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APPENDIX J

Geotechnical Assessment Reports for Pit and WRS

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Our ref: PSM71-224R

16 February 2018

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ATTENTION: LOUIE HERRERO

Dear Louie

RE: GEOTECHNICAL REVIEW OF DEEPDELL PIT STAGE 3 DESIGN

We are pleased to submit our report providing a geotechnical review of Deepdell pit design for operations and closure.

We trust it is in keeping with your requirements, but should you have any queries please do not hesitate to contact us.

For and on behalf of
PELLS SULLIVAN MEYNINK

ROBERT BERTUZZI

Distribution: pdf copy emailed to Louie.Herrero@oceanagold.com
Original held by PSM

OceanaGold

GEOTECHNICAL REVIEW
DEEPDELL STABILITY ASSESSMENT

PSM71-224R **FEBRUARY 2018**

PSM

EXECUTIVE SUMMARY

This report presents a geotechnical stability assessment carried out by PSM to accompany a resource consent application for the proposed Deepdell Stage 3 pit development. This study was requested by OceanaGold Corporation to confirm slope performance during the following phases.

- Operational conditions during excavation - This assumes the water table is drawn down below the ultimate pit floor to approximately 372 mRL.
- Closure planning Scenario 1 – A pit lake forms to the lowest intersection point with the topography at the southern end of the pit, approximately 445 mRL.
- Closure planning Scenario 2 – A pit lake fills to the lowest intersection point at the northern end of the pit, approximately 475 mRL.

The typical slope design for Deepdell Stage 3 comprises:

- North and east walls comprising 15 m high, 60° batters and 4.3 to 7.5 m wide berms producing and 90 to 125 m high, 40 to 48° inter-ramp slopes.
- West wall (orientated towards 090°) comprising variable batter and berm configurations, producing a 145 m high, 23 to 38° inter-ramp slopes.

Geotechnical stability assessments undertaken have shown to have a minimum factor of safety ≥ 1.5. This exceeds the general acceptance level for mine slope stability. A sensitivity analysis was carried out on the east wall to test the design for seismic loading. A horizontal load of 0.13g (equivalent to a M 4.5 earthquake 0 km from the mine) was applied in the analysis. The resultant factor of safety = 1.2 indicating that the design would remain stable under the earthquake.

The proposed waste rock stacks to the north and south of the pit will have no effect on stability.

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FIGURES

APPENDICES

1 INTRODUCTION

This report presents a geotechnical stability assessment carried out by PSM to accompany a resource consent application for the proposed Deepdell Stage 3 pit development. This study was requested by Mr Pieter Doelman [(1)] of OceanaGold Corporation (OceanaGold) to confirm the stability of the proposed slope design during mining and at closure where an in pit lake is to be established.

OceanaGold has been mining at Macraes Flat since 1990 targeting mineralisation within the Hyde-Macraes Shear Zone (HMSZ), Figure 1. Deepdell is one of eleven open pits within OceanaGold's operations and is located in the northern part of the operation between the Coronation and Golden Point pits.

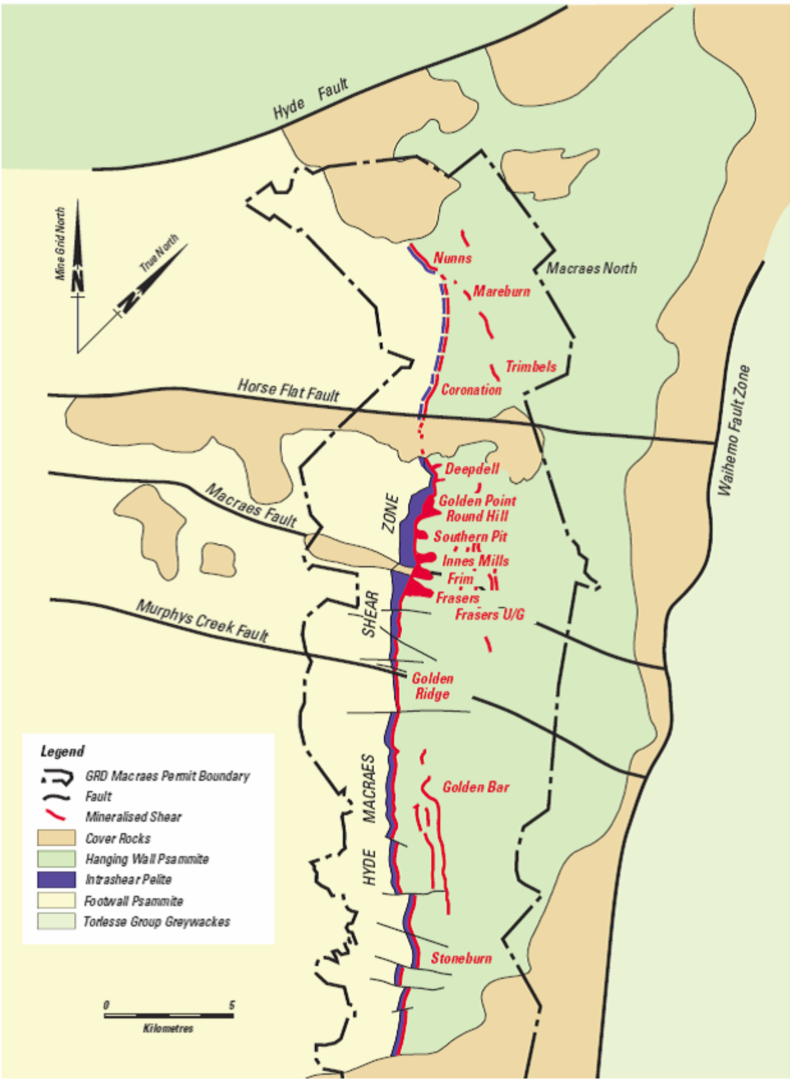

Figure 1: **Schematic view of the open pit which develops along strike of the Hyde-Macraes Shear Zone**

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(1) Email from Pieter Doelman, dated 13 December 2017

Deepdell has been mined in three phases prior to the current development, Figure 2. This includes smaller Stage 1 and 2 satellite excavations plus the more prominent Deepdell south pit (located on the opposite side of Deepdell Creek). Currently the Stage 1 and 2 pits are back filled with a waste dump overlying the excavations.

The following aspects will be covered to provide an understanding of the geological environment and geotechnical analysis included as part of this study:

- Data sources,
- Geotechnical Model,
- Kinematic and Statistical Stability Analysis,
- Limit Equilibrium Stability Analysis,
- Slope Design Conformance, and
- Recommendations.

All figures are included at the end of the text. Some figures are reproduced within the text, where they assist in the narrative.

2 SCOPE

Oceanagold requested PSM conduct a geotechnical stability assessment of the Deepdell Stage 3 pit development, Figure 3, to confirm slope performance during the following phases.

1. Operational conditions during excavation - This assumes the water table is drawn down below the ultimate pit floor to approximately 372 mRL.
2. Closure planning Scenario 1 – A pit lake forms to the lowest intersection point with the topography at the southern end of the pit, approximately 445 mRL.
3. Closure planning Scenario 2 – A pit lake fills to the lowest intersection point at the northern end of the pit, approximately 475 mRL.

To achieve the design water level and provide adequate freeboard for Scenario 2 an in-pit embankment will be constructed in the southern end of the pit. This option provides redundancy if OceanaGold cannot ensure the lake water quality is suitable for discharge, or if the erosion risk of the discharge on the south side cannot be managed due to steep topography.

3 AVAILABLE DATA

The following data sources have been made available for this review.

Pit shell and topographic wireframes

- Deepdell Stage 3 pit,

- As built topographic surface – Current backfilled topography,
- As mined topographic surface – Mining extent during Stage 1 and 2, and
- Waste rock stack surfaces (Proposed) – North and South of Deepdell.

Geology

PSM has a long standing relationship with OceanaGold having contributed to the Macraes operations for more than twenty years. The geological understanding is well established with numerous publications detailing the origin and genesis of the area's geology.

Geological surfaces

- Three dimensional fault wireframe of the site persistent "Footwall Fault".
- Three dimensional fault wireframes of inferred geological structures within the northern wall. "DD_Fault_plane_1–3.dxf".

Maps and Plans

- Two dimensional surface traces (.dxf) of the Horse Flat, Table Top and Cyanide Creek Faults.
- Failure outlines and observed surface cracking (.dxf) – Deepdell North: DD02, DD03, DD04, DD05, DD06.

3.1 Geotechnical Investigations

PSM collected geotechnical data during the development of Stage 1, 2 and Deepdell South. This information includes:

Trench Excavations

Exploratory trenches were excavated to establish an early understanding of the geological conditions at Deepdell prior to establishment of the initial workings. A trench was orientated parallel to the east wall of the Stage 1 pit with three additional trenches excavated normal to this. Each trench was geotechnically mapped and data recorded in accordance with OceanaGold logging standards. Mapped defects are presented on stereoplots to provide an overview of structural orientation in the area. Summary histograms capture key defect characteristics including length, spacing, surface roughness infill and water. All of the above data is included in Appendix A.

Borehole data

Seven diamond cored boreholes located within the Stage 1 pit. Geotechnical parameters logged include weathering, infill type and thickness. Two holes (DDH39 and 42) include fractures per metre.

Summary borehole logs and histograms of defect characteristics for the available data is included in Appendix B.

Borehole and trench locations are illustrated spatially in Figure 2. No new geotechnical investigations have been undertaken as part of this study.

4 GEOTECHNICAL MODEL

4.1 Geology

The Macraes Flat area is within the extensively deformed and moderately metamorphosed Otago-Haast Schist Belt. The schist comprises a sequence of gradational psammitic and pelitic lithologies derived by metamorphism of Mesozoic aged sandstone and mudstone. The rocks are strongly foliated and depending on the origins, are either light grey, quartz rich and laminated (psammite) or dark grey to green, micaceous and finely laminated (< 5mm thick) (pelite).

Mineralisation occurs within the north-south [(2)] trending HMSZ (the Shear Zone) has a strike length of at least 35 km, Figure 1. The Shear Zone thickness varies from 5 to 140 m and is defined by the relatively continuous Hanging Wall Shear (HWS) and Footwall Fault (FF) which also approximate its lithological boundaries. Its tectonic displacement has been inferred to be hundreds of metres. The strain associated with that tectonic displacement was probably concentrated within the intra-shear pelite which could more readily absorb strain than the coarsely grained psammite above and below the Shear Zone. The structural geology of the area is dominated by two main orthogonal fault sets, striking to the north and east.

The Shear Zone dips gently to the east from Stoneburn in the south to Coronation in the north but displays a broad bend at Nunns, turning to dip to the northeast, Figure 1. A schematic geological cross section illustrating the adjacent Golden Point development illustrated the typical assemblage throughout the deposit, Figure 4.

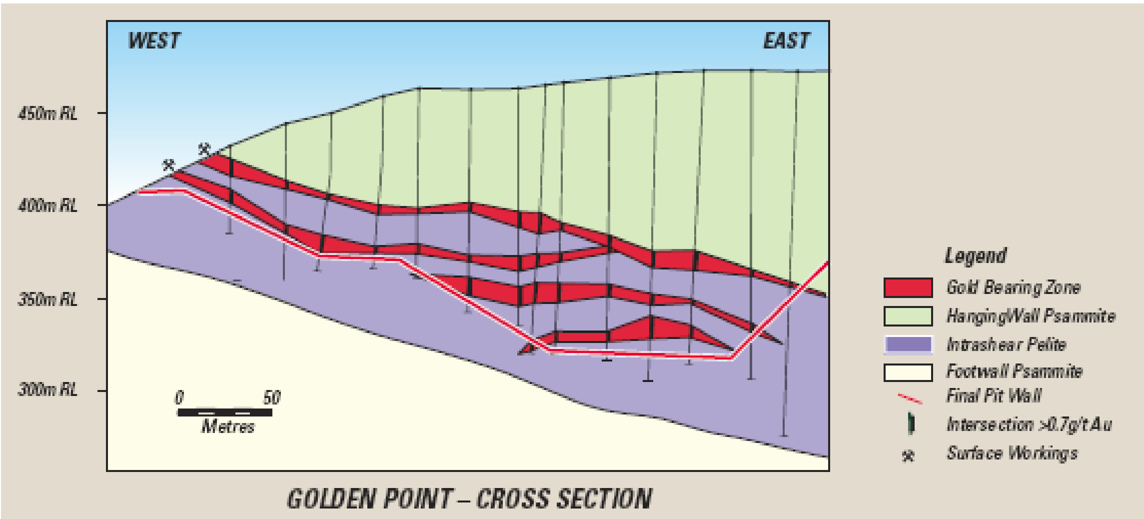

Figure 4: Typical geological cross section for the adjacent Golden Point Pit.

[(2)] All directions quoted are relative to Macraes' mine grid which is 45° west of true north. The magnetic declination at Macraes (45.38°S, 170.43°E) is approximately +25° (https://ww.ncdc.noaa.gov/news/national-centers-environmental-information 15/3/16)

The geological model for Deepdell has been refined from the initial trenching and borehole investigations through the mining of Stage 1 and 2. The dominant lithology expected within the Stage 3 excavation is intershear pelite. This unit makes up the majority of the rock mass between the HWS and FF beneath.

Further discussion regarding the pit scale geology is included below in Section 4.4.

4.2 Geological Structure

Geological structure defines defects within a rock mass resulting from the time of deposition/formation and the sites evolution though changes in stress condition/deformation over geological time. These structures provide an insight into the history of a geological environment and can be analysed to predict future performance of an excavated slope.

The geological structure model at Macraes typically comprises:

- Foliation, foliation shears and faults showing a broad range of dips from flat to moderately dipping towards the east (average 15 to 45°/100). This set parallels the FF and HWS of the HMSZ.
- Mine and regional scale faults that moderately to steeply dip towards the east (≈ 60°/090°). These faults are often infilled with clay or breccia to 100mm thick. This fault set includes the Northern Gully Fault and East Fault.
- Batter and mine scale faults and shears showing a broad range of dips from flat to moderately dipping towards the west (average ≈ 50°). This fault set includes the Ramp Shears which are typically truncated by the easterly dipping faults, described in Section 4.
- Joints and faults that are moderately to steeply dipping towards the north and south (≈ 55-75°/025°).

Structural data collection at Deepdell is limited to the initial exploratory trench mapping and discrete measurements surrounding individual zones of instability.

The available data was initially analysed to divide it into structural domains, i.e. areas of similar pattern. However, assessment of the stereoplots generated separately for trenches 1, 2 and 3 (Appendix A) indicated no significant spatial difference in structure. Therefore, the area of the proposed pit has been structurally analysed in terms of one domain only. A stereoplot summarising the trench mapping data is shown in Figure 5.

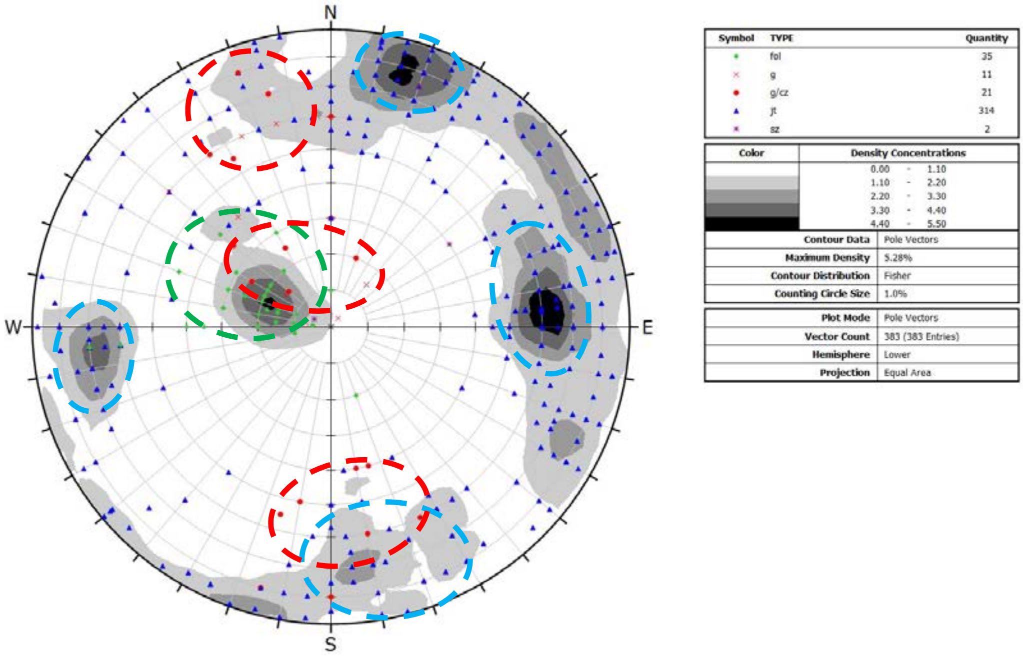

Figure 5: Defect stereonet illustrating geological structure trends from trench mapping at Deepdell. Foliation (Green), Joints (Blue) and Gouge/Shear Zones (Red).

The major structural trends specific to Deepdell are summarised below.

- Foliation dips at between 5° and 45° to the east/south east.
- Joints are typically sub vertical to steeply dipping to the south and west. Secondary sets dip steeply to sub vertical to the east and north.
- Three zones of gouge/crushed rock and shearing are apparent:
  - The first is flat to moderately dipping to the south to southeast, although a small number of defects are indicated as dipping to the southwest.
  - The second is moderately to steeply dipping to the southeast.
  - The third dips moderately to steeply to the north, but is poorly defined. These structures are favourably orientated with respective to the pit walls as they dip approximately perpendicular to the major wall aspects.

4.2.1 Defect Characteristics

Defect characteristics including length, continuity, roughness and water condition were recorded during trench logging. Information on defect infill and infill thickness was recorded in the borehole logs for gouge, crushed zones and shear zones. Typical descriptions for the major defect types with the exception of foliation (experience indicates that foliation is typically not a controlling defect for pit wall stability) are summarised below.

- Joints: Visible length typically in the range 0.5 – 1.5 m and continuous out of exposure. Spacing between joint planes typically ranges from <0.25 m to 0.75 m. The joints are mostly undulose on the large scale, rough on the small scale and tight. Experience from other pits at Macraes tends to indicate that the typical length of the majority of joints is less than 5 m.
- Gouge/Sheared and Crushed Zones: Visible length typically in the range of 1.0 to 5 m, and continuous out of exposure. The defects are undulose on the large scale and smooth on the small scale. The defects have been logged as being predominantly moist to damp. Borehole logging indicates that the typical infill type is gouge/rock fragments. Infill thicknesses are variable; however appear to be typically in the ranges of 20 to 50 mm and 200 to 500 mm.

4.2.2 Major Geological Structures

Major geological structures (first order) at Macraes typically refers to the FF and HWS as these features are known to significantly impact slope stability when undercut. The FF maintains a relatively consistent orientation throughout the operation, with a dip and dip direction in the Deepdell area of 12°/075°. This indicates that the fault is located approximately 92 m beneath the Stage 3 pit shell with a relatively shallow dip toward the east. A cross section illustrating this geometry is included in Figure 6.

Geological studies carried out between 1996 and 1999 identified the Deepdell Creek landforms as indicative of an ancient landslide with the FF as its basal plane. This suggested that movement around the Deepdell Creek area had occurred along the FF prior to any mining.

Reviewing second order geological structures (pit scale compared to regional structures) there are a number of features with the potential to negatively affect pit wall stability. This occurs when a feature is unfavourably orientated relative to a specific pit wall aspect and the structure dips out of the slope at an angle shallower than the design wall angle.

Surface traces of second order structures were provided by Oceanagold as mapped during development of the Stage 1 and 2 pits. This information has been combined with defect orientation data by PSM to generate three dimensional fault projections through the as built topography. A detailed explanation of this process is included for reference in Appendix C.

The resultant model is illustrated in Figure 7. Features of note include:

- The intersection of the Horse Flat Fault and inferred Fault Plane “2” within the northern wall. This is an unfavourable geometry as it isolates and potentially decouples a rock block dipping out of the slope.
- The orientation of the Cyanide Creek Fault relative to the existing east wall of the previous development. This fault strikes toward the south east direction which is oblique to the typical north south orientation of other major/first order structures in the area.
- The Table Top Fault is considered to be a benign feature due to its orientation striking towards the east wall of the Stage 3 design. There is potential for an area of structural complexity where this structure

converges with the Cyanide Creek Fault in the lower west wall of the proposed development.

Stability implications relating to these structures are discussed further in Section 8.

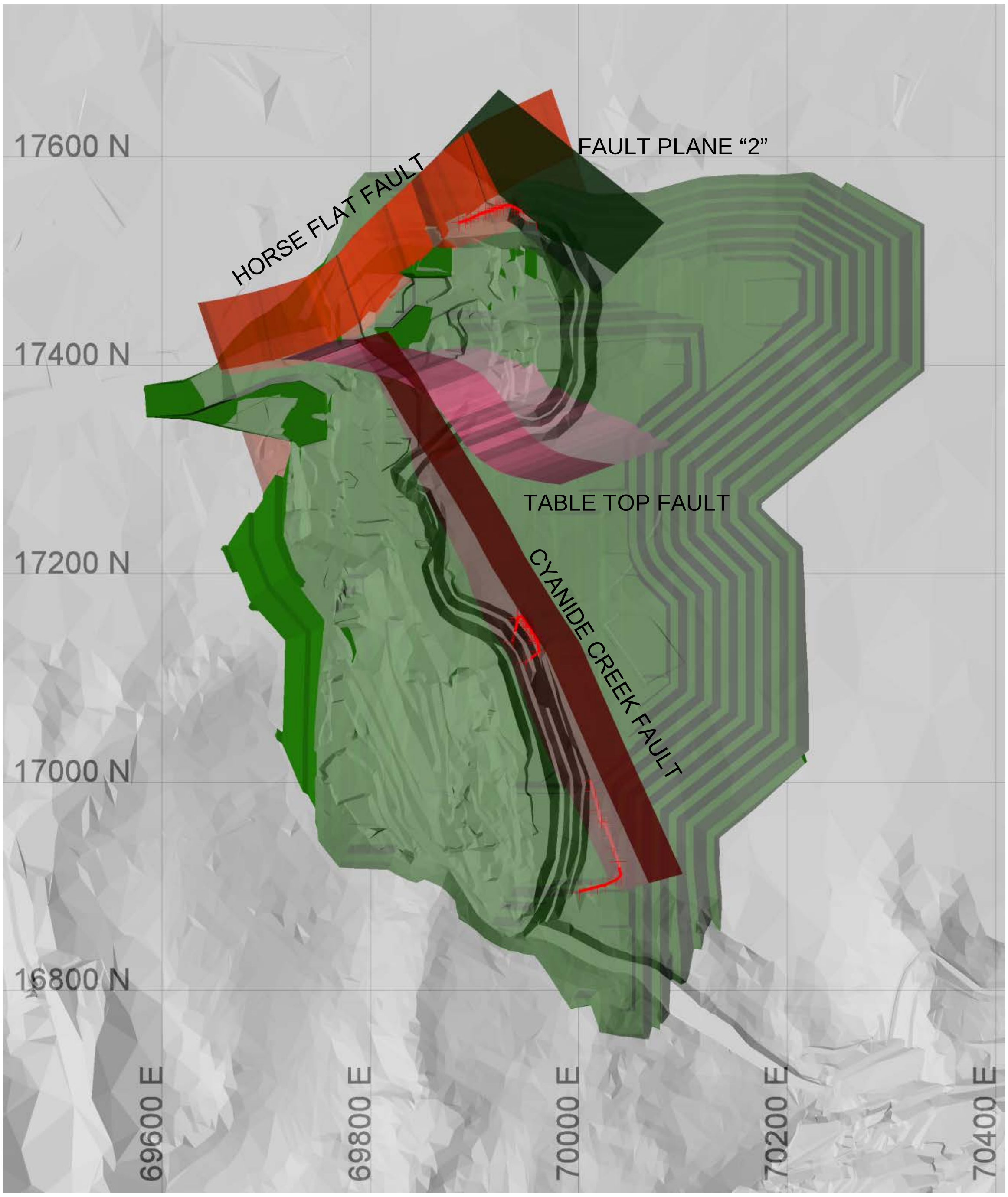

Figure 7: **Plan view of Deepdell as built Stage 1 and 2 topography (Grey) superimposed with the proposed Deepdell Stage 3 pit shell (Green). Second order fault structure projections included as noted. Historic instabilities outlined in red appear to be associated with the Cyanide Creek Fault.**

4.3 Rock Mass Conditions

- The pelitic schist is typically weathered to a depth of 12 to 15 m. This corresponds to the majority of the proposed pit walls being formed in fresh rock. The degree of weathering is noted to vary from highly to slightly weathered.
- Typical fracture spacing is about two defects per metre, ranging between one and seven. Fracture spacing is used to estimate block sized during stability analysis and give an indication to how intact the rock mass may be when excavated.
- Rock mass strength was not recorded as part of the borehole logging. However, based on the trench mapping the weathered pelitic schist has a typical field estimated strength of R3 to R4. This corresponds to an unconfined compressive strength (UCS) of about 25 MPa.
- The strength of fresh pelitic schist is typically higher than that of weathered schist; hence it is interpreted that the fresh rock should typically be at least R4 to R5 (typical UCS greater than 50 MPa). This value is greater than that logged in adjacent boreholes south of Deepdell Creek.

4.4 Groundwater

The *in situ* schist at Macraes has a very low permeability. However, the numerous faults, shears, shear zones and fractures throughout the rock mass in general provide paths for groundwater movement. The overall permeability therefore within the rock mass is not uniform but rather defined into compartments by the faults and shears.

No active groundwater monitoring piezometers are understood to be available within the Deepdell footprint. The Deepdell south pit has an in pit lake of approximately 370 mRL that can be used to assume a basic standing water level.

5 HISTORIC SLOPE PERFORMANCE

5.1 Slope Design Parameters

Recommended slope design parameters for Deepdell were previously derived for the Stage 1, 2 and Deepdell South pits, (References 2 & 3). These are summarised below.

- Deepdell 1 - 30m high, 75° batters with 10 m wide berms, and
- Deepdell South,
  - 15 m high, 60° batters with 7.5 m berms for the northern and eastern walls. This results in a 43° overall slope angle.
  - 70° batters and 5 m berms for the southern and western walls. This results in a 55° overall slope angle.
  - Batters in the weathered/oxide material should be 10 m high and 60° all around the pit.

5.2 Slope Stability Precedent

Initial designs for Deepdell aimed to achieve batter face angle of 75° degrees in fresh rock slopes along all slopes aspects. A number of instabilities occurred where persistent structure was exposed in the north and east walls.

Highlighted in Figure 7 are the locations of three multi bench wall instabilities recorded from the early stage Deepdell developments. The two east wall failures are orientated parallel to the Cyanide Creek fault. Exposure of sympathetic structures within the adjacent damaged rock mass are likely to be associated with these instabilities.

Photographs 1 and 2 illustrate the site condition at the time of failure.

Photograph 1: View of failure head scarp looking south

Photograph 2: **View of east wall multi bench failure at Deepdell**

Slope performance precedent from early developments in Stages 1 and 2 were used to educate a revised set of design angles for Deepdell South. These angles have been adopted for ongoing development of the proposed Deepdell Stage 3.

6 PIT GEOMETRY

6.1 Changes from current as built design

Deepdell Stage 3 cutbacks focus on development towards the east. The pit floor deepens by approximately 66 m from 438 mRL to 372 mRL, (Figure 3). The length of the north wall increases significantly but with a favourable slope aspect (180°), this does not undercut major structures of geotechnical concern. The east wall minimises slope aspects orientated between 255 and 295° by using a stepped profile (in plan) alternating between 270° and 320°. This has been implemented to avoid exposure of geological structures along known slope aspects that are more susceptible to cause slope instabilities.

The typical slope design for Deepdell comprises:

- North and east walls comprising 15 m high, 60° batters and 4.3 to 7.5 m wide berms producing and 90 to 125 m high, 40 to 48° inter-ramp slopes.
- West wall (orientated towards 090°) comprising variable batter and berm configurations, producing a 145 m high, 23 to 38° inter-ramp slopes.

7 STABILITY ANALYSIS - GEOLOGICAL STRUCTURE

Assessment of potential failure mechanisms through intersection of geological structures was carried out using kinematic and statistical methods. Kinematic analysis is a stereographic based technique that considers the mean orientation of defect sets, the slope orientation, the defect shear strength and potential failure modes. The analyses are simply an assessment of the geometrical possibility of simple block movements, i.e. planar sliding, wedge failure and toppling.

These methods can be applied to a range of slope scales depending on the nature of the local geology. However, for Deepdell this method is used to assess individual and multi bench stability due to the relative short persistence of local geological structures.

Statistical analyses extend the results of kinematic analyses and are utilised for two main reasons. Firstly, the scatter in defect orientation is often large which suggests that a traditional kinematic analysis which uses the mean orientation may yield either optimistic or conservative slope angles. Secondly, the sensitivity of defect dips may be qualitatively assessed. The risk of failure on a defect set (C_f) has commonly been defined as:

$C_f = C_u \times C_l$

Where C_u is a measure that a slope is undercut by a defect. The apparent dip of either a defect (planar failure) or an intersection (wedge failure) is steeper than the friction angle and shallower than the batter. C_u is influenced by the size and quality of data set. It assumes the data set is representative of the structural domain.

C_l is a measure of the length of the defect compared to the height of the slope. Because the statistical analyses are based on the results of trench mapping, it is not possible to filter out data less than the height of the slope, as in fact all data would be removed. Consequently, $C_f = C_u$.

Various published procedures as well as in-house techniques have been used to assess appropriate slope angles. Published data and experience suggests that a C_f = 10 to 30 % generally provides appropriate bench slopes (slopes up to about 30m high) at a level of risk commensurate with open pit mining practice in hard rock.

Results of the kinematic analyses are summarised in Table 7 .1. The result sheets are presented in Appendix D.

TABLE 7.1
RESULTS OF KINEMATIC AND STATISTICAL ANALYSES

WALL	SLOPE ASPECT (°)	FAILURE MECHANISM	KINEMATIC ANGLE (°)	STATISTICAL ANGLE (°)		
				INTERRAMP SLOPE	BATTER SLOPE	
				(~1 TO 3 %)	(~10 %)	(~30 %)
Northeast	200	Planar sliding on joints	78	48	55	66
East	255	Planar sliding on joints	65	50	54	61
Southeast	285	Planar sliding on joints	62	50	55	62

The results indicate inter-ramp angles [3] of 48 to 50° and batter angles of 54 to 78°. Experience from the other pits and rock exposures at Macraes indicate that joint lengths are typically less than 5 m. As such, the suggested batter angles may be conservative.

Although the chosen slope aspects refer to the wall orientations from the initial mining stages, they are considered reliable for the proposed development of major slope aspects with the proposed Deepdell Stage 3 design.

A tabulated summary of the proposed slope design parameters and a qualitative risk assessment for respective walls is included in Appendix E.

8 LIMIT EQUILIBRIUM ANALYSIS

Limit equilibrium analysis using RocScience's *Slide* software was used to assess structural and rock mass failure mechanisms for inter ramp and overall wall stability within the proposed Deepdell Stage 3 pit.

Due to the strength of the unweathered rock mass and its relative intact nature (compared to having a closely spaced blocky rock mass), non-circular failure surfaces were analysed to establish the Factor of Safety (FoS) for different scenarios.

The FoS of a slope can be established using the following formula:

$$FoS = \frac{Shear\ Strength\ of\ a\ material}{Shear\ stress\ required\ for\ equilibrium}$$

The output result is therefore numerical, the following scheme of interpretation being widely accepted in geotechnical engineering. If the FoS was to result in a value ≤ 1 then

[3] Toe-to-angles.

it is not deemed to be in an equilibrium state. This would infer that the slope in question is facing imminent failure. Results that exceed 1 are interpreted as stable in terms of slope equilibrium. It should be emphasised that the outputs from such analysis are only as accurate as the input data utilised in the simulation. A number of guidelines have been developed to provide a "buffer" or level of assurance for any given result. In general, for mining applications an acceptable FoS is considered any value >1.2 [4]. This may vary depending on the acceptable level of risk for a given scenario or the design life of the excavation.

The GLE Morgenstern Price method was selected for the analysis as it better suited to capture the potential failure mechanisms applicable to the observed ground conditions. For Deepdell this includes structural sliding along crushed rock/gouge infill associated with first and second order geological structures.

Analysis scenarios considered the following:

- Operational stability,
- Closure stability at 445 mRL (considering a lake filling the Pit),
- Closure stability at 475 mRL (considering a lake filling the Pit), and
- Seismic load applied to the section with the lowest FoS.

8.1 Material Properties

This study has adopted established rock mass shear strength properties used in a suite of previous studies. The equivalent Mohr-Coulomb strength parameters are presented in Table 8.1.

TABLE 8.1
SHEAR STRENGTH PARAMETERS

LITHOLOGY	UNIT WEIGHT, γ [kN/m^3]	COHESION, C [kPa]	FRICTION ANGLE, Φ [°]
Waste Rock	20	1	35
Weathered Schist	25	120	35
Intershear Pelite	25	180	43
Faults	20	0	15
Footwall Fault	25	0	9

[4] Read, J and Stacey P., (2009) Guidelines for open pit slope design. *Chapter 9 - Acceptance Criteria*

8.2 Groundwater Conditions

A key component of this stability review was to test the slopes sensitivity to changes in groundwater level. As discussed earlier, three scenarios have been tested as part of this review:

1. Operational conditions during excavation - This assumes the water table is drawn down below the ultimate pit floor to approximately 372 mRL.
2. Closure planning Scenario 1 – A pit lake forms to the lowest intersection point with the topography at the southern end of the pit, approximately 445 mRL.
3. Closure planning Scenario 2 – A pit lake fills to the lowest intersection point at the northern end of the pit, approximately 475 mRL.

Figure 8 illustrates these three scenarios in plan and provides an indication of the possible water extents.

8.3 Seismic Loading

The potential effects of an earthquake on the stability of the Deepdell pit walls at Macraes has been considered. Figure 9 illustrates the mine location relative to the 2016 Kaikoura earthquake site as an example of a recent major seismic event. This clearly identifies the higher earthquake hazard expected at Kaikoura compared with Macraes. The lower seismic hazard at Macraes is the result of the comparatively small amount of relative plate motion accommodated in the east of the Otago Region as evidenced by the region's low seismicity rate.

A comprehensive assessment of the specific seismic hazard at the Macraes Mine was undertaken by the Institute of Geological and Nuclear Sciences (IGNS) (Litchfield et al, 2005). That report assessed the probabilistic seismic hazard of the mine based on the following data and estimated peak ground accelerations (PGA) for different return periods (Table 8.2). This included the following assumptions:

- Knowledge of 21 active faults within 100 km from the mine
- The Seismic hazard associated with the Alpine Fault
- Distributed seismicity sources zones (based on historical earthquake data)
- The mine is a 'rock site'.

TABLE 8.2
MACRAES PGA FOR DIFFERENT RETURN PERIODS (LITCHFIELD ET AL., 2005)

RETURN PERIOD (YEARS)	150	475	1000	2500	10,000
PGA (g)	0.13	0.25	0.38	0.65	1.1

It is considered that the IGNS 2005 study remains applicable for assessing the seismic hazard of the Macraes as it consistent with the post-Christchurch events New Zealand Seismic Hazard Model (Stirling et al., 2012).

Hence, based on these two sources and Macraes tectonic setting, it is extremely unlikely that an earthquake such as the Kaikoura earthquake could occur close to the mine.

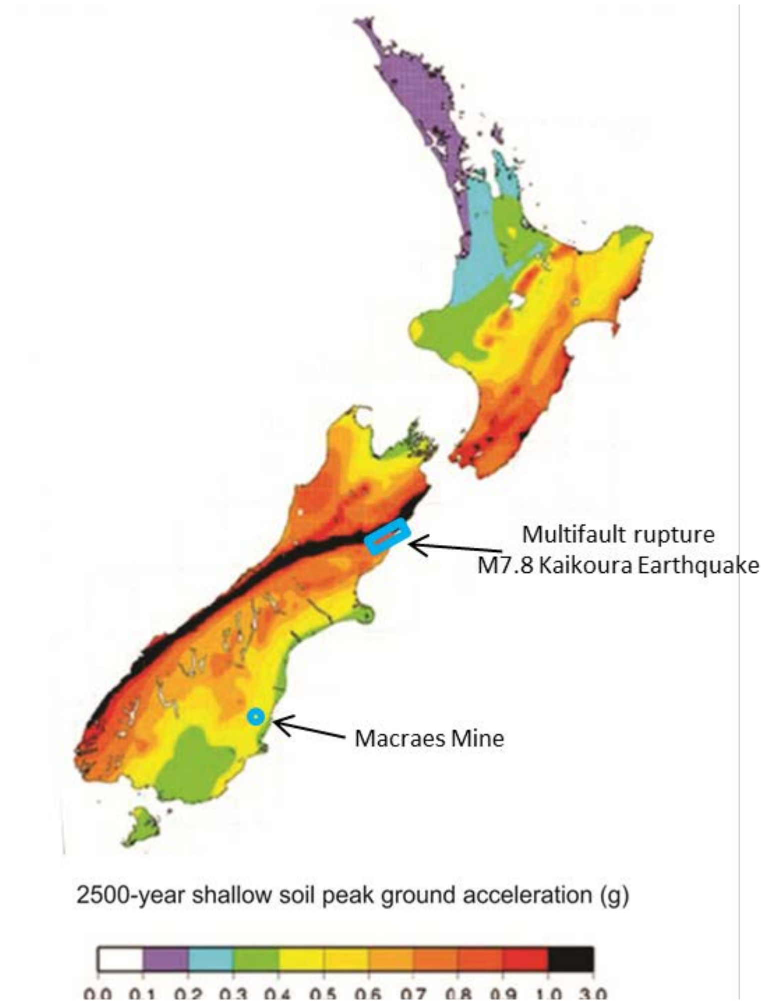

Figure 9: **Seismic hazard model of New Zealand showing the expected PGA values with 2500-year return period. The seismic hazard of the Macraes mine is moderate comparing with the high seismic hazard expected where the M7.8 Kaikoura earthquake occurred (modified from Stirling et al., 2012).**

8.3.1 Earthquake Return Periods

As part of this analysis a 10-year return period local event is based on a general assessment of the local earthquake records from the GNS/GeoNet database(5) considering the following aspects.

- The return period of earthquakes does not correspond to an exact and periodic time of recurrence but rather to an average time of occurrence between earthquakes with similar magnitude measured over a long period of time.
- In earthquake terms, the coverage of the local GNS/GeoNet database is very short (i.e. 52 years) and this may affect the estimation of the return periods, especially for large magnitudes which have longer recurrence.
- The completeness of the earthquake database, which refers to the date from which all earthquakes of certain magnitude have been recorded. According to Litchfield et al (2005) the database is complete:
  - Post 1840 for magnitudes greater than 6.5,
  - Post 1940 for magnitudes greater than 5, and
  - Post 1964 for magnitudes greater than 4.
- The 505 earthquakes of ≤ M3 recorded since 1978, suggest more than 13 earthquakes with these characteristics occur each year. The return period of M3 or less earthquakes is much shorter than the 10-year return period.
- Similarly, the 80 M3 to M4 earthquakes recorded during the last 50 years, indicate return periods shorter than one year.
- 11 earthquakes with magnitudes between M4 and M4.3 have been recorded since 1978. This suggests an average 3 to 4 years return period for these events.
- One earthquake of M4.6 and one earthquake of M5.1 have occurred since the local database began in 1965. This suggests an average 25-year return period for events with similar magnitudes during the short coverage of the database.
- No earthquakes greater than M5.1 have been recorded in the last 52 years, since records began for the area in 1965. The database for events greater than M5 is complete during this period. Consequently, it is considered that earthquakes with magnitudes greater than 5.1 have return periods greater than 10 years.

Therefore, earthquakes with magnitudes between M4.5 and M5 are considered likely to represent the events with return periods of about 10 years based on:

- Consideration of uncertainties associated with the short coverage of the database,

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(5) It is acknowledged that the magnitudes in the database are reported in two different scales, M and M_L. It is beyond the scope of this report to determine the equivalence between the reported magnitude scales. It is assumed that the magnitude values were equivalent and therefore comparable for the magnitude range considered in the assessment (i.e. M≤5.1).

- The shorter return period (shorter than 10 years) of earthquakes with magnitudes lower than M4.4, and
- The longer return periods (longer than 10 years) of earthquakes with magnitudes greater than M5.1.

This analysis did not consider the likelihood of the events with 10-year return period being associated with a particular seismic source. It conservatively assumes that this type of event may occur at any location around Macraes even though the actual earthquake records show earthquakes with magnitudes similar to the 10-year return period event (M4.5 to 5) occurred more than 30 km from Macraes.

8.3.2 Scenarios

The effects on Macraes of an earthquake depend, among other factors, on its distance from the mine. To further consider the possible effects of the 10-year return period earthquake on Macraes and the influence of earthquake location, two hypothetical scenarios were assessed:

- Scenario 1 - M5.0 earthquake at 30 km from the mine.

  This scenario was selected from the database which shows that all earthquakes with magnitudes greater than M4 have occurred more than 30 km.
- Scenario 2 - M4.5 earthquake on the Billy's Ridge Fault – Macraes Fault.

  This hypothetical scenario was assessed to estimate the effect of the 10-year return period earthquake occurring at the mine (i.e. 0 km). This scenario assumes a rupture on the Macraes Fault which crosses the mine site and is considered the northwest extension of the Billy's Ridge Fault (Litchfield et al., 2005). The location of the fault was extracted from the GNS active fault database.

  This scenario is hypothetical, it does not consider the actual probability of rupture of the Billy's Ridge Fault – Macraes Fault and is only evaluated to illustrate the worst case associated with the 10-year return period earthquake.

8.3.3 Peak Ground Accelerations

As the earthquake scenarios (Section 8.3.2) are hypothetical, there is no record of the ground motion at the mine. Hence, the PGA values at the mine site are estimated by ground motion prediction models (GMPE).

The GMPE developed for New Zealand by McVerry et al. (2006) and a global GMPE developed from data from tectonic regions similar to New Zealand (i.e. NGA West 2 models, 2012) were used for this assessment. The input parameters for the GMPE include:

- Distance to earthquake rupture: Taken for this assessment as 30 km (Scenario 1) and 0 km (Scenario 2), respectively.
- Type of fault: Assumed to be a reverse fault (in agreement with the mine's tectonic setting and data from the nearby faults, including the Billy's Ridge Fault).

- Site conditions: The mine is a rock site (Vs_{30} ≈ 1000 m/s).

Table 8.3 shows the average PGA at the mine site estimated for each scenario and those adopted for limit equilibrium sensitivity analysis as part of this study.

Note that for the first earthquake scenario (i.e. M5.0 at 30 km) all the GMPE (i.e. McVerry et al., 2006 and NGA West 2 models) were used. However, for the second scenario (i.e. M4.5 at 0 km) only NGA West 2 models were used because the magnitude 4.5 of this scenario is outside the magnitude range applicable to the New Zealand models.

TABLE 8.3
ESTIMATED PGA

EARTHQUAKE SCENARIO	ESTIMATED PGA AT MINE (AVERAGE)
M5.0 earthquake at 30 km	0.04 g
M4.5 earthquake at 0 km	0.13 g

8.4 Modelled Sections

Critical analysis sections were selected based on wall aspect, scale (final height and length), exposure of critical infrastructure (haul roads accessing the pit) and geological condition, as such the north, east and west walls were considered analysis. The topographic depression at the southern end of the pit results in a partial height wall with no major structure intersections, therefore the southern wall was not analysed. A plan of all sections is included in Figure 3.

The north wall intersection of the Horse Flat Fault and the inferred “Fault Plane Two” (as outlined in Section 4.3.2) creates an adverse geometry with the potential to expose the haul road. Based on review of the design, this wall has two benches above the haul road, should failure occur it will likely happen during the excavation and can be managed using operational controls. This scenario will not have an ongoing affect on stability and was therefore not included as part of the stability analysis.

A typical analysis setup is included for reference in Figure 10, this shows the upper bench is formed within weathered pelite schist, beneath the base of oxidation between 12 and 15 m depth is fresh rock for the remaining benches at depth.

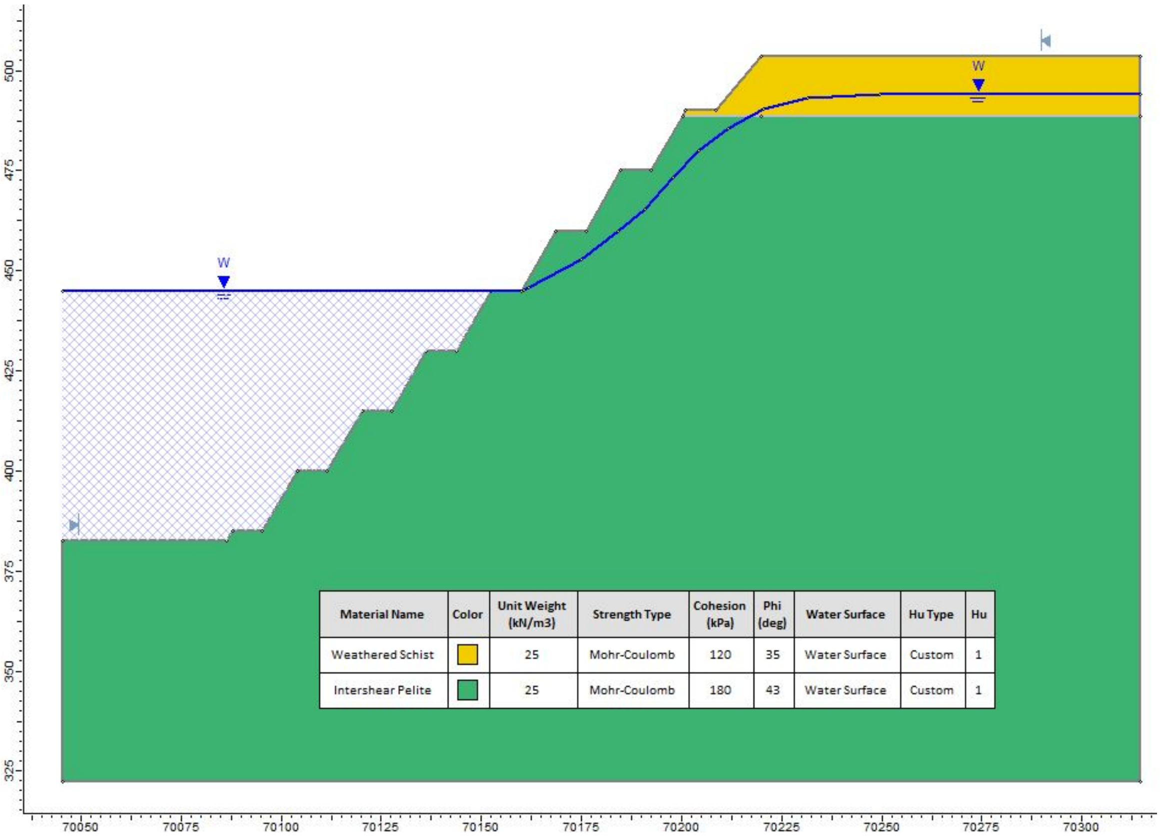


Figure 10: Typical model setup for LE modelling conducted as part of the Deepdell Stage 3 stability assessment.

8.5 Results

The limit equilibrium stability analysis indicates all critical pit sections, result in a FoS greater than 1.5 as outlined in Table 8.4. The east wall recorded the lowest FoS at the intermediate pit lake level. Two horizontal seismic loads (as outlined in Table 8.3) have been applied to this section as a sensitivity run to replicate the earthquake response within the pit. The resultant FoS value of 1.2 indicates that the design is suitable for the current PGA at Macraes.

A complete summary of modelled sections are included in Appendix F.

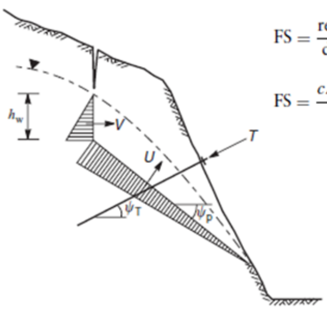
TABLE 8.4
LIMIT EQUILIBRIUM RESULTS

SECTION	SENSITIVITY RUN	LAKE LEVEL (MRL)	SEISMIC LOADING (G)	FOS
North Wall (max elev = 485m)	Operational	385	-	1.6
	Closure Scenario 1	445	-	1.6
	Closure Scenario 2	475	-	2.1
East Wall (max elev = 504m)	Operational	385	-	1.7
	Closure Scenario 1	445	-	1.5
	Closure Scenario 2	475	-	2.0
	Closure Scenario 1+ Seismic	445	0.04	1.4
	Closure Scenario 1+ Seismic	445	0.13	1.2
West Wall (max elev = 519m)	Operational	385	-	2.1
	Closure Scenario 1	445	-	1.8
	Closure Scenario 2	475	-	2.3

8.5.1 Effects of Pit Lake Filling

Groundwater and surface run-off water will enter the void created by mining the Deepdell Stage 3 pit. Over time the water collecting in the void will form a lake. The impact of that lake on the stability of the west wall is assessed in this section.

The rise in the level of the lake increases the pore water pressures within the rock mass near the base of the void's walls. This increase in pore water pressures effectively reduces the strength of the rock mass and also adds to the force which drives movement of the slopes, as illustrated in the equations below [6].



$$FS = \frac{\text{resisting forces}}{\text{driving forces}}$$

$$FS = \frac{cA + (W\cos\psi_p - U - V\sin\psi_p + T\sin(\psi_T + \psi_p))\tan\phi}{W\sin\psi_p + V\cos\psi_p - T\cos(\psi_T + \psi_p)}$$

where pore water pressure, U and V, are

$$V = \frac{1}{2}\gamma_w h_w^2 \quad \text{and} \quad U = \frac{1}{2}\gamma_w h_w A$$

---

[6] Modified from Wyllie & Mah *Rock slope engineering*, 4th edition Spon Press

Hence, the initial water level rise decreases the stability of the void's walls. Analyses carried out for similar conditions in Deepdell's final void suggest a lake level 60 m above the base of the void decreases wall stability by approximately 12%.

Rises in the lake level, while increasing the pore water pressures acting in the rock mass, also add weight to the base of the void and to the toe of the void's walls. This additional weight increases the resisting force, by effectively increasing the term $W\cos\varphi_p\tan\phi$ in the above equations. The analyses of the Deepdell's final void suggest the balance is in favour of increasing stability with lake level rises higher than 90 m above the base of the void. The overall increase in wall stability is greater than 10%.

Figure 11 presents a chart of the results to illustrate the effects the rising water level has on stability at Deepdell.

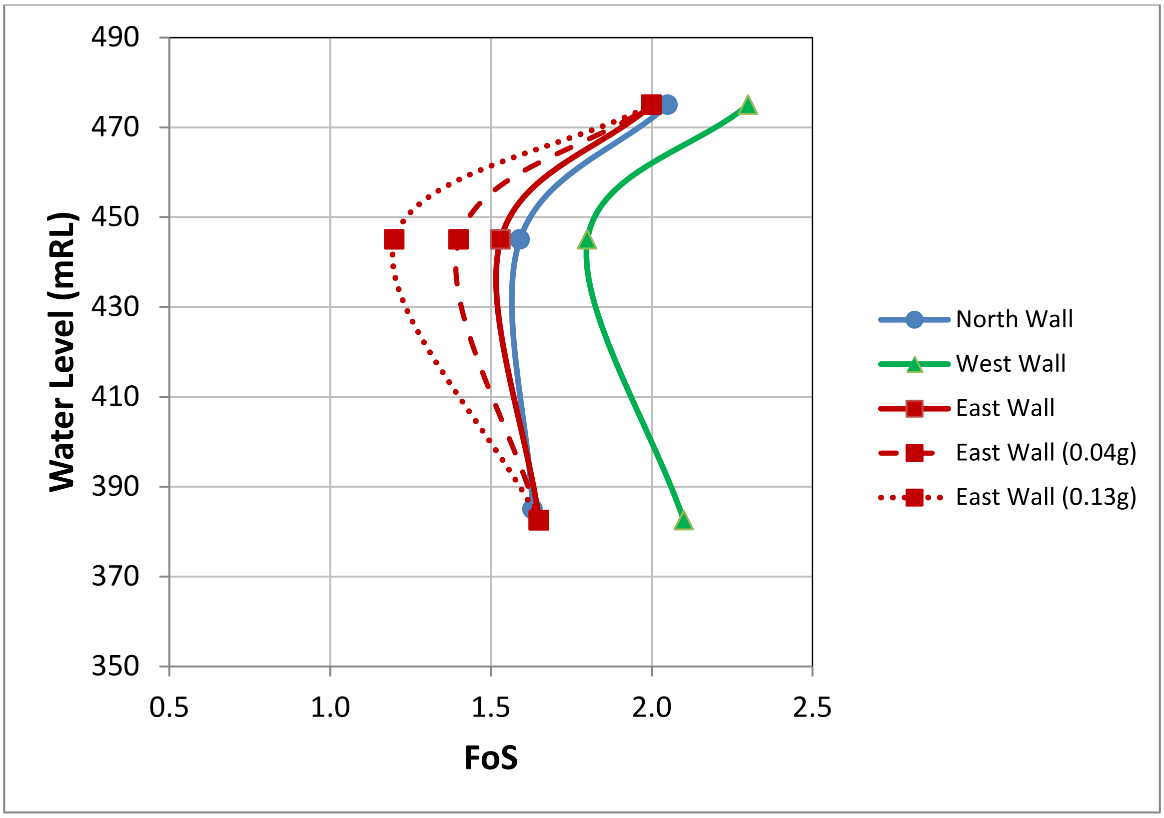


Figure 11: **Stability results illustrating the FoS response to changes in pit lake level during closure filling.**

8.5.2 Proposed Waste Rock Stacks

To accommodate existing backfill, and waste generated from development of the Stage 3 pit design two waste rock stacks are proposed. This material will fill the existing Deepdell South pit and require a new site located approximately 125 m to the north of the final pit boundary (Figure 3). The northern offset is sufficient that no additional loads will be placed on the adjacent pit wall; as such this will not have an effect on stability.

9 CONCLUSIONS

Geotechnical stability assessments undertaken by PSM has shown to have a minimum FoS ≥ 1.5. This exceeds the general acceptance level for mine slope stability. A sensitivity analysis was carried out on the east wall for test the design for seismic loading. A horizontal load of 0.13g (equivalent to a M 4.5 earthquake 0 km from the mine) was applied in the analysis that provided a resultant FoS = 1.2 indicating that the overall slope would remain stable.

Filling of an in pit lake at the cessation of mining has been analysed to show while the relative stability reduces while the water level is in at intermediate depth, the ultimate stability of the slopes increases beyond operational levels at final filling.

The proposed waste rock stacks to the north and south of the pit will have no effect on stability.

10 CLOSING

We trust this is in keeping with your immediate requirements. Should you have any queries please do not hesitate to contact the undersigned.

For and on behalf of
PELLS SULLIVAN MEYNINK

RICHARD BREHAUT
Associate

ROBERT BERTUZZI
Principal

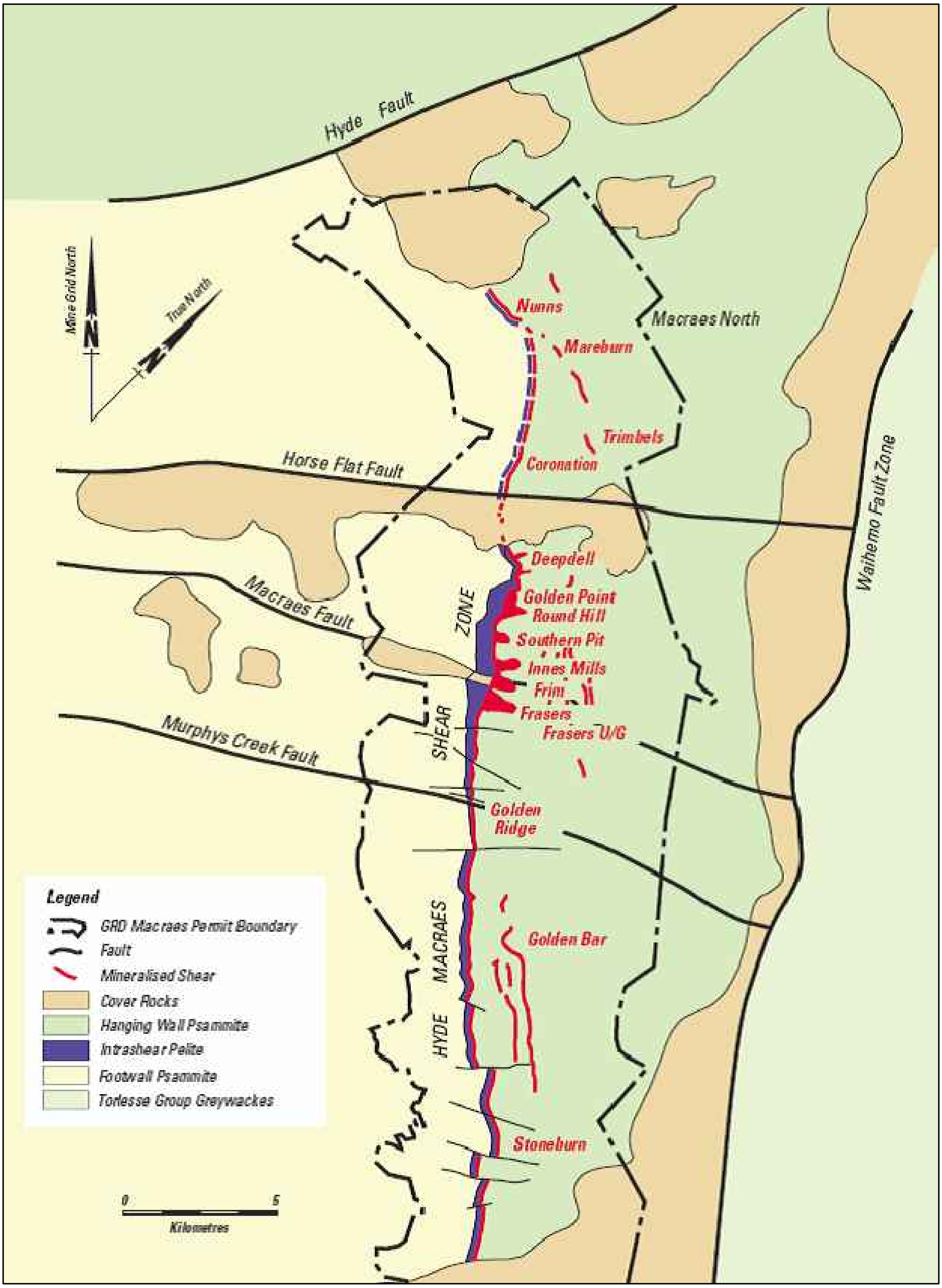
REFERENCES

1. *OceanaGold, Email* from Pieter Doelman, 13 December 2017.
2. Slope Design, DeepDell Stage 1 Pit, PSM71.R15, 24 August 2000.
3. March 2002 Site Visit, PSM71.R23, 26 March 2002.
4. Geotechnical Review Macraes LOM Design, PSM71-130R, September 2012.
5. Deepdell South Lake, PSM71.L83, 28 October 2005.

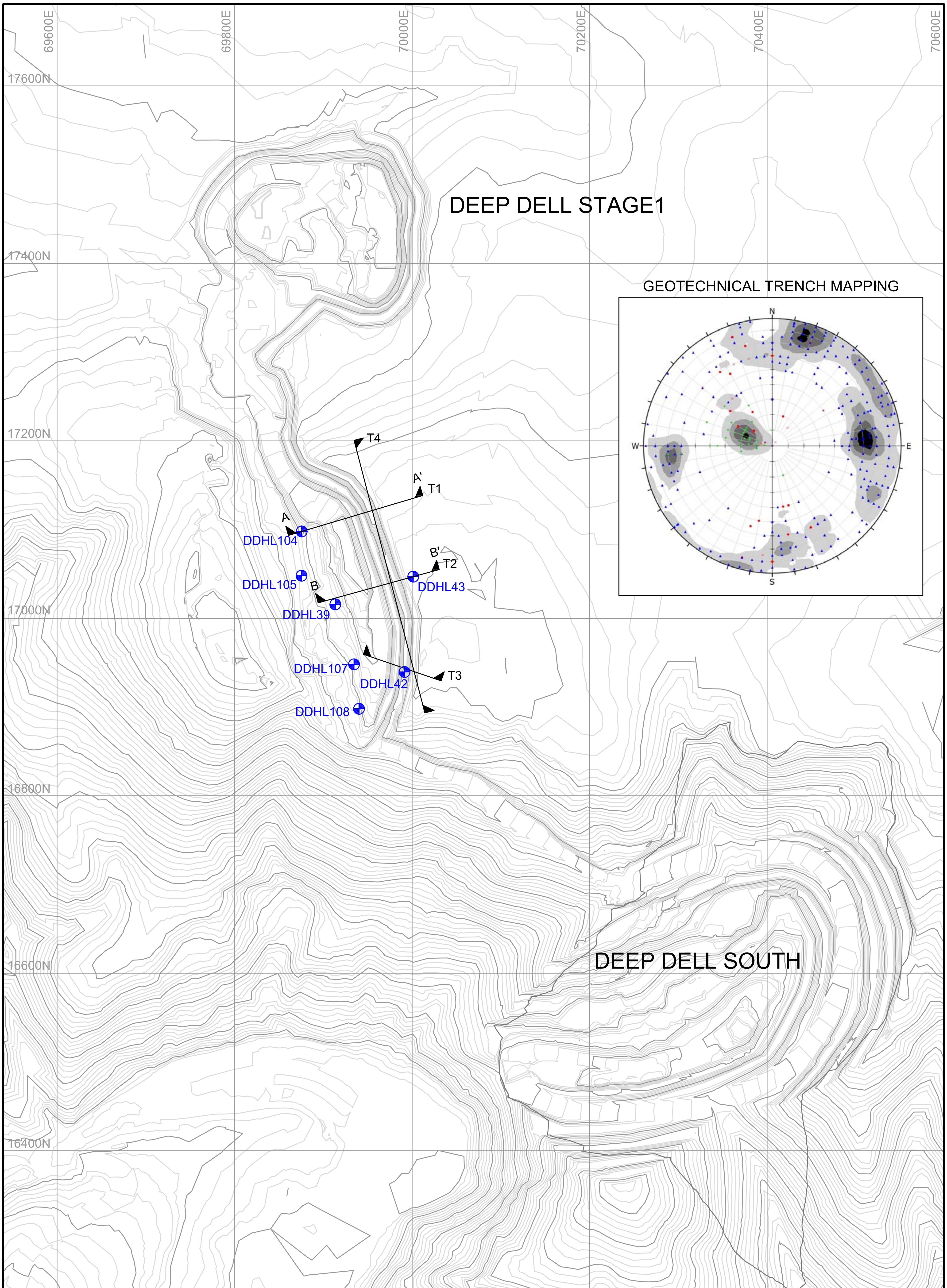
6. Litchfield, N., McVerry, G., Smith, W., Berryman, K. and Stirling, M. 2005. Seismic study for tailings embankments at Macraes Gold Project. Institute of Geological and Nuclear Sciences, Client report 2005/135 October 2005.

7. McVerry, G., Zhao, J, Abrahamson, A. and Somerville, P. (2006). New Zealand acceleration relation for crustal and subduction zone earthquakes. Bulletin of the New Zealand Society for Earthquake Engineering, V39 (1).

8. Stirling., M., McVerry, G., Gerstenberg. M & 17 other authors. 2012. National seismic hazard model for New Zealand: 2010 Update. Bulletin of the Seismological Society of America, 102(4), p1514-1542.



