May 9, 2016

REPORT ON

Geotechnical Review of LOM Cariboo Pit and Springer Pit Slope Designs

Submitted to:
Mount Polley Mine
PO Box 12
Likely, BC
V0L 1N0

Attention: Ryan Brown, Senior Mine Engineer

REPORT

Reference Number: 051413027-111-R-Rev0-2115

Distribution:

1 Electronic Copy - Mount Polley Mine
1 Hard Copy - Mount Polley Mine
1 Hard Copy - Golder Associates Ltd.

Golder Associates

Executive Summary

Mount Polley Mining Corporation (MPMC) has retained Golder Associates Ltd. (Golder) to carry out an updated geotechnical review of the pit slope design of the proposed ultimate pits at the Mt. Polley open pit mining operation located in east-central British Columbia. This report presents:

- a summary of the proposed ultimate pit configurations;
- a discussion of the engineering geology of the deposits, based on ongoing pit wall mapping programs that have been carried out by Golder since the opening of the mine;
- a review of the pit slope stability performance of the existing pit walls;
- a discussion of the factors that are expected to control the stability of the proposed ultimate pits;
- the results of kinematic and overall pit slope stability analyses; and
- a summary of conclusions and recommendations.

Mining is currently being carried out in the Cariboo, C2 and WX Pits. The Springer Pit is temporarily being backfilled with tailings. Eventually, the tailings will be removed from the Springer Pit and all of the pits will be expanded and merged. The existing pits will be expanded and merged, and the proposed pit shells are shown in Figure 2. The combined pits will be approximately 1,665 metres long in the northwest-southeast direction, and approximately 845 metres wide in the northeast-southwest direction, and will be excavated to depths of approximately 80 and 300 m.

Golder have carried out geotechnical mapping investigations at the mine on an annual basis since 2008. This data base is augmented with the results of geotechnical drilling and televiewer investigations. The majority of the diorite and monzonite host rocks that will be exposed in the pit walls exhibit intact rock Medium strong to strong rock. The rock mass contains well defined geologic fractures in the form of joint and fault sets. The rock mass rating (RMR_{76}) varies from 53 to 57, and is classified as fair quality rock.

The results of overall circular type slope stability assessments for the Southwest and the Northwest Walls of the Springer Pit, which will be the highest pit walls, indicate that these walls are expected to exhibit Factors of Safety well in excess of 1.3 for a range of groundwater conditions, from dry to a r_u of 0.2. Consequently, the stability of the pit slopes are expected to be controlled by structurally controlled type failure mechanisms, largely wedge and planar failure mechanisms with some localized toppling instability.

Kinematic slope stability analyses have been carried out to assess the stability of the pit walls with respect to wedge and planar type failures. The results of these analyses have been used to establish recommended design bench configurations for the various proposed pit walls. The design recommendations for the Springer and Cariboo Pit areas are summarized in Table E-1 and Table E-2, respectively.

Table E-1: Summary of Springer Pit Recommended Bench Design Configurations

Wall Dip Direction (Azimuth, in degrees)	Pit Design Sector Azimuth (degrees)	Bench Height (m)	Bench Face Angle (degrees)	Inter-ramp Angle (degrees)	Bench Width (m)	Rationale
000°	180°	12	70	43	8.5	Single bench due to shallower dipping Set 3 structures on South Wall.
030°	210°	24	70	50	11.5	
060° to 180°	240° to 000°	24	65	46.5	11.5	
210° to 240°	030° to 060°	12	70	43	8.5	Single bench through Polley and Springer Faults.
270°	090°	12	70	43	8.5	Single bench through Polley and Springer Faults. Single bench due to shallow westerly dipping structures at bottom of East Wall.
300° to 330°	120° to 150°	12	70	43	8.5	Single bench due to shallower dipping Set 3 structures on South Wall.

Table E-2: Summary of Cariboo and C2 Pit Recommended Bench Design Configurations

Wall Dip Direction (Azimuth, in degrees)	Pit Design Sector Azimuth (degrees)	Bench Height (m)	Bench Face Angle (degrees)	Inter-ramp Angle (degrees)	Bench Width (m)	Rationale
000°	180°	24	65	46	12	Shallow dipping, discontinuous Set 4 creates bench scale ravelling along small planar failures along south walls. Use a double bench configuration with 65 degree BFA.
030°	210°	24/12	65/70	46/43	12/8.5	Use single bench with 70° BFA in Polley Fault. Otherwise double bench at 65° BFA.
060° to 090°	240° to 270°	24/12	70	49/43	12/8.5	Use single bench with 70° BFA in Polley Fault. Otherwise double bench at 65° BFA.
120°	300°	24/12	65/70	46/43	12/8.5	Use single bench with 70° BFA in Polley Fault. Otherwise double bench at 65° BFA.
150°	330°	24	65	46	12	
180° to 240°	000° to 060°	24	70	49	12.13	
270°	090°	12	70	43	8.5	Original design was 51 degree IRA (Golder 2013). However, current design is single bench due to toppling along East Cariboo Fault.
300°	120°	24	70	49	12.13	
330°	150°	24	65	46	12	Shallow dipping, discontinuous Set 4 creates bench scale ravelling along small planar failures along south walls. Use a double bench configuration with 65 degree BFA.

Table of Contents

EXECUTIVE SUMMARY i

1.0 INTRODUCTION 1

2.0 PROPOSED MOUNT POLLEY MINE AND SPRINGER AND CARIBOO PIT DEVELOPMENT 2

2.1 Proposed Pit Development 2

3.0 PIT GEOLOGY 4

4.0 ENGINEERING GEOLOGY 5

4.1 Structural Geology 5

4.1.1 Major Faults 5

4.1.2 Rock Fabric 6

4.2 Rock Strength 8

4.2.1 Intact Rock Strength 8

4.2.2 Rock Mass Strength 9

5.0 REVIEW OF STABILITY PERFORMANCE OF THE EXISTING SPRINGER AND CARIBOO PITS 12

5.1 Springer Pit 12

5.2 Cariboo Pit 12

6.0 PIT SLOPE STABILITY ASSESSMENT 15

6.1 Slope Design Terminology 15

6.2 Rock Slope Failure Mechanisms 15

6.2.1 Structurally Controlled Failure Mechanisms 15

6.2.2 Overall Rock Mass Strength Failure Mechanisms 16

6.3 Overall Stability with Respect to Major Faults Assessment 16

6.4 Overall Rock Slope Stability Assessment 18

6.5 Kinematic Stability Assessment 20

6.5.1 Bench Scale Stability Assessment Methodology 22

6.5.2 Inter-ramp Scale Stability Assessment Methodology 22

6.5.3 Springer Pit Recommended Bench Design Configurations 23

6.5.4 Cariboo and C2 Pit Recommended Bench Design Configurations 23

7.0 OPERATIONAL CONSIDERATIONS 25

7.1 Blasting and Excavation 25

7.2 Geotechnical Monitoring Program 26

7.2.1 Geologic Mapping 26

7.2.2 Slope Stability Monitoring 26

8.0 CLOSURE 28

REFERENCES 29

STUDY LIMITATIONS 30

TABLES

Table 1: Proposed Ultimate Pit Wall Heights 2

Table 2: Pit Phase Design Parameters 3

Table 3: Geologic Structure Continuity on the Basis of Structure Type 6

Table 4: Summary of Discontinuous and Continuous Structural Sets in the Springer Pit Area 8

Table 5: Summary of Discontinuous and Continuous Structural Sets in the Cariboo, C2 and WX Pit Areas 8

Table 6: Intact Rock Strength Estimates Based on 1997 Geotechnical Mapping Program 9

Table 7: RMR_{76} Classification Parameters and Ratings 10

Table 8: Rock Mass Classes Based on RMR_{76} 10

Table 9: Summary of RMR_{76} Assessment of Exploration Core Hole Geotechnical Data 11

Table 10: Strength Input Parameters for Northeast Wall Slope Stability Analyses 18

Table 11: Summary of Springer Pit Northeast Wall Slope Stability Analysis Results 19

Table 12: Reference to Joint and Fault Design Sets 20

Table 13: Summary of Springer Pit Recommended Bench Design Configurations 23

Table 14: Summary of Cariboo and C2 Recommended Bench Design Configurations 24

FIGURES

Figure 1: Existing Pit Development 31

Figure 2: Proposed Ultimate Pits 32

Figure 3: Springer Pit Geology 33

Figure 4: Cariboo Pit and Major Faults 34

Figure 5: Major Faults and Dykes 35

Figure 6: As-Built Cariboo and Springer Pits (December 2015) Fault Model 36

Figure 7: Ultimate Cariboo and Springer Pits Fault Model 37

Figure 8: Stereographic Projection of Mapped Major Faults in the Mount Polley Area 38

Figure 9: Slope Design Elements 39
Figure 10: Structurally Controlled Instability Mechanisms in Rock Slopes 40
Figure 11: Overall Rock Mass Failure Mechanism 41

APPENDIX A
Photographs

APPENDIX B
Stereographic Projections of Geotechnical Mapping Data

APPENDIX C
Results of Springer Pit Northeast Wall Overall Slope Stability Analyses

APPENDIX D
Results of Kinematic Slope Stability Analyses

1.0 INTRODUCTION

Mount Polley Mining Corporation (MPMC) is currently mining copper ore from the Cariboo, C2 and WX Pits at their Mt. Polley Mine in central British Columbia, approximately 56 km northeast of the town of Williams Lake. These pits will be expanded and ultimately merged with the adjacent Springer pit. MPMC has retained Golder Associates Ltd. (Golder) to carry out an updated geotechnical review of the pit slope design of the proposed ultimate pits. This report presents:

- a summary of the proposed ultimate pit configurations;
- a discussion of the engineering geology of the deposits, based on ongoing pit wall mapping programs that have been carried out by Golder since the opening of the mine;
- a review of the pit slope stability performance of the existing pit walls;
- a discussion of the factors that are expected to control the stability of the proposed ultimate pits;
- the results of kinematic and overall pit slope stability analyses; and
- a summary of conclusions and recommendations.

2.0 PROPOSED MOUNT POLLEY MINE AND SPRINGER AND CARIBOO PIT DEVELOPMENT

2.1 Proposed Pit Development

A plan of the existing pit development at the Mt. Polley mine, as of December 2015, is shown in Figure 1. Photographs of the existing pit walls are included in Appendix A. Mining is currently being carried out in the Cariboo, C2 and WX Pits. The Springer pit is temporarily being backfilled with tailings. Eventually, the tailings will be removed from the Springer Pit and all of the pits will be expanded and merged. The proposed merged pit shells are shown in Figure 2.

The proposed ultimate Springer Pit will be excavated in several phases. Currently, the Springer Pit is in Phase 3 development. Springer Phase 4 Pit will consist of pushback of the Northeast and East Walls of the Springer Pit, excavation of the Cariboo Pit and the C2 pit. This will be followed by excavation of the Springer Phase 5 Pit which is essentially a pushback of the Springer Pit to the north. At the Phase 6 the Springer and WX Pits will deepen.

The combined pits will be approximately 1,665 metres long in the northwest-southeast direction, and approximately 845 metres wide in the northeast-southwest direction. The Springer and the Cariboo Pits will be excavated to ultimate pit floor elevations of 772 and 940 metres respectively. A saddle will be developed between the pits. The WX Pit will be excavated along the south side of the Springer Pit, and the ultimate pit floor will be excavated down to the 880 metre elevation. A saddle will also remain between the Springer and WX pits. The C2 Pit will be excavated as a west facing alcove along the south side of the Cariboo Pit. The following pit wall heights will be excavated in the pits.

Table 1: Proposed Ultimate Pit Wall Heights

Pit Wall	Height (metres)
Springer Pit	
Northeast Wall	340
West Wall	265
South Wall	320
Cariboo Pit	
Northeast Wall	145
Southeast Wall	180
WX Pit	
West Wall	205
South Wall	170
East Wall	145
C2 Pit	
North Wall	80
East Wall	95
South Wall	70

Table 2 summarizes the current proposed design criteria utilized for each pit phase design. All production benches are mined on 12 metre high benches, with walls either configured in a single bench (12 metre high face between catchment berms) or a double bench (24 metre high face between catchment berms).

Table 2: Pit Phase Design Parameters

Pit Phase	Wall Segment	Wall Type	Inter-Ramp Angle (degrees)	Face Angle (degrees)	Berm Width (metres)
Cariboo	North and East Wall	Double Bench	49	70	12.13
	Far East Corner	Double Bench	51	70	10.70
	South Wall	Double Bench	46	65	12.00
	West Wall (Cariboo)	Double Bench	46	65	12.00
	WX Area	Double Bench	46	65	12.00
	C2 Area	Double Bench	46	65	12.00
	Polley Fault Intersections	Single Bench	43	70	8.50
	Access Slot Walls	Single Bench	43	70	8.50
	West Wall Adjacent SP4	Single Bench	43	70	8.50
Springer Phase 4	West Wall	Double Bench	46	65	11.50
	North, East, and South Walls	Single Bench	43	70	8.50
Springer Phase 5	West Wall	Double Bench	46.5	65	11.50
	North, East and South Walls	Single Bench	43	70	8.50
Springer Phase 6	West Wall	Double Bench	46.5	65	11.50
	North, East and South Walls	Single Bench	43	70	8.50
WX	West Wall	Double Bench	46.5	65	11.50
	North, East, and South Walls	Single Bench	43	70	8.50

3.0 PIT GEOLOGY

The Mount Polley deposits are located within an alkalic intrusive complex within the northwest-southeast trending Quesnel Trough, a 35-kilometer-wide, northwest trending volcanic sedimentary belt. The copper and gold mineralization is contained predominantly within north-south trending, elongated intrusive breccia stocks that have intruded late phase diorites and monzonite porphyries. Later stage, north-south trending dykes have been intruded along the regional structural trend.

The geological interpretation of the pit areas has been provided by MPMC. A geological plan of the Springer Pit is shown in Figure 3, while the geology of the Cariboo Pit is shown in Figure 4.

The mineralized hydrothermal breccia in the Springer Deposit occurs along a north-northwest-south-southeast trend, as shown in Figure 3. To the west, the mineralized breccia zone is bounded by a "mix" of breccia and intrusive rocks, which are then bounded by monzonite rocks. Monzonites rocks are the dominant rock type along the south side of the Springer Pit. Intrusive diorite rocks bound the mineralized breccia to the north and northeast. Finally, a series of younger north-south trending augite porphyry dikes are interpreted to occur throughout the proposed pit area. These dikes are often chlorite and calcite-altered, and commonly faulted. These younger dikes intersect the different rock types and the major faults, as shown in Figure 3.

In general, the rocks in the Cariboo Pit consist of monzonite intrusion breccias that have intruded the host monzonite rocks. Monzonite is exposed in the majority of the pit walls, while breccias are exposed in the centre of the pit. However, localized blocks of diorite are exposed in the Northwest and East Walls, while plagioclase porphyry is exposed along the Southeast Wall.

Based on the current geological interpretation, the following rock types are expected to be exposed on the various pit walls.

- Diorite rocks are expected to be predominant on the Northeast Wall of the proposed Springer Pit.
- Breccia rocks will be exposed on the North and Northwest Walls of the Springer Pit. In addition, breccia will be predominant at the pit floor.
- Monzonites are the dominant rock type at the mine site, and will be exposed in the West, East and South Walls of the Springer Pit and all walls in the WX Pit.
- Monzonite in the Northeast Wall of the Cariboo Pit.
- Monzonite and porphyry in the Southeast Wall of the Cariboo Pit and the all walls in the C2 Pit.

4.0 ENGINEERING GEOLOGY

4.1 Structural Geology

4.1.1 Major Faults

Several major continuous faults are interpreted to exist in the area of the proposed pits. The approximate surface traces of these features are shown in Figures 4 and 5. Golder has constructed 3D models of selected faults based on current pit intersections, and these surfaces are shown with respect to the December 2015 and ultimate pit shells in Figures 6 and 7, respectively. A stereographic projection of the orientations of some of the major faults that have been mapped at Mt. Polley are shown in Figure 8 (Wafforn 2013). This section presents a brief discussion on the major fault structures in the area of the Springer and Cariboo Pits.

Springer Pit Faults

- The South Wishbone Fault, a northeast/southwest trending fault, truncates the mineralized breccia zone to the north.
- The South Boundary Fault, a northwest/southeast trending fault, truncates the mineralized breccia zone to the south. This fault is interpreted to exist across the proposed pit, intersecting the West and Southeast Walls, and to terminate at the Polley Fault.
- The Polley Fault is a wide, steep, north/south trending, easterly-dipping zone of poor quality rock. The Polley Fault is interpreted to intersect the Southeast and Northeast Walls of the proposed pits, and is currently exposed at the south end of the Northeast Wall.
- The Springer Fault is a steep, north-south trending, easterly-dipping fault. It is interpreted to exist along the centre of the Springer Pit, where it crosses the pit floor, and to intersect the North Wall of the proposed pit. This fault is shown to terminate at the South Wishbone Fault and the South Boundary Fault, to the north and south, respectively.
- Finally, a set of northeast-southwest trending faults are interpreted to occur within the central portion of the Springer Pit area. These faults off-set the mineralized breccia zone and are shown to terminate at the South Boundary Fault to the south. To the north, these faults are shown to terminate at the various north-south trending faults, namely the Springer Fault, the Polley Fault and the East Cariboo Fault, with the last fault located further to the east of the Springer Pit area.

Cariboo Pit Faults

- The most continuous and dominant faults in the Cariboo Pit are the north to north-northwest trending Polley Fault, the Son-of-Polley Fault and the East Cariboo/Bell Fault. These faults are interpreted to dip toward northeast at inclinations of approximately 70 to 80 degrees.
- Northwest/southeast striking faults that dip toward the southwest have been identified at the north end of the pit. These faults include the North Boundary Fault, the 20 metre wide Oxide Boundary Fault, and the Chrysocolla Fault. These faults appear to be internal to the pit, and have been cut off by the northwest-southeast trending faults. The dip of the North Boundary and of the Oxide Boundary Faults is 67 to 70 degrees and 54 to 56 degrees, respectively.

- A number of northeast-southwest striking faults that dip toward the southeast have also been identified. The Northwest Wall Fault is exposed on the northwest side of the pit and dips toward the east/southeast at 55 to 65 degrees. The River of Waste Fault reportedly defines the limit of deep weathering in the pit, and cuts off the oxide zone to the south. This fault is located near the center of the pit and dips toward approximately 212° azimuth at an inclination of approximately 55 degrees. The rocks to the south of the fault have been weathered to considerable depth. The weathering is characterized by oxidized envelopes and staining along geologic structures such as faults and joints. Weathering is limited to the near-surface rocks to the north of the fault. The northeast-southwest trending Ian's Fault has been identified to the south of the River of Waste Fault. This fault dips towards the south-southeast at an inclination of 60 to 70 degrees, and defines the boundary between intrusive breccia to the north and unmineralized plagioclase porphyry to the south.
- A number of unnamed faults and very continuous, north-south trending augite porphyry dykes have also been identified in the both pits. In general, these structures define a pervasive, penetrative fabric that dips to the east at steep inclinations, and that can be identified across the pits.

4.1.2 Rock Fabric

In addition to the major faults, the deposits also contain other geologic structures in the form of faults, dykes and joint sets. The orientations of these structures have been determined through geotechnical mapping programs that have been carried out on an annual basis since 2008. In addition, televiewer surveys were carried in core holes that were drilled in the C2 Pit area in 2006.

The results of these various programs have been combined for the Springer Pit, and for the combined Cariboo, C2 and WX Pits. The data have been separated on the basis of continuity by feature type as follows.

Table 3: Geologic Structure Continuity on the Basis of Structure Type

Discontinuous Structures	Continuous Structures
Joints	Fault
Closed Joint	Major Fault
Gapped Joint	Polley Fault
	Dyke
	Gapped Fault
	Wide Fault
	Wide Joint
	Contact

Stereographic projections of the discontinuous and continuous structures for the Springer and Cariboo Pit are shown in Figures B-1 to B-4, in Appendix B. In general, the same geologic structures sets are observed in the two pit areas. However, there appears to be minor variations in the concentrations and the orientations of the structures between the two pits.

The data have been divided into sets for structures that exhibit similar and consistent orientations throughout the deposits. These sets are used in the kinematic slope stability analyses presented in Section 6.5. The chosen design sets for the discontinuous joints and the more continuous faults and dykes are discussed on the following page.

Sets 1A and 1B

Sets 1A and 1B include structures that strike parallel to the major northwest-southeast striking structural trend, and that dip to the northeast and southwest, respectively. These include structures that are related to and oriented sub-parallel to the Polley and the East Cariboo Faults.

Set 2

Set 2 includes east-northeast--west-southwest striking structures that dip steeply toward the southeast. These structures are likely related to the recent strike-slip faulting (Wafforn 2013), and to the Wishbone, Springer South Boundary and similarly oriented faults.

Set 3

Set 3 includes northeast-southwest to east-west striking structures that dip steeply toward the northwest. These structures may also be related to the recent strike-slip faulting, and to the Wishbone, Springer South Boundary and similarly oriented faults.

Set 4

Set 4 includes northeast-southwest striking structures that dip at a moderate inclination toward the northwest. These structures are likely related to the recent strike-slip faulting. These structure are well defined along the south side of the Cariboo Pit, and in the C2 and WX Pits.

Set 5A and 5B

Sets 5A and 5B include north-south striking structures that exhibit steep dips, and that dip toward the east and west, respectively.

Set 6A and 6B

Sets 6A and 6B includes structures that strike northeast-southwest and that dip toward the southwest and the northwest, respectively.

The average orientations of the discontinuous and the continuous structural sets observed in the Springer Pit and Cariboo Pit mapping data are summarized below in Table 4 and Table 5 respectively.

Table 4: Summary of Discontinuous and Continuous Structural Sets in the Springer Pit Area

Set Name	Discontinuous Structures		Continuous Structures	
	Average Dip (degrees)	Average Dip Direction (azimuth, in degrees)	Average Dip (degrees)	Average Dip Direction (azimuth, in degrees)
Set 1A	Not observed in the mapping data		70	46
Set 1B	72	72	65	218
Set 2	70	70	75	153
Set 3	81	81	75	330
Set 4	37	37	40	295
Set 5A	70	70	75	87
Set 5B	82	82	75	266
Set 6A	Not observed in the mapping data		76	125
Set 6B	Not observed in the mapping data		75	301

Table 5: Summary of Discontinuous and Continuous Structural Sets in the Cariboo, C2 and WX Pit Areas

Set Name	Discontinuous Structures		Continuous Structures	
	Average Dip (degrees)	Average Dip Direction (azimuth, in degrees)	Average Dip (degrees)	Average Dip Direction (azimuth, in degrees)
Set 1A	72	61	57	42
Set 1B	78	223	85	223
Set 2	59	181	Not observed in the mapping data	
Set 3	69	359	75	4
Set 4	35	344	Not observed in the mapping data	
Set 5A	71	99	68	92
Set 5B	79	271	85	267
Set 6A	65	140	69	126
Set 6B	Not observed in the mapping data		76	295

4.2 Rock Strength

4.2.1 Intact Rock Strength

Intact rock strength is generally expressed as the uniaxial compressive strength (UCS) of the rock, which is a laboratory compression test carried out on intact rock core cylinders. The intact strength of the rocks can also be estimated qualitatively using the International Society of Rock Mechanics (ISRM) rock strength measurement system. Field estimates of intact rock strength were recorded during the geotechnical mapping programs in 1997, 2008, 2009, 2010, 2011 and 2014.

The rock strengths and corresponding UCS for each lithology estimated as part of the 1997 surface mapping program are summarized in the Table 6.

Table 6: Intact Rock Strength Estimates Based on 1997 Geotechnical Mapping Program

Rock Type	Field Strength Estimates (ISRM 1981)	Description	UCS (MPa)
Breccia	R3	Medium Strong Rock	25-50
Diorite	R4	Strong Rock	50-100
Fault/Shear Zone Material	R0	Extremely Weak Rock	0.25-1.0

The field estimates of rock hardness logged as part of the geotechnical mapping in 2008 indicated that diorite rocks predominantly strong rock, i.e., R4 rock hardness (ISRM 1981). This field intact rock strength rating corresponds to a UCS of approximate 50 to 100 MPa.

Qualitative estimates of rock strength carried out during wall mapping program in 2009 indicated that breccia and monzonite rocks are predominantly strong rock (ISRM field intact rock strength rating of R4).

Strength of monzonite rocks exposed in Northwest and West Walls was estimated as R4 (strong rock) during 2010 mapping program. However, strength of monzonite rocks exposed in North Wall was estimated as R3 (medium strong rock).

Estimated rock hardness was R4 for monzonite rocks in Northeast, South and West Walls mapped in 2011.

Results of mapping programs indicated that rocks in the Springer Pit area are expected to be predominantly strong (50 -100 MPa) in terms of intact rock strength.

4.2.2 Rock Mass Strength

Rock mass classification systems are used to assess the various factors that influence the overall strength of a rock mass, including the influence of the intact rock strength and the fractures, to essentially grade the quality of the rock mass to determine its overall strength and deformation characteristics. For the purpose of this assessment, the RMR_{76} system (Rock Mass Rating – Bieniawski 1976) has been used to assess the rock mass quality in the pits.

A summary of the Rock Mass Rating (RMR_{76}) method is presented in Table 7 on the following page.

Table 7: RMR76 Classification Parameters and Ratings

<table>
<tr><th colspan="3">PARAMETER</th><th colspan="7">RANGES OF VALUES</th></tr>
<tr><td rowspan="3">1</td><td rowspan="2">Strength of intact rock material</td><td>Point load strength index</td><td>> 8 Mpa</td><td>4-8 MPa</td><td>2-4 MPa</td><td>1-2 MPa</td><td colspan="3">For this low range uniaxial</td></tr>
<tr><td>Uniaxial compressive strength</td><td>> 200 MPa</td><td>100-200 MPa</td><td>50-100 MPa</td><td>25-50 MPa</td><td>10-25 MPa</td><td>3-10 MPa</td><td>1-3 MPa</td></tr>
<tr><td colspan="2">Rating</td><td>15</td><td>12</td><td>7</td><td>4</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">2</td><td colspan="2">Drill core quality RQD</td><td>90% - 100 %</td><td>75% - 90%</td><td>50% - 75%</td><td>25% - 50%</td><td colspan="3"><25%</td></tr>
<tr><td colspan="2">Rating</td><td>20</td><td>17</td><td>13</td><td>8</td><td colspan="3">3</td></tr>
<tr><td rowspan="2">3</td><td colspan="2">Spacing of joints</td><td>>3 m</td><td>1 - 3 m</td><td>0.3 - 1 m</td><td>50 - 300 mm</td><td colspan="3"><50 mm</td></tr>
<tr><td colspan="2">Rating</td><td>30</td><td>25</td><td>20</td><td>10</td><td colspan="3">5</td></tr>
<tr><td rowspan="2">4</td><td colspan="2">Condition of joints</td><td>Very rough surfaces
Not continuous
No separation
Hard joint wall rock</td><td>Slightly rough surfaces
Separation <1 mm
Hard joint wall rokc</td><td>Slightly rough surfaces
Separation <1 mm
Soft joint wall rokc</td><td>Slickensided surfaces
OR Gouge < 5 mm thick
OR Joints open 1-5 mm
Continuous joints</td><td colspan="3">Soft gouge > 5mm thick
OR
Joints open >5 mm
Continuous joints</td></tr>
<tr><td colspan="2">Rating</td><td>25</td><td>20</td><td>12</td><td>6</td><td colspan="3">0</td></tr>
<tr><td rowspan="4">5</td><td rowspan="3">Ground water</td><td>Inflow per 10 m tunnel length</td><td colspan="2">none</td><td><25 litres / min</td><td>25-125 litres / min</td><td colspan="3">>125 litres / min</td></tr>
<tr><td>Ratio joint water pressure / major principal stress</td><td colspan="2">0</td><td>0.0-0.2</td><td>0.2-0.5</td><td colspan="3">>0.5</td></tr>
<tr><td>General conditions</td><td colspan="2">Completely dry</td><td>Moist only (interstitial water)</td><td>Water under moderate pressure</td><td colspan="3">Severe water problems</td></tr>
<tr><td colspan="2">Rating</td><td colspan="2">10</td><td>7</td><td>4</td><td colspan="3">0</td></tr>
</table>

In order to obtain RMR76 estimates, the rating for each parameter is assessed and the individual rating values are summed. RMR76 varies from 0 to 100, i.e., from very poor to very good rock; the rock mass classes and corresponding rating ranges are described in Table 8.

