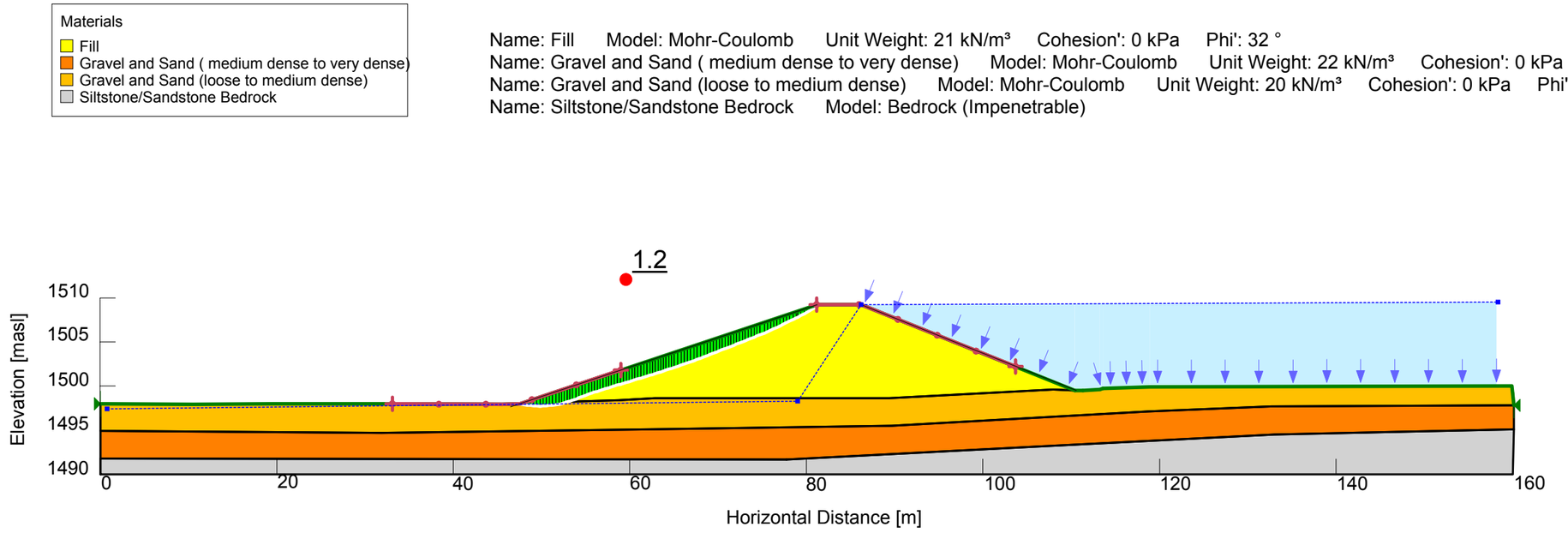
Profile 2: South East Surge Pond
Undrained Condition