Pells Sullivan Meynink	OceanaGold Macraes Mine Deepdell Stage 3 Design Review SITE OVERVIEW
	PSM71-224R — Figure 1



LEGEND

2m Contoures

T1 Trench Locations

Boreholes with Geotechnical Information

0 50 100 150 200

Scale (m)

PSM

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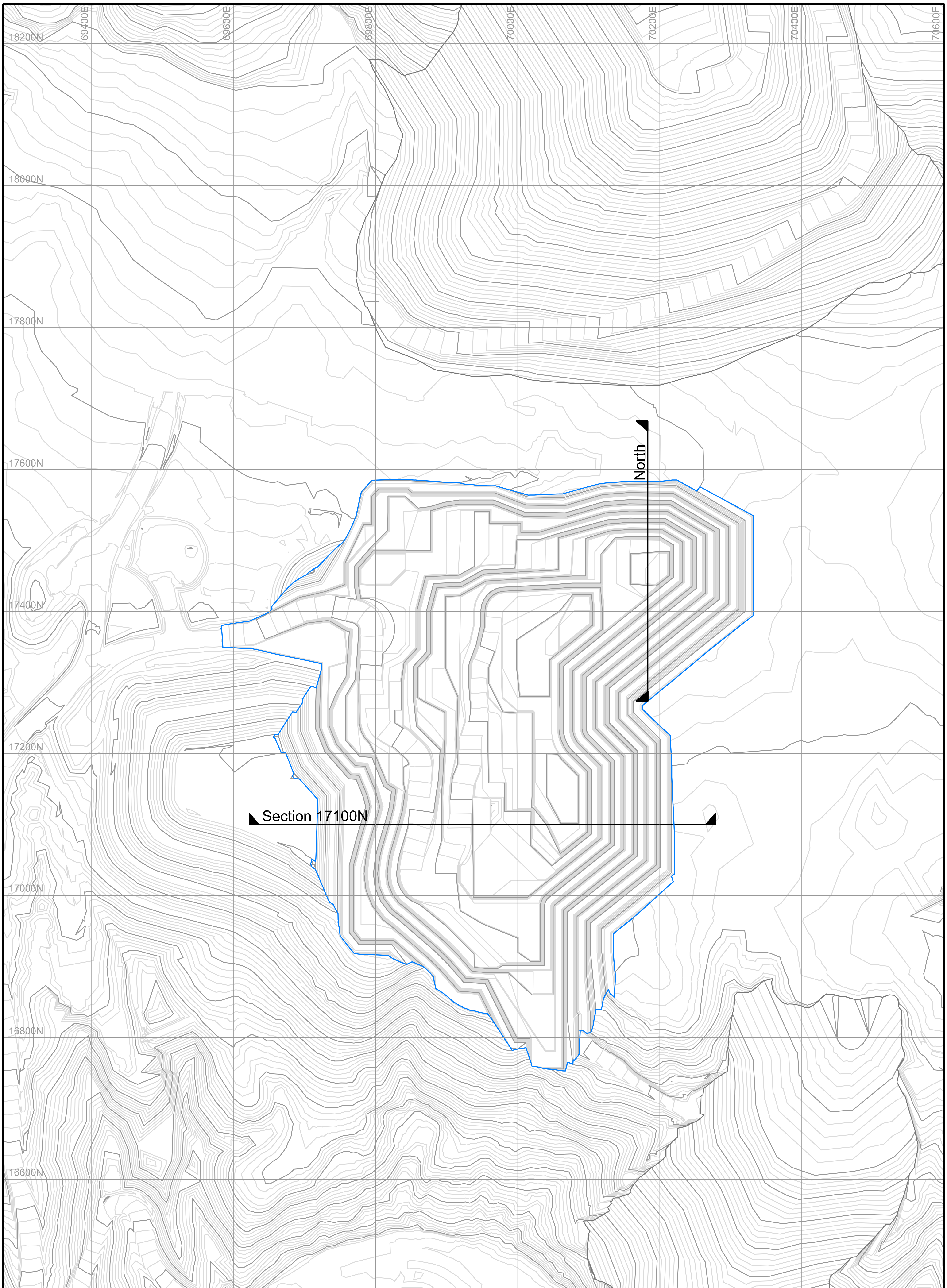
Macraes Mine
Deepdell Stage 3 Design Review

PIT PLAN
AS MINED

PSM 71-224R

Figure 2



LEGEND

Stage 3 Pit Design

Geotechnical Section Locations

0 50 100 150 200

Scale (m)

PSM

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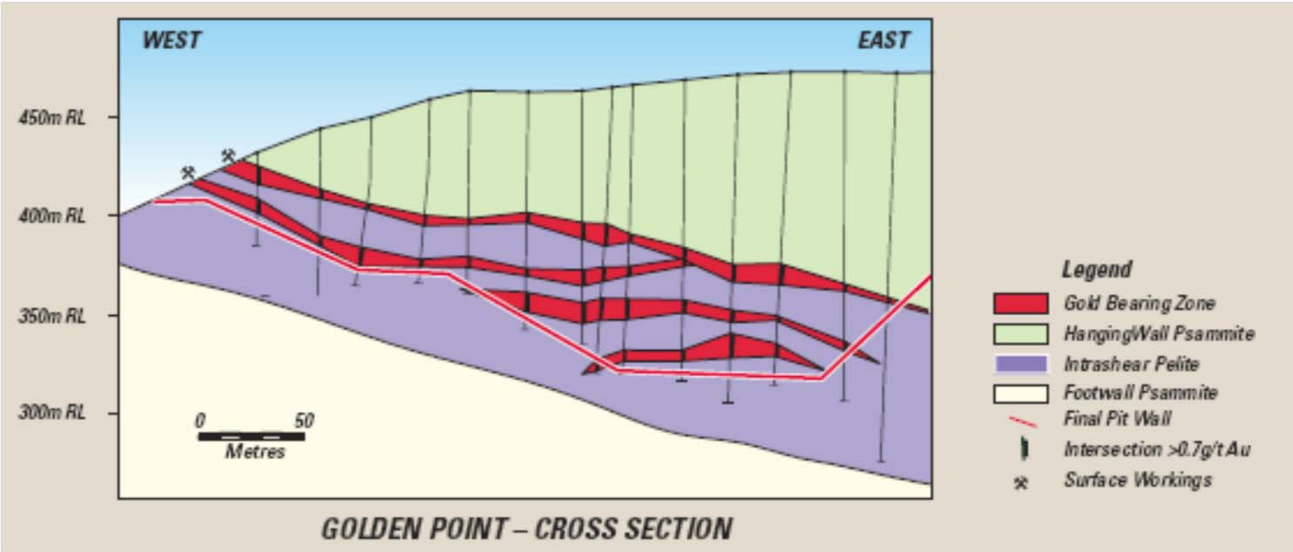
OceanaGold
Macraes Mine
Deepdell Stage 3 Design Review

PIT PLAN
PROPOSED STAGE 3 DESIGN

PSM 71-224R | Figure 3



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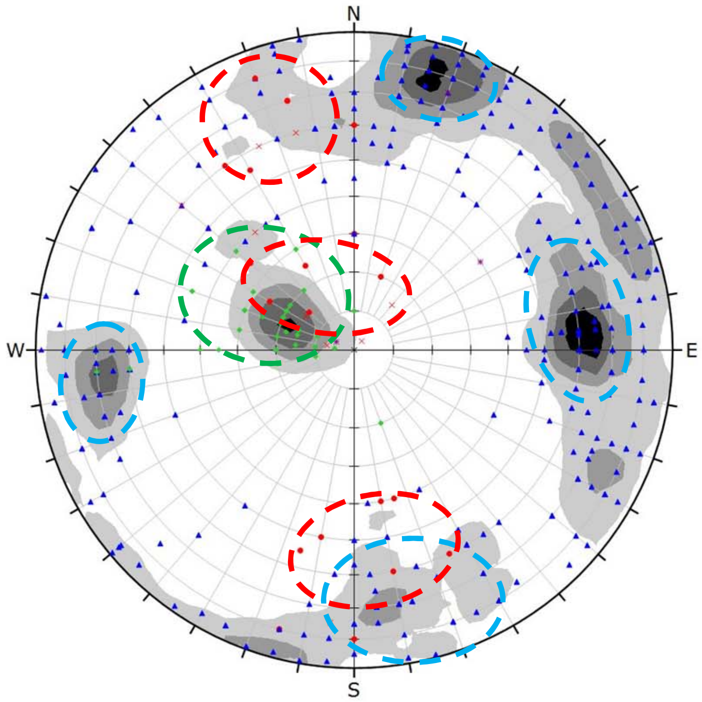
OceanaGold Macraes Deepdell Stage 3 Design Review TYPICAL GEOLOGICAL CROSS SECTION	
PSM71-224R	Figure 4



Symbol	TYPE	Quantity
◆	fol	35
×	g	11
●	g/cz	21
▲	jt	314
✱	sz	2

Color	Density Concentrations
	0.00 - 1.10
	1.10 - 2.20
	2.20 - 3.30
	3.30 - 4.40
	4.40 - 5.50

Contour Data	Pole Vectors
Maximum Density	5.28%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Pole Vectors
Vector Count	383 (383 Entries)
Hemisphere	Lower
Projection	Equal Area

Note: Defect sets highlighted as follows
Foliation (Green), Joints (Blue) and Gouge/Shear Zones (Red).

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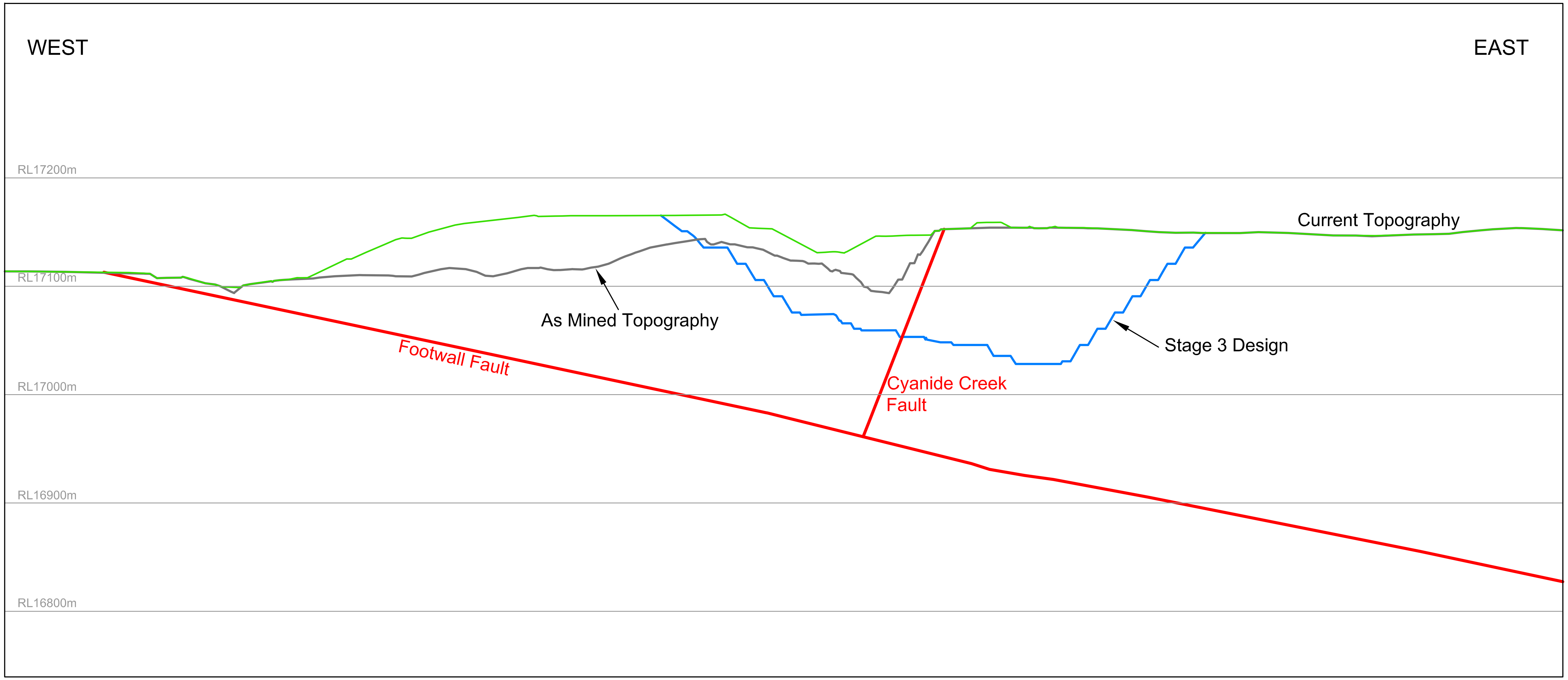
OceanaGold
Macraes
Deepdell Stage 3 Design Review
GEOTECHNICAL TRENCH MAPPING
DEFECT STEREONET

PSM71-224R	**Figure 5**



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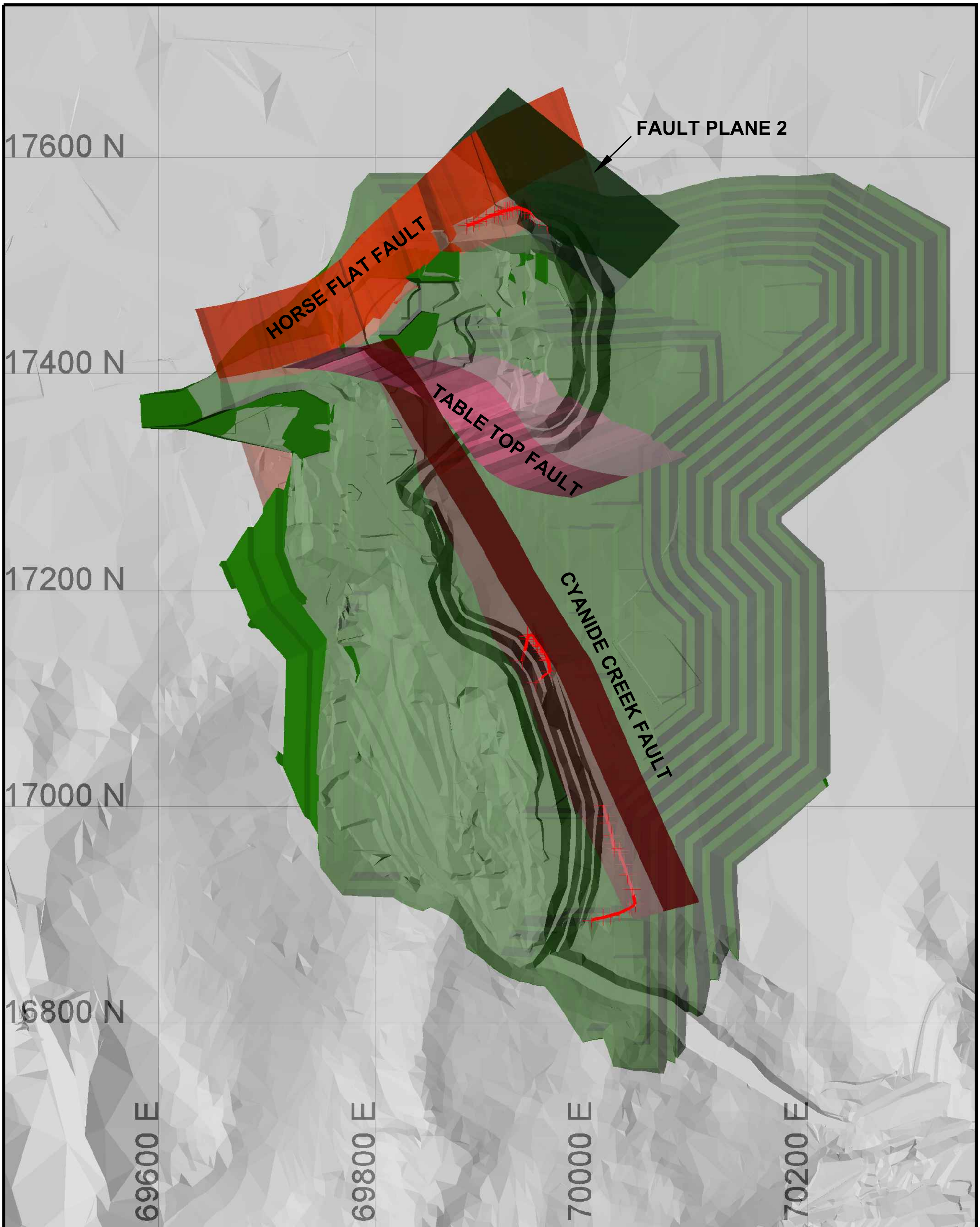
OceanaGold Macraes Mine Deepdell Stage 3 Design Review SECTION 17100N FOOTWALL FAULT GEOMETRY	
PSM 71-224R	Figure 6



LEGEND

Previous Failures

"As Mined" Topograp□□

Proposed Stage 3 Design

PSM

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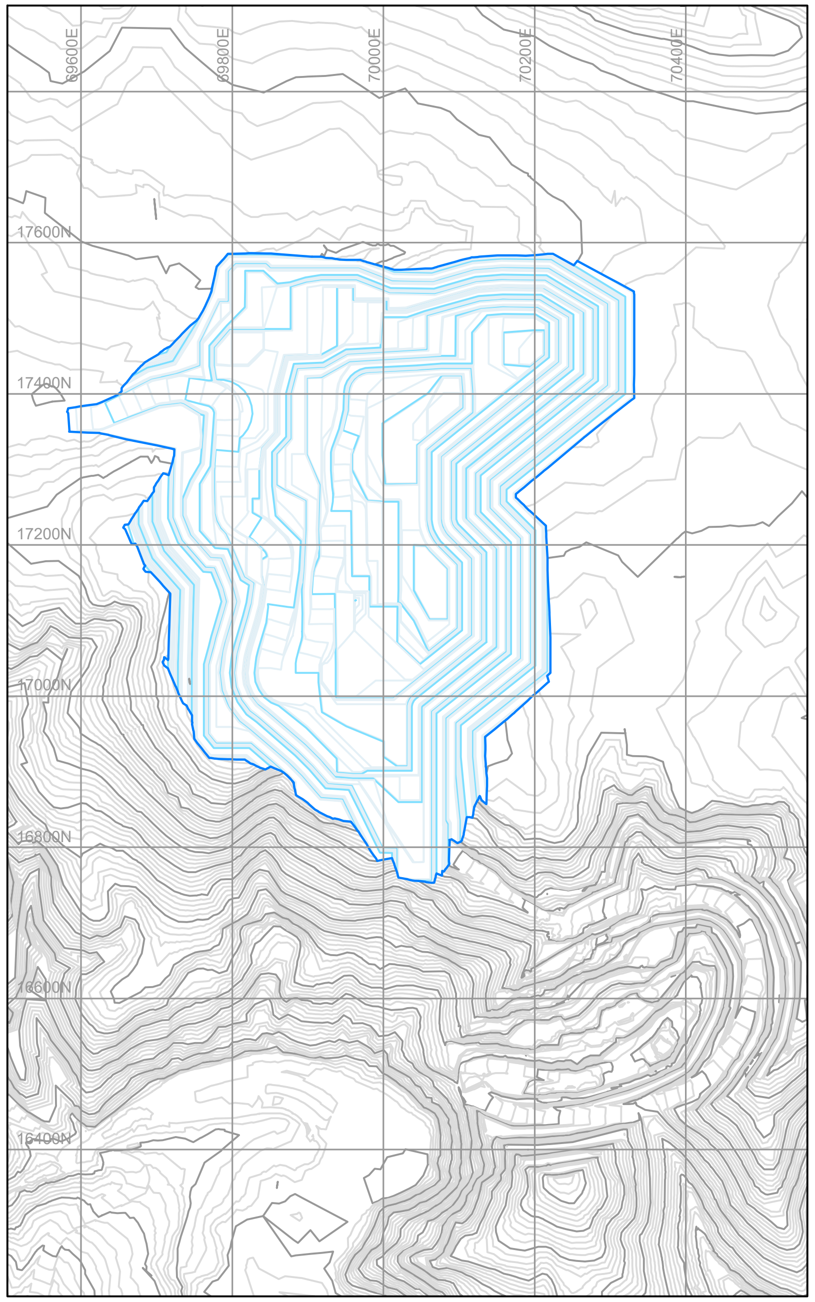
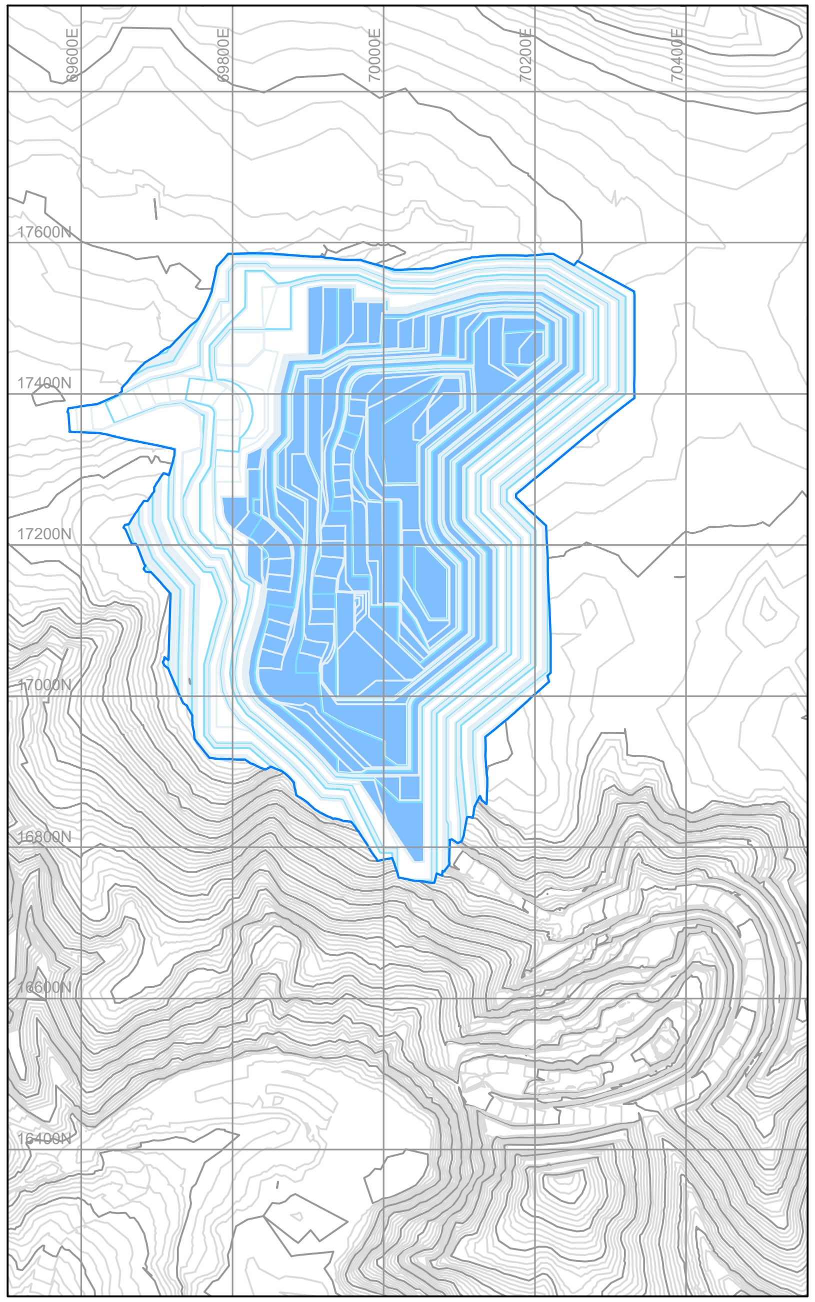
OceanaGold
Macraes Mine
Deepdell Stage 3 Design Review

PIT PLAN
MODELLED FAULT STRUCTURE OVERVIEW

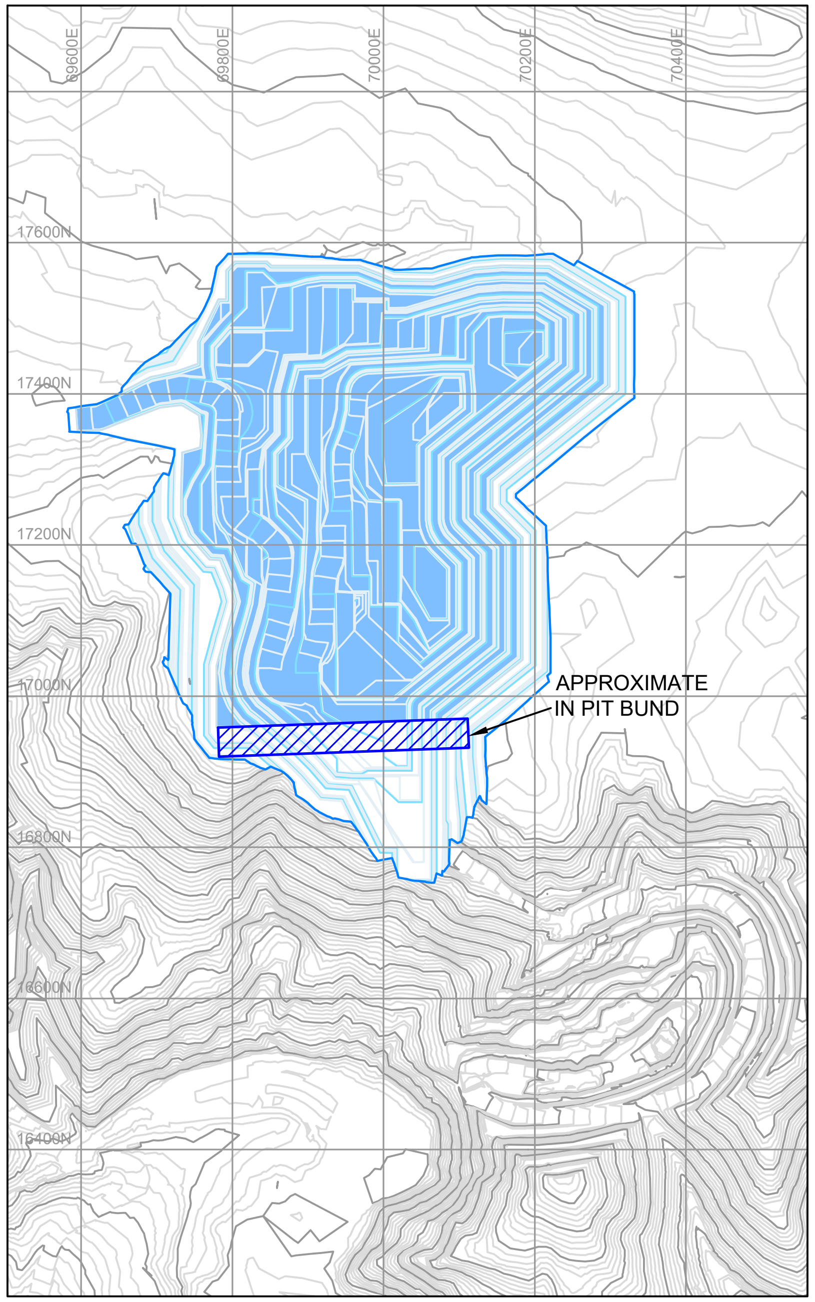
PSM 71-224R	Figure 7



OPERATIONAL - NO PIT WATER



PIT LAKE 445mRL
"SCENARIO 1"



PIT LAKE 475mRL
"SCENARIO 2"

LEGEND

- As Mined Design Contours
- Proposed Stage 3 Design
- Pit Lake Filling Extents

0 100 200 300 400 500

Scale (m)

PSM

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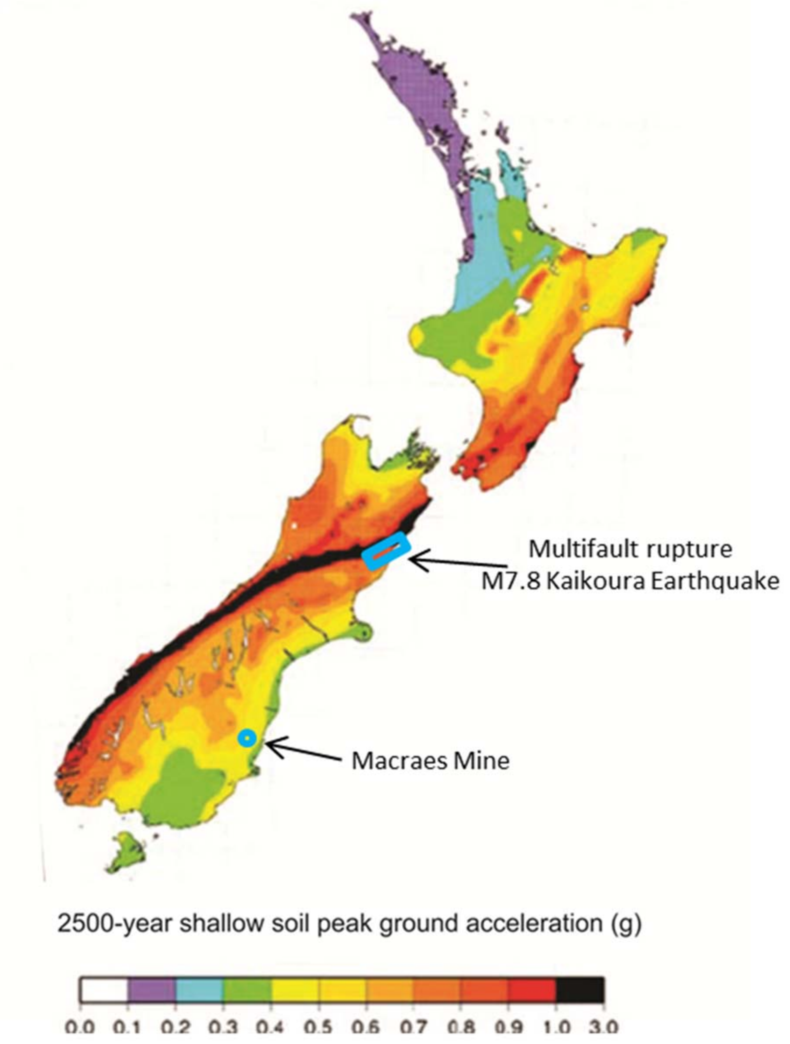
OceanaGold Macraes Mine Deepdell Stage 3 Design Review APPROXIMATE EXTENT OF PIT LAKE FILLING	
PSM 71-224R	Figure 8



Note: Modified from Stirling et al., 2012

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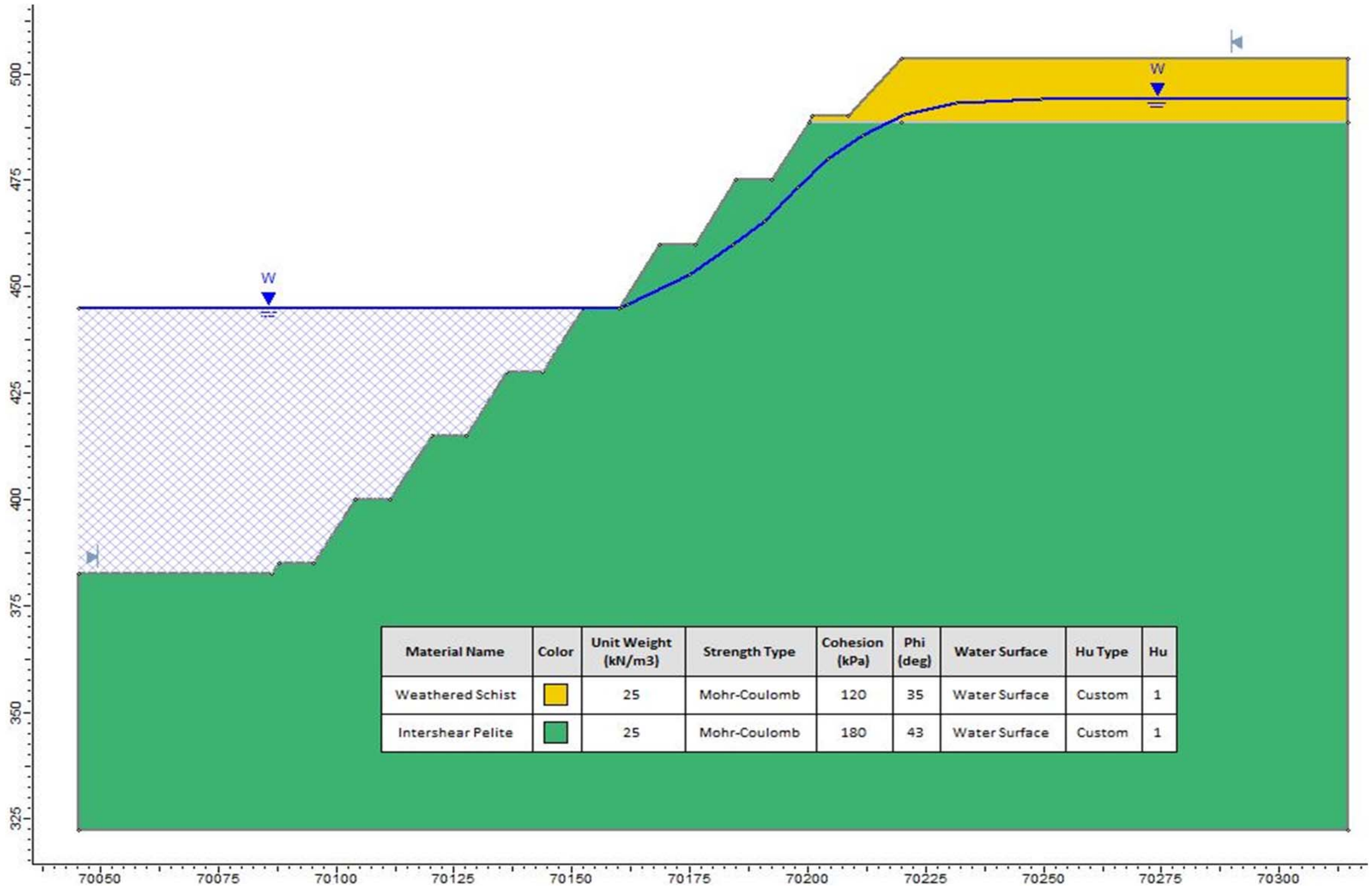
OceanaGold Macraes Deepdell Stage 3 Design Review SEISMIC HAZARD MAP OF NEW ZELAND	
PSM71-224R	Figure 9



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Weathered Schist		25	Mohr-Coulomb	120	35	Water Surface	Custom	1
Intershear Pelite		25	Mohr-Coulomb	180	43	Water Surface	Custom	1

PSM

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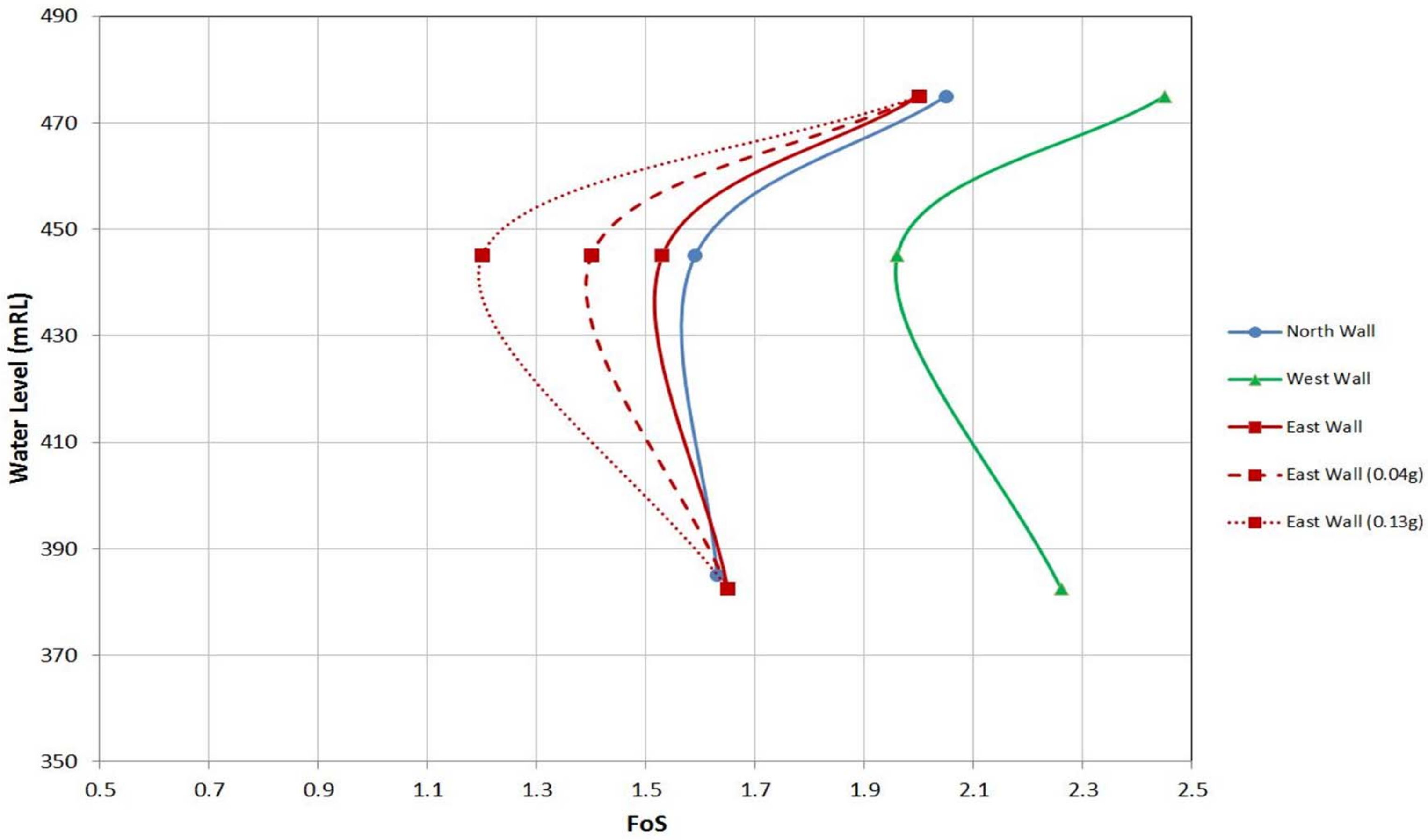
OceanaGold

Macraes

Deepdell Stage 3 Design Review

LIMIT EQUILIBRIUM ANALYSIS SETUP

PSM71-224R	**Figure 10**



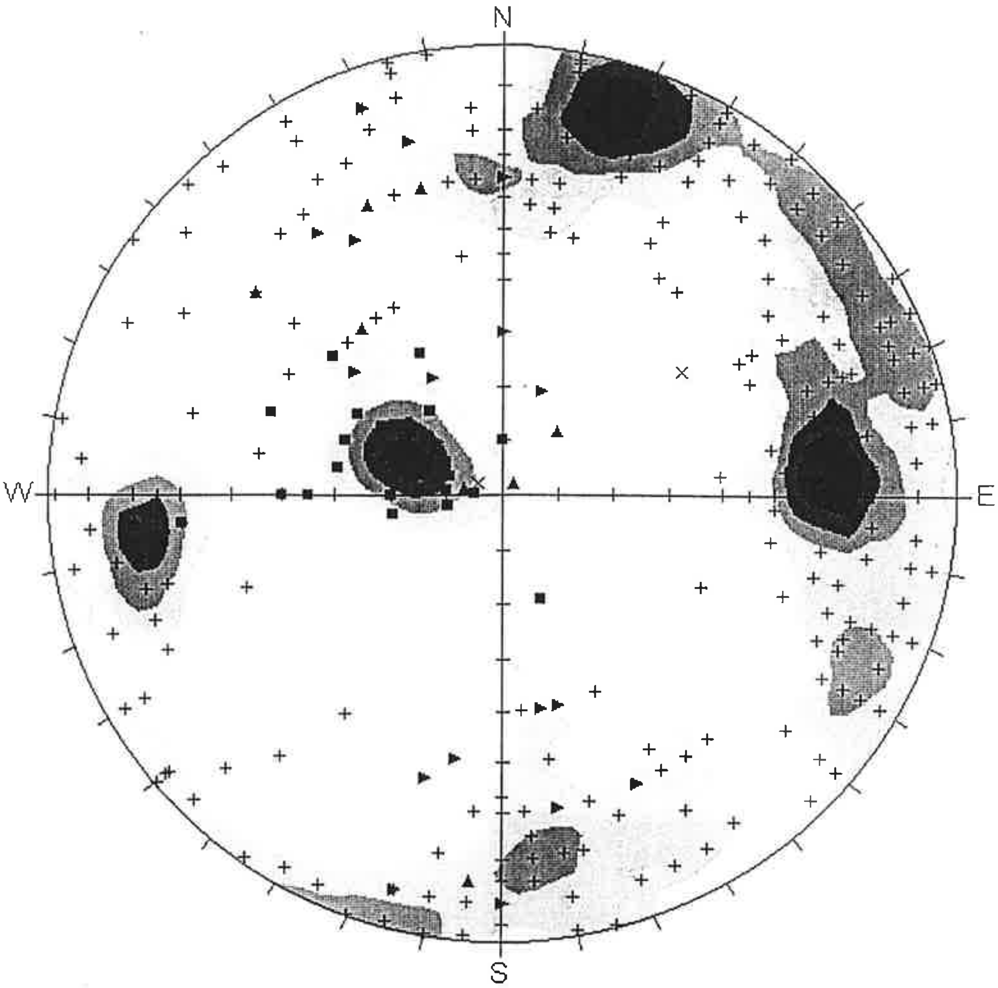
OceanaGold Macraes Deepdell Stage 3 Design Review LIMIT EQUILIBRIUM STABILITY RESULTS CHART	
PSM71-224R	Figure 11

PSM

Pells Sullivan Meynink

APPENDIX A

GEOTECHNICAL TRENCH EXCAVATIONS – STEREONETS AND HISTOGRAMS



TYPE

■ FOLIATION

▲ GOUGE

► GOUGE/
CRUSHED ZONES

+ JOINT

× SHEAR ZONES

Equal Area
Lower Hemisphere
383 Poles
383 Entries

GRD Macraes Ltd
Deepdell Stage I Pit

STRUCTURAL MODEL

PSM

Pells Sullivan Meynink Pty Ltd

PSM 71 · R15

Figure 4

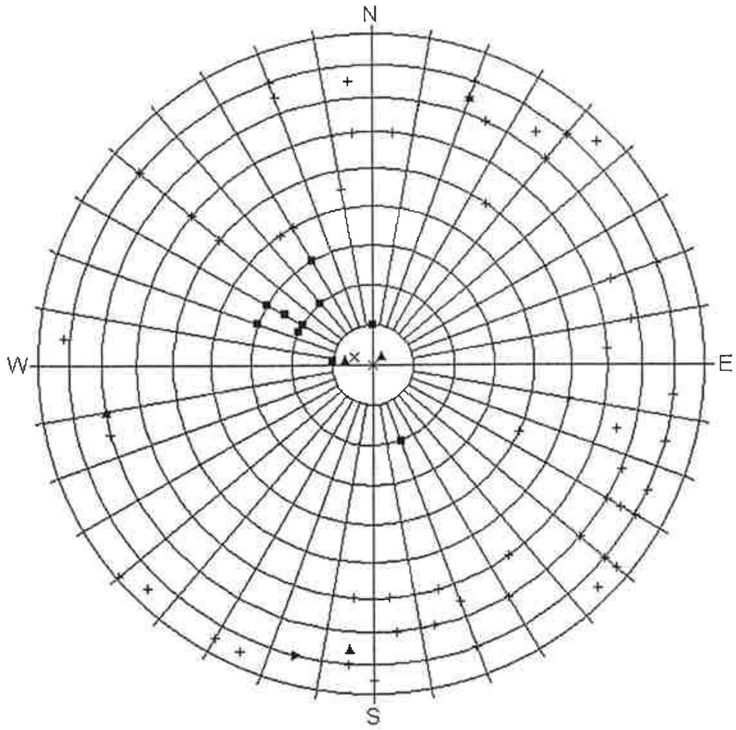
A.C.N. 061 347 621

PSM **Pells Sullivan Meynink Pty Ltd**

Stereo Plot

Job no PSM071

Project: Deep Dell Stage 1 Pit	North datum: Mine	Domain:
Lithology: Processed by: RJ	Defect type: All	Traverse: Trench 1



TYPE

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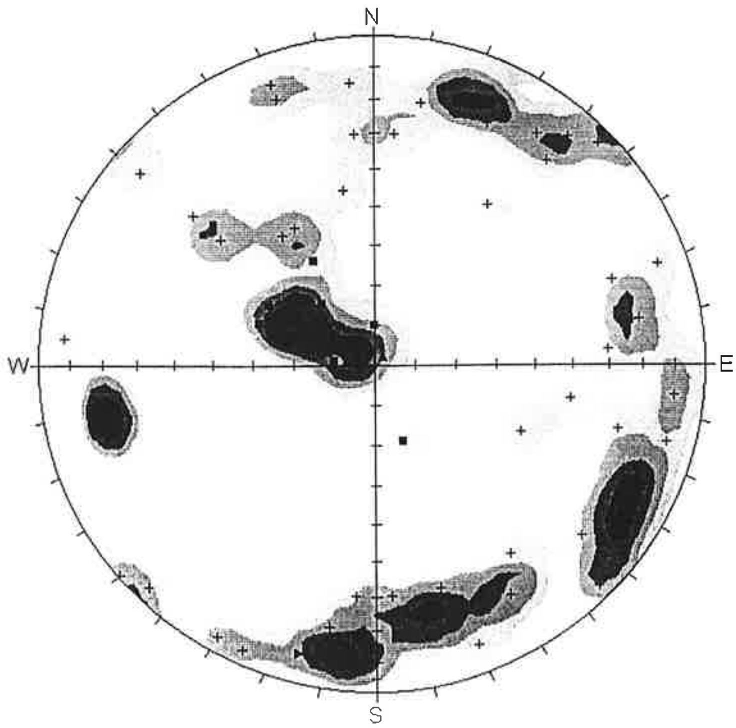
▲	g [5]
►	g/cz [1]
+	jt [64]
×	sz [1]

Equal Area
Lower Hemisphere
82 Poles
82 Entries



TYPE

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▲	g [5]
►	g/cz [1]
+	jt [64]
×	sz [1]

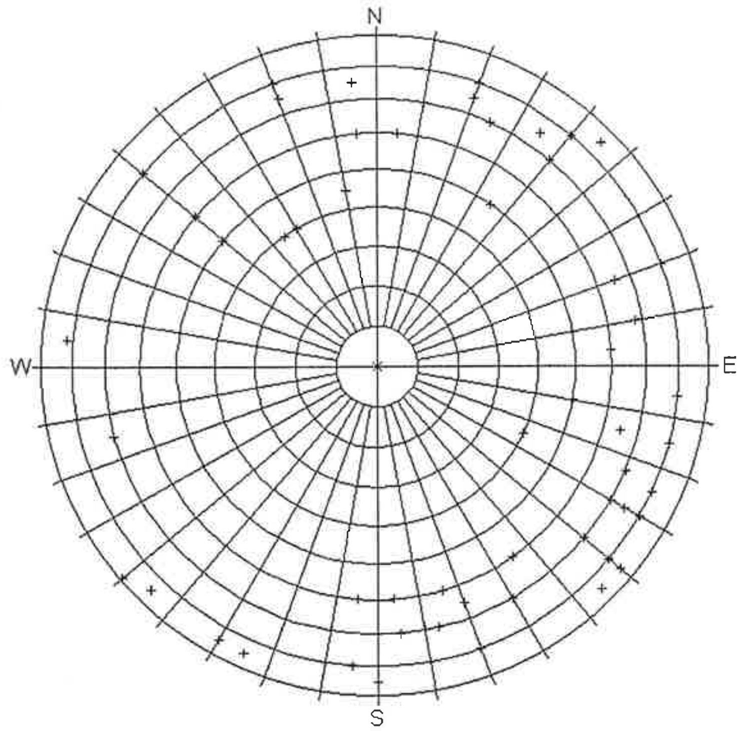
Equal Area
Lower Hemisphere
82 Poles
82 Entries

Pells Sullivan Meynink Pty Ltd

Stereo Plot

Job no PSM071

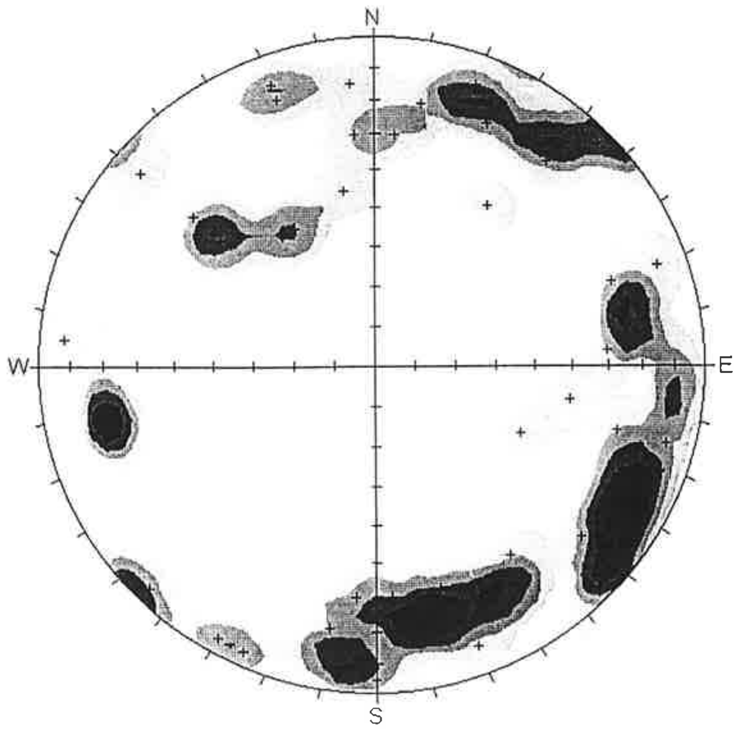
Project: Deep Dell Stage 1 Pit	North datum: Mine	Domain:
Lithology:	Defect type: Joint	Traverse: Trench 1
Processed by: RJ		



TYPE

\+ jt [64]

Equal Area
Lower Hemisphere
64 Poles
64 Entries



TYPE

\+ jt [64]

Equal Area
Lower Hemisphere
64 Poles
64 Entries

PSM **Pells Sullivan Meynink Pty Ltd**

Stereo Plot

Job no PSM071

Project: Deep Dell Stage 1 Pit

North datum: Mine

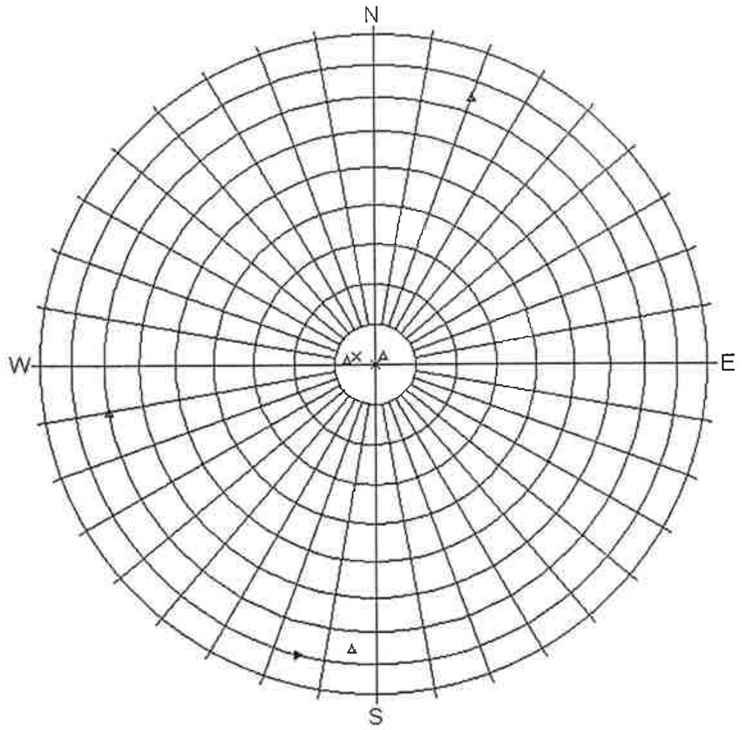
Domain:

Lithology:

Defect type: Gouge/Shear Zones

Traverse: Trench 1

Processed by: RJ



TYPE

▵	g [5]
▸	g/cz [1]
×	sz [1]

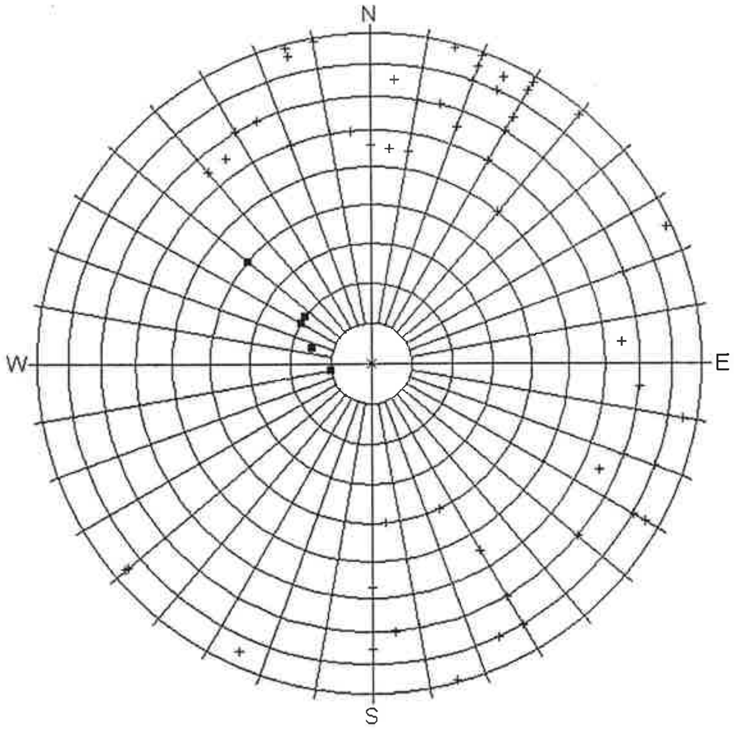
Equal Area
Lower Hemisphere
7 Poles
7 Entries

Pells Sullivan Meynink Pty Ltd

Stereo Plot

Job no PSM071

Project: Deep Dell Stage 1 Pit	North datum: Mine	Domain:
Lithology:	Defect type: All	Traverse: Trench 2
Processed by: RJ		



TYPE

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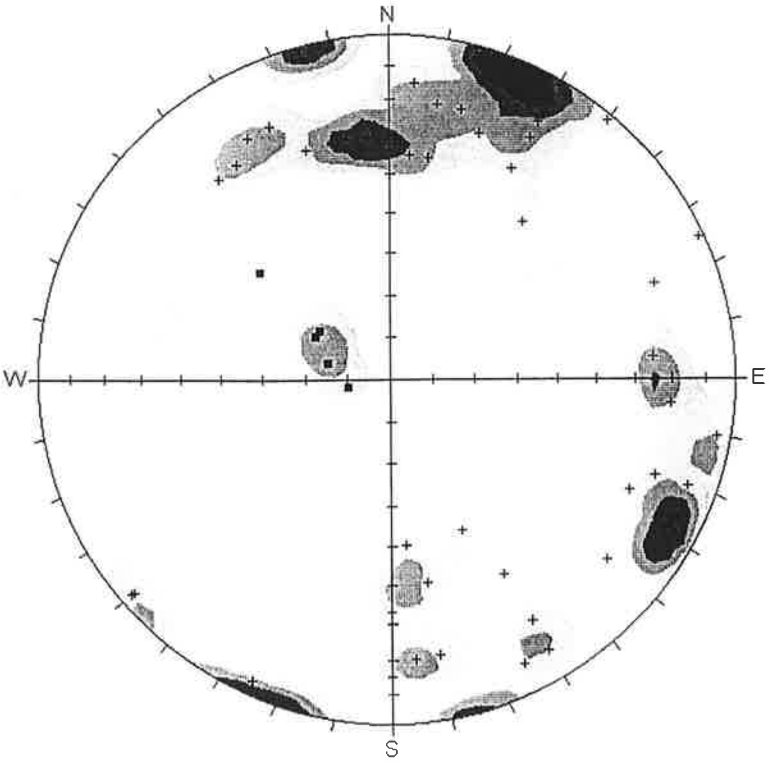
\+ jt [65]

Equal Area
Lower Hemisphere
70 Poles
70 Entries



TYPE

■ fol [5]

\+ jt [65]

Equal Area
Lower Hemisphere
70 Poles
70 Entries

Pells Sullivan Meynink Pty Ltd

Stereo Plot

Job no PSM071

Project: Deep Dell Stage 1 Pit

North datum: Mine

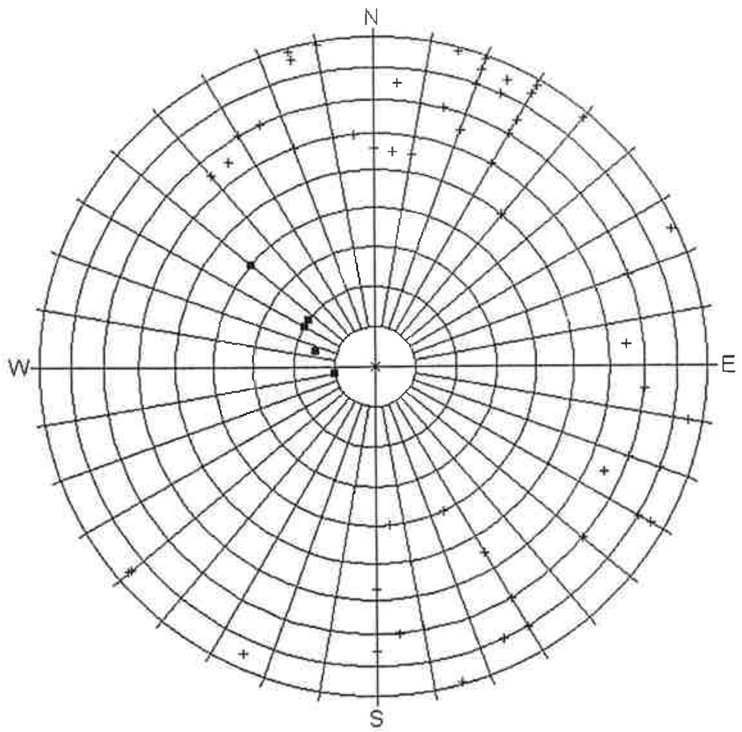
Domain:

Lithology:

Processed by: RJ

Defect type: Joints

Traverse: Trench 2

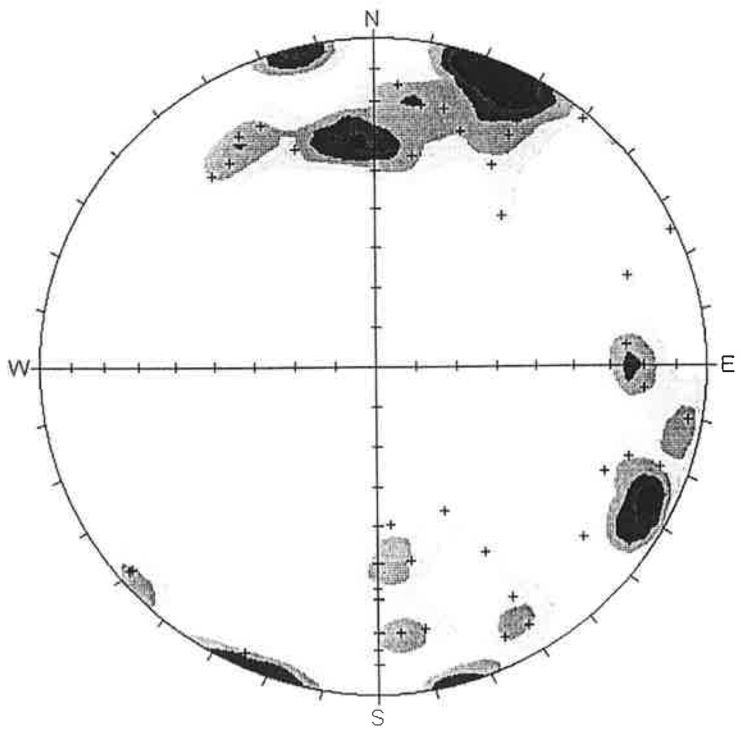


TYPE

■ fol [5]

\+ jt [65]

Equal Area
Lower Hemisphere
70 Poles
70 Entries



TYPE

\+ jt [65]

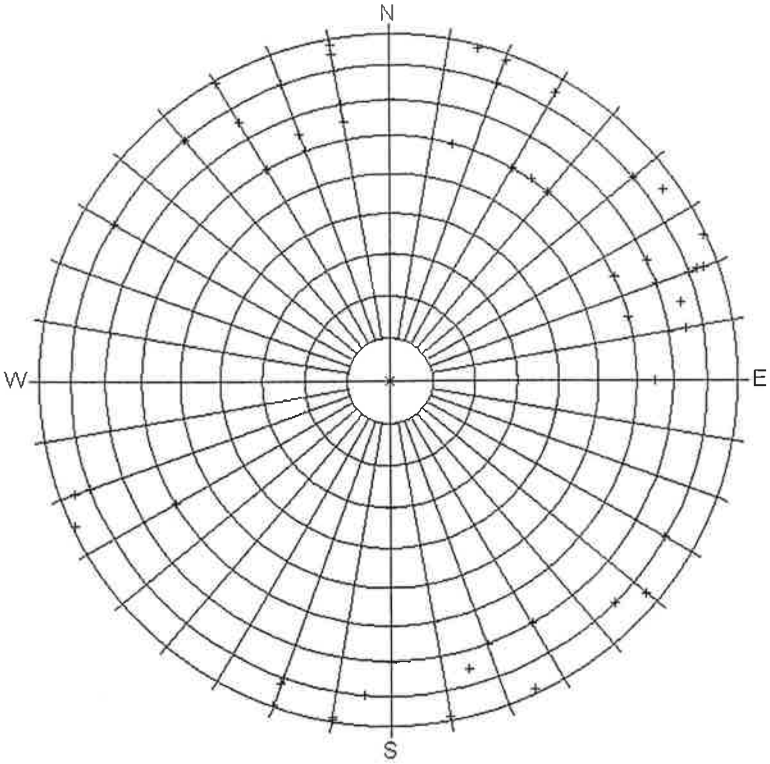
Equal Area
Lower Hemisphere
65 Poles
65 Entries

PSM **Pells Sullivan Meynink Pty Ltd**

Stereo Plot

Job no PSM071

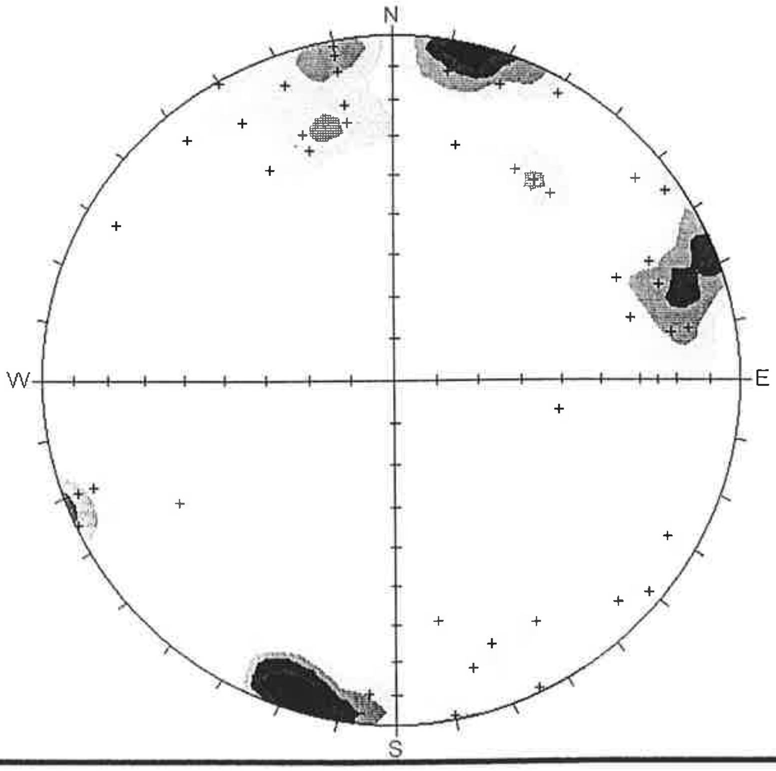
Project: Deep Dell Stage 1 Pit	North datum: Mine	Domain:
Lithology:	Defect type: Joints	Traverse: Trench 3
Processed by: RJ		



TYPE

+ jt [66]

Equal Area
Lower Hemisphere
66 Poles
66 Entries



TYPE

+ jt [66]

Equal Area
Lower Hemisphere
66 Poles
66 Entries

Pells Sullivan Meynink Pty Ltd

Stereo Plot

Job no PSM071

Project: Deep Dell Stage 1 Pit

North datum: Mine

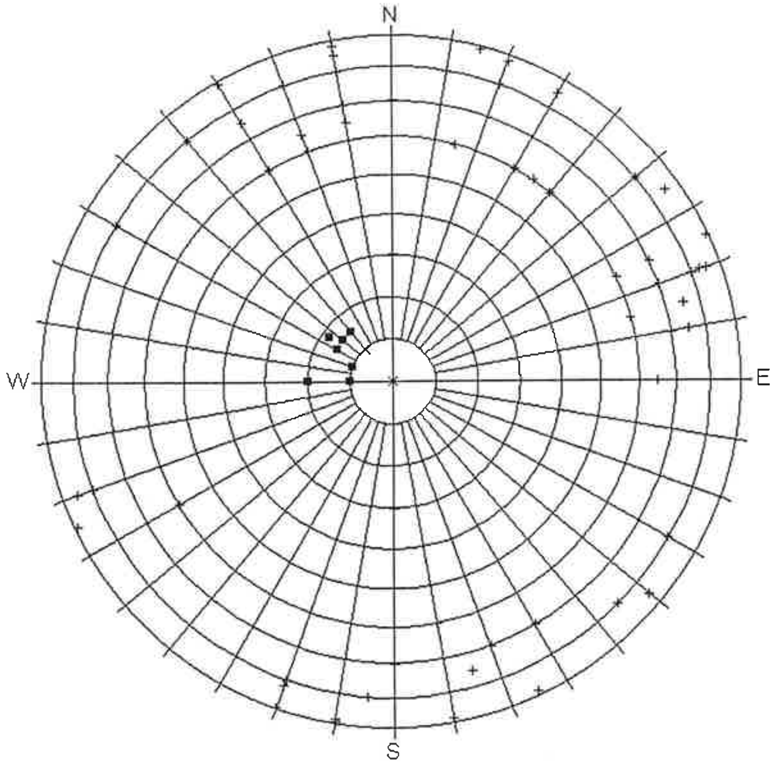
Domain:

Lithology:

Defect type: All

Traverse: Trench 3

Processed by: RJ



TYPE

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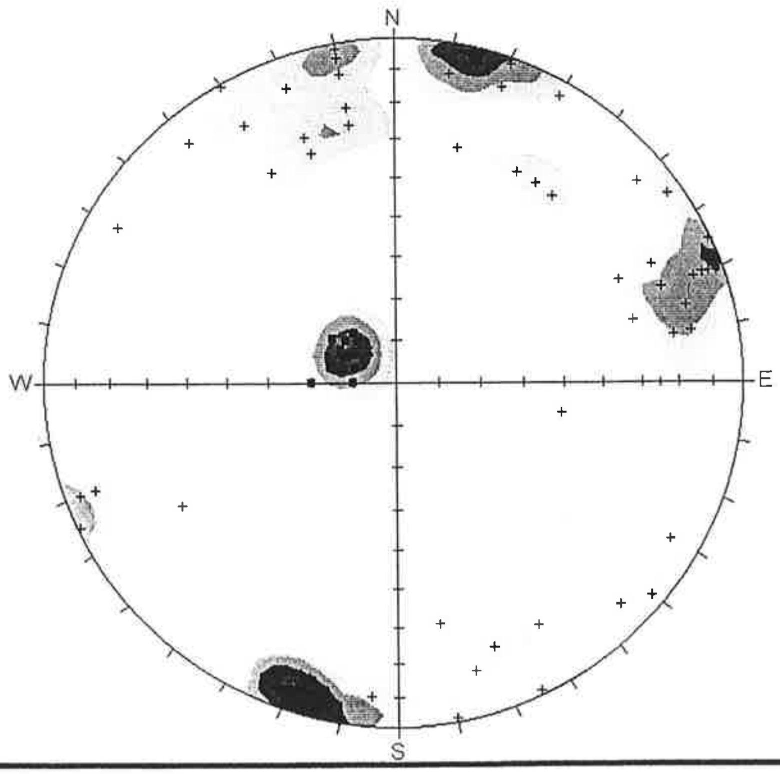
+	jt [66]
×	sz [1]

Equal Area
Lower Hemisphere
74 Poles
74 Entries



TYPE

■	fol [7]
+	jt [66]
×	sz [1]

Equal Area
Lower Hemisphere
74 Poles
74 Entries

Pells Sullivan Meynink Pty Ltd

Stereo Plot

Job no PSM071

Project: Deep Dell Stage 1 Pit

North datum: Mine

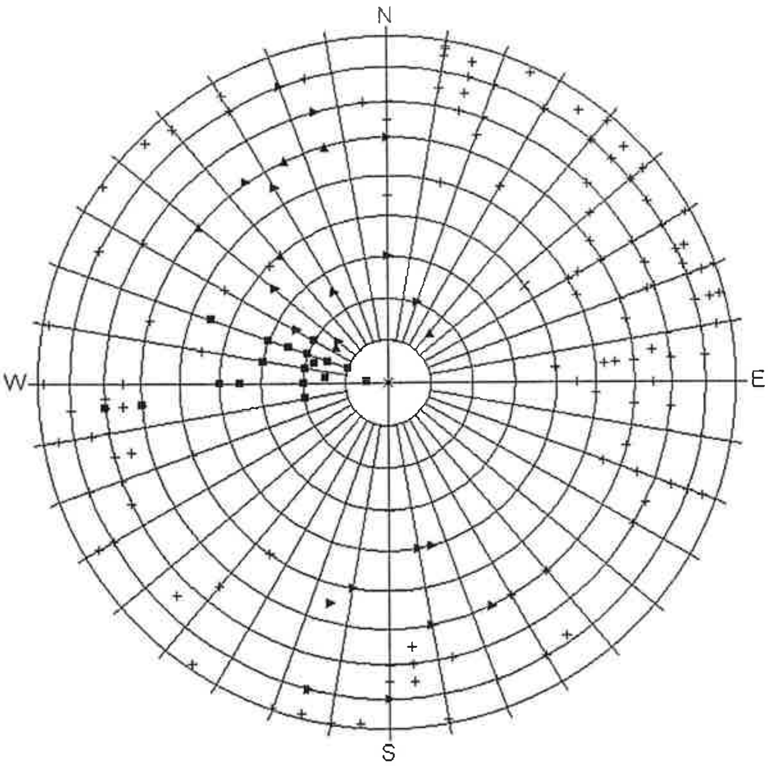
Domain:

Lithology:

Defect type: All

Traverse: Trench 4

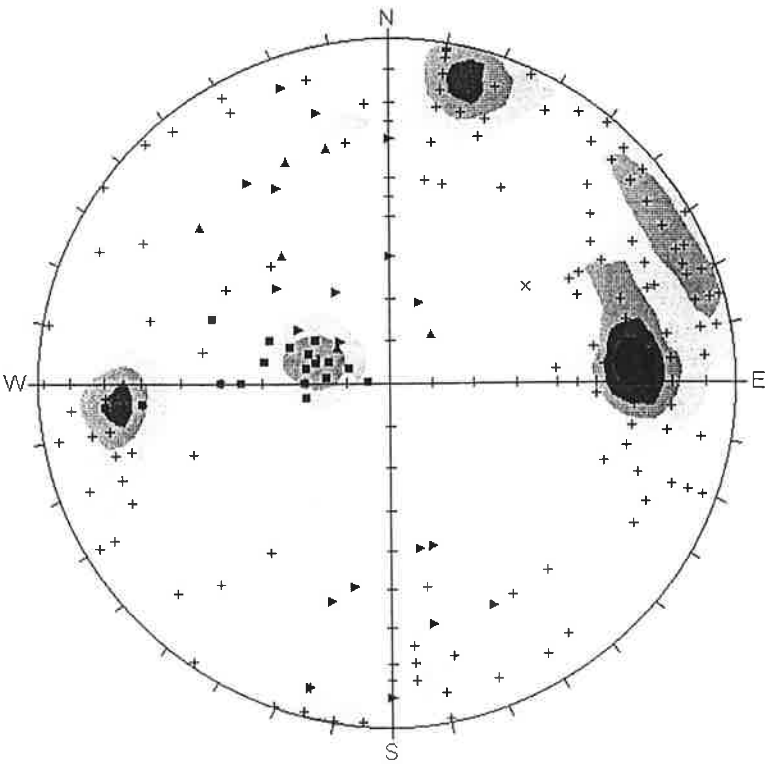
Processed by: RJ



TYPE

■	fol [19]
▲	g [6]
►	g/cz [20]
+	jt [185]
×	sz [1]

Equal Area
Lower Hemisphere
231 Poles
231 Entries



TYPE

■	fol [19]
▲	g [6]
►	g/cz [20]
+	jt [185]
×	sz [1]

Equal Area
Lower Hemisphere
231 Poles
231 Entries

PSM **Pells Sullivan Meynink Pty Ltd**

Stereo Plot

Job no PSM071

Project: Deep Dell Stage 1 Pit

North datum: Mine

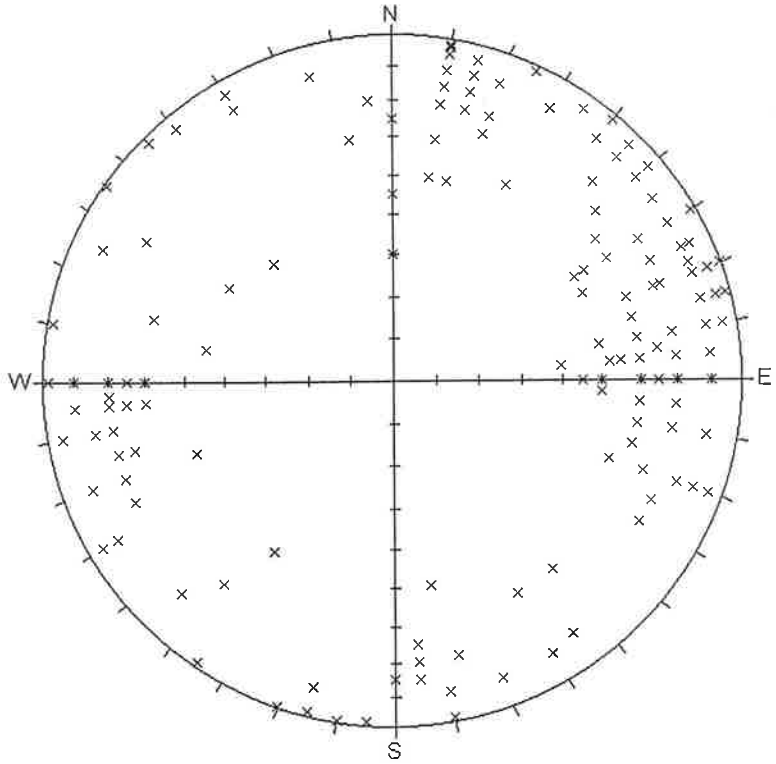
Domain:

Lithology:

Defect type: Joints

Traverse: Trench 4

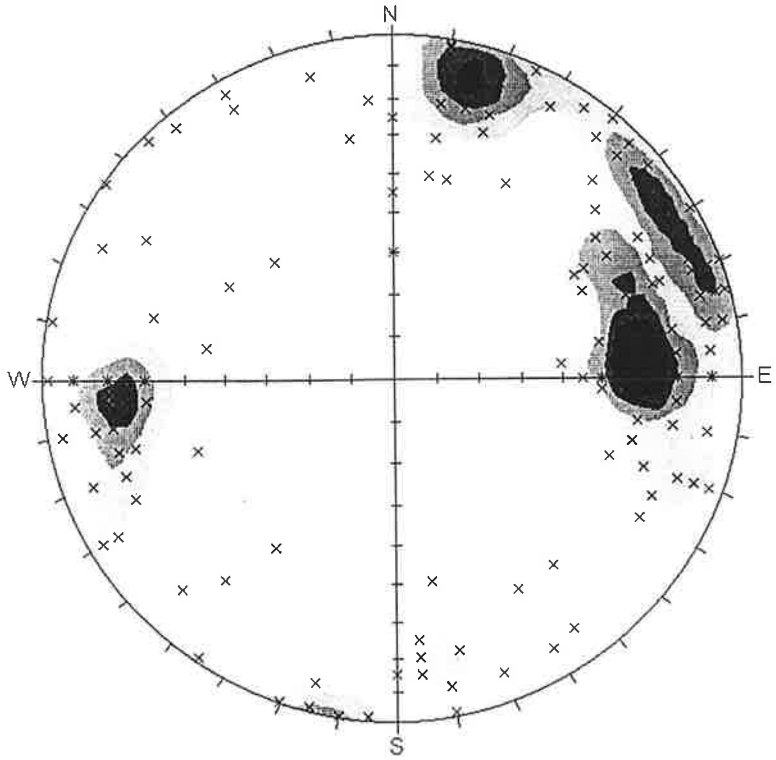
Processed by: RJ



TYPE

× jt [185]

Equal Area
Lower Hemisphere
185 Poles
185 Entries



TYPE

× jt [185]

Equal Area
Lower Hemisphere
185 Poles
185 Entries

Pells Sullivan Meynink Pty Ltd

Stereo Plot

Job no PSM071

Project: Deep Dell Stage 1 Pit

North datum: Mine

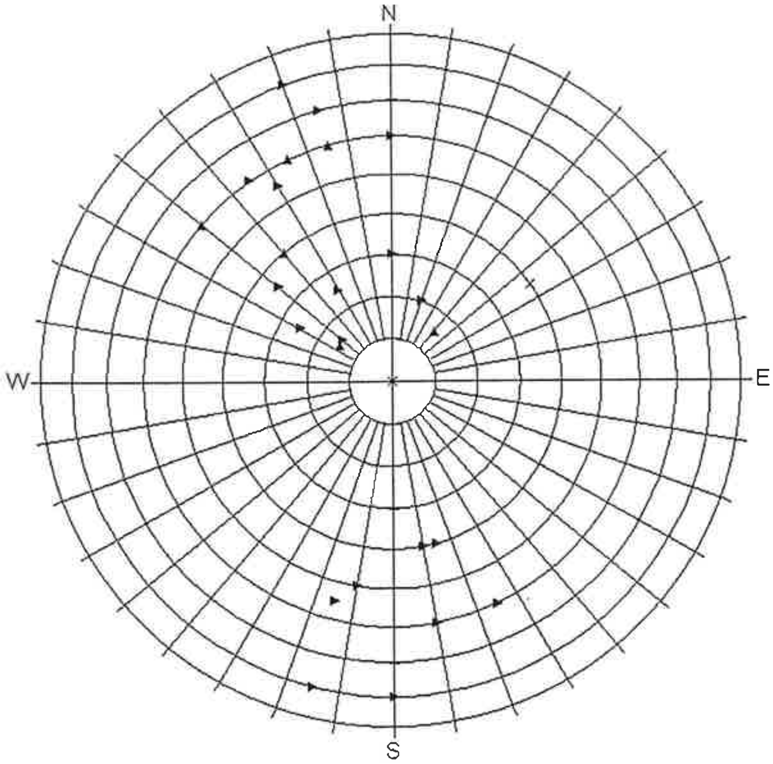
Domain:

Lithology:

Defect type: Gouge/Crush Zones

Traverse: Trench 4

Processed by: RJ



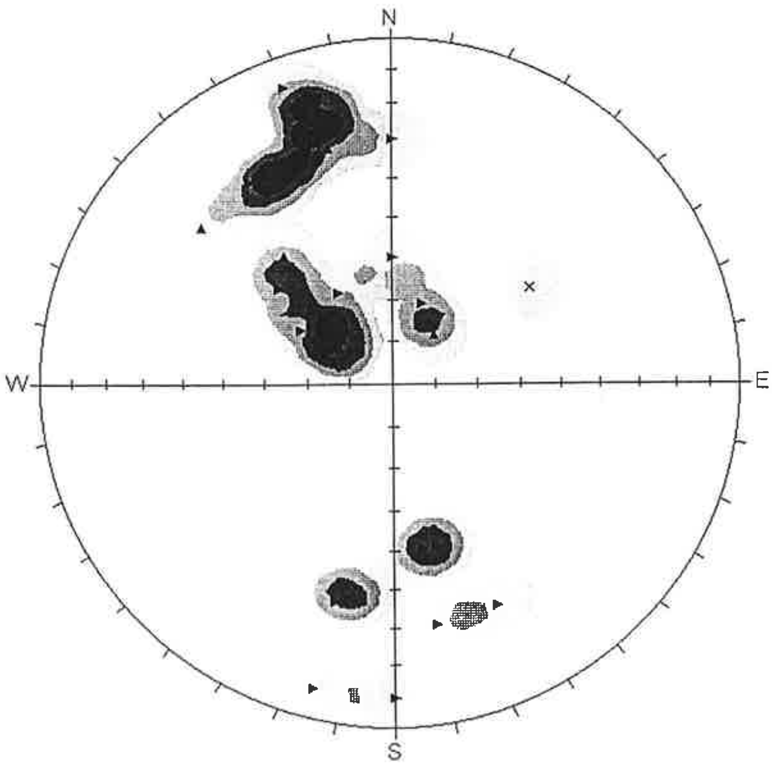
TYPE

▲ g [6]

► g/cz [20]

× sz [1]

Equal Area
Lower Hemisphere
27 Poles
27 Entries



TYPE

▲ g [6]

► g/cz [20]

× sz [1]

Equal Area
Lower Hemisphere
27 Poles
27 Entries

PSM Pells Sullivan Meynink Pty Ltd

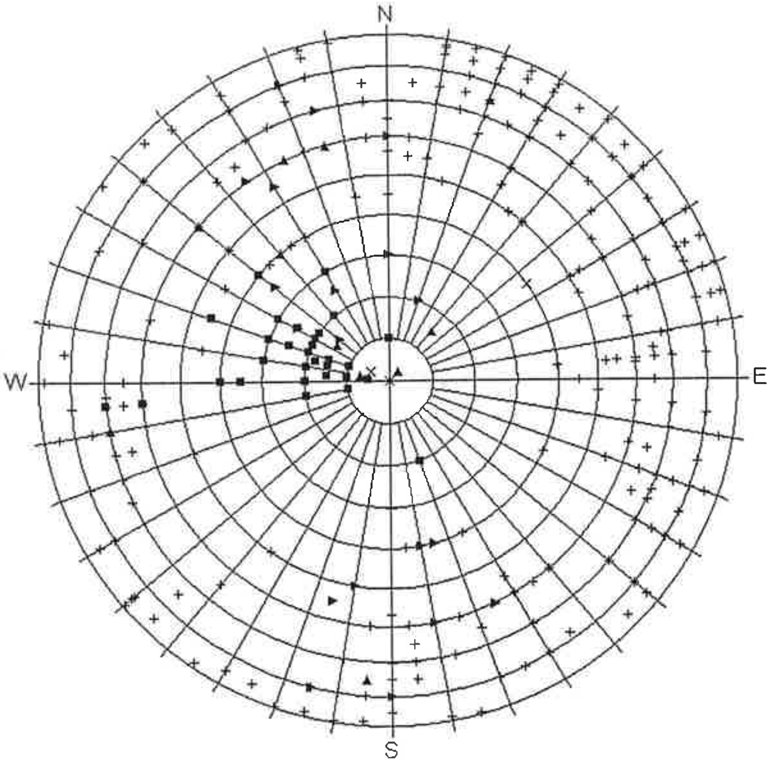
Stereo Plot

Job no PSM071

Project: Deep Dell Stage 1 Pit | North datum: Mine | Domain:

Lithology: | Defect type: All | Traverse: Trenches 1 to 4

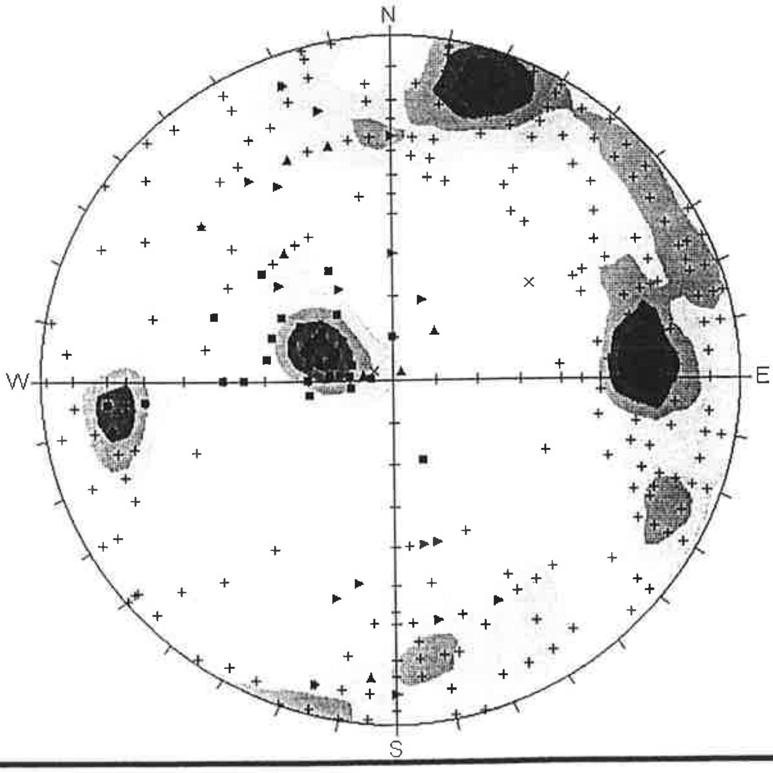
Processed by: RJ



TYPE

- ■ fol [35]
- ▲ g [11]
- ▶ g/cz [21]
- + jt [314]
- × sz [2]

Equal Area
Lower Hemisphere
383 Poles
383 Entries



TYPE

- ■ fol [35]
- ▲ g [11]
- ▶ g/cz [21]
- + jt [314]
- × sz [2]

Equal Area
Lower Hemisphere
383 Poles
383 Entries

PSM **Pells Sullivan Meynink Pty Ltd**

Stereo Plot

Job no PSM071

Project: Deep Dell Stage 1 Pit

Lithology:

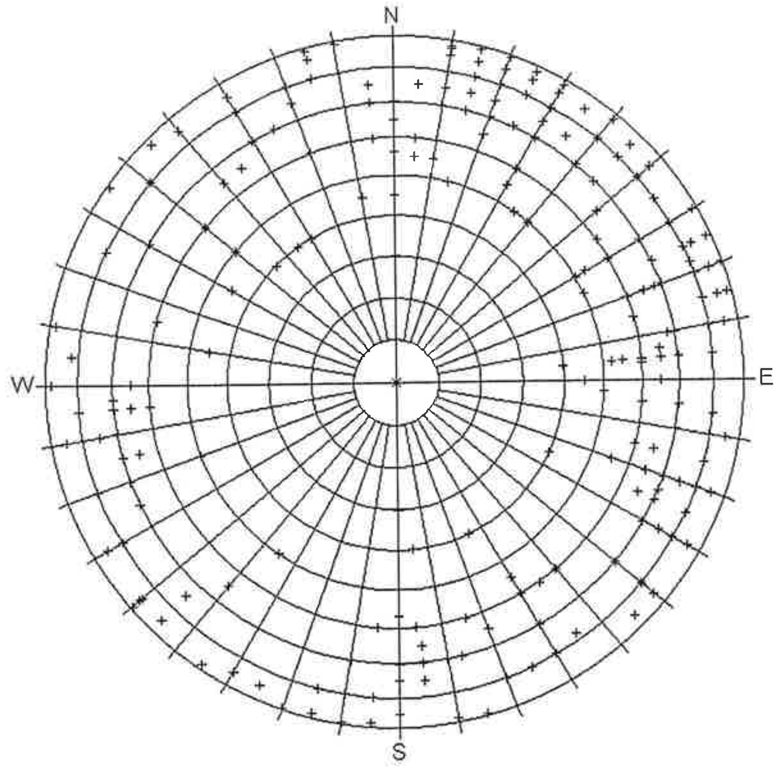
Processed by: RJ

North datum: Mine

Defect type: Joints

Domain:

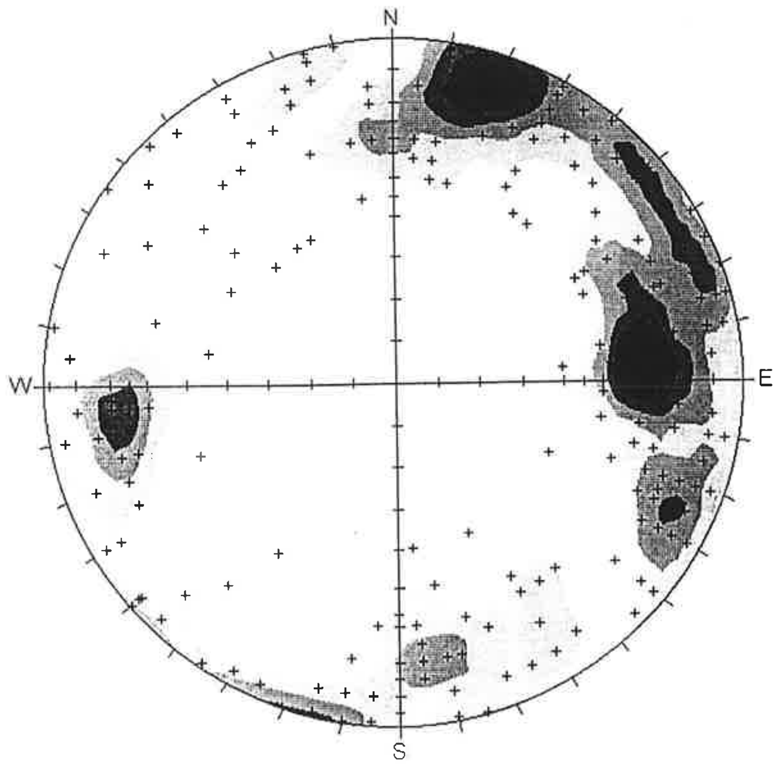
Traverse: Trenches 1 to 4



TYPE

+ jt [314]

Equal Area
Lower Hemisphere
314 Poles
314 Entries



TYPE

+ jt [314]

Equal Area
Lower Hemisphere
314 Poles
314 Entries

Pells Sullivan Meynink Pty Ltd

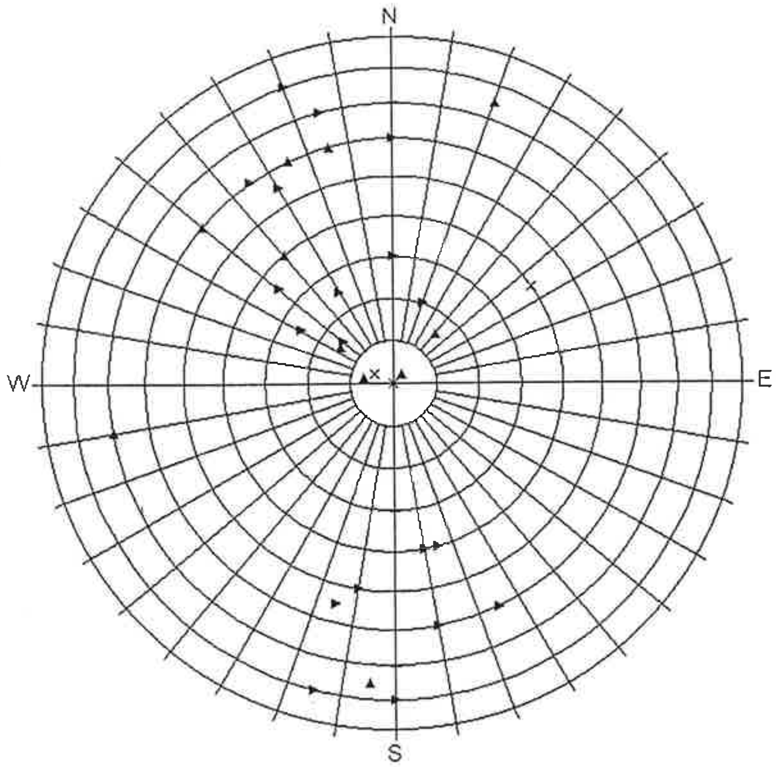
Stereo Plot

Job no PSM071

Project: Deep Dell Stage 1 Pit
North datum: Mine
Domain:

Lithology:
Defect type: Gouge, crushed zones
Traverse: Trenches 1 to 4

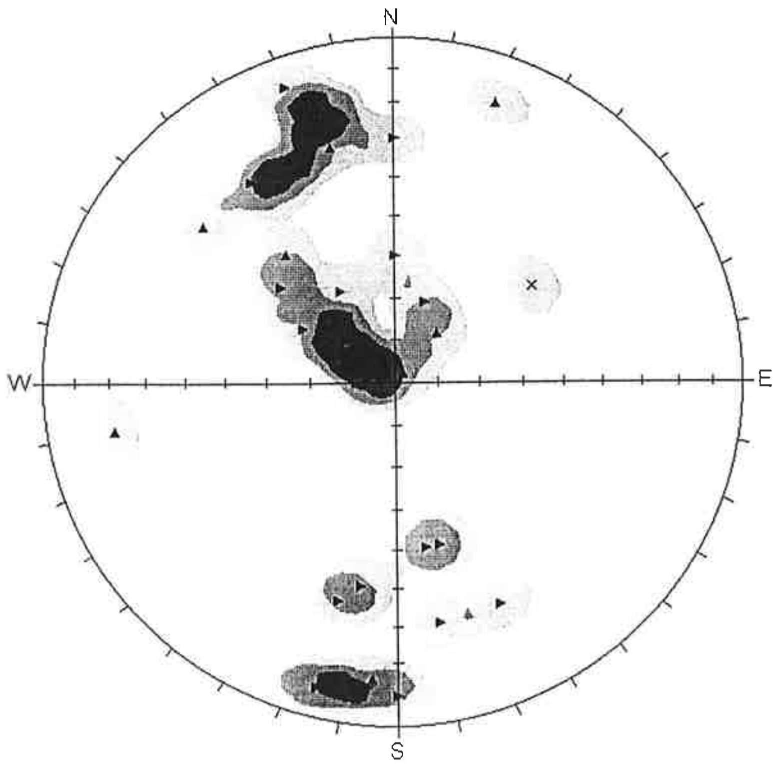
Processed by: RJ



TYPE

▲ g [11]
► g/cz [21]
× sz [2]

Equal Area
Lower Hemisphere
34 Poles
34 Entries



TYPE

▲ g [11]
► g/cz [21]
× sz [2]

Equal Area
Lower Hemisphere
34 Poles
34 Entries

PSM

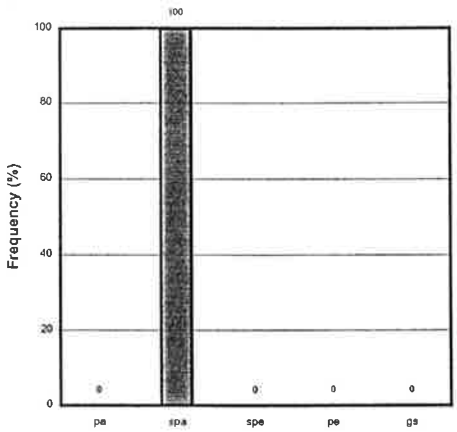
GRD Macraes Ltd

Geotechnical Line Mapping
Data Histograms

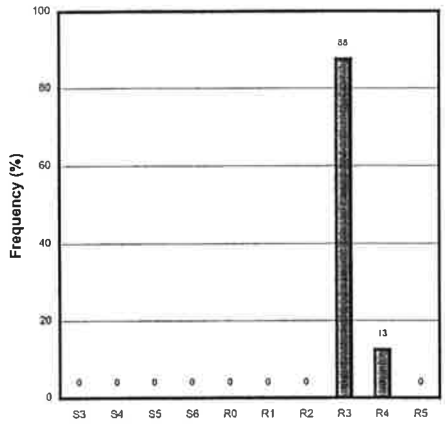
Trench 1

project:	Deepdell Stage 1 Pit Design	datum:	assumed
location:	Deepdell	date:	10-Aug-00

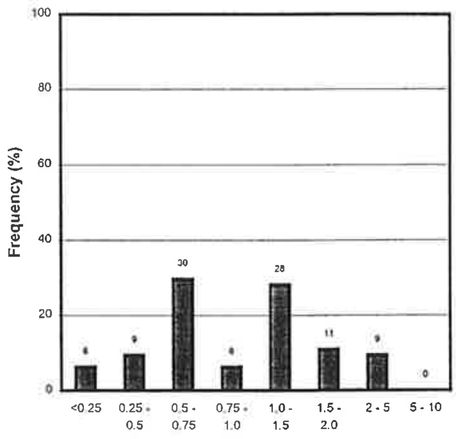
Data records	**64**	**Lithology:**	All	**Traverse**	Trench 1	**Type Defect:**	Joints



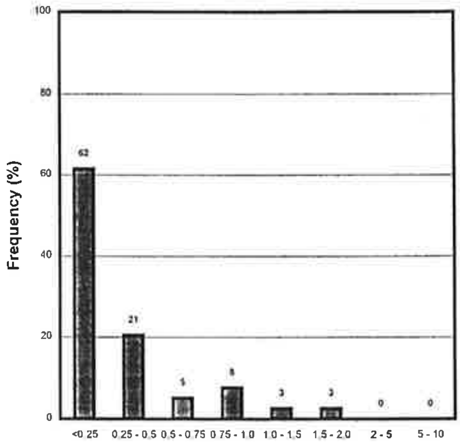
Lithology



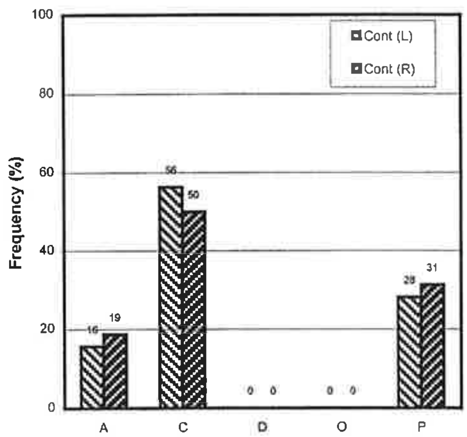
Strength



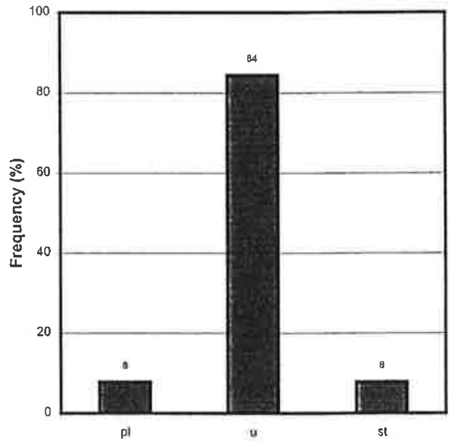
Length (m)



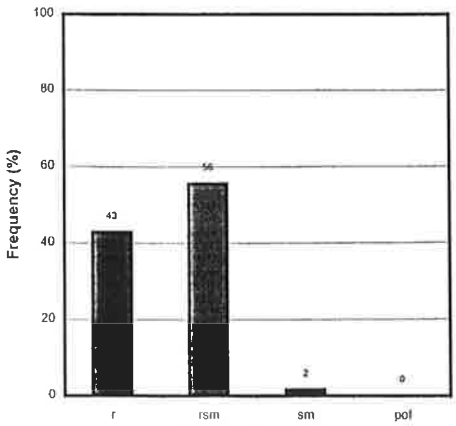
Spacing (m)



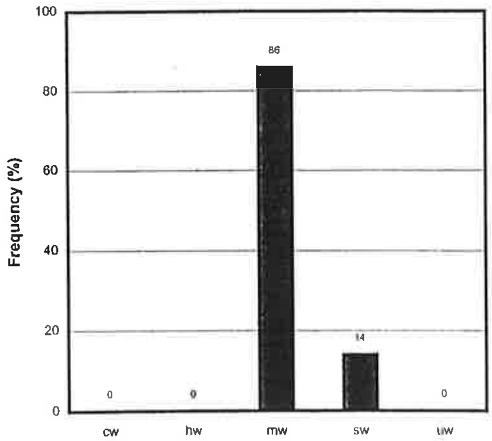
Defect Continuity



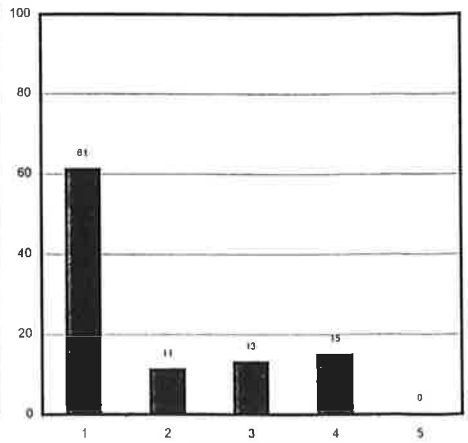
Large scale roughness



Small scale roughness



Weathering



Water Condition

PSM

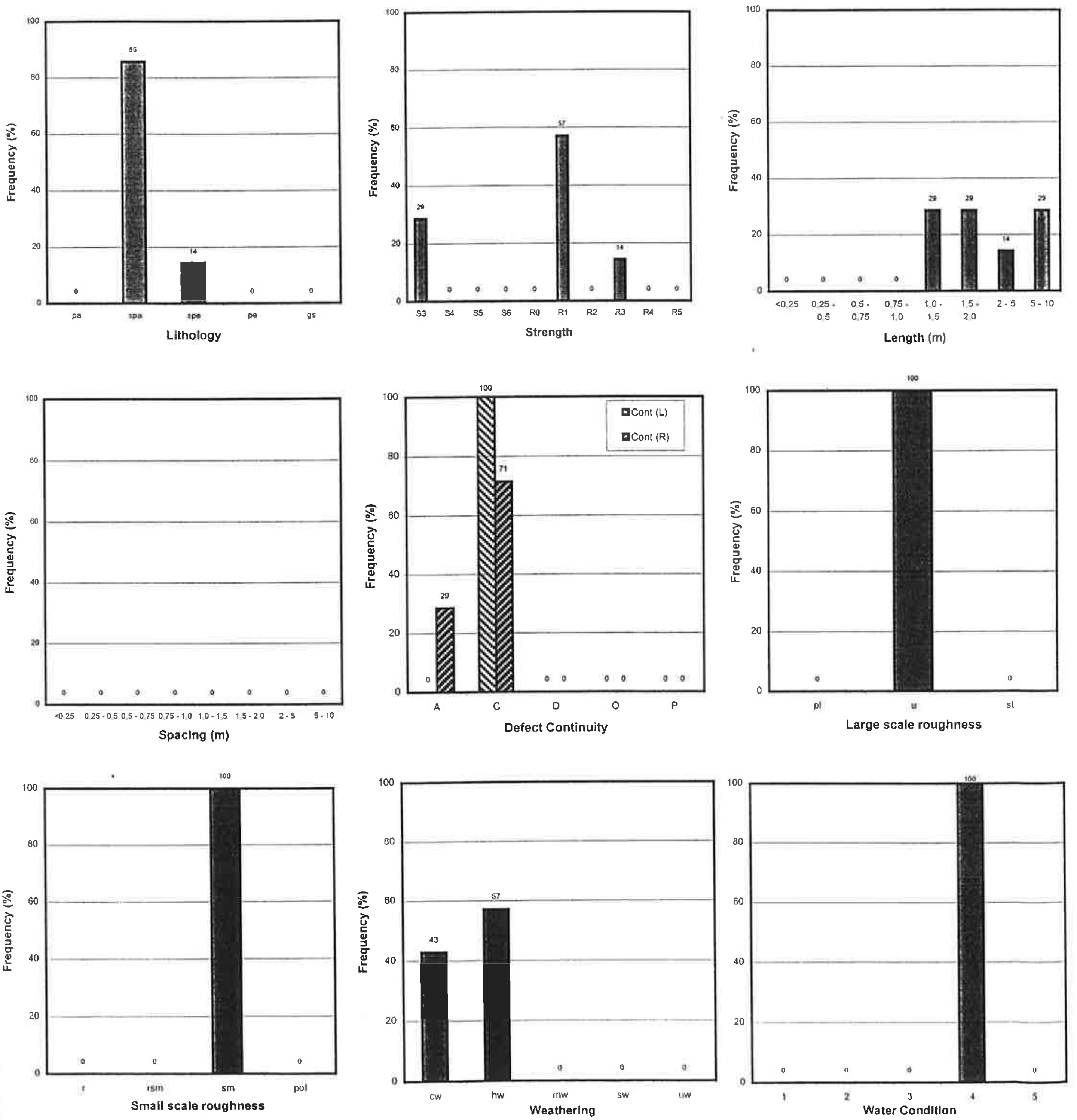
GRD Macraes Ltd

Geotechnical Line Mapping
Data Histograms

Trench 1

project:	Deepdell Stage 1 Pit Design	datum:	assumed
location:	Deepdell	date:	10-Aug-00

Data records	7	**Lithology:**	All	**Traverse**	Trench 1	**Type Defect:**	Gouge/Shr zones



PSM

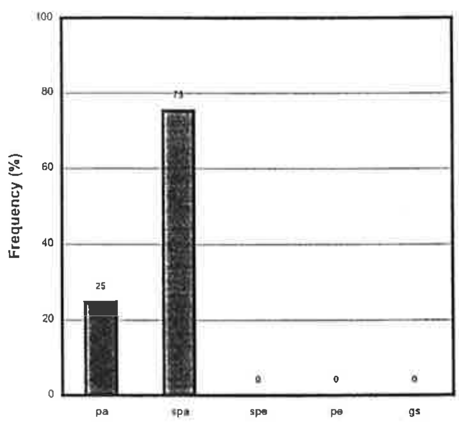
GRD Macraes Ltd

Geotechnical Line Mapping
Data Histograms

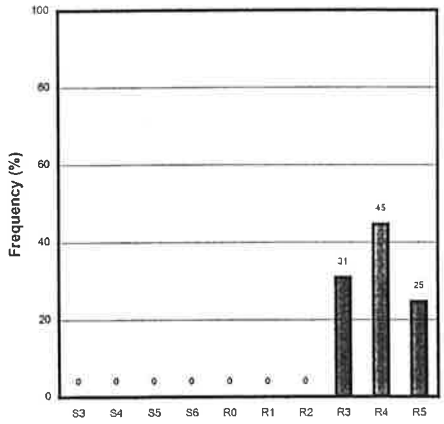
Trench 2

project:	Deepdell Stage 1 Pit Design	datum:	assumed
location:	Deepdell	date:	10-Aug-00

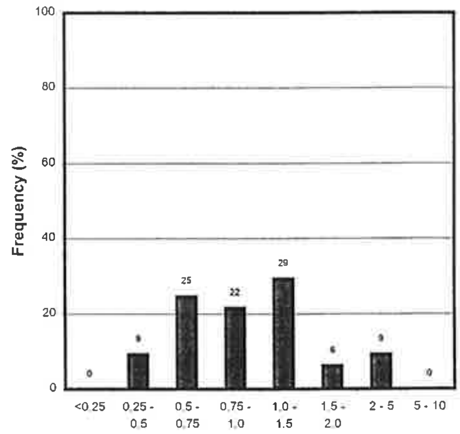
Data records 65 **Lithology:** All **Traverse** Trench 2 **Type Defect:** Joints



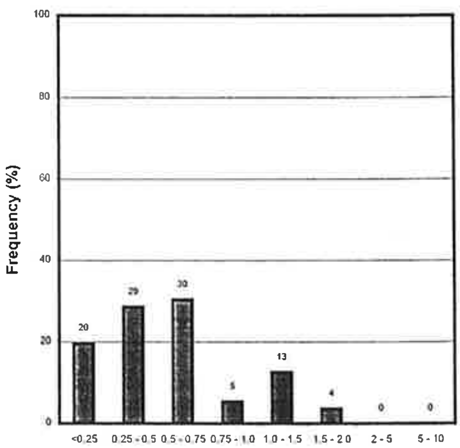
Lithology



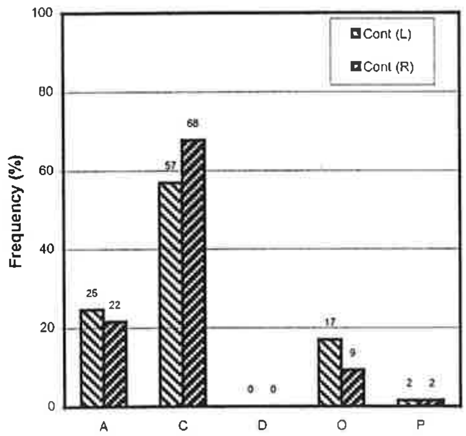
Strength



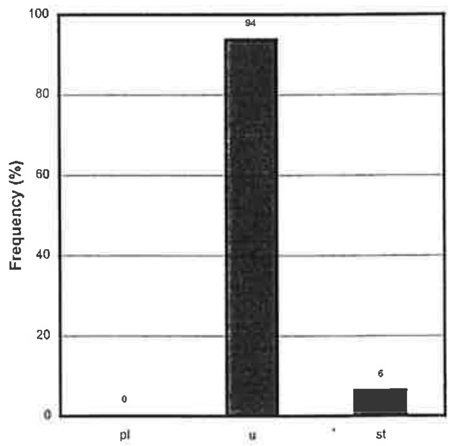
Length (m)



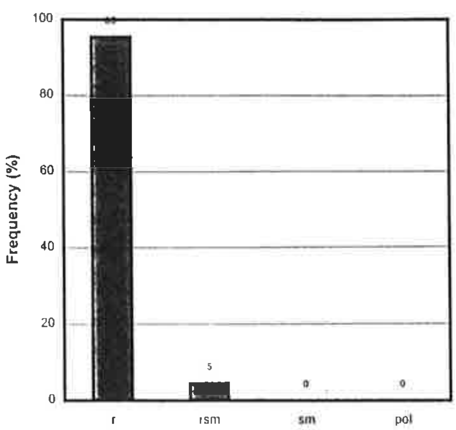
Spacing (m)



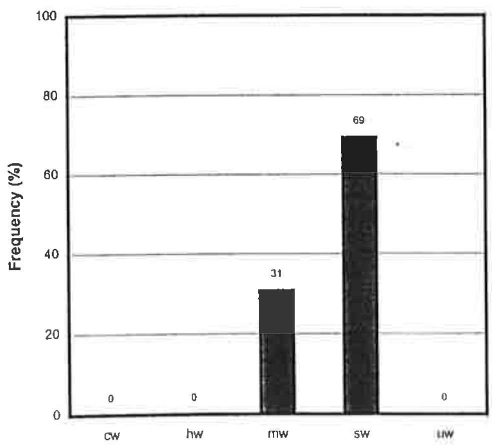
Defect Continuity



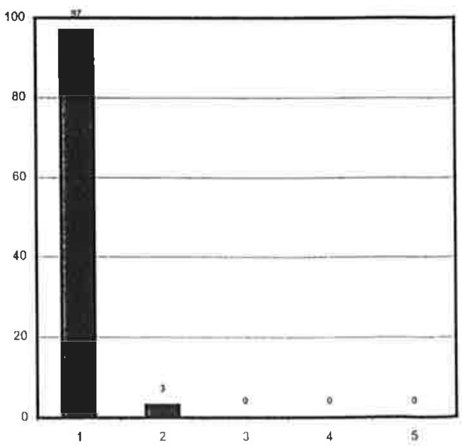
Large scale roughness



Small scale roughness



Weathering



Water Condition

PSM

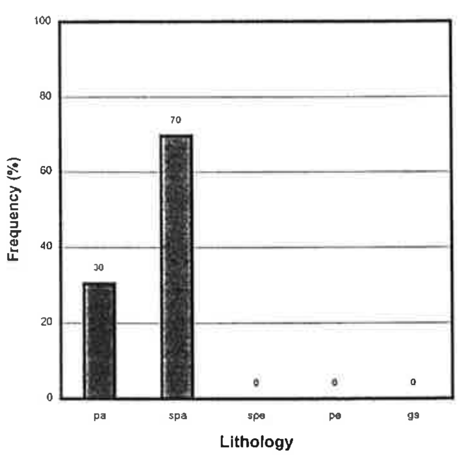
GRD Macraes Ltd

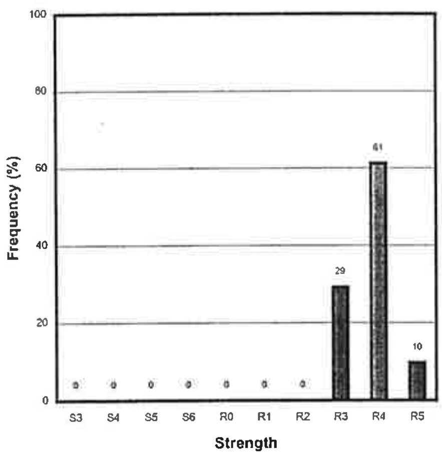
Geotechnical Line Mapping
Data Histograms

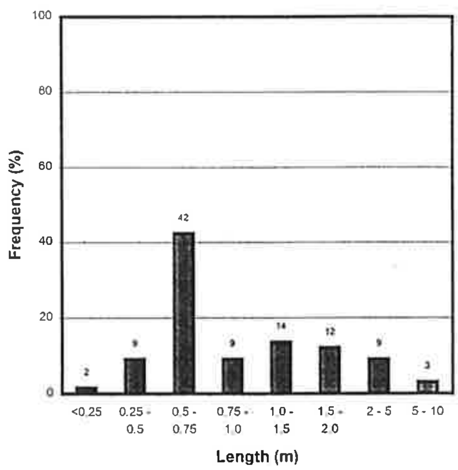
Trench 3

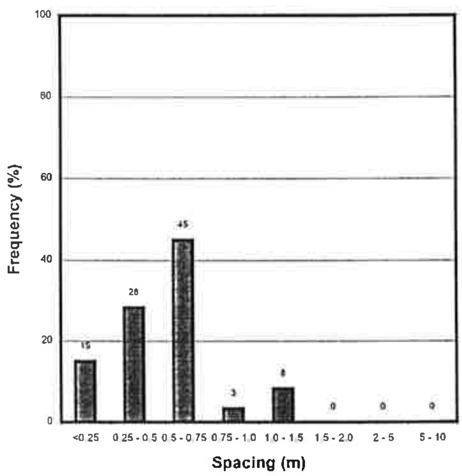
project:	Deepdell Stage 1 Pit Design	datum:	assumed
location:	Deepdell	date:	10-Aug-00

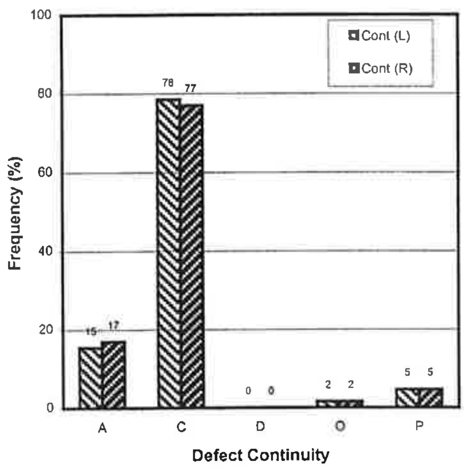
Data records 66 **Lithology:** All **Traverse** Trench 3 **Type Defect:** Joints

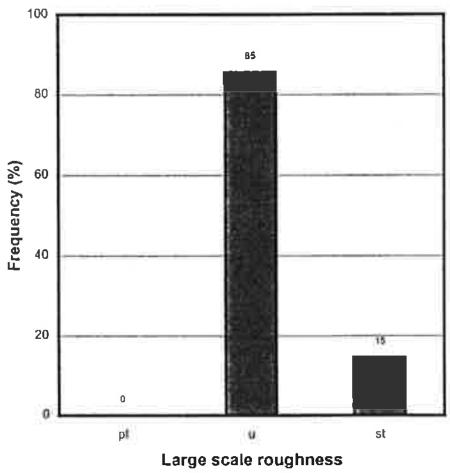


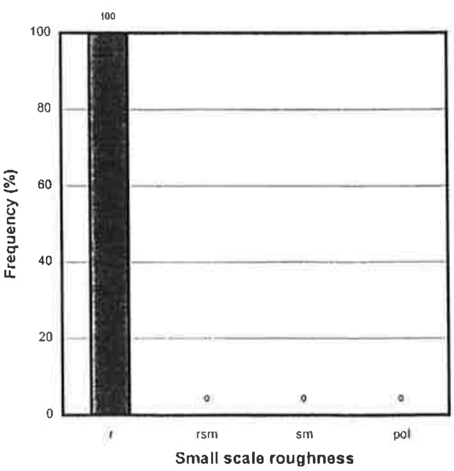


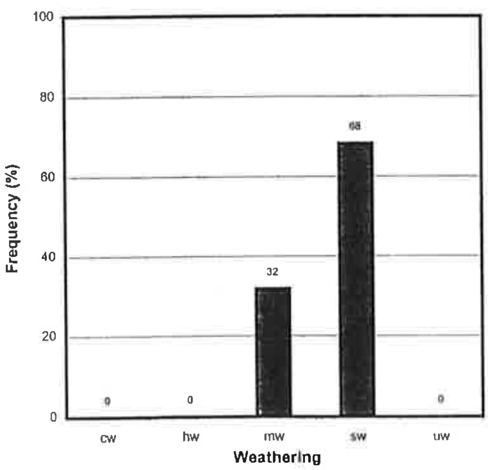


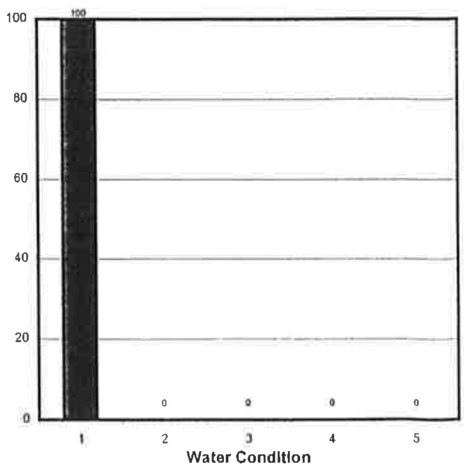












PSM

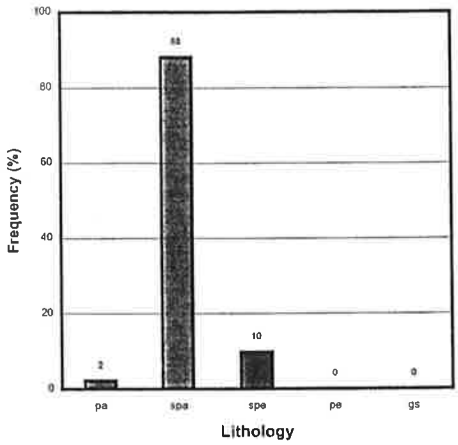
GRD Macraes Ltd

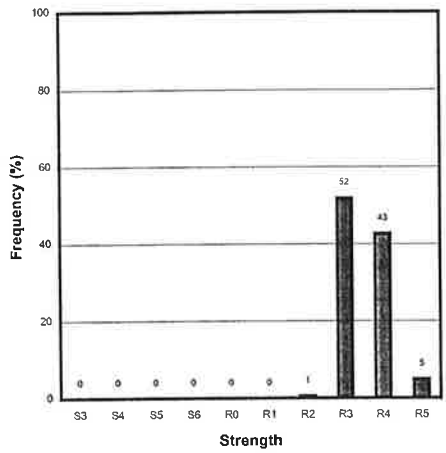
Geotechnical Line Mapping Data Histograms

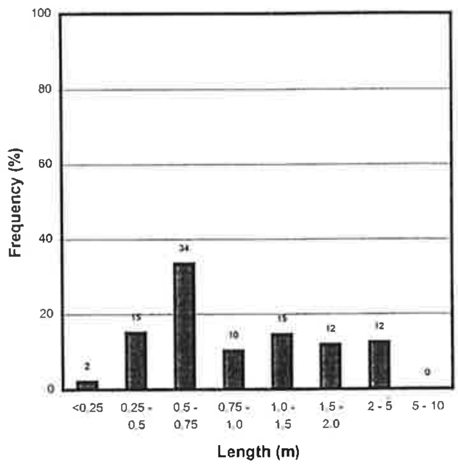
Trench 4

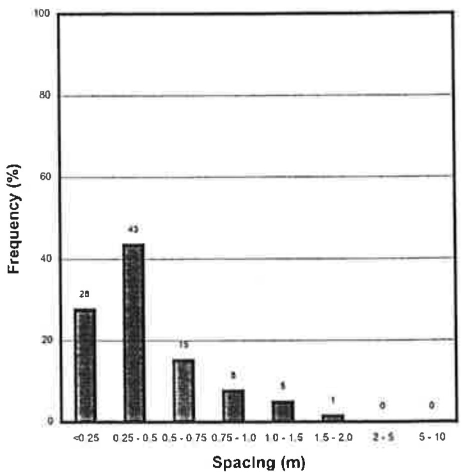
project:	Deepdell Stage 1 Pit Design	datum:	assumed
location:	Deepdell	date:	10-Aug-00

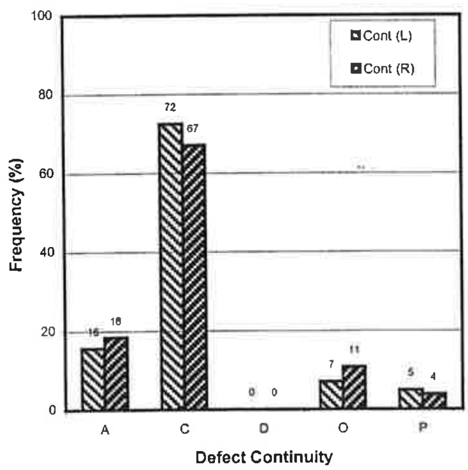
Data records	185	**Lithology:**	All	**Traverse**	Trench 4	**Type Defect:**	Joints

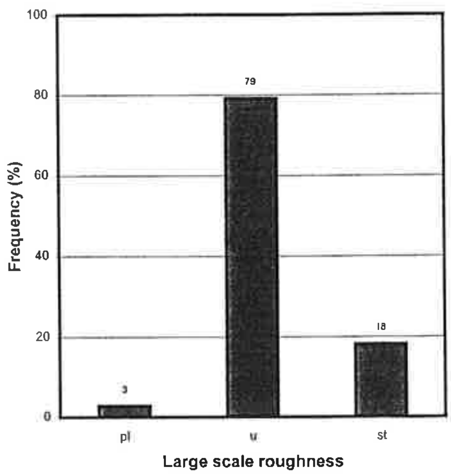


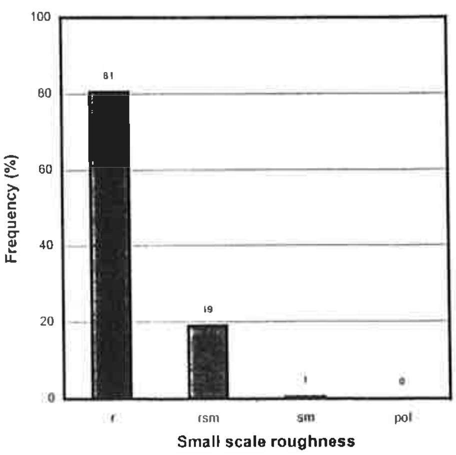


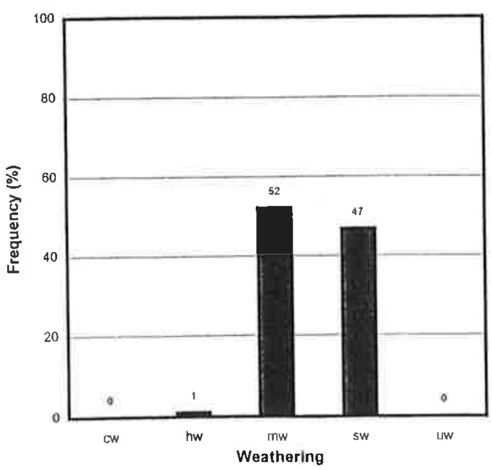


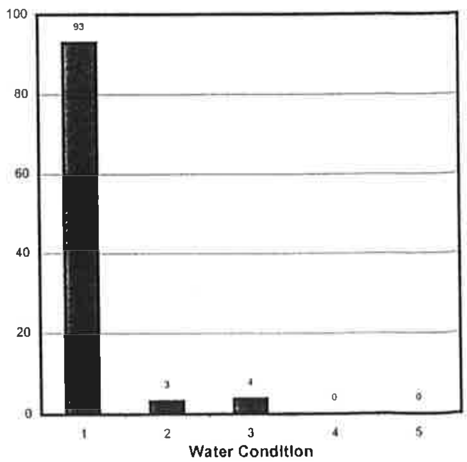








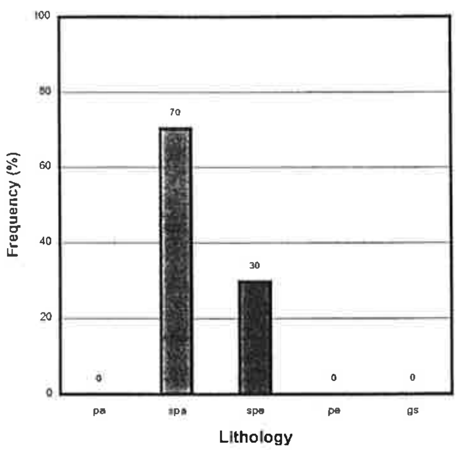


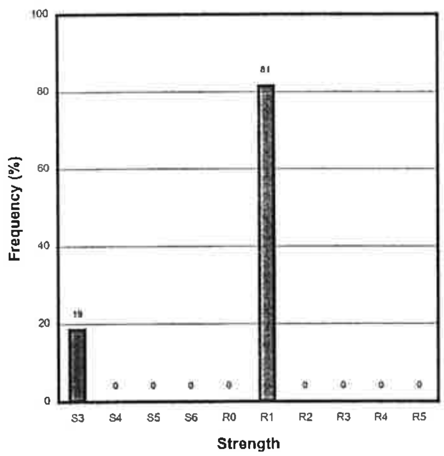


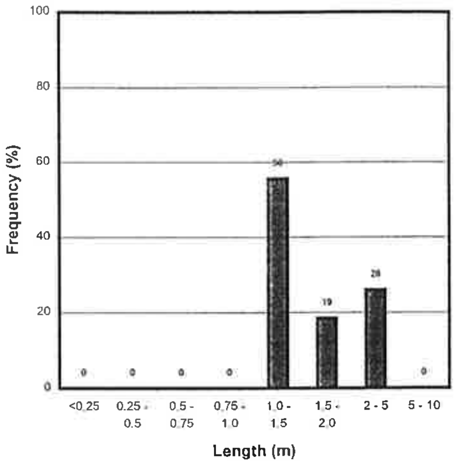
PSM	GRD Macraes Ltd	Geotechnical Line Mapping Data Histograms
		Trench 4

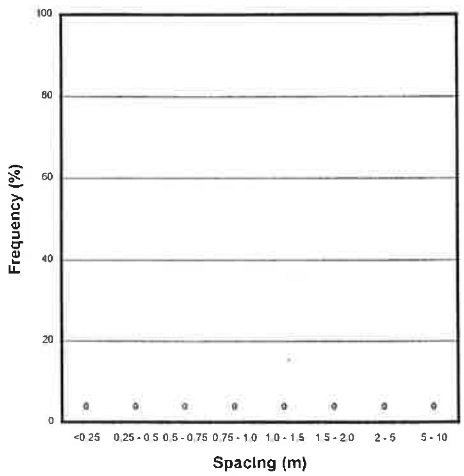
project:	Deepdell Stage 1 Pit Design	datum:	assumed
location:	Deepdell	date:	10-Aug-00

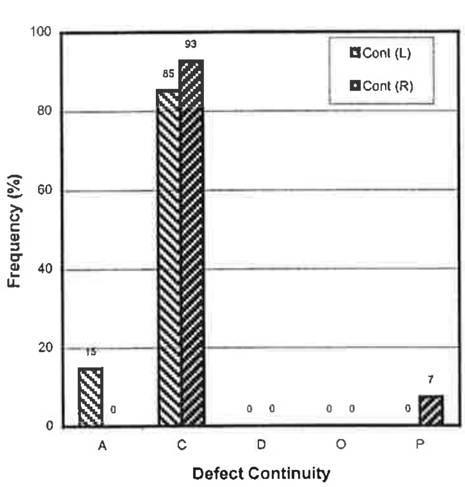
Data records	**27**	**Lithology:**	All	**Traverse**	Trench 4	**Type Defect:**	Gouge/shr zones

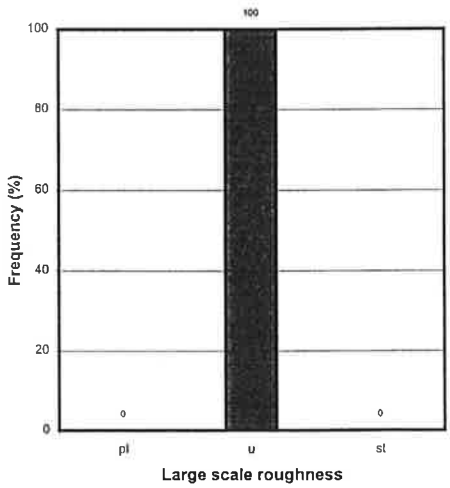


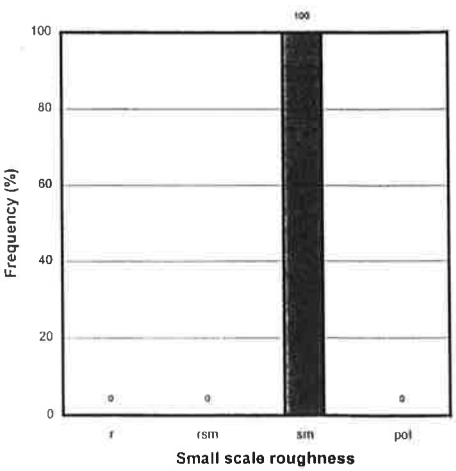


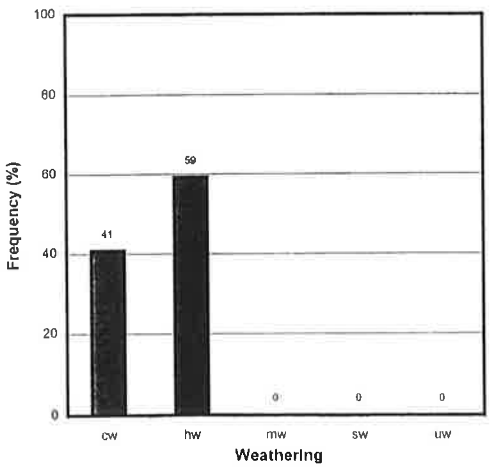


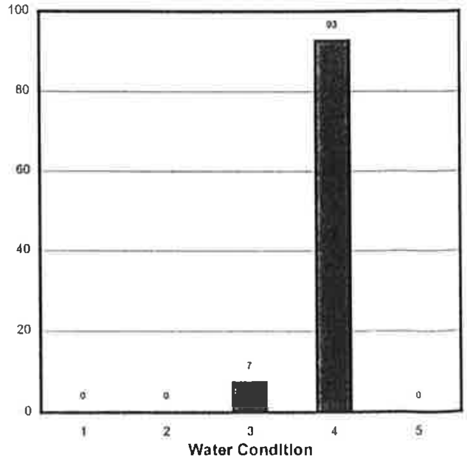












PSM

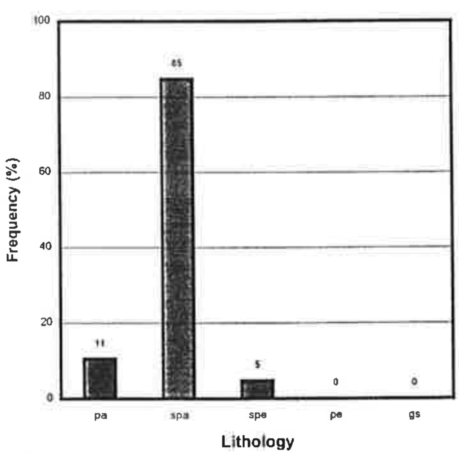
GRD Macraes Ltd

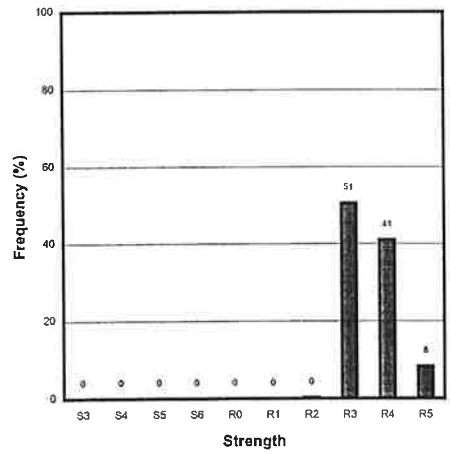
Geotechnical Line Mapping
Data Histograms

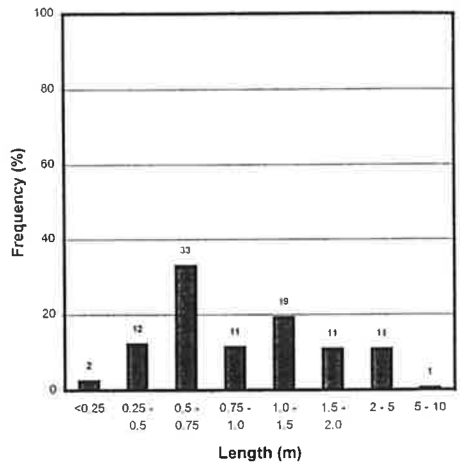
All Trenches

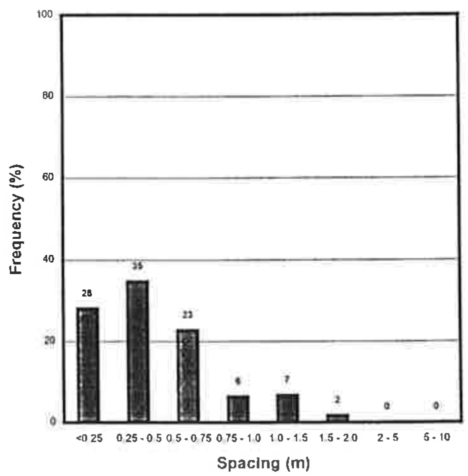
project:	Deepdell Stage 1 Pit Design	datum:	assumed
location:	Deepdell	date:	10-Aug-00

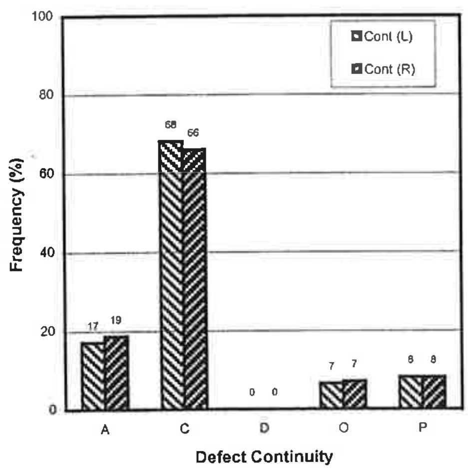
Data records 380 **Lithology:** All **Traverse** All **Type Defect:** Joints

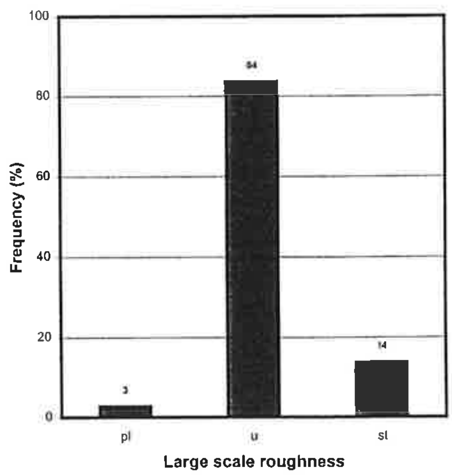


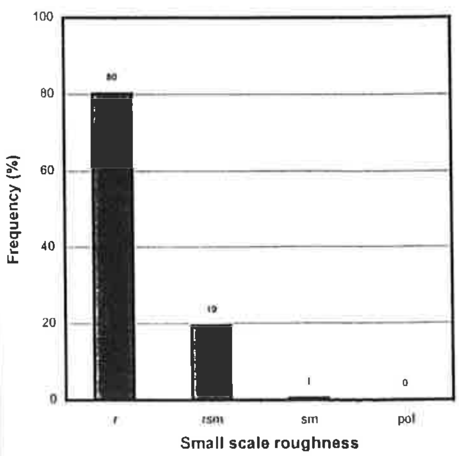


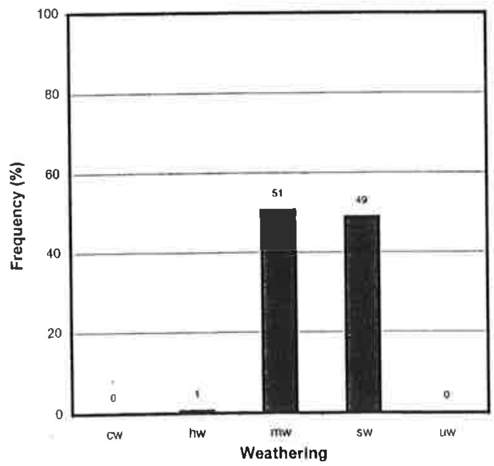


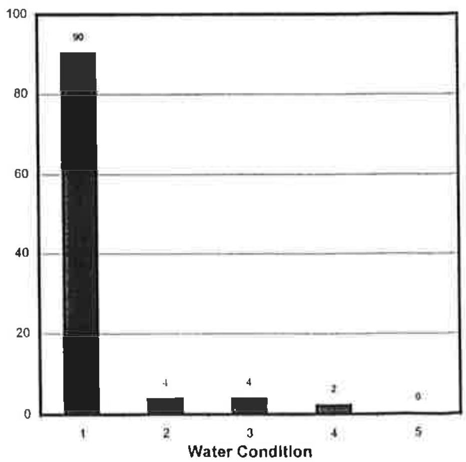












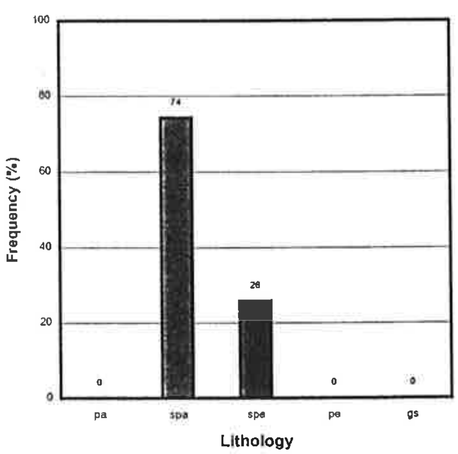
GRD Macraes Ltd

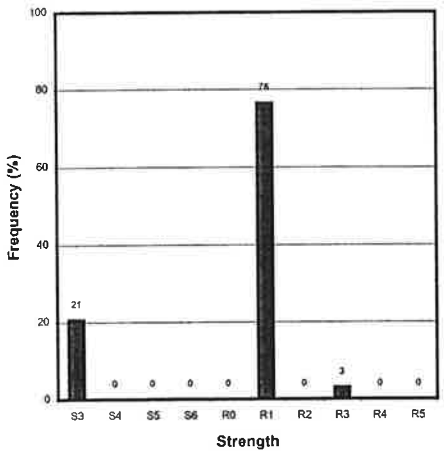
Geotechnical Line Mapping
Data Histograms