Table 8: Rock Mass Classes Based on RMR76

Rating Range	Description
100 - 81	Very Good Rock
80 – 61	Good Rock
60 – 41	Fair Rock
40 – 21	Poor Rock
0 – 20	Very Poor Rock

MPMC collected geotechnical data as part of exploration drilling carried out in 2008. An average RMR76 rating was assigned for each geotechnical parameter per drilling interval, and RMR76 values were computed for each interval. A summary of the RMR76 assessment based on the core hole data is presented in Table 9.

Table 9: Summary of RMR_{76} Assessment of Exploration Core Hole Geotechnical Data

RMR_{76} Summary Statistics	Breccia	Diorite	Monzonite
Mean	55 (Fair Rock)	57 (Fair Rock)	53 (Fair Rock)
Standard Deviation	15	17	16
Range	71	63	65
Minimum	19	19	19
Maximum	90	82	84
Count	2435	491	1856

The interpretation of the RMR_{76} assessment indicated the following.

- The breccia rocks exhibit poor to good rock mass quality, and exhibit predominantly fair rock mass quality. The breccia rocks yielded an average RMR_{76} value of 55, i.e., fair rock quality.
- The diorite rocks exhibit predominantly fair and good rock mass quality. The diorite rocks yielded an average RMR_{76} value of 57, i.e., fair rock quality.
- The monzonite rocks exhibit poor to good rock mass quality, and exhibit predominantly fair rock mass quality. The monzonite rocks yielded an average RMR_{76} value of 53, i.e., fair rock quality.
- The results of the RMR_{76} assessment indicate a similar distribution of RMR_{76} values between the breccia and monzonite rocks, i.e., ranging between poor to good rock mass quality with fair rock quality being dominant. However, data from the diorite rocks indicate mostly fair to good quality, and therefore indicating a comparatively better rock mass quality.

5.0 REVIEW OF STABILITY PERFORMANCE OF THE EXISTING SPRINGER AND CARIBOO PITS

This section presents a brief review of the conditions have been observed in the Springer and Cariboo Pits during Golder's geotechnical site inspections. A summary of Golder's most recent site visits in 2014 and 2015 have been provided to MPMC under separate cover (Golder 2016).

5.1 Springer Pit

Photographs of the existing Springer Pit are shown in Appendix A. With the exception of toppling instability that has occurred along the east side of the previous pushback of the Northeast Wall adjacent to the Polley fault, the walls in the Springer Pit have exhibited adequate overall slope stability and have not shown any signs of developing deep-seated instability.

The bench scale toppling in the Northwest Wall is related to toppling along northeasterly dipping structures within and adjacent to the Polley Fault. These faults dip into the wall at an oblique angle. The toppling caused the ravelling of catch-benches and the loss of the catch-benches along the exposure of the Polley Fault. The toppling deformations did not have a major impact on the stability of the wall, and did not adversely affect mining in the pit.

Bench scale planar and wedge failures have occurred along southeasterly and southwesterly dipping joints that are exposed in the west side of the Northeast Wall (Photograph A-6). The joints are not continuous, but are closely spaced. Consequently, the instability has been limited to bench scale ravelling along the exposed wedges. There is an adequate amount of catchment on the North Wall, and rock fall has not been a problem.

Localized bench scale planar failures have occurred along the lower portion of the East Wall. The planar failures are occurring along discontinuous joint sets that dip toward the northeast at moderate inclinations (Photograph A-7). The bench scale failures have reduced the amount of available catchment on the East Wall. These structures will need to be taken into consideration for the design of the ultimate East Wall.

Localized multi-bench scale planar failures have occurred along the South Wall, along continuous faults and joint sets that dip toward the north at steep inclinations (Photograph A-7). These structures have resulted in the localized loss of catchment on the benches. However, there is adequate catchment along the slope.

5.2 Cariboo Pit

Photographs of the existing Cariboo Pit are shown in Appendix A. With the exception of the rock in and adjacent to the Polley Fault, overall rock mass quality in the Cariboo Pit is generally fair to good, and slope stability is controlled by geologic structures. The slope stability performance exhibited by the various walls that were excavated in the previous and existing pit is discussed below.

Cracks developed behind the crest of the Northwest Wall of the original pit. The instability zone developed along the intersection of the north-south trending Son-Of-Polley Fault (SOP Fault) and the east-west trending Oxide Boundary Fault (OB Fault). The poor quality rock in the hangingwall of the SOP Fault together with the wide fault gouge zone on the hangingwall of the OB Fault created an approximately 60 metre wide zone of very poor quality rock in the bench face. Instability occurred within this zone as a result of toppling and ravelling at the top of the bench. The wedge formed by the intersection of the SOP and the OB Faults plunged toward 151 degrees azimuth at an inclination of 36 degrees.

The majority of the major geologic structures are favourably oriented with respect to the North Wall. The north-northwest-south-southeast striking regional trend intersected the North Wall at an oblique angle. Southerly to southeasterly dipping S2 structures strike sub-parallel to the North Wall, and the relatively steep bench faces broke back to the structures. There was no evidence of instability along the North Wall. Individual bench faces broke back to the easterly to southeasterly dipping structures. In addition to the southeasterly dipping structures, southwesterly dipping closely spaced joints, and north to northwesterly dipping structures that exhibit moderate and steep dips were also very prevalent along the Northwest Wall. Near vertical structures that exhibited a northeast dip-direction were visible along the west side of the pit. These structures were favourably oriented with respect to the Northwest Wall, but did act as release structures for planar instability along the southeasterly dipping structures. The structures intersected in a near orthogonal pattern and gave the rock mass a very blocky appearance.

In general, geologic structures exposed in the East Wall of the original were favourably oriented with respect to the wall and the bench faces excavated along the wall exhibited adequate overall stability. However, with the exception of the South Wall, ravelling along this slope was more extensive than along the other slopes of the pit. The ravelling was occurring due to minor bench scale planar and wedge failures that were occurring along the south-southwesterly dipping structures. The continuous, easterly dipping structures act as release surfaces along the backside of these failures and further contributed to the ravelling on the slope.

The exception to the favourable stability performance along the Northeast Wall was a bench high wedge failure that occurred along the intersection of a south-southwesterly dipping shear and a splay of the East Cariboo Fault. This splay fault dipped steeply to the west and intersected the bench face at an obtuse angle. The splay fault was partially undercut by the bench face and bench scale planar failure occurred along a portion of the splay fault.

Cracking at the crest and bench scale toppling instability has developed along the Northeast Wall of the existing pit. The toppling is occurring along the East Cariboo Fault and sub-parallel faults that dip into the wall at approximately 60 degrees (Photograph A-13).

The rock mass exposed in the South Wall is highly fractured and blocky. This resulted in extensive ravelling along the slope. The ravelling was exacerbated by bench scale planar and wedge failures that occurred along the northwesterly dipping structures exposed in the South Wall (Photograph A-14). However, the continuity of these structures is disrupted by offsets along the more continuous east to southeasterly dipping structures and by southwesterly dipping structures. This limited the continuity of the individual planar failures along the northwesterly dipping structures. The southeasterly dipping structures and the southwesterly dipping structures acted as release surfaces and backscarps for the planar and wedge failures along the northwesterly dipping structures.

The dominant geologic structure on the Southwest Wall was the Polley Fault Zone. The Polley Fault was interpreted to consist of the following zones.

- A hangingwall transition zone that varies in width from approximately 0 to 14 metres. This material is broken and blocky but not intensely altered.
- A fault breccia zone that varies in width from 26 to 49 metres. This zone varies from fresh, highly fractured ground to intensely altered, crushed ground that resembles sand. An approximately 15 metre wide dyke is located within this zone, near the upper hangingwall contact. Very wet conditions were encountered in the vicinity of the fault.

- A footwall transition zone that varies in width from 5 to 33 metres. This zone is exhibit similar quality to the hangingwall transition zone.
- A Footwall Fault zone, that is in fact a second fault located in the footwall of the Polley Fault. This second fault varies in width from 3 to 8 metres and is similar quality to the fault breccia zone.

For the most part, individual bench faces that were exposed within the fault zone exhibited adequate stability performance. However, an approximately 100 metre long crack developed along the 1,120 and 1,130 metre benches in the original pit. The crack appeared to coincide with the trace of the Polley Fault. The crack was located behind the double benched portion of the slope, and it would appear that a large portion of the slope was sliding down the fault through overall deformation or relaxation of the rock mass in the toe of the slope.

6.0 PIT SLOPE STABILITY ASSESSMENT

6.1 Slope Design Terminology

The basic components of a pit slope are the operating bench height and the bench face angle (BFA) that can be achieved in the excavation. These elements are shown schematically in Figure 9.

The bench height is a function of the type of excavation equipment used. The bench face angle is normally a function of geotechnical factors such as material strength or structural discontinuities in the rock mass. However, where no such geological controls exist, it may be a function of the blasting damage or the type of excavation equipment used.

It is normal practice to establish catch-benches on a pit slope to retain any loose materials that may fall from either the immediate bench face or from the upper part of the slope. Where conditions are suitable, it is common practice to place catch-benches at vertical intervals of two or occasionally more operating bench heights, thereby creating a multi-bench configuration.

The angle between the horizontal and a line joining the toes of the bench on the wall is a basic element of slope design and is termed the “inter-ramp angle” (IRA). The incorporation of ramps onto a wall will result in a slope that has an “overall slope angle” (OSA) that is shallower than the inter-ramp angle.

6.2 Rock Slope Failure Mechanisms

The stability of slopes excavated in competent rock is normally a function of structurally controlled failure mechanisms. However, in high slopes or slopes excavated in incompetent rock, overall slope failure mechanisms that involve the development of failure surfaces through intact rock and along pre-existing geologic surfaces are also a concern. These two principal failure mechanisms are discussed in further detail in the following sections.

6.2.1 Structurally Controlled Failure Mechanisms

The three basic mechanisms of structurally controlled failure in rock slopes are plane failures, wedge failures, and toppling failures, as described below. These mechanisms are shown schematically in Figure 10.

Planar failures may occur when a geologic discontinuity dips out of a rock slope at an angle that is shallower than the inclination of the slope, but steeper than the effective angle of friction along the discontinuities. Planar failures typically only develop to a significant extent if the azimuth 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 wedge failure to occur, 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 azimuth of the slope face.

Toppling failures may develop when a rock mass contains multiple, parallel, steeply dipping, continuous geologic structures, such as bedding or continuous joints or foliation planes, that strike nearly parallel to the strike of the face of the rock slope. Toppling failures 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 slope angle, and by the spacing, inclination, and continuity of the toppling blocks. Widely spaced and/or discontinuous structures 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.

All structurally controlled failure modes are influenced by groundwater pressure within the slope, and toppling failures are particularly sensitive to groundwater pressure. The magnitude and frequency of structurally controlled failures are directly related to the continuity of the structures along which sliding can occur. Rock mass structures that exhibit limited continuity, such as joints, may result in small 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. Therefore, it is these more continuous structures that are of primary concern for pit slope design.

6.2.2 Overall Rock Mass Strength Failure Mechanisms

Slopes excavated in weak or heavily fractured rock masses, or extremely high slopes, can be susceptible to overall rock mass failure, which involves the development of pseudo-circular type failure zones through intact rock (Figure 11). Where major structures are present with an appropriate orientation, these structures may be partially involved in a more complex failure mechanism by creating release planes for the rock mass failure.

The geotechnical assessment of the rock mass quality in the proposed pit areas, based on data from simplified geotechnical logging of exploration core holes, has indicated that the majority of the rock is expected to exhibit fair quality in terms of the RMR_{76} (1976) classification system. The intact rock strength is expected to be strong for the majority of the rock types, i.e. breccias, diorites and monzonites.

The main consideration for rock slope failure mechanisms in the proposed pits will be structurally controlled mechanisms (kinematics), at either a small scale (i.e., benches) along less continuous structures (joints), or at a larger scale (i.e. inter-ramp and multi-bench slopes) along more continuous structures (persistent joints and faults). The assessment of the potential, structurally-controlled failure mechanisms was carried out through kinematic stability analyses.

6.3 Overall Stability with Respect to Major Faults Assessment

Figures 6 and 7 show the projected location of the major faults with respect to the existing and the proposed ultimate pit walls, respectively. The influence that these faults are expected to have on the proposed ultimate pit walls are discussed below.

Wishbone, Springer South Boundary and Unnamed Faults

These faults are located along the northwest side of the existing Springer Pit (Photograph A-9). The steep, northwesterly dipping faults are expected to strike obliquely to the Northeast and West Walls of the Springer Pit, and to dip into the walls. The faults will be favorably oriented with respect to these walls, and potential instability is expected to be limited to minor bench scale ravelling along the exposure of the faults. This is extent of instability being exhibited in the existing pit walls.

Springer Fault

The north-south striking Springer Fault is expected to dip steeply into the Northeast Wall. The fault zone has been intruded by a number of late stage dykes. Instability along the existing exposure has been limited to localized ravelling and loss of bench crests along the exposure of the fault (Photograph A-3). The ultimate wall is expected to exhibit similar stability performance with respect to the fault exposure.

Southwest Fault

The north-northwest dipping Southwest Fault is expected to be exposed in the West and the East Walls, and in the south side of the pit floor. According to Figure 6, the fault should be exposed in the current pit walls. There is little evidence of this fault in the East Wall, and the fault may be intersected and cut-off by other faults or north-south trending dykes before it intersects the East Wall. The fault does appear to be exposed in the west side of the existing South Wall. This steeply dipping fault has been intruded by a dyke, and instability has been limited to localized ravelling and the loss of bench crests along the dyke. The ultimate pit is expected to exhibit similar stability performance with respect to this fault.

Polley Fault

The steep, east-northeast dipping Polley Fault is exposed in the existing Springer and Cariboo Pits (Photographs A-4 and A-5). Multi-bench scale toppling instability occurred in the upper portion of the previous pushback of the Northeast Wall. The toppling resulted in extensive ravelling and the loss of benches and catch-benches in the immediate hangingwall and footwall of the fault. The fault will again strike obliquely to the proposed ultimate Northeast Wall, and toppling instability is again expected to occur adjacent to the fault. A single bench configuration is proposed for the Northeast Wall, and this is expected to provide adequate overall slope stability performance and bench scale catchment, as it did on the previous pushback.

East Cariboo Fault

The ultimate pit wall is currently being excavated along the east side of the Cariboo Fault. The steep, northeast dipping East Cariboo Fault is exposed in the existing wall, and toppling deformations are occurring within the existing slope. The deformations have resulted in ravelling and cracking behind the crest of the slope.

The toppling is not expected to results in catastrophic failure of the slope. Rather, the slope is expected to exhibit going deformation as the wall is excavated deeper. This is typical for toppling instability. A single bench configuration has been recommended for the portion of the East Wall that strikes parallel to the fault. If the rock quality improves at depth, and steep northeasterly dipping structures are not exposed in the wall, it may be possible to resume using a double bench configuration on the lower portion of the wall.

6.4 Overall Rock Slope Stability Assessment

The stability of the Southwest Wall of the Springer Pit with respect to circular type failure through overall rock mass was assessed previously in Golder's 2015 geotechnical assessment for the pit closure report (Golder 2015a). The results of those analyses indicated that the Southwest Wall is expected to exhibit adequate stability with respect to overall slope failure through intact rock mass. Those analyses are considered to be adequate for the current configuration of the life of mine Springer Pit, and no additional analyses are required for the Southwest Wall at this time.

The stability of the Northeast Wall in the Springer Pit has been assessed with respect to potential circular type failure through the rock mass. The slope of the Northeast Wall will exhibit the most adverse combination of slope height and overall slope angle, and consequently has been selected as the critical scenario for the stability analyses. The location of the stability analysis cross section is shown in Figure C-1, in Appendix C.

No critical infrastructure is located near the Springer Pit. Failure of a significant portion of the Northeast Wall could impact mining production by limiting access to the pit floor, thereby temporarily limiting production from mining operations. This can be considered to be a medium consequence of failure, and a Factor of Safety of 1.3 is considered to be appropriate (Read and Stacey 2009) at the overall slope scale during operation.

The following strength parameters in Table 10 have been used in the stability analyses, and are based on the results of previous mapping and drilling geotechnical investigations carried out in the existing pits.

Table 10: Strength Input Parameters for Northeast Wall Slope Stability Analyses

Rock Type	Unit Weight	Hoek-Brown Strength Input Parameters				Mohr-Coloumb Input Parameters	
	kN/m^3	UCS (MPa)	m_i	GSI(1)	D(2)	Friction Angle (ϕ, in degrees)	Cohesion (c, in kPa)
Diorite	26	75	25	57	0.8 within 24m of the face, 0 elsewhere	Not applicable	
Faults	24	Not applicable				25	0

1) RMR_{76} assumed to be equivalent to GSI.

2) Blast disturbance damage assumed to be 0 at the overall slope scale (Hoek 2012). The disturbance factor of 0.8 is intended to account for blast damage and weaker rock observed within 24 meters of the pit wall.

To our knowledge there are no piezometers or other hydrogeological instrumentation have been installed in the vicinity of the Northeast Wall of the Springer Pit. Based on field observations, some localized seepage is occurring into the pit through Northeast Wall. Consequently, some water pressures are expected to exist within the wall. In order to account for the uncertainty of the groundwater conditions, a sensitivity analysis was carried out, and the following three groundwater scenarios were modeled:

- dry slope conditions; and
- some natural drainage of groundwater pressures within the rock slope, with r_u values of 0.1 and 0.2.

The r_u method was used to model groundwater pressures within the pit slopes. The r_u method evaluates groundwater pressure as the ratio of the weight of the water pressure to the weight of the corresponding overburden pressure above a given point in the rock slope.

These scenarios are shown schematically in the stability analysis material properties summary Figure C-2 presented in Appendix C.

For each groundwater case, overall slope stability with respect to circular failure through intact rock was assessed using the auto-refine circular search method in SLIDE. A summary of the slope stability analyses results is presented in Table 11.

Table 11: Summary of Springer Pit Northeast Wall Slope Stability Analysis Results

Failure Mechanism	Scale of Failure Surface	Groundwater Pressure	Target Factor of Safety (GLE)	Indicated Factor of Safety (GLE)	Figure No.
Circular failure through blast-damaged rock within 24 m of the slope face	Inter-ramp Slope	Dry	1.3	3.37	C-3
		Partially Saturated $r_u = 0.1$		3.00	C-4
		Partially Saturated $r_u = 0.2$		2.63	C-5
Circular failure through intact rock	Overall Slope	Dry	1.3	3.55	C-6
		Partially Saturated $r_u = 0.1$		3.18	C-7
		Partially Saturated $r_u = 0.2$		2.81	C-8

The results of the stability analyses are shown in Figures C-3 through C-8, in Appendix C. The results of the analyses indicate that the proposed slope is expected to exhibit Factors of Safety of between 3.37 and 2.63 with respect to potential circular failure through the near surface blast damaged rock mass for dry conditions and for an r_u of 0.2, respectively. The results of the analyses indicate that the proposed slope is expected to exhibit Factors of Safety of between 3.55 and 2.81 with respect to potential circular failure through the overall slope for dry conditions and for an r_u of 0.2, respectively. Consequently, the slope is expected to exhibit adequate stability with respect to these two mechanisms.

Given that the other pit walls are expected to exhibit either lower heights or lower overall slope angles, and similar overall rock mass strengths are expected, the remaining pit walls are also expected to exhibit adequate overall slope stability.

6.5 Kinematic Stability Assessment

Given that the proposed pit walls are expected to be controlled structural type failure mechanisms, kinematic stability analyses have been carried out to determine optimum bench face angles and inter-ramp angles for the various pit wall sectors. Planar and wedge failure mechanisms were considered in the stability analyses.

The stability of the bench faces will be controlled by the discontinuous joint sets that will be exposed as the benches mined. The stability of the inter-ramp slopes of the proposed walls will be controlled by the more continuous structures, such as faults, that will be exposed in the pit walls. These joints and faults were mapped by Golder in the field, and were discussed previously in Section 4.1.2. The discontinuous and continuous structural sets presented in Figures B-1 through B-4 were used in the planar and wedge stability analyses. Their orientations were summarized previously in Section 4.1.2(in Table 4 and Table 5) and a reference those previous summary tables and figures is presented in Table 12.

Table 12: Reference to Continuous and Discontinuous Structural Design Sets

Pit Area	Discontinuity Type	Number of Sets	Applicable Kinematic Stability Analyses	Reference Figure Number	Reference Table Number
Springer	Discontinuous Structure Sets	9	Bench Face Angle	Figure B-1	Table 4 in Section 4.1.2
Springer	Continuous Structure Sets	6	Inter-Ramp Angle	Figure B-2	
Cariboo and C2 Pits	Discontinuous Structure Sets	7	Bench Face Angle	Figure B-3	Table 5 in Section 4.1.2
Cariboo and C2 Pits	Continuous Structure Sets	8	Inter-Ramp Angle	Figure B-4	

Based on the pit wall geotechnical mapping of the discontinuity surface conditions, and using the Barton-Bandis relationship between intact rock strength, JRC and slope height (1990), strength parameters were developed for the discontinuous and continuous structural sets at Mt. Polley Mine. The discontinuous structures are expected to control the stability of the benches, and consequently a relatively low confining stress, equivalent to the height of a twelve metre single bench, was used to develop the strength parameters for the bench-scale kinematic analyses. The following strength parameters were used for the discontinuous structures surfaces in the kinematic analyses:

<u>Discontinuous Structure Surface Strength Parameters</u>

Friction Angle: 43 degrees
Cohesion: 0 kPa.

The continuous structures are expected to control the stability of the inter-ramp slopes. These structures will be subjected to higher confining stresses than those used in the bench-scale analyses. Consequently, a confining stress equivalent to the height of an inter-ramp slope (approximately 48 metres), was used to develop the strength parameters for the inter-ramp scale kinematic analyses. The following strength parameters were used for the continuous structures surfaces in the kinematic analyses:

Continuous Structure Surface Strength Parameters

Friction Angle:	32 degrees
Cohesion:	21 kPa.

The discontinuous structure surface strength parameters were used for the analyses of the discontinuous structures in the bench faces, while the continuous structure strength parameters were used for the analyses of continuous structures at the inter-ramp scale.

Groundwater pressures are expected within the benches and within the inter-ramp slopes. In order to account for this pressure, the water table was set at one half of the slope height in the planar bench scale and inter-ramp kinematic analyses. This results in water pressure being applied to approximately one half of the surface area of each planar failure that is analysed. The geometry of the wedge analyses causes a smaller portion of the wedge surface area to be formed within the bottom half of the slope. In order to account for this, the water table was set at two thirds of the slope height in the wedge bench-scale and inter-ramp kinematic analyses.

The potential for planar and wedge failures for bench scale stability was assessed for 12 metre bench heights using planar and wedge stability analyses. The potential for planar and wedge failures for inter-ramp stability was assessed for a height of four benches, or 48 meters. The stability of the pit walls and the optimum design bench configurations will depend on the orientations of the walls with respect to the major faults and joint sets that are expected to be exposed in the pit walls. Therefore, recommendations regarding optimum design bench configurations are provided in terms of wall orientations. The wall orientations are expressed in terms of the wall "dip-direction", *i.e.,* the direction the wall faces, and in terms of "Sector Azimuth" for mine engineering pit design purposes. The Sector Azimuth is the dip-direction of the wall minus 180 degrees, and this is shown conceptually in Figure 9. The Sector Azimuth is essentially the side of the pit that the wall is located on. The analyses have been carried out for the following 12 wall sector orientation azimuths (direction the wall faces): 000°, 030°, 060°, 090°, 120°, 150°, 180°, 210°, 240°, 270°, 300°, and 330°.

The stability of all structures that exhibit a dip-direction of plus or minus 30 degrees from the sector azimuth was assessed in the planar analyses. The stability of all potential wedges that exhibit a line of intersection trend of plus or minus 45 degrees of the sector azimuth was assessed in the wedge analyses. The dips of all planes and the plunges of all wedges that exhibited a Factor of Safety (FOS) of less than 1.0 have been plotted by design sector on cumulative frequency plots for both the wedge and planar analyses, for the bench and inter-ramp scale kinematic analyses. These plots are summarized in the tables in Appendix D in the following sections. Examples of planar and wedge cumulative frequency plots used in the kinematic stability analyses are also shown in Appendix D, in Figures D-1 and D-2, respectively.

The results of the bench and inter-ramp scale kinematic stability analyses were used to determine bench design configurations for the Springer and Cariboo Pits. These results are summarized for each pit area in the following sections.

6.5.1 Bench Scale Stability Assessment Methodology

Bench scale kinematic stability assessments were carried out for the Springer and Cariboo Pits using the discontinuous structural sets presented in Figure B-1 and Figure B-3, respectively. A summary of the kinematically admissible planes and wedges, and planes and wedges with an FOS of less than 1.0, for the Springer and Cariboo Pits are presented in Tables D-1 and D-4, respectively, in Appendix D. The optimum design bench face angles (BFAs) required to limit undercutting to 50 percent of the steeply dipping structures are also shown in the table.

The recommended design bench face angles were reviewed on the basis of the critical case (i.e., the shallower indicated BFA) between the wedge and planar analyses, and were rounded to the nearest 5 degree increment. The results of the kinematic wedge analyses indicate that bench face angles between 65 and 70 degrees may be achieved in the proposed pit walls. This is consistent with observed stability performance in the existing pits.

However, some of the results of the planar analyses indicate low BFAs in comparison to the wedge analyses for the same slope angles. These results are not consistent with observed performance to date in the date in the Springer Pit and Cariboo Pit areas. This typically occurs where structures exhibit a continuity that is significantly less than the bench heights, Set 4 on the South Walls for example. Consequently, based on Golder's previous experience in the Springer and Cariboo Pits, the recommended bench face angles shown in the tables in Appendix D were used to develop the pit slope design recommendations presented in the following sections.

6.5.2 Inter-ramp Scale Stability Assessment Methodology

Inter-ramp scale kinematic stability assessments were carried out for the proposed Springer and Cariboo Pits using the continuous structural sets presented in Figure B-2 and B-4. It is recommended that the maximum IRA for each wall be designed to undercut no more than approximately 25 percent of kinematically feasible planar and wedge failures.

A summary of the kinematically admissible planes and wedges, with an FOS of less than 1.0, and the IRAs required to limit undercutting to 25 percent of the structures are presented in Table D-2 and D-5 for the Springer and Cariboo Pits, respectively, in Appendix D.

6.5.3 Springer Pit Recommended Bench Design Configurations

Bench design recommendations for walls to be excavated in the Springer Pit are presented in Table 13 (note that this table is essentially a condensed version of Table D-3, presented in Appendix D).