Profile 2: South East Surge Pond
Rapid Drawdown Condition



Profile 2: South East Surge Pond
Drained Condition

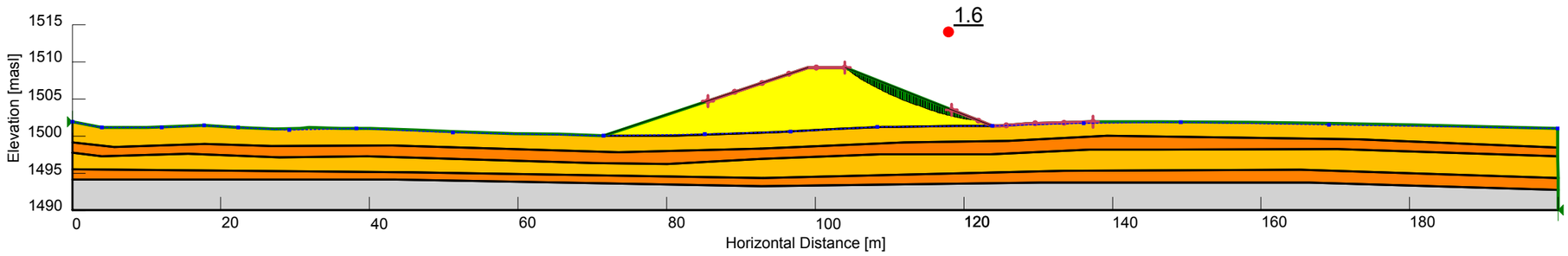


Profile 2: South East Surge Pond
Seismic Condition

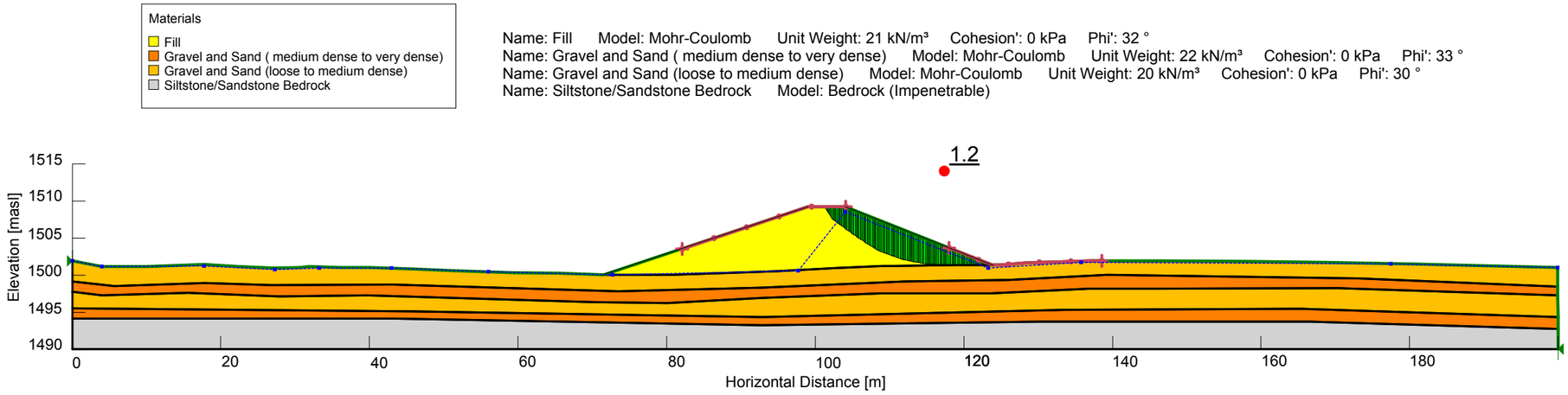
Materials

- Fill
- Gravel and Sand (medium dense to very dense)
- Gravel and Sand (loose to medium dense)
- Siltstone/Sandstone Bedrock

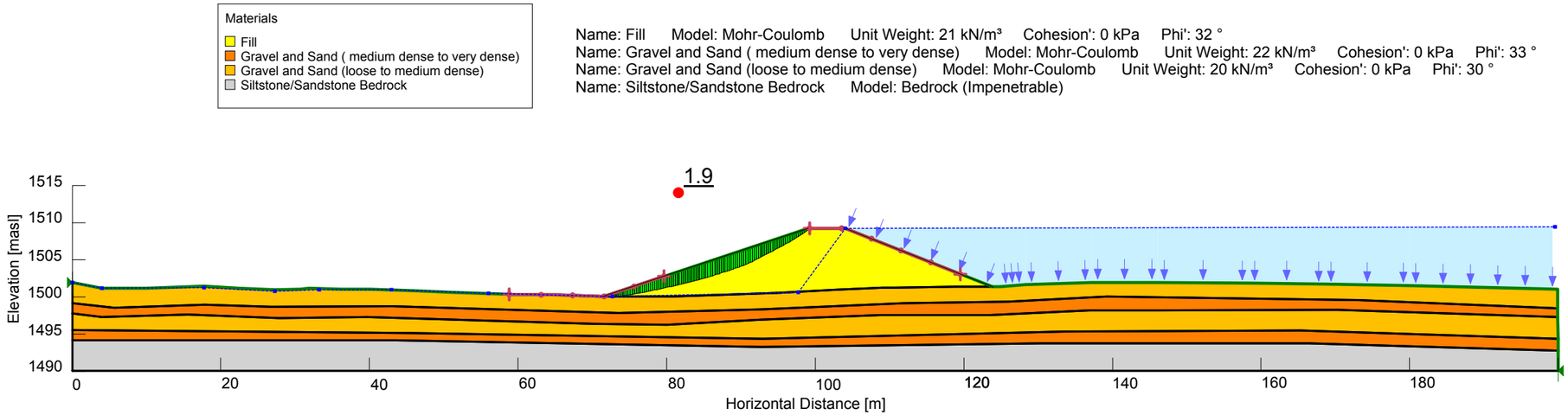
Name: Fill Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion': 0 kPa Phi': 32 °
Name: Gravel and Sand (medium dense to very dense) Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion': 0 kPa Phi': 33 °
Name: Gravel and Sand (loose to medium dense) Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Siltstone/Sandstone Bedrock Model: Bedrock (Impenetrable)