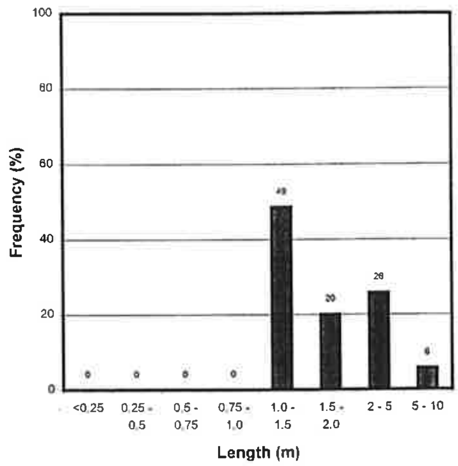
All Trenches

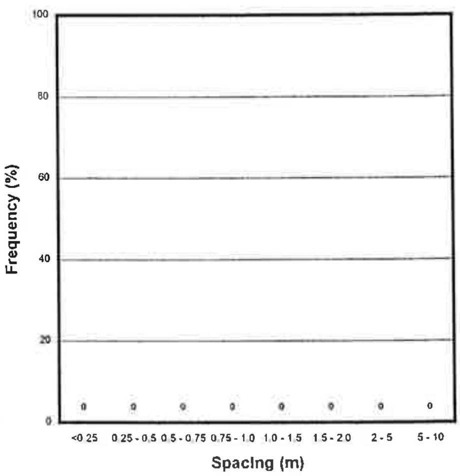
project:	Deepdell Stage 1 Pit Design	datum:	assumed
location:	Deepdell	date:	10-Aug-00

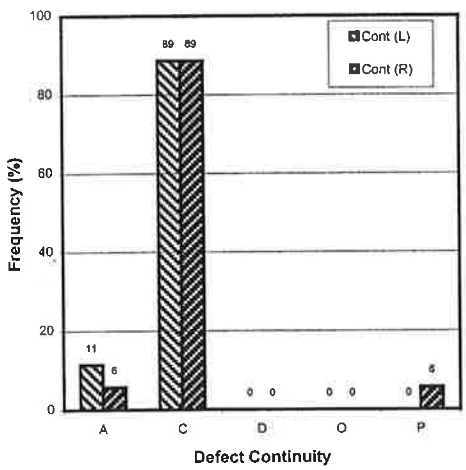
Data records	35	**Lithology:**	All	**Traverse**	All	**Type Defect:**	Gouge/Shr zones

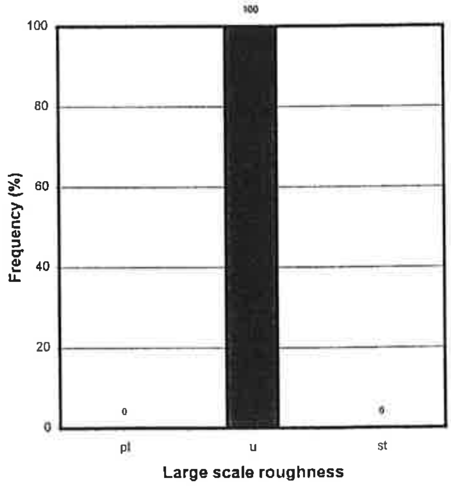


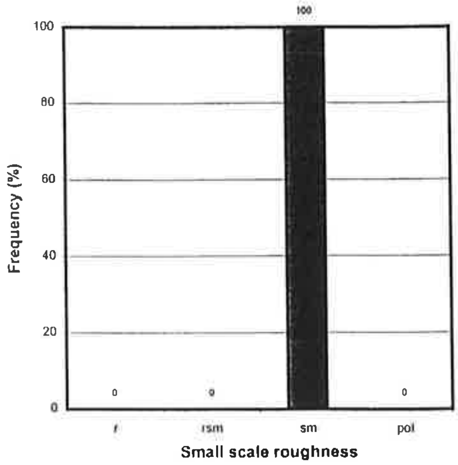


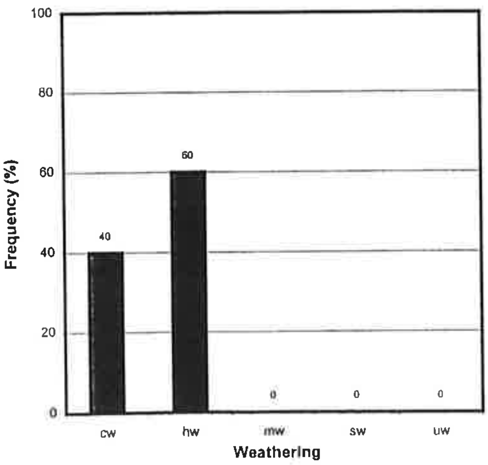


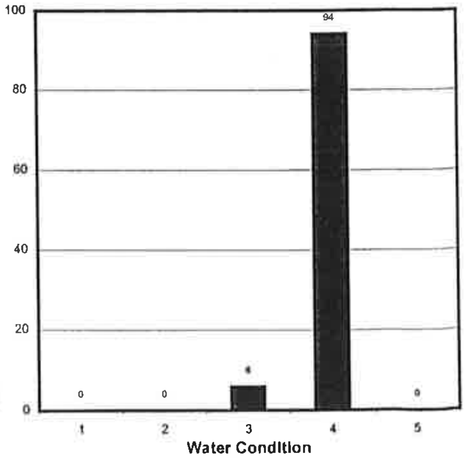












APPENDIX B

BOREHOLE LOGS

PSM

Pells Sullivan Meynink Pty Ltd

Engineering Consultants
Rock-Soil-Water

A.C.N. 061447621

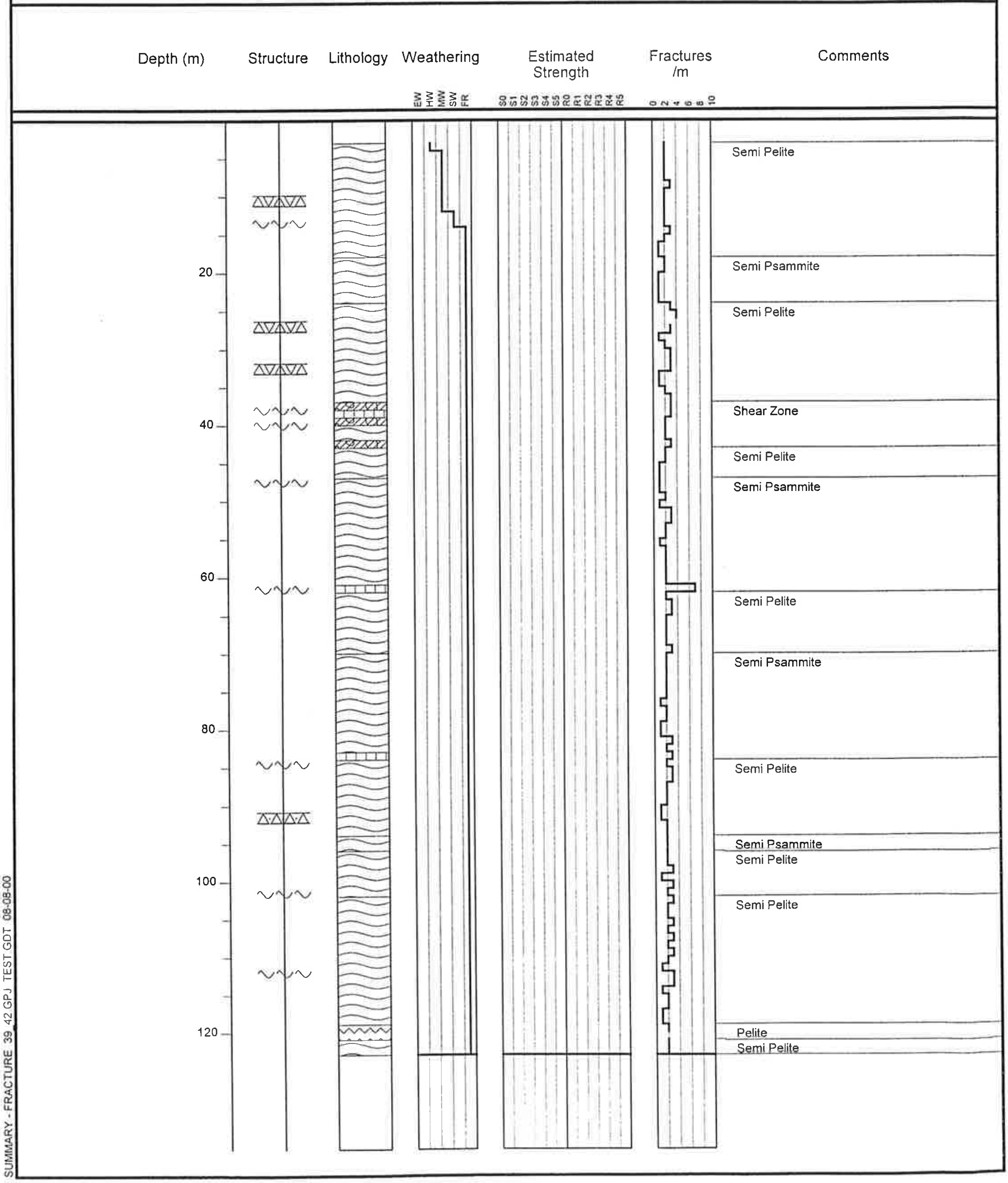
Summary Borehole Log

Hole No: DDH39

job no: PSM071
client: GRD Macraes Ltd
project: Deep Dell Stage 1 Pit Design
drilling subcontractor:
date hole commenced:
date hole complete:

drill information:
borehole location:
inclination/azimuth: -90° /
surface R.L.:
datum: Mine
core diameter:

Logged by:



SUMMARY - FRACTURE 39 42 GPJ TEST GDT 08-08-00

PSM

Pells Sullivan Meynink Pty Ltd

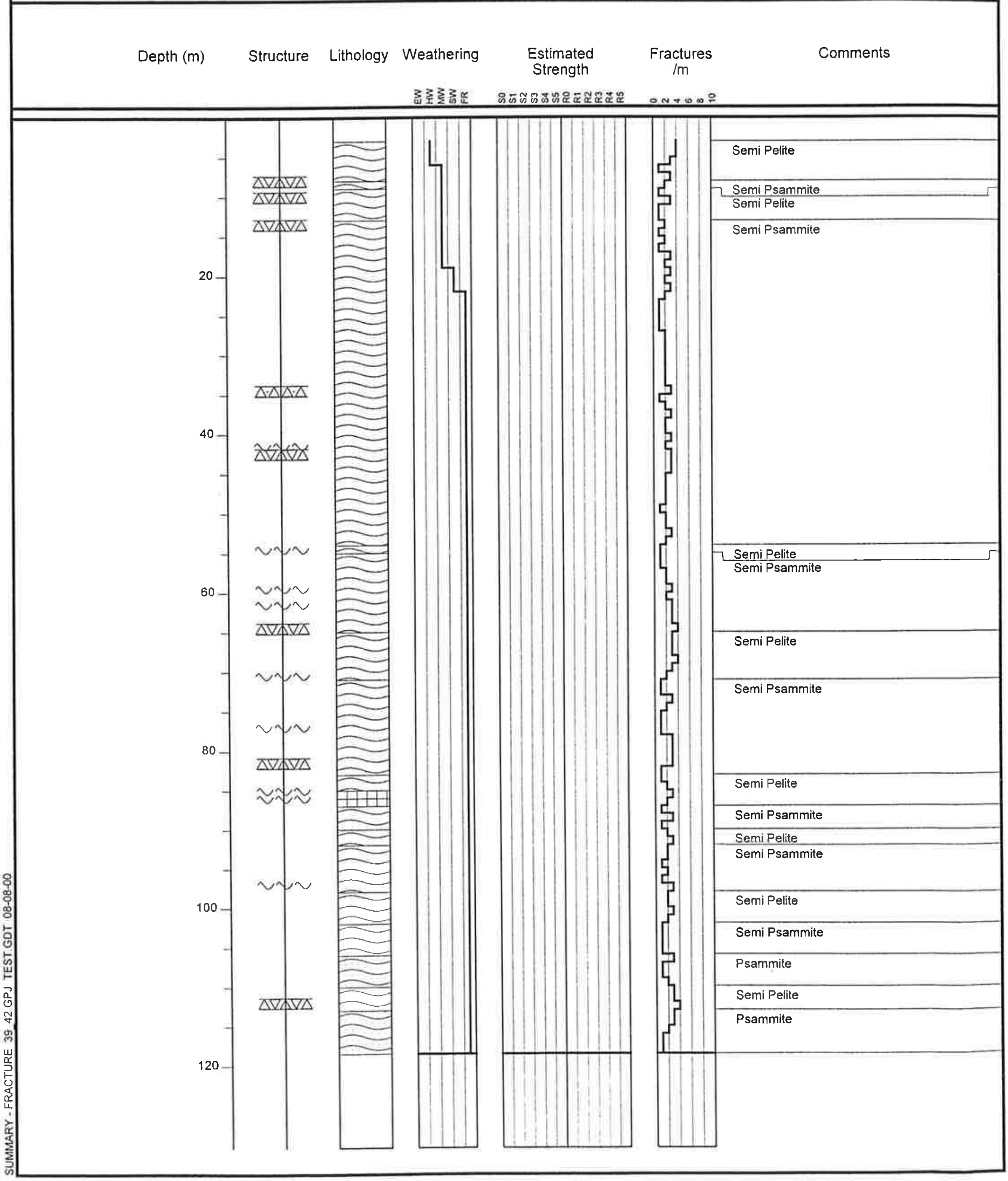
Engineering Consultants
Rock-Soil-Water

A.C.N. 061447621

Summary Borehole Log

Hole No: DDH42

job no: PSM071	**drill information:**	**Logged by:**
client: GRD Macraes Ltd	**borehole location:**	
project: Deep Dell Stage 1 Pit Design	**inclination/azimuth:** -90° /	
drilling subcontractor:	**surface R.L.:**	
date hole commenced:	**datum:** Mine	
date hole complete:	**core diameter:**	



SUMMARY - FRACTURE 39 42 GPJ TEST GDT 08-08-00

PSM

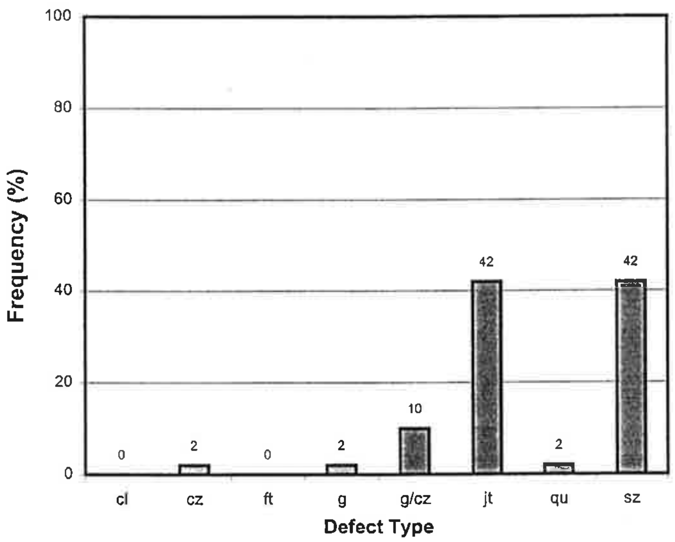
GRD Macraes Ltd

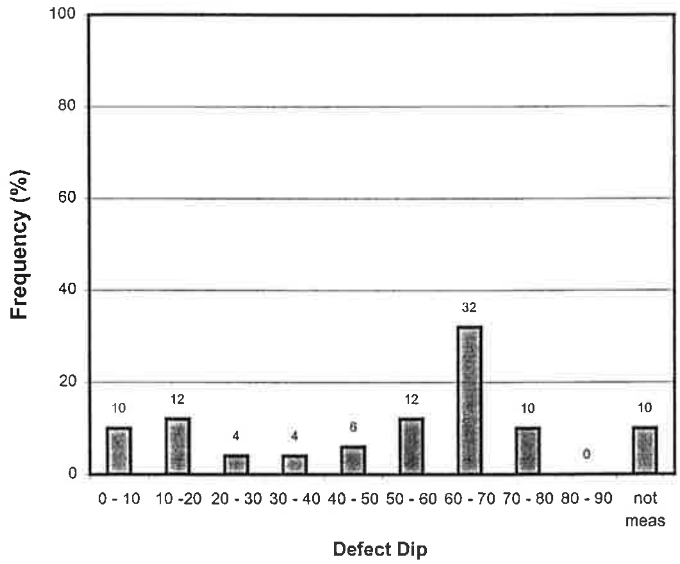
Geotechnical Boreholes
Data Histograms

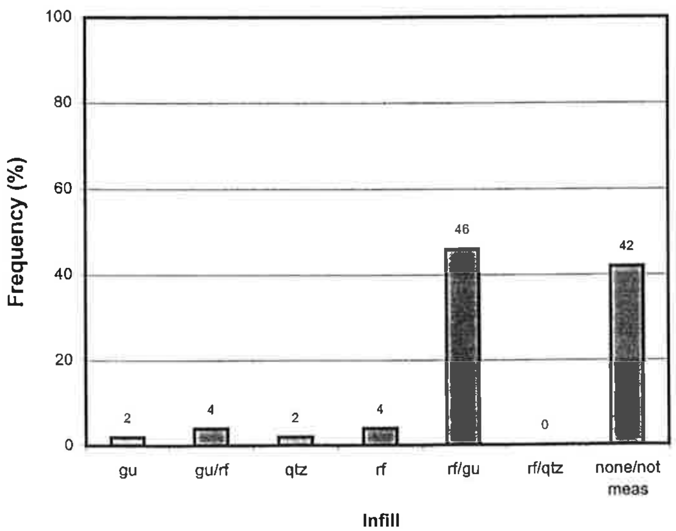
DDH39

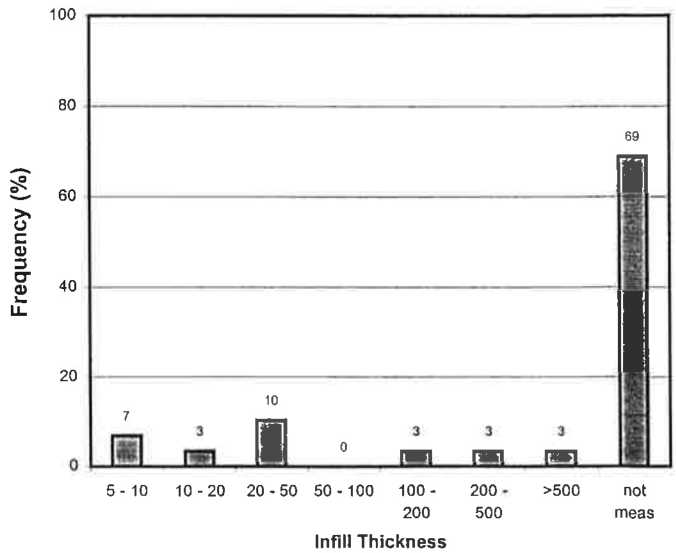
project:	Deepdell Stage 1 Pit Design	datum:	assumed
location:	Deepdell	date:	08-Aug-00

Data records **50** **Lithology:** All **Borehole** DDH39 **Type Defect:** All









PSM

GRD Macraes Ltd

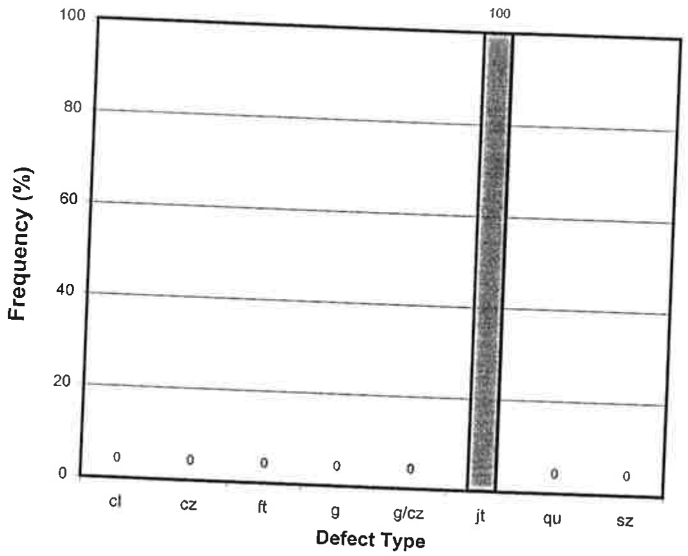
Geotechnical Boreholes Data Histograms

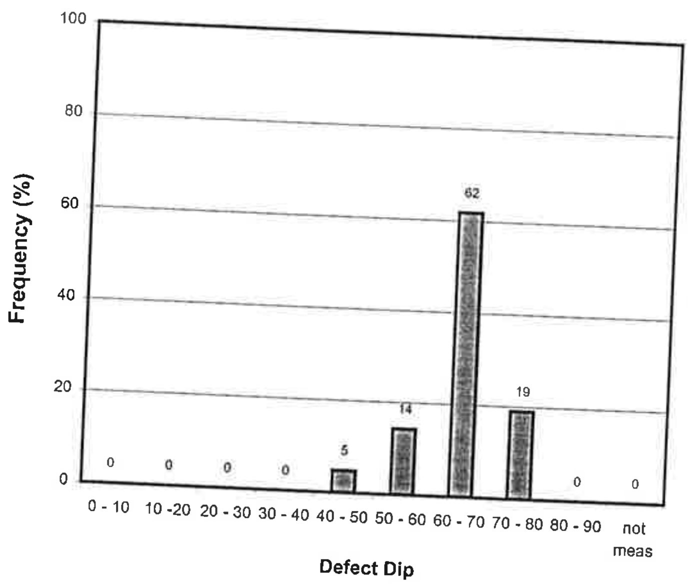
DDH39

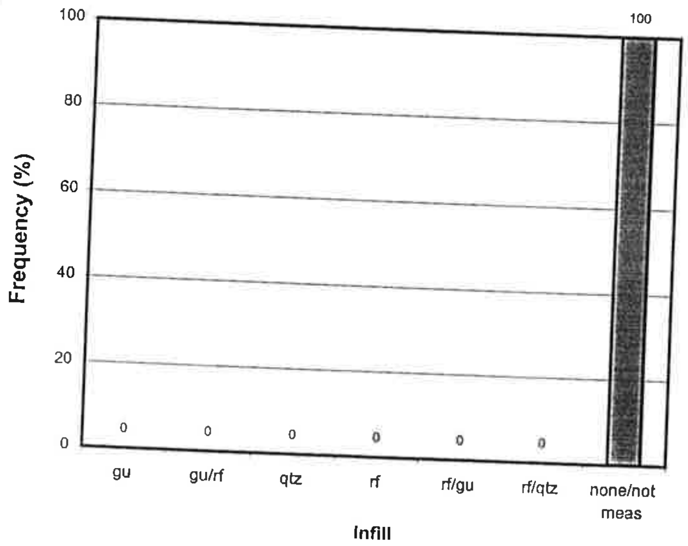
project: Deepdell Stage 1 Pit Design
location: Deepdell

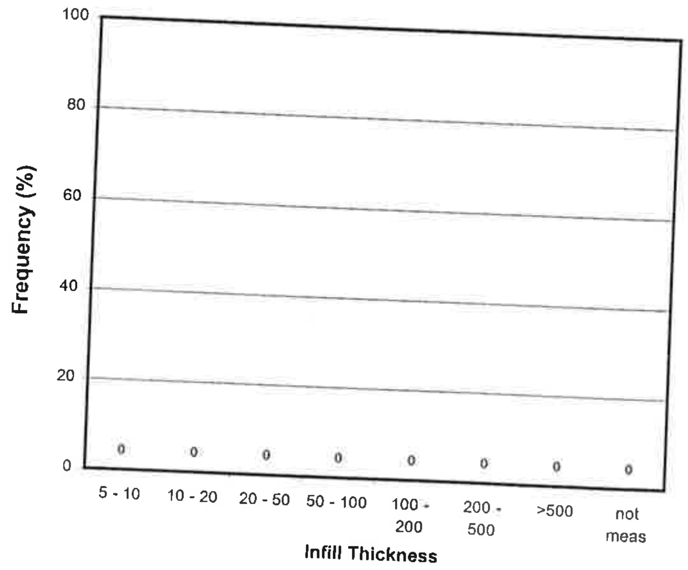
datum: assumed
date: 08-Aug-00

Data records 21 **Lithology:** All **Borehole** DDH39 **Type Defect:** Joints









PSM

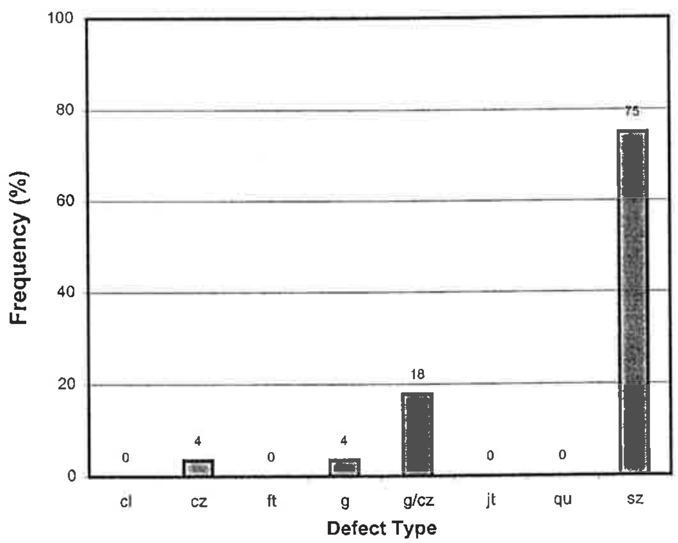
GRD Macraes Ltd

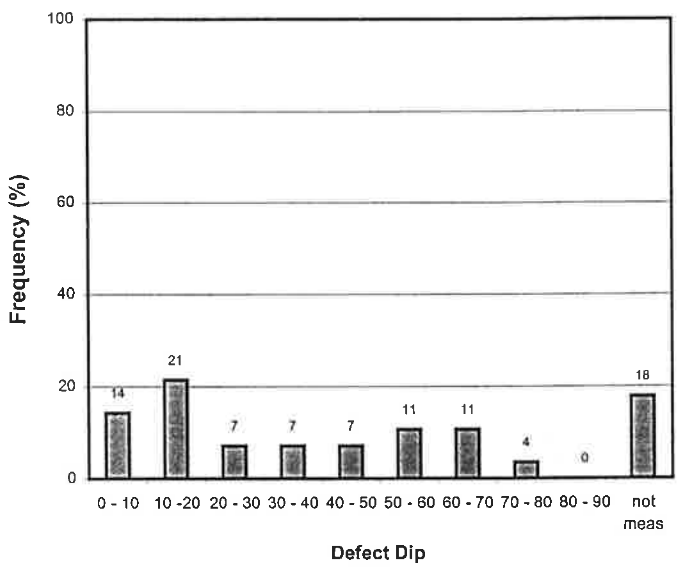
Geotechnical Boreholes Data Histograms

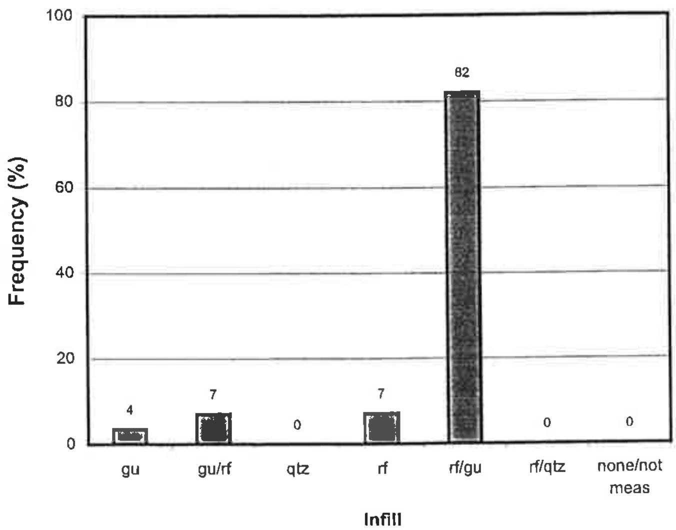
DDH39

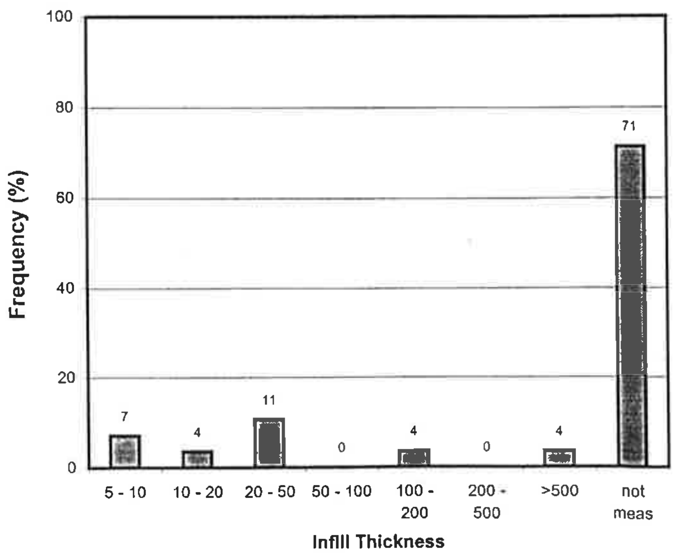
project:	Deepdell Stage 1 Pit Design	datum:	assumed
location:	Deepdell	date:	08-Aug-00

Data records 28 **Lithology:** All **Borehole** DDH39 **Type Defect:** Gouge, crush zones etc









PSM

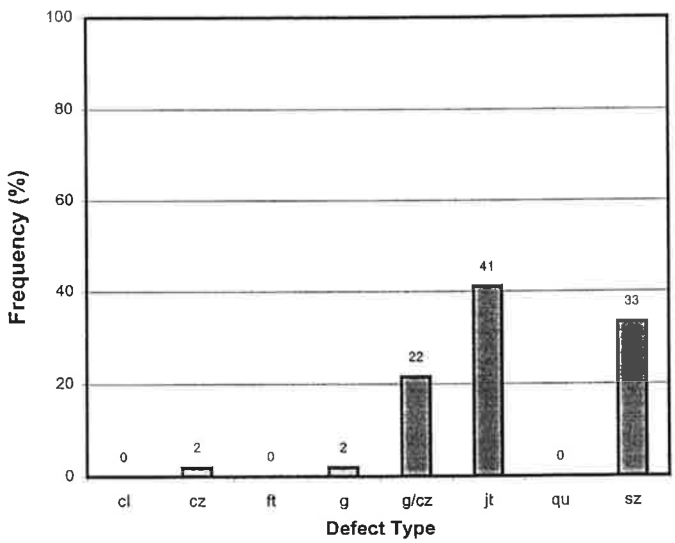
GRD Macraes Ltd

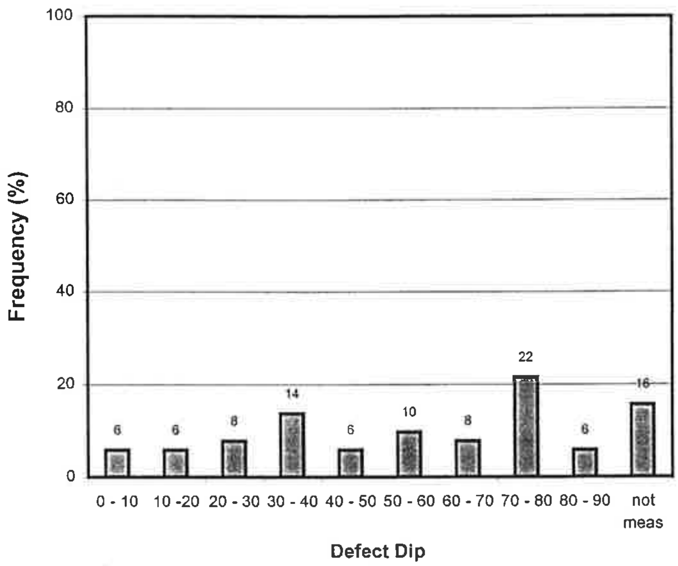
Geotechnical Boreholes
Data Histograms

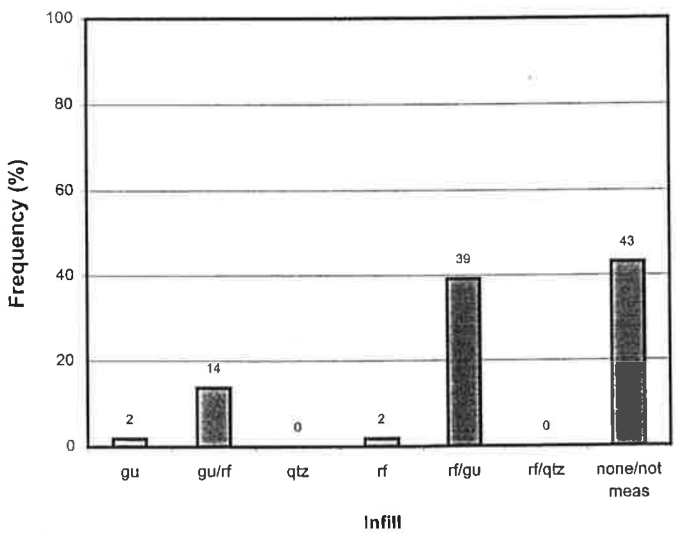
DDH42

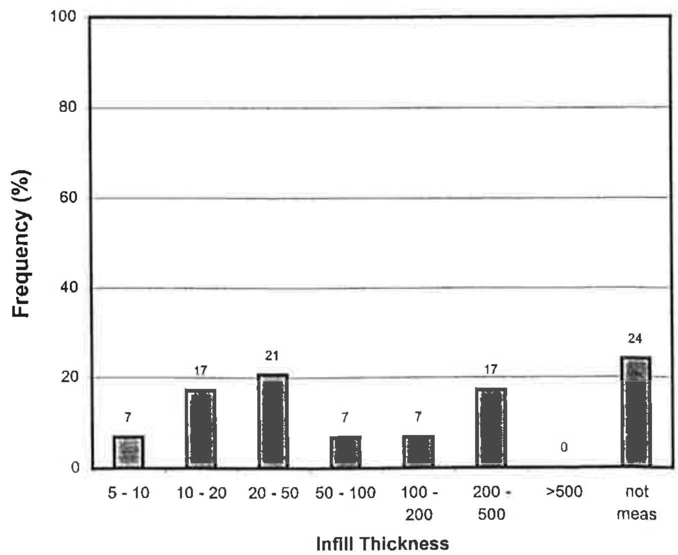
project:	Deepdell Stage 1 Pit Design	datum:	assumed
location:	Deepdell	date:	08-Aug-00

Data records 51 **Lithology:** All **Borehole** DDH42 **Type Defect:**









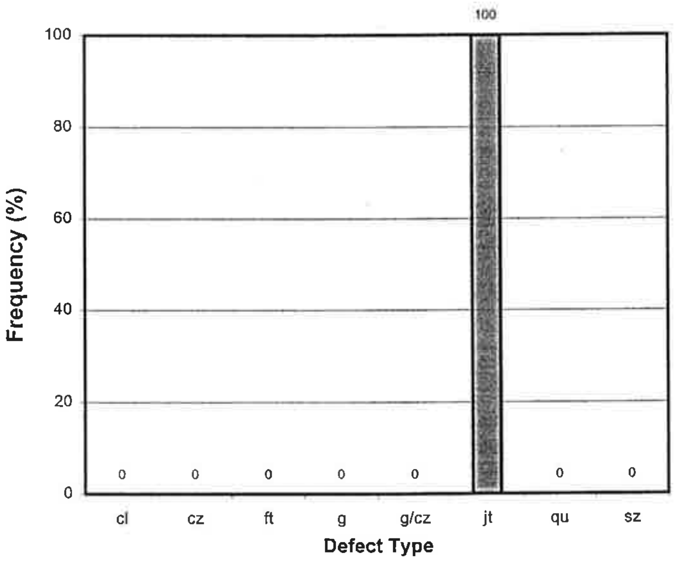
GRD Macraes Ltd

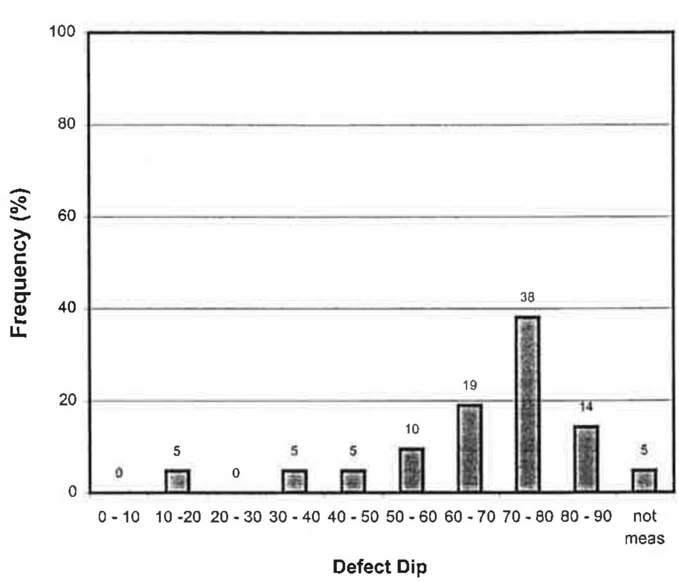
Geotechnical Boreholes
Data Histograms

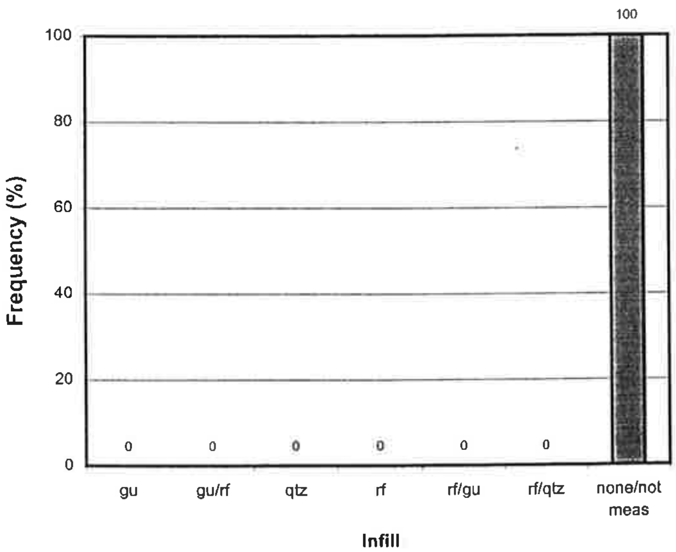
DDH42

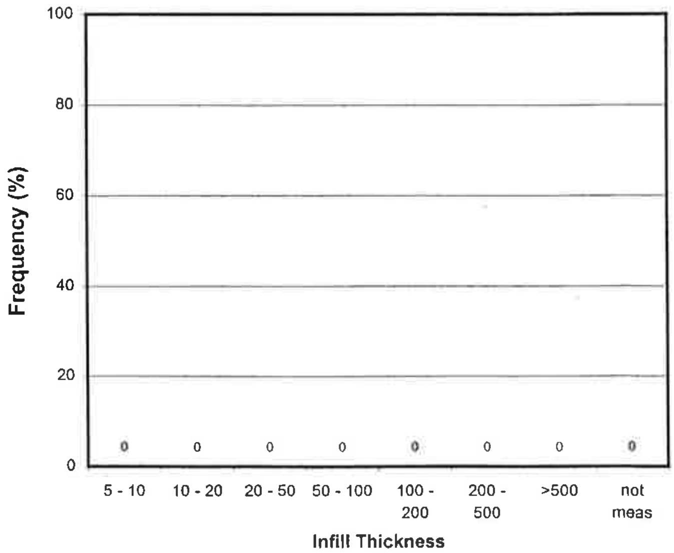
project:	Deepdell Stage 1 Pit Design	datum:	assumed
location:	Deepdell	date:	08-Aug-00

Data records 21 **Lithology:** All **Borehole** DDH42 **Type Defect:** Joints









PSM

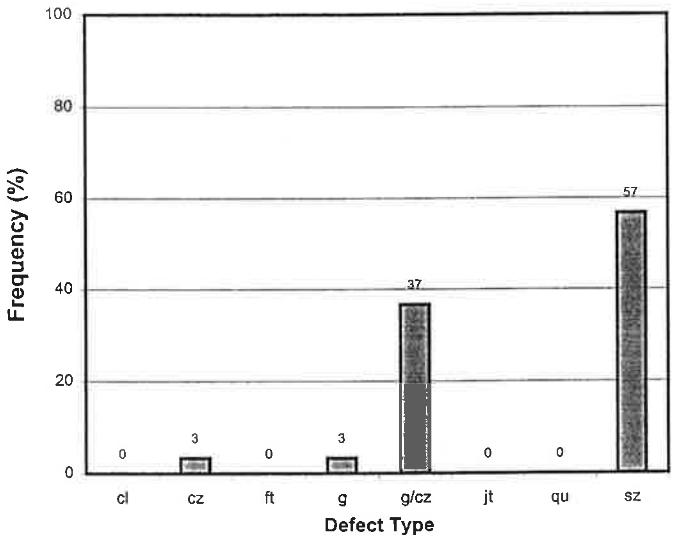
GRD Macraes Ltd

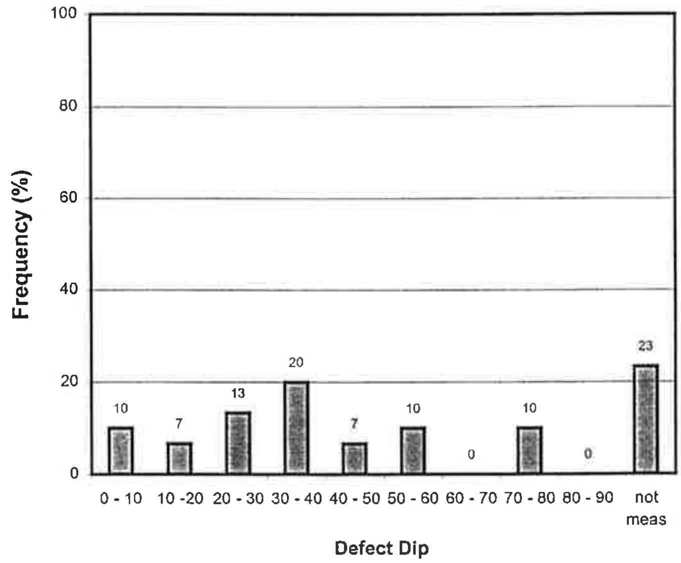
Geotechnical Boreholes
Data Histograms

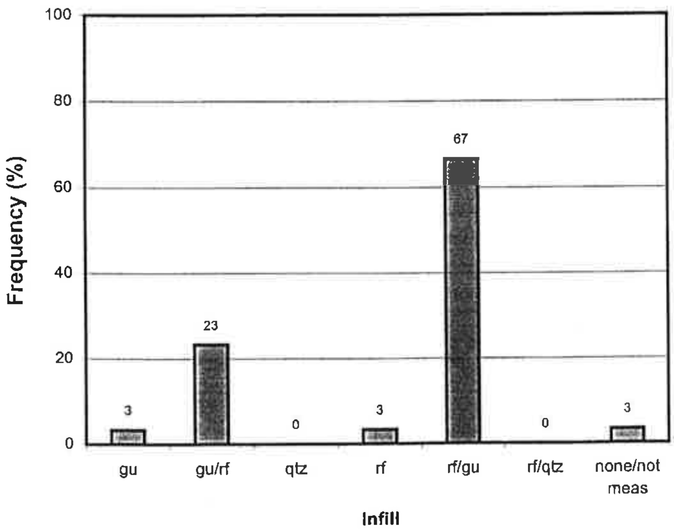
DDH42

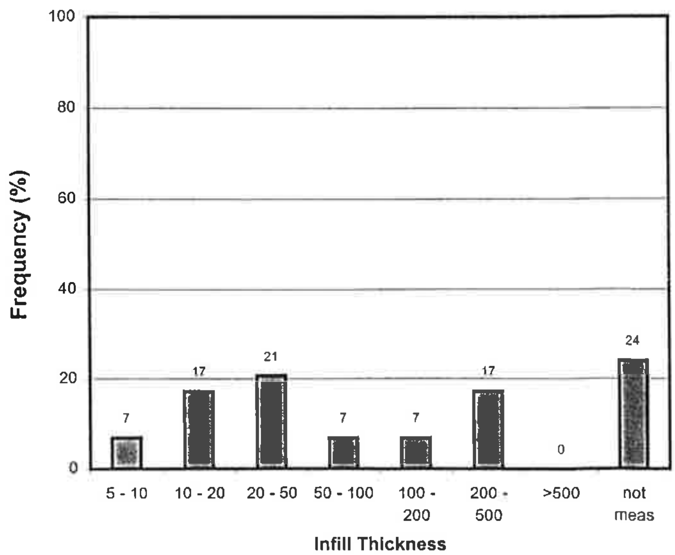
project:	Deepdell Stage 1 Pit Design	datum:	assumed
location:	Deepdell	date:	08-Aug-00

Data records	30	**Lithology:**	All	**Borehole**	DDH42	**Type Defect:**	Gouge, crush zones etc









PSM

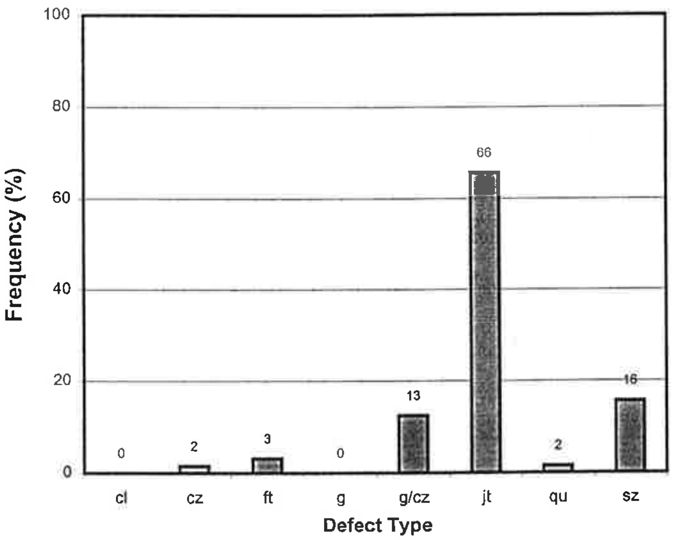
GRD Macraes Ltd

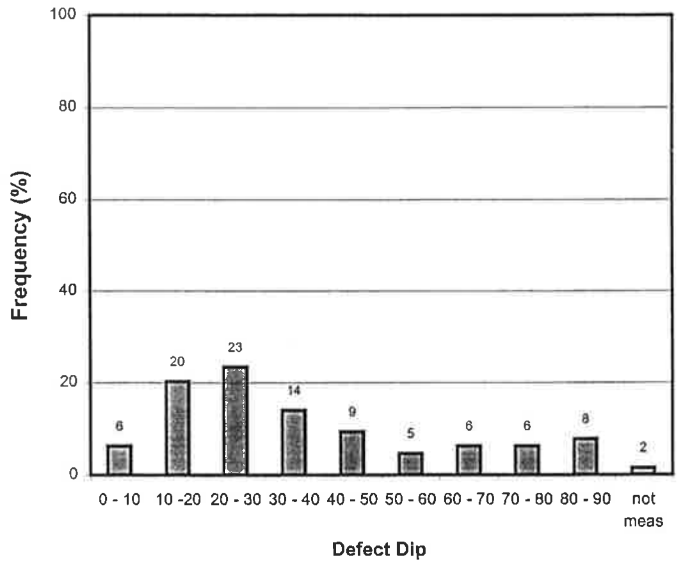
Geotechnical Boreholes
Data Histograms

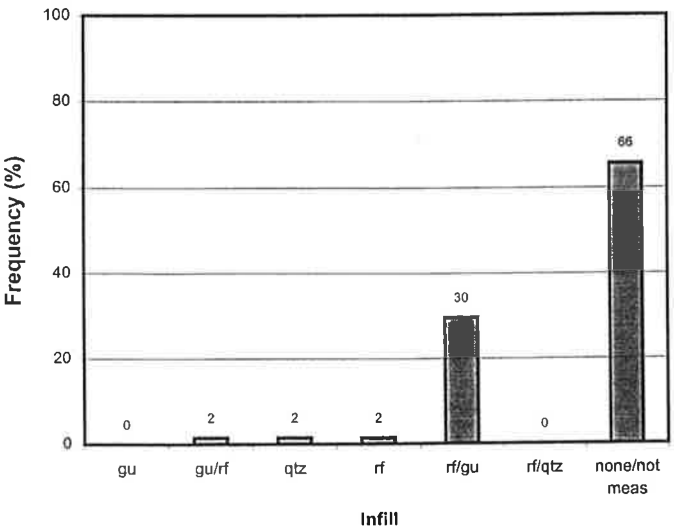
DDH43

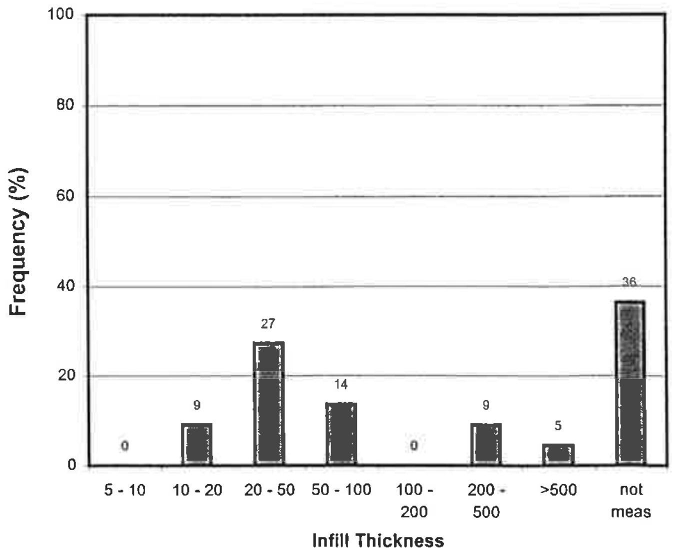
project: Deepdell Stage 1 Pit Design
location: Deepdell
datum: assumed
date: 08-Aug-00

Data records 64 **Lithology:** All **Borehole** DDH43 **Type Defect:** All









PSM

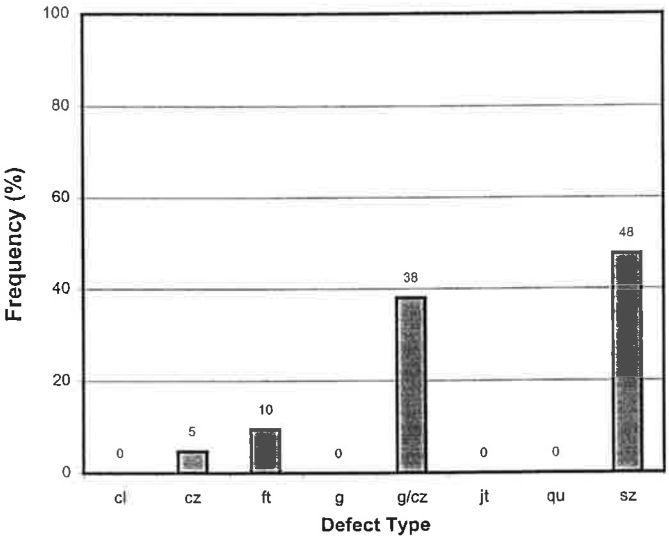
GRD Macraes Ltd

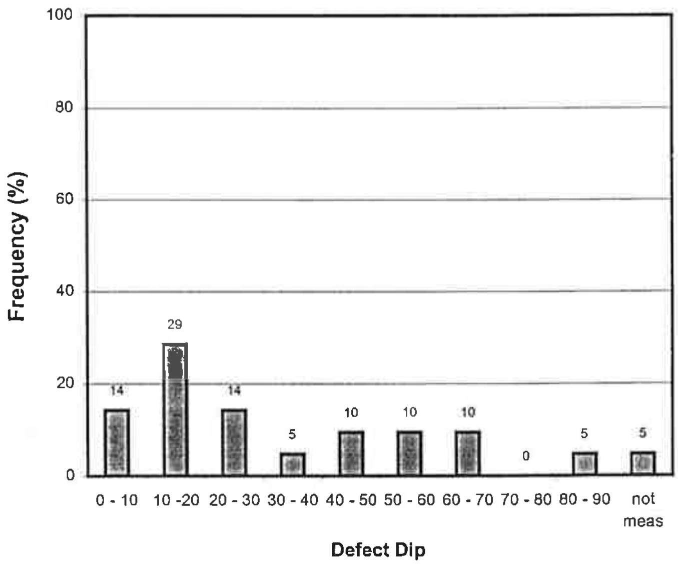
Geotechnical Boreholes Data Histograms

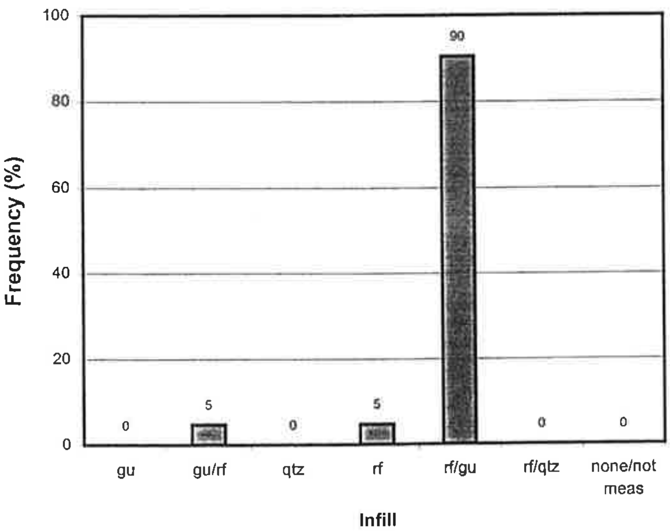
DDH43

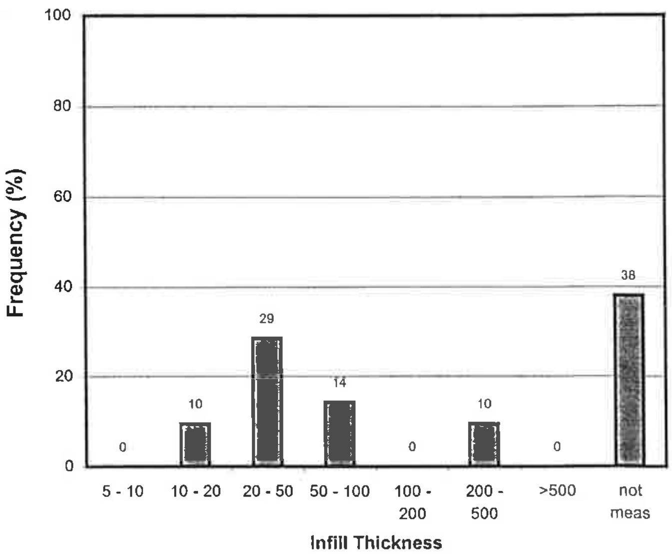
project:	Deepdell Stage 1 Pit Design	datum:	assumed
location:	Deepdell	date:	08-Aug-00

Data records **21** **Lithology:** All **Borehole** DDH43 **Type Defect:** Gouge, shear zones etc









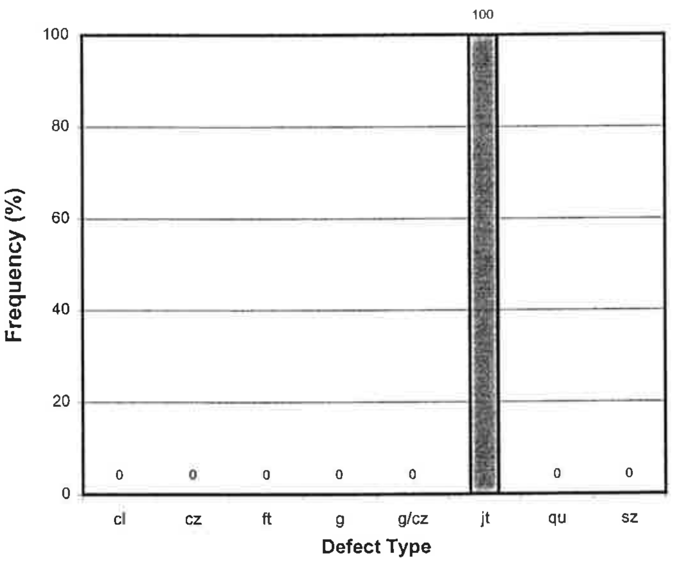
GRD Macraes Ltd

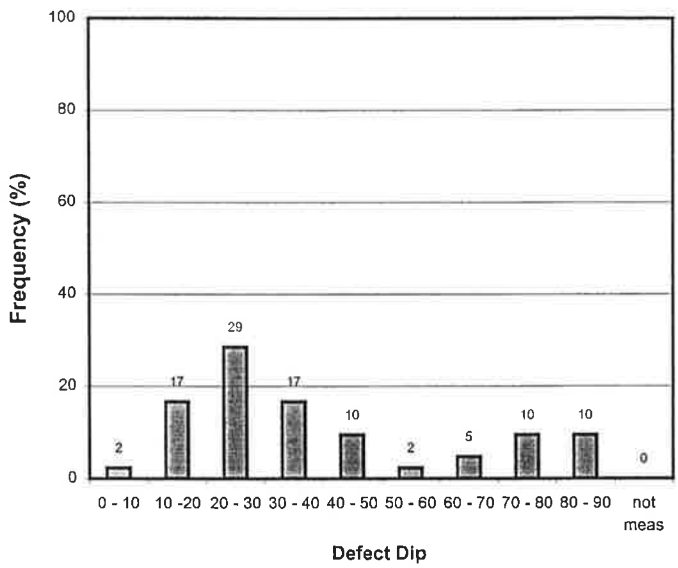
Geotechnical Boreholes
Data Histograms

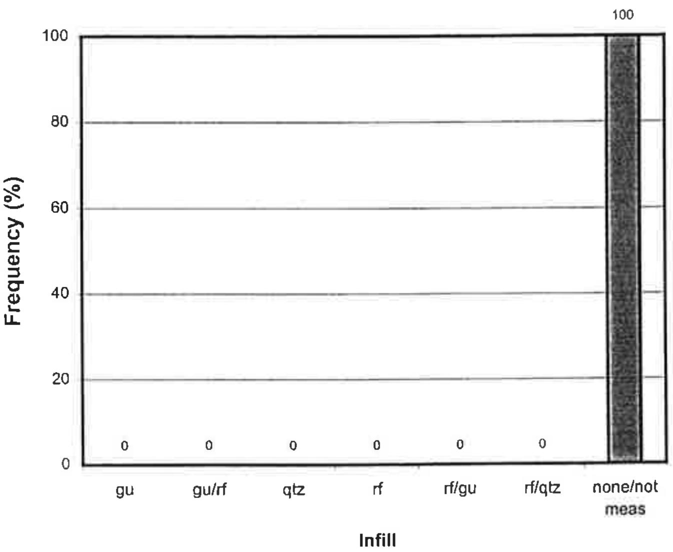
DDH43

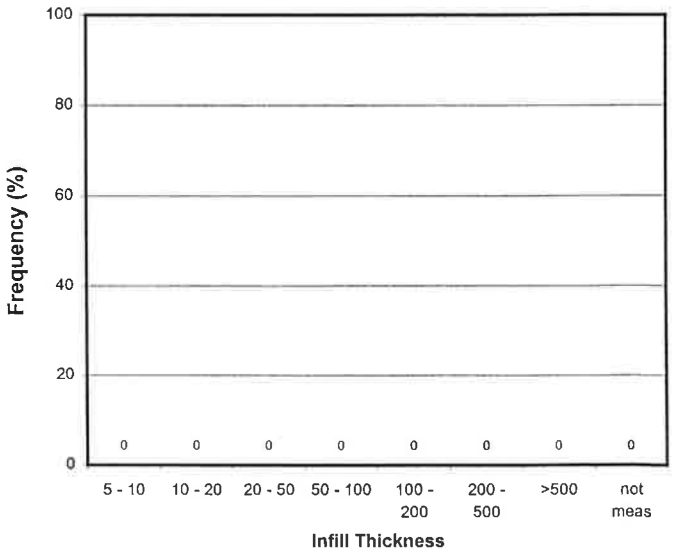
project:	Deepdell Stage 1 Pit Design	datum:	assumed
location:	Deepdell	date:	08-Aug-00

Data records 42 **Lithology:** All **Borehole** DDH43 **Type Defect:** Joints









PSM

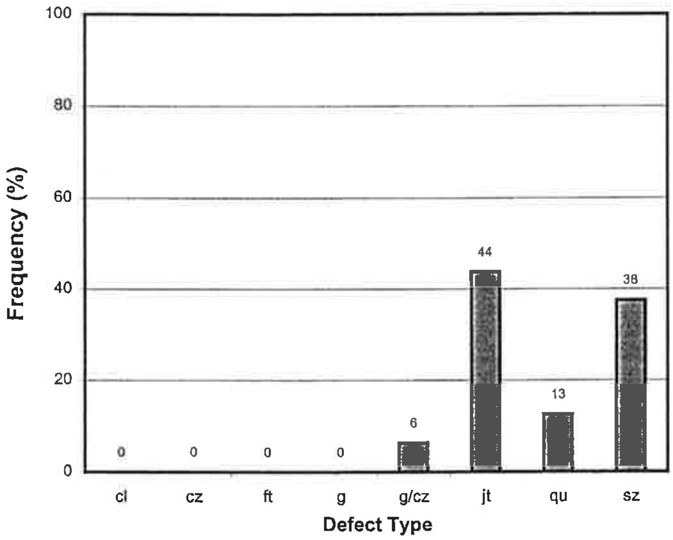
GRD Macraes Ltd

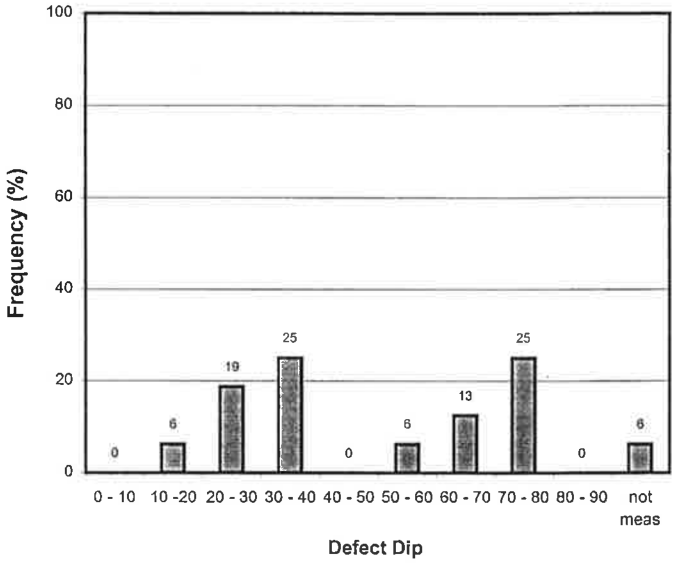
Geotechnical Boreholes Data Histograms

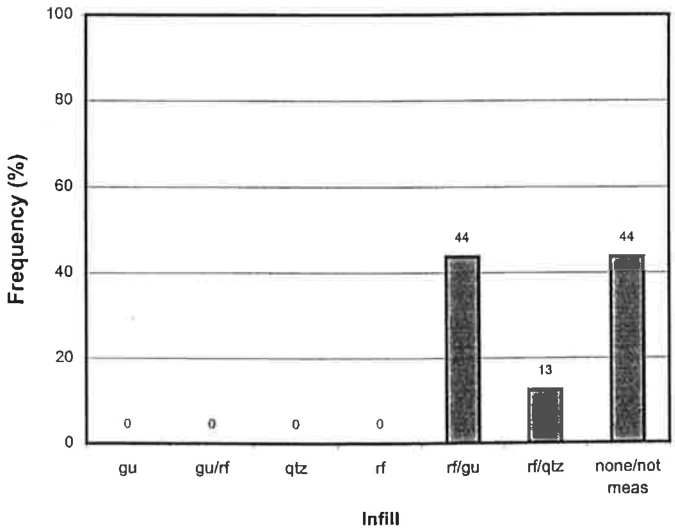
DDH104

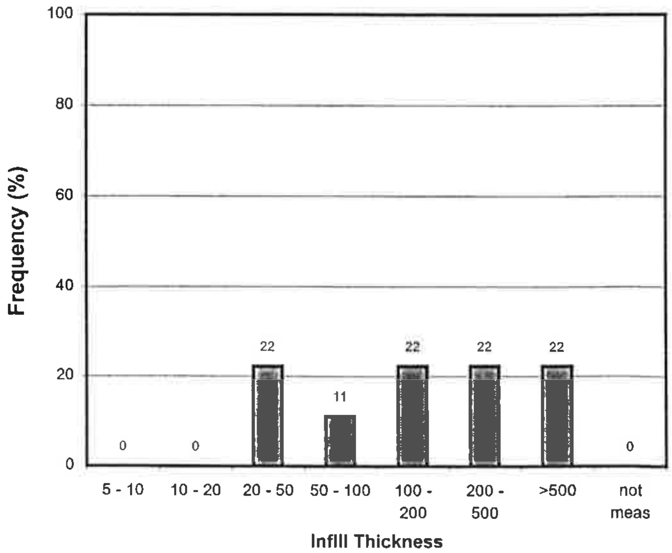
project:	Deepdell Stage 1 Pit Design	datum:	assumed
location:	Deepdell	date:	08-Aug-00