Table 13: Summary of Springer Pit Recommended Bench Design Configurations

Wall Dip Direction (Azimuth, in degrees)	Pit Design Sector Azimuth (degrees)	Bench Height (m)	Bench Face Angle (degrees)	Inter-ramp Angle (degrees)	Bench Width (m)	Rationale
000°	180°	12	70	43	8.5	Single bench due to shallower dipping Set 3 structures on South Wall.
030°	210°	24	70	50	11.5	
060° to 180°	240° to 000°	24	65	46.5	11.5	
210° to 240°	030° to 060°	12	70	43	8.5	Single bench through Polley and Springer Faults
270°	090°	12	70	43	8.5	Single bench through Polley and Springer Faults Single bench due to shallow westerly dipping structures at bottom of East Wall.
300° to 330°	120° to 150°	12	70	43	8.5	Single bench due to shallower dipping Set 3 structures on South Wall.

6.5.4 Cariboo and C2 Pit Recommended Bench Design Configurations

Bench design recommendations for walls to be excavated in the Cariboo Pit and the C2 Pit are presented in Table 14 (note that this table is essentially a condensed version of Table D-6, presented in Appendix D).

Table 14: Summary of Cariboo and C2 Recommended Bench Design Configurations

Wall Dip Direction (Azimuth, in degrees)	Pit Design Sector Azimuth (degrees)	Bench Height (m)	Bench Face Angle (degrees)	Inter-ramp Angle (degrees)	Bench Width (m)	Rationale
000°	180°	24	65	46	12	Shallow dipping, discontinuous Set 4 creates bench scale ravelling along small planar failures along south walls. Use a double bench configuration with 65 degree BFA.
030°	210°	24/12	65/70	46/43	12/8.5	Use single bench with 70° BFA in Polley Fault. Otherwise double bench at 65° BFA.
060° to 090°	240° to 270°	24/12	70	49/43	12/8.5	Use single bench with 70° BFA in Polley Fault. Otherwise double bench at 65° BFA.
120°	300°	24/12	65/70	46/43	12/8.5	Use single bench with 70° BFA in Polley Fault. Otherwise double bench at 65° BFA.
150°	330°	24	65	46	12	
180° to 240°	000° to 060°	24	70	49	12.13	
270°	090°	12	70	43	8.5	Original design was 51 degree IRA (Golder 2013). However, current design is single bench due to toppling along East Cariboo Fault.
300°	120°	24	70	49	12.13	
330°	150°	24	65	46	12	Shallow dipping, discontinuous Set 4 creates bench scale ravelling along small planar failures along south walls. Use a double bench configuration with 65 degree BFA.

7.0 OPERATIONAL CONSIDERATIONS

7.1 Blasting and Excavation

The stability of the individual benches in the proposed expansion pits will be largely dependent upon the degree of disturbance or damage that the benches are exposed to during blasting and excavation. Blast damage or over-excavation at the toe of the benches will result in undercutting of the benches, and will increase the potential for developing instability. Therefore, some form of controlled blasting (either buffer blasting or pre-shear blasting) and excavation control will be necessary during the drilling, blasting and excavation. MPMC have had good success with pre-shear blasting in the past, and with trim and buffer blasting more recently.

The relatively competent rocks in the pit will be amenable to true pre-shear blasting, where a line of closely-spaced final wall holes are fired in unison prior to initiating the trim and buffer shot. The following principals should be used in pre-shear blasting.

- Successful pre-shear blasting is dependent upon developing a tension zone that propagates to form a continuous crack between adjacent drill holes. In order to form this tension zone, the holes must be very closely-spaced. A general rule of thumb is that the blast hole spacing measured in feet should be no more than the blast hole diameter measured in inches. For example, the maximum hole spacing for a 6-inch diameter drill hole is 6 feet. This is where most open pre-shear blasting fails, in that mines are unwilling to drill at such a close spacing, or are unable to do so due to large size of drilling equipment in use.
- Production blasts should be fired no closer than four to five rows from the final wall in order to avoid damaging the final wall before the pre-shear blast is fired. Often the buffer zone is too small to prevent pre-damage of the rocks before the pre-shear pattern is initiated.
- Rather than distribute the blasting agent evenly along the length of the pre-shear blast hole, a toe charge is usually used, which results in excessive damage at the toe of the hole and inadequate fragmentation in the upper portion of the hole.

As an alternative to pre-shear blasting, trim and buffer blasting can be used. This involves the firing a four to six row shot to a free face, without a pre-shear row. The burden, spacing and loading are reduced on each successive row. The key to successful trim and buffer blasting is rapid and consistent burden relief so that blast vibrations and gases move toward the free face and away from the final wall. Aspects of adequate burden relief include the following.

- The powder factor must be maintained or increased slightly to retain proper fragmentation, muck movement and burden relief. A common mistake is to reduce the powder factor on buffer and trim rows in the belief that it will reduce blast vibrations that damage the wall. However, a given rock mass requires a minimum powder factor to achieve adequate fragmentation. Anything less results in reduced fragmentation, reduced muck moment, reduced burden relief and consequent higher blast vibrations and high gas pressures behind the blast, i.e., in the final wall.
- Timing between rows is critical to achieve burden relief. The rock ahead of each blast hole must be adequately fragmented in order to provide adequate burden relief.

At most operations, shovel or loader operators typically dig back to hard ground when conducting the final clean-up of benches, in order to remove loose rock and to reduce the incidence of ravelling. While this practice is appropriate for the upper portion of the bench, it must be discouraged for the toe area of the benches. The need to avoid undercutting of the toes of the slopes should be passed onto the operators through a series of meetings with the mine engineering staff.

7.2 Geotechnical Monitoring Program

The ongoing development of the pits will require an observational approach. With this method, which is common practice in the mining industry, the initial pit excavations are monitored and the pit slope designs are modified on an ongoing basis throughout the life of the pit. It is expected that revisions will be made based on further review and mapping and stability performance monitoring, as mining exposes subsurface geology in the proposed pit.

A pit slope monitoring program should be established as part of the ongoing geotechnical program for the pit. The monitoring program is intended to both confirm the assumptions made regarding the geology and to detect unexpected conditions in sufficient time that remedial measures can be adopted.

The program recommended in the following paragraphs is intended to be carried out largely by the mine staff, although routine review by an experienced rock slope design engineer is recommended.

7.2.1 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 orientation and character of the systematic rock fabric and continuous structures with respect to the interpreted orientation, as the locations of the slope design sectors are based on the orientation of these features; and
- the presence and orientation of major continuous structures, such as 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.

7.2.2 Slope Stability Monitoring

A major part of the slope stability monitoring program will be the 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. These regular inspections should ideally be carried out by the same individual to maintain continuity of the observations. 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.

Survey monitoring should be considered, and it is routine practice in large open pit mines to install monitoring prisms on every second or third bench at spacings on the order of 100 metres. If necessary, the services of a specialty contractor can be retained to install the prisms where they are required in areas where inadequate coverage exists.

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, visual monitoring should be carried out once per month during the summer and winter months, and weekly during the spring runoff. Prism monitoring should be carried out on a monthly basis, and increased as necessary should instability develop.

8.0 CLOSURE

The reader is referred to the Study Limitations, which follows the text and forms an integral part 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.

J. Kelly Hood, P.Eng.
Geotechnical Engineer

Al Chance, P.Eng.
Principal, Geotechnical Engineer

JKH/AVC/ls/rs

o:\final\2005\2005\1413\05-1413-027\051413027-111-r-rev0-2115\051413027-111-r-rev0-2115-springer and cariboo pit design report 09may_16.docx

REFERENCES

Barton, N.R. and Bandis, S. 1990. *Review of predictive capabilities of JRC-JCS model in engineering practice.* In Rock joints, proc. int. symp. on rock joints, Loen, Norway, (eds N. Barton and O. Stephansson), 603-610. Rotterdam: Balkema.

Bieniawski, Z.T. 1976. *Rock Mass Classification of Jointed Rock Masses. Exploration for Rock Engineering.* Z.T. Bieniawski Ed. Balkema, Johannesburg, pp. 97-106.

Golder. 2014b. *Review of Cariboo Pit Slope Design, Mount Polley Mine.* Report submitted January 31, 2014.

Golder 2015a. *Results Of Geotechnical Assessment For The Springer Pit Slope Stability, Mount Polley Mine – Return To Full Operations.* Technical memorandum submitted October 30, 2015. Reference No. 1411734-092-TM-Rev0-15000.

Golder 2015b. *Draft Report on Mount Polley Mine 2013 Annual Pit Slope and Waste Dump Stability Review*. Draft report submitted November 4, 2015.

Golder 2016. *Draft Report on Mount Polley Mine 2014/2015 Pit Slope and Waste Dump Stability Review.* Draft report submitted April 20, 2016.

ISRM (International Society for Rock Mechanics). 1981. Technical procedure. *Rock characterization, testing and monitoring*. In: Brown, E.T. (ed.), ISRM Suggested Methods. Pergamon Press. Oxford, p. 211.

Wafforn. 2013. *Structural Geology of the Mt. Polley Cu-Au District, South Central British Columbia.* A Thesis submitted to Oregon State University on July 11, 2013.

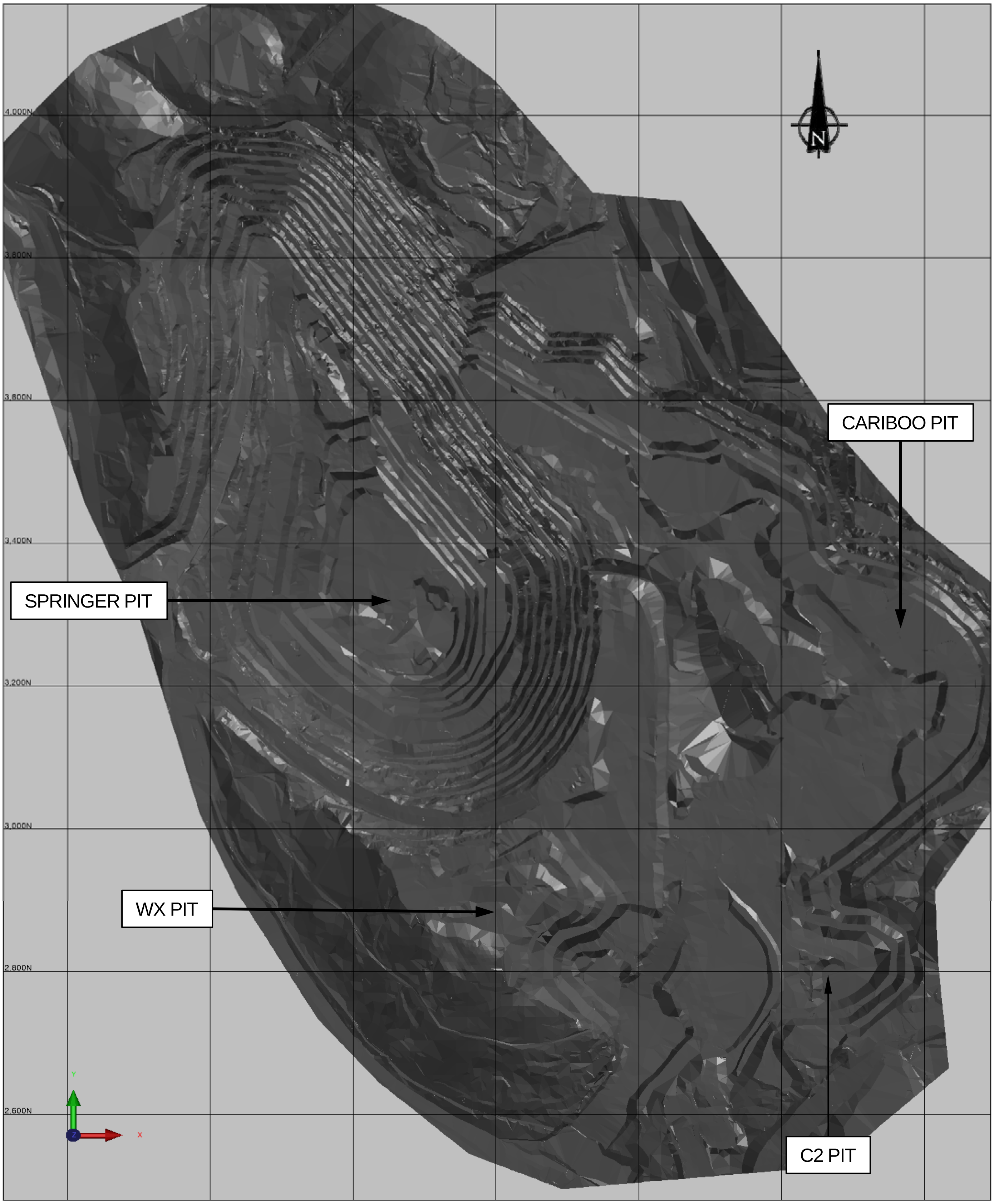
STUDY LIMITATIONS

Golder Associates Ltd. (Golder) has prepared this document in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this document. No warranty, express or implied, is made.

This document, including all text, data, tables, plans, figures, drawings and other documents contained herein, has been prepared by Golder for the sole benefit of Mount Polley Mine. It represents Golder's professional judgement based on the knowledge and information available at the time of completion. Golder is not responsible for any unauthorized use or modification of this document. All third parties relying on this document do so at their own risk.

The factual data, interpretations, suggestions, recommendations and opinions expressed in this document pertain to the specific project, site conditions, design objective, development and purpose described to Golder by Mount Polley Mine, and are not applicable to any other project or site location. In order to properly understand the factual data, interpretations, suggestions, recommendations and opinions expressed in this document, reference must be made to the entire document.

This document, including all text, data, tables, plans, figures, drawings and other documents contained herein, as well as all electronic media prepared by Golder are considered its professional work product and shall remain the copyright property of Golder. Mount Polley Mine may make copies of the document in such quantities as are reasonably necessary for those parties conducting business specifically related to the subject of this document or in support of or in response to regulatory inquiries and proceedings. Electronic media is susceptible to unauthorized modification, deterioration and incompatibility and therefore no party can rely solely on the electronic media versions of this document.



Reference: Dec 31,2015 Topo.dxf | Received from MPMC on February 18, 2016

CLIENT
MOUNT POLLEY MINING CORPORATION

PROJECT
GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-05-09
PREPARED	KGV
DESIGN	JKH
REVIEW	JKH
APPROVED	AVC

TITLE
EXISTING PIT DEVELOPMENT

PROJECT NO.	PHASE	REV.	FIGURE
051413027	**2115**	**0**	**1**

Reference: MP Total Reserve Merged Surface.dxf | Received from MPMC on February 18, 2016

CLIENT	PROJECT
MOUNT POLLEY MINING CORPORATION	GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS

CONSULTANT: Golder Associates

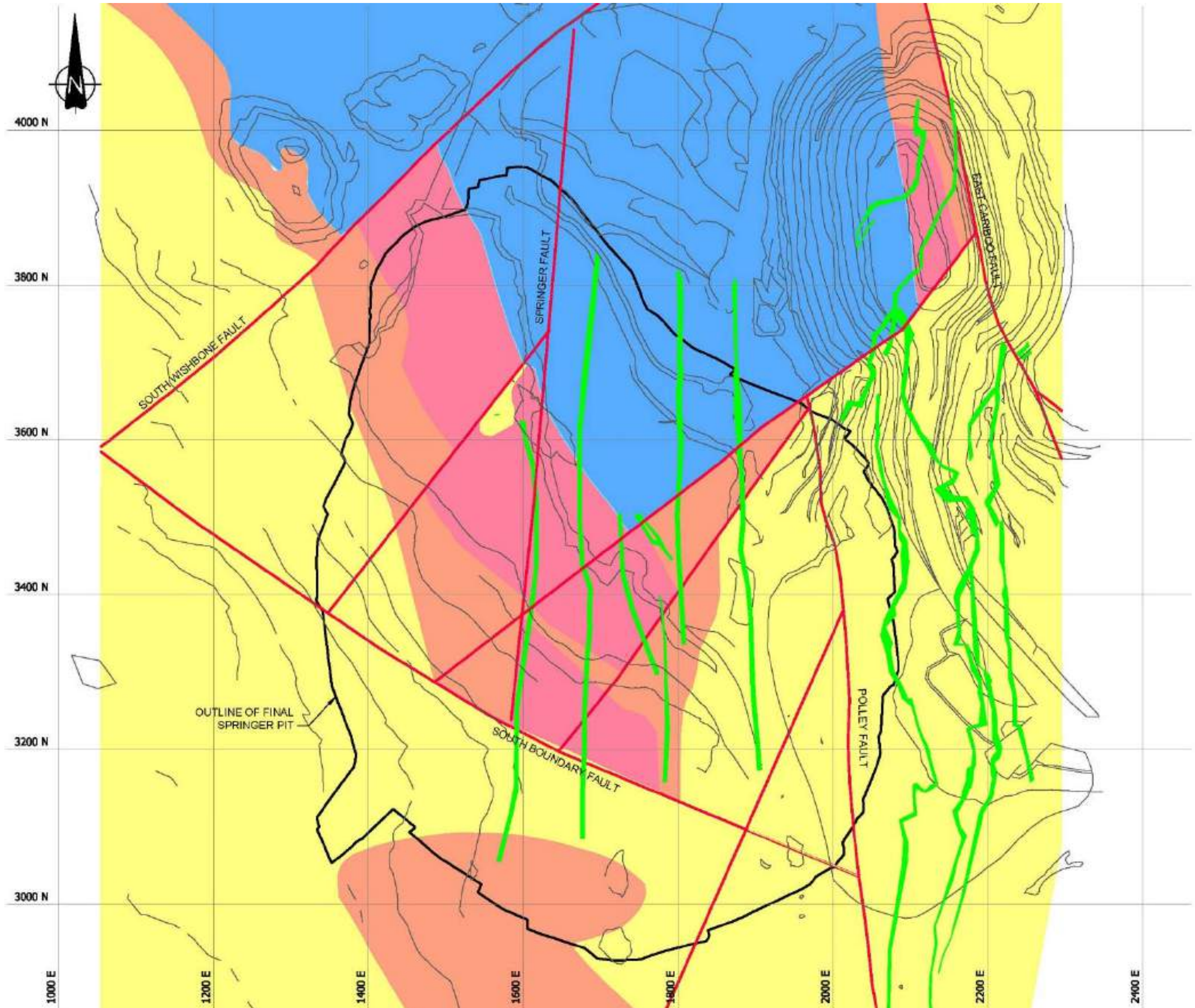
YYYY-MM-DD	2016-05-09
PREPARED	KGV
DESIGN	JKH
REVIEW	JKH
APPROVED	AVC

TITLE
PROPOSED ULTIMATE PITS

PROJECT NO.	PHASE	REV.	FIGURE
051413027	**2115**	**0**	**2**

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

Path: ---- | O:\Active_2005\1413\05-1413-027 Mt. Polley\2016 LOM Pit Design Review\Report\Rev 0



LEGEND

- MIX OF SEVERAL TYPES OF MONZONITE
- DIORITE
- MIX OF BRECCIA AND INTRUSIVE
- MINERALIZED BRECCIA
- FAULT
- AUGITE PORPHYRY DIKE

CLIENT
MOUNT POLLEY MINING CORPORATION

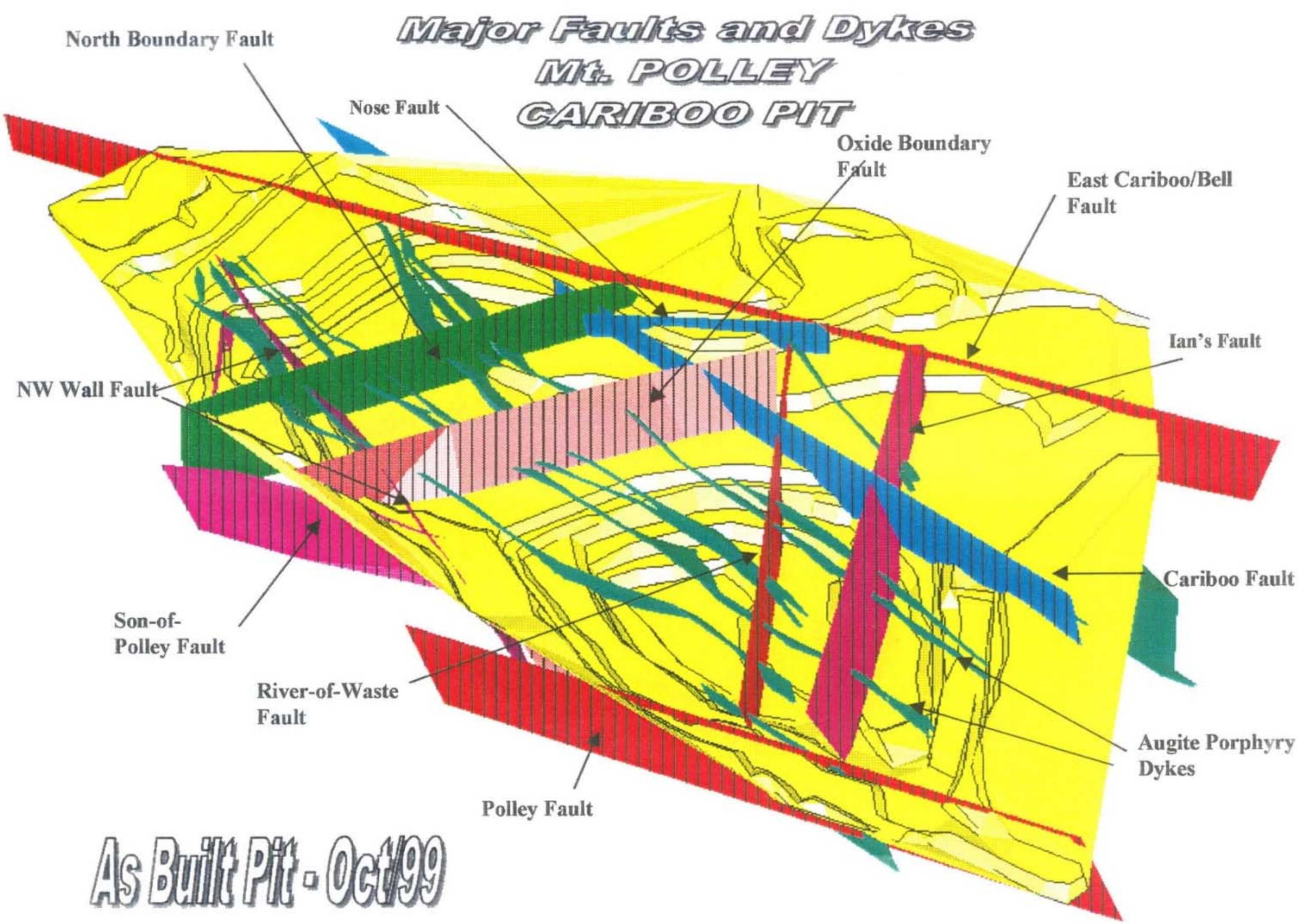
PROJECT
LOM CARIBOO AND SPRINGER PIT SLOPE DESIGN REVIEW

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-09
PREPARED	KGV
DESIGNED	JKH
REVIEWED	JKH
APPROVED	AVC

TITLE
SPRINGER PIT GEOLOGY

PROJECT NO.	PHASE	REV.	FIGURE
051413027	2115	0	3

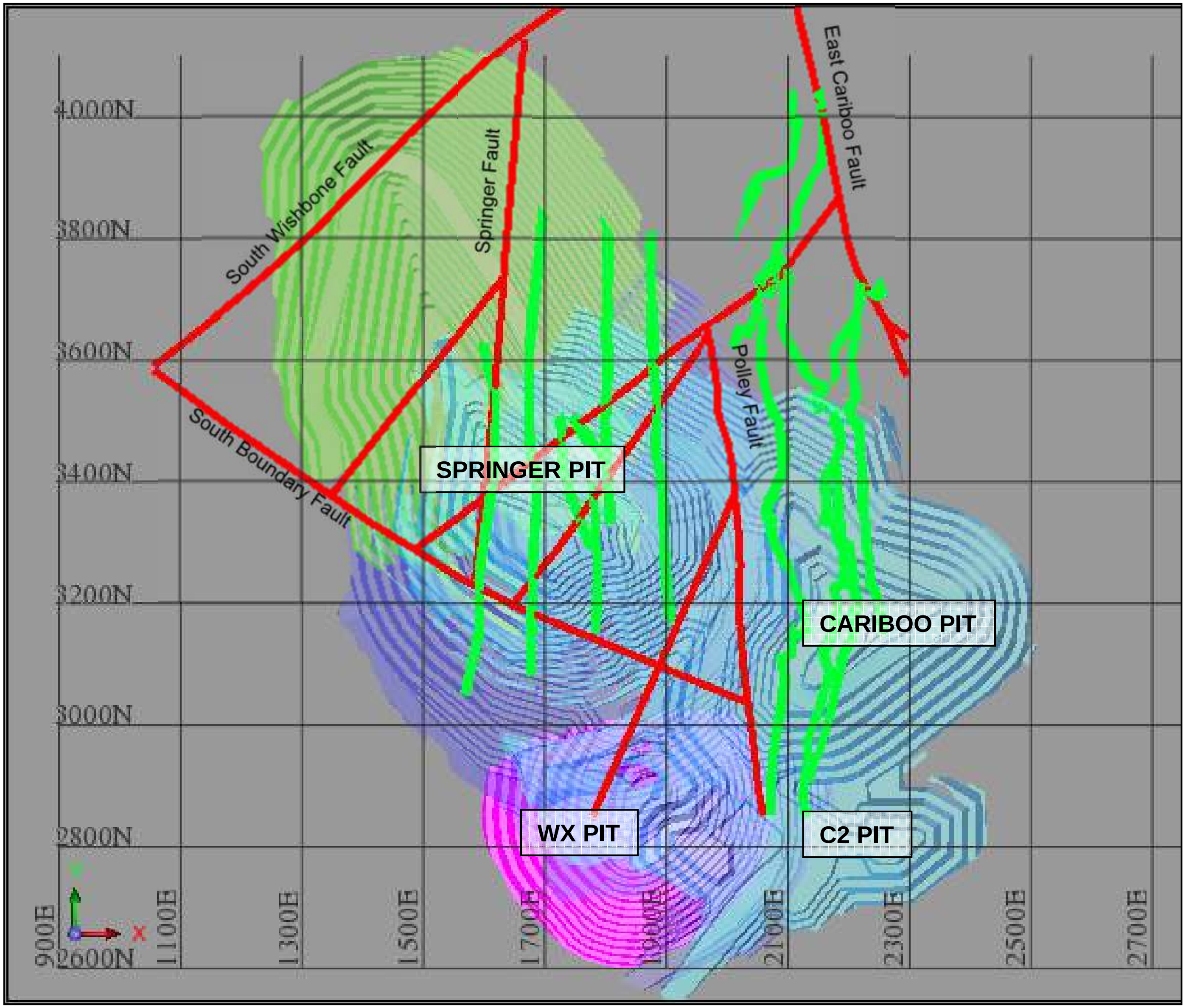


CLIENT MOUNT POLLEY MINING CORPORATION	PROJECT LOM CARIBOO AND SPRINGER PIT SLOPE DESIGN REVIEW
CONSULTANT Golder Associates	TITLE **CARIBOO PIT AND MAJOR FAULTS**