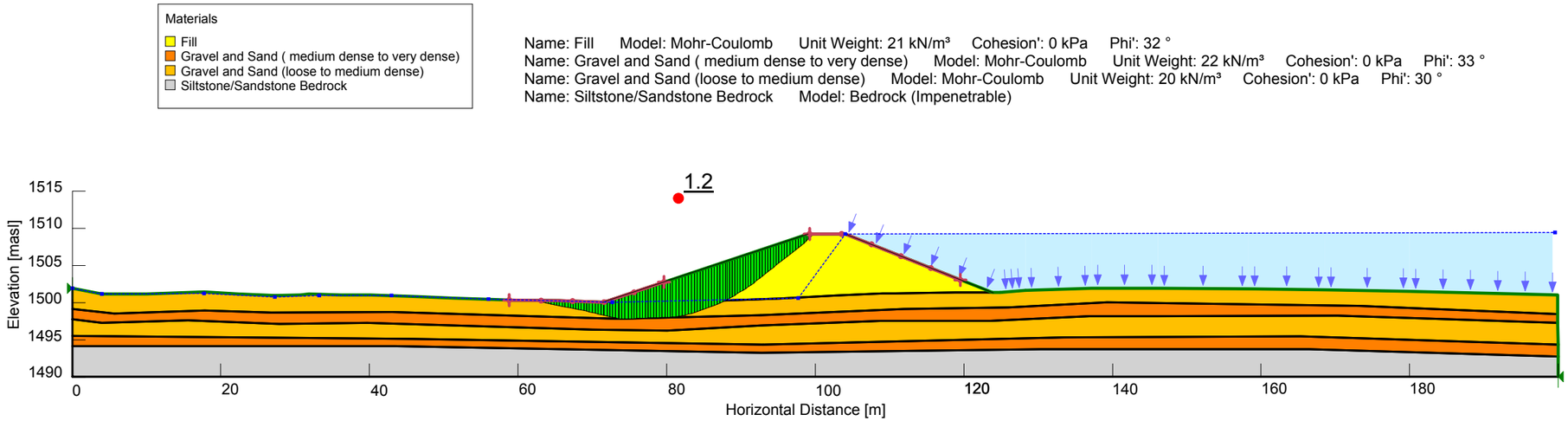
Profile 3: South East Surge Pond
Undrained Condition



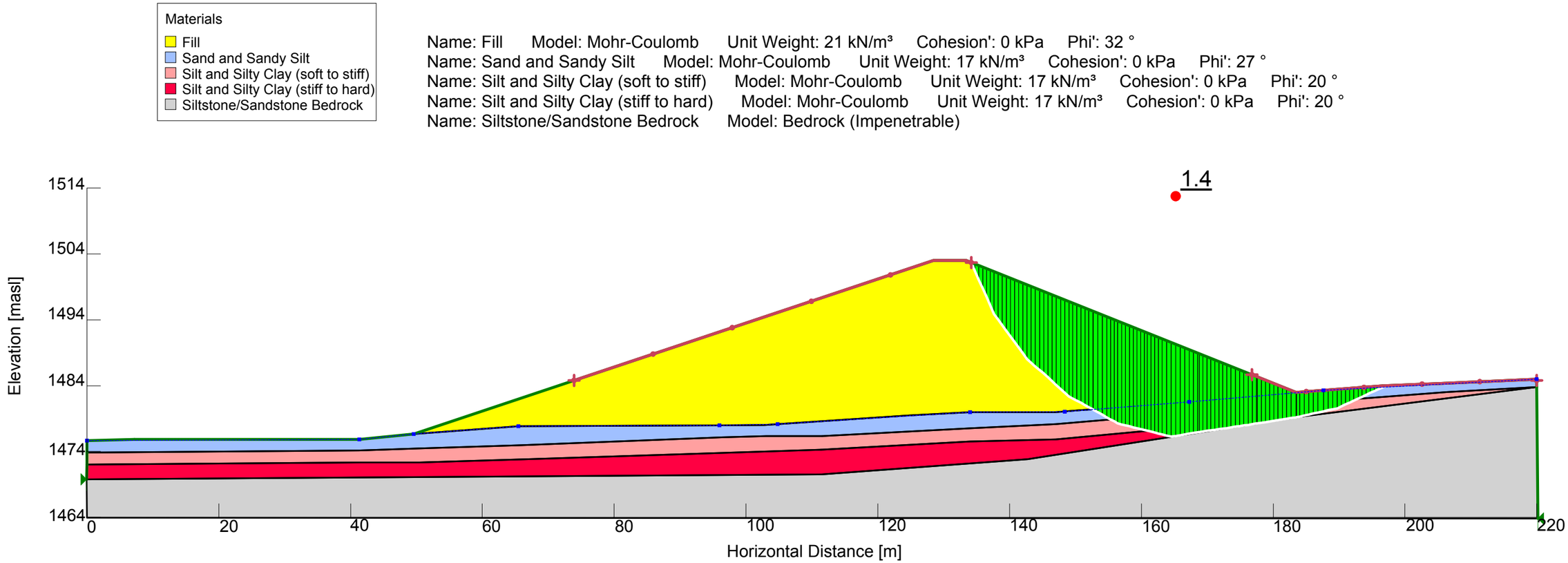
Profile 3: South East Surge Pond
Rapid Drawdown Condition