Data records 16 **Lithology:** All **Borehole** DDH104 **Type Defect:** All









PSM

GRD Macraes Ltd

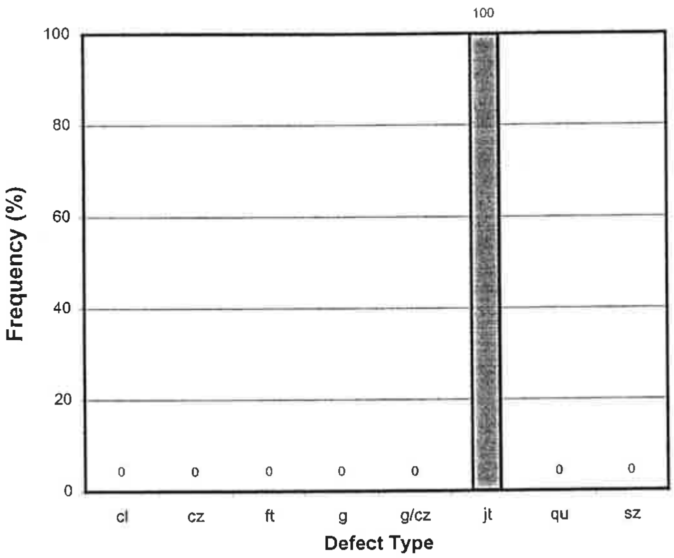
Geotechnical Boreholes
Data Histograms

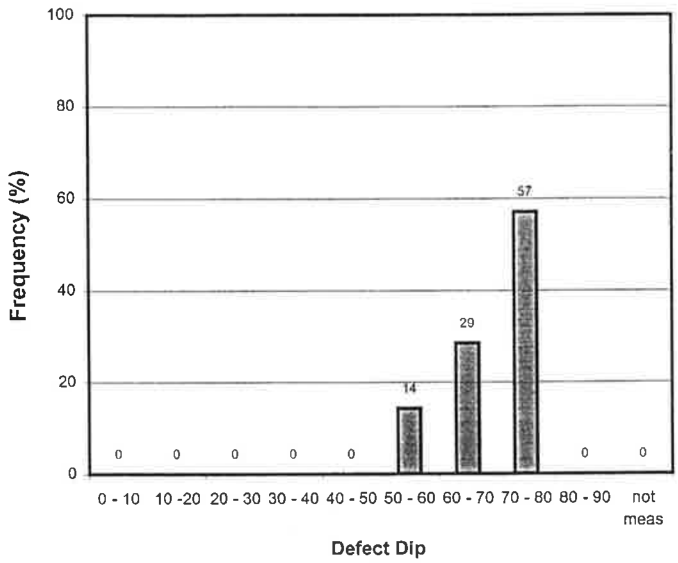
DDH104

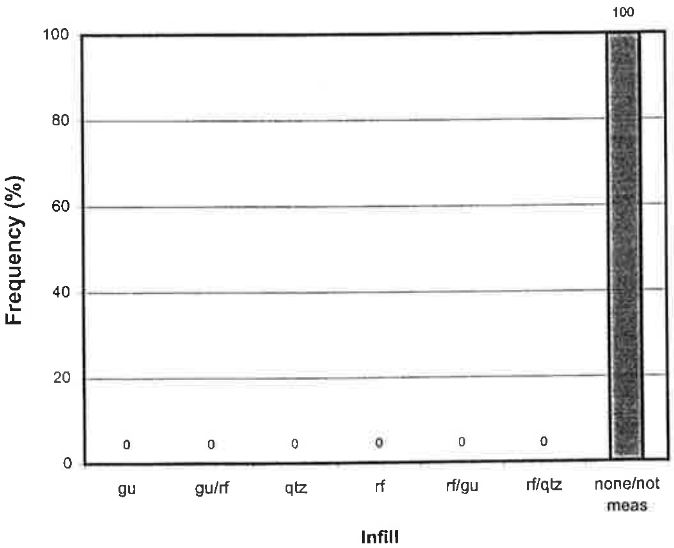
project: Deepdell Stage 1 Pit Design
location: Deepdell

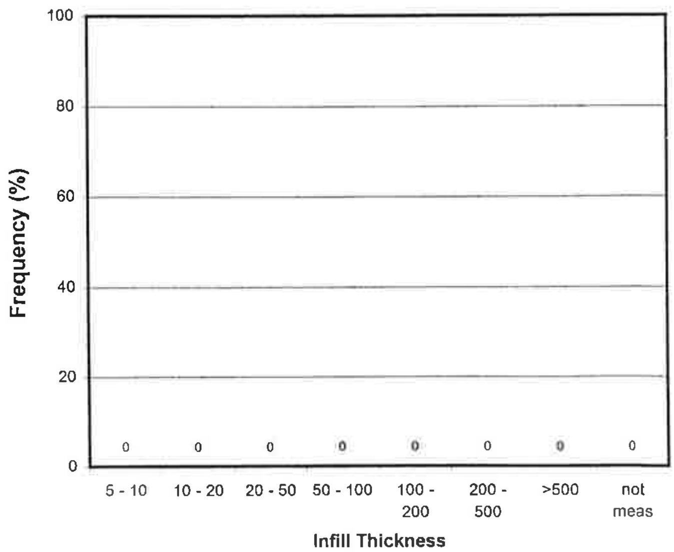
datum: assumed
date: 08-Aug-00

Data records 7 **Lithology:** All **Borehole** DDH104 **Type Defect:** Joints









PSM

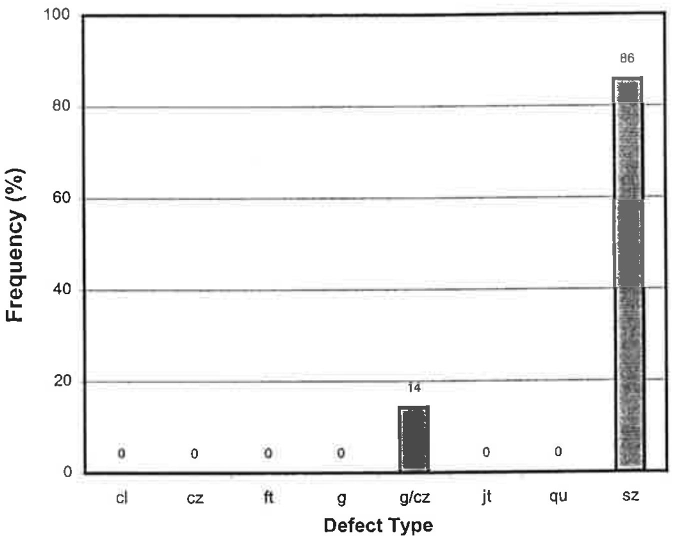
GRD Macraes Ltd

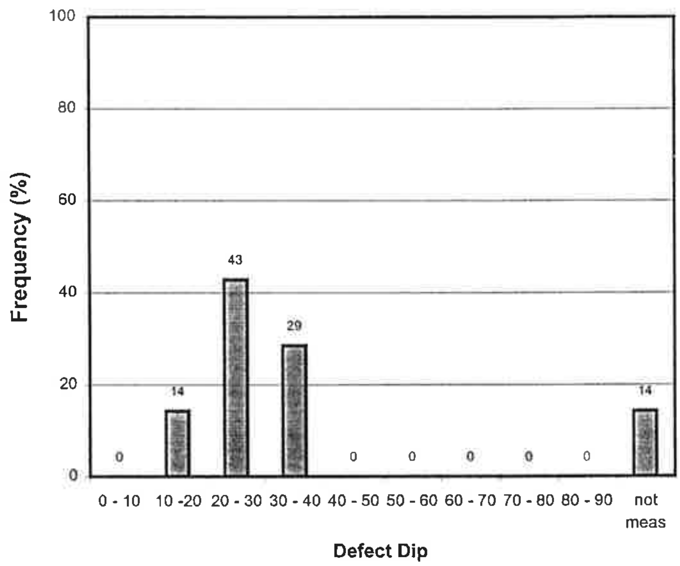
Geotechnical Boreholes
Data Histograms

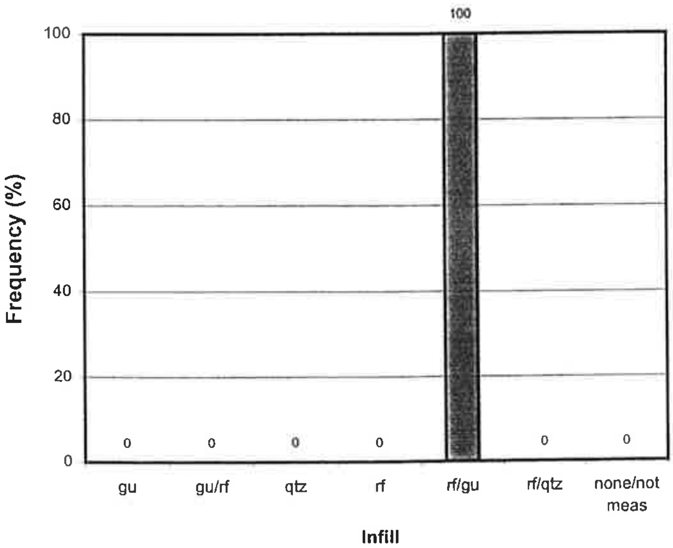
DDH104

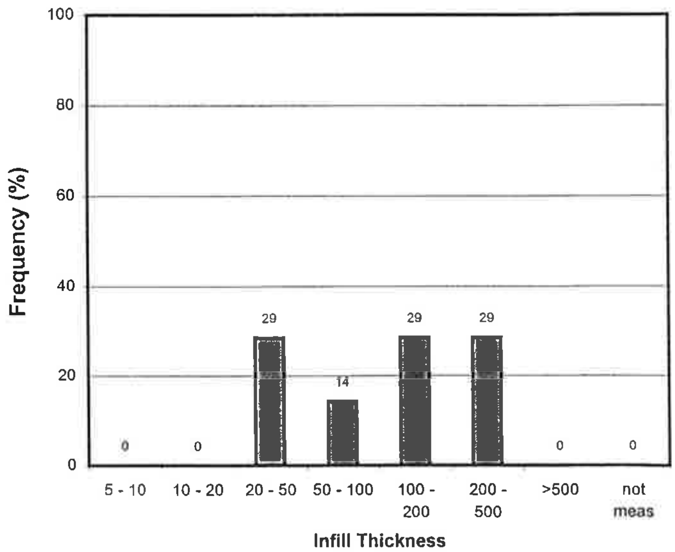
project:	Deepdell Stage 1 Pit Design	datum:	assumed
location:	Deepdell	date:	08-Aug-00

Data records	7	**Lithology:**	All	**Borehole**	DDH104	**Type Defect:**	Gouge, shear zones etc









PSM

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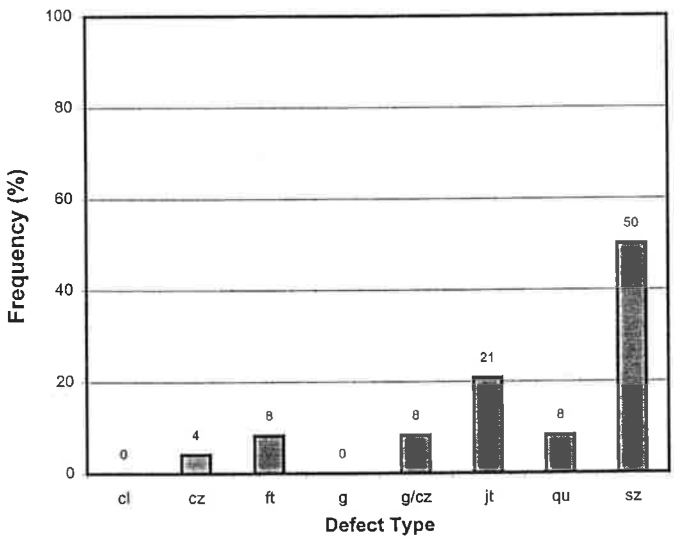
Geotechnical Boreholes Data Histograms

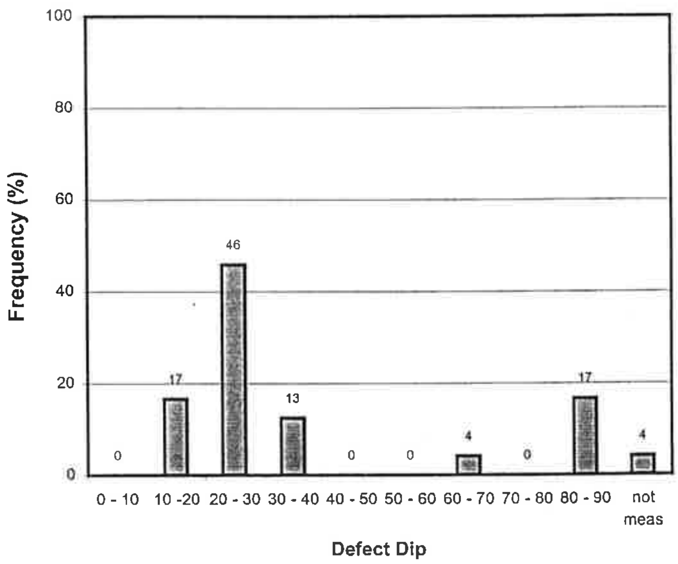
DDH105

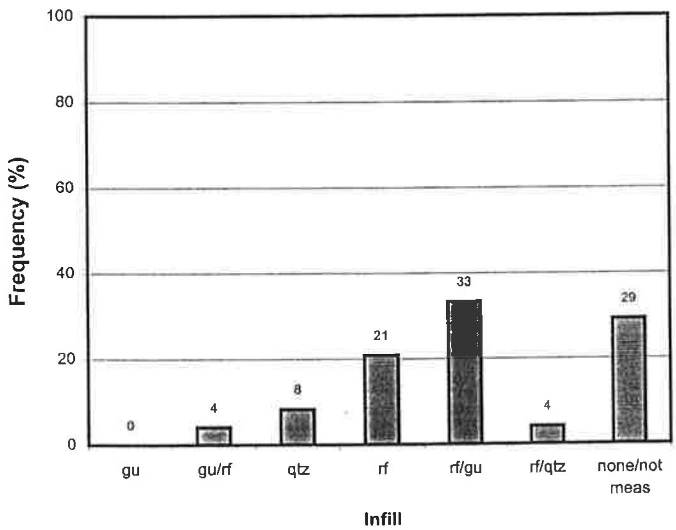
project: Deepdell Stage 1 Pit Design
location: Deepdell

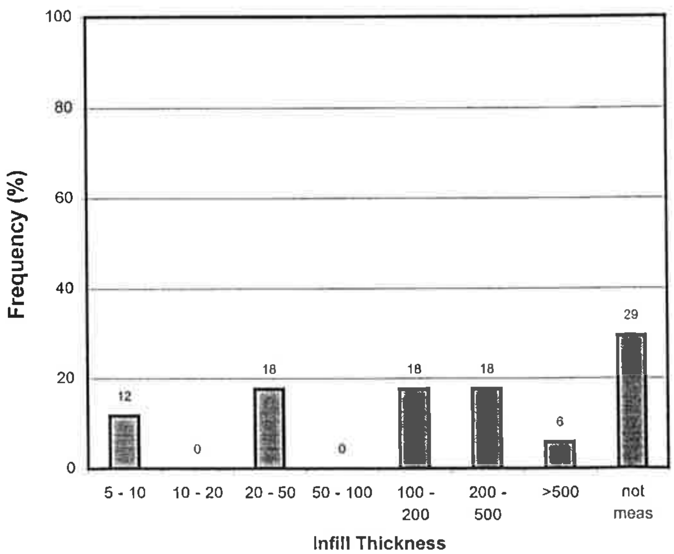
datum: assumed
date: 08-Aug-00

Data records **24** **Lithology:** All **Borehole** DDH105 **Type Defect:** All









PSM

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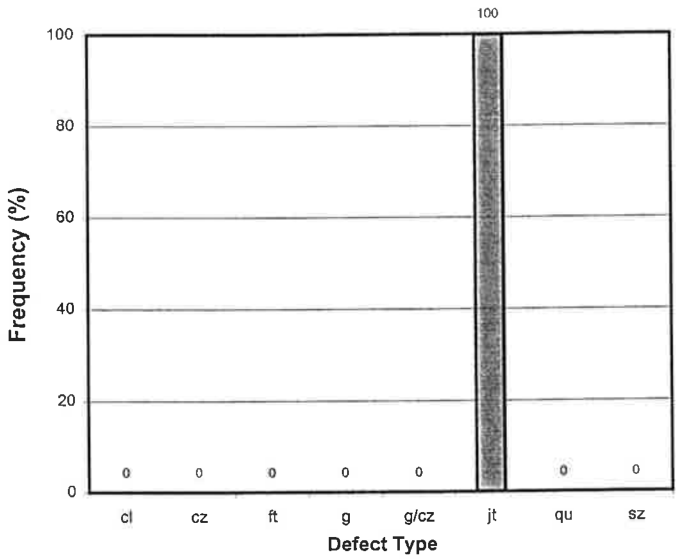
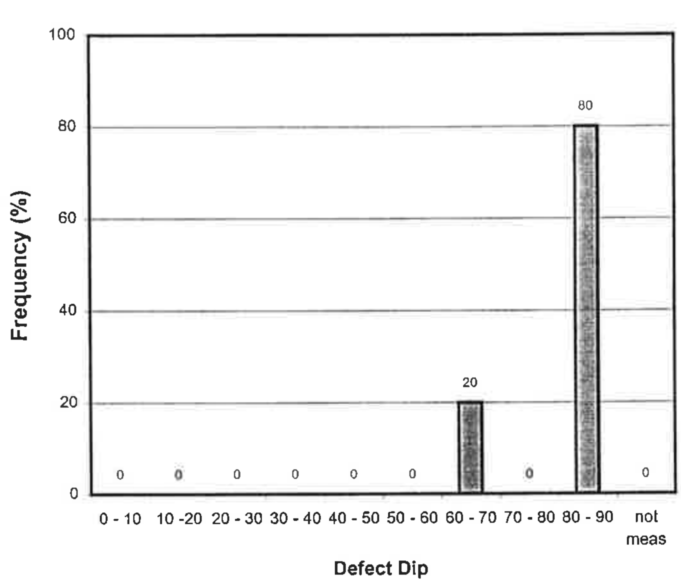
Geotechnical Boreholes
Data Histograms

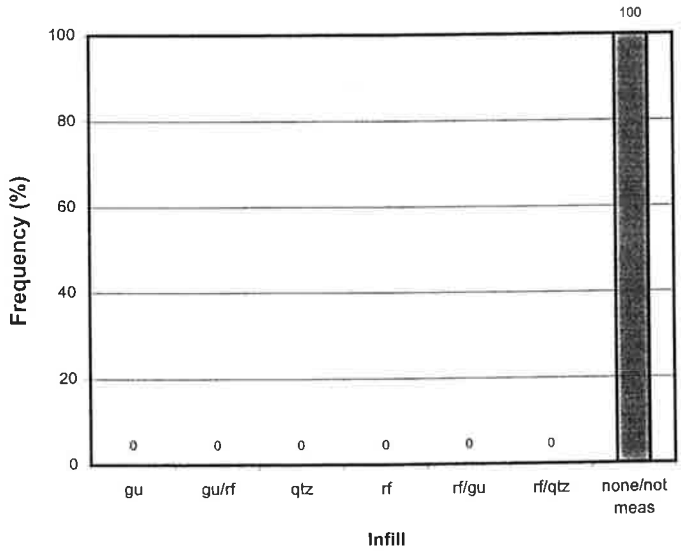
DDH105

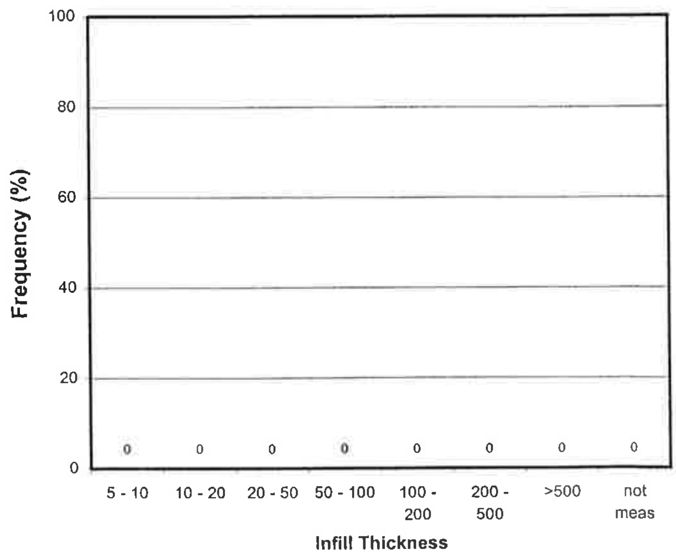
project:	Deepdell Stage 1 Pit Design	datum:	assumed
location:	Deepdell	date:	08-Aug-00

Data records 5 **Lithology:** All **Borehole** DDH105 **Type Defect:** Joints









GRD Macraes Ltd

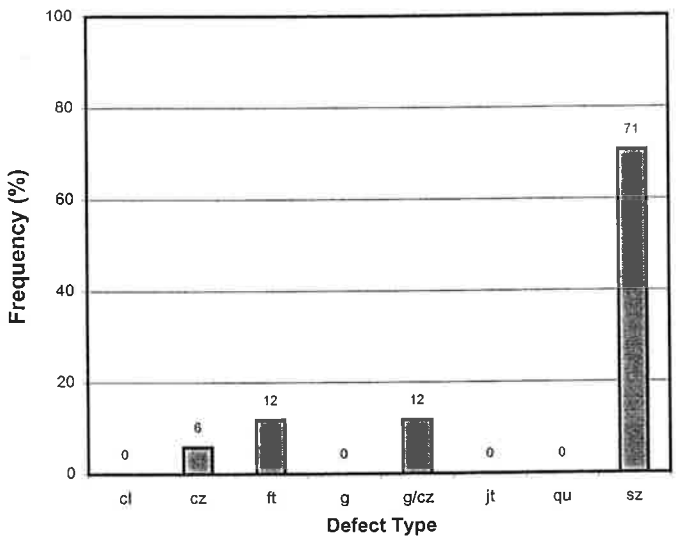
Geotechnical Boreholes
Data Histograms

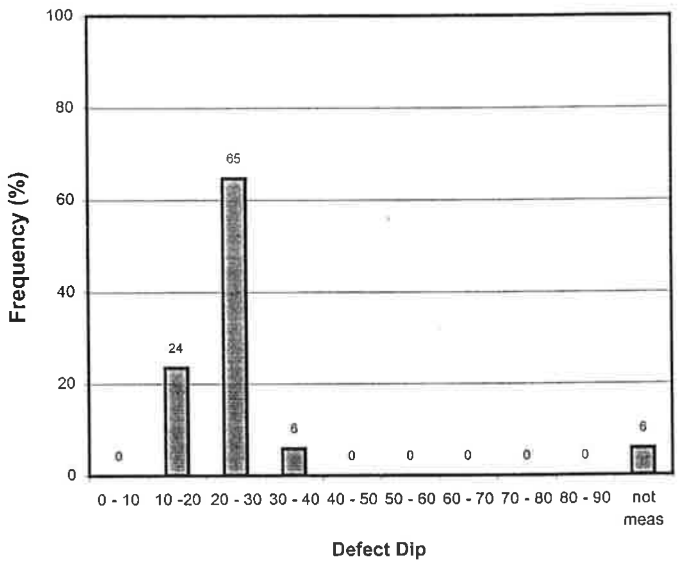
DDH105

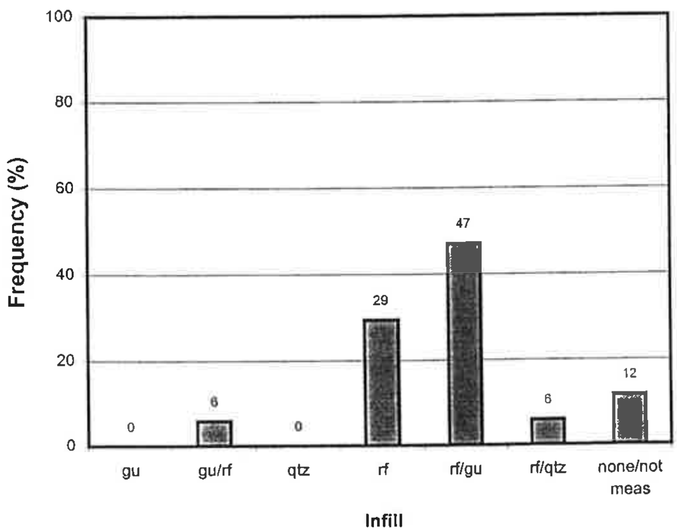
project: Deepdell Stage 1 Pit Design
location: Deepdell

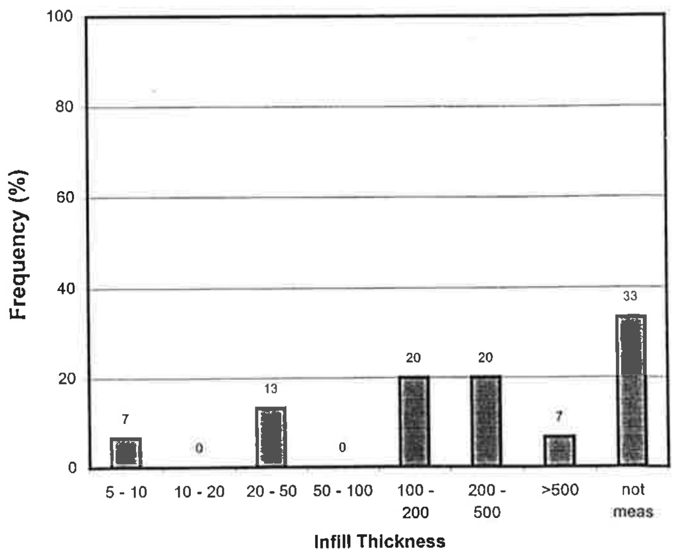
datum: assumed
date: 08-Aug-00

Data records 17 **Lithology:** All **Borehole** DDH105 **Type Defect:** Gouge, shear zones etc









PSM

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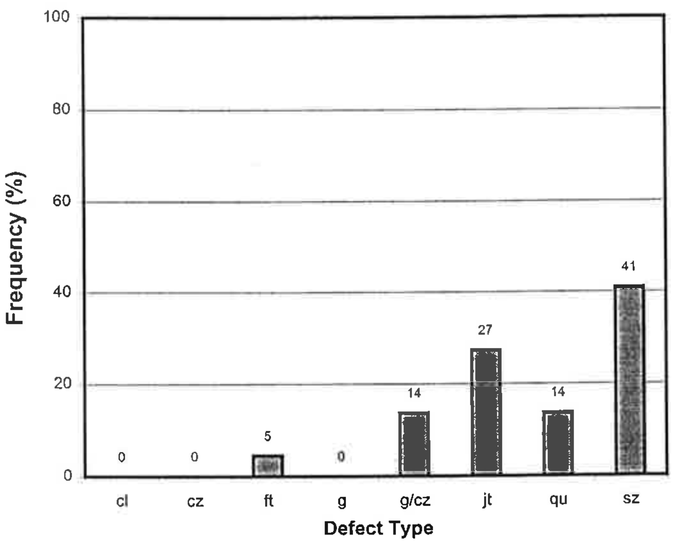
Geotechnical Boreholes Data Histograms

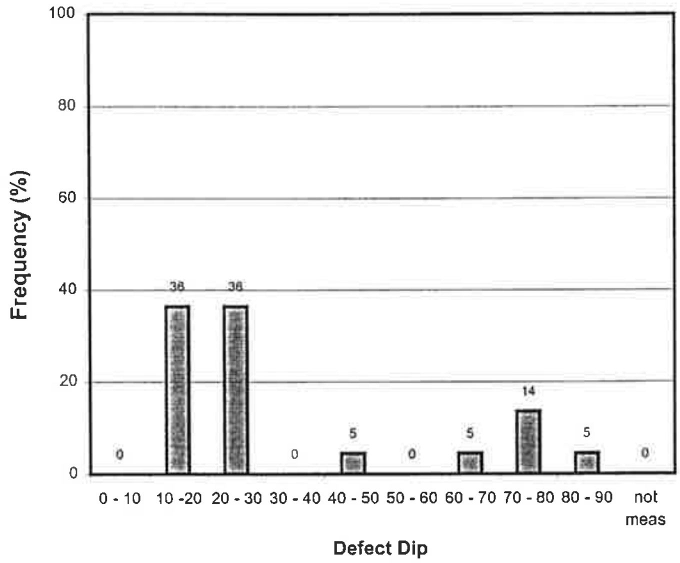
DDH107

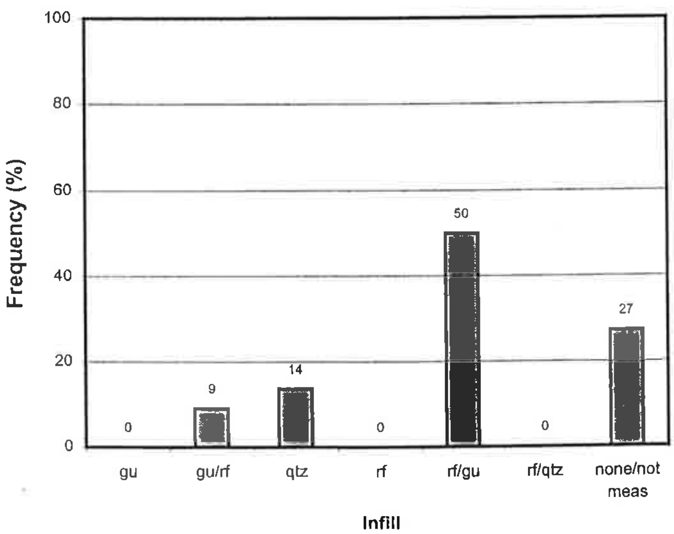
project: Deepdell Stage 1 Pit Design
location: Deepdell

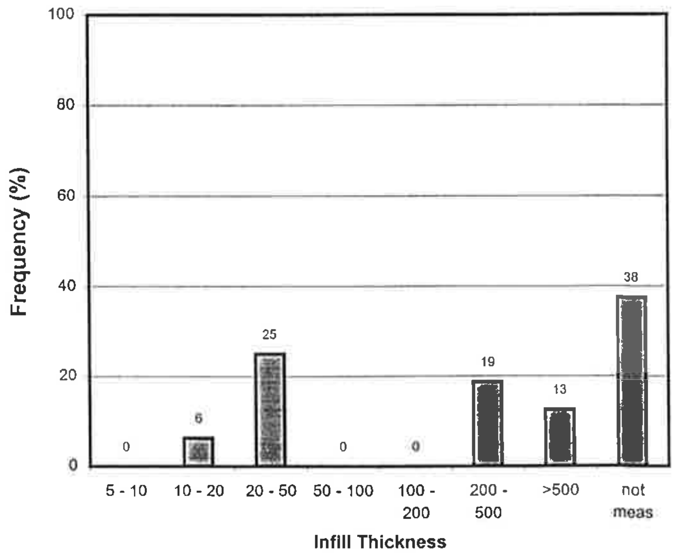
datum: assumed
date: 09-Aug-00

Data records **22** **Lithology:** All **Borehole** DDH107 **Type Defect:** All









PSM

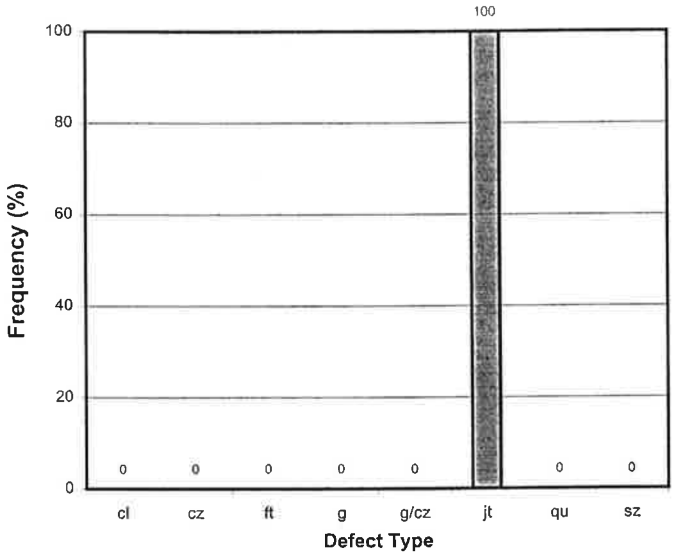
GRD Macraes Ltd

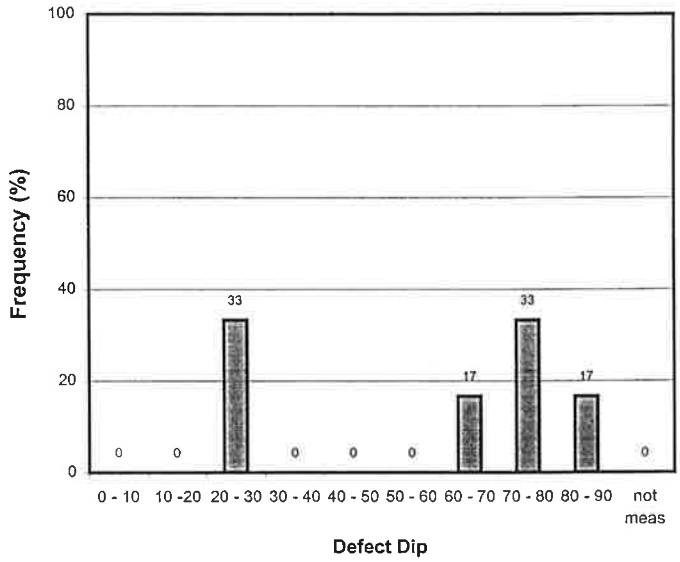
Geotechnical Boreholes
Data Histograms

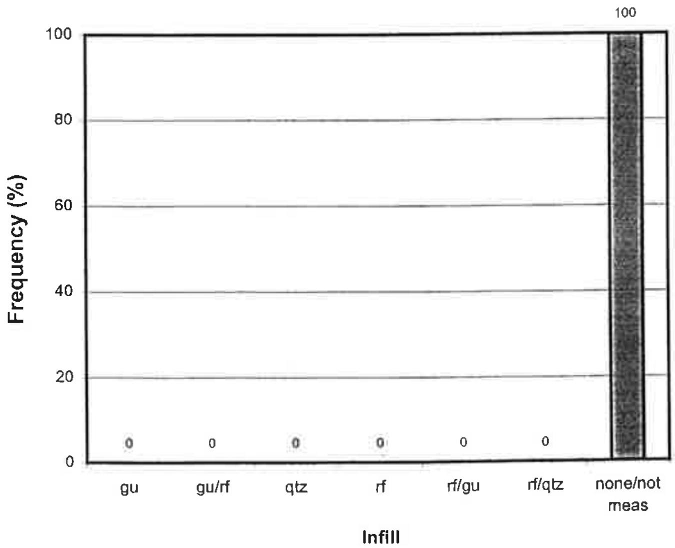
DDH107

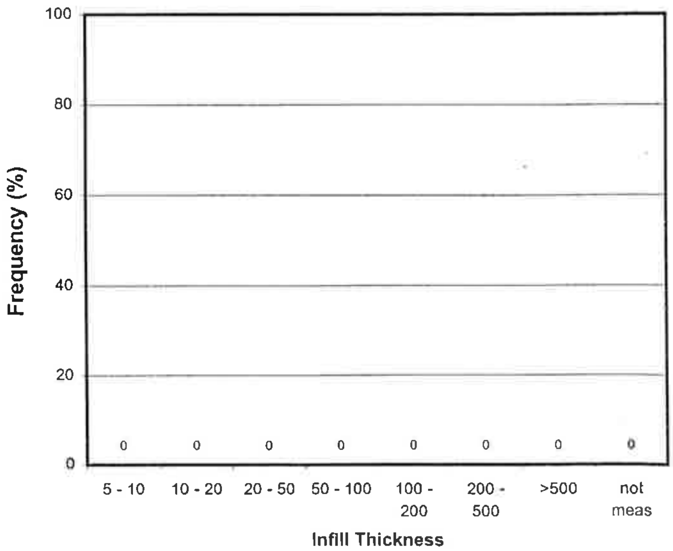
project:	Deepdell Stage 1 Pit Design	datum:	assumed
location:	Deepdell	date:	09-Aug-00

Data records 6 **Lithology:** All **Borehole** DDH107 **Type Defect:** Joint









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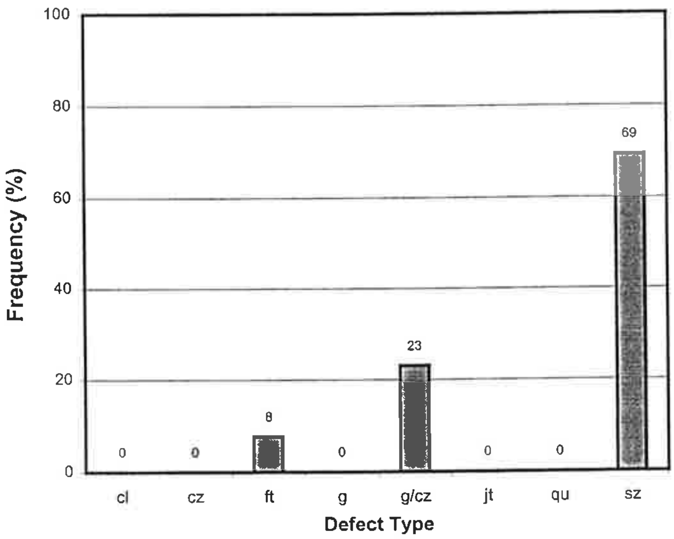
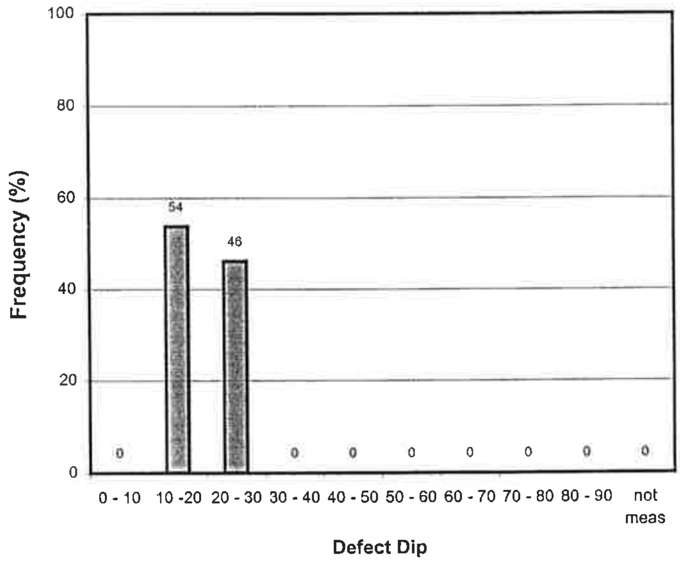
Geotechnical Boreholes
Data Histograms

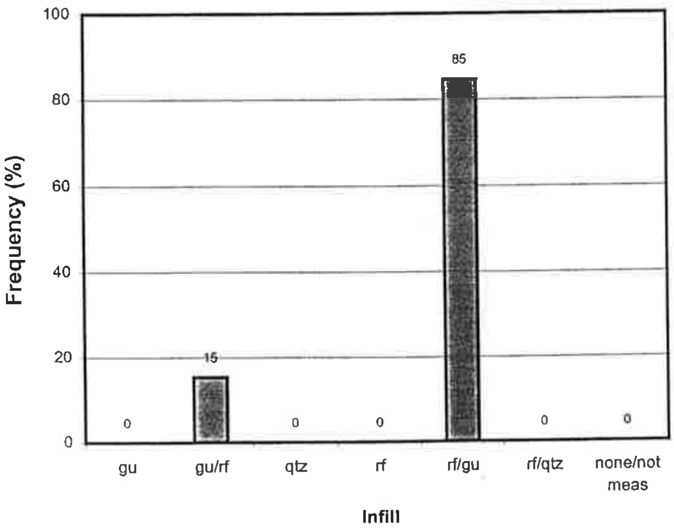
DDH107

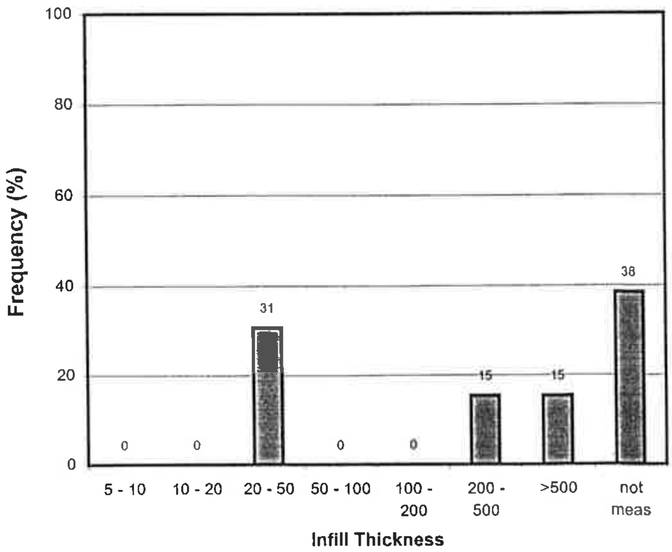
project:	Deepdell Stage 1 Pit Design	datum:	assumed
location:	Deepdell	date:	09-Aug-00

Data records 13 **Lithology:** All **Borehole** DDH107 **Type Defect:** Gouge/shear zones









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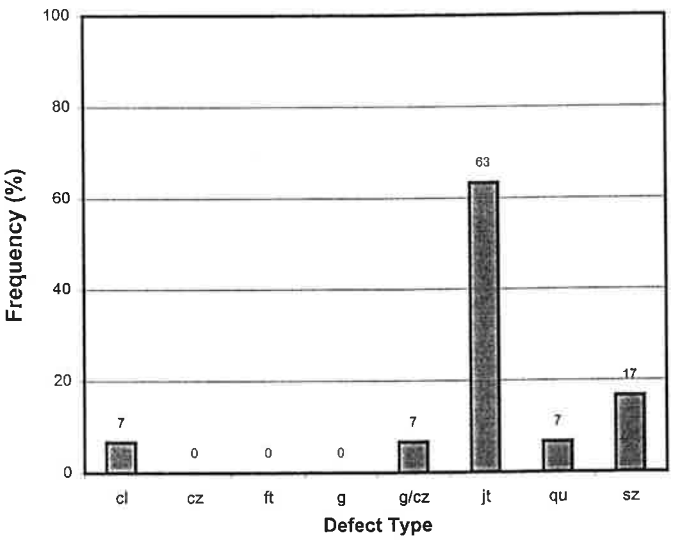
Geotechnical Boreholes Data Histograms

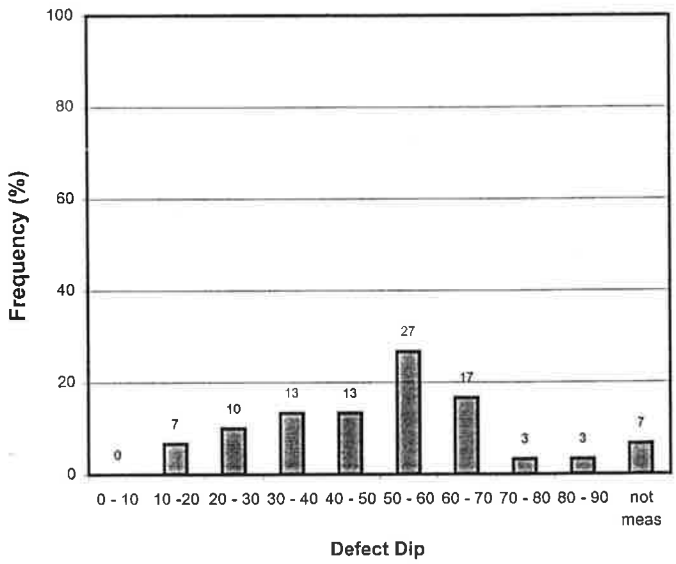
DDH108

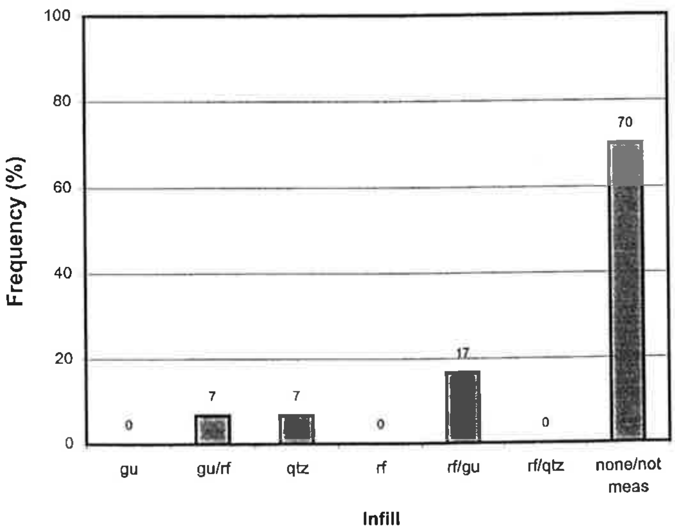
project: Deepdell Stage 1 Pit Design
location: Deepdell

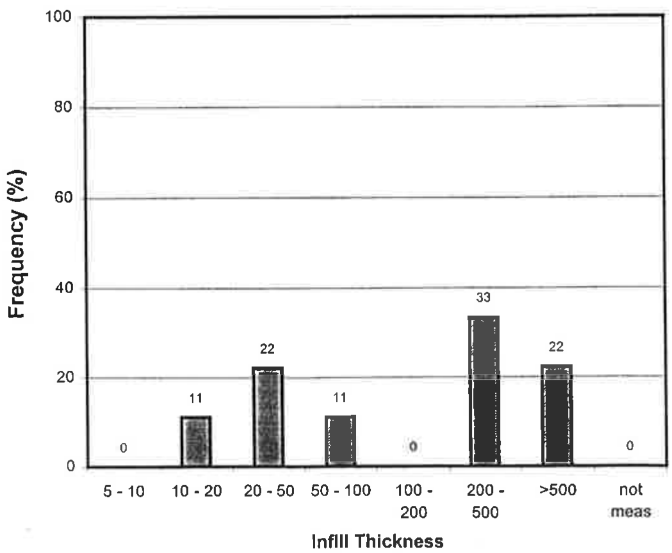
datum: assumed
date: 09-Aug-00

Data records 30 **Lithology:** All **Borehole** DDH108 **Type Defect:** All









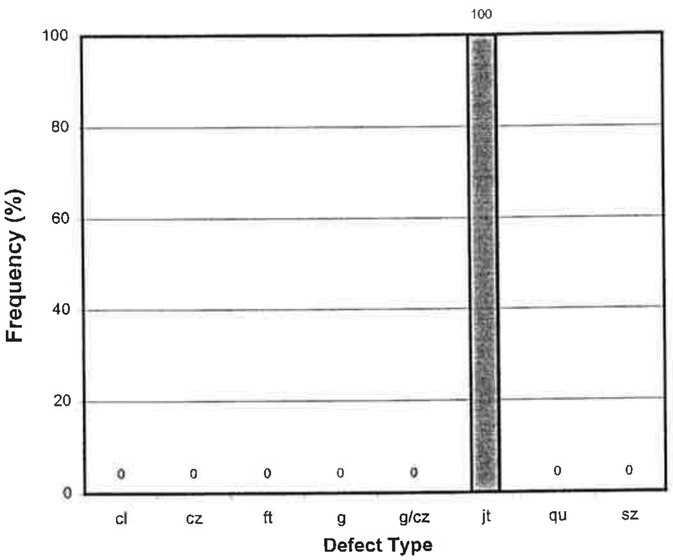
GRD Macraes Ltd

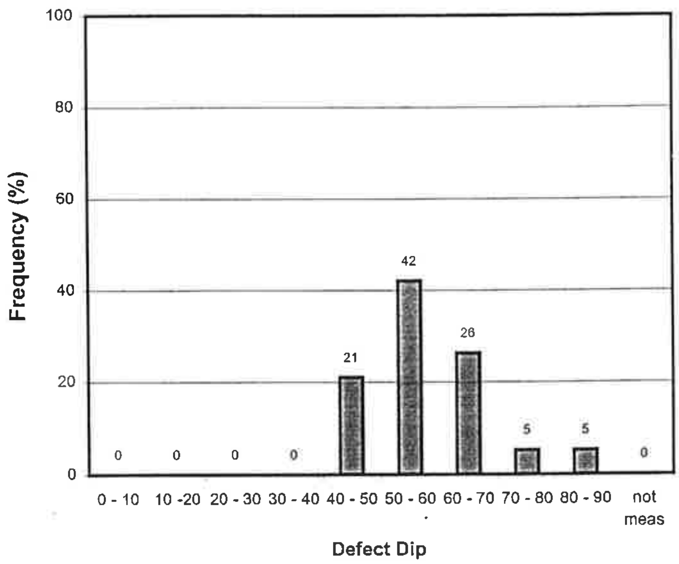
Geotechnical Boreholes Data Histograms

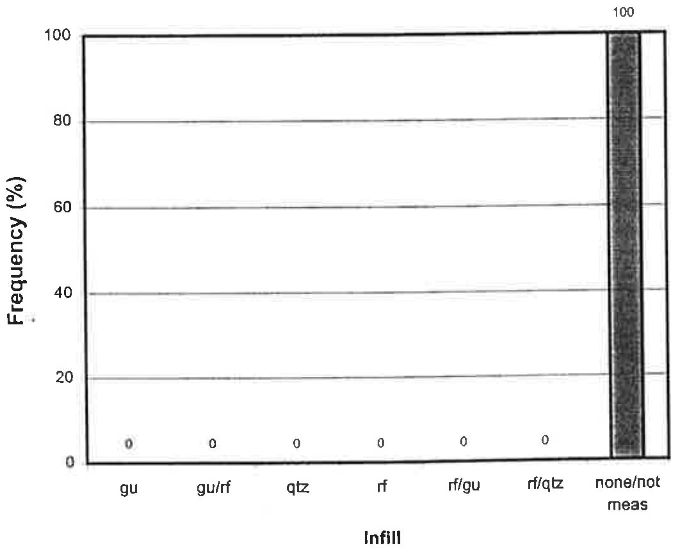
DDH108

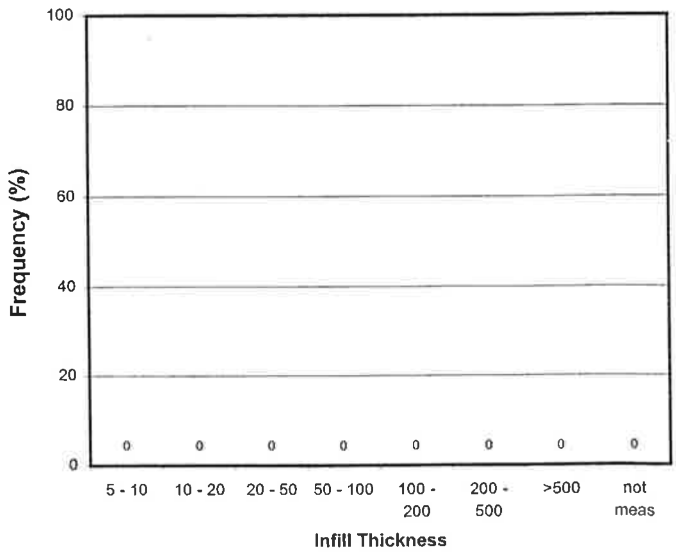
project:	Deepdell Stage 1 Pit Design	datum:	assumed
location:	Deepdell	date:	09-Aug-00

Data records 19 **Lithology:** All **Borehole** DDH108 **Type Defect:** Joint









PSM

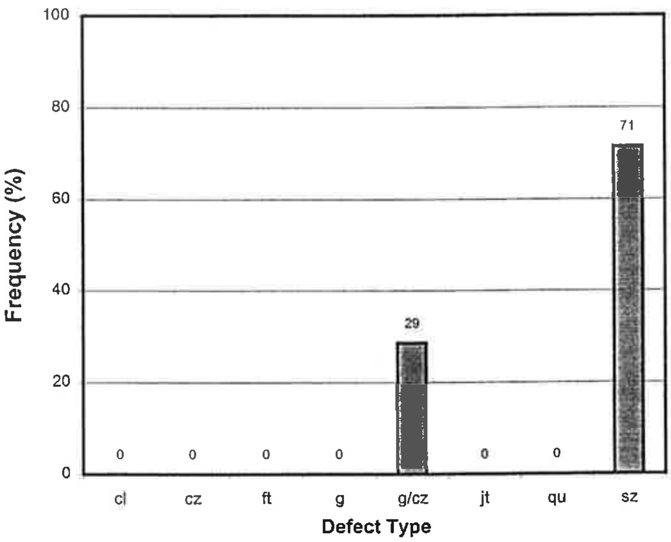
GRD Macraes Ltd

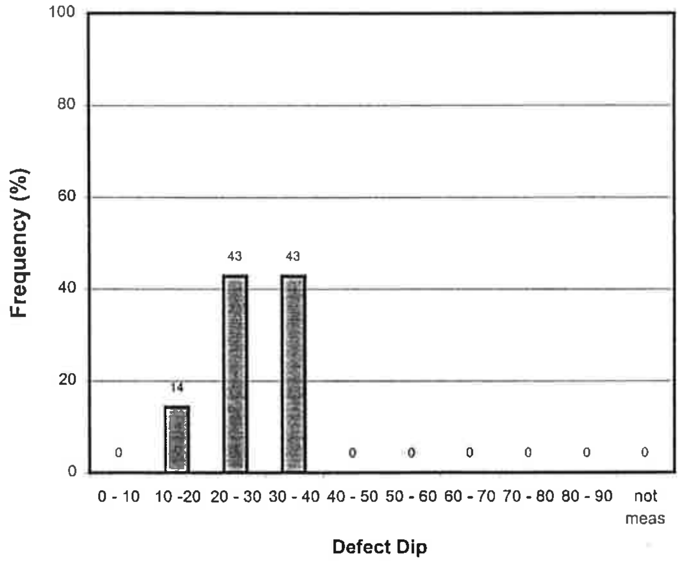
Geotechnical Boreholes Data Histograms

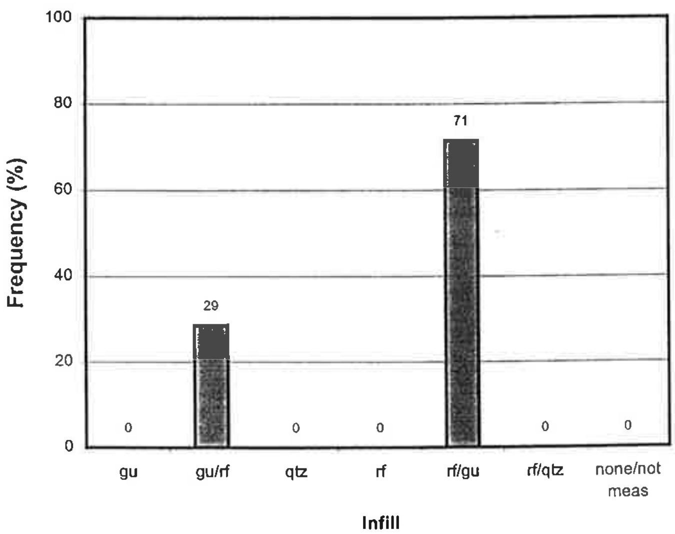
DDH108

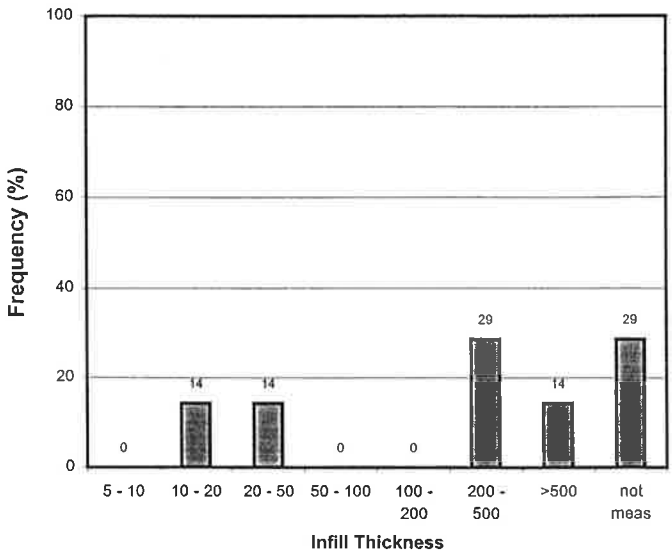
project:	Deepdell Stage 1 Pit Design	datum:	assumed
location:	Deepdell	date:	09-Aug-00

Data records 7 **Lithology:** All **Borehole** DDH108 **Type Defect:** Gouge/shear zones









PSM

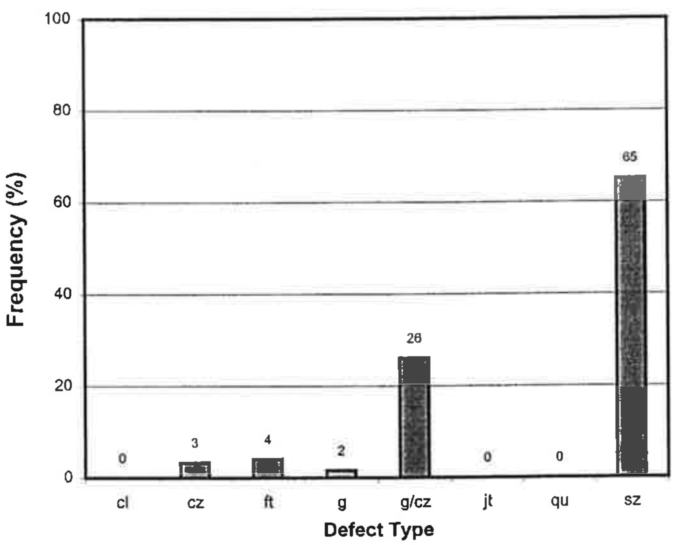
GRD Macraes Ltd

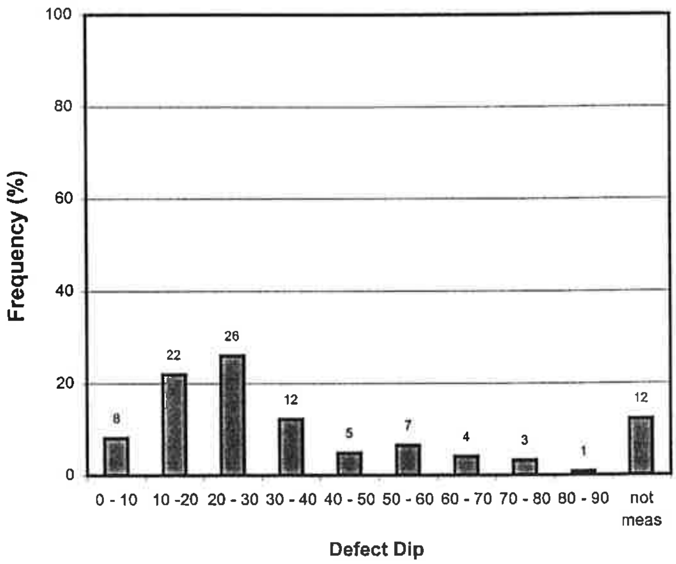
Geotechnical Boreholes
Data Histograms

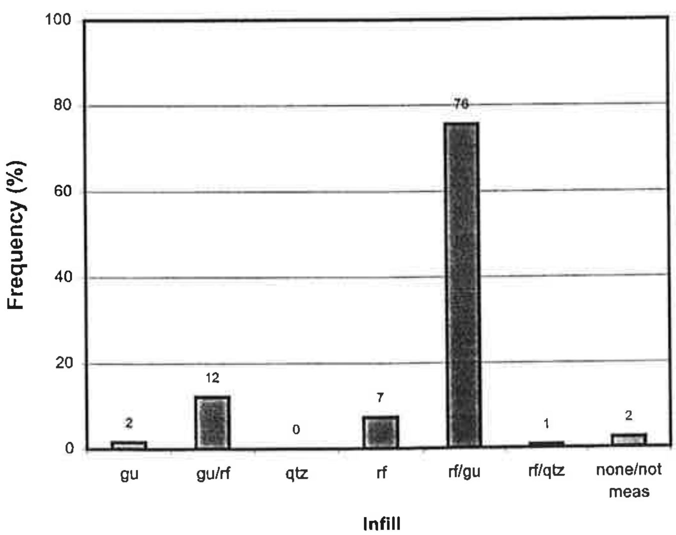
All boreholes

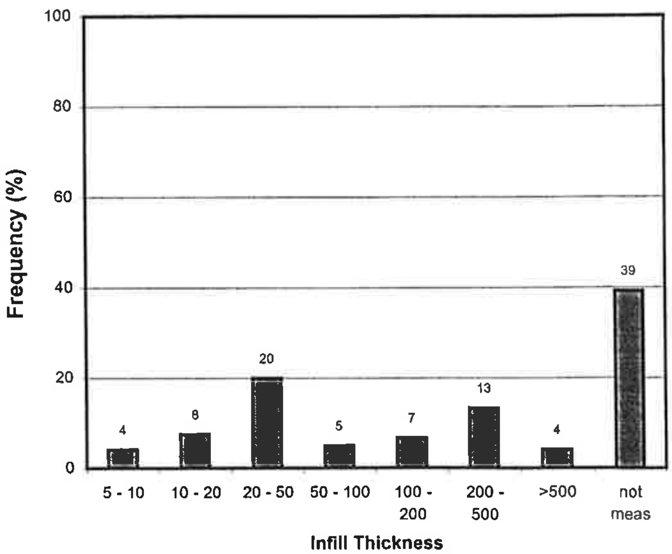
project:	Deepdell Stage 1 Pit Design	datum:	assumed
location:	Deepdell	date:	10-Aug-00

Data records 123 **Lithology:** All **Borehole** All **Type Defect:** Gouge/shr zones









APPENDIX C

GEOLOGICAL STRUCTURE MODELLING

Pells Sullivan Meynink
Engineering Consultants
Rock-Soil-Water

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North Ryde NSW 2113
P: 61-2 9812 5000
F: 61-2 9812 5001
mailbox@psm.com.au
www.psm.com.au

MEMORANDUM

COMPANY:	**OCEANAGOLD**
ATTENTION:	**ANDY WINNEKE**
OUR REF:	**PSM71-224R APPENDIX C**
FROM:	**RICHARD BREHAUT**
DATE:	**7/02/2018**

RE: MODELLING OF MAJOR GEOLOGICAL STRUCTURES - DEEPDELL

This memorandum summarises PSM's geological interpretation of two dimensional fault structures provided for Deepdell and the development of these into three dimensional surface wireframes for use in analysis.

1 AVAILABLE DATA

OceanaGold provided the following material:

- 2D contour plan fault traces, Figure 1:
  - Horse Flat
  - Table top
  - Cyanide Creek
- Historic failure mapping for Deepdell North, Figure 2
- 3D fault planes as "DD_Fault_plane_1–3.dxf"
- 3D pit geometry surfaces:
  - As built
  - As mined
  - Stage 3 Proposed

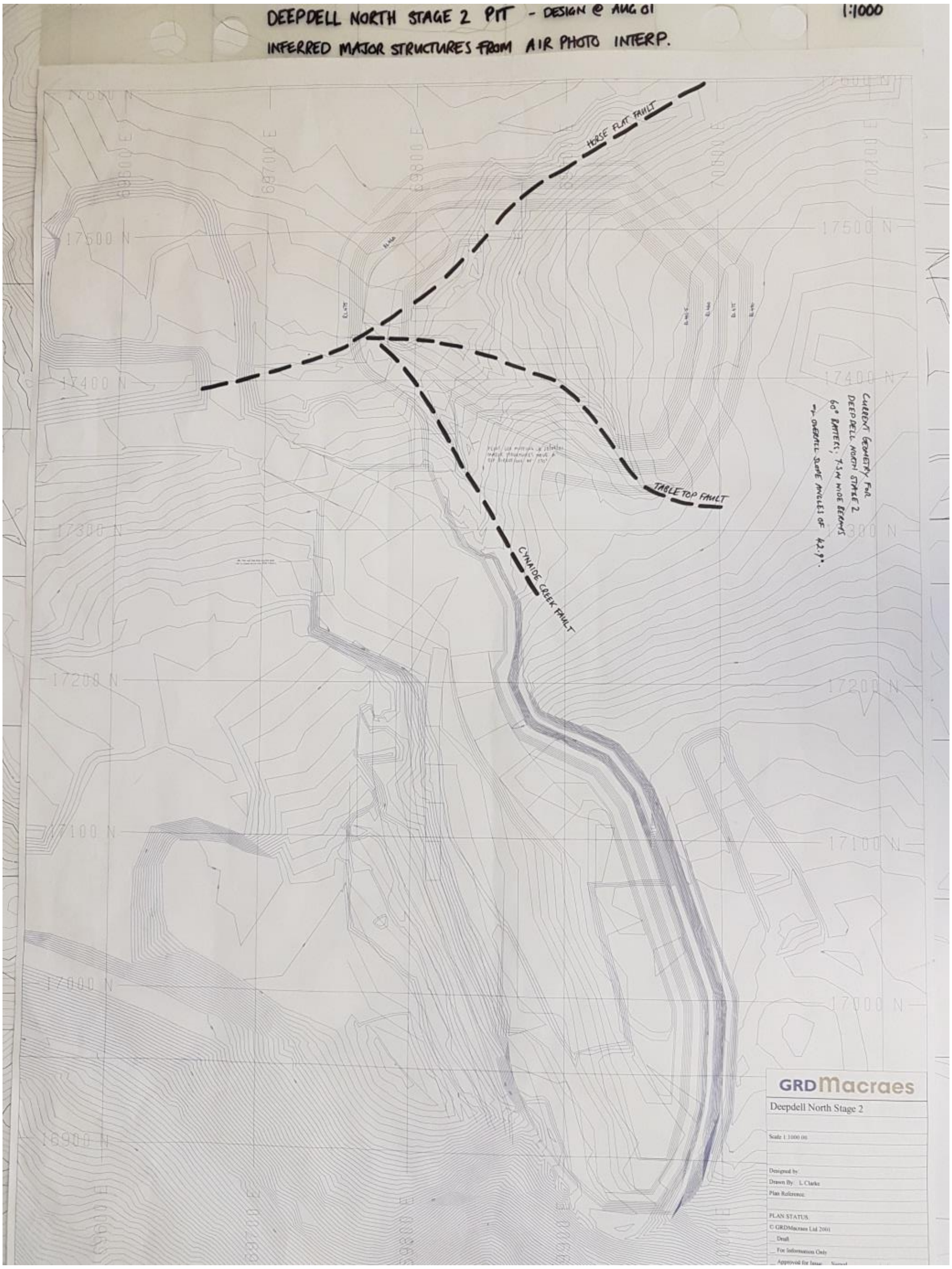


Figure 1: Plan traces of Deepdell faults

Figure 2: Example of geological structure mapping from historic failures in Deepdell Stage 1 and 2.

2 METHODOLOGY

PSM utilised the following process to develop 3D fault projections using Maptek's Vulcan.

1. Register contour plan traces to the as mined topography "DD_As_Mined_surface.dxf"
2. Geological structure orientations educated from historic failure mapping data, Figure 2 were used to for the Cyanide Creek and Table Top Faults. The Horse Flat Fault orientation was educated from "DD_Fault_Plane_2.dxf"
3. The Cyanide Creek fault was extended beyond the original trace shown in Figure 1. The strike of this feature lines up almost directly with failures from Deepdell Stage 1 (Figure 2). It is inferred that the fault is likely to have contributed to these instabilities and has therefore been modelled to fit this hypothesis.
4. Respective defect orientations then projected "up and down dip" of the structures intersection to create a three dimensional plane.
5. Fault plane projections were relimited against the Footwall Fault for completeness

3 RESULTS

The resultant fault projections are illustrated in Figure 3. These structures have been overlain against the Deepdell Stage 1 "as mined" topographic surface and the proposed Stage 3 pit shell for context.

PSM note that the Footwall Fault strikes North to South throughout the operation. The modelled Cyanide Creek Fault appears to have been rotated approximately 30 degrees to Southeast. Such a structural arrangement is atypical when compared to general site experience and may indicate further structural complexity in the area.