YYYY-MM-DD	2016-05-09
PREPARED	KGV
DESIGNED	JKH
REVIEWED	JKH
APPROVED	AVC

PROJECT NO.	PHASE	REV.	FIGURE
051413027	**2115**	**0**	**4**

0 1 in



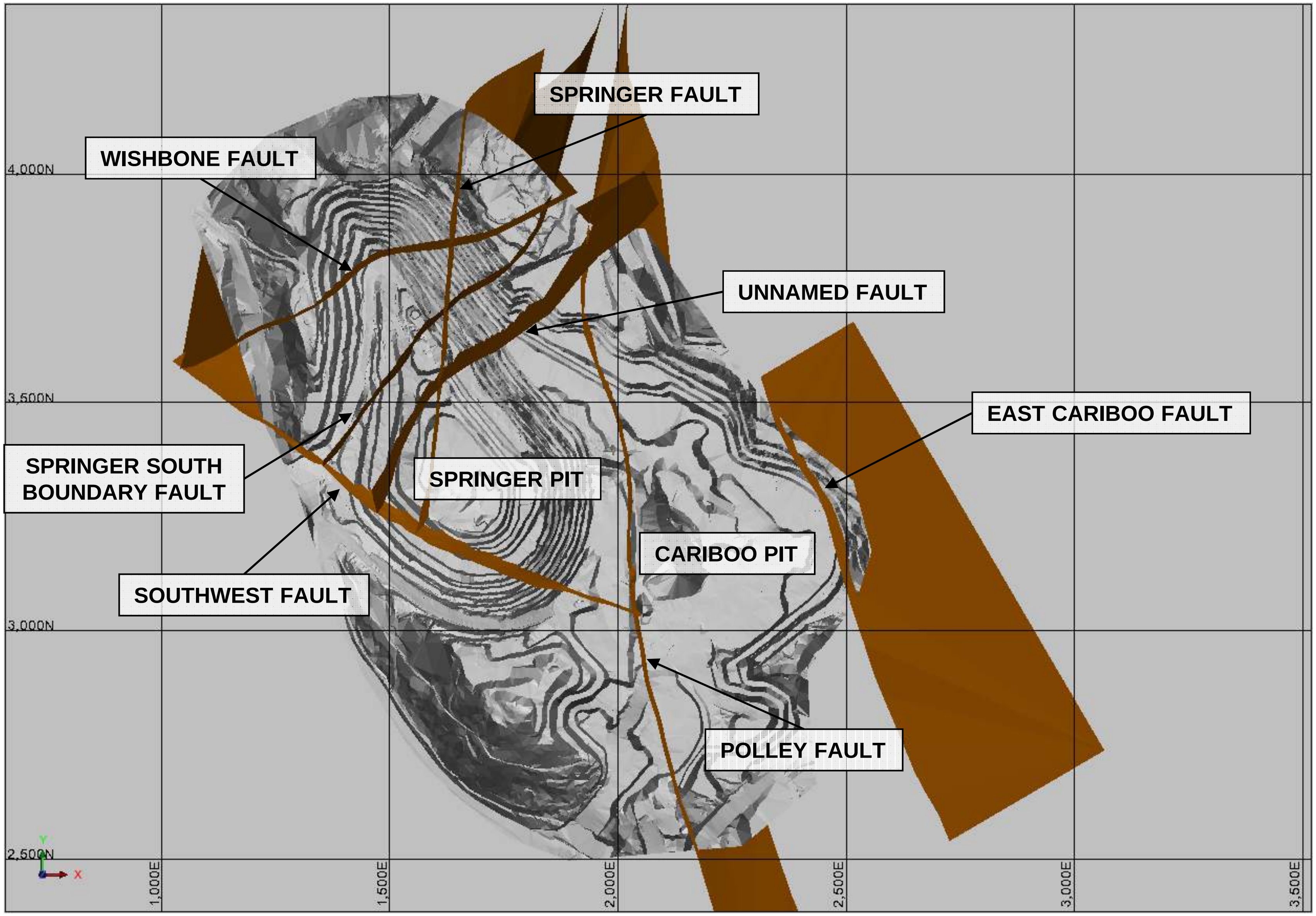
LEGEND

FAULTS

DYKES

CLIENT	MOUNT POLLEY MINING CORPORATION
PROJECT	LOM CARIBOO AND SPRINGER PIT SLOPE DESIGN REVIEW
CONSULTANT	Golder Associates
YYYY-MM-DD	2016-05-09
PREPARED	KGV
DESIGNED	JKH
REVIEWED	JKH
APPROVED	AVC
TITLE	**MAJOR FAULTS AND DYKES**
PROJECT NO.	051413027
PHASE	2115
REV.	0
FIGURE	5

Path: O:\Active_2005\1413\05-1413-027 Mt. Polley\2016 LOM Pit Design Review\Report\Rev 0 | File Name: Figures 3 to 7 Landscape Figures.pptx



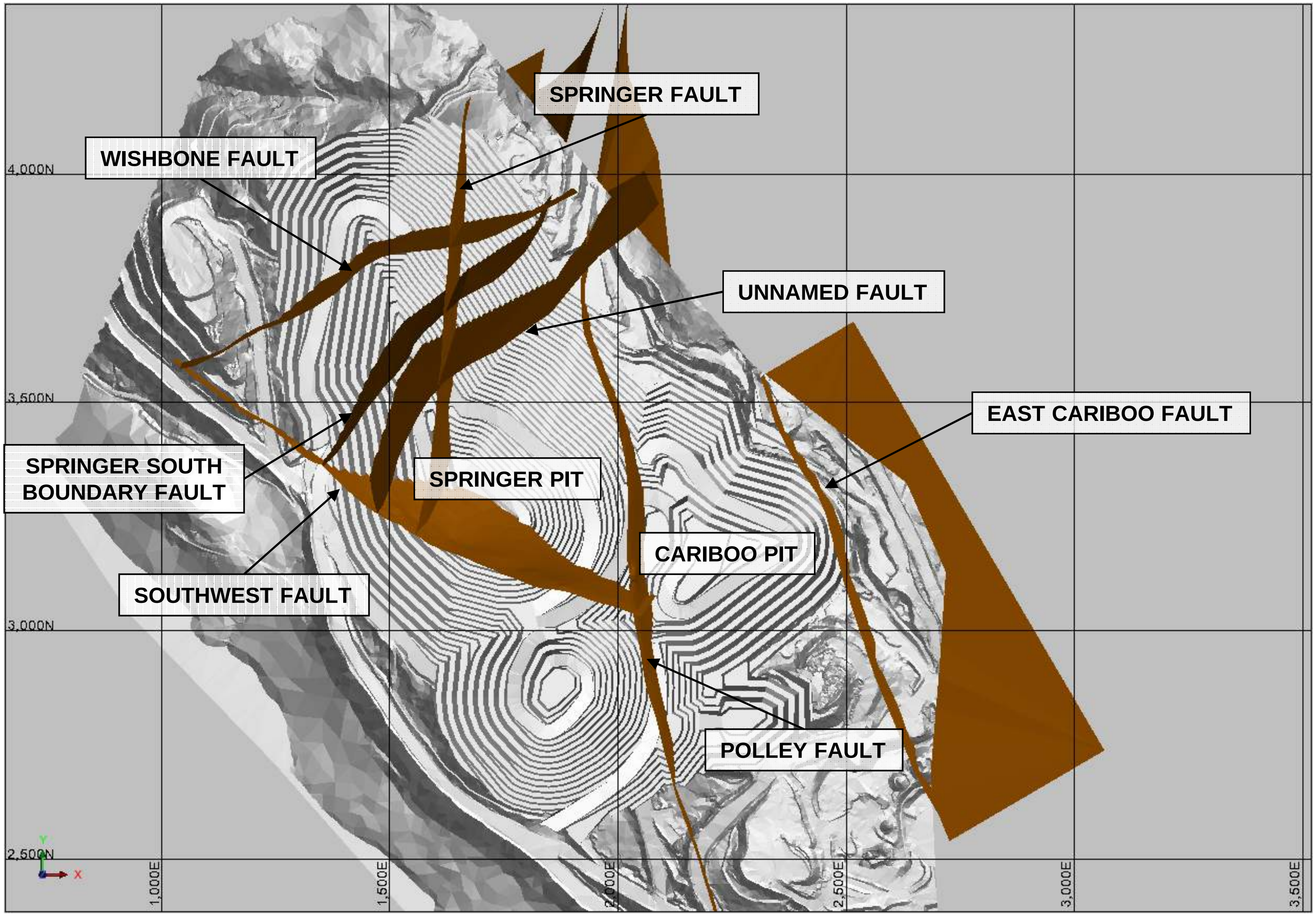
CLIENT MOUNT POLLEY MINING CORPORATION	PROJECT LOM CARIBOO AND SPRINGER PIT SLOPE DESIGN REVIEW
CONSULTANT Golder Associates	TITLE **AS-BUILT CARIBOO AND SPRINGER PITS (DECEMBER 2015) FAULT MODEL**

YYYY-MM-DD	2016-05-09
PREPARED	KGV
DESIGNED	JKH
REVIEWED	JKH
APPROVED	AVC

PROJECT NO.	PHASE	REV.	FIGURE
051413027	2115	0	6

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

Path: O:\Active_2005\1413\05-1413-027 Mt. Polley\2016 LOM Pit Design Review\Report\Rev 0 | File Name: Figures 3 to 7 Landscape Figures.pptx



CLIENT
MOUNT POLLEY MINING CORPORATION

PROJECT
LOM CARIBOO AND SPRINGER PIT SLOPE DESIGN REVIEW

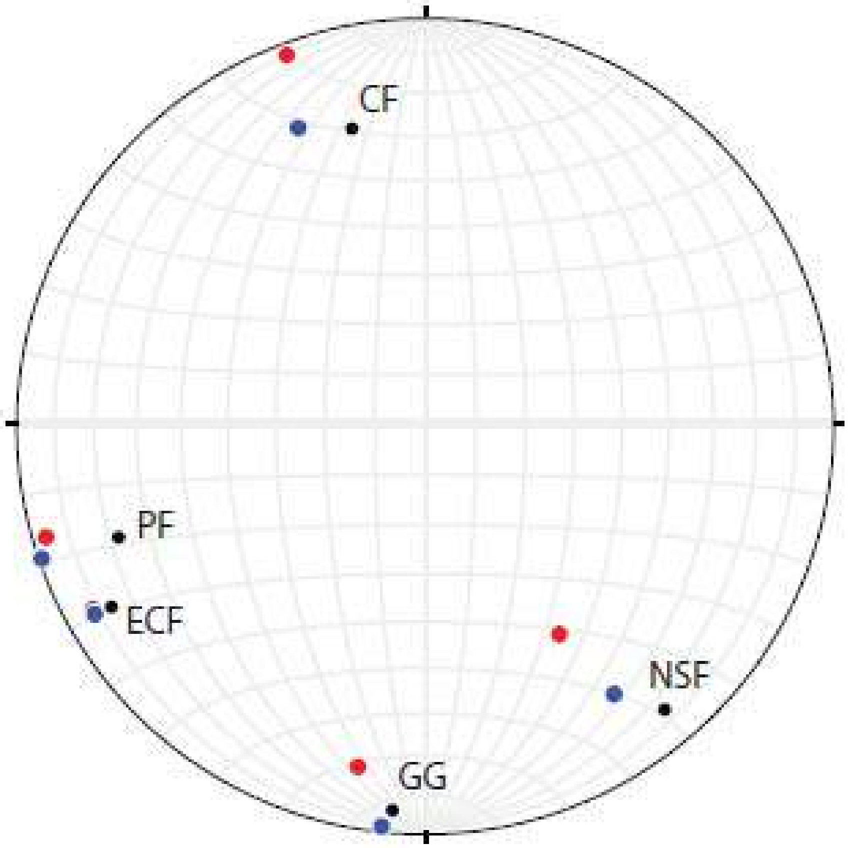
CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-09
PREPARED	KGV
DESIGNED	JKH
REVIEWED	JKH
APPROVED	AVC

TITLE
ULTIMATE CARIBOO AND SPRINGER PITS FAULT MODEL

PROJECT NO.	PHASE	REV.	FIGURE
051413027	2115	0	7

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



BLACK POLES SHOW THE FOLLOWING MAJOR FAULTS IDENTIFIED IN 2013:
PF – POLLEY FAULT
ECF – EAST CARIBOO FAULT
NSF – NORTH SPRINGER FAULT
GG – GREEN GIANT FAULT
CF – INFERRED CENTER FAULT

SOURCE OF STEREOGRAPHIC PROJECTION AND LEGEND – WAFFORN 2013

CLIENT
MOUNT POLLEY MINING CORPORATION

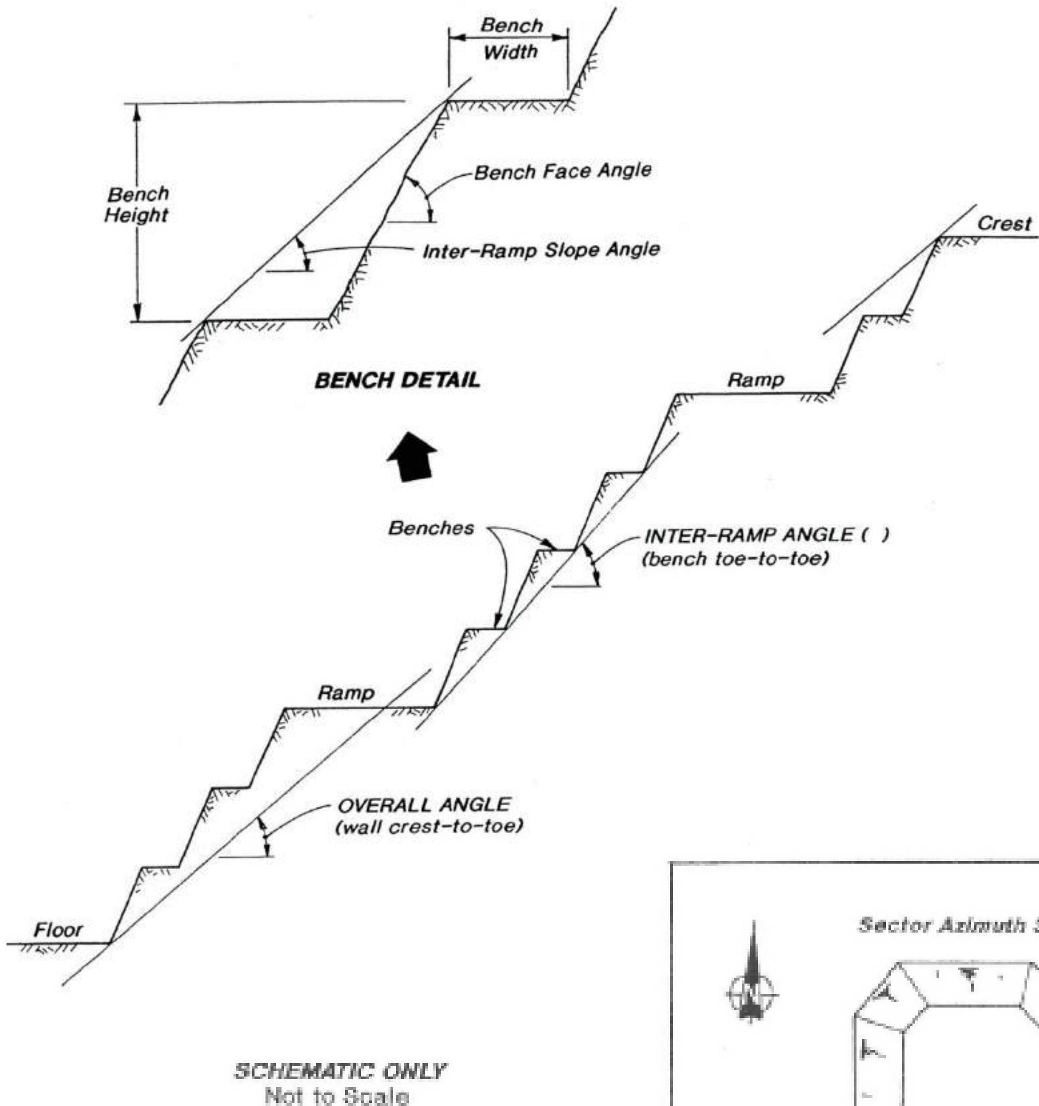
PROJECT
GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS

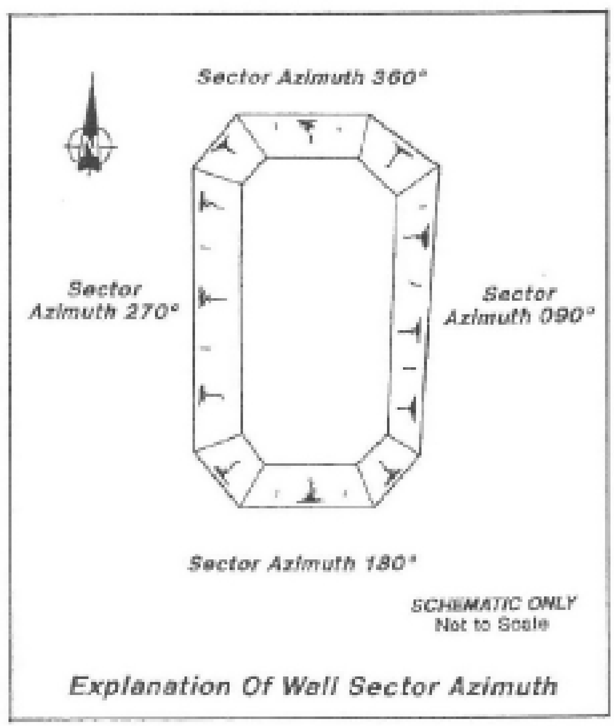
CONSULTANT

YYYY-MM-DD	2016-05-09
PREPARED	KGV
DESIGN	JKH
REVIEW	JKH
APPROVED	AVC

TITLE
STEREOGRAPHIC PROJECTION OF MAPPED MAJOR FAULTS IN THE MOUNT POLLEY AREA (SOURCE: WAFFORN 2013)

PROJECT NO.	PHASE	REV.	FIGURE
051413027	2115	0	8





CLIENT
MOUNT POLLEY MINING CORPORATION

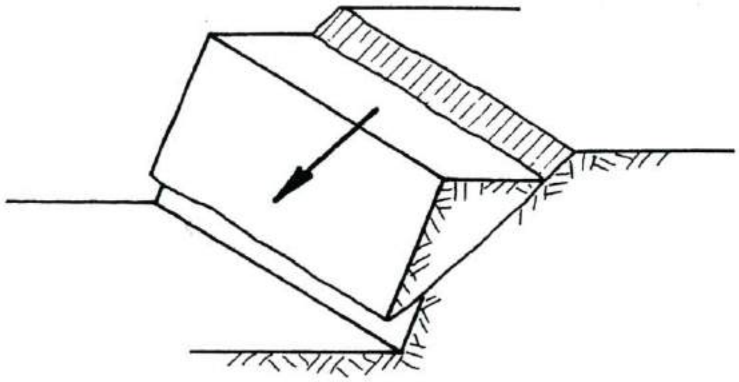
PROJECT
GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS

CONSULTANT
Golder Associates

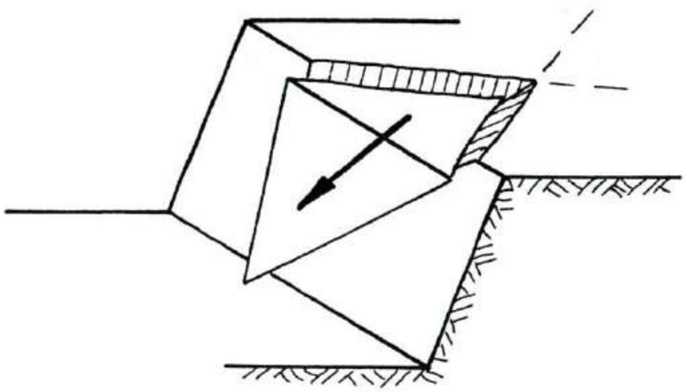
YYYY-MM-DD	2016-05-09
PREPARED	KGV
DESIGN	JKH
REVIEW	JKH
APPROVED	AVC

TITLE
SLOPE DESIGN ELEMENTS

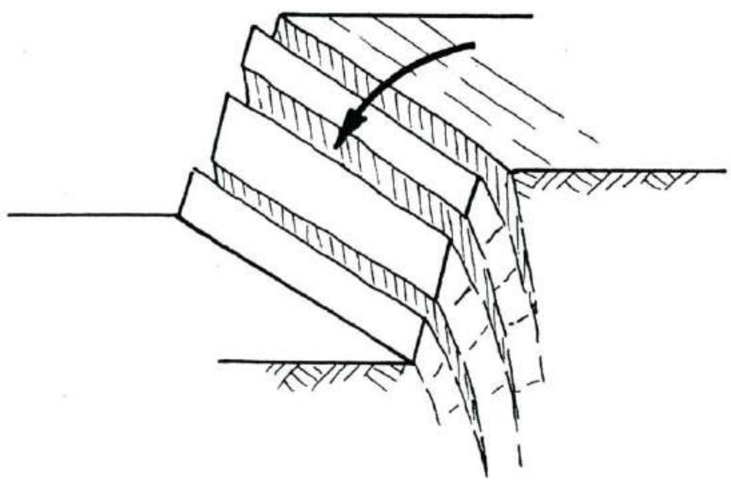
PROJECT NO.	PHASE	REV.	FIGURE
051413027	2115	0	9



a) Plane Failure on Through Going Discontinuities



b) Wedge Failure Along Line of Intersection of Discontinuities



c) Toppling Failure in Hard Rock with Steeply Dipping Joints

CLIENT
MOUNT POLLEY MINING CORPORATION

PROJECT
GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS

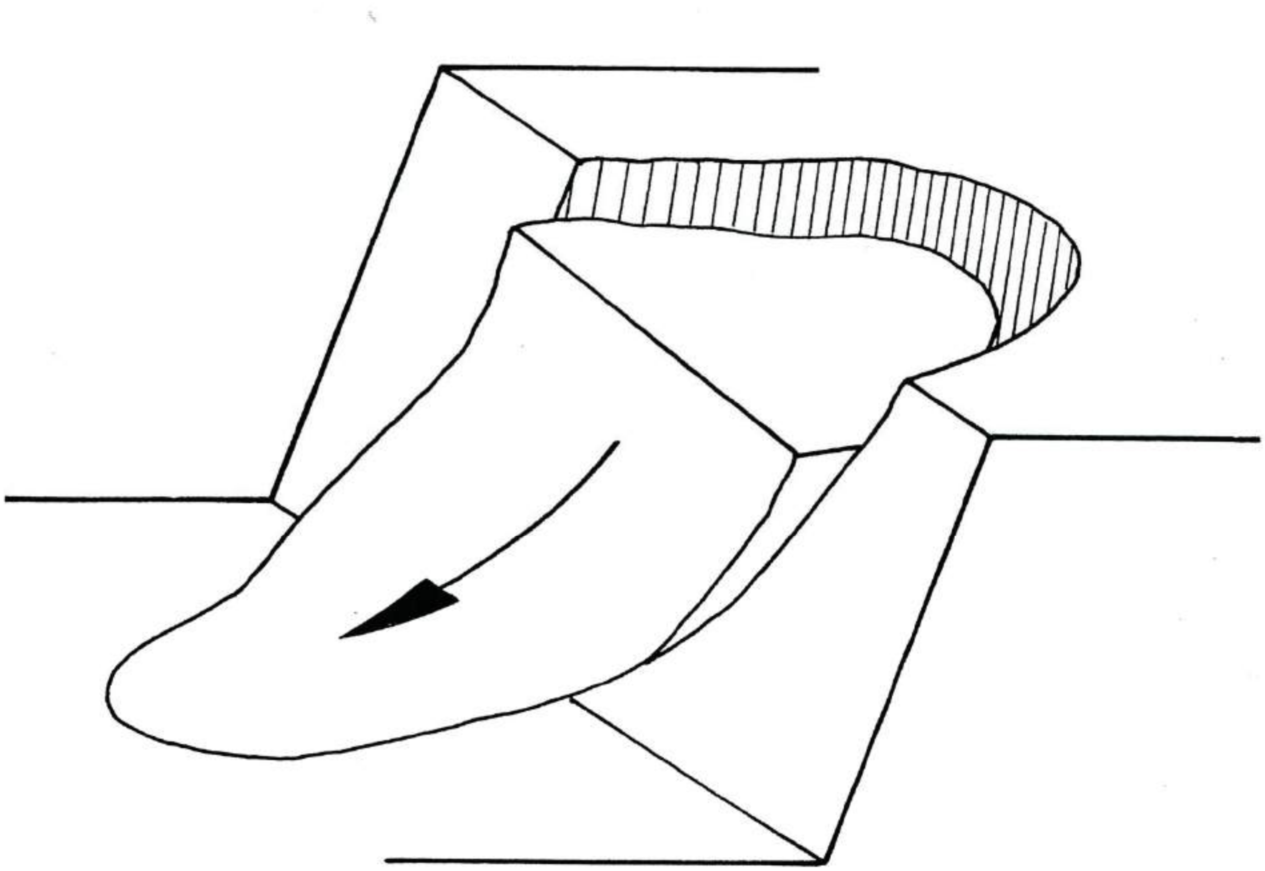
CONSULTANT

Golder Associates

YYYY-MM-DD	2016-05-09
PREPARED	KGV
DESIGN	JKH
REVIEW	JKH
APPROVED	AVC

TITLE
STRUCTURALLY CONTROLLED INSTABILITY MECHANISMS IN ROCK SLOPES

PROJECT NO.	PHASE	REV.	FIGURE
051413027	**2115**	**0**	**10**



Quasi-Circular Failure in Weak or Heavily Fractured Rock

CLIENT
MOUNT POLLEY MINING CORPORATION

PROJECT
GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-09
PREPARED	KGV
DESIGN	JKH
REVIEW	JKH
APPROVED	AVC

TITLE
OVERALL ROCK MASS FAILURE MECHANISM

PROJECT NO.	PHASE	REV.	FIGURE
051413027	**2115**	**0**	**11**

APPENDIX A

Photographs

PHOTOGRAPH LOOKING NORTH-NORTHWEST

PHOTOGRAPH TAKEN OCTOBER 20, 2015

CLIENT
MOUNT POLLEY MINING CORPORATION
LIKELY, BC

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-09
PREPARED	JKH
DESIGNED	JKH
REVIEWED	JKH
APPROVED	AVC

PROJECT
GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS

TITLE
SPRINGER PIT (LEFT) AND CARIBOO PIT (RIGHT) NORTHEAST WALL OVERVIEW (2015)