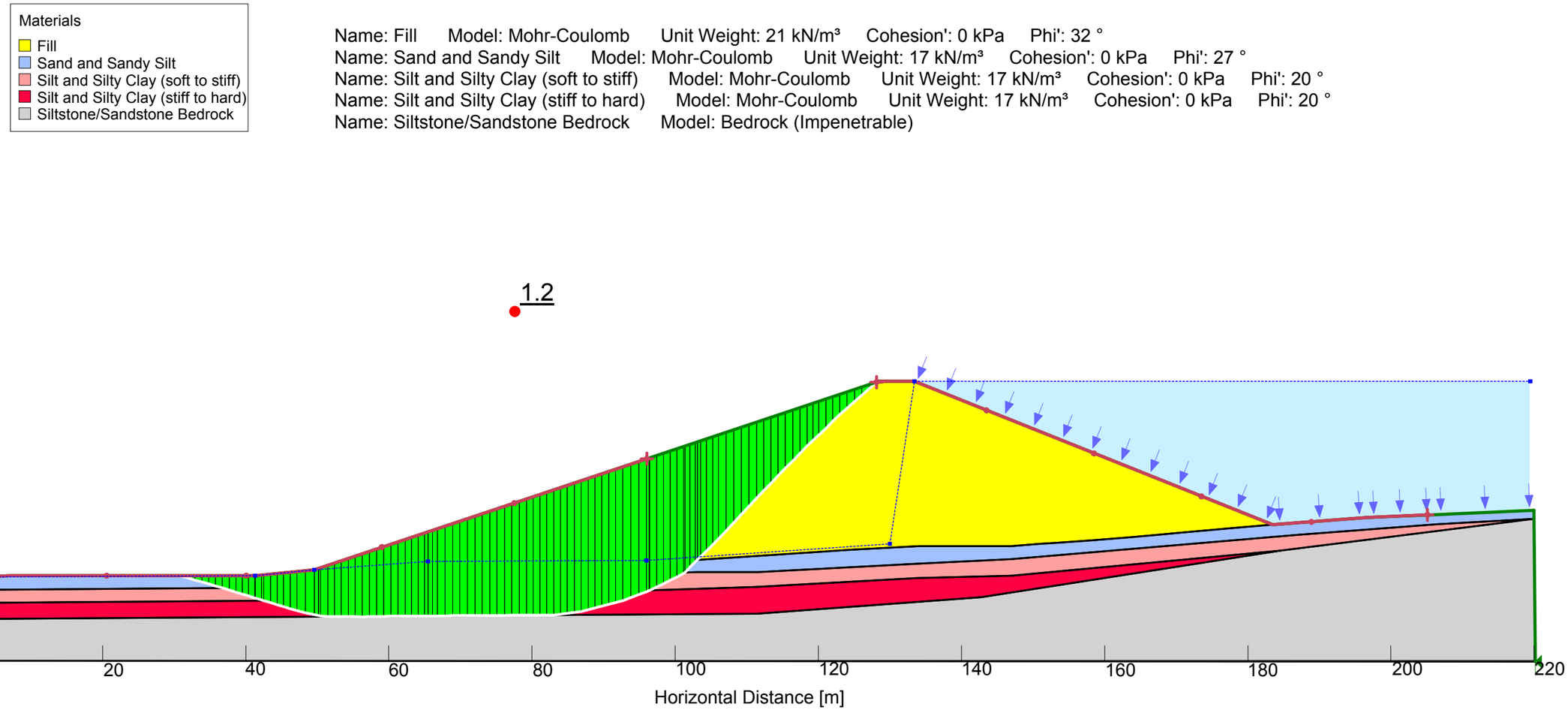
Profile 3: South East Surge Pond
Drained Condition



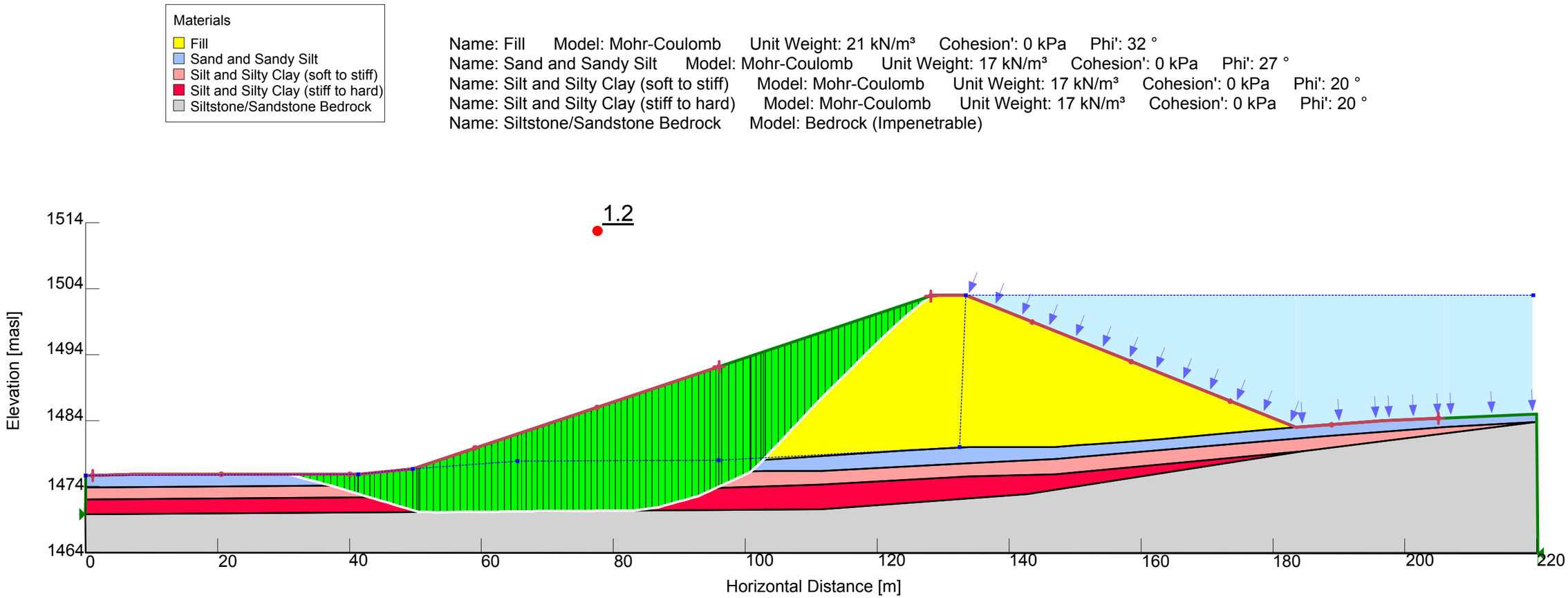
Profile 3: South East Surge Pond
Seismic Condition