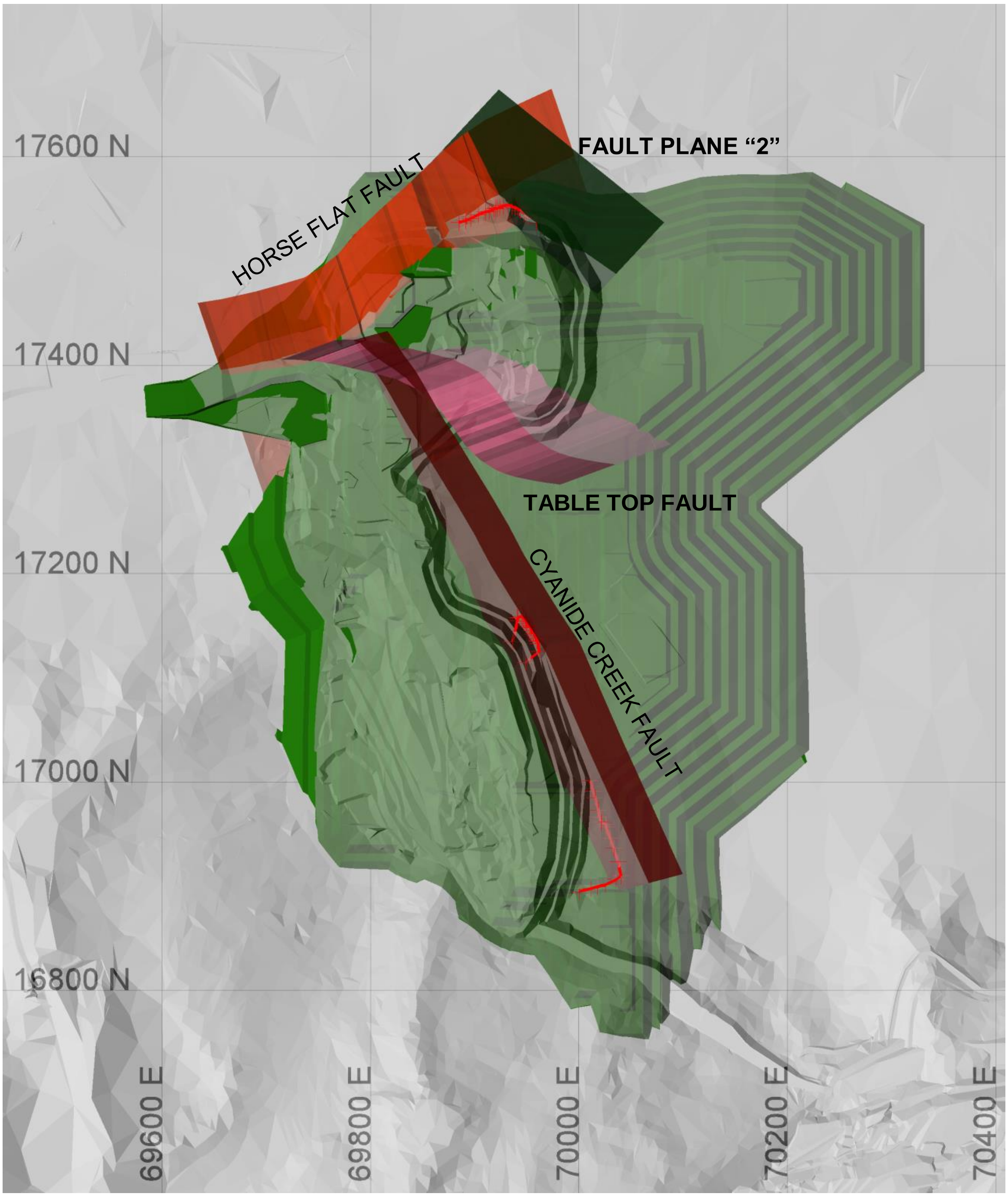


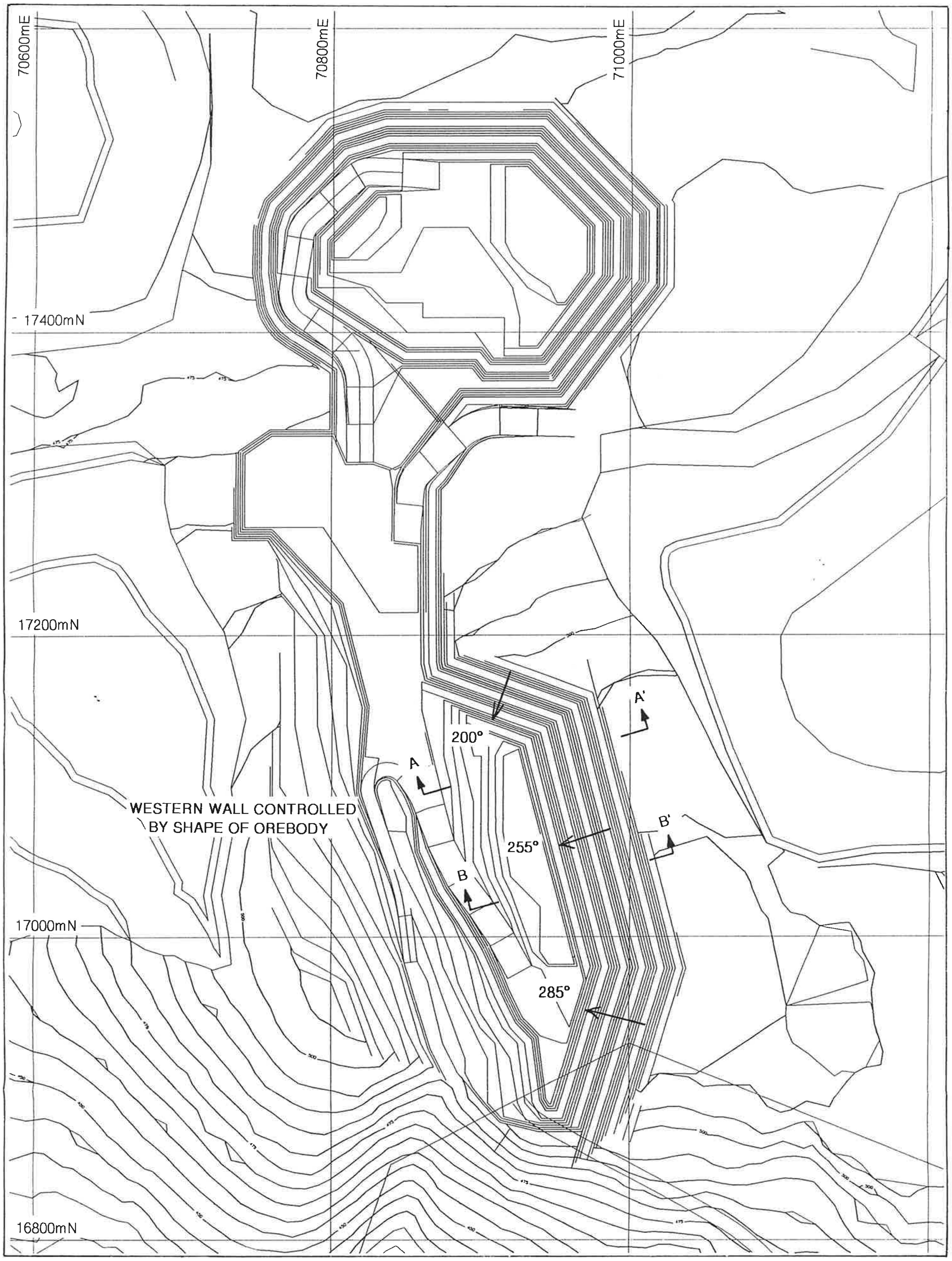
Figure 3: 3D Fault surfaces with outline of previous failures (Highlighted with a red line)

For and on behalf of
PELLS SULLIVAN MEYNINK

Richard Brehaut
Associate

APPENDIX D

KINEMATIC STABILITY ASSESSMENTS



LEGEND

200° SLOPE ASPECT

A A' LINE OF CROSS SECTION

0 50 100

GRD Macraes Ltd
Deepdell Stage I Pit

MAJOR PIT WALL ORIENTATIONS

PSM

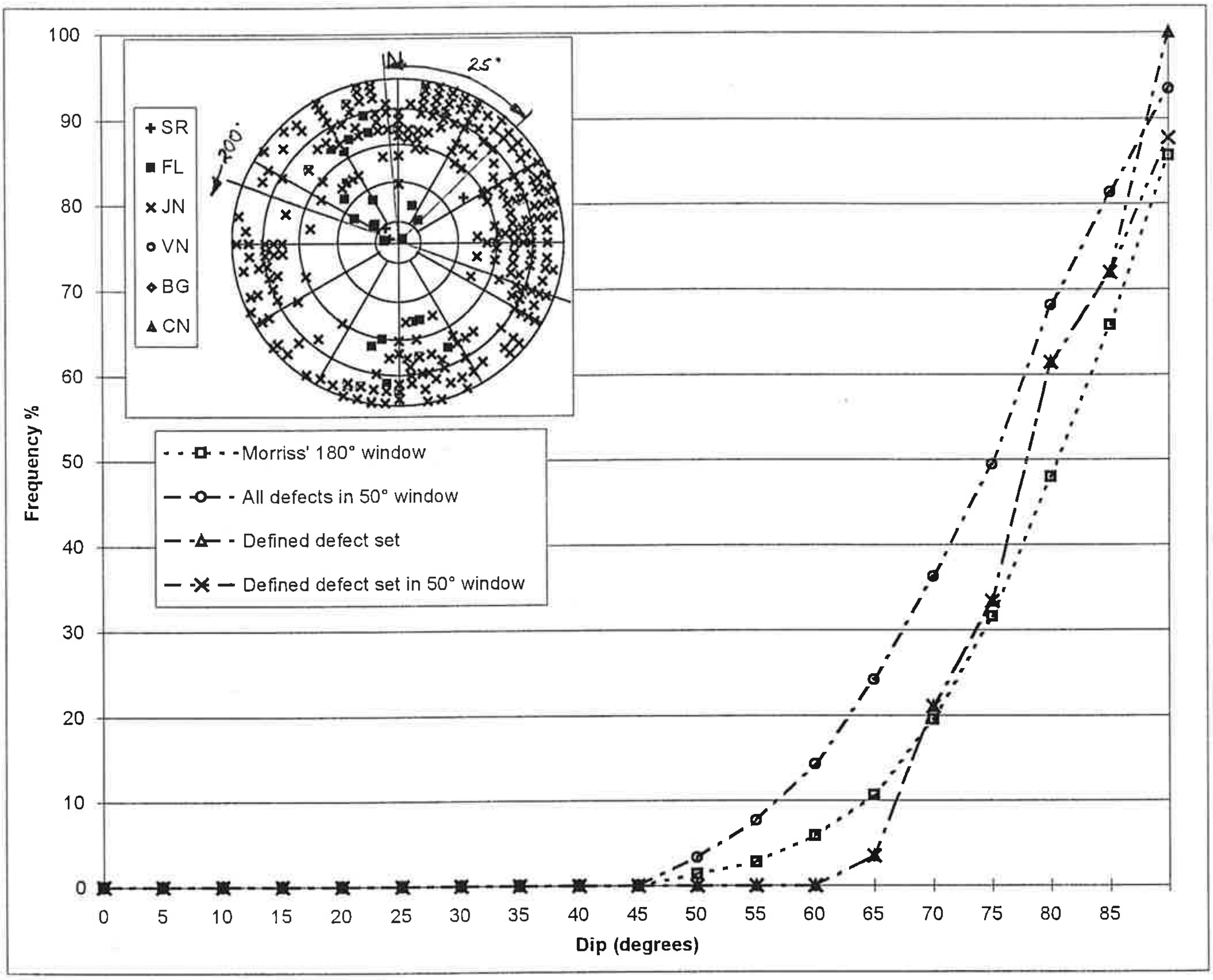
Pells Sullivan Meynink Pty Ltd

PSM 71·R15

Figure 2

Deepdell Stage 1 Pit Design

GRD Macraes
Northeast Wall
Planar "J1"



PARAMETERS OF THE PIT WALL	
Slope Direction	200
Kinematic Window ±	25

DEFECT SHEAR STRENGTHS

Cohesion	=	0 kPa
Friction Angle	=	40°

PARAMETERS OF THE DEFECT SET
Defining the defect set for planar

Defect Set		
J1	Mean	±
Dip	78	18
Dip Direction	198	15

Number of defects in set J3 57

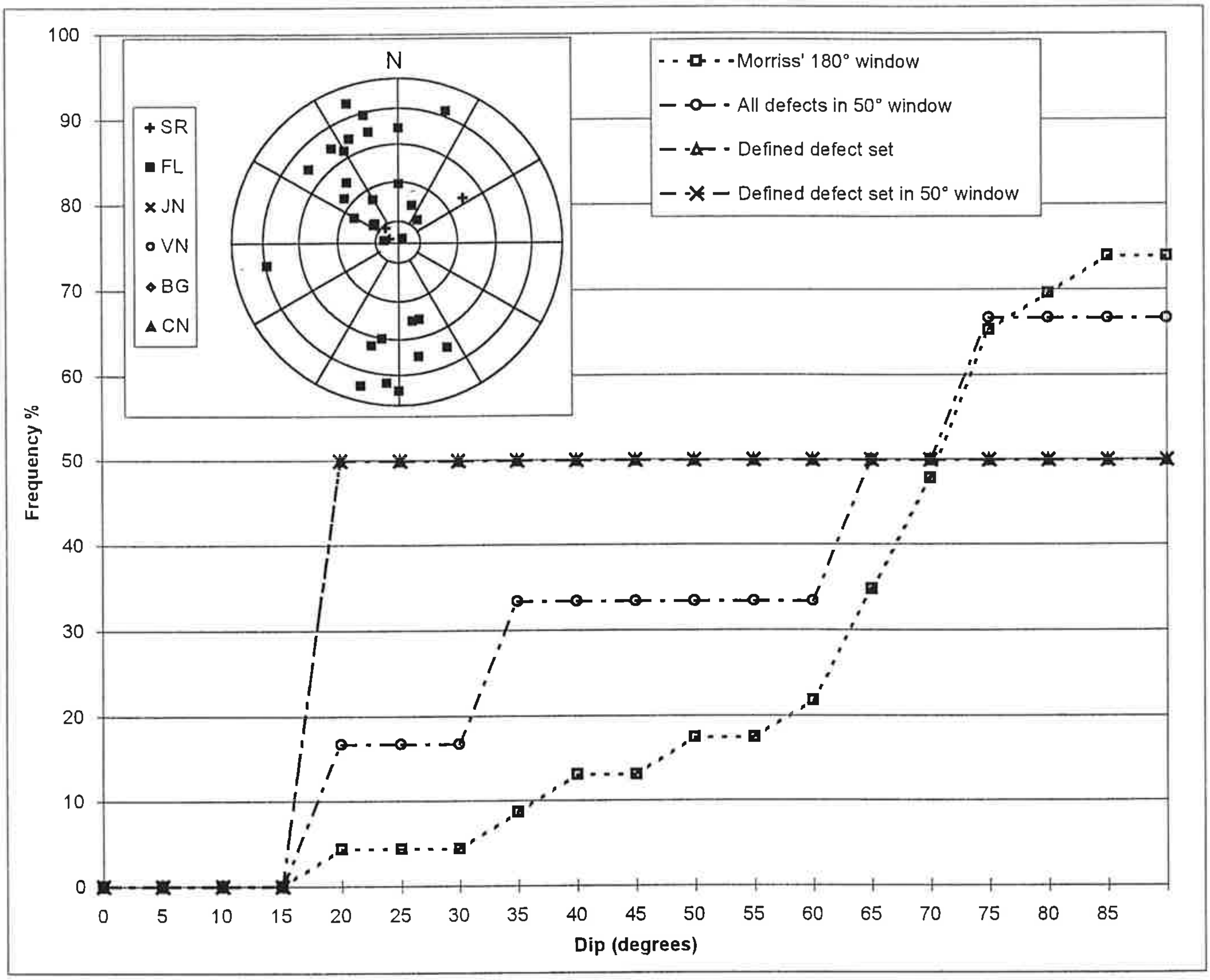
Kinematic Window
Total Number of Defects 85

Morriss Method
Number of Defects Dipping out of Slope
250

Defined Defect Set
Total Number of Defects 57
Kinematic in window 50

Deepdell Stage 1 Pit Design

GRD Macraes
Northeast Wall
Planar - Gouge/crushed zones



PARAMETERS OF THE PIT WALL	
Slope Direction	200
Kinematic Window ±	25

DEFECT SHEAR STRENGTHS		
Cohesion	=	0 kPa
Friction Angle	=	16°

PARAMETERS OF THE DEFECT SET
Defining the defect set for planar

Defect Set		
S1	Mean	±
Dip	18	15
Dip Direction	209	20

Number of defects in set S1 2

Kinematic Window
Total Number of Defects 4

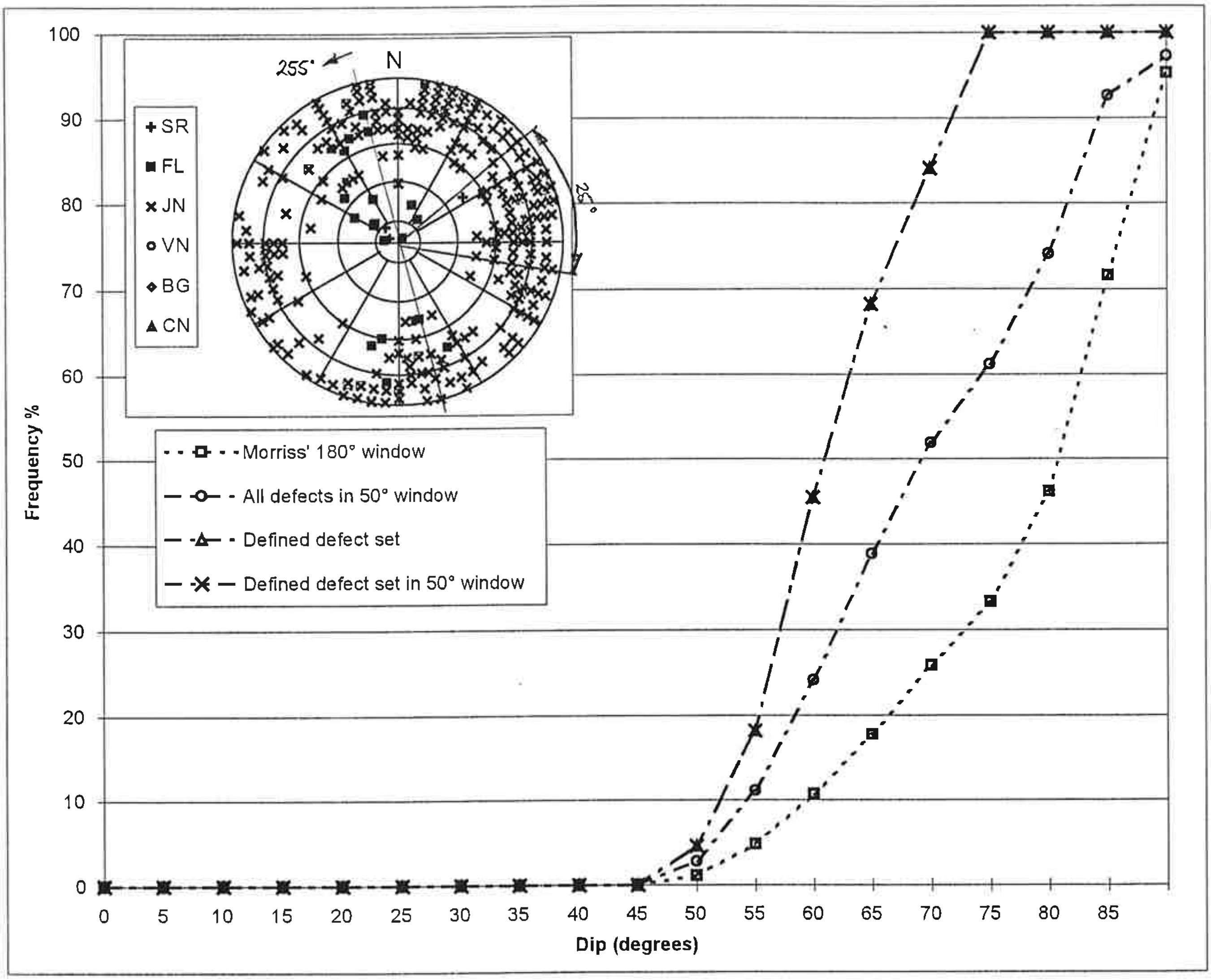
Defined Defect Set
Total Number of Defects 1
Kinematic in window 1

Morriss Method
Number of Defects Dipping out of Slope 17

KinematicStats Chart for Planar 09-08-2000 2:19 PM

Deepdell Stage 1 Pit Design

GRD Macraes
Northeast Wall
Planar "J2"



PARAMETERS OF THE PIT WALL	
Slope Direction	255
Kinematic Window ±	25

DEFECT SHEAR STRENGTHS		
Cohesion	=	0 kPa
Friction Angle	=	40°

PARAMETERS OF THE DEFECT SET
Defining the defect set for planar

Defect Set		
J2	Mean	±
Dip	62	18
Dip Direction	266	15
Number of defects in set	J3	44

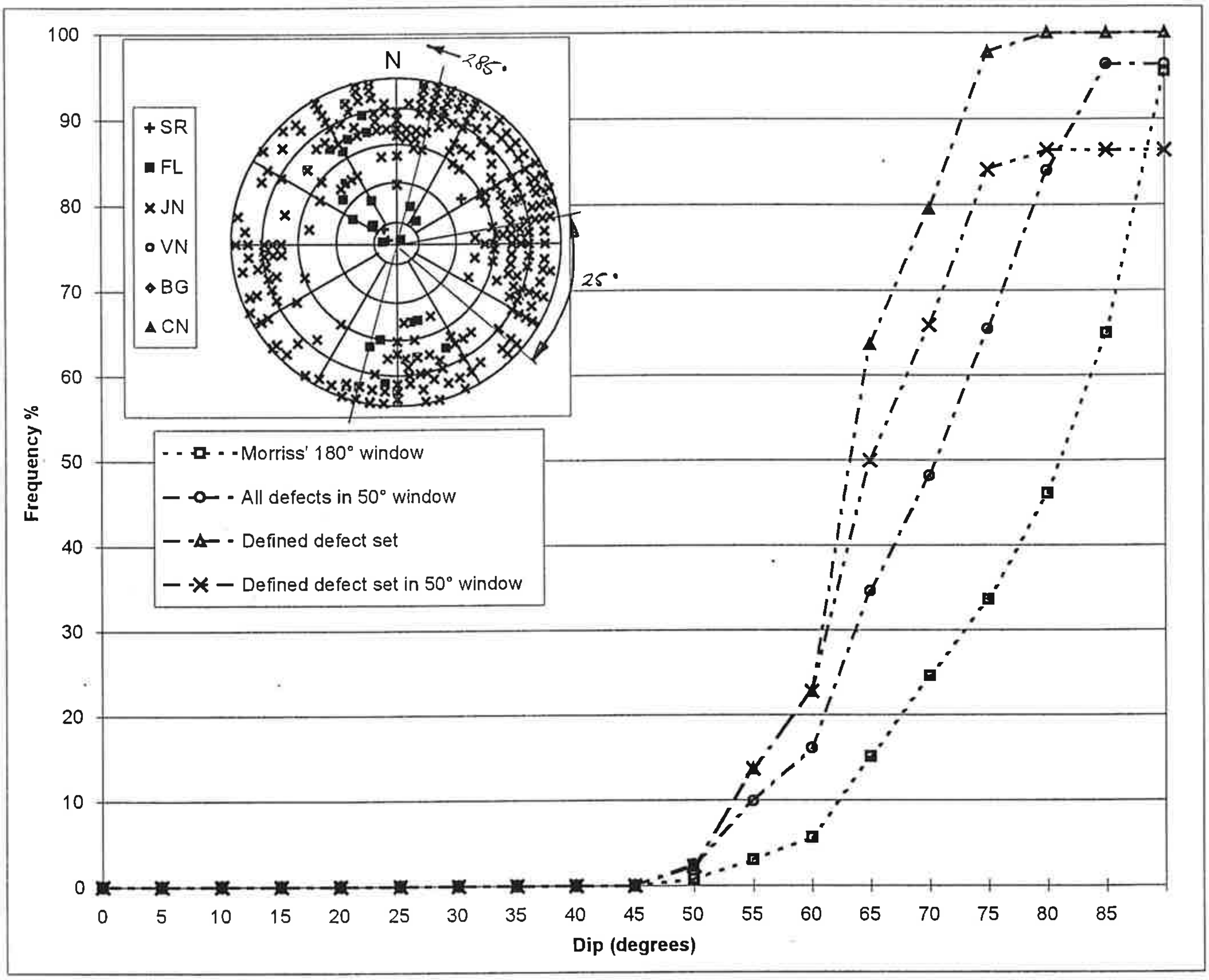
Kinematic Window
Total Number of Defects 105

Morriss Method
Number of Defects Dipping out of Slope 258

Defined Defect Set
Total Number of Defects 44
Kinematic in window 44

Deepdell Stage 1 Pit Design

GRD Macraes
Northeast Wall
Planar "J2"



PARAMETERS OF THE PIT WALL	
Slope Direction	285
Kinematic Window ±	25

DEFECT SHEAR STRENGTHS		
Cohesion	=	0 kPa
Friction Angle	=	40°

PARAMETERS OF THE DEFECT SET
Defining the defect set for planar

Defect Set		
J2	Mean	±
Dip	62	18
Dip Direction	266	15
Number of defects in set J3		44

Kinematic Window
Total Number of Defects 78

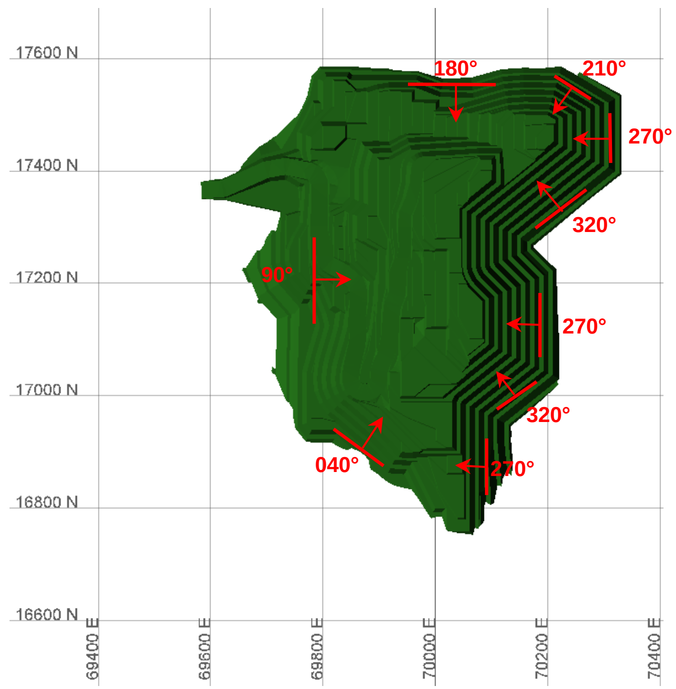
Defined Defect Set
Total Number of Defects 44
Kinematic in window 38

Morriss Method
Number of Defects Dipping out of Slope 253

APPENDIX E

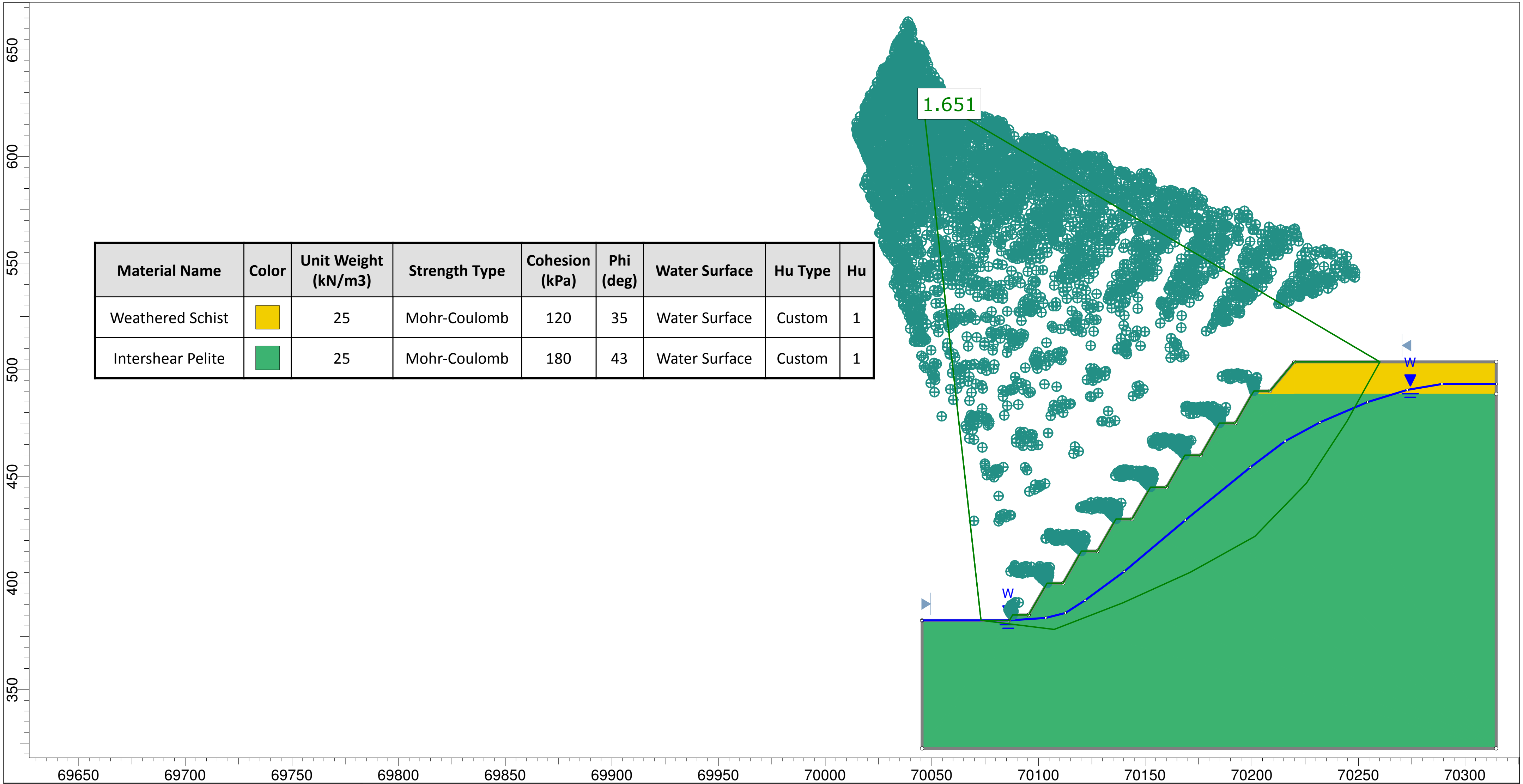
QUALITATIVE RISK ASSESSMENT

APPENDIX E
QUALITATIVE RISK ASSESSMENT – DEEPDELL

PHASE	SLOPE ASPECT (Azimuth °)	MAXIMUM OVERALL SLOPE HEIGHT (m)	BENCH GEOMETRY			INTER-RAMP ANGLE (°)	QUALITATIVE RISK*	LOCATION ON PIT
			BATTER ANGLE (°)	HEIGHT (m)	BERM (m)			
Stage 1	090	145	60	Various	Various	23 to 38	Moderate – Potential for planar sliding on isolated low angle shears dipping out of the wall	
	180	105	60	15	4.3 (1x 16m)	41 & 48	Moderate – Potential for planar sliding on isolated low to moderate angle faults and shears dipping out of the wall	
	210	100	60	15	4.3	48	Low	
	270	110	60	15	7.5	42	Low – Potential for planar block release from joints dipping out of the face	
	320	100	60	15	7.5	40		
	270	125	60	15	7.5	42		
	320	120	60	15	7.5	43		
	270	90	60	15	7.5	41		
	040	90	60	15	7.5	40	Low	

APPENDIX F

LIMIT EQUILIBRIUM STABILITY ANALYSIS



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Weathered Schist		25	Mohr-Coulomb	120	35	Water Surface	Custom	1
Intershear Pelite		25	Mohr-Coulomb	180	43	Water Surface	Custom	1

PSM **Pells Sullivan Meynink**
Engineering Consultants
Rock-Soil-Water

Client:	**OceanaGold Corporation**
Project:	**Macraes Mine - Deepdell Closure**
Location:	
Analysis description:	**East Wall - Operational Stability**

Job No:	By:	Date:	Scale:	Run:
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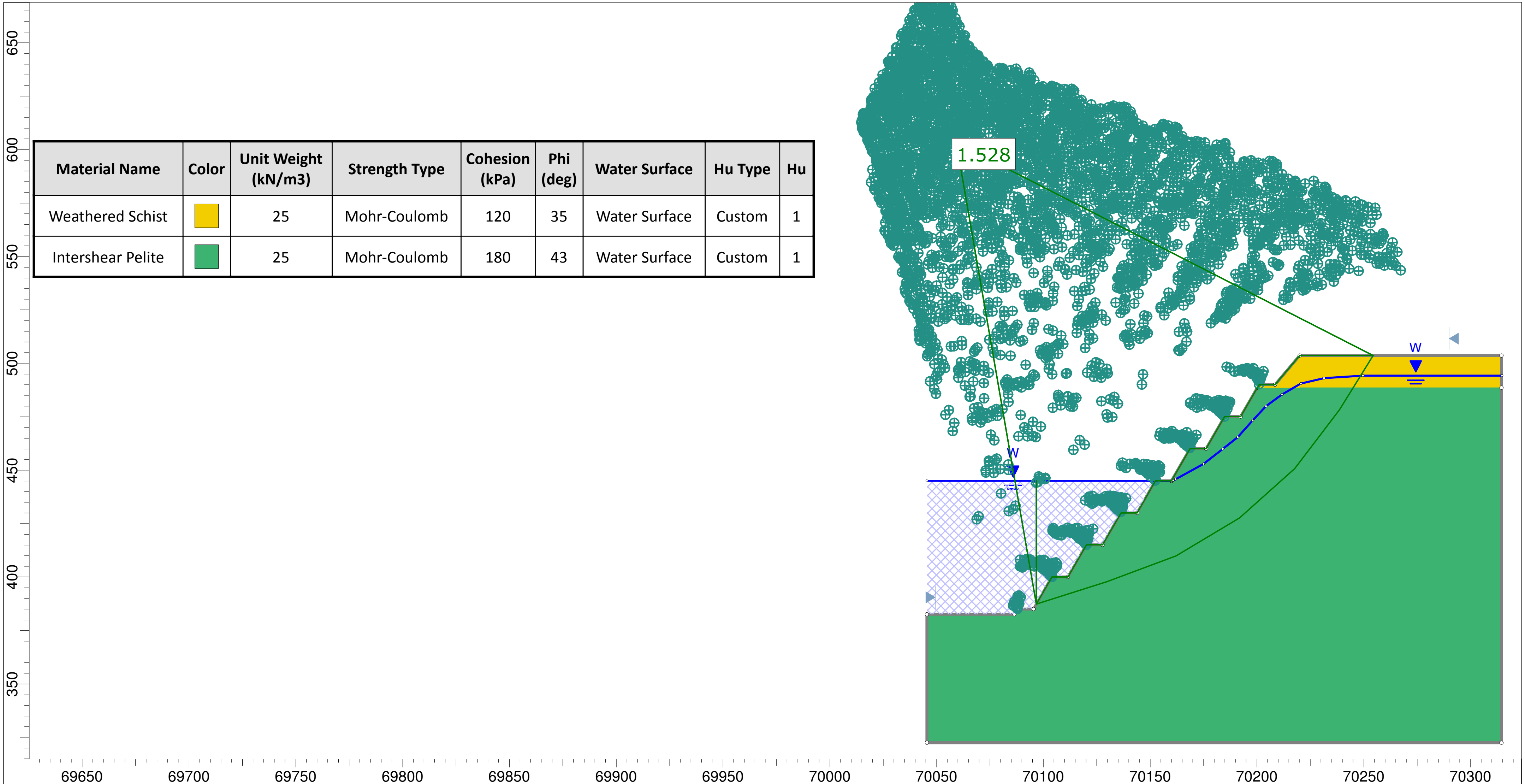
Y:\0000\PSM071\S071\Deepdell_Sections\East1.slim

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Weathered Schist		25	Mohr-Coulomb	120	35	Water Surface	Custom	1
Intershear Pelite		25	Mohr-Coulomb	180	43	Water Surface	Custom	1



PSM Pells Sullivan Meynink
Engineering Consultants
Rock-Soil-Water

Client:	OceanaGold Corporation
Project:	Macraes Mine - Deepdell Closure
Location:	
Analysis description:	East Wall - Water Table 445mRL

Job No:	By:	Date:	Scale:	Run:
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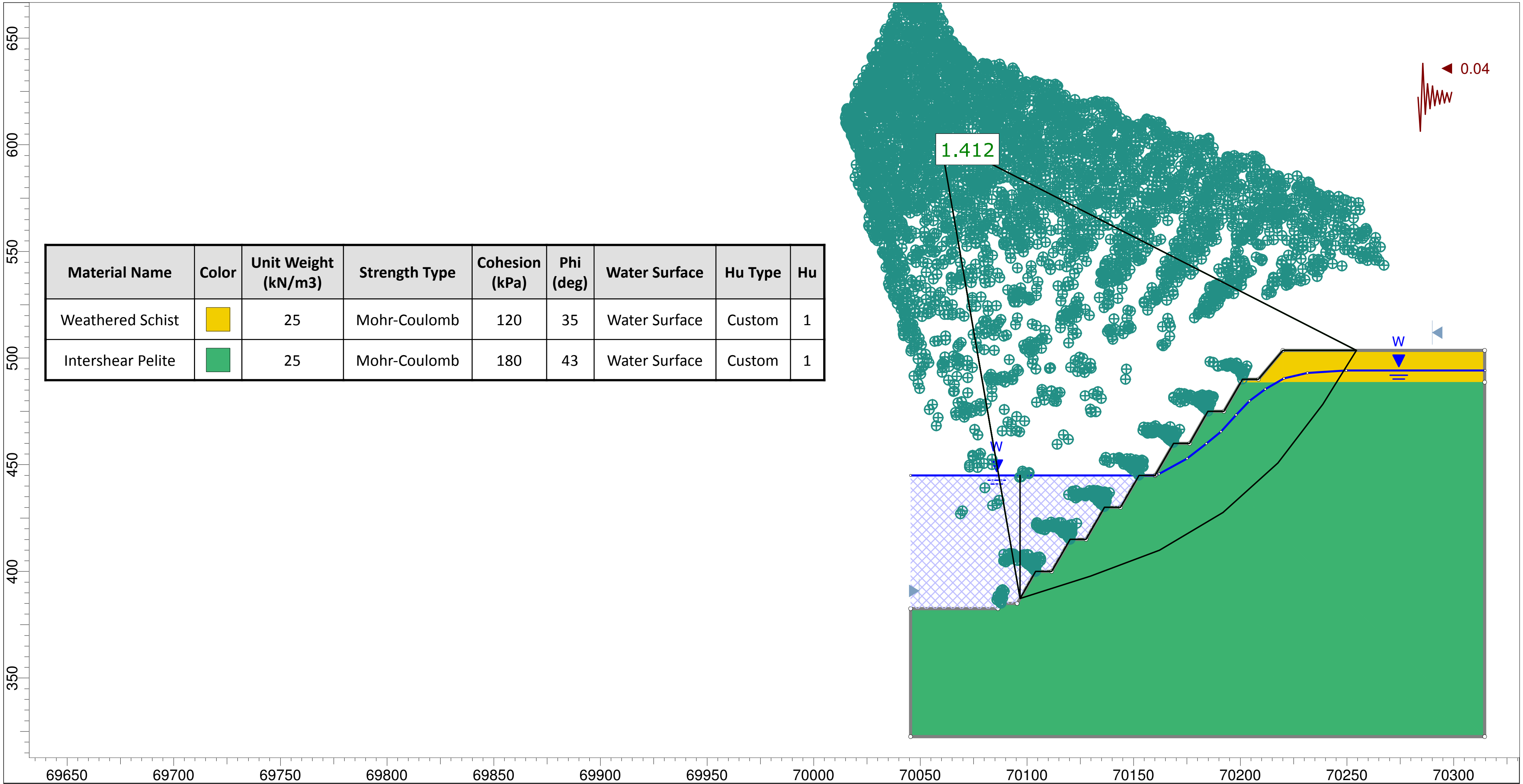

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Weathered Schist		25	Mohr-Coulomb	120	35	Water Surface	Custom	1
Intershear Pelite		25	Mohr-Coulomb	180	43	Water Surface	Custom	1

PSM **Pells Sullivan Meynink**
Engineering Consultants
Rock-Soil-Water

Client:	**OceanaGold Corporation**
Project:	**Macraes Mine - Deepdell Closure**
Location:	
Analysis description:	**East Wall - Water Table 445mRL - 0.04g critical acceleration**

Job No:	**PSM71**	By:	**DC**	Date:	**1/30/2018**	Scale:	**1:2500**	Run:	**East1_closure_445mRL_Seismic004.slim**

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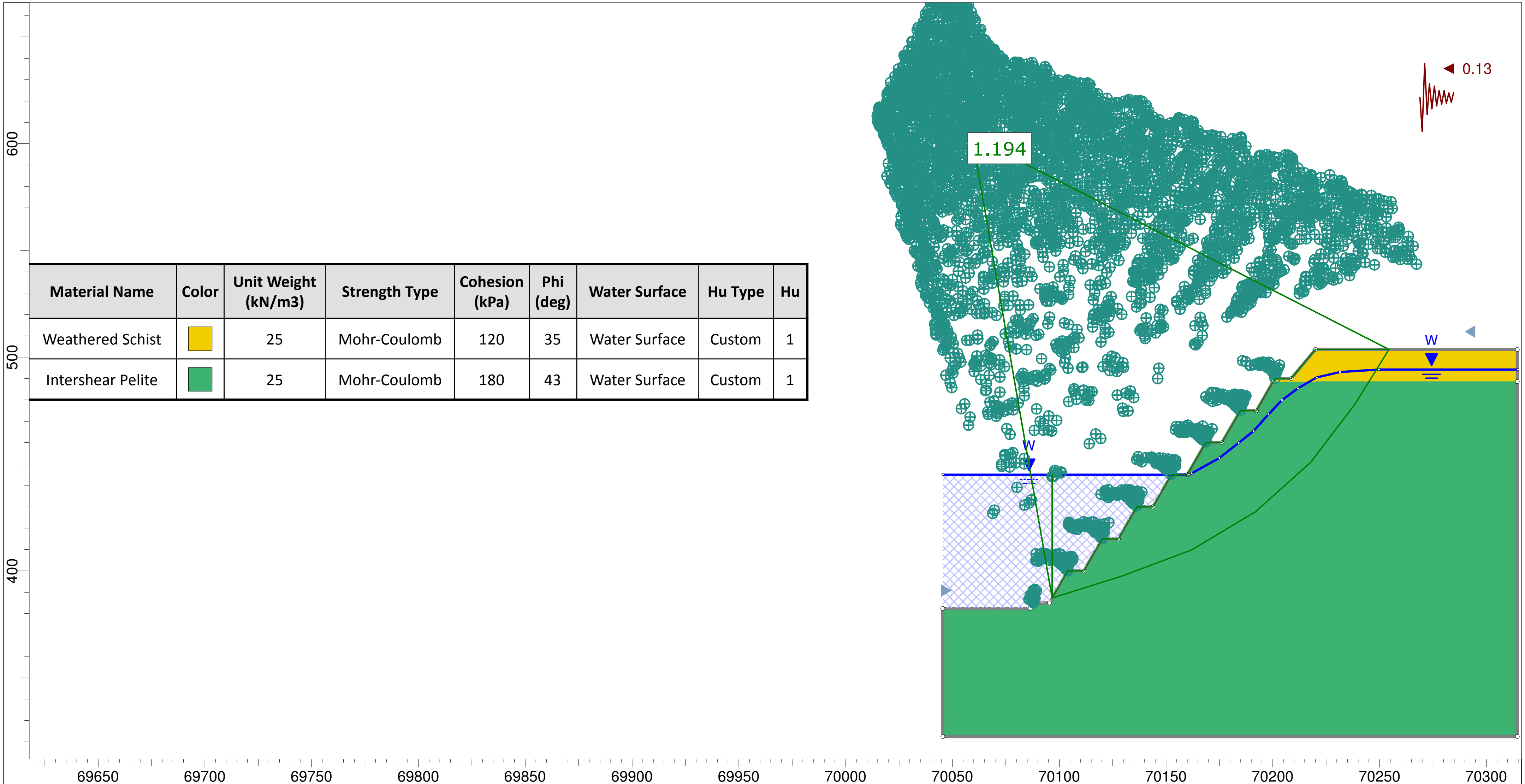

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
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Intershear Pelite		25	Mohr-Coulomb	180	43	Water Surface	Custom	1

PSM Pells Sullivan Meynink Engineering Consultants Rock-Soil-Water	Client:	**OceanaGold Corporation**
	Project:	**Macraes Mine - Deepdell Closure**
	Location:	
	Analysis description:	**East Wall - Water Table 445mRL - 0.13g critical acceleration**

Job No:	By:	Date:	Scale:	Run:
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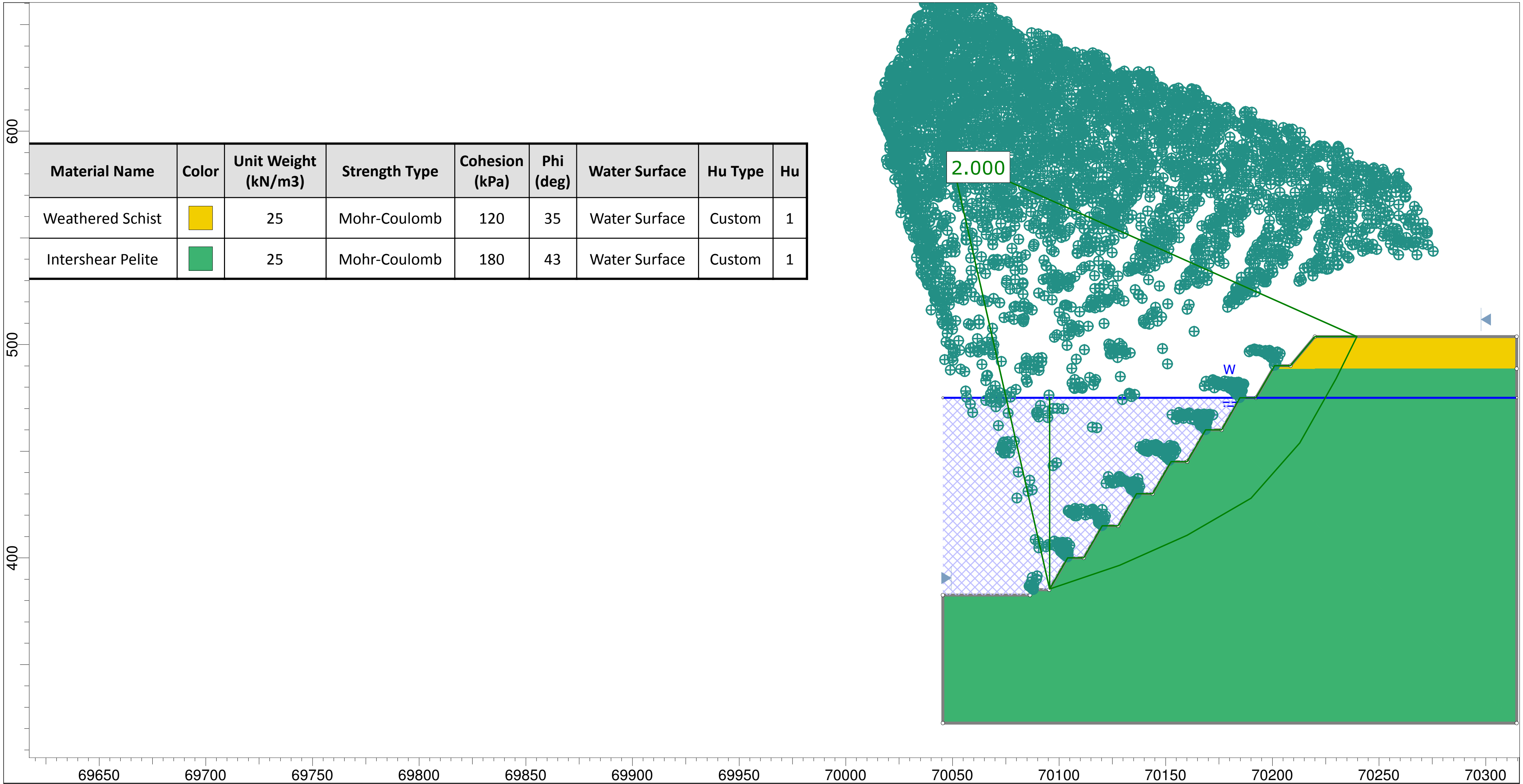

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Weathered Schist		25	Mohr-Coulomb	120	35	Water Surface	Custom	1
Intershear Pelite		25	Mohr-Coulomb	180	43	Water Surface	Custom	1

PSM **Pells Sullivan Meynink**
Engineering Consultants
Rock-Soil-Water

Client:	**OceanaGold Corporation**
Project:	**Macraes Mine - Deepdell Closure**
Location:	
Analysis description:	**East Wall - Water Table 475mRL**

Job No:	By:	Date:	Scale:	Run:
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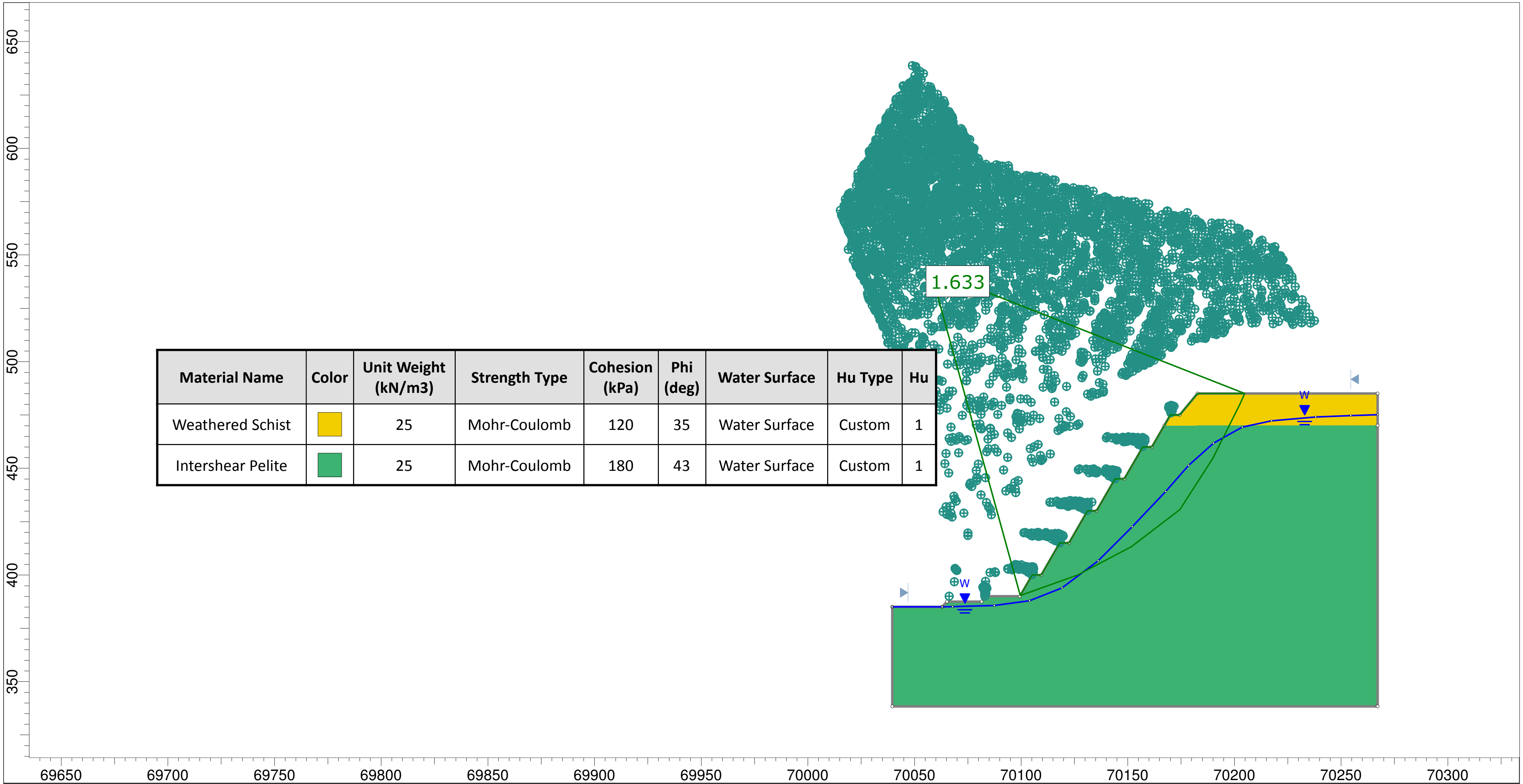

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Weathered Schist		25	Mohr-Coulomb	120	35	Water Surface	Custom	1
Intershear Pelite		25	Mohr-Coulomb	180	43	Water Surface	Custom	1

PSM Pells Sullivan Meynink
Engineering Consultants
Rock-Soil-Water

Client:	OceanaGold Corporation								
Project:	Macraes Mine - Deepdell Closure								
Location:									
Analysis description:	North Wall 2 - Operational Stability								
Job No:	PSM71	By:	DC	Date:	1/25/2018	Scale:	1:2500	Run:	North2.slim

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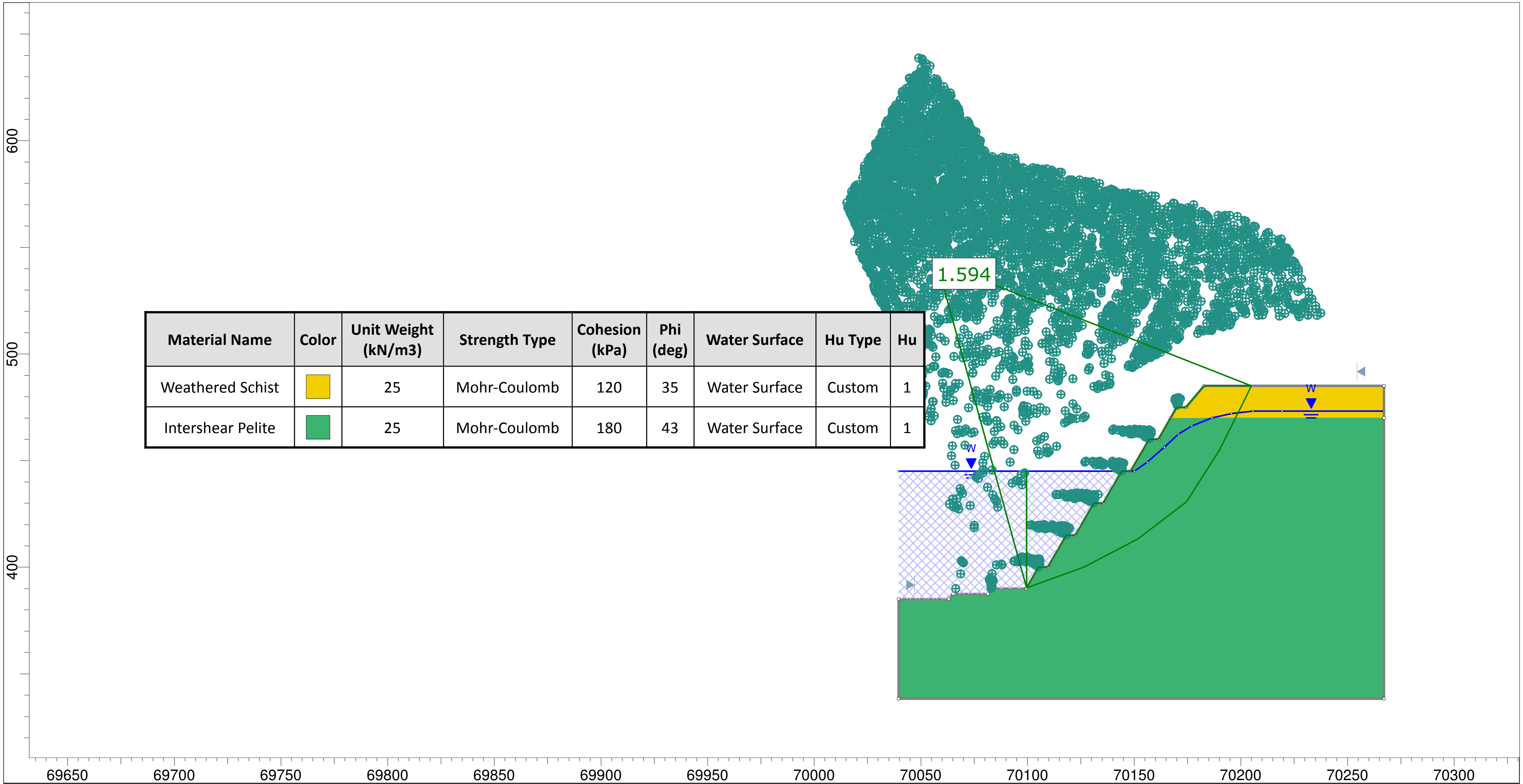

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Weathered Schist		25	Mohr-Coulomb	120	35	Water Surface	Custom	1
Intershear Pelite		25	Mohr-Coulomb	180	43	Water Surface	Custom	1

PSM **Pells Sullivan Meynink**
Engineering Consultants
Rock-Soil-Water

Client:	**OceanaGold Corporation**
Project:	**Macraes Mine - Deepdell Closure**
Location:	
Analysis description:	**North Wall 2 - Water Table 445mRL**

Job No:	By:	Date:	Scale:	Run:
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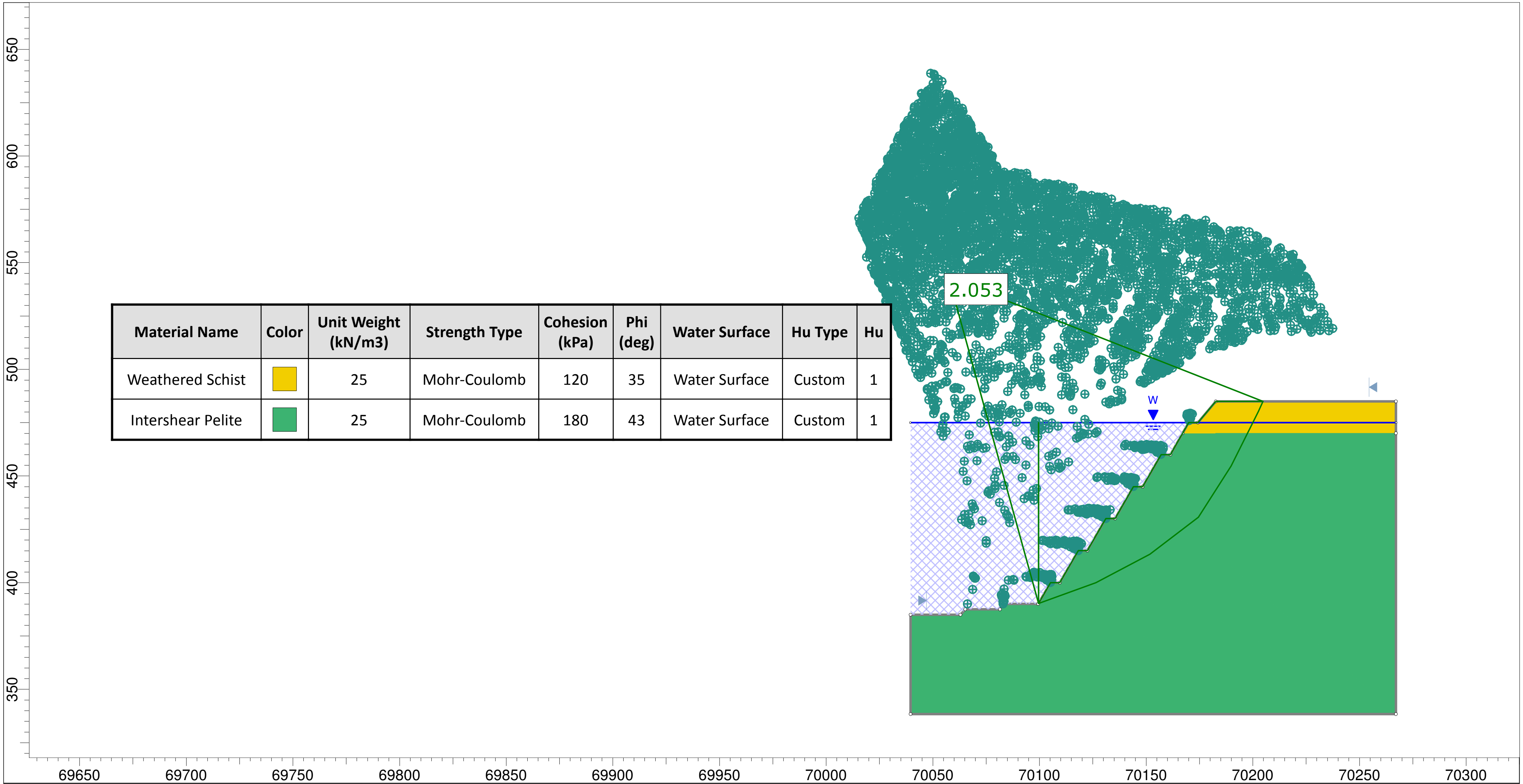

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Weathered Schist		25	Mohr-Coulomb	120	35	Water Surface	Custom	1
Intershear Pelite		25	Mohr-Coulomb	180	43	Water Surface	Custom	1

Pells Sullivan Meynink
Engineering Consultants
Rock-Soil-Water

Client:	**OceanaGold Corporation**
Project:	**Macraes Mine - Deepdell Closure**
Location:	
Analysis description:	**North Wall 2 - Water Table 475mRL**

Job No:	By:	Date:	Scale:	Run:
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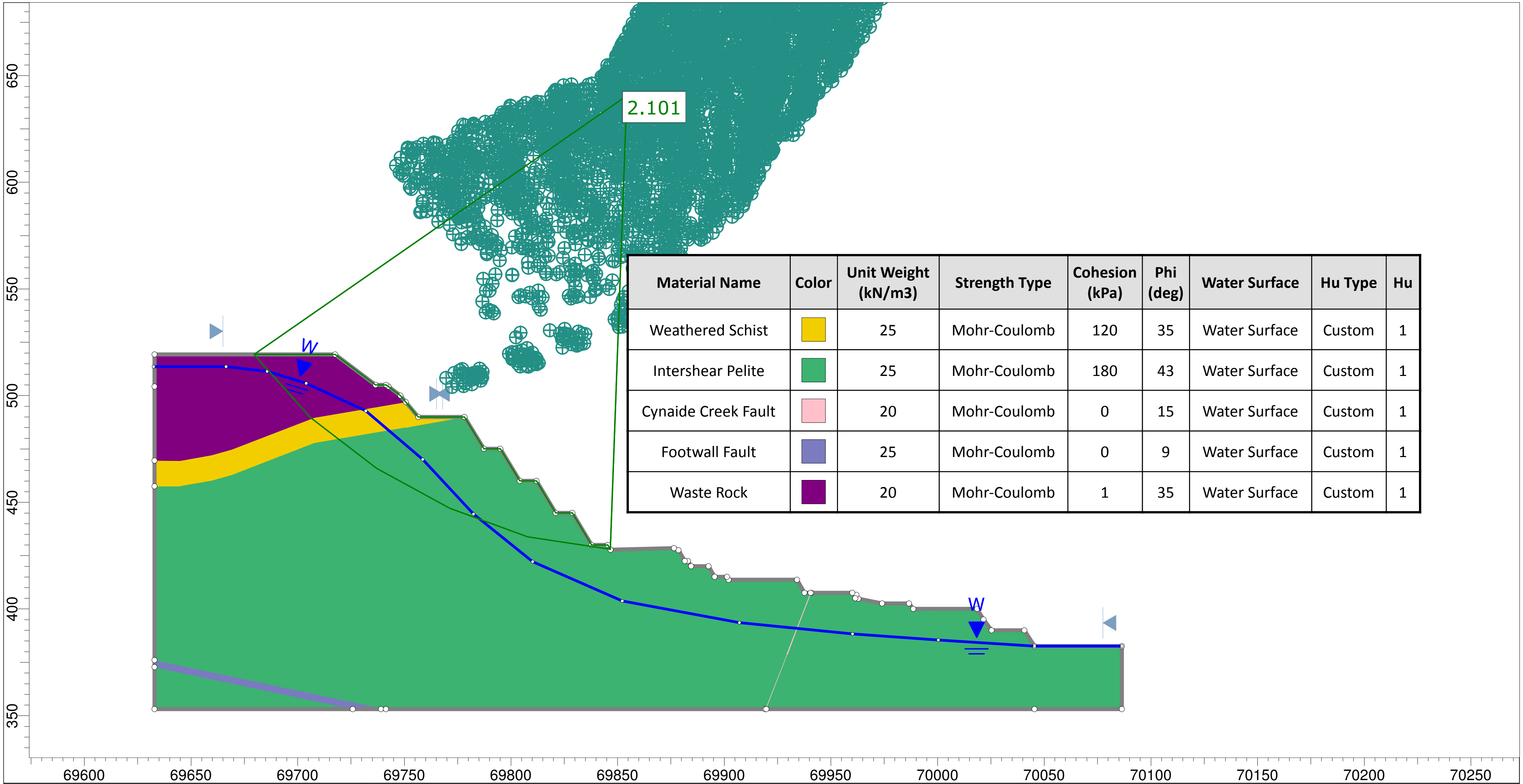

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Weathered Schist		25	Mohr-Coulomb	120	35	Water Surface	Custom	1
Intershear Pelite		25	Mohr-Coulomb	180	43	Water Surface	Custom	1
Cynaide Creek Fault		20	Mohr-Coulomb	0	15	Water Surface	Custom	1
Footwall Fault		25	Mohr-Coulomb	0	9	Water Surface	Custom	1
Waste Rock		20	Mohr-Coulomb	1	35	Water Surface	Custom	1

PSM Pells Sullivan Meynink
Engineering Consultants
Rock-Soil-Water

Client:	**OceanaGold Corporation**
Project:	**Macraes Mine - Deepdell Closure**
Location:	
Analysis description:	**West Wall - Operational Stability - Waste Stack**

Job No:	By:	Date:	Scale:	Run:
PSM71	**DC**	**2/9/2018**	**1:2500**	**West1_Operational_Waste_Stack.slim**

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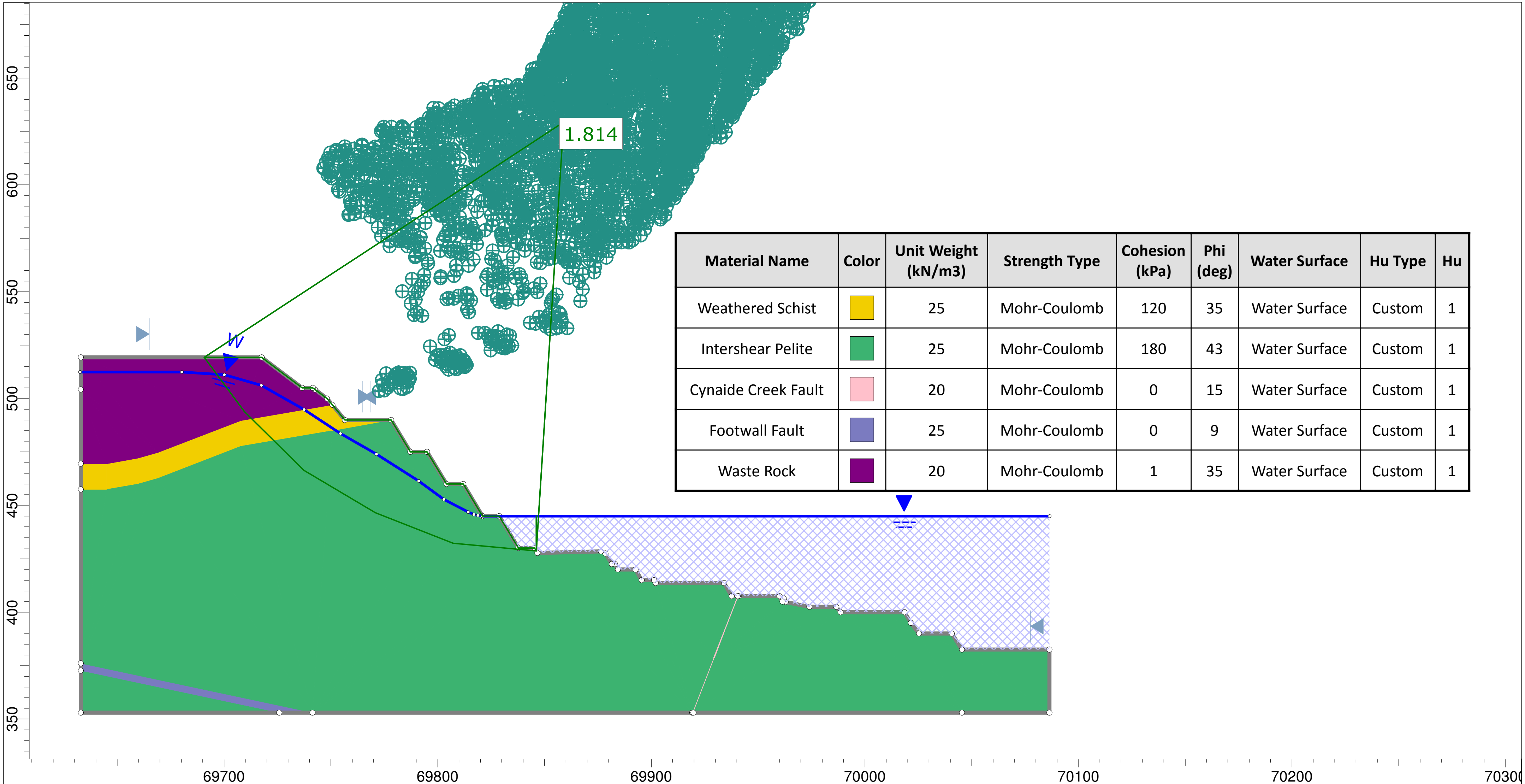

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Weathered Schist		25	Mohr-Coulomb	120	35	Water Surface	Custom	1
Intershear Pelite		25	Mohr-Coulomb	180	43	Water Surface	Custom	1
Cynaide Creek Fault		20	Mohr-Coulomb	0	15	Water Surface	Custom	1
Footwall Fault		25	Mohr-Coulomb	0	9	Water Surface	Custom	1
Waste Rock		20	Mohr-Coulomb	1	35	Water Surface	Custom	1

Pells Sullivan Meynink
Engineering Consultants
Rock-Soil-Water

Client: **OceanaGold Corporation**

Project: **Macraes Mine - Deepdell Closure**

Location:

Analysis description: **West Wall - Water Table 445mRL - Waste Stack**

Job No: **PSM71** | By: **DC** | Date: **2/9/2018** | Scale: **1:2500** | Run: **West1_closure_445mRL_Waste_Stack.slim**

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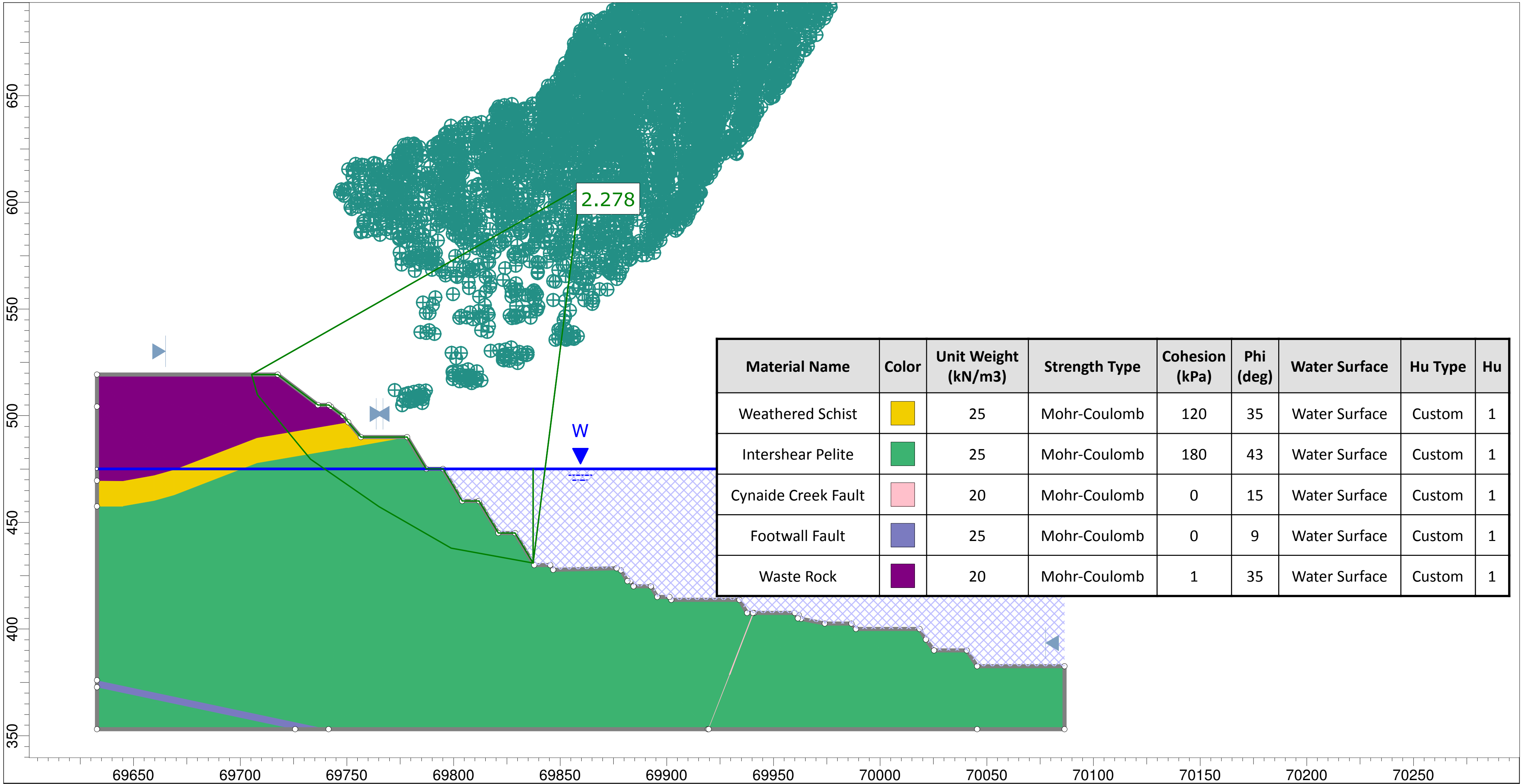

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Weathered Schist		25	Mohr-Coulomb	120	35	Water Surface	Custom	1
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Footwall Fault		25	Mohr-Coulomb	0	9	Water Surface	Custom	1
Waste Rock		20	Mohr-Coulomb	1	35	Water Surface	Custom	1

Pells Sullivan Meynink
Engineering Consultants
Rock-Soil-Water

Client:	**OceanaGold Corporation**
Project:	**Macraes Mine - Deepdell Closure**
Location:	
Analysis description:	**West Wall - Water Table 475mRL - Waste Stack**

Job No:	By:	Date:	Scale:	Run:
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Our Ref: PSM71-238L

12 June 2019

Planning Engineer
OceanaGold Corporation
Golden Point Road
RD3, Macraes Flat 9483
East Otago
NEW ZEALAND
Louie.Herrero@oceanagold.com

Attention: Louie Herrero

Dear Louie

RE: GEOTECHNICAL REVIEW OF UPDATED DEEPDELL STAGE 3 PIT

1. Introduction

This letter presents a geotechnical review of the proposed Deepdell Stage 3 Pit carried out by PSM at the request of Louie Herrero of OceanaGold Corporation (OceanaGold) (1). The proposed pit was recently slightly revised by OceanaGold. This letter therefore supplements our previous review of the pit (2). For ease of reference, sections of that previous review which remain applicable, such as the geological setting and geotechnical model, are reproduced herein.