PROJECT NO.	PHASE	REV.	FIGURE
05-1413-027	2115	0	A-1

PHOTOGRAPH LOOKING
NORTH-NORTHWEST

PHOTOGRAPH TAKEN OCTOBER 20, 2015

CLIENT
MOUNT POLLEY MINING CORPORATION
LIKELY, BC

PROJECT
GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS

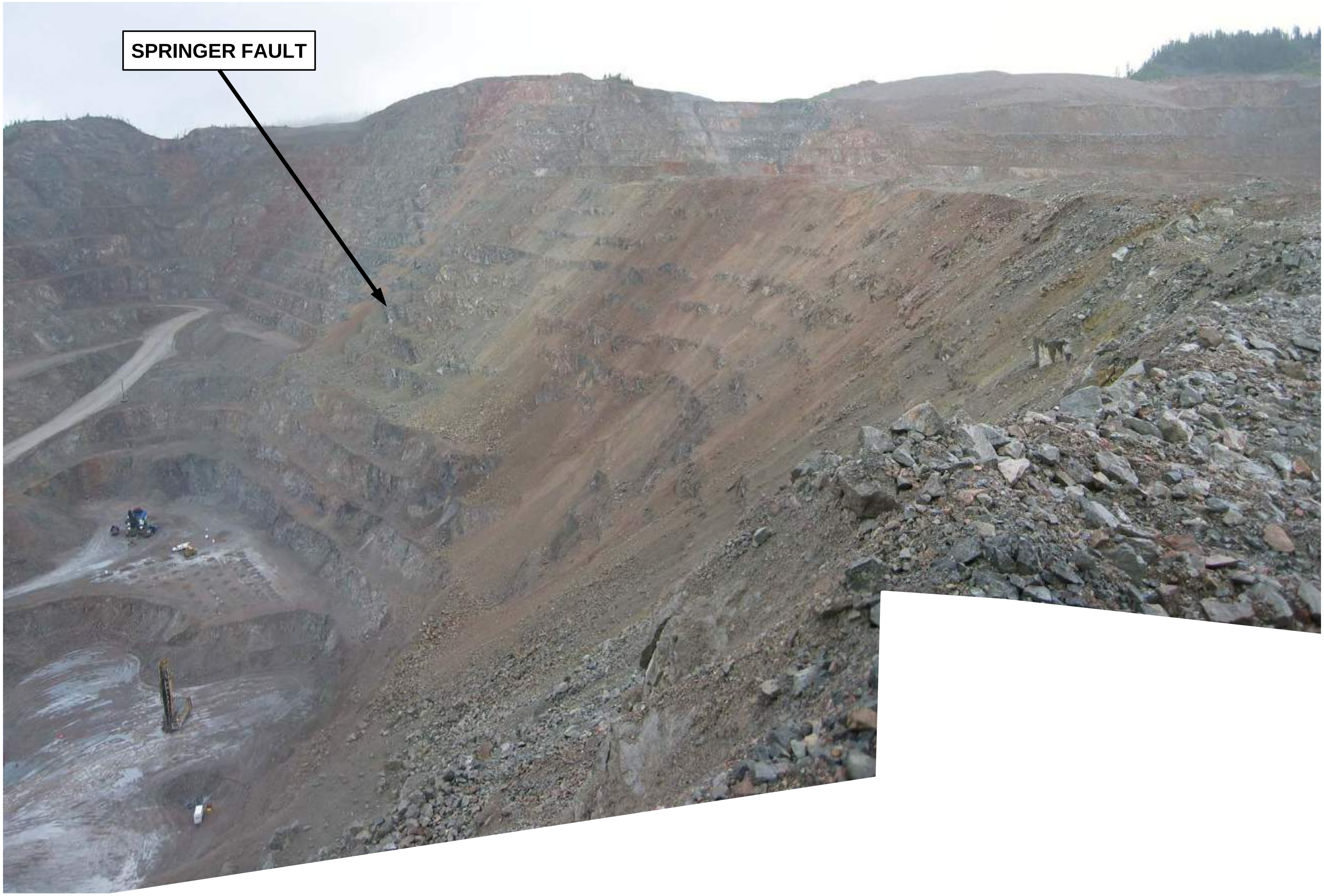
CONSULTANT

Golder Associates

YYYY-MM-DD	2016-05-09
PREPARED	JKH
DESIGNED	JKH
REVIEWED	JKH
APPROVED	AVC

TITLE
SPRINGER AND CARIBOO PIT NORTHEAST WALLS (2015)

PROJECT NO.	PHASE	REV.	FIGURE
05-1413-027	2115	0	A-2



PHOTOGRAPH LOOKING NORTHWEST

PHOTOGRAPH TAKEN JUNE 24, 2014

CLIENT
MOUNT POLLEY MINING CORPORATION
LIKELY, BC

PROJECT
GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-05-09
PREPARED	JKH
DESIGNED	JKH
REVIEWED	JKH
APPROVED	AVC

TITLE
SPRINGER PIT NORTHEAST WALL (2014)

PROJECT NO.	PHASE	REV.	FIGURE
05-1413-027	2115	0	A-3

PHOTOGRAPH LOOKING NORTHWEST

PHOTOGRAPH TAKEN OCTOBER 20, 2015

CLIENT
MOUNT POLLEY MINING CORPORATION
LIKELY, BC

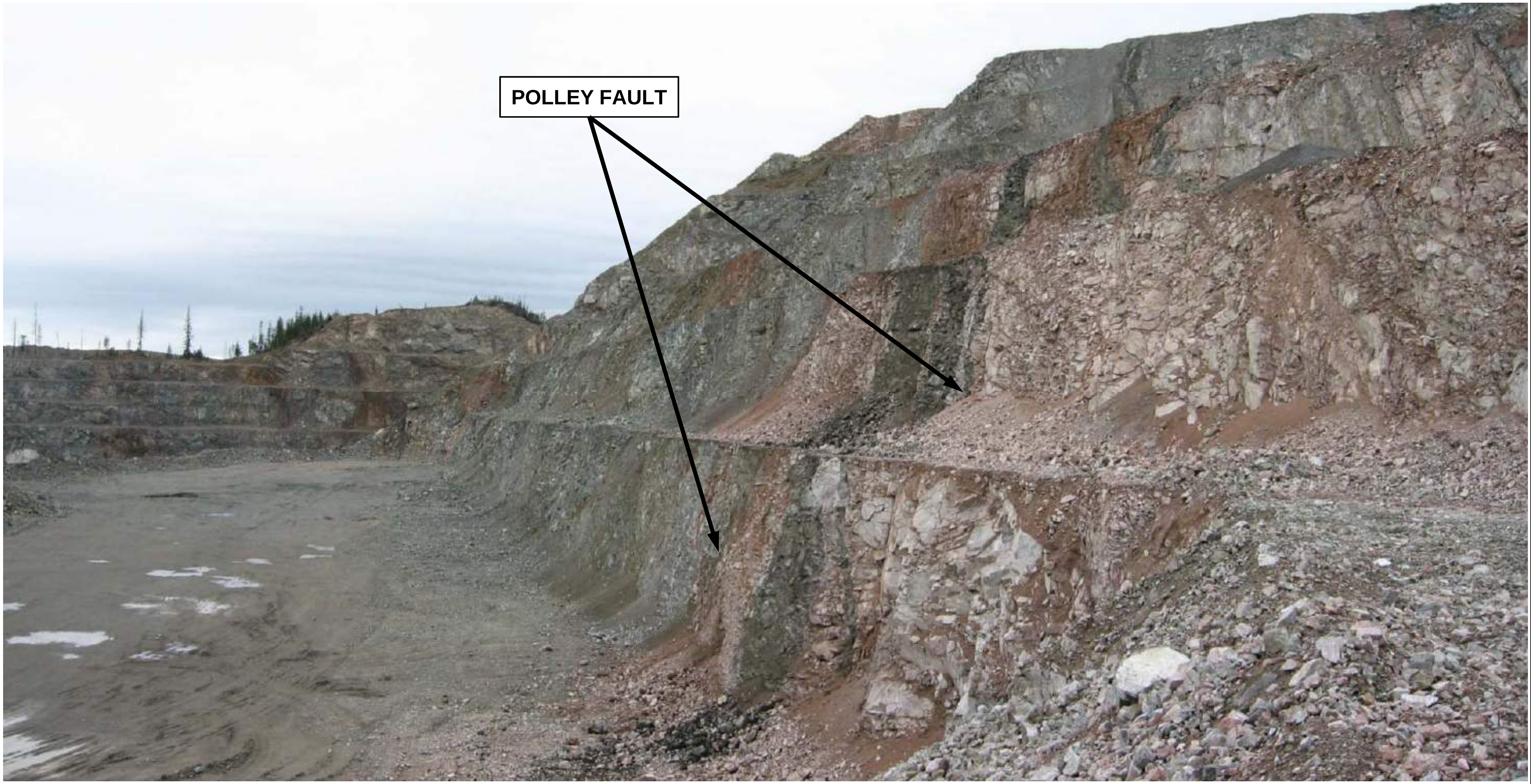
PROJECT
GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-09
PREPARED	JKH
DESIGNED	JKH
REVIEWED	JKH
APPROVED	AVC

TITLE
SPRINGER NORTHEAST WALL OVERVIEW (2015)

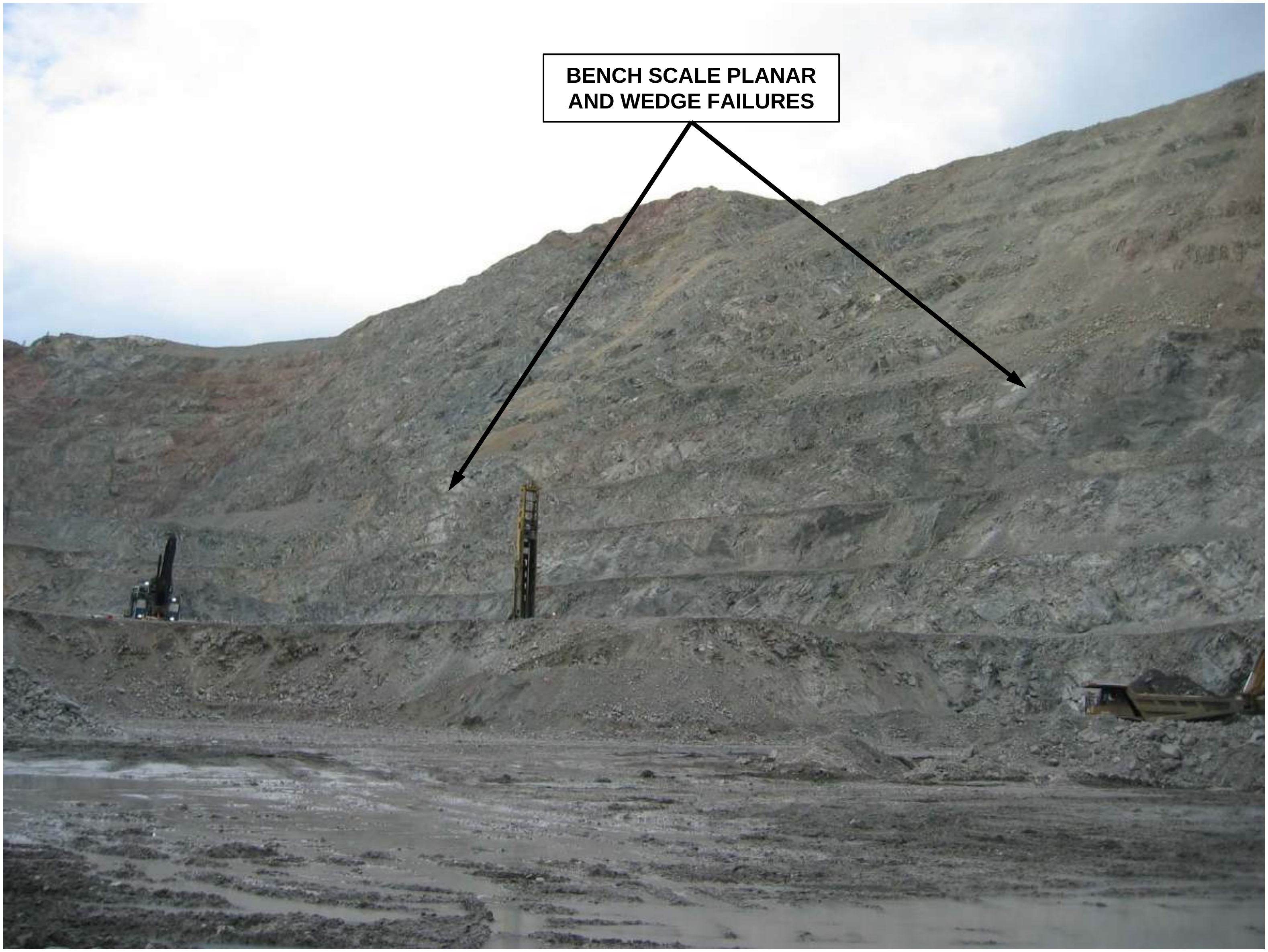
PROJECT NO.	PHASE	REV.	FIGURE
05-1413-027	2115	0	A-4



PHOTOGRAPH LOOKING WEST

PHOTOGRAPH TAKEN OCTOBER 20, 2015

CLIENT	MOUNT POLLEY MINING CORPORATION LIKELY, BC
PROJECT	GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS
CONSULTANT	Golder Associates
YYYY-MM-DD	2016-05-09
PREPARED	JKH
DESIGNED	JKH
REVIEWED	JKH
APPROVED	AVC
TITLE	**SPRINGER PIT NORTHEAST WALL NORTH SEGMENT (2015)**
PROJECT NO.	05-1413-027
PHASE	2115
REV.	0
FIGURE	A-5



CLIENT
MOUNT POLLEY MINING CORPORATION
LIKELY, BC

PROJECT
GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS

CONSULTANT

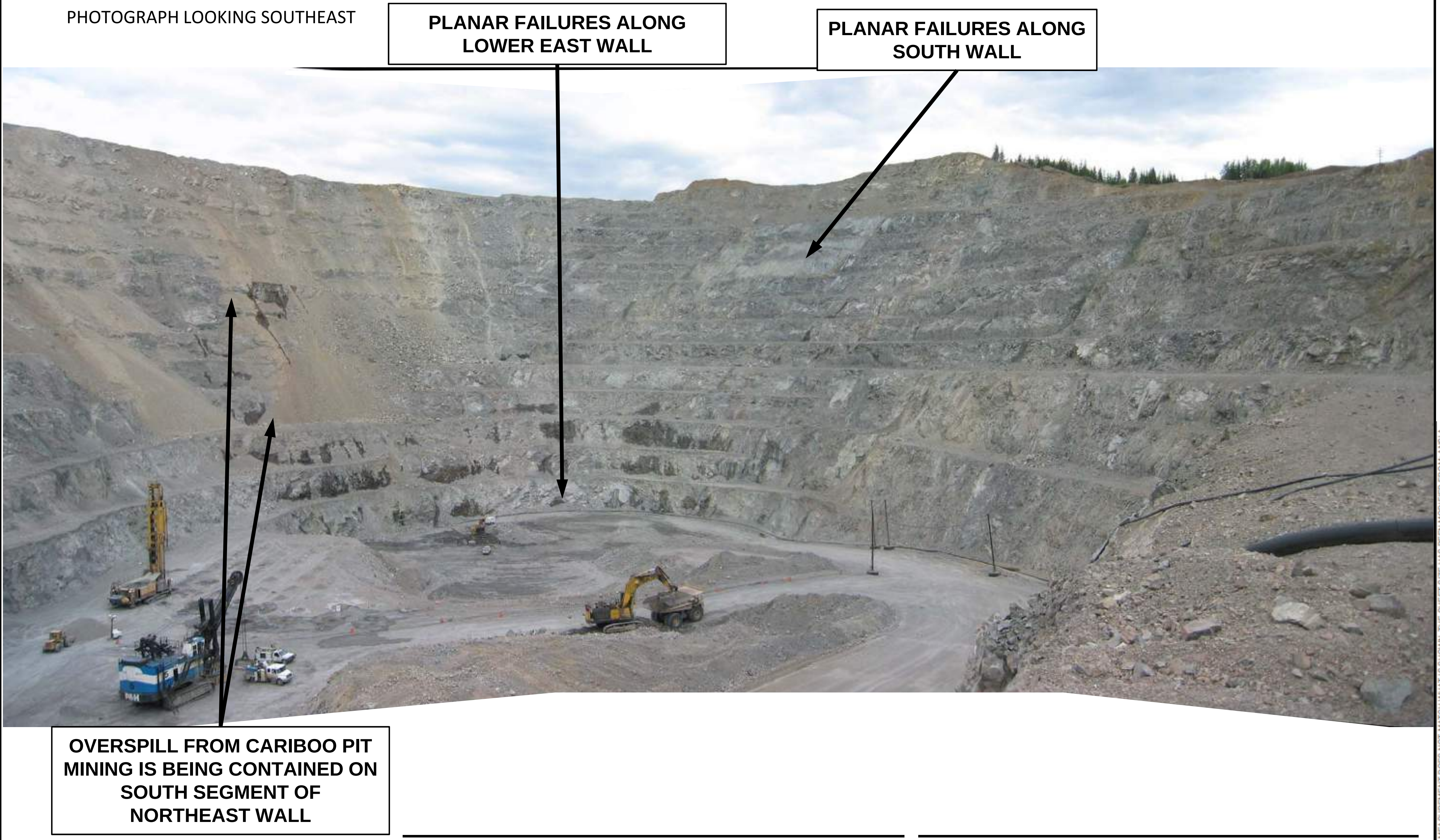
Golder Associates

YYYY-MM-DD	2016-05-09
PREPARED	JKH
DESIGNED	JKH
REVIEWED	JKH
APPROVED	AVC

TITLE
SPRINGER PIT NORTHEAST WALL
BENCH SCALE PLANAR AND WEDGE FAILURES

PROJECT NO.	PHASE	REV.	FIGURE
05-1413-027	2115	0	A-6

PHOTOGRAPH LOOKING SOUTHEAST



PHOTOGRAPH TAKEN OCTOBER 20, 2015

CLIENT
MOUNT POLLEY MINING CORPORATION
LIKELY, BC

PROJECT
GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-05-09
PREPARED	JKH
DESIGNED	JKH
REVIEWED	JKH
APPROVED	AVC

TITLE
SPRINGER PIT EAST AND SOUTH WALLS (2014)

PROJECT NO.	PHASE	REV.	FIGURE
05-1413-027	2115	0	A-7

PHOTOGRAPH LOOKING WEST

PHOTOGRAPH TAKEN JUNE 24, 2014

CLIENT MOUNT POLLEY MINING CORPORATION LIKELY, BC		PROJECT GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS	
CONSULTANT Golder Associates	YYYY-MM-DD: 2016-05-09 PREPARED: JKH DESIGNED: JKH REVIEWED: JKH APPROVED: AVC	TITLE **SPRINGER PIT SOUTH WALL (2014)**	
		PROJECT NO. 05-1413-027 · PHASE 2115 · REV. 0	FIGURE **A-8**

PHOTOGRAPH LOOKING WEST

PHOTOGRAPH TAKEN JUNE 24, 2014

CLIENT
MOUNT POLLEY MINING CORPORATION
LIKELY, BC

PROJECT
GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-05-09
PREPARED	JKH
DESIGNED	JKH
REVIEWED	JKH
APPROVED	AVC

TITLE
SPRINGER PIT SOUTHWEST WALL (2014)

PROJECT NO.	PHASE	REV.	FIGURE
05-1413-027	2115	0	A-9

PHOTOGRAPH LOOKING WEST

PHOTOGRAPH TAKEN OCTOBER 20, 2015

CLIENT
MOUNT POLLEY MINING CORPORATION
LIKELY, BC

PROJECT
GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS

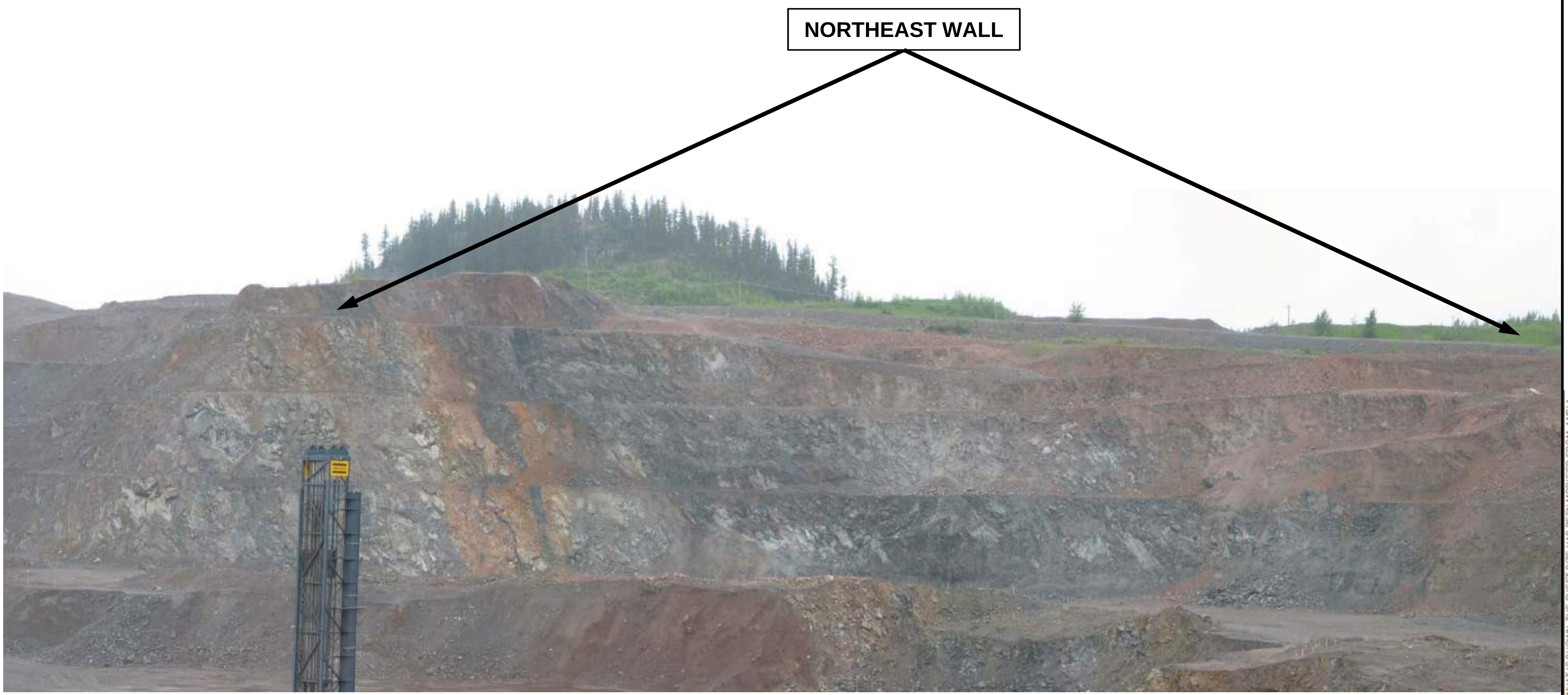
CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-09
PREPARED	JKH
DESIGNED	JKH
REVIEWED	JKH
APPROVED	AVC

TITLE
SPRINGER PIT WEST WALL OF UPPER PUSHBACK (2015)

PROJECT NO.	PHASE	REV.	FIGURE
05-1413-027	2115	0	A-10

\\golder.gds\gal\burnaby\Active_2005\1413\05-1413-027 Mt. Polley\2016 LOM Pit Design Review\Report\Rev 0\



PHOTOGRAPH LOOKING NORTHEAST

PHOTOGRAPH TAKEN JUNE 24, 2014

CLIENT MOUNT POLLEY MINING CORPORATION LIKELY, BC	PROJECT GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS
CONSULTANT: Golder Associates YYYY-MM-DD 2016-05-09 PREPARED JKH DESIGNED JKH REVIEWED JKH APPROVED AVC	TITLE **CARIBOO PIT NORTHEAST WALL (2014)** PROJECT NO. 05-1413-027 · PHASE 2115 · REV. 0 · FIGURE **A-11**

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

\\golder.gds\gal\burnaby\Active_2005\1413\05-1413-027 Mt. Polley\2016 LOM Pit Design Review\Report\Rev 0\

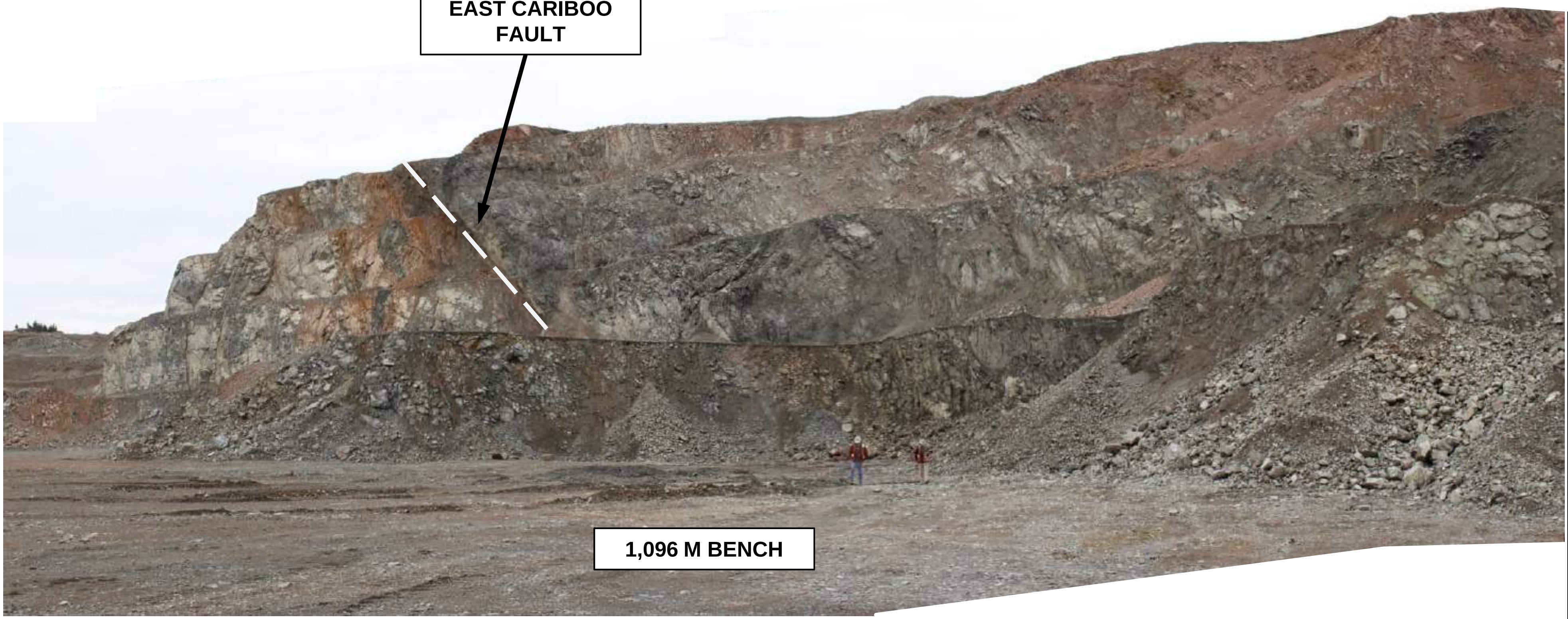
PHOTOGRAPH LOOKING WEST

PHOTOGRAPH TAKEN OCTOBER 20, 2015

CLIENT MOUNT POLLEY MINING CORPORATION LIKELY, BC		PROJECT GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS	
CONSULTANT Golder Associates	YYYY-MM-DD: 2016-05-09	TITLE **CARIBOO PIT OVERVIEW (2015)**	
	PREPARED: JKH		
	DESIGNED: JKH		
	REVIEWED: JKH	PROJECT NO. 05-1413-027	PHASE 2115
	APPROVED: AVC	REV. 0	FIGURE **A-12**

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

1 in



PHOTOGRAPH LOOKING NORTH

PHOTOGRAPH TAKEN OCTOBER 20, 2015

CLIENT
MOUNT POLLEY MINING CORPORATION
LIKELY, BC

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-09
PREPARED	JKH
DESIGNED	JKH
REVIEWED	JKH
APPROVED	AVC

PROJECT
GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS

TITLE
CARIBOO PIT NORTHEAST WALL (2015)

PROJECT NO.	PHASE	REV.	FIGURE
05-1413-027	2115	0	A-13

\\golder.gds\gal\burnaby\Active_2005\1413\05-1413-027 Mt. Polley\2016 LOM Pit Design Review\Report\Rev 0\

PHOTOGRAPH LOOKING SOUTHWEST

PHOTOGRAPH TAKEN OCTOBER 20, 2015

CLIENT
MOUNT POLLEY MINING CORPORATION
LIKELY, BC

PROJECT
GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-09
PREPARED	JKH
DESIGNED	JKH
REVIEWED	JKH
APPROVED	AVC

TITLE
CARIBOO PIT SOUTHEAST WALL (2015)

PROJECT NO.	PHASE	REV.	FIGURE
05-1413-027	2115	0	A-14

PHOTOGRAPH LOOKING EAST

PHOTOGRAPH TAKEN OCTOBER 20, 2015

CLIENT
MOUNT POLLEY MINING CORPORATION
LIKELY, BC

PROJECT
GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-09
PREPARED	JKH
DESIGNED	JKH
REVIEWED	JKH
APPROVED	AVC

TITLE
C2 PIT NORTH WALL (2015)