Profile 4: Raw Water Pond
Undrained Condition



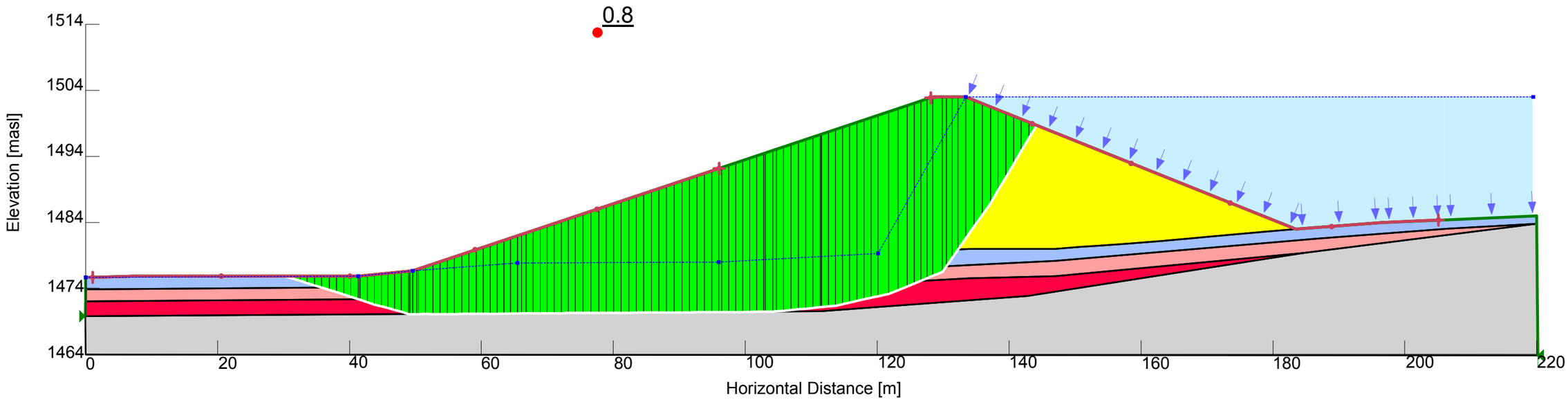
Profile 4: Raw Water Pond
Rapid Drawdown Condition



Profile 4: Raw Water Pond
Drained Condition

Materials
- Fill
- Sand and Sandy Silt
- Silt and Silty Clay (soft to stiff)
- Silt and Silty Clay (stiff to hard)
- Siltstone/Sandstone Bedrock

Name: Fill Model: Mohr-Coulomb Unit Weight: 21 kN/m³ Cohesion': 0 kPa Phi': 32 °
Name: Sand and Sandy Silt Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion': 0 kPa Phi': 27 °
Name: Silt and Silty Clay (soft to stiff) Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion': 0 kPa Phi': 20 °
Name: Silt and Silty Clay (stiff to hard) Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion': 0 kPa Phi': 20 °
Name: Siltstone/Sandstone Bedrock Model: Bedrock (Impenetrable)