There have been three prior phases of mining at Deepdell; the Stage 1 and 2 pits plus the more prominent Deepdell south pit. The Stage 1 and 2 pits are partly backfilled with a waste rock. The proposed Stage 3 pit extends the Stage 1 and 2 pits to the east (Figure 1).

2. Scope

The following scope of work was carried out for this review.

- Slope stability analysis of the Deepdell Stage 3 pit design
- Geotechnical assessment of the interaction between the Deepdell pit and waste rock stack
- The analysis and assessment were done under three conditions:
  - Operational - during mining
  - Closure - post mining.
    - Scenario 1 – A pit lake forms to the lowest intersection point with the topography at the southern end of the pit, at approximately RL 445m
    - Scenario 2 – A pit lake fills to the lowest intersection point of the northern end of the pit, approximately at RL 475m.

(1) email from Louie Herrero to Robert Bertuzzi dated 15th May 2019
(2) Geotechnical review of Deepdell Pit Stage 3 Design, PSM71-224R, 16th February 2018

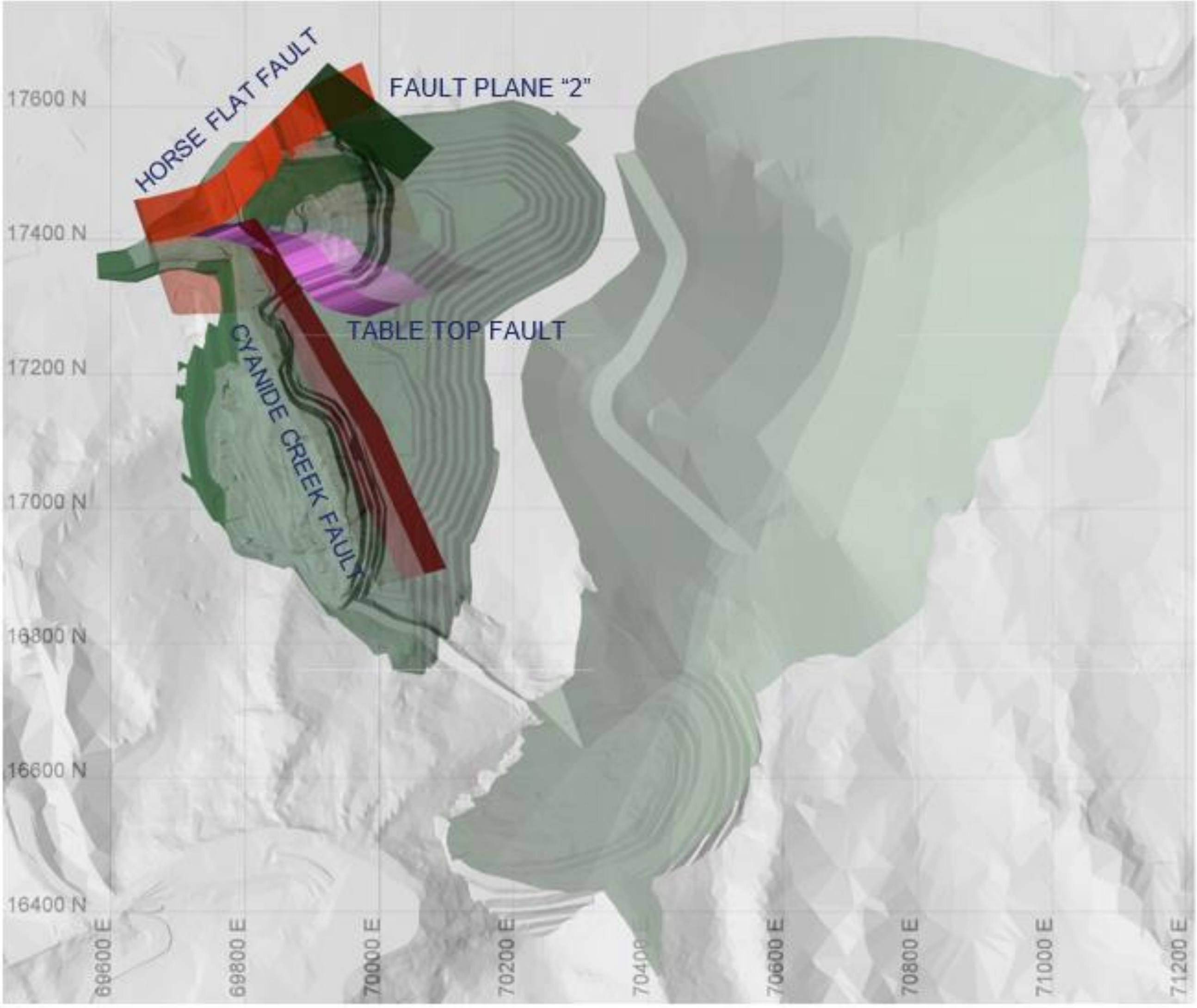

Figure 1: **Plan view of Deepdell's existing Stages 1 & 2 (in khaki shade) and the proposed Stage 3 pit shell (darker green) which overlies Stages 1 & 2. The adjacent rock waste stack is shown in a light shade to the east of the pit. The major faults encountered in Stage 1 and 2 pits are also shown.**

3. Supplied Information

OceanaGold supplied the following information for this review.

- Pit design (190327_DD_pit.dxf)
- Waste Rock Stack design (DDWRS East)
- Existing Surface (As_Built_surface.dxf)
- Mined out surface (As-Mined_surface.dxf).

4. Geotechnical Model

A detailed description of the geological setting and geotechnical model for Deepdell is presented in our previous review [2]. Below is a summary of the salient points.

The dominant structural trends at Deepdell are presented in the stereonet in Figure 2.

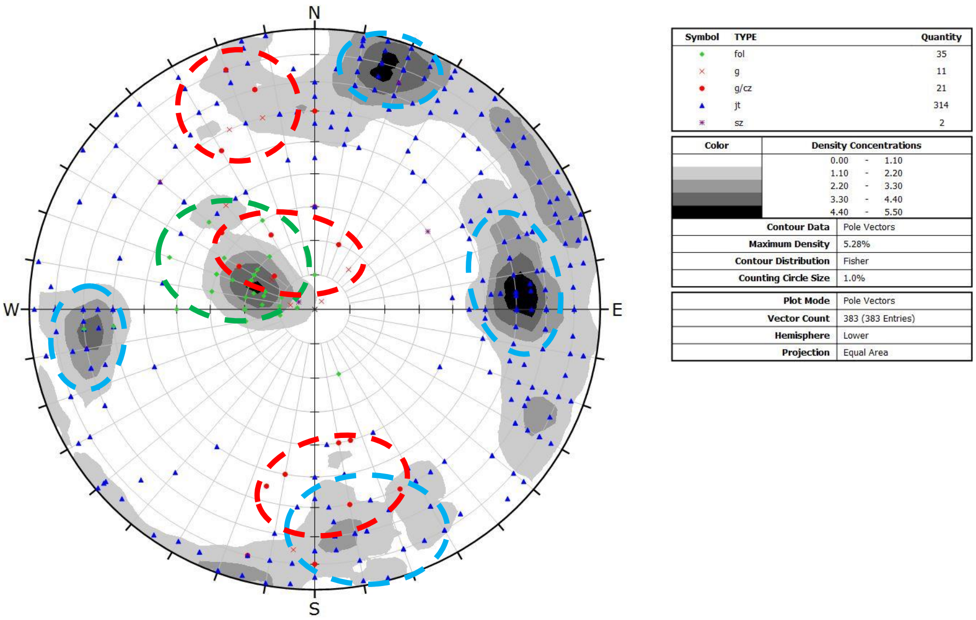

Figure 2: Stereonet illustrating the geological structure trends at Deepdell: foliation (green), joints (blue) and gouge / shear zones (red).

- Foliation dips at between 5° and 45° to the east / south east

  Macraes' experience is that foliation is typically not a controlling defect for pit wall stability
- Joints are typically sub vertical to steeply dipping to the south and west. Secondary sets dip steeply to sub vertical to the east and north

  Visible length typically in the range 0.5 – 1.5 m and continuous out of exposure. Spacing between joint planes typically ranges from <0.25 m to 0.75 m. The joints are mostly undulose on the large scale, rough on the small scale and tight. Experience from other pits at Macraes tends to indicate that the typical length of the majority of joints is less than 5 m.
- Three zones of gouge / crushed rock and shearing are apparent:
  - The first is flat to moderately dipping to the south to southeast, although a small number of defects are indicated as dipping to the southwest
  - The second is moderately to steeply dipping to the southeast
  - The third dips moderately to steeply to the north but is poorly defined. These structures are favourably orientated with respective to the pit walls as they dip approximately perpendicular to the major wall aspects.

  Visible length typically in the range of 1.0 to 5 m, and continuous out of exposure. The defects are undulose on the large scale and smooth on the small scale. The typical infill type is gouge/rock fragments and is moist to damp. Infill thicknesses are variable; however, appear to be typically in the ranges of 20 to 50 mm and 200 to 500 mm.

Major geological structures at Macraes are the Footwall Fault (FF) and Hanging Wall Shear (HWS). The FF maintains a relatively consistent orientation and has a dip and dip direction in Deepdell of approximately 12° / 075°. The FF will be approximately 90 m beneath the proposed Stage 3 pit. A cross section illustrating this geometry is included in Figure 3.

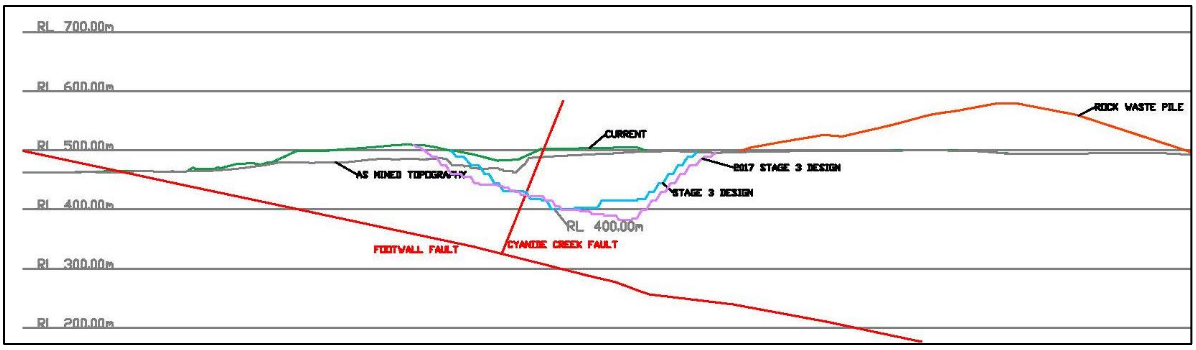

Figure 3: West-east section through the deepest part of the proposed Stage 3 pit at approximately 17200 mN. The distance between the FF and the pit is more than 90 m.

5. Slope Design

The proposed Stage 3 pit focusses on developing the prior Stages 1 and 2 pits towards the east.

- The pit floor deepens by approximately 70 m
- The northern wall lengthens but with a favourable slope aspect (180°)
- The eastern wall minimises orientations which have proved to be more susceptible to slope instability
- There is effectively no southern wall.

The slope design for the Stage 3 pit follows that successfully used in Deepdell South, namely:

- Batters in the weathered / oxide material are 10 m high and 60° all around the pit
- 15 m high, 60° batters with 7.5 m berms for the northern and eastern walls, resulting in a 43° inter-ramp slope angle (3)
- 70° batters and 5 m berms for the southern and western walls, resulting in a 55° inter-ramp slope angle. In practice, the west wall is much shallower (23 to 38°) as it follows the ore zone.

This design is consistent with the kinematic and statistical analyses which were carried out in our previous review (2) for the eastern wall and are presented in Table 1.

Kinematic analysis is a stereographic based technique that considers the mean orientation of defect sets, the slope orientation, the defect shear strength and potential failure modes. It is an assessment of the geometrical possibility of simple block movements, i.e. planar sliding, wedge failure and toppling. Statistical analysis extends this by considering the scatter in defect dip and orientation.

Table 1 - Results of kinematic and statistical analyses

WALL	SLOPE ASPECT (°)	FAILURE MECHANISM	KINEMATIC ANGLE (°)	STATISTICAL ANGLE (°)	
				BATTER	INTERRAMP
East	200	Planar sliding on joints	78	55 – 66	48
	255	Planar sliding on joints	65	54 – 61	50
	285	Planar sliding on joints	62	55 – 62	50

(3) inter-ramp slope angles are defined as toe-to-toe

6. Material Properties

6.1 Rock mass

There are two main approaches to estimate rock mass strengths; back-analyse failures and rock mass classification. The rock mass strengths used by PSM in studies at Macraes are based on back-analyses and the GSI [(4)] / Hoek-Brown classification (Table 2). Uncertainty in these properties is catered for by including variability. In most analyses this is done by way of normal distributions based on the mean ± standard deviation.

Table 2 - Rock mass strength properties used at Macraes

Material	Unit Weight (kN/m^3) mean ± sd, range	Cohesion (kPa) mean ± sd, range	Friction Angle (°) mean ± sd, range
Weathered schist	25 ± 1	120 ± 10, 70 – 140	35 ± 2, 30 – 40
Hanging wall schist	25 ± 1	400 ± 70, 200 – 600	45 ± 2, 35 – 48
Inter-shear pelite (Hyde-Macraes Shear Zone)	25 -3 +2, 22 - 27 25 ± 1	180 -15 +25, 170 – 205 200 ± 25, 100 – 250	43 -5 +2, 38 – 45 43 ± 2, 35 – 45
FF	25 ± 1	0	9
Footwall psammite	25 ± 1	1000	50

For comparison, Bertuzzi et al (2017) [(5)] suggested typical values of GSI [(6)] for the schist encountered at Macraes:

- GSI = 75 (70 to 80): Class A schist - lithified rock with frequent defects and rare shearing
- GSI = 60 (45 to 70): Class B schist - fractured rock with frequent defects and some shearing
- GSI = 30 (25 to 35): Class C schist - fractured to fragmented rock with frequent shearing
- GSI = 15 (12 to 20): Class D schist - fragmented/sheared rock.

The weathered schist can be thought of as equivalent to Class C and the inter-shear pelite as Class B / Class C. The GSI / Hoek-Brown system would lead to the greater strengths than the values used at Macraes (refer to Table 3).

Table 3 – GSI / Hoek-Brown estimate of rock mass strength

Rock mass	UCS (MPa)	GSI / mi	Cohesion (kPa) / Friction Angle (°)	
			GSI / Hoek-Brown	Adopted
Weathered schist	10	30 / 12	200 / 34	120 / 35
Inter-shear pelite	25	55 / 12	570 / 49	180 / 43 or 200 / 43
		30 / 12	275 / 40	

[(4)] Geological Strength Index
[(5)] Bertuzzi R, Douglas K, Mostyn G. Comparison of quantified and chart GSI for four rock masses, Engineering Geology 202 (2016), pp 24–35
[(6)] Geological Strength Index

6.2 Waste rock

In 2013 a study of the waste rock stacks at Macraes was carried out to address the absence of site specific data [(7)]. Rill angles, which can be considered as lower bound estimates of friction angle, were observed as; 35 to 38° for fresh schist, 34 to 35° for sheared pelite and 29 to 34° for oxidised schist. Published literature suggests friction angles in the order of 45 to 35 °, decreasing as a function of increasing normal pressure and increasing cohesion (Figure 4). Others for different work at Macraes have utilised such a relationship, e.g. shear strength = 1.29 x normal stress [(8)].

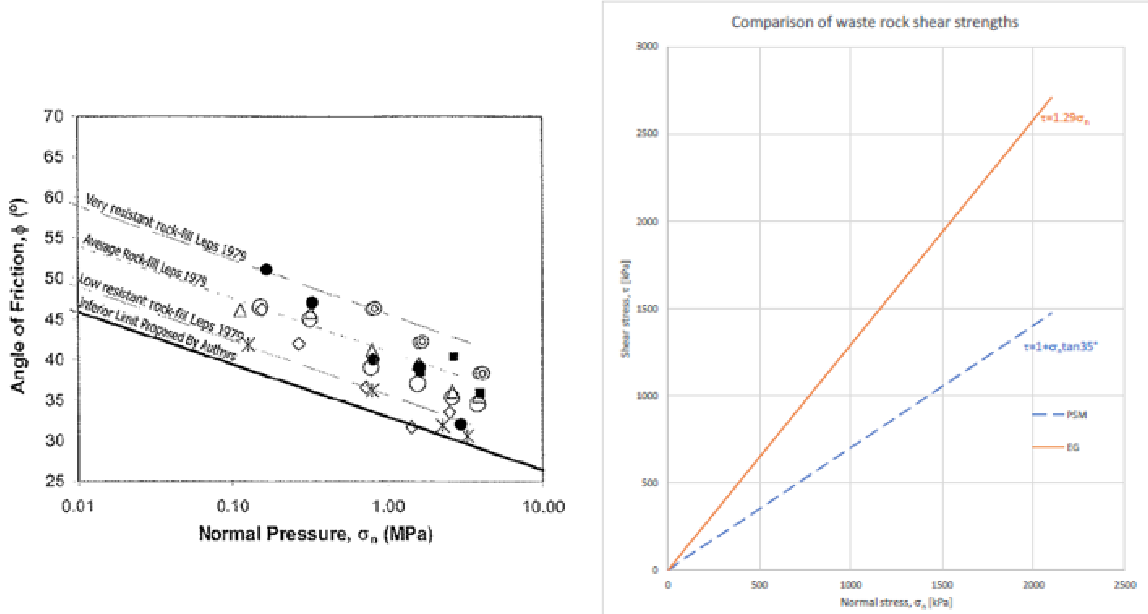

Figure 4: Left chart: Friction angle as a function of normal stress within a rock fill from Linero et al (2007) [(9)] reported in 2013 study [()]. Right chart: comparison of adopted shear strength.

As the waste rock stack is physically only a minor part of the stability analysis for this review, adopting a conservative shear strength for it does not impact on the design. Hence, conservative Mohr-Coulomb parameters of c’ = 1 kPa and ϕ’ = 35° for the shear strength of waste rock used (Figure 4).

6.3 Summary

The relevant materials for the proposed Deepdell Stage 3 pit are the inter-shear pelite which is overlain by a thin layer of weathered schist. In this case, as the weathered schist has minor influence on overall stability only typical values are used for it. The properties adopted for this review are presented in Table 4.

Table 4 – Adopted rock mass strength properties

Material	Unit Weight (kN/m^3) mean ± sd, range	Cohesion (kPa) mean ± sd, range	Friction Angle (°) mean ± sd, range
Waste rock	20	1	35
Weathered schist	25	120	35
Inter-shear pelite	25 -3 +2, 22 - 27	180 -15 +25, 170 – 205	43 -5 +2, 38 – 45

(7) Coronation waste rock stack stability, PSM71-135L Rev C dated 28th March 2013: Waste dump study, PSM71-145R dated 1st May 2013
(8) e.g. Engineering Geology
(9) Linero. S., Palma. C., & Apablaza. R. (2007) Geotechnical Characterisation of Waste Material in Very High Dumps with Large Scale Triaxial Testing, Australian Centre for Geomechanics, Perth.

7. Earthquake

Previous earthquake scenario assessments undertaken for the Macraes pits concluded that a hypothetical and conservatively worse-case of an M4.5 earthquake on the Macraes Fault (i.e. at a distance of 0 km to the mine), yielded a peak ground acceleration (PGA) of 0.13g [(10,11)].

The 0.13g PGA is adopted in stability analyses as the operating basis earthquake (OBE) as it corresponds to an earthquake of 150-year return period at the mine site according to Litchfield et al (2005) [(12)]. The maximum design earthquake (MDE) has an equivalent peak ground acceleration of 0.65g, which is applicable to 1 in 2500-year return event [(12)].

No amplification factor is applied. Earthquake amplification depends on many factors including topography, material stiffness and thickness. Normally, amplification factors are introduced when the structure is founded on soils. In this case, the waste rock stack is founded on *in situ* rock and the open pit slope is within *in situ* rock. Hence, no amplification factor is warranted.

8. Acceptance Criteria

8.1 Static

Minimum values of the Factor of Safety (FoS) were adopted as the acceptance criteria as provided in Table 9.9 of Read & Stacey 2009, Open Pit Slope Design [(13)].

- FoS ≥ 1.2 as commonly accepted for mining applications
- FoS ≥ 1.5 for pit closures.

8.2 Earthquake

A pseudo-static FoS ≥ 1.0 is the target when assessing earthquakes. Should the pseudo-static FoS be less than 1.0, additional analyses will be carried out to assess the magnitudes of displacements predicted to occur under the seismic loading. These additional analyses will follow the method of Bray and Travasarou [(14, 15)] which was developed from a large suite of numerical simulations calibrated against observed seismic slope performance.

During an earthquake, the seismic force may act in one direction for only a few tenths of a second before its direction is changed. The result is a series of pulses. For every pulse that exceeds a critical value, which is dependent on the site conditions, some small amount of permanent displacement will occur. In the Bray and Travasarou method, it is acceptable to select a seismic coefficient (k) that is a fraction of the maximum seismic demand (PGA) because exceeding the maximum seismic resistance for a few instances leads only to minor seismic displacement. Satisfactory performance is therefore determined by whether or not the accumulated displacement is tolerable.

The California Geological Survey (2008) guidelines for mitigating seismic hazards [(16)] state that for natural slopes, predicted displacements:

- Less than 15 cm are unlikely to correspond to serious landslide movement and damage
- Between 15 - 100 cm could be serious enough to cause stress loss and failure
- Greater than 100 cm are very likely to correspond to damaging slide movement.

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(10) Assessment of earthquake effects on pit walls, PSM71-215R dated 6th May 2017
(11) Assessment of 10-year return period earthquake effects on pit walls, PSM71-216R dated 22nd May 2017
(12) Litchfield N, McVerry G, Smith W, Berryman K and Stirling M. Seismic study for tailings embankments at Macraes Gold Project. Institute of Geological and Nuclear Sciences, Client report 2005/135, October 2005
(13) Guidelines for open pit slope design, Ed. Read & Stacey, CRC Press, 2009.
(14) Bray JD, Travasarou T, 2007. Simplified procedure for estimating earthquake-induced deviatoric slope displacements. Journal of Geotechnical and Geoenvironmental Engineering, ASCE, April 2007, pp. 381-392
(15) Bray JD, Travasarou T, 2009. Pseudostatic Coefficient for Use in Simplified Seismic Slope Stability Evaluation. J. of Geotechnical and Geoenv. Engineering, ASCE, 135(9), 2009, 1336-1340
(16) Jibson RW, 2011. Methods for assessing the stability of slopes during earthquakes—A retrospective: Engineering Geology, v. 122, p. 43-50

These guidelines are for natural slopes and are likely to be conservative for open pit rock slopes. Published literature indicates that open pit rock slopes are not significantly impacted by earthquakes ([13, 17, 18]).

Assuming the allowable accumulated displacement during an earthquake is 100 cm for the open pit rock slope, the equivalent seismic coefficient for the MDE is k = 0.14g following the Bray and Travasarou method.

9. Limit Equilbruim Analysis

9.1 Models

The limit equilibrium analyses were carried out using RocScience's Slide software. The critical slip surfaces were found by the software.

Five sections through the proposed Deepdell Stage 3 pit are used to assess slope stability of the eastern wall and the interaction between the pit and the waste rock stack. The locations of the sections are shown in Figure 5. The sections themselves are shown in Figure 6. Two of the sections – B & E – are also used to assess the overall slope stability of the northern and western walls, respectively.

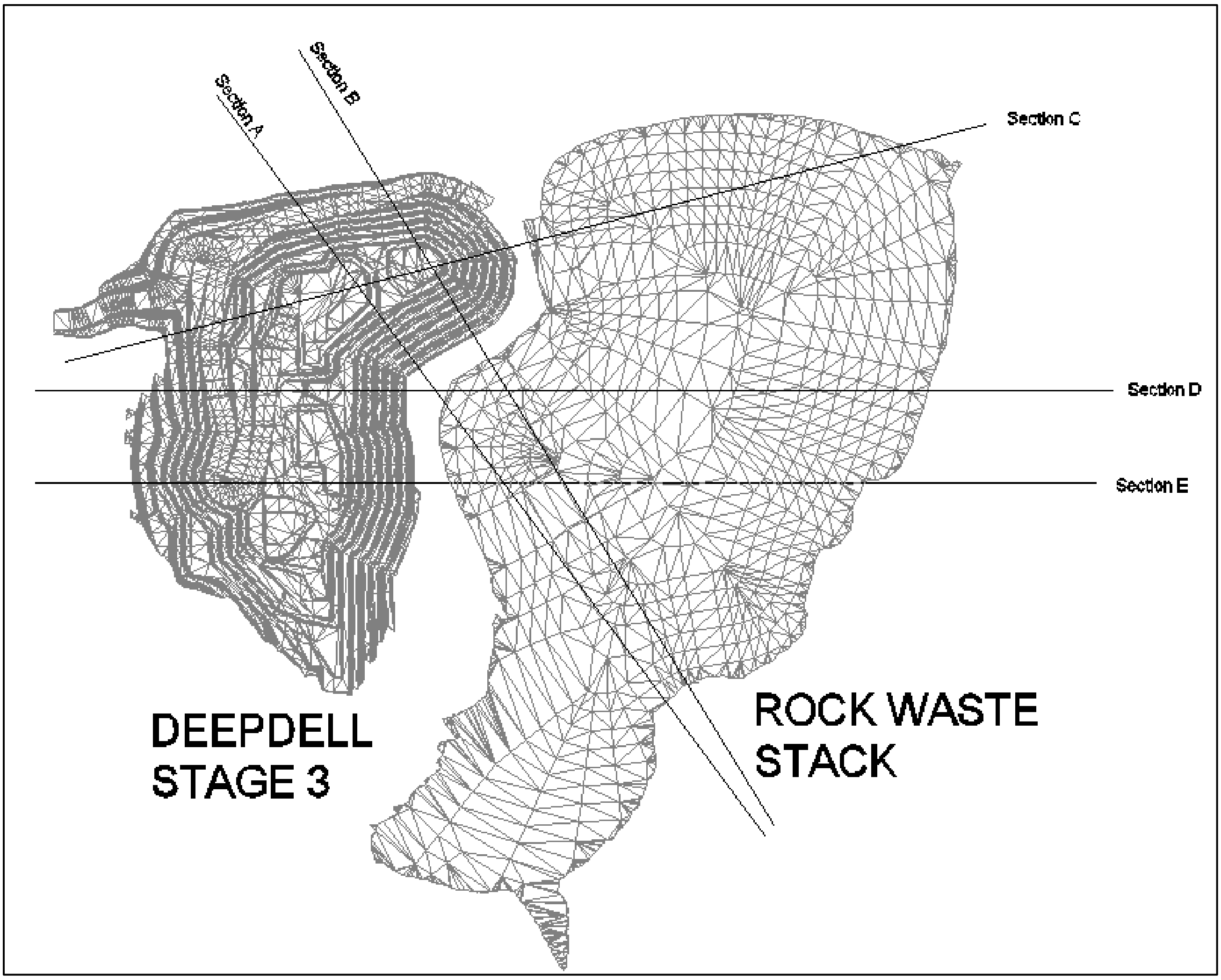

Figure 5: Plan view of the Deepdell Stage 3 design and adjacent rock waste stack showing sections lines considered for limit equilibrium stability analysis.

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[17] Lorig L, 2016. Designing for extreme events in open pit slope stability. Journal of the Southern African Institute of Mining and Metallurgy, 116(5), pp.387-398

[18] Azhari A, 2016. Evaluating the effects of earthquakes on open pit mine slopes, PhD Thesis, Colorado School of Mines

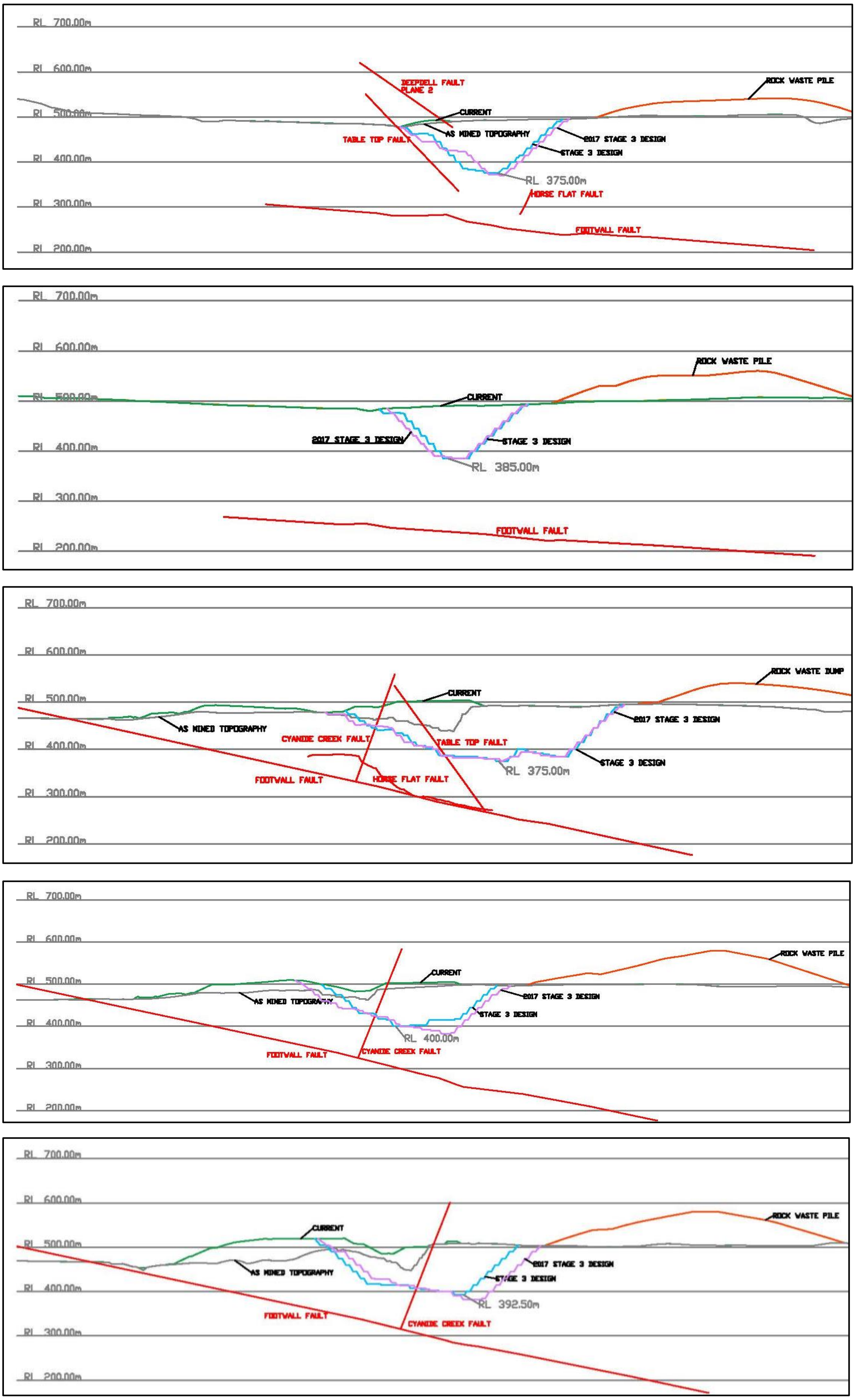


Figure 6: Sections A, B, C, D & E (top to bottom) though the Deepdell Stage 3 design and adjacent rock waste stack.

Groundwater pressures were included in the analyses by adopting conservatively high groundwater surfaces, as shown in Figure 7 for example.

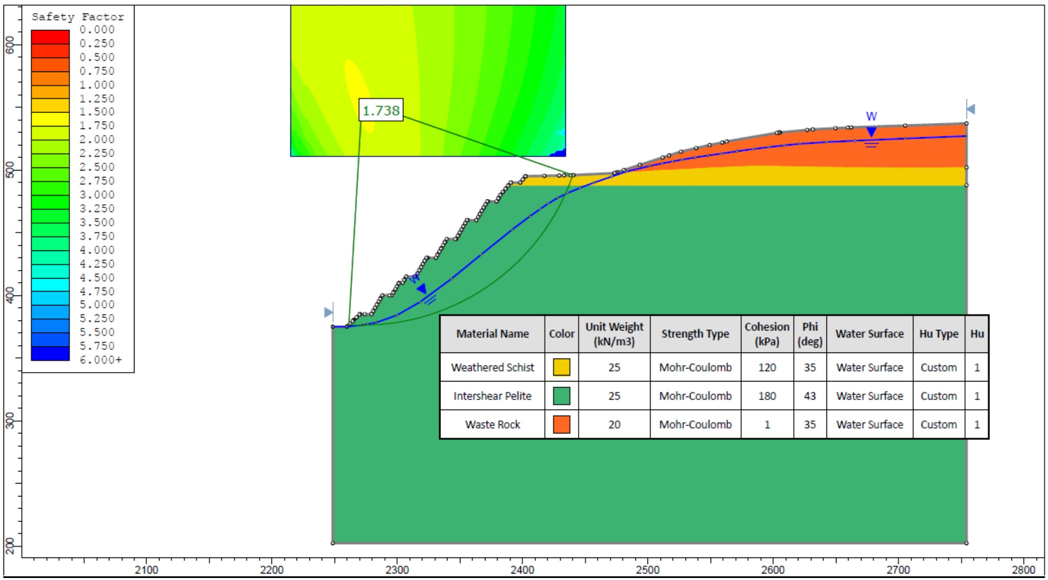


Figure 7: Example of Slide analysis showing the assumed high groundwater surface.

9.2 Results

9.2.1 Static

The results of the limit equilibrium analyses are presented in Appendix A and summarised in Table 5. Minimum FoS for all the deterministic cases exceeds 1.5.

The minimum FoS of 1.47 and 1.49 for the sensitivity analyses of the pit closure scenario 1 case (RL 425 m lake level), were obtained with the lower bound friction angle of 38°. Considering that these results are for the lower bound sensitivity analyses and the general conservatism built into the model (strength properties, groundwater load) the 2% difference in the minimum FoS from 1.5 is inconsequential.

Table 5 – Results of LE analyses

Section	Case	Lake Level (mRL)	Minimum FoS	
			Deterministic	Sensitivity
A – East wall	Operational	0	1.74	1.55
	Closure Scenario 1	425	1.76	1.55
	Closure Scenario 2	475	2.09	1.87
B – East wall	Operational	0	1.81	1.58
	Closure Scenario 1	425	1.72	1.53
	Closure Scenario 2	475	2.11	1.88
B – North wall	Operational	0	1.77	1.56
	Closure Scenario 1	425	1.74	1.55
	Closure Scenario 2	475	2.25	2.03
C – East wall	Operational	0	1.64	1.45
	Closure Scenario 1	425	1.66	1.47
	Closure Scenario 2	475	1.98	1.78

Section	Case	Lake Level (mRL)	Minimum FoS	
			Deterministic	Sensitivity
D – East wall	Operational	0	2.09	1.87
	Closure Scenario 1	425	2.00	1.78
	Closure Scenario 2	475	2.26	2.05
E – East wall	Operational	0	1.89	1.68
	Closure Scenario 1	425	1.83	1.62
	Closure Scenario 2	475	2.01	1.80
E – West wall	Operational	0	1.67	1.49
	Closure Scenario 1	425	1.67	1.49
	Closure Scenario 2	475	1.84	1.60

9.2.2 Waste rock stack

The analyses presented in Appendix A did not identify minimum FoS for failure paths in the waste rock stack. The overall slope of the waste rock stack is less than 18°, typically 15°. A failure path confined to the face of the waste rock stack, is the infinite slope problem with the FoS calculated as the ratio of the friction angle to the slope (ignoring any benefit of cohesion). That is FoS ≥ tan 35° / tan 18° ≥ 2.16. The FoS for slip circles that pass through the waste rock stack, and not just along its surface, will therefore be greater than 2.16, i.e. above the acceptance criteria.

9.2.3 Earthquake

The effects of earthquakes were assessed by applying horizontal accelerations to the models in a pseudo-static analysis. Section C was used for the assessment as it provided the lowest static FoS (all other sections would yield higher FoS). The results are presented in Appendix B and summarised in Table 6.

Table 6 – Results of LE analyses of earthquake loading

Section	Case	Lake Level (mRL)	Seismic coefficient (g)	Minimum FoS
C – East wall	Operational	0	0.13	1.32
	Closure Scenario 1	425	0.65	0.56*
			0.14	1.29
	Closure Scenario 2	475	0.65	0.55*
			0.14	1.44

* FoS < 1.0 means permanent displacement will occur under this seismic event

The FoS for the operational cases, i.e. OBE (0.13g) and amplified OBE (0.2g), exceed 1.0. The FoS for the closure scenarios under the MDE (0.65g) is less than 1.0 which indicates that permanent displacement of the slopes is expected. Hence, additional analyses were carried out using the Bray and Travasarou method [14,15] Accepting a permanent displacement of 100 cm gives a resultant seismic coefficient of 0.14g. The FoS results with 0.14g exceed 1.0 and hence meet the acceptance criterion.

10. Conclusions

This letter presents the results of a geotechnical review of the Deepdell Stage 3 pit design including the interaction between the pit and waste rock stack. Slope stability was assessed for the expected conditions during mining as well conditions post mining. This includes two pit lake levels. The impacts of a 1 in 150-year seismic event occurring during mining and of a 1 in 2500-year seismic event occurring post-mining were assessed.

The results of the analyses for the proposed pit during mining and closure are in keeping with the acceptance criteria.

The results of the analyses suggest that should a 1 in 2500-year earthquake effect Deepdell, then permanent displacement in the order of 100 cm will occur but the slopes will remain stable.

The risk of landslides triggering a wave-overtopping event in the pit lake is negligible because the open pit rock slopes are stable under earthquake events.

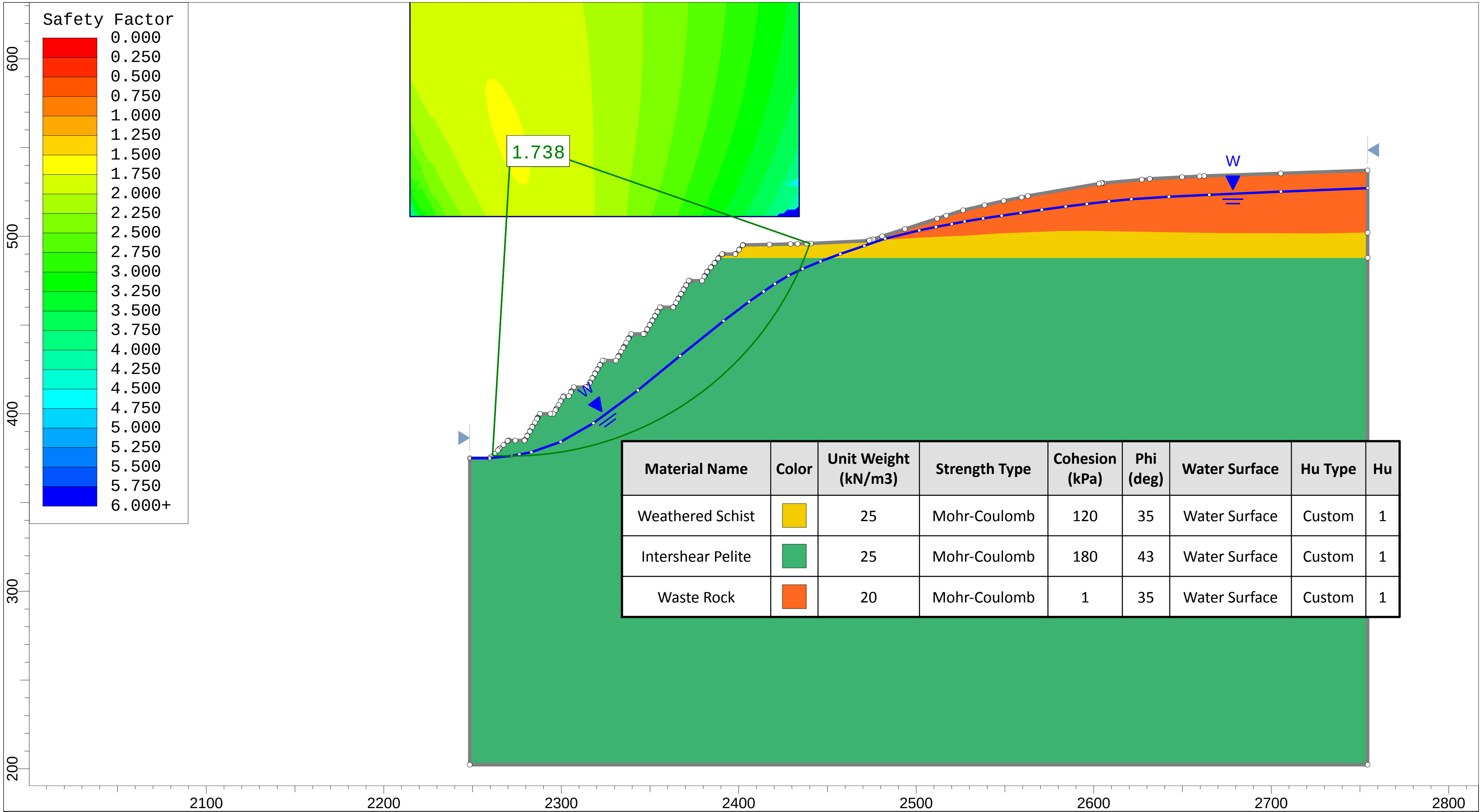
We trust this letter is in keeping with your requirements.

For and on behalf of

PELLS SULLIVAN MEYNINK

ROBERT BERTUZZI
PRINCIPAL

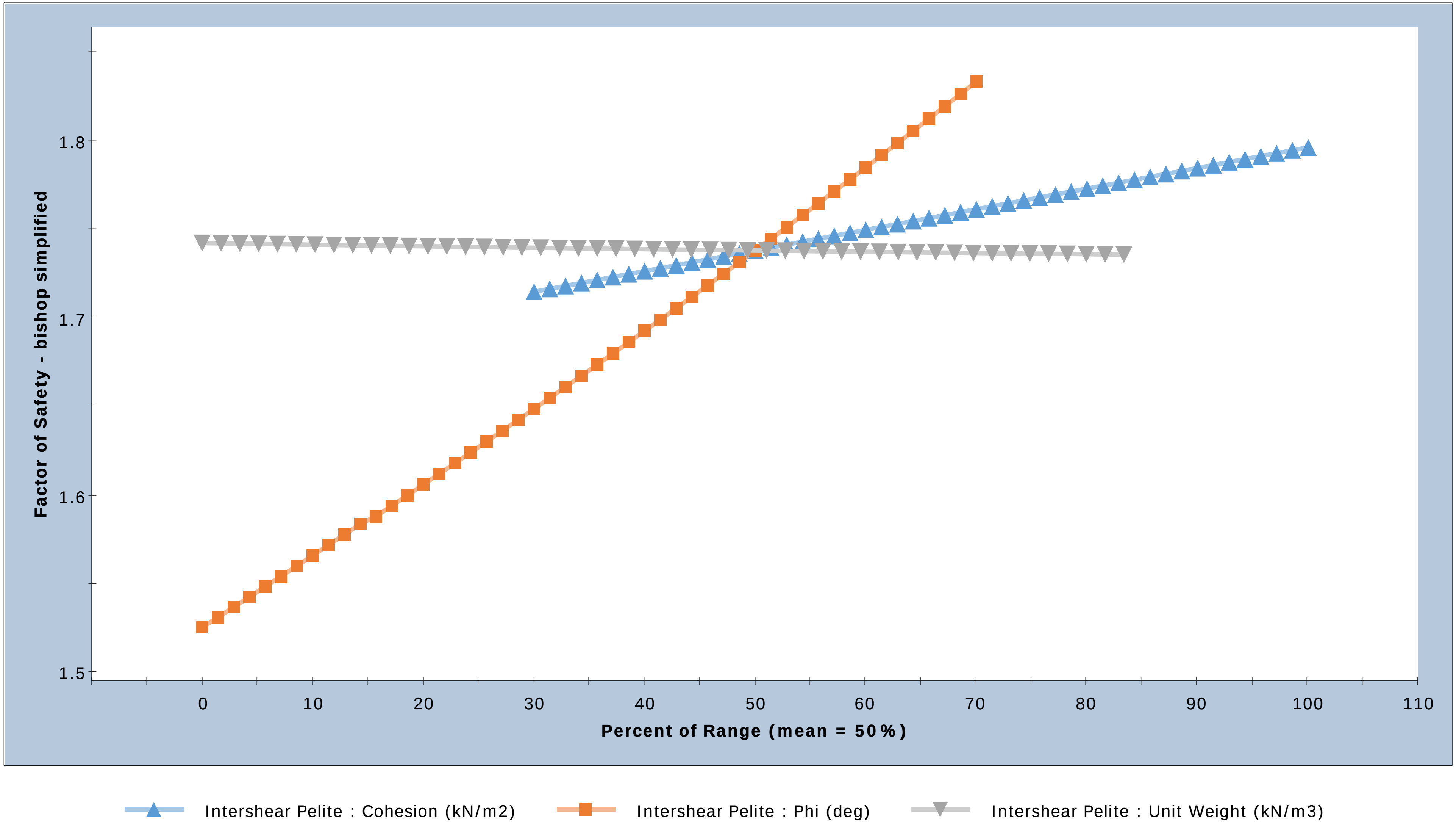
Appendix A
Results of Slide Analyses – Static Cases



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Weathered Schist		25	Mohr-Coulomb	120	35	Water Surface	Custom	1
Intershear Pelite		25	Mohr-Coulomb	180	43	Water Surface	Custom	1
Waste Rock		20	Mohr-Coulomb	1	35	Water Surface	Custom	1

SLIDEINTERPRET 8.010

Project	Macraes Mine - Deepdell CLosure
Analysis Description	East Wall - Operational Stability
Drawn By	GF
Scale	1:3000
Company	OceanaGold Corporation
Date	23.05.2019
File Name	Section A - Operational Stability.slmd



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	Analysis Description	East Wall - Operational Stability		
	Drawn By GF	*Scale*	*Company*	OceanaGold Corporation
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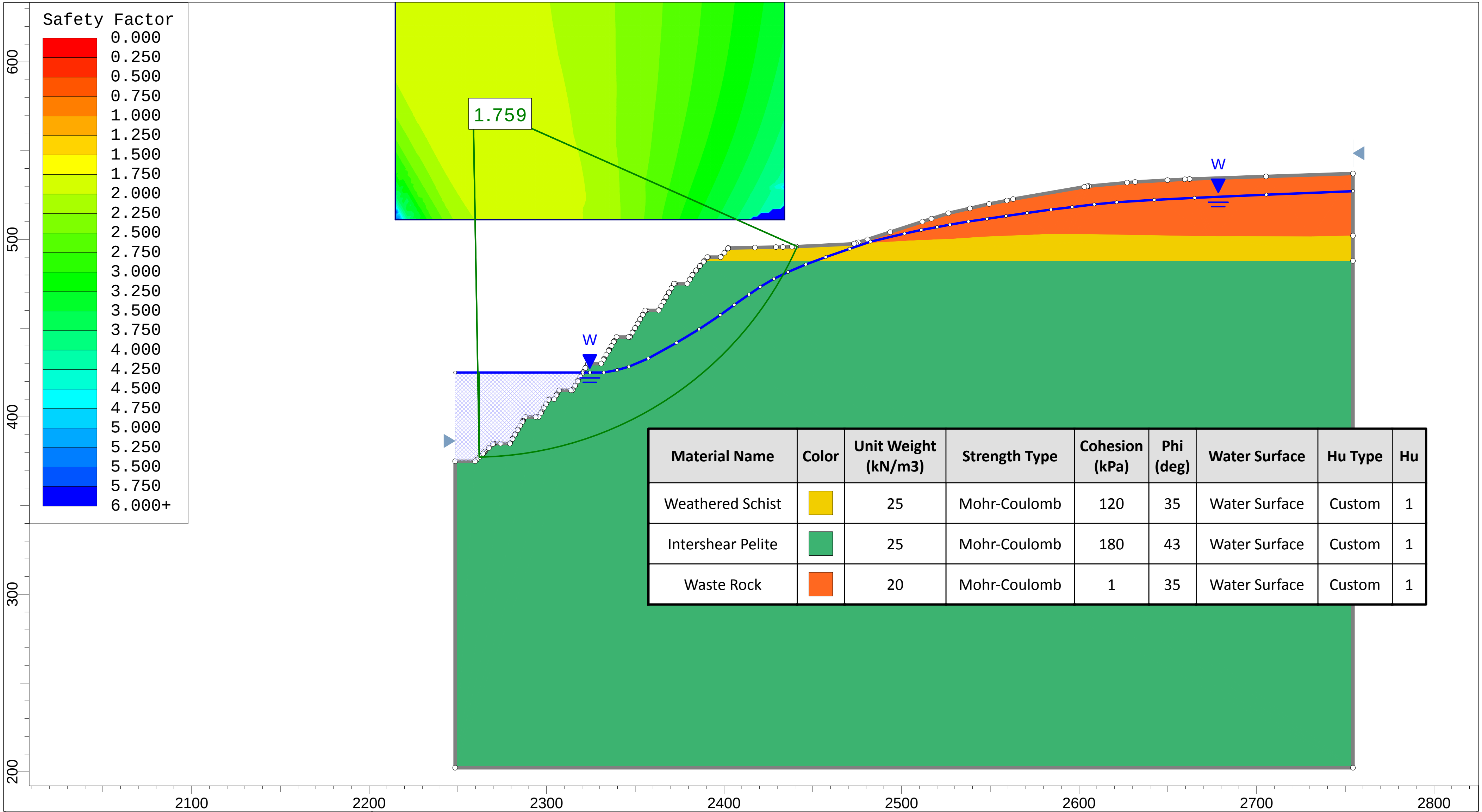

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
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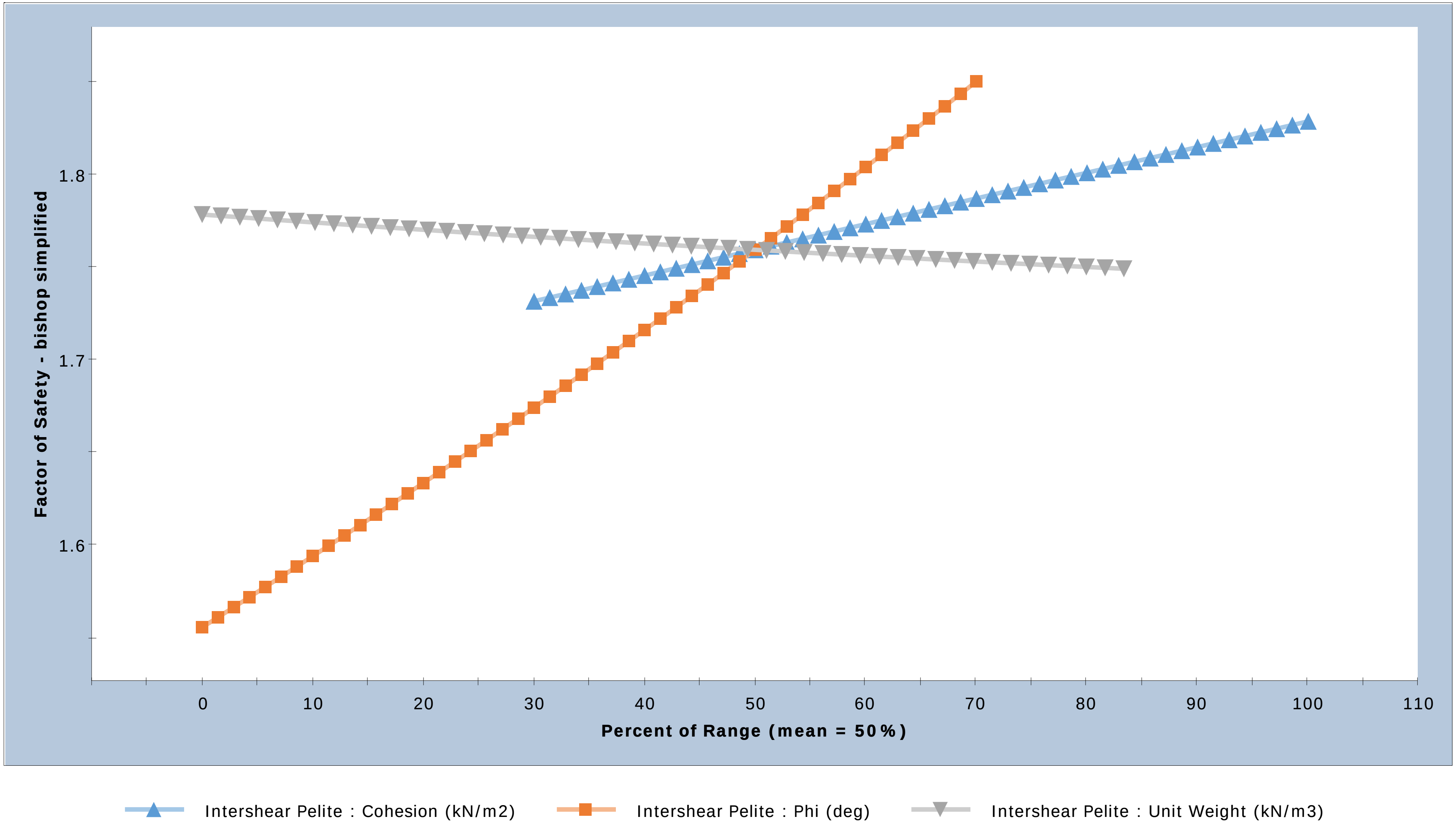
Waste Rock		20	Mohr-Coulomb	1	35	Water Surface	Custom	1

PSM

SLIDEINTERPRET 8.010

Project	Macraes Mine - Deepdell CLosure
Analysis Description	East Wall - Closure Scenario 1
Drawn By	GF
Scale	1:3000
Company	OceanaGold Corporation
Date	23.05.2019
File Name	Section A - Closure Scenario 1.slmd



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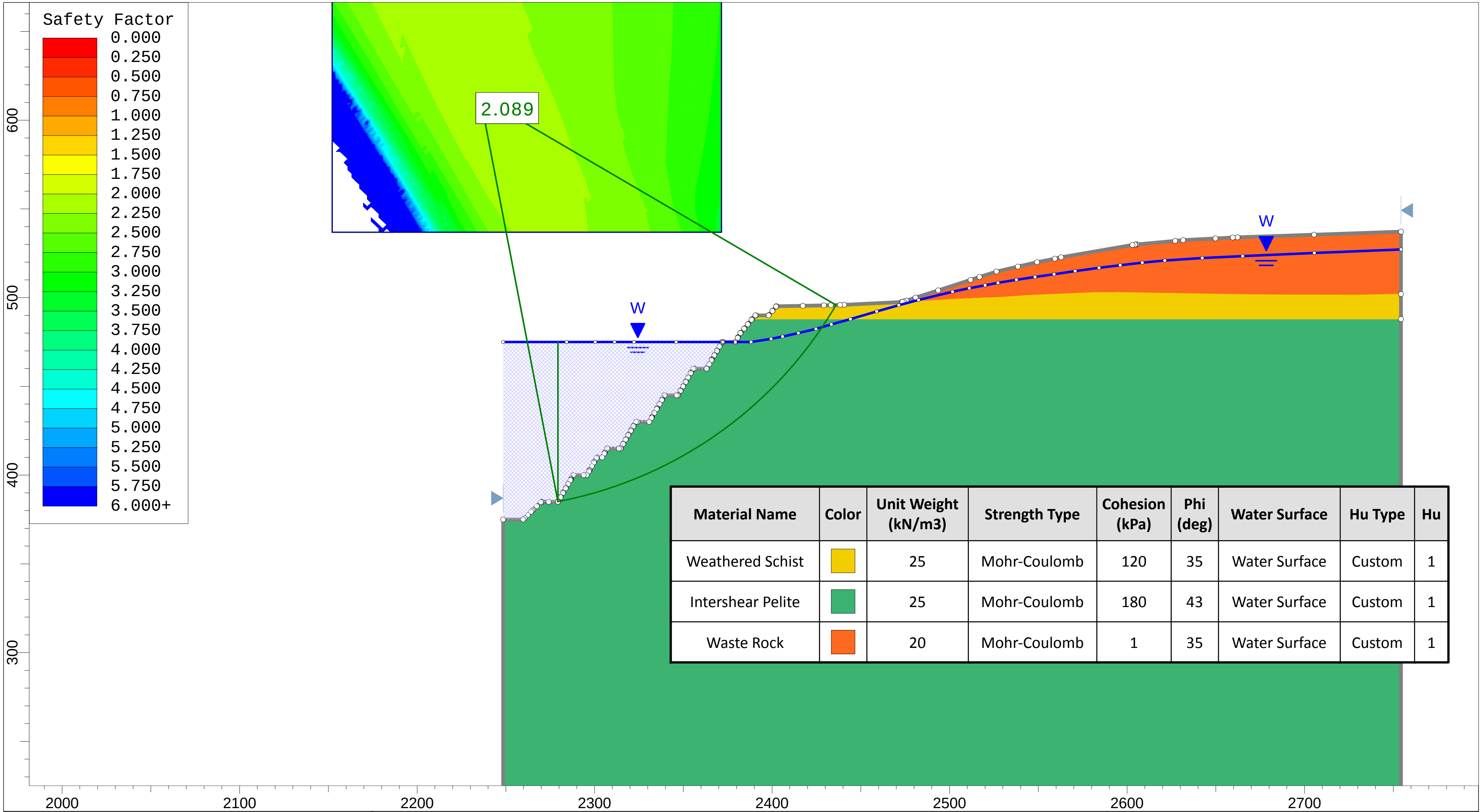
Analysis Description	East Wall - Closure Scenario 1		
Drawn By GF	*Scale*	*Company*	OceanaGold Corporation
Date 23.05.2019		*File Name*	Section A - Closure Scenario 1.slmd