PROJECT NO.	PHASE	REV.	FIGURE
05-1413-027	2115	0	A-15

1 in
0

PHOTOGRAPH LOOKING SOUTHWEST

PHOTOGRAPH TAKEN OCTOBER 20, 2015

CLIENT
MOUNT POLLEY MINING CORPORATION
LIKELY, BC

PROJECT
GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS

CONSULTANT

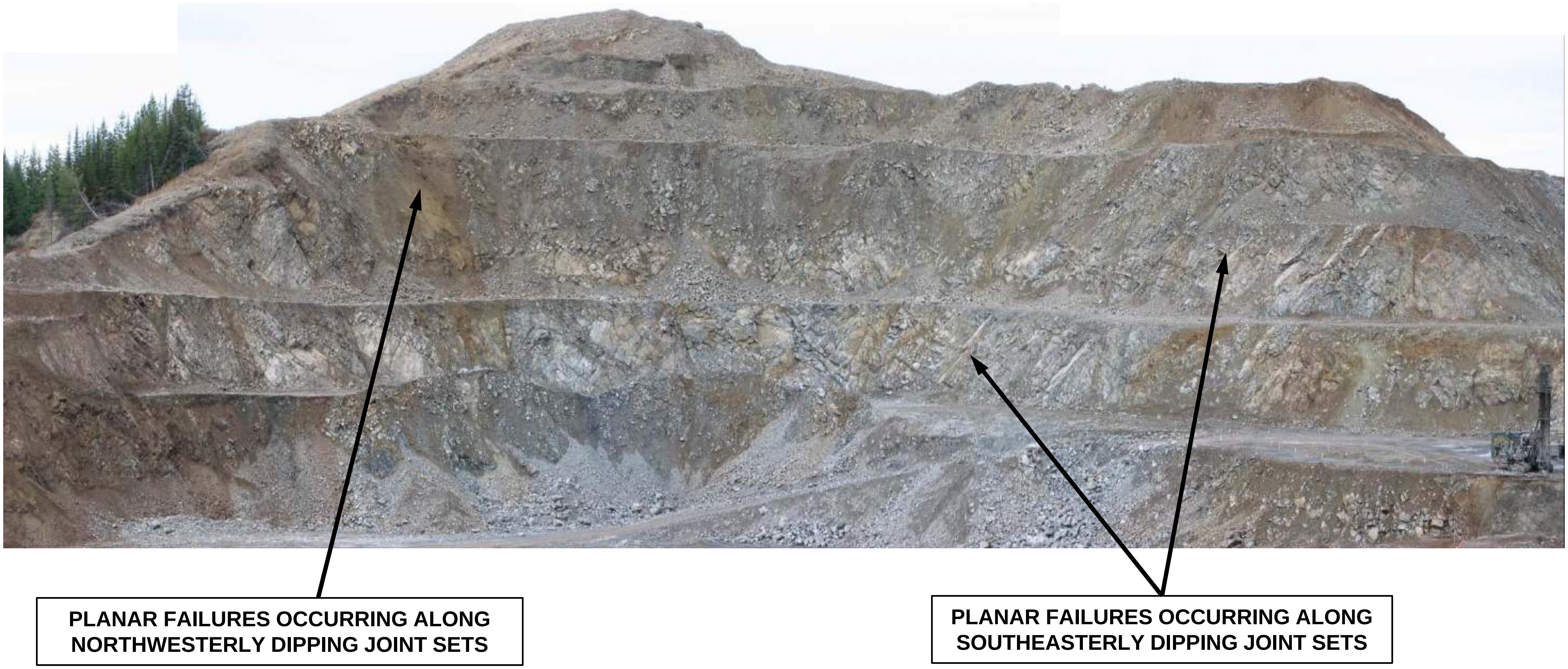
Golder Associates

YYYY-MM-DD	2016-05-09
PREPARED	JKH
DESIGNED	JKH
REVIEWED	JKH
APPROVED	AVC

TITLE
WX PIT OVERVIEW (2015)

PROJECT NO.	PHASE	REV.	FIGURE
05-1413-027	2115	0	A-16

\\golder.gds\gal\burnaby\Active_2005\1413\05-1413-027 Mt. Polley\2016 LOM Pit Design Review\Report\Rev 0\



CLIENT
MOUNT POLLEY MINING CORPORATION
LIKELY, BC

PROJECT
GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS

CONSULTANT
Golder Associates

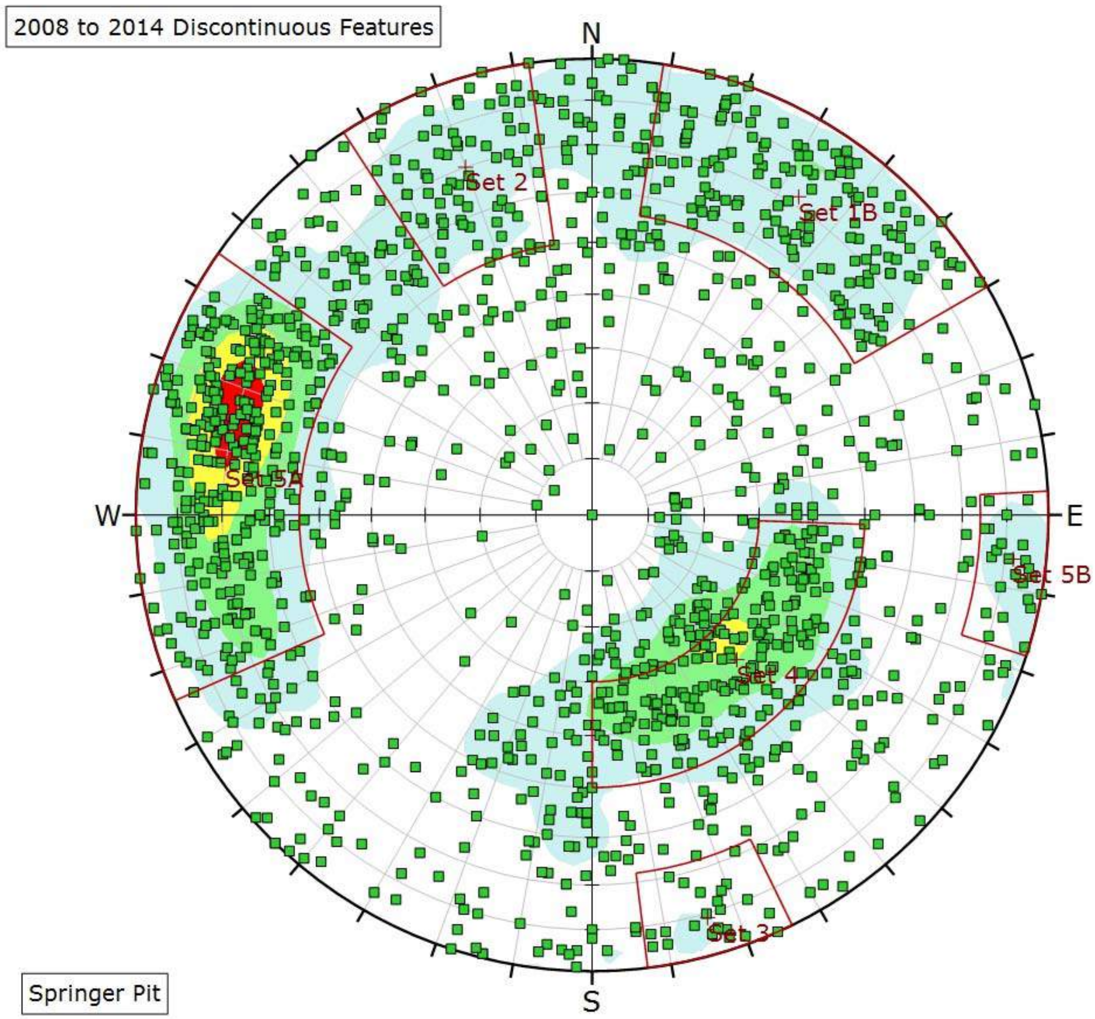
YYYY-MM-DD	2016-05-09
PREPARED	JKH
DESIGNED	JKH
REVIEWED	JKH
APPROVED	AVC

TITLE
WX PIT PLANAR FAILURES

PROJECT NO.	PHASE	REV.	FIGURE
05-1413-027	2115	0	A-17

APPENDIX B

Stereographic Projections of Geotechnical Mapping Data



Symbol	TYPE	Quantity
■	JN	1618

Color	Density Concentrations
	0.00 - 1.00
	1.00 - 2.00
	2.00 - 3.00
	3.00 - 4.00
	4.00 - 5.00
Maximum Density	4.77%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
Mean Set Planes				
1m	■	72	213	Set 1B
2m	■	70	160	Set 2
3m	■	81	344	Set 3
4m	■	37	315	Set 4
5m	■	70	98	Set 5A
6m	■	82	276	Set 5B

Plot Mode	Pole Vectors
Vector Count	1618 (1355 Entries)
Hemisphere	Lower
Projection	Equal Area

Set	Mean Set Planes		Fisher's K (unweighted)
	Dip (degrees)	Dip Direction (degrees)	
1B	72	213	25
2	70	160	39
3	81	344	119
4	37	315	25
5A	70	98	23
5B	82	276	152

CLIENT
MOUNT POLLEY MINING CORPORATION
LIKELY, BC

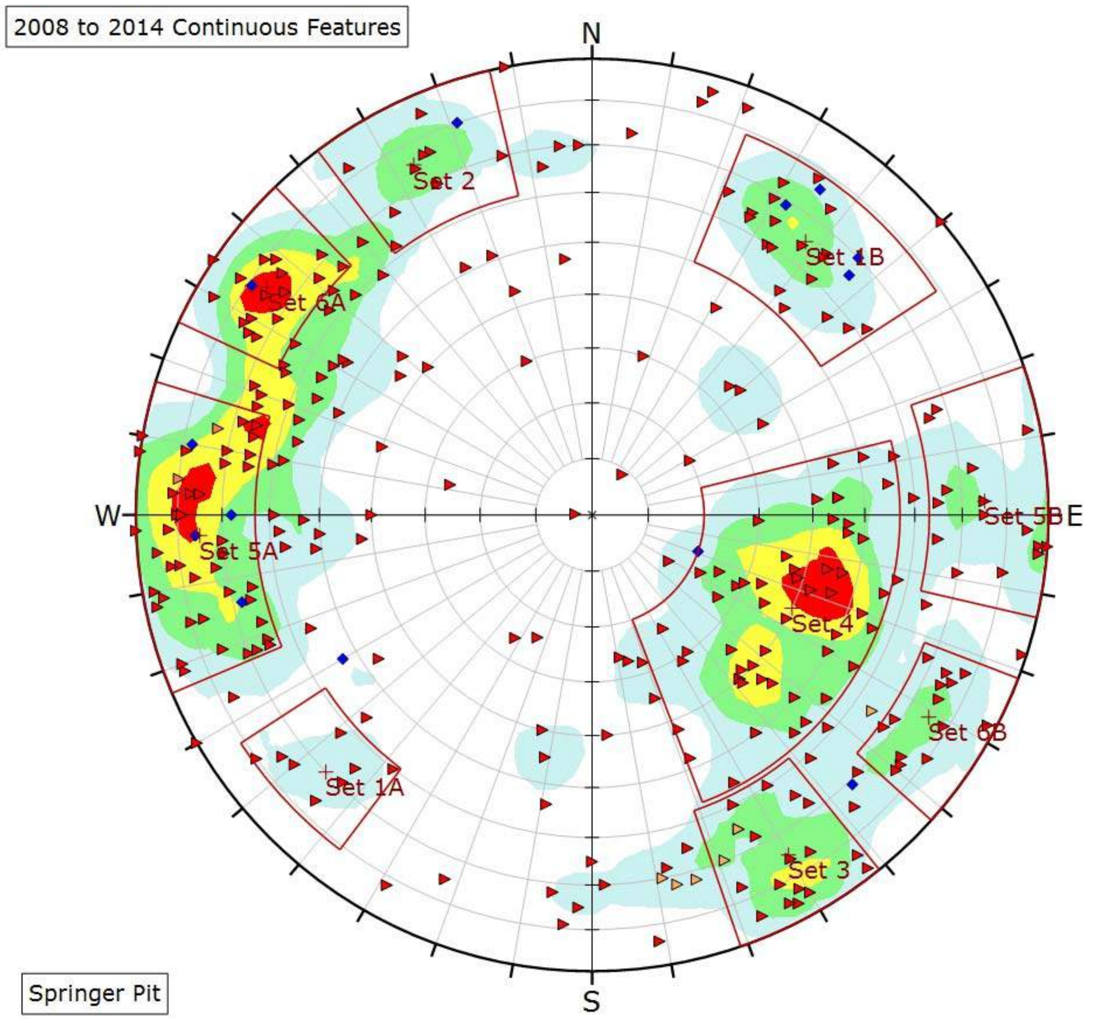
PROJECT
GEOTECHNICAL REVIEW OF LOM CARIBOO PIT
AND SPRINGER PIT SLOPE DESIGNS

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-09
PREPARED	KGV
DESIGNED	JKH
REVIEWED	JKH
APPROVED	AVC

TITLE
STEREOGRAPHIC PROJECTION OF DISCONTINUOUS STRUCTURES IN THE SPRINGER PIT AREA MAPPED FROM 2008 THROUGH 2014

PROJECT NO.	PHASE	REV.	FIGURE
051413027	2115	0	B-1



Symbol	TYPE	Quantity
◆	Dyke	13
▶	FLT	348
▷	Major Fault	6
▷	Polley Fault	2

Color	Density Concentrations
	0.00 - 0.90
	0.90 - 1.80
	1.80 - 2.70
	2.70 - 3.60
	3.60 - 4.50
Maximum Density	4.35%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
Mean Set Planes				
1m		70	46	Set 1A
2m		65	218	Set 1B
3m		75	153	Set 2
4m		75	330	Set 3
5m		40	295	Set 4
6m		75	87	Set 5A
7m		75	268	Set 5B
8m		76	125	Set 6A
9m		75	301	Set 6B

Plot Mode	Pole Vectors
Vector Count	369 (305 Entries)
Hemisphere	Lower
Projection	Equal Area

Set	Mean Set Plane		Fisher's K (unweighted)
	Dip (degrees)	Dip Direction (degrees)	
1A	70	46	94
1B	65	218	63
2	75	153	88
3	75	330	62
4	40	295	25
5A	75	87	37
5B	75	266	51
6A	76	125	124
6B	75	301	105

CLIENT
MOUNT POLLEY MINING CORPORATION
LIKELY, BC

PROJECT
GEOTECHNICAL REVIEW OF LOM CARIBOO PIT
AND SPRINGER PIT SLOPE DESIGNS

CONSULTANT

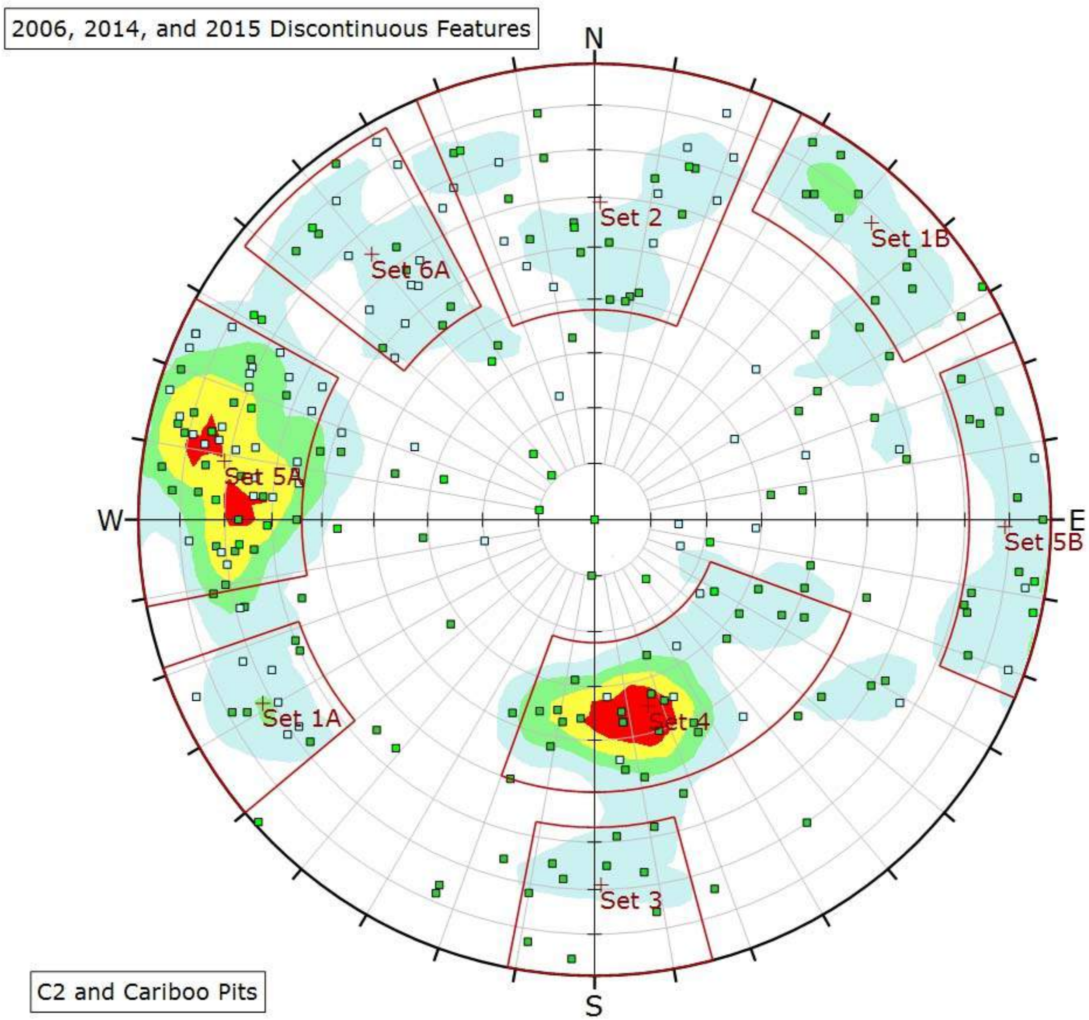
Golder Associates

YYYY-MM-DD	2016-05-09
PREPARED	KGV
DESIGNED	JKH
REVIEWED	JKH
APPROVED	AVC

TITLE
STEREOGRAPHIC PROJECTION OF CONTINUOUS STRUCTURES IN THE SPRINGER PIT AREA MAPPED FROM 2008 THROUGH 2014

PROJECT NO.	PHASE	REV.	FIGURE
051413027	2115	0	B-2

\\golder.gds\gal\burnaby\Active_2005\1413\05-1413-027 Mt. Polley\2016 LOM Pit Design Review\Report\Rev 0\



Symbol	TYPE	Quantity
□	Closed Joint	78
■	Gapped Joint	26
■	JN	259

Color	Density Concentrations
	0.00 - 1.10
	1.10 - 2.20
	2.20 - 3.30
	3.30 - 4.40
	4.40 - 5.50
Maximum Density	5.47%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
Mean Set Planes				
1m	■	72	61	Set 1A
2m	■	78	223	Set 1B
3m	■	59	181	Set 2
4m	■	69	359	Set 3
5m	■	35	344	Set 4
6m	■	71	99	Set 5A
7m	■	79	271	Set 5B
8m	■	65	140	Set 6A

Plot Mode	Pole Vectors
Vector Count	363 (242 Entries)
Hemisphere	Lower
Projection	Equal Area

Set	Mean Set Planes		Fisher's K (unweighted)
	Dip (degrees)	Dip Direction (degrees)	
1A	72	61	89
1B	78	223	53
2	59	181	21
3	69	359	50
4	35	344	30
5A	71	99	36
5B	79	271	32
6A	65	140	30

CLIENT
MOUNT POLLEY MINING CORPORATION
LIKELY, BC

PROJECT
GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS

CONSULTANT

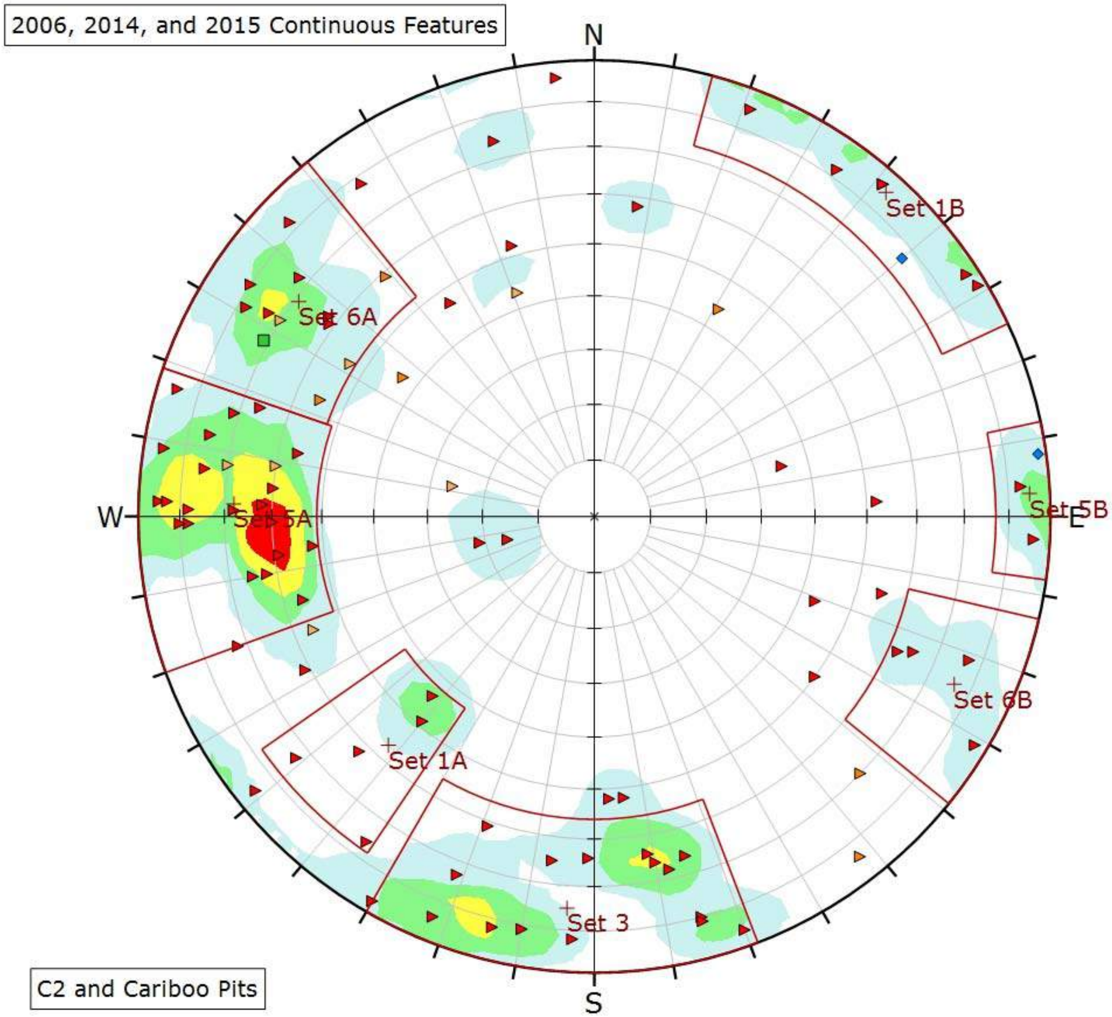
Golder Associates

YYYY-MM-DD	2016-05-09
PREPARED	KGV
DESIGNED	JKH
REVIEWED	JKH
APPROVED	AVC

TITLE
STEREOGRAPHIC PROJECTION OF DISCONTINUOUS STRUCTURES IN THE C2 AND CARIBOO PIT AREAS MAPPED IN 2006, 2014, AND 2015

PROJECT NO.	PHASE	REV.	FIGURE
051413027	2115	0	**B-3**

\\golder.gds\gal\burnaby\Active_2005\1413\05-1413-027 Mt. Polley\2016 LOM Pit Design Review\Report\Rev 0\



Symbol	TYPE	Quantity
◆	CON	2
▶	FLT	99
▷	Gapped Fault	6
▷	Wide Fault	7
■	Wide Joint	1

Color	Density Concentrations
	0.00 - 1.40
	1.40 - 2.80
	2.80 - 4.20
	4.20 - 5.60
	5.60 - 7.00
Maximum Density	6.75%
Contour Data	Pole Vectors
Contour Distribution	Fisher
Counting Circle Size	1.0%

	Color	Dip	Dip Direction	Label
Mean Set Planes				
1m	■	57	42	Set 1A
2m	■	85	222	Set 1B
3m	■	75	4	Set 3
4m	■	68	92	Set 5A
5m	■	85	267	Set 5B
6m	■	69	126	Set 6A
7m	■	76	295	Set 6B

Plot Mode	Pole Vectors
Vector Count	115 (95 Entries)
Hemisphere	Lower
Projection	Equal Area

Set	Mean Set Planes		Fisher's K (unweighted)
	Dip (degrees)	Dip Direction (degrees)	
1A	57	42	32
1B	85	223	29
3	75	4	19
5A	68	92	36
5B	85	267	245
6A	69	126	45
6B	76	295	50