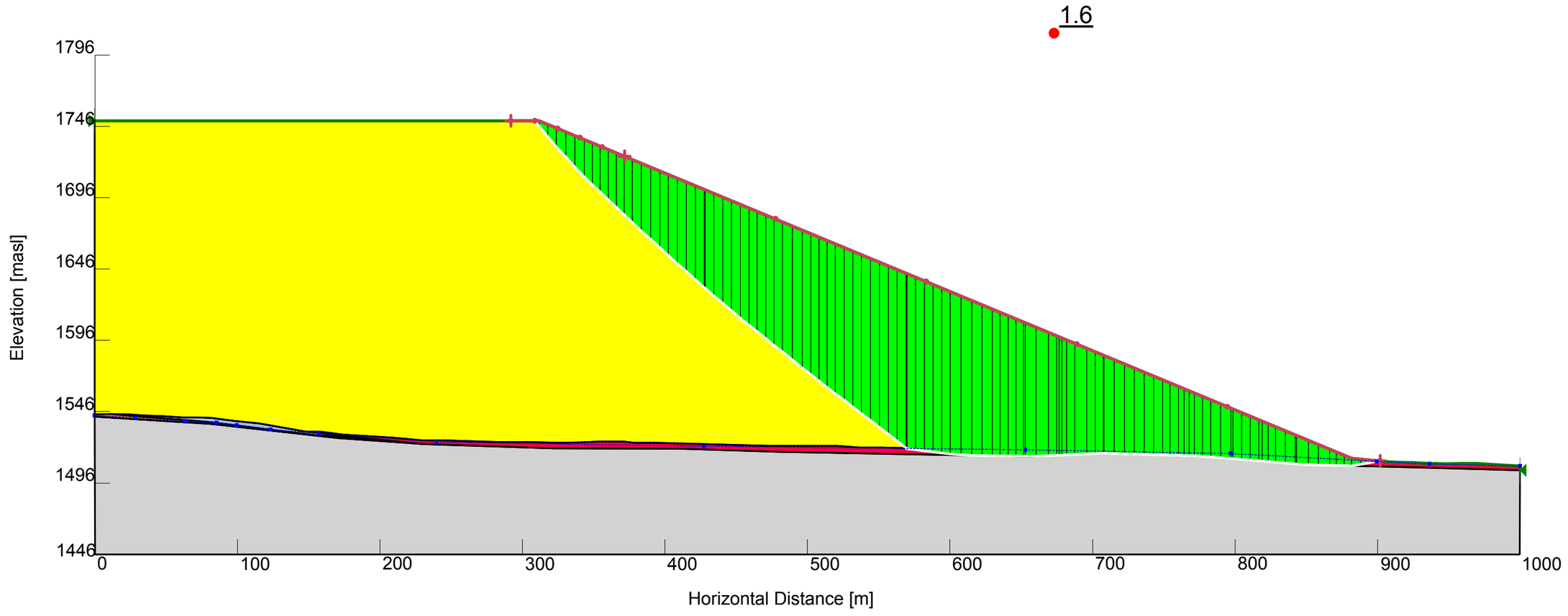


Profile 4: Raw Water Pond
Seismic Condition

Materials

- Waste Rock
- Gravel and Sand (medium dense to very dense)
- Sand and Sandy Silt
- Silt and Silty Clay (stiff to hard)
- Siltstone/Sandstone Bedrock

Name: Waste Rock Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion': 0 kPa Phi': 37 °
Name: Gravel and Sand (medium dense to very dense) Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion': 0 kPa Phi': 33 °
Name: Sand and Sandy Silt Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion': 0 kPa Phi': 27 °
Name: Silt and Silty Clay (stiff to hard) Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion': 0 kPa Phi': 20 °
Name: Siltstone/Sandstone Bedrock Model: Bedrock (Impenetrable)