CLIENT
MOUNT POLLEY MINING CORPORATION
LIKELY, BC

PROJECT
GEOTECHNICAL REVIEW OF LOM CARIBOO PIT
AND SPRINGER PIT SLOPE DESIGNS

CONSULTANT

Golder Associates

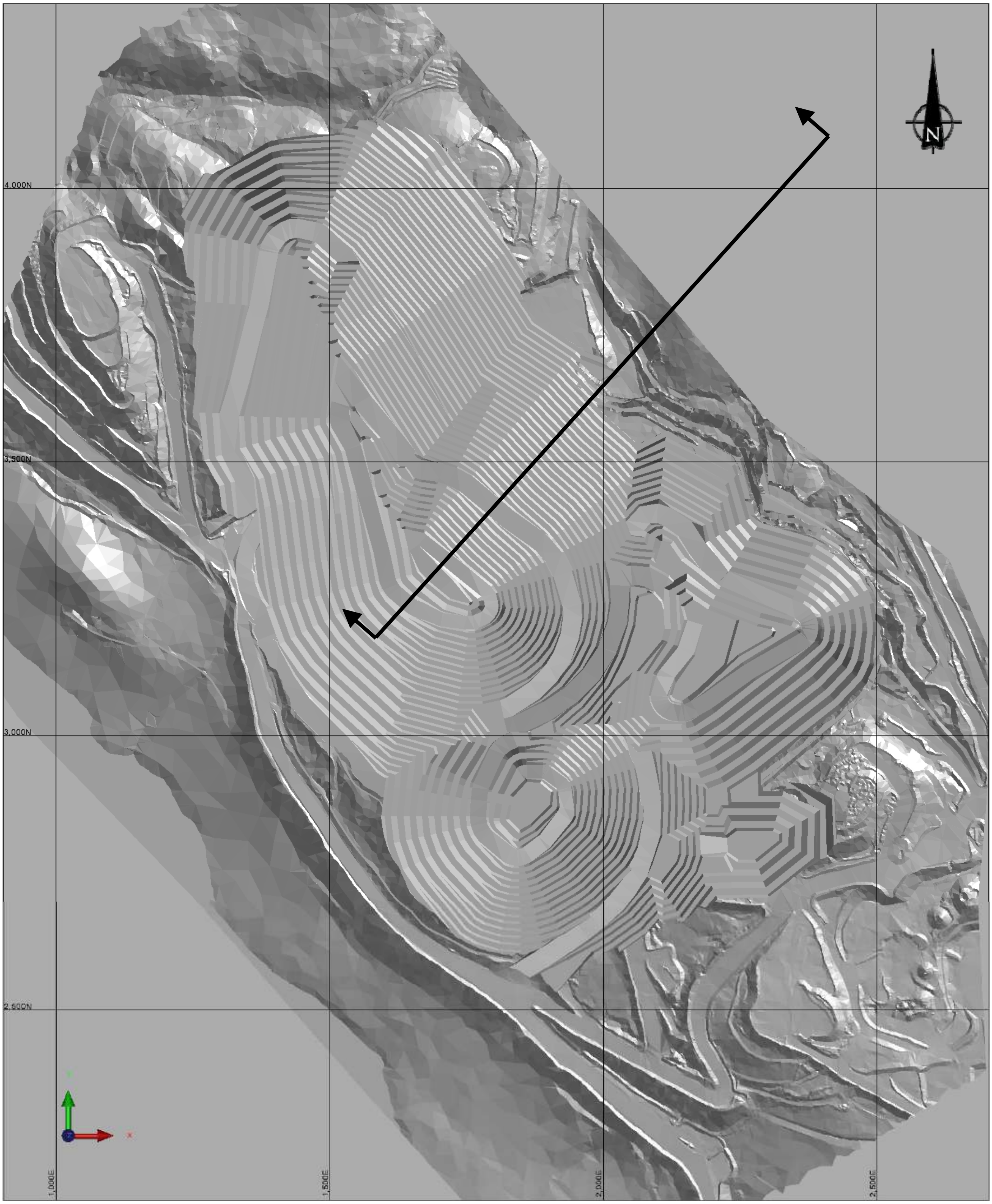
YYYY-MM-DD	2016-05-09
PREPARED	KGV
DESIGNED	JKH
REVIEWED	JKH
APPROVED	AVC

TITLE
STEREOGRAPHIC PROJECTION OF CONTINUOUS STRUCTURES IN THE C2 AND CARIBOO PIT AREAS MAPPED IN 2006, 2014, AND 2015

PROJECT NO.	PHASE	REV.	FIGURE
051413027	2115	0	B-4

APPENDIX C

Results of Springer Pit Northeast Wall Overall Slope Stability Analyses



CLIENT
MOUNT POLLEY MINING CORPORATION
LIKELY, BC

PROJECT
GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS

CONSULTANT

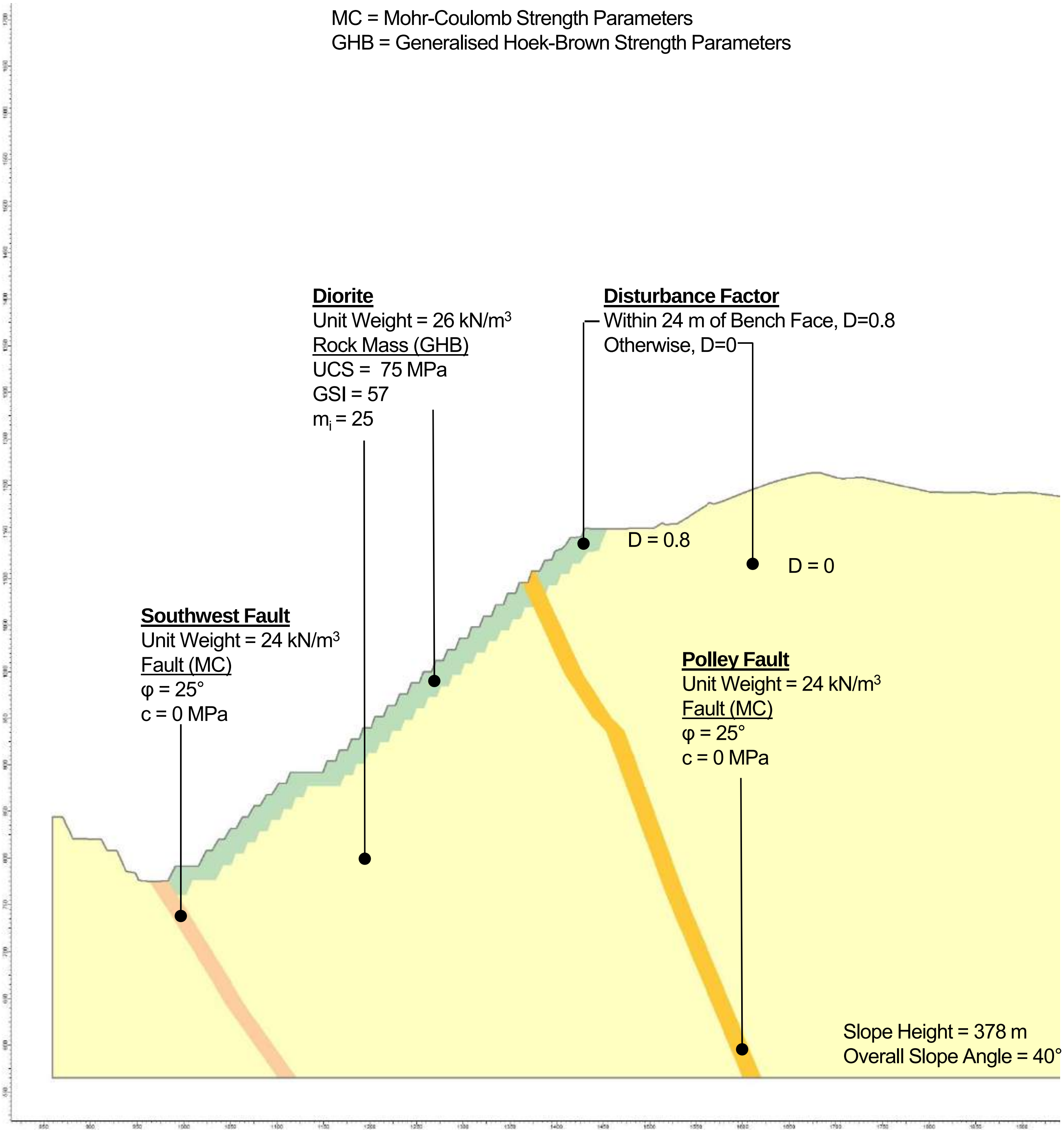
Golder Associates

YYYY-MM-DD	2016-05-09
PREPARED	KGV
DESIGN	JKH
REVIEW	JKH
APPROVED	AVC

TITLE
ULTIMATE SPRINGER PIT SHOWING LOCATION OF NORTHEAST WALL STABILITY ANALYSIS CROSS SECTION

PROJECT NO.	PHASE	REV.	FIGURE
051413027	2115	0	C-1

Path: ---- \\golder.gds\gal\burnaby\Active_2005\1413\05-1413-027 Mt. Polley\2016 LOM Pit Design Review\Report\Rev 0\



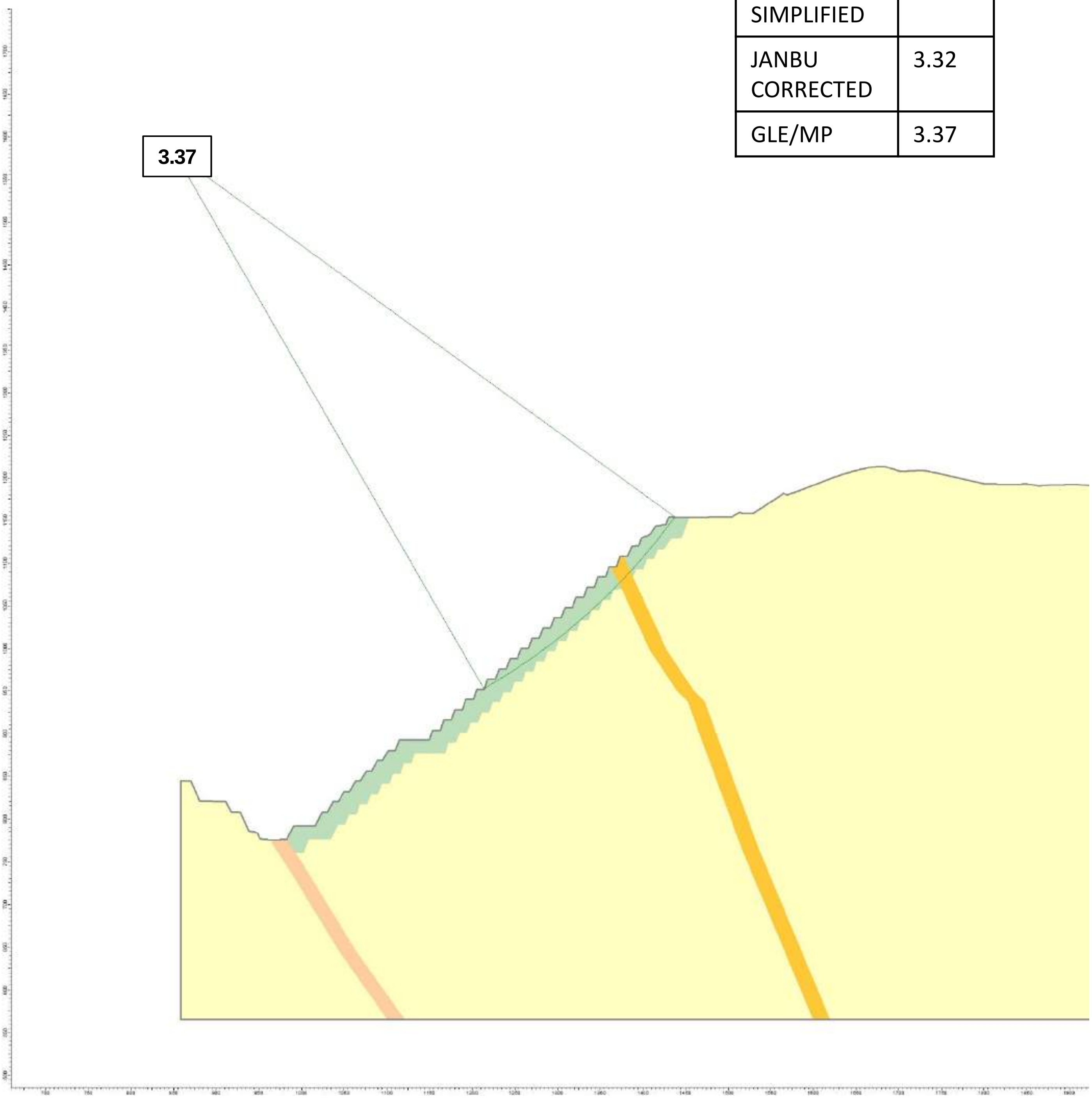
CLIENT MOUNT POLLEY MINING CORPORATION LIKELY, BC	PROJECT GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS
CONSULTANT Golder Associates	TITLE **SPRINGER PIT NORTHEAST WALL** **STABILITY ANALYSIS CROSS SECTION** **SUMMARY OF MATERIAL PROPERTIES**

YYYY-MM-DD	2016-05-09
PREPARED	KGV
DESIGN	JKH
REVIEW	JKH
APPROVED	AVC

PROJECT NO.	PHASE	REV.	FIGURE
051413027	**2115**	**0**	**C-2**

GLE/MORGENSTERN-PRICE

METHOD	FOS
BISHOP SIMPLIFIED	3.30
JANBU CORRECTED	3.32
GLE/MP	3.37



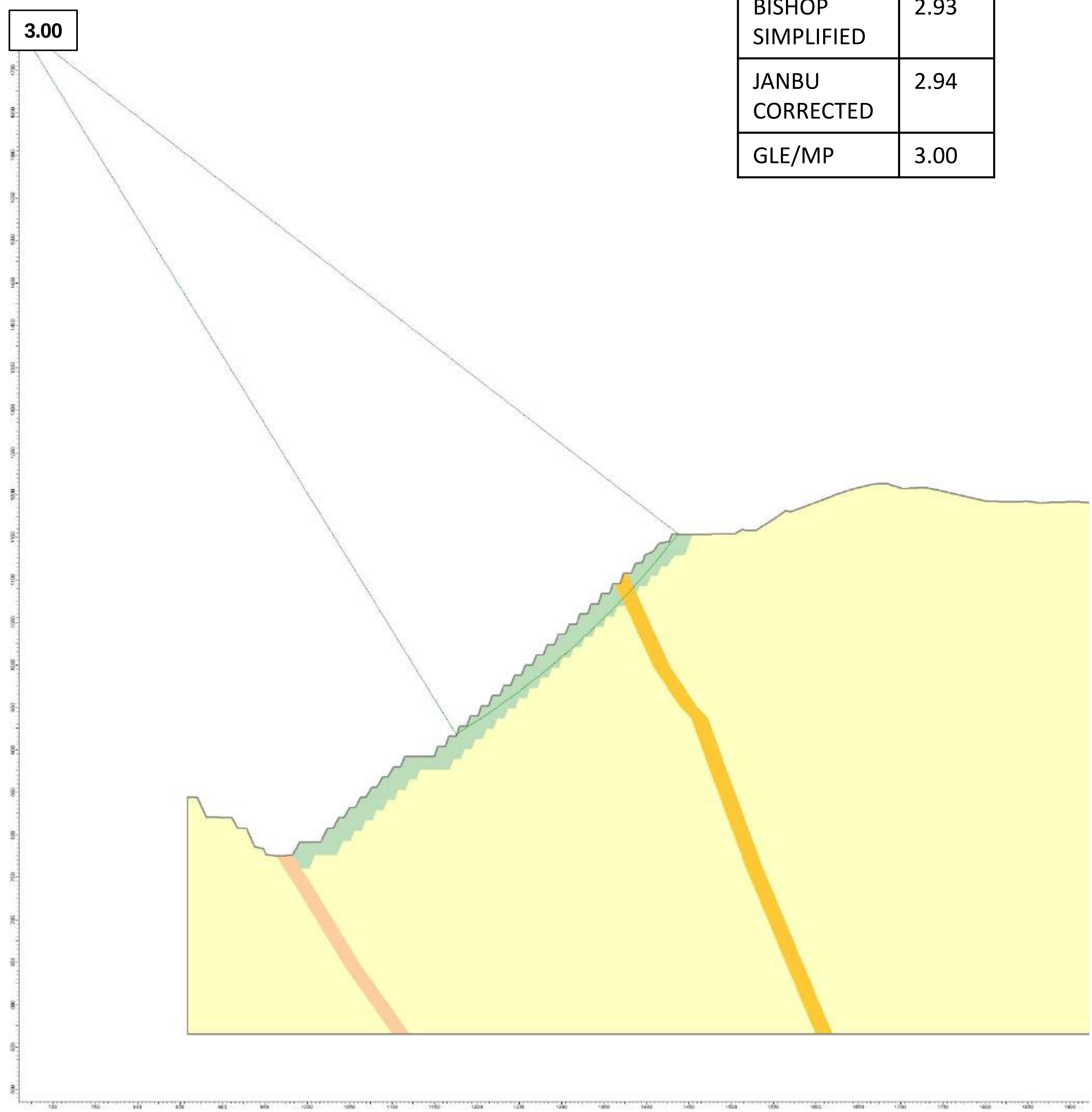
Path: \\golder.gds\gal\burnaby\Active_2005\1413\05-1413-027 Mt. Polley\2016 LOM Pit Design Review\Report\Rev 0\

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

CLIENT	MOUNT POLLEY MINING CORPORATION LIKELY, BC
PROJECT	GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS
CONSULTANT	Golder Associates
YYYY-MM-DD	2016-05-09
PREPARED	KGV
DESIGN	JKH
REVIEW	JKH
APPROVED	AVC
TITLE	**SPRINGER PIT NORTHEAST WALL STABILITY ANALYSIS INTER-RAMP CIRCULAR FAILURE THROUGH ROCK MASS DRY CONDITIONS**
PROJECT NO.	051413027
PHASE	2115
REV.	0
FIGURE	C-3

GLE/MORGENSTERN-PRICE

METHOD	FOS
BISHOP SIMPLIFIED	2.93
JANBU CORRECTED	2.94
GLE/MP	3.00



CLIENT
MOUNT POLLEY MINING CORPORATION
LIKELY, BC

PROJECT
GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS

CONSULTANT
Golder Associates

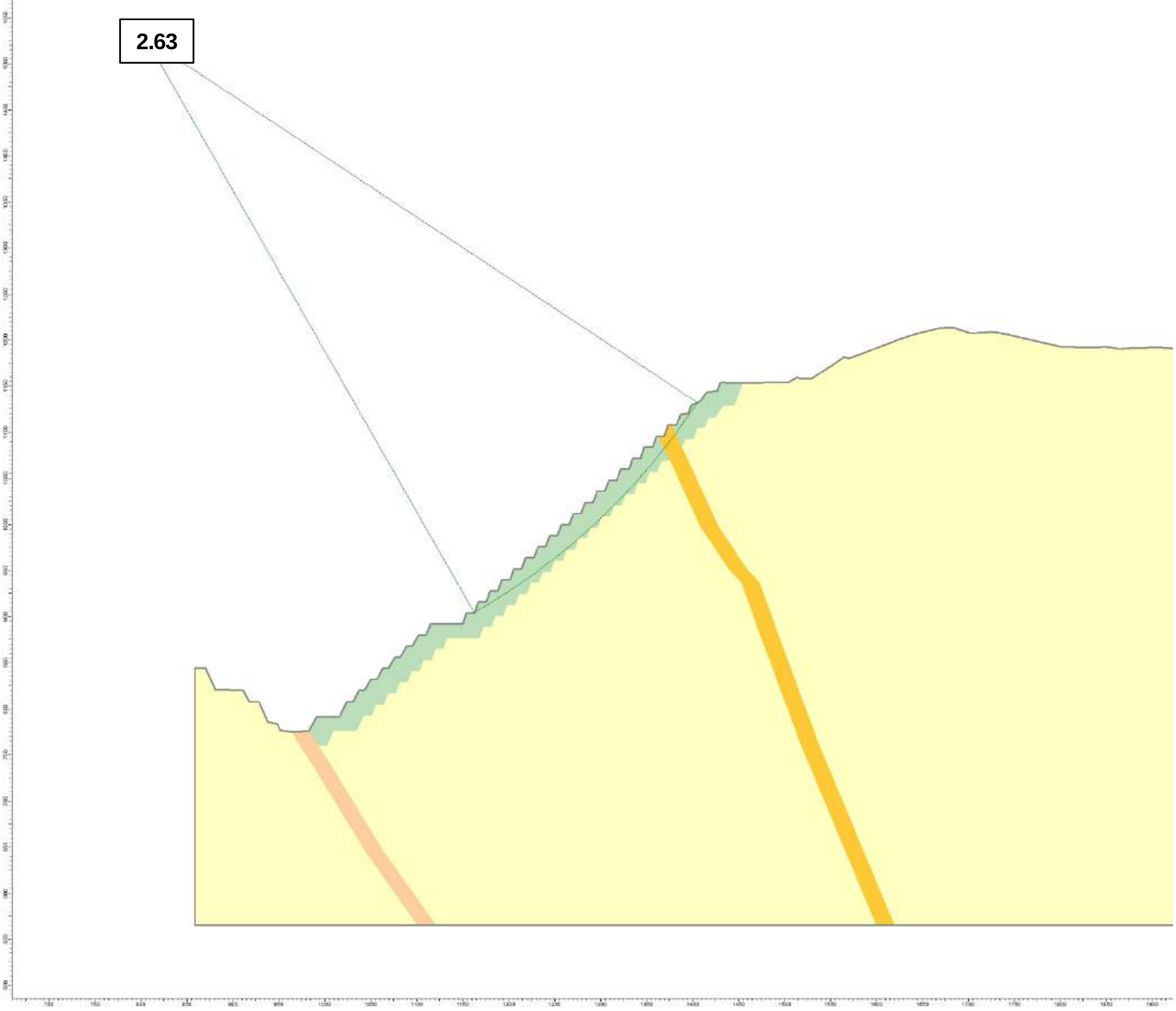
YYYY-MM-DD	2016-05-09
PREPARED	KGV
DESIGN	JKH
REVIEW	JKH
APPROVED	AVC

TITLE
SPRINGER PIT NORTHEAST WALL STABILITY ANALYSIS
INTER-RAMP CIRCULAR FAILURE THROUGH ROCK MASS
GROUNDWATER PRESSURE r_u = 0.1

PROJECT NO.	PHASE	REV.	FIGURE
051413027	2115	0	C-4

GLE/MORGENSTERN-PRICE

METHOD	FOS
BISHOP SIMPLIFIED	2.60
JANBU CORRECTED	2.59
GLE/MP	2.63



CLIENT
MOUNT POLLEY MINING CORPORATION
LIKELY, BC

PROJECT
GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS

CONSULTANT

Golder Associates

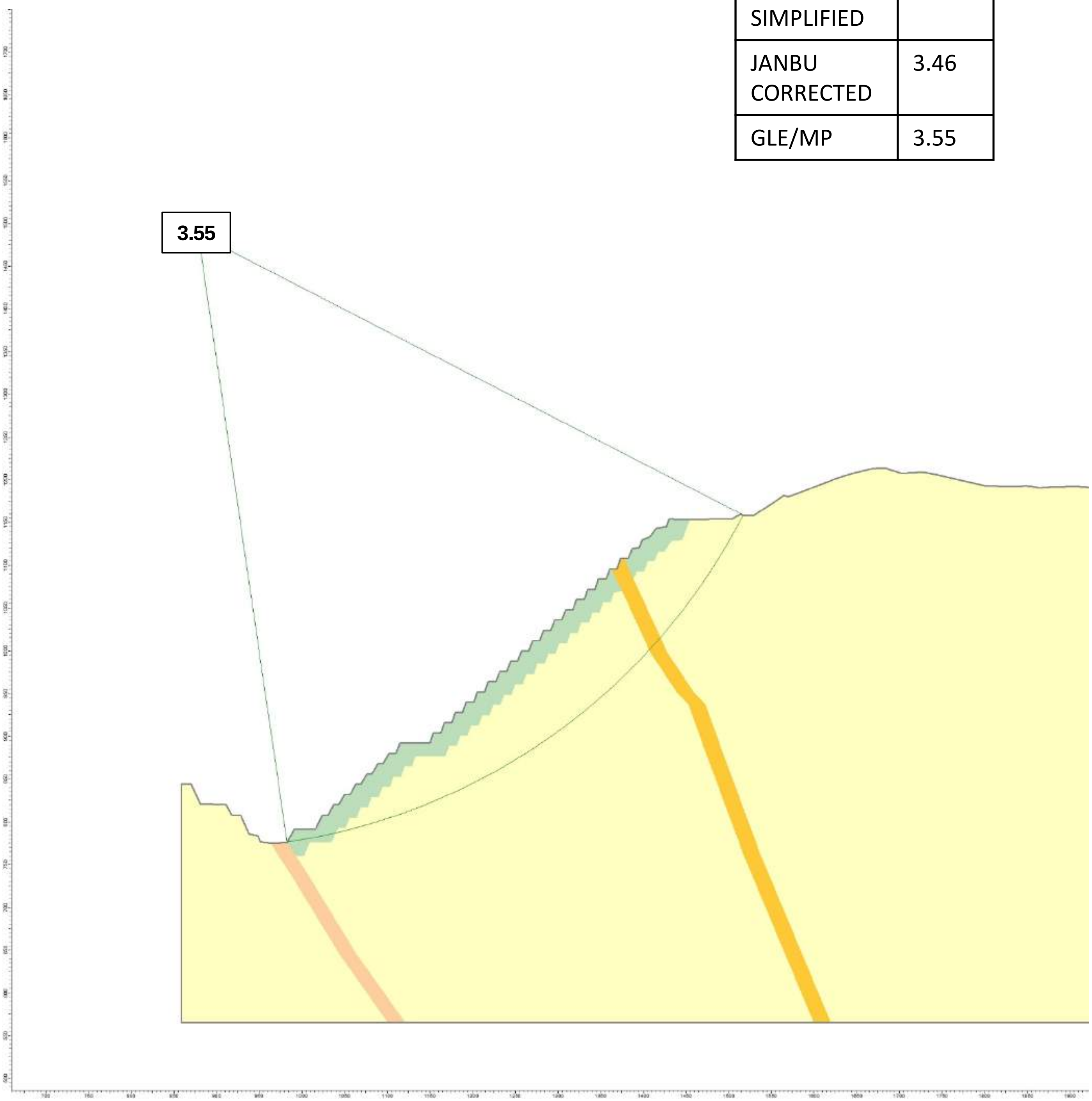
YYYY-MM-DD	2016-05-09
PREPARED	KGV
DESIGN	JKH
REVIEW	JKH
APPROVED	AVC

TITLE
SPRINGER PIT NORTHEAST WALL STABILITY ANALYSIS
INTER-RAMP CIRCULAR FAILURE THROUGH ROCK MASS
GROUNDWATER PRESSURE r_u = 0.2

PROJECT NO.	PHASE	REV.	FIGURE
051413027	2115	0	C-5

GLE/MORGENSTERN-PRICE

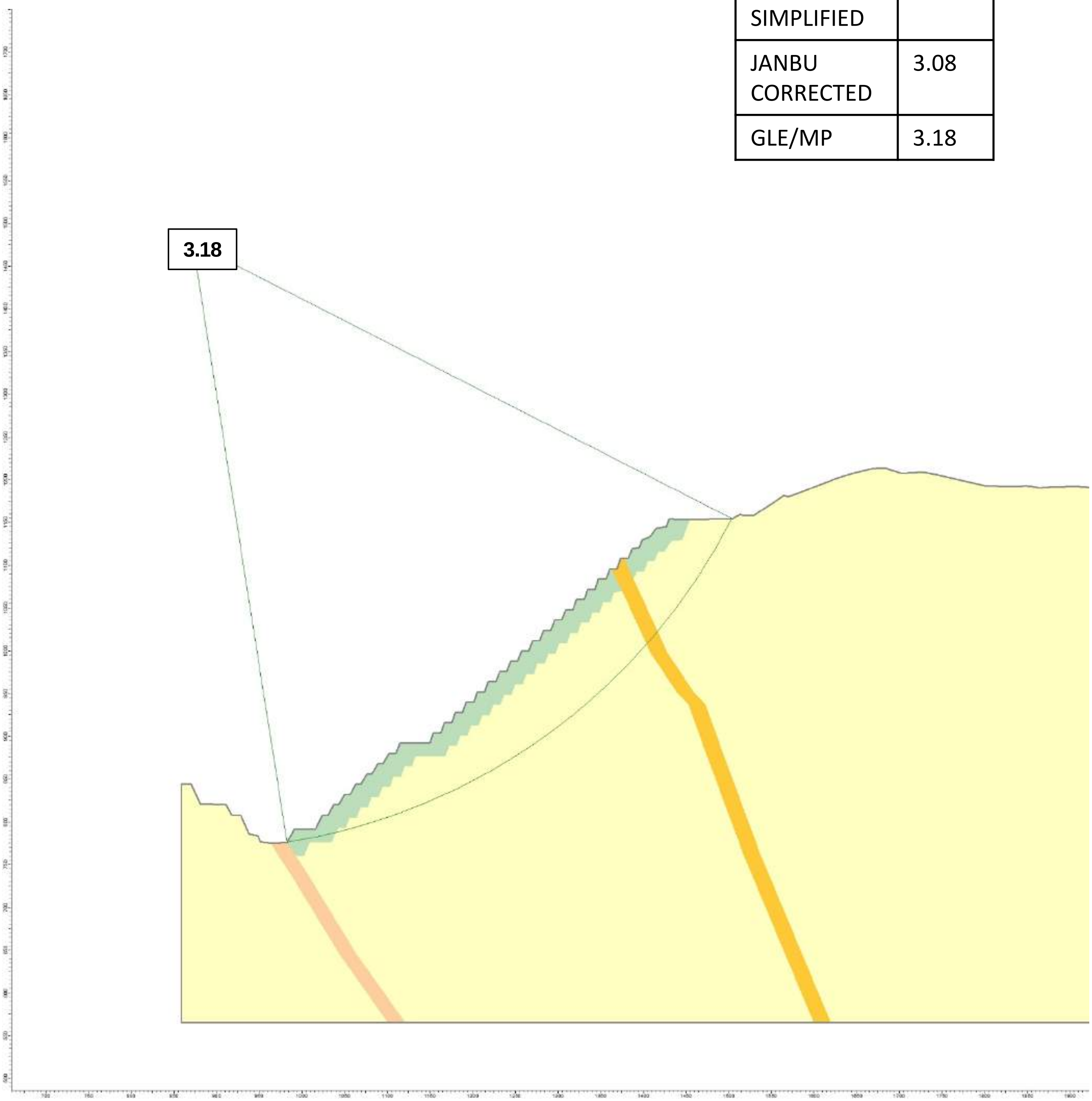
METHOD	FOS
BISHOP SIMPLIFIED	3.53
JANBU CORRECTED	3.46
GLE/MP	3.55



CLIENT MOUNT POLLEY MINING CORPORATION LIKELY, BC		PROJECT GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS	
CONSULTANT Golder Associates	YYYY-MM-DD: 2016-05-09 PREPARED: KGV DESIGN: JKH REVIEW: JKH APPROVED: AVC	TITLE **SPRINGER PIT NORTHEAST WALL STABILITY ANALYSIS OVERALL SLOPE CIRCULAR FAILURE THROUGH ROCK MASS DRY CONDITIONS**	
PROJECT NO. **051413027**	PHASE **2115**	REV. **0**	FIGURE **C-6**