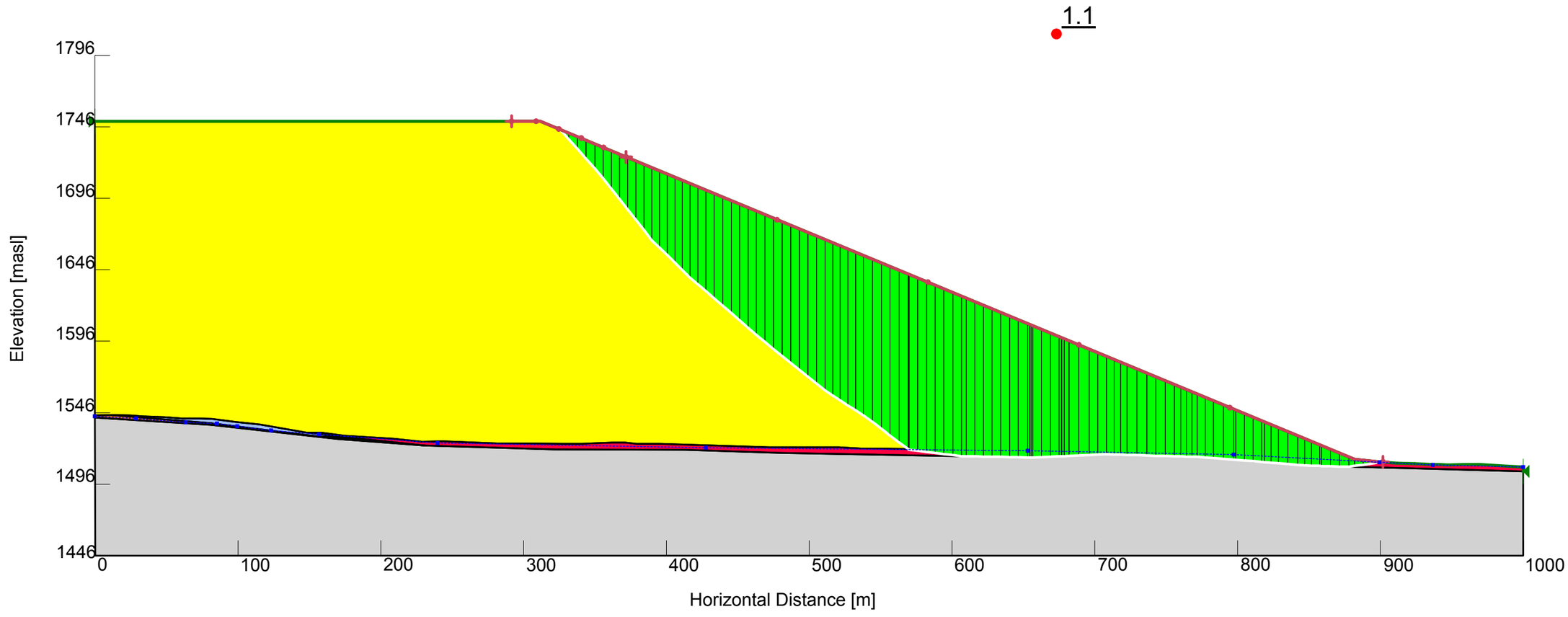


Profile 5: South Waste Dump
Drained Condition

Materials

- Waste Rock
- Gravel and Sand (medium dense to very dense)
- Sand and Sandy Silt
- Silt and Silty Clay (stiff to hard)
- Siltstone/Sandstone Bedrock

Name: Waste Rock Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion': 0 kPa Phi': 37 °
Name: Gravel and Sand (medium dense to very dense) Model: Mohr-Coulomb Unit Weight: 22 kN/m³ Cohesion': 0 kPa Phi': 33 °
Name: Sand and Sandy Silt Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion': 0 kPa Phi': 27 °
Name: Silt and Silty Clay (stiff to hard) Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion': 0 kPa Phi': 20 °
Name: Siltstone/Sandstone Bedrock Model: Bedrock (Impenetrable)

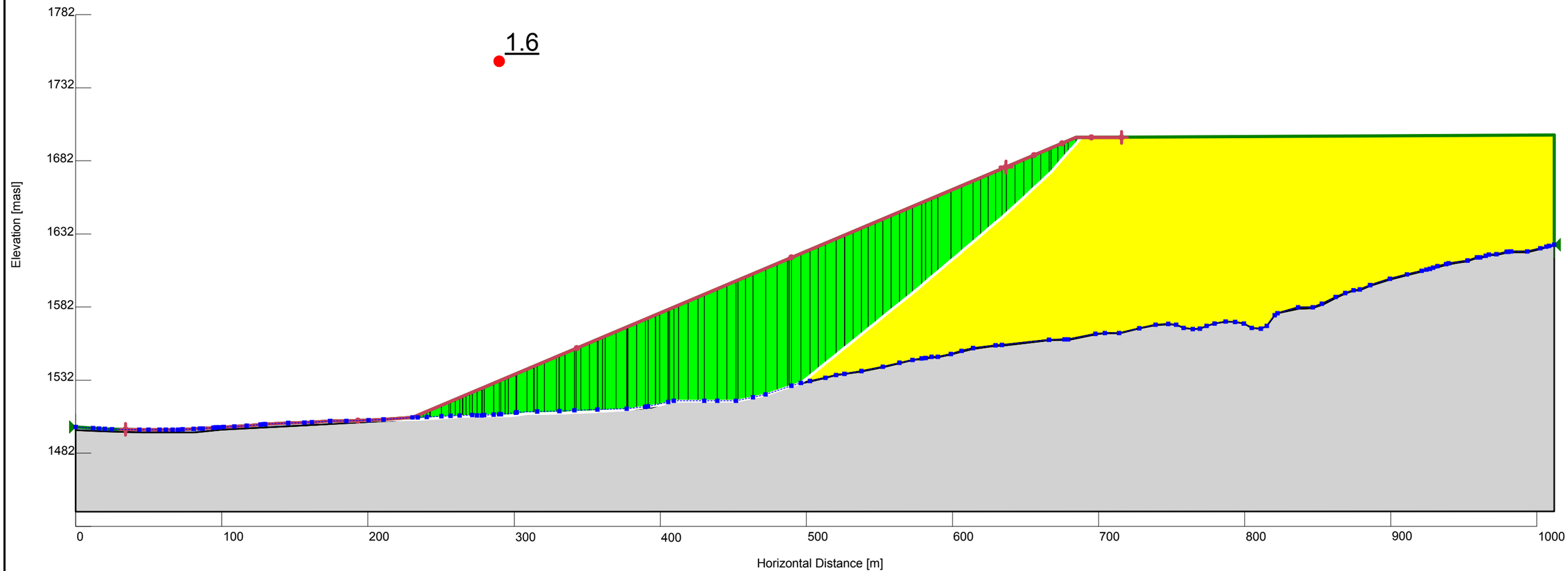


Profile 5: South Waste Dump
Seismic Condition

Materials

- Sand and Sandy Silt
- Siltstone/Sandstone Bedrock
- Gravel and Sand (loose to medium dense)
- Silt and Silty Clay (stiff to hard)
- Waste Rock