GLE/MORGENSTERN-PRICE

METHOD	FOS
BISHOP SIMPLIFIED	3.17
JANBU CORRECTED	3.08
GLE/MP	3.18



CLIENT
MOUNT POLLEY MINING CORPORATION
LIKELY, BC

PROJECT
GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS

CONSULTANT

Golder Associates

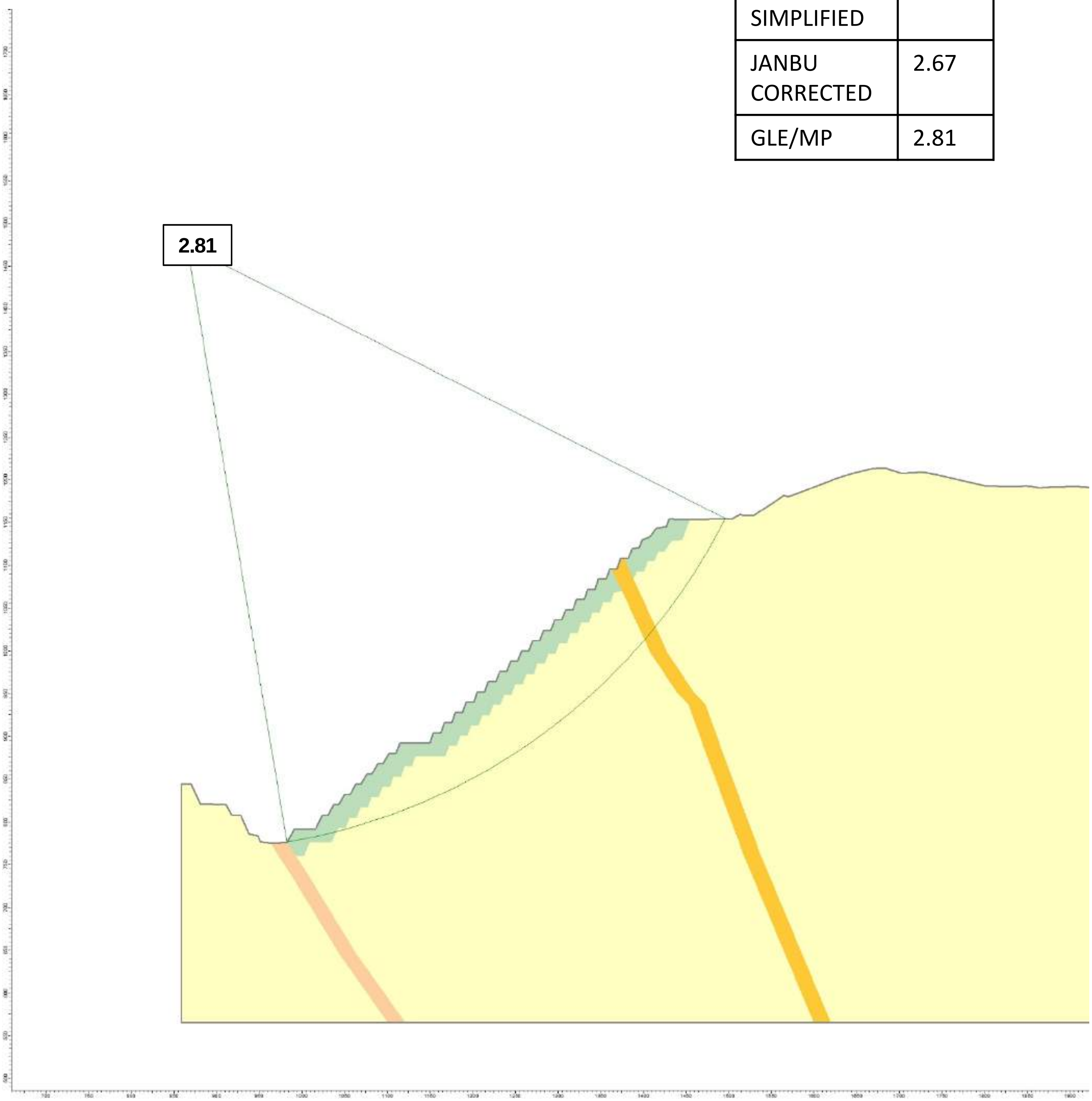
YYYY-MM-DD	2016-05-09
PREPARED	KGV
DESIGN	JKH
REVIEW	JKH
APPROVED	AVC

TITLE
SPRINGER PIT NORTHEAST WALL STABILITY ANALYSIS
OVERALL SLOPE CIRCULAR FAILURE THROUGH ROCK MASS
GROUNDWATER PRESSURE r_u = 0.1

PROJECT NO.	PHASE	REV.	FIGURE
051413027	2115	0	C-7

GLE/MORGENSTERN-PRICE

METHOD	FOS
BISHOP SIMPLIFIED	2.79
JANBU CORRECTED	2.67
GLE/MP	2.81



CLIENT
MOUNT POLLEY MINING CORPORATION
LIKELY, BC

PROJECT
GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-09
PREPARED	KGV
DESIGN	JKH
REVIEW	JKH
APPROVED	AVC

TITLE
SPRINGER PIT NORTHEAST WALL STABILITY ANALYSIS
OVERALL SLOPE CIRCULAR FAILURE THROUGH ROCK MASS
GROUNDWATER PRESSURE r_u = 0.2

PROJECT NO.	PHASE	REV.	FIGURE
051413027	2115	0	C-8

APPENDIX D

Results of Kinematic Slope Stability Analyses

Table D-1: Summary of Springer Pit Bench-Scale Kinematic Stability Analyses

Wall Dip Direction (Azimuth, in degrees)	Bench Height (m)	Design Probability of Failure (percentage)	Planar Kinematic Results				Wedge Kinematic Results				Rationale	Recommended BFA
			Total No. Planes with FOS <1	Total No. Kinematically Admissible Planes	Percent Failed Planes	Indicated BFA from Planar Analyses (degrees)	Total Wedges with FOS <1	Total # Kinematically Admissible Wedges	Percent Failed Wedges	Indicated BFA from Wedge Analyses (degrees)		
000°	12	50%	95	95	100%	42	3527	85946	4%	70	Shallow dipping, discontinuous Set 4 creates bench scale planar failures along South Walls. Also current experience has shown that shallower dipping members of Set 3 have caused the loss of double benches on the South Wall. Use a single bench configuration with wider catch-bench.	70
030°	12	50%	2	2	100%	50	10750	98293	11%	68	No planar controls. Only two planar structures plotted in this analyses. Use wedge results. Double bench acceptable	70
060°	12	50%	120	120	100%	71	16408	63878	26%	67	Use wedge restrictions. Double benching acceptable.	65
090°	12	50%	353	353	100%	71	33128	47958	69%	68	Use wedge restrictions. Double benching acceptable. Use 65 degree BFA to merge IRA with adjacent West Wall segments.	65
120°	12	50%	267	267	100%	71	65251	88551	74%	66	Use wedge restrictions. Double benching acceptable.	65
150°	12	50%	114	114	100%	70	76684	112065	68%	65	Use wedge restrictions. Double benching acceptable.	65
180°	12	50%	176	176	100%	72	69752	111431	63%	66	Use wedge restrictions. Double benching acceptable.	65
210°	12	50%	184	185	100%	73	32897	75780	43%	67	Use wedge restrictions. Use the 240° azimuth design to blend with the remainder of the Northeast Wall.	70
240°	12	50%	113	113	100%	75	18332	66504	28%	69	Use wedge restrictions. Use single bench to control toppling from Polley and Springer Faults.	70
270°	12	50%	102	102	100%	43	11811	71113	17%	65	Same comments as wall facing 000° azimuth.	70
300°	12	50%	174	174	100%	41	8576	53553	16%	56	Same comments as wall facing 000° azimuth.	70
330°	12	50%	174	174	100%	40	7942	72391	11%	51	Same comments as wall facing 000° azimuth.	70

Table D-2: Summary of Springer Pit Inter-ramp Scale Kinematic Stability Analyses

Wall Dip Direction (Azimuth, in degrees)	Inter-ramp Slope Height (m)	Design Probability of Failure (percentage)	Planar Kinematic Results				Wedge Kinematic Results				Rationale	Recommended IRA
			Total No. Planes with FOS <1	Total No. Kinematically Admissible Planes	Percent Failed Planes	Indicated IRA from Planar Analyses (degrees)	Total Wedges with FOS <1	Total # Kinematically Admissible Wedges	Percent Failed Wedges	Indicated IRA from Wedge Analyses (degrees)		
000°	48	25%	18	18	100%	61	2399	9912	24%	56		Limited by BFA and catch-bench width considerations
030°	48	25%	9	9	100%	65	2635	9843	27%	61		Limited by BFA and catch-bench width considerations
060°	48	25%	39	39	100%	68	2464	5357	46%	64		Limited by BFA and catch-bench width considerations
090°	48	25%	57	57	100%	70	2047	3113	66%	66		Limited by BFA and catch-bench width considerations
120°	48	25%	51	51	100%	70	2127	3114	68%	66		Limited by BFA and catch-bench width considerations
150°	48	25%	35	35	100%	71	2606	4904	53%	65		Limited by BFA and catch-bench width considerations
180°	48	25%	17	17	100%	69	2821	7254	39%	60		Limited by BFA and catch-bench width considerations
210°	48	25%	24	24	100%	60	2017	9157	22%	58	Single bench in Polley Fault	Limited by BFA and catch-bench width considerations
240°	48	25%	39	39	100%	59	3182	8946	36%	54	Single bench in Polley Fault	Limited by BFA and catch-bench width considerations
270°	48	25%	63	74	85%	45	2520	6889	37%	49	Single bench in Polley Fault	Limited by BFA and catch-bench width considerations
300°	48	25%	81	96	84%	44	2044	4699	43%	49		Limited by BFA and catch-bench width considerations
330°	48	25%	54	58	93%	50	1540	8047	19%	53		Limited by BFA and catch-bench width considerations

Table D-3: Summary of Springer Pit Recommended Bench Design Configurations

Wall Dip Direction (Azimuth, in degrees)	Pit Design Sector Azimuth (degrees)	Bench Height (m)	Bench Face Angle (degrees)	Inter-ramp Angle (degrees)	Bench Width (m)	Rationale
000°	180°	12	70	43	8.5	Single bench due to shallower dipping Set 3 structures on South Wall.
030°	210°	24	70	50	11.5	
060°	240°	24	65	46.5	11.5	
090°	270°	24	65	46.5	11.5	
120°	300°	24	65	46.5	11.5	
150°	330°	24	65	46.5	11.5	
180°	000°	24	65	46.5	11.5	
210°	030°	12	70	43	8.5	Single bench through Polley and Springer Faults
240°	060°	12	70	43	8.5	Single bench through Polley and Springer Faults
270°	090°	12	70	43	8.5	Single bench through Polley and Springer Faults Single bench due to shallow westerly dipping structures at bottom of East Wall.
300°	120°	12	70	43	8.5	Single bench due to shallower dipping Set 3 structures on South Wall.
330°	150°	12	70	43	8.5	Single bench due to shallower dipping Set 3 structures on South Wall.

Table D-4: Summary of Cariboo and C2 Pit Bench-Scale Kinematic Stability Analyses

Wall Dip Direction (Azimuth, in degrees)	Bench Height (m)	Design Probability of Failure (percentage)	Planar Kinematic Results				Wedge Kinematic Results				Rationale	Recommended BFA
			Total No. Planes with FOS <1	Total No. Kinematically Admissible Planes	Percent Failed Planes	Indicated BFA from Planar Analyses (degrees)	Total Wedges with FOS <1	Total # Kinematically Admissible Wedges	Percent Failed Wedges	Indicated BFA from Wedge Analyses (degrees)		
000°	12	50%	63	63	100%	40	1668	9367	18%	65	Shallow dipping, discontinuous Set 4 creates bench scale ravelling along small planar failures along South Walls. Use a double bench configuration with 65 degree BFA.	65
030°	12	50%	26	26	100%	50	2356	10663	22%	64	Use single bench with 70 BFA in Polley Fault. Otherwise double bench at 65 degrees.	65
060°	12	50%	33	33	100%	71	2690	8957	30%	69	Use single bench with 70 BFA in Polley Fault. Otherwise double bench at 70 degrees.	70
090°	12	50%	84	84	100%	72	2963	6766	44%	69	Use single bench with 70 BFA in Polley Fault. Otherwise double bench at 70 degrees.	70
120°	12	50%	86	86	100%	71	4874	8297	59%	64	Use single bench with 70 BFA in Polley Fault. Otherwise double bench at 65 degrees.	65
150°	12	50%	43	43	100%	64	5845	10545	55%	63	Double bench at 65 degrees.	65
180°	12	50%	39	39	100%	63	5341	10462	51%	66	Double bench at 70 degrees to blend with adjacent wall segments on the Northeast Wall.	70
210°	12	50%	41	41	100%	74	3205	7142	45%	69	Double bench at 70 degrees.	70
240°	12	50%	36	36	100%	78	1391	5044	28%	74	Double bench at 70 degrees.	70
270°	12	50%	33	33	100%	76	720	4884	15%	73	Double bench at 70 degrees.	70
300°	12	50%	26	26	100%	73	820	5702	14%	70	Double bench at 70 degrees.	70
330°	12	50%	49	49	100%	37	1303	7163	18%	60	Shallow dipping, discontinuous Set 4 creates bench scale ravelling along small planar failures along South Walls. Use a double bench configuration with 65 degree BFA.	65

Table D-5: Summary of Cariboo and C2 Pit Inter-ramp Scale Kinematic Stability Analyses

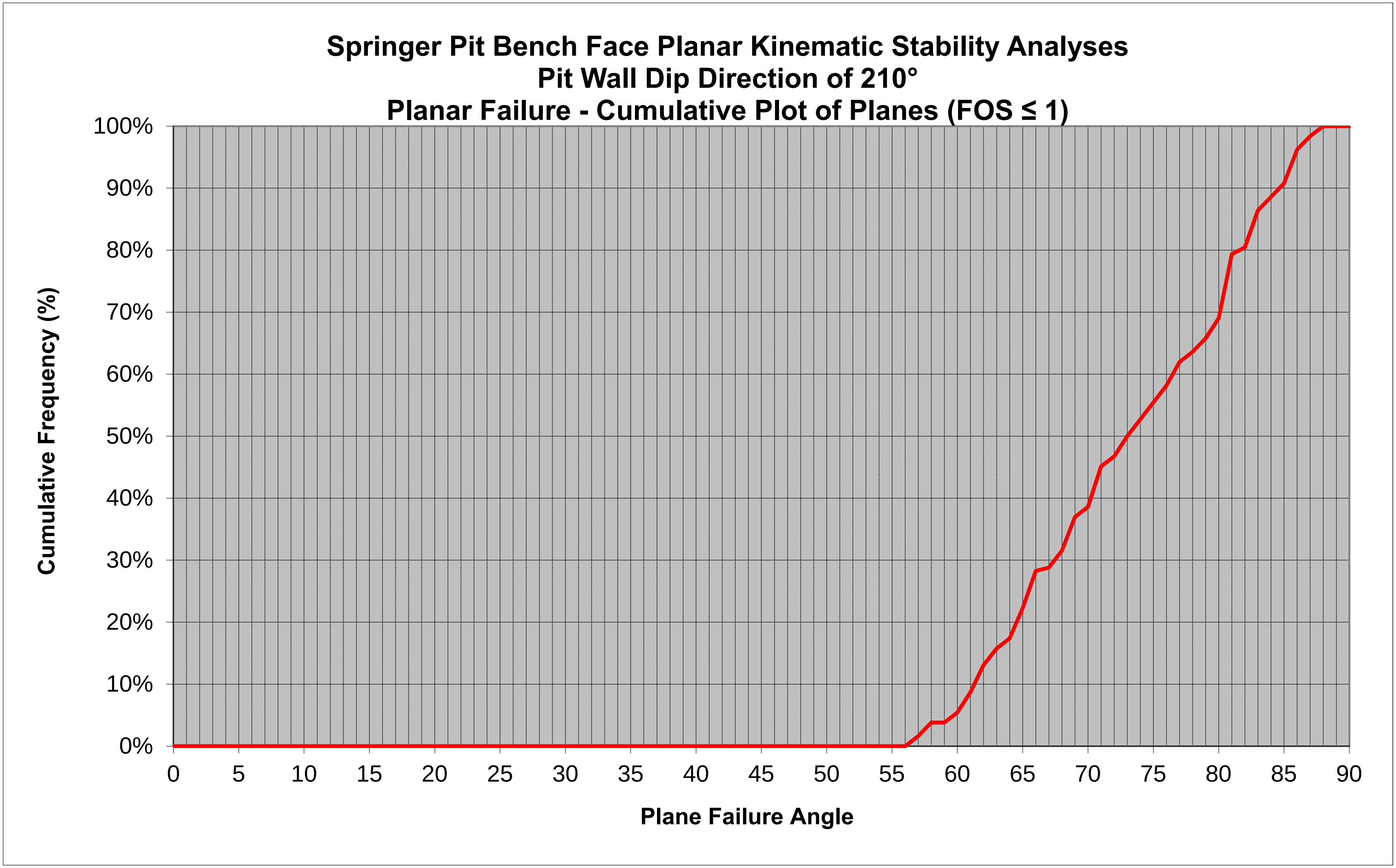
Wall Dip Direction (Azimuth, in degrees)	Inter-ramp Slope Height (m)	Design Probability of Failure (percentage)	Planar Kinematic Results				Wedge Kinematic Results				Rationale	Recommended IRA
			Total No. Planes with FOS <1	Total No. Kinematically Admissible Planes	Percent Failed Planes	Indicated IRA from Planar Analyses (degrees)	Total Wedges with FOS <1	Total # Kinematically Admissible Wedges	Percent Failed Wedges	Indicated IRA from Wedge Analyses (degrees)		
000°	48	25%	23	23	100%	66	535	898	60%	62		Limited by BFA and catch-bench width considerations
030°	48	25%	21	21	100%	62	838	1334	63%	55	Single bench in Polley Fault	Limited by BFA and catch-bench width considerations
060°	48	25%	20	20	100%	53	1113	1460	76%	55	Single bench in Polley Fault	Limited by BFA and catch-bench width considerations
090°	48	25%	28	28	100%	60	788	1323	60%	57	Single bench in Polley Fault	Limited by BFA and catch-bench width considerations
120°	48	25%	28	28	100%	62	604	984	61%	60	Single bench in Polley Fault	Limited by BFA and catch-bench width considerations
150°	48	25%	11	11	100%	62	424	781	54%	61		Limited by BFA and catch-bench width considerations
180°	48	25%	2	2	100%	85	257	602	43%	65		Limited by BFA and catch-bench width considerations
210°	48	25%	9	9	100%	85	79	315	25%	72		Limited by BFA and catch-bench width considerations
240°	48	25%	10	10	100%	83	103	180	57%	76		Limited by BFA and catch-bench width considerations
270°	48	25%	8	8	100%	66	181	271	67%	67		Limited by BFA and catch-bench width considerations
300°	48	25%	7	7	100%	66	328	457	72%	65	Planar ravelling	Limited by BFA and catch-bench width considerations
330°	48	25%	11	11	100%	66	366	673	54%	64	Planar ravelling	Limited by BFA and catch-bench width considerations

.

Table D-6: Summary of Cariboo and C2 Pit Recommended Bench Design Configurations

Wall Dip Direction (Azimuth, in degrees)	Pit Design Sector Azimuth (degrees)	Bench Height (m)	Bench Face Angle (degrees)	Inter-ramp Angle (degrees)	Bench Width (m)	Rationale
000°	180°	24	65	46	12	Shallow dipping, discontinuous Set 4 creates bench scale ravelling along small planar failures along South Walls. Use a double bench configuration with 65 degree BFA.
030°	210°	24/12	65/70	46/43	12/8.5	Use single bench with 70° BFA in Polley Fault. Otherwise double bench at 65° BFA.
060°	240°	24/12	70	49/43	12/8.5	Use single bench with 70° BFA in Polley Fault. Otherwise double bench at 65° BFA.
090°	270°	24/12	70	49/43	12/8.5	Use single bench with 70° BFA in Polley Fault. Otherwise double bench at 65° BFA.
120°	300°	24/12	65/70	46/43	12/8.5	Use single bench with 70° BFA in Polley Fault. Otherwise double bench at 65° BFA.
150°	330°	24	65	46	12	
180°	000°	24	70	49	12.13	
210°	030°	24	70	49	12.13	
240°	060°	24	70	49	12.13	
270°	090°	12	70	43	8.5	Original design was 51 degree IRA (Golder 2013). However, current design is single bench due to toppling along East Cariboo Fault.
300°	120°	24	70	49	12.13	
330°	150°	24	65	46	12	Shallow dipping, discontinuous Set 4 creates bench scale ravelling along small planar failures along South Walls. Use a double bench configuration with 65 degree BFA.

o:\final\2005\2005\1413\05-1413-027\051413027-111-r-rev0-2115\appendices\appendix d - kinematic analyses\appendix d1 - kinematic stability analyses summary - 11x17.docx



CLIENT
MOUNT POLLEY MINING CORPORATION
LIKELY, BC

PROJECT
GEOTECHNICAL REVIEW OF LOM CARIBOO PIT
AND SPRINGER PIT SLOPE DESIGNS

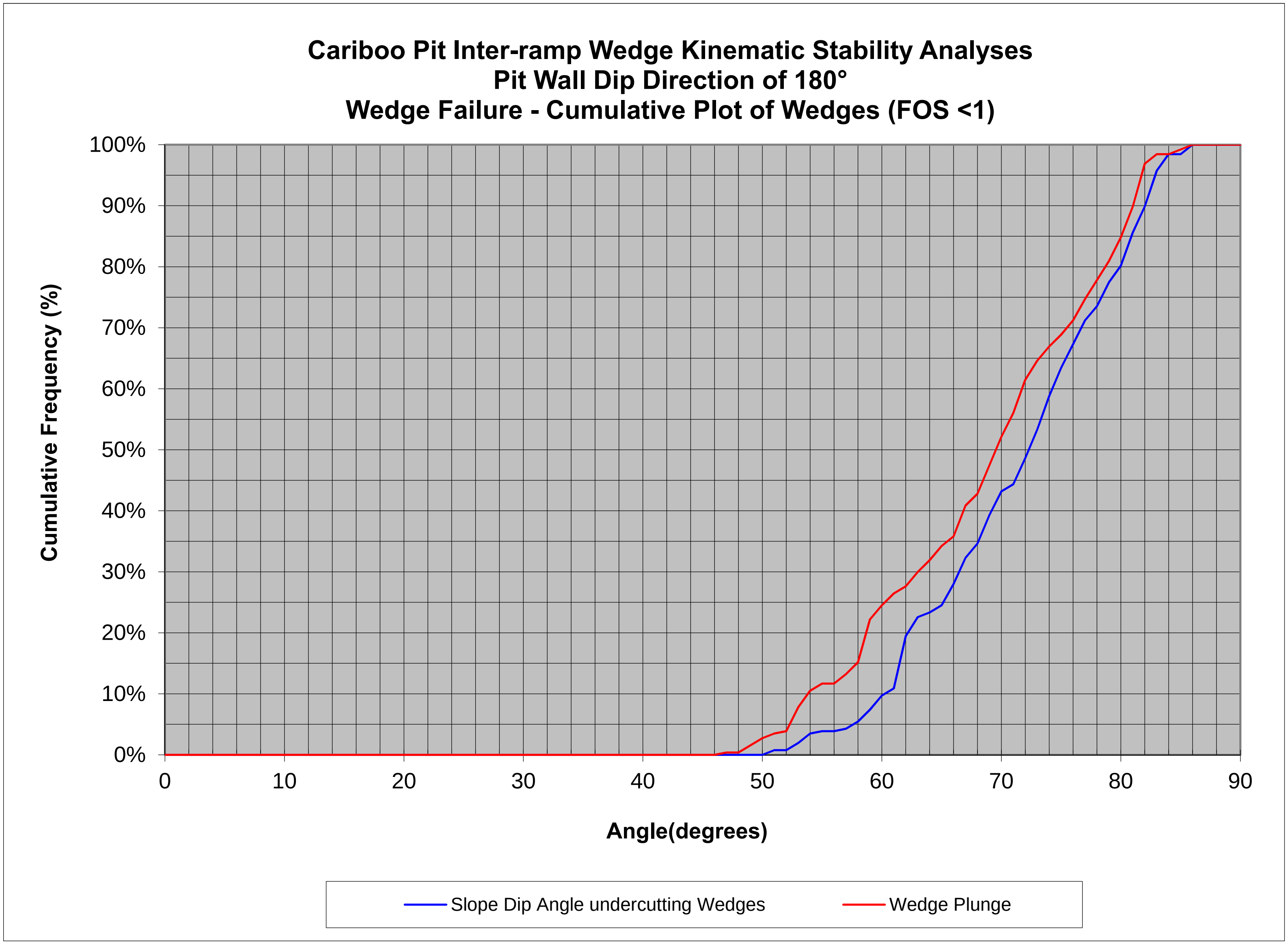
CONSULTANT

Golder Associates

YYYY-MM-DD	2016-05-09
PREPARED	KGV
DESIGNED	JKH
REVIEWED	JKH
APPROVED	AVC

TITLE
PLANAR KINEMATIC BFA STABILITY ANALYSES
EXAMPLE CUMULATIVE FREQUENCY PLOT
SPRINGER PIT – WALL DIP DIRECTION 210°

PROJECT NO.	PHASE	REV.	FIGURE
051413027	**2115**	**0**	**D-1**



CLIENT
MOUNT POLLEY MINING CORPORATION
LIKELY, BC

PROJECT
GEOTECHNICAL REVIEW OF LOM CARIBOO PIT AND SPRINGER PIT SLOPE DESIGNS

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-05-09
PREPARED	KGV
DESIGNED	JKH
REVIEWED	JKH
APPROVED	AVC

TITLE
WEDGE KINEMATIC IRA STABILITY ANALYSES
EXAMPLE CUMULATIVE FREQUENCY PLOT
CARIBOO PIT – WALL DIP DIRECTION 180°

PROJECT NO.	PHASE	REV.	FIGURE
051413027	2115	0	D-2

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

Africa	+ 27 11 254 4800
Asia	+ 852 2562 3658
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Ltd.
Suite 200 - 2920 Virtual Way
Vancouver, BC, V5M 0C4
Canada
T: +1 (604) 296 4200

Golder Associates