Name: Sand and Sandy Silt Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion': 0 kPa Phi': 27 °
Name: Siltstone/Sandstone Bedrock Model: Bedrock (Impenetrable)
Name: Gravel and Sand (loose to medium dense) Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Silt and Silty Clay (stiff to hard) Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion': 0 kPa Phi': 20 °
Name: Waste Rock Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion': 0 kPa Phi': 37 °

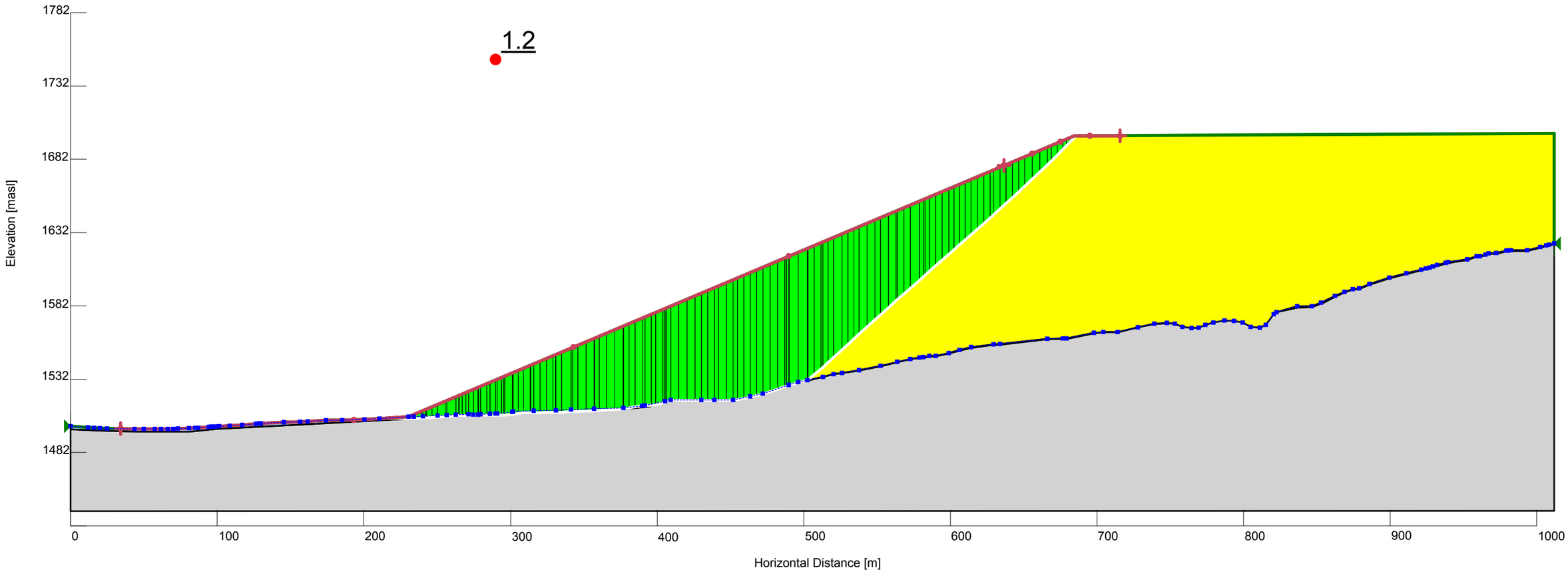


Profile 6: South Waste Dump
Drained Condition

Materials

- Sand and Sandy Silt
- Siltstone/Sandstone Bedrock
- Gravel and Sand (loose to medium dense)
- Silt and Silty Clay (stiff to hard)
- Waste Rock

Name: Sand and Sandy Silt Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion': 0 kPa Phi': 27 °
Name: Siltstone/Sandstone Bedrock Model: Bedrock (Impenetrable)
Name: Gravel and Sand (loose to medium dense) Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion': 0 kPa Phi': 30 °
Name: Silt and Silty Clay (stiff to hard) Model: Mohr-Coulomb Unit Weight: 17 kN/m³ Cohesion': 0 kPa Phi': 20 °
Name: Waste Rock Model: Mohr-Coulomb Unit Weight: 20 kN/m³ Cohesion': 0 kPa Phi': 37 °



Profile 6: South Waste Dump
Seismic Condition