SLIDEINTERPRET 8.010



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
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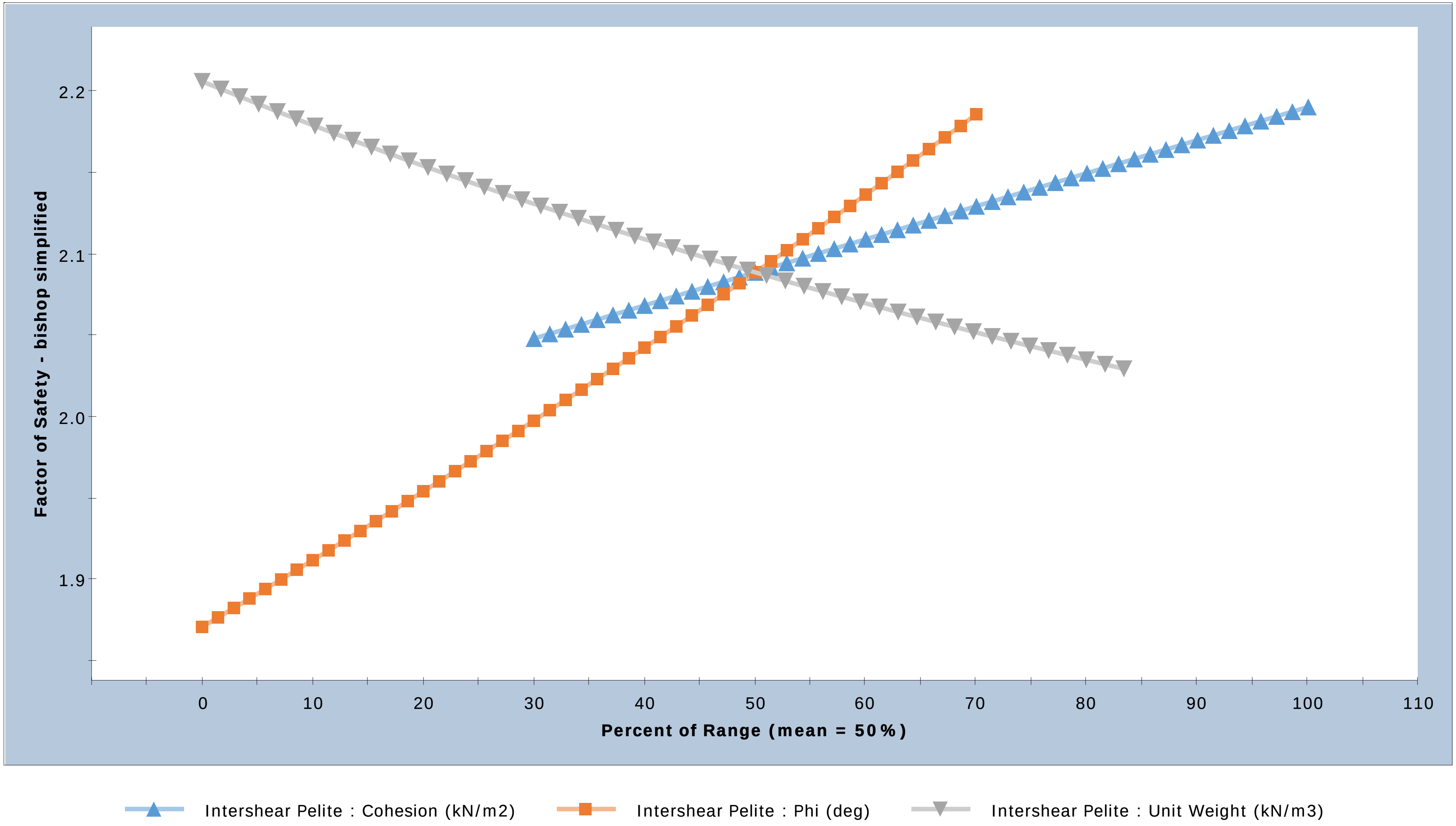
SLIDEINTERPRET 8.010

Project	Macraes Mine - Deepdell CLosure		
Analysis Description	East Wall - Closure Scenario 2		
Drawn By	GF	*Scale*	1:3000
Company	OceanaGold Corporation		
Date	23.05.2019	*File Name*	Section A - Closure Scenario 2.slmd



PSM	*Project* Macraes Mine - Deepdell CLosure		
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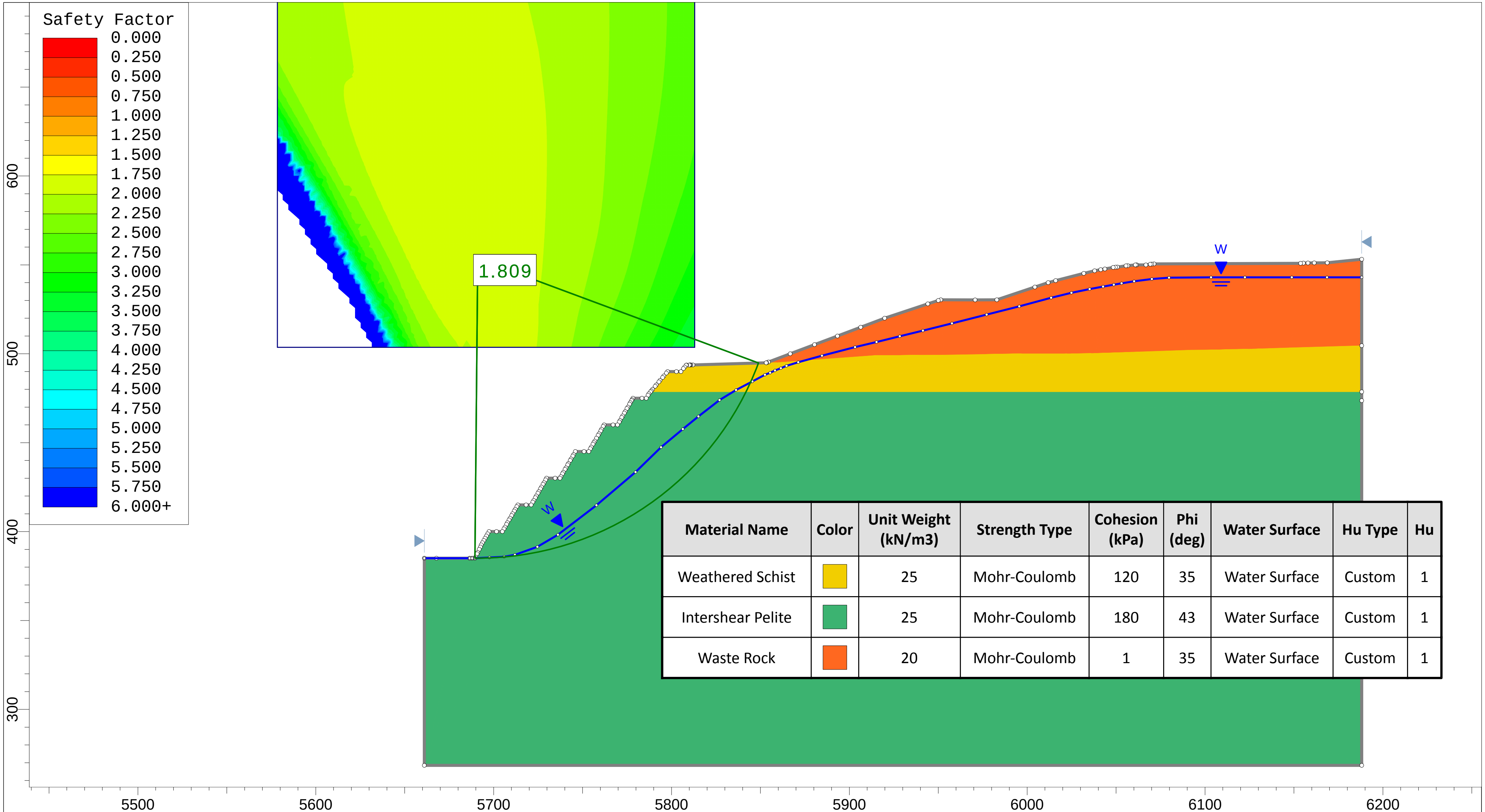
	Drawn By GF	*Scale*	*Company* OceanaGold Corporation
SLIDEINTERPRET 8.010	*Date* 23.05.2019		*File Name* Section A - Closure Scenario 2.slmd



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
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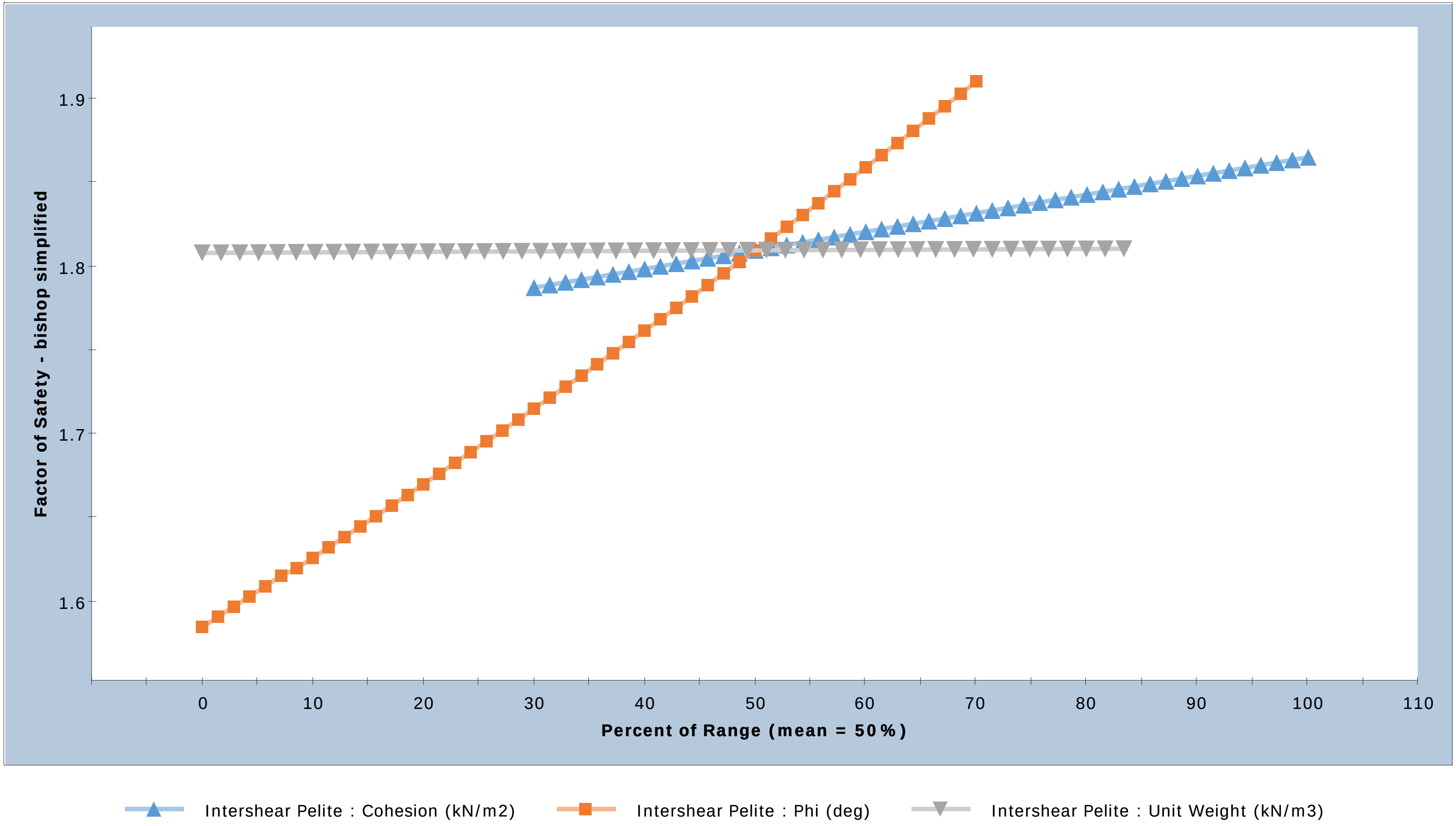
Waste Rock		20	Mohr-Coulomb	1	35	Water Surface	Custom	1

PSM

SLIDEINTERPRET 8.010

Project	Macraes Mine - Deepdell Closure
Analysis Description	East Wall - Operational Stability
Drawn By	GF
Scale	1:3000
Company	OceanaGold Corporation
Date	23.05.2019
File Name	Section B - Operational Stability.slmd



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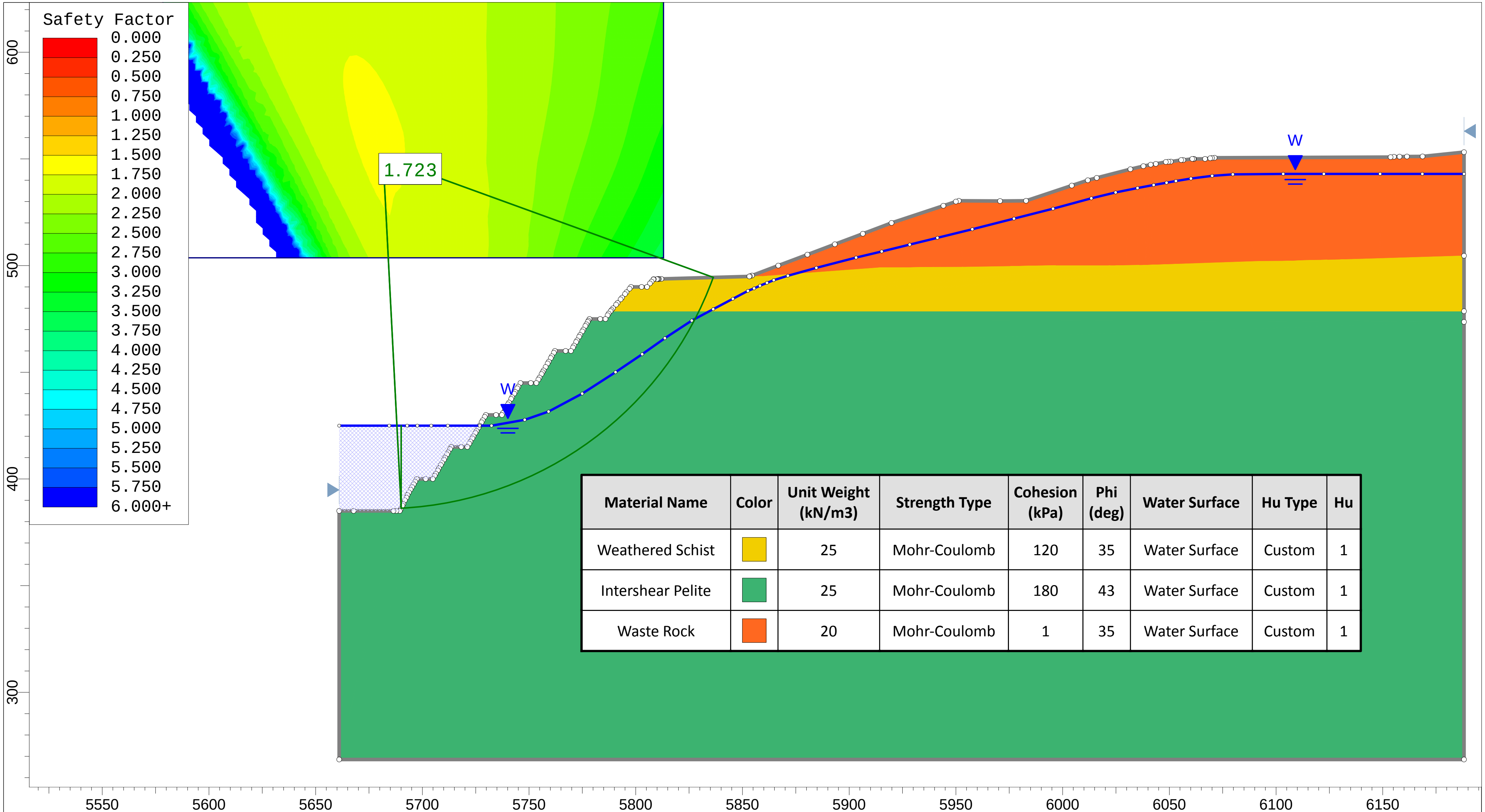
Analysis Description	East Wall - Operational Stability		
Drawn By GF	*Scale*	*Company* OceanaGold Corporation	
Date 23.05.2019		*File Name* Section B - Operational Stability.slmd	

SLIDEINTERPRET 8.010



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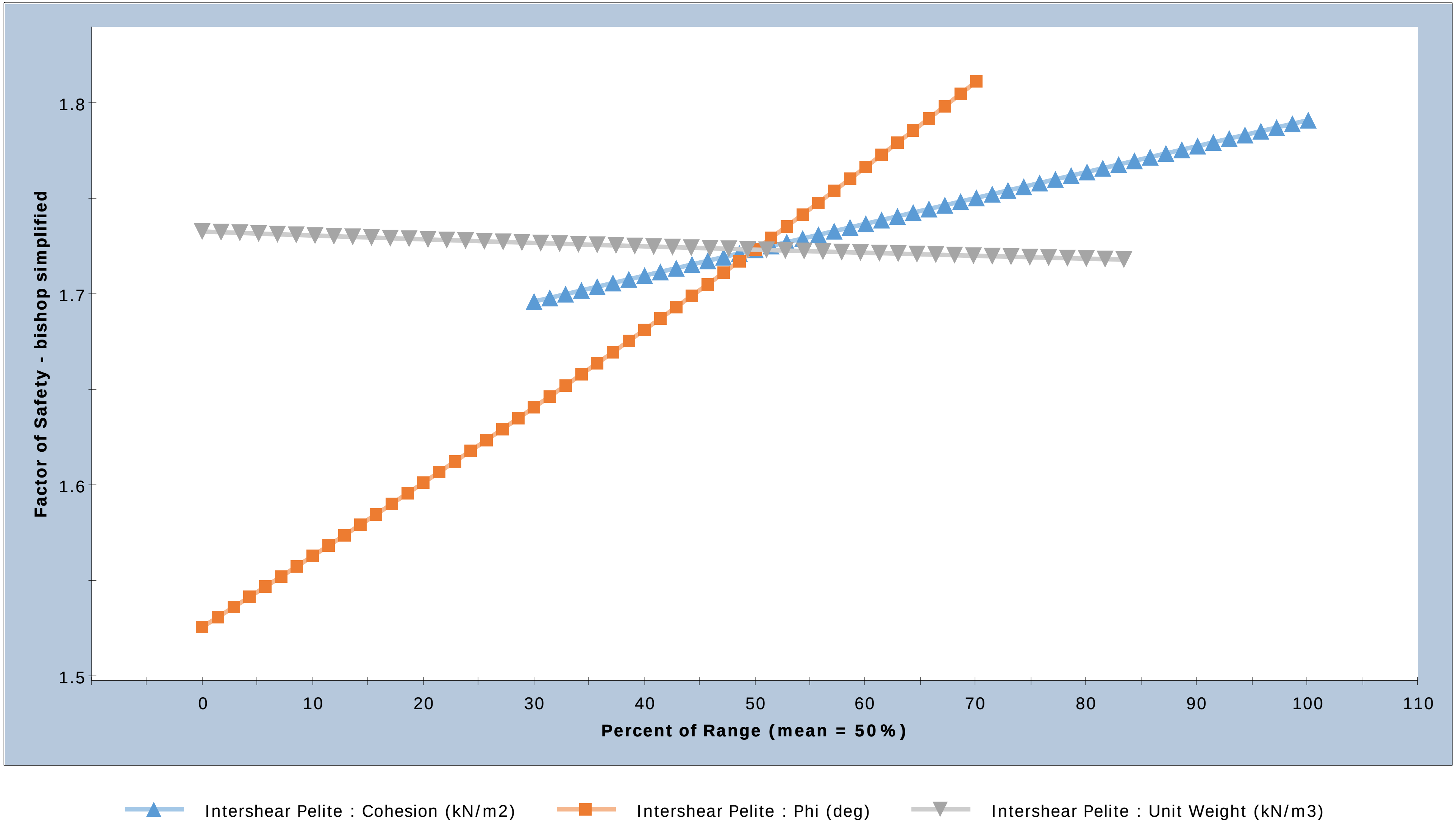
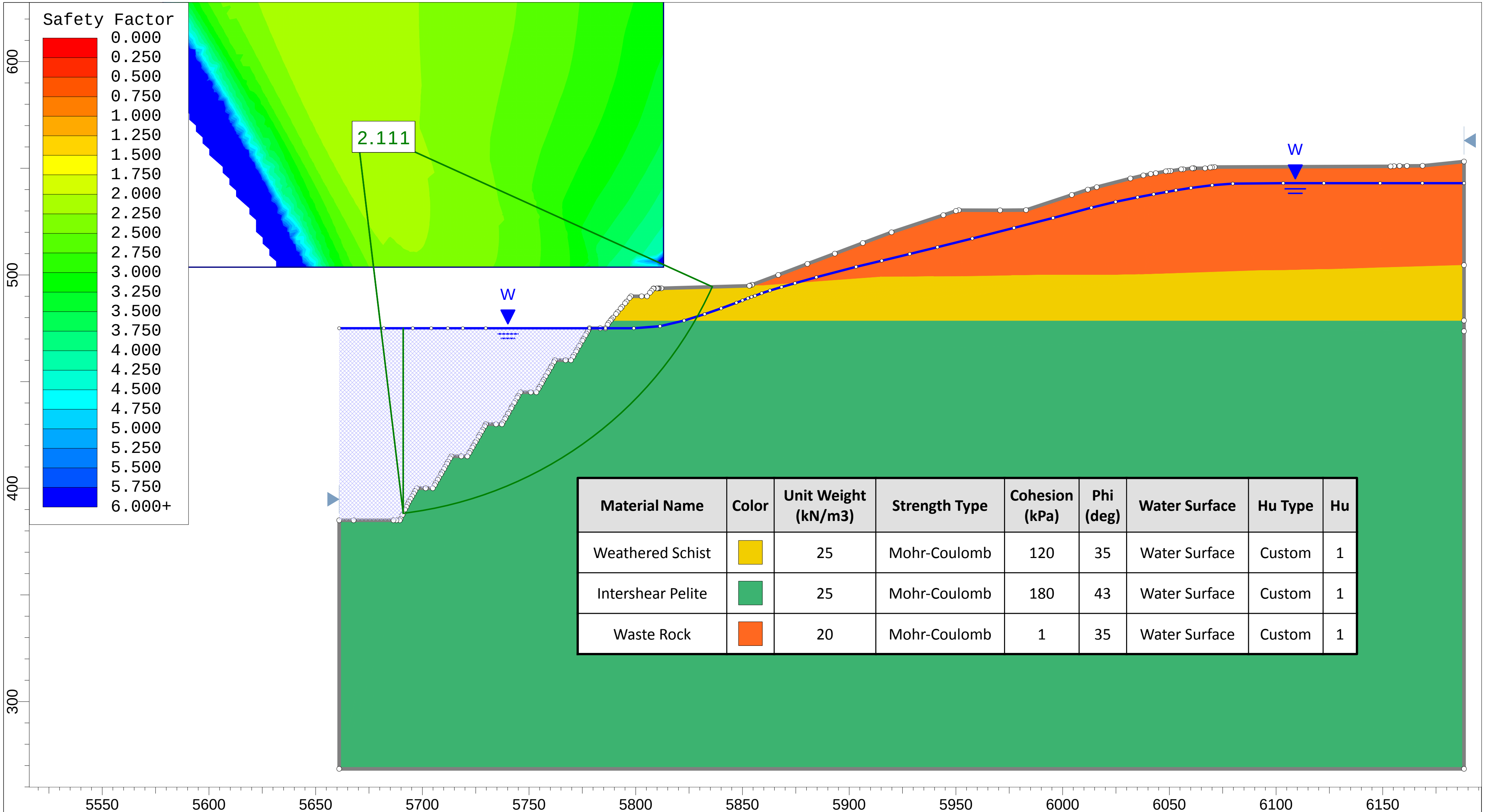
Waste Rock		20	Mohr-Coulomb	1	35	Water Surface	Custom	1

Project	Macraes Mine - Deepdell Closure		
Analysis Description	East Wall - Closure Scenario 1		
Drawn By GF	*Scale* 1:2500	*Company*	OceanaGold Corporation
Date	23.05.2019	*File Name*	Section B - Closure Scenario 1.slmd



PSM	*Project* Macraes Mine - Deepdell Closure		
	Analysis Description East Wall - Closure Scenario 1		
	Drawn By GF	*Scale*	*Company* OceanaGold Corporation
SLIDEINTERPRET 8.010	*Date* 23.05.2019		*File Name* Section B - Closure Scenario 1.slmd



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
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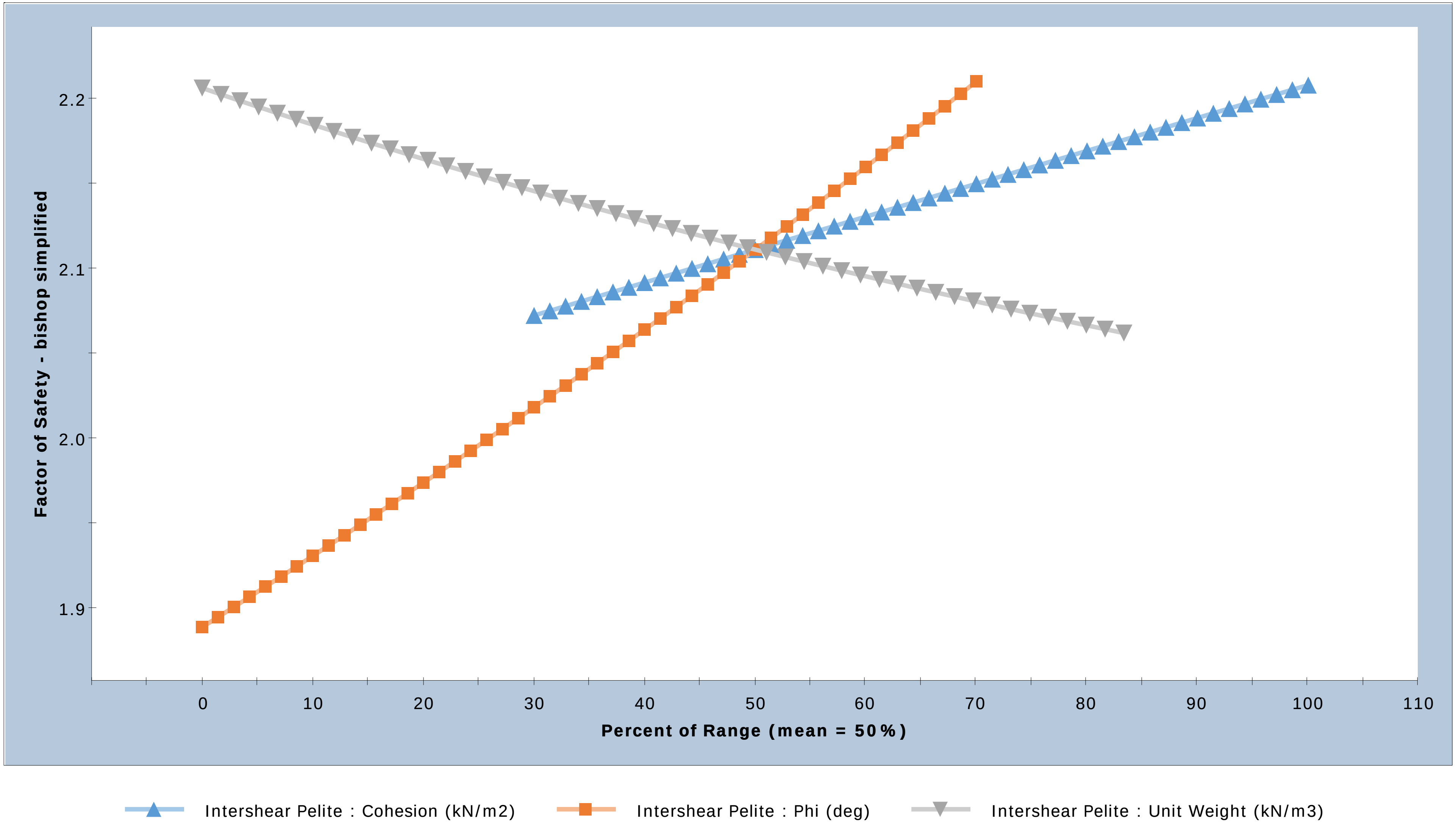
Waste Rock		20	Mohr-Coulomb	1	35	Water Surface	Custom	1

Project	Macraes Mine - Deepdell Closure		
Analysis Description	East Wall - Closure Scenario 2		
Drawn By	GF	*Scale*	1:2500
Company	OceanaGold Corporation		
Date	23.05.2019	*File Name*	Section B - Closure Scenario 2.slmd

SLIDEINTERPRET 8.010



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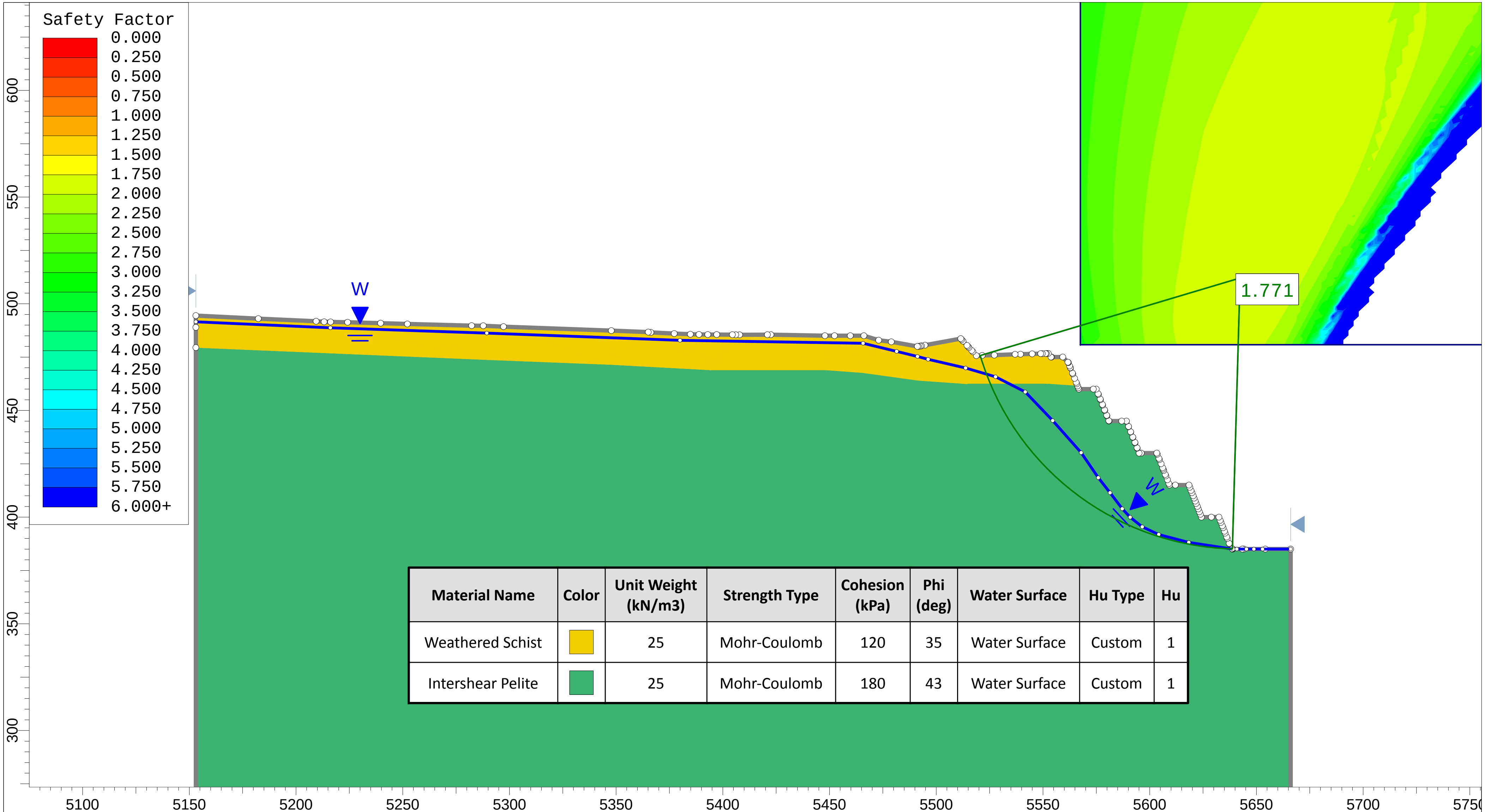
SLIDEINTERPRET 8.010	*Date* 23.05.2019		*File Name* Section B - Closure Scenario 2.slmd



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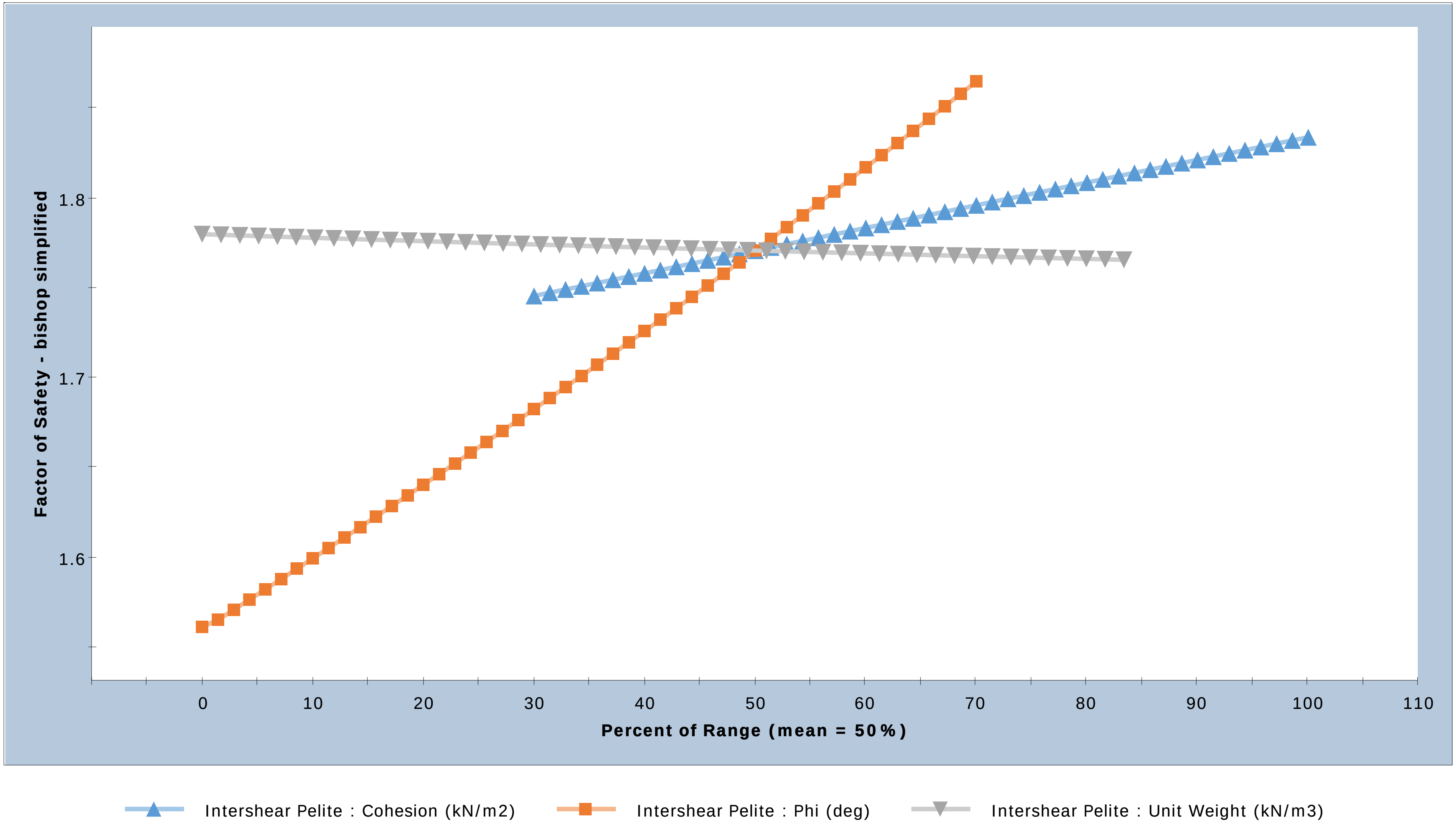
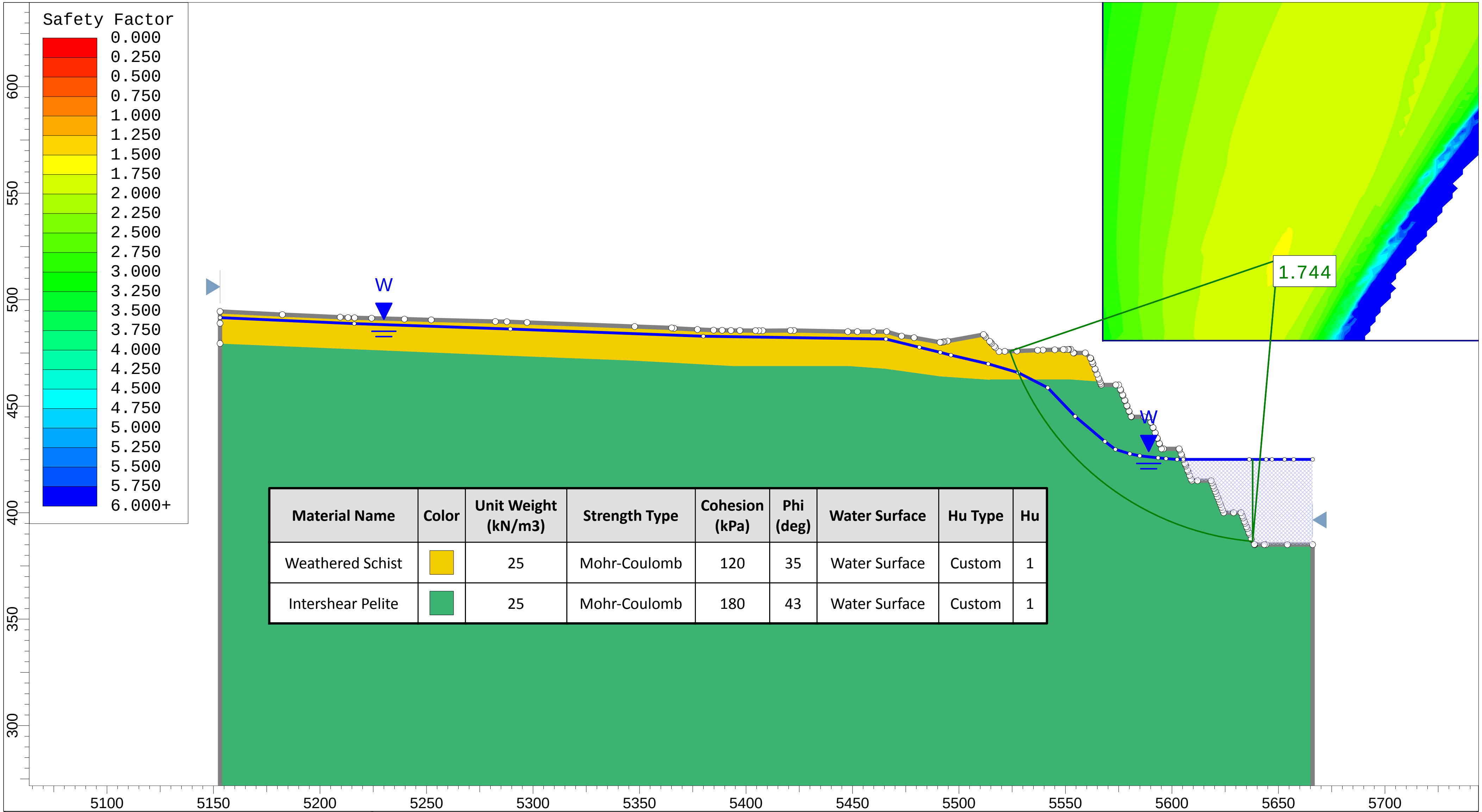
Project	Macraes Mine - Deepdell Closure
Analysis Description	North Wall - Operational Stability
Drawn By	GF
Scale	1:2500
Company	OceanaGold Corporation
Date	24.05.2019
File Name	Section B North - Operational Stability.slmd



Project	Macraes Mine - Deepdell Closure		
Analysis Description	North Wall - Operational Stability		
Drawn By GF	*Scale*	*Company*	OceanaGold Corporation
Date 24.05.2019		*File Name*	Section B North - Operational Stability.slmd

SLIDEINTERPRET 8.010



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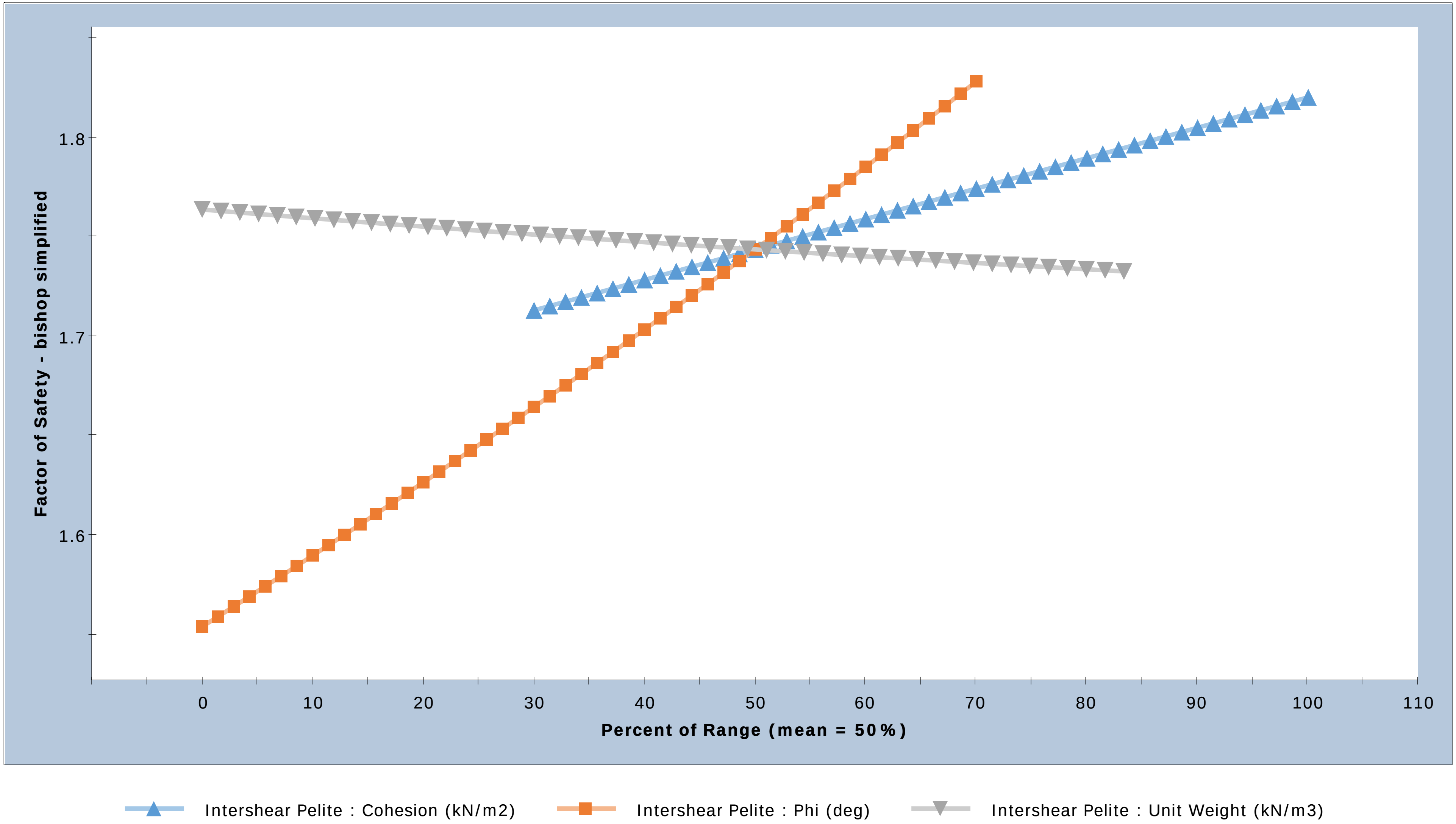
Intershear Pelite		25	Mohr-Coulomb	180	43	Water Surface	Custom	1

PSM	*Project* Macraes Mine - Deepdell Closure		
	Analysis Description North Wall - Closure Scenario 1		
	Drawn By GF	*Scale* 1:2500	*Company* OceanaGold Corporation
SLIDEINTERPRET 8.010	*Date* 24.05.2019		*File Name* Section B North - Closure Scenario 1.slmd



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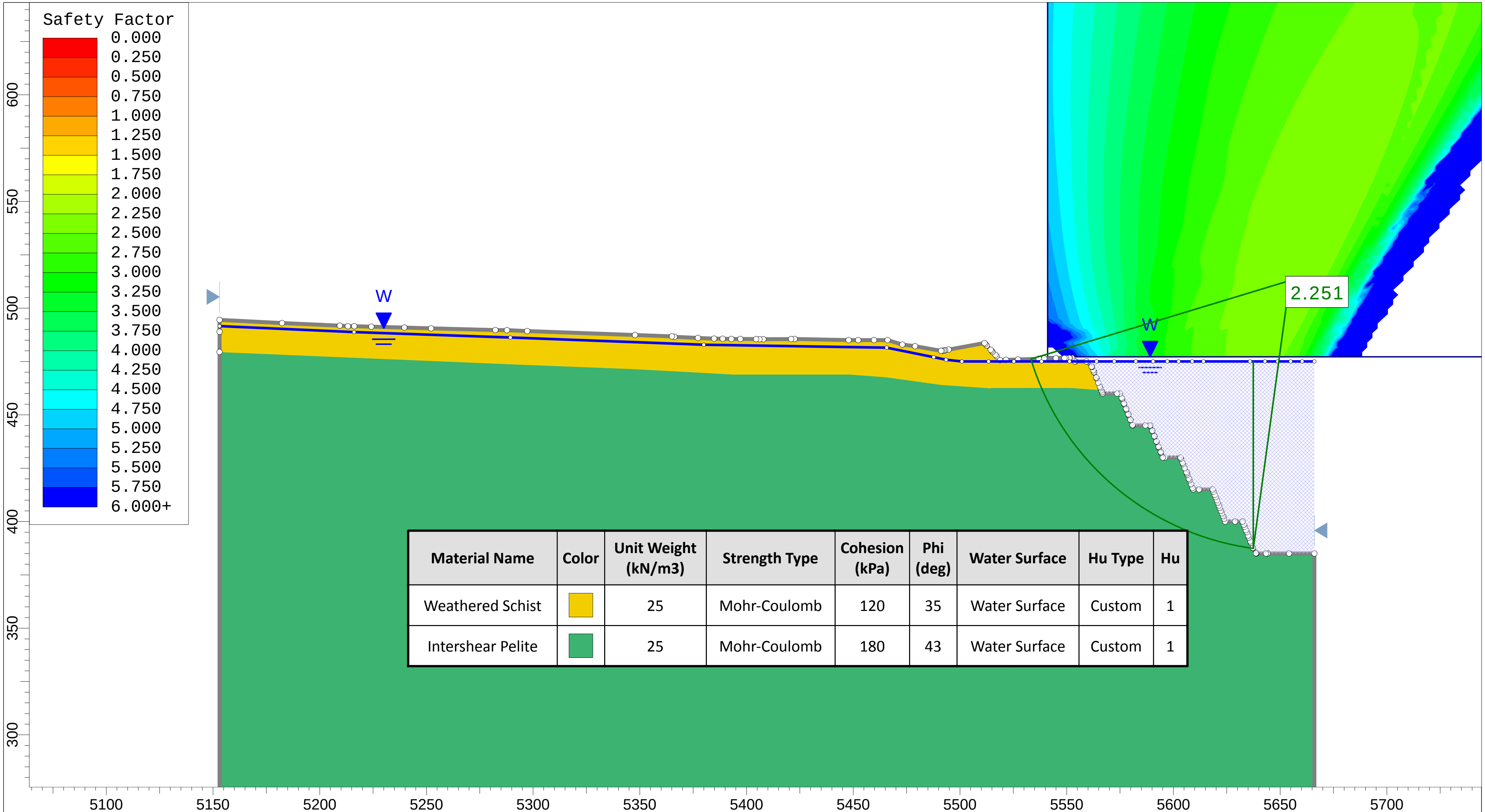
	Analysis Description North Wall - Closure Scenario 1		
	Drawn By GF	*Scale*	*Company* OceanaGold Corporation
SLIDEINTERPRET 8.010	*Date* 24.05.2019		*File Name* Section B North - Closure Scenario 1.slmd



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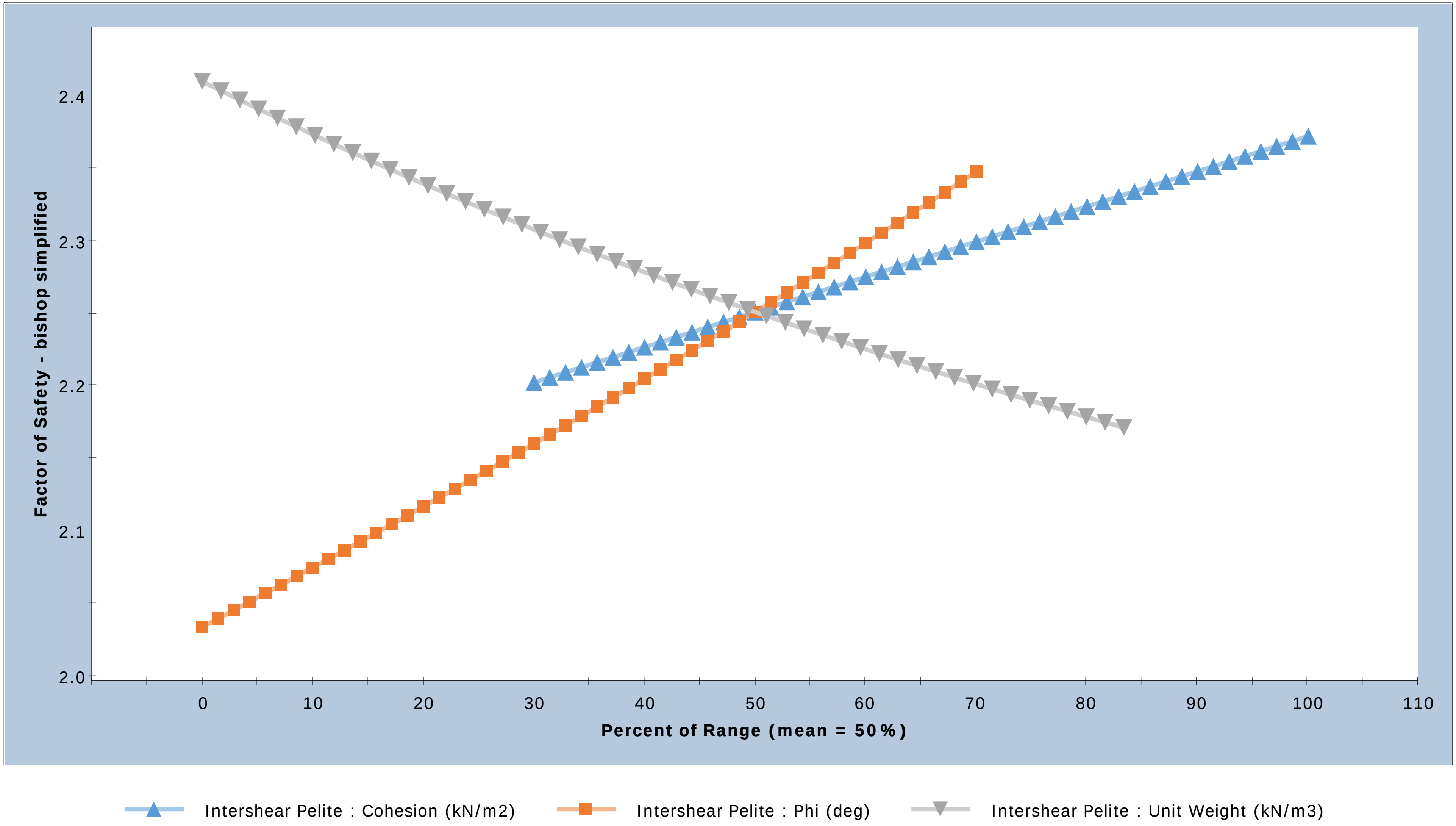
Project	Macraes Mine - Deepdell Closure		
Analysis Description	North Wall - Closure Scenario 2		
Drawn By GF	*Scale* 1:2500	*Company*	OceanaGold Corporation
Date	24.05.2019	*File Name*	Section B North - Closure Scenario 2.slmd

SLIDEINTERPRET 8.010



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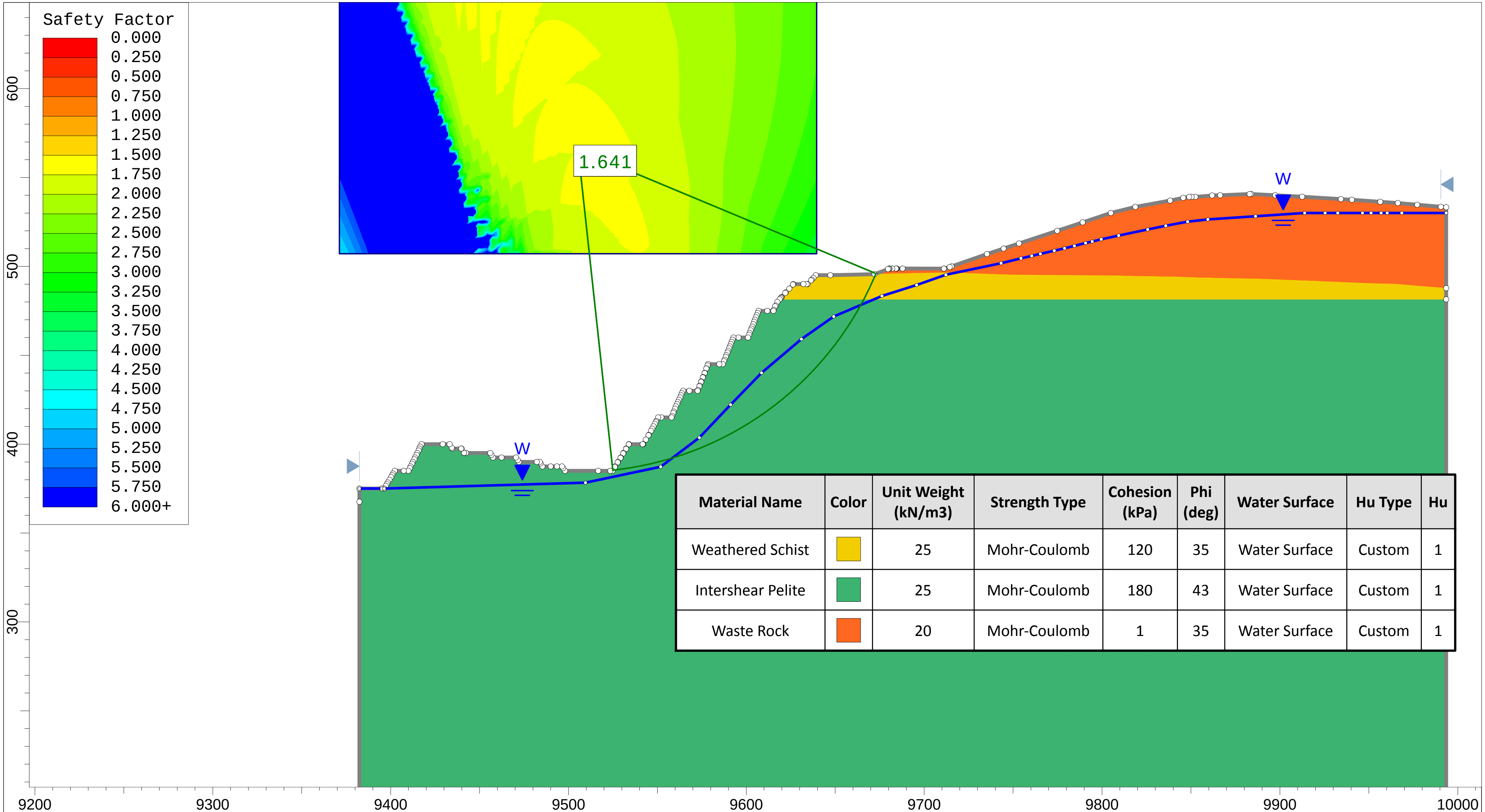
Analysis Description	North Wall - Closure Scenario 2		
Drawn By	GF	Scale	Company: OceanaGold Corporation
Date	24.05.2019	File Name	Section B North - Closure Scenario 2.slmd

SLIDEINTERPRET 8.010



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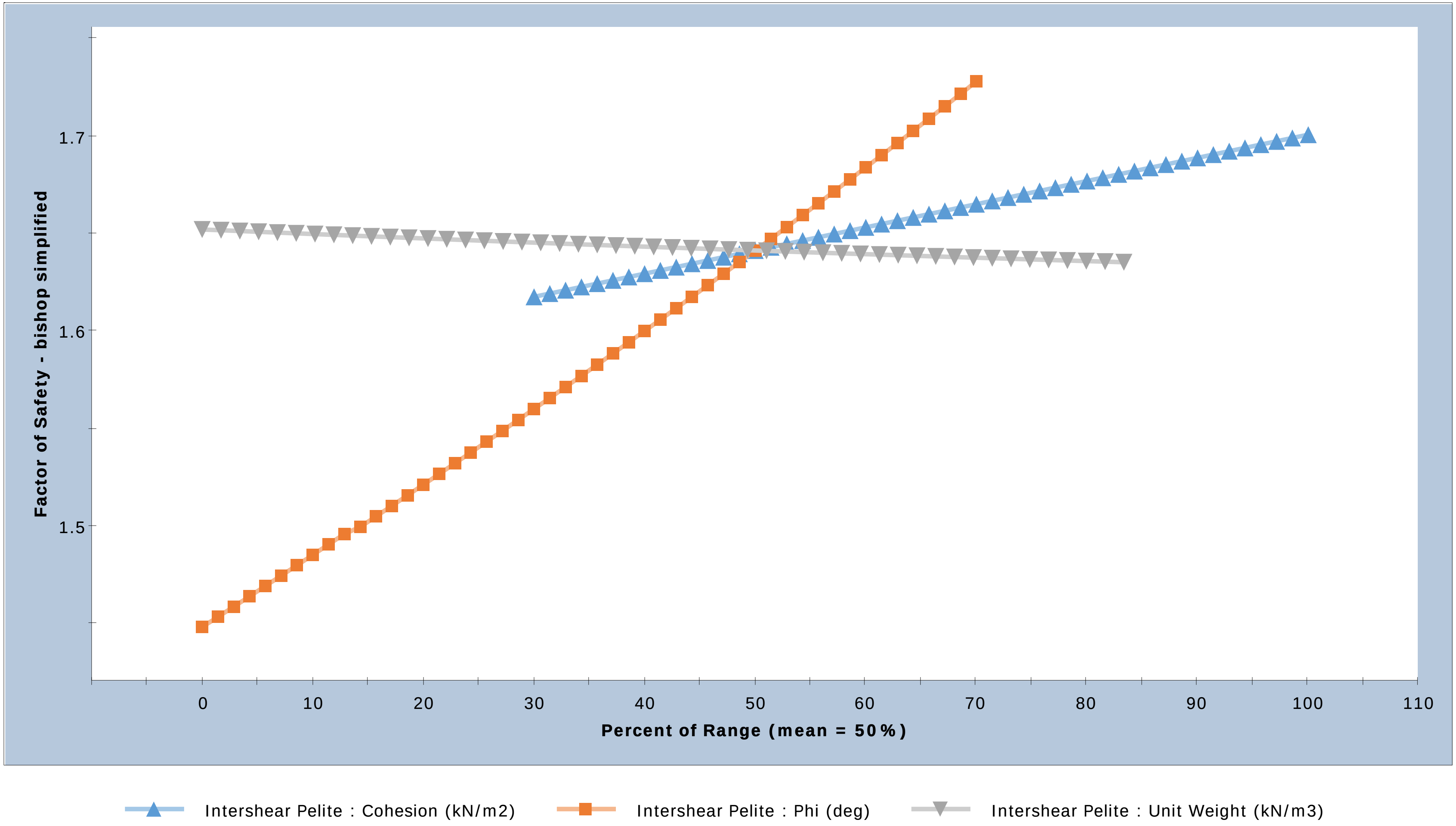
Waste Rock		20	Mohr-Coulomb	1	35	Water Surface	Custom	1

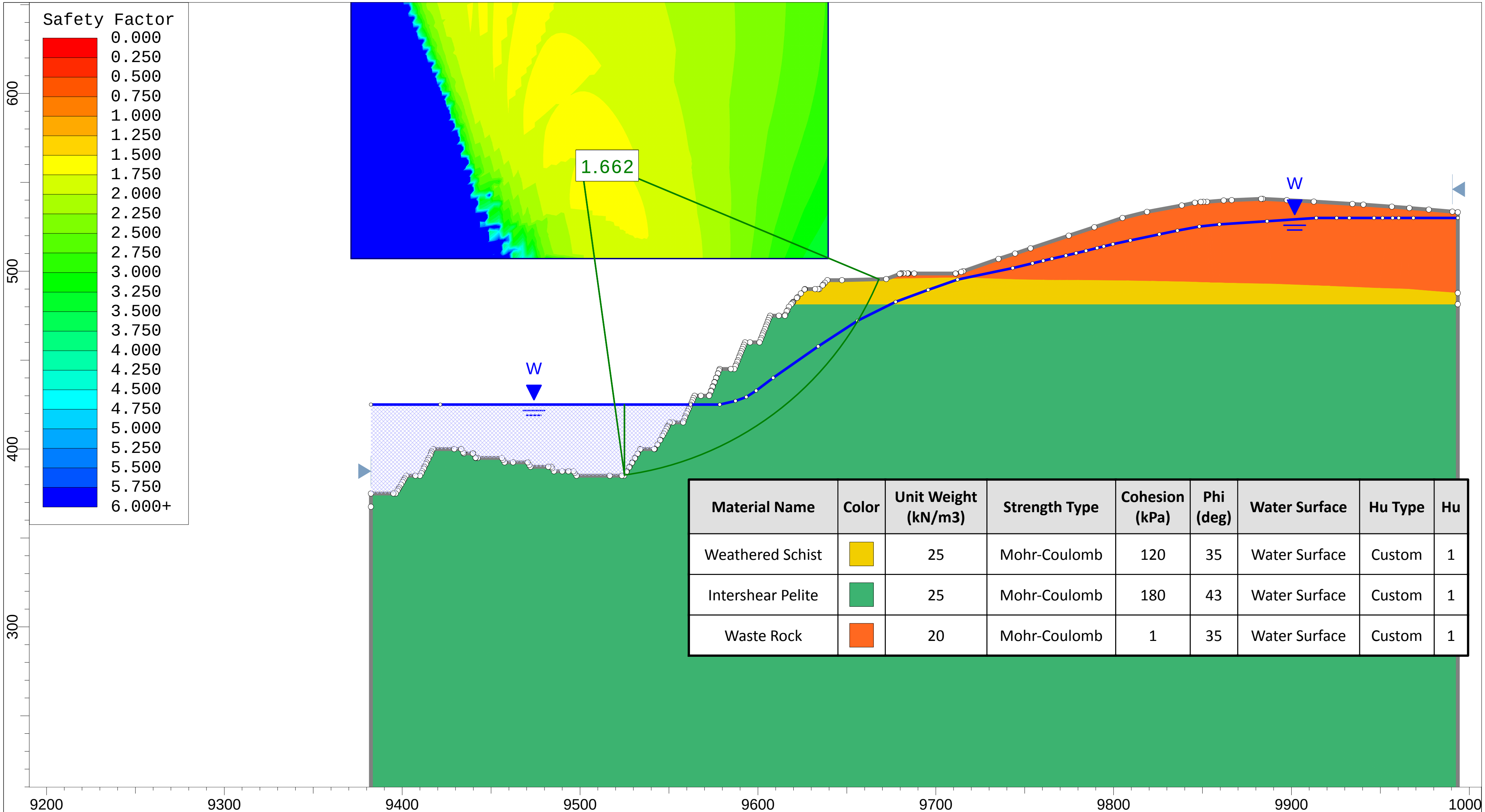
Project	Macraes Mine - Deepdell Closure
Analysis Description	East Wall - Operational Stability
Drawn By	GF
Scale	1:3000
Company	OceanaGold Corporation
Date	23.05.2019
File Name	Section C - Operational Stability.slmd

SLIDEINTERPRET 8.010



Project	Macraes Mine - Deepdell Closure		
Analysis Description	East Wall - Operational Stability		
Drawn By	GF	Scale	
Company	OceanaGold Corporation		
Date	23.05.2019	File Name	Section C - Operational Stability.slmd

SLIDEINTERPRET 8.010



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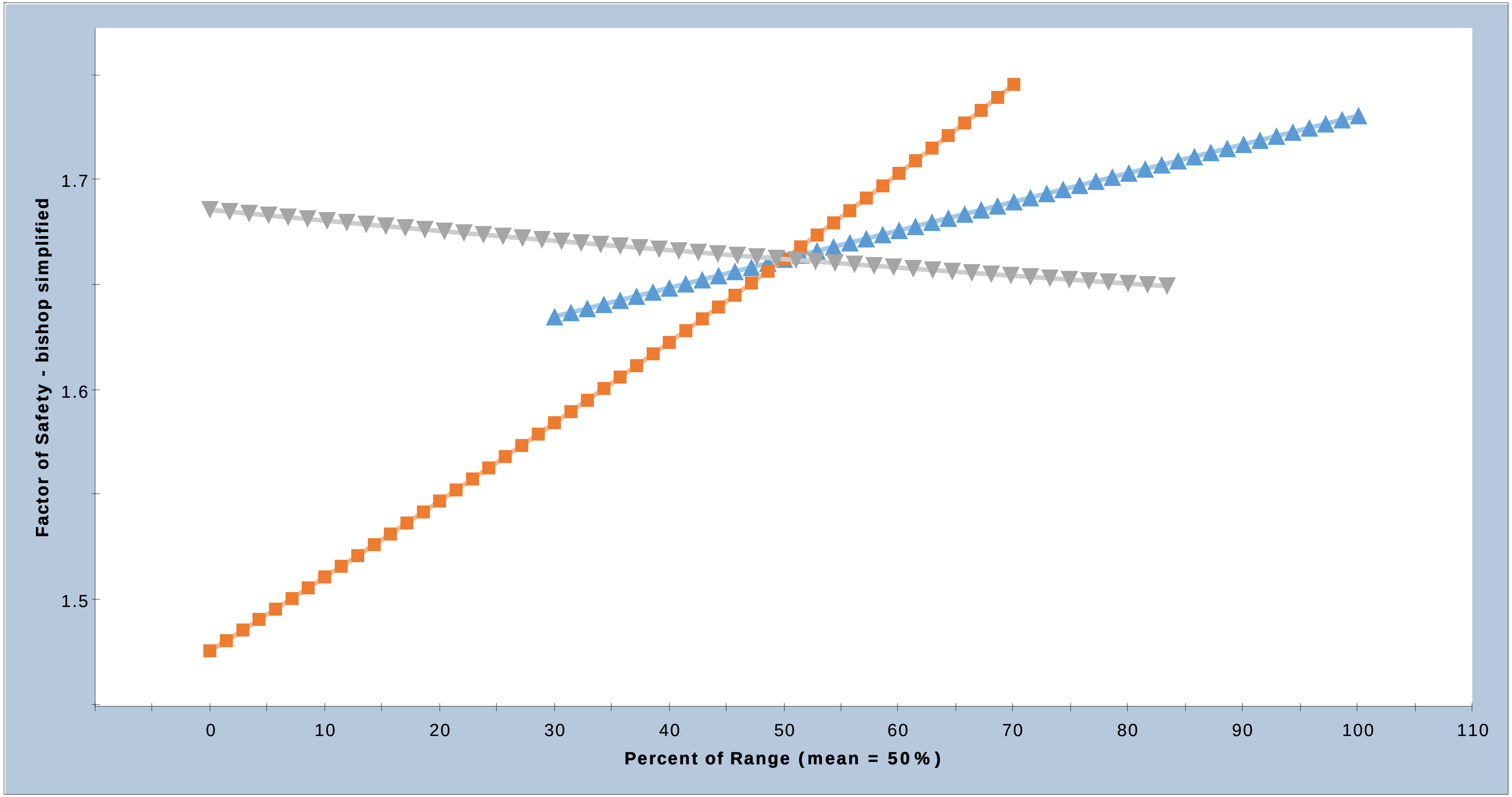
Waste Rock		20	Mohr-Coulomb	1	35	Water Surface	Custom	1

SLIDEINTERPRET 8.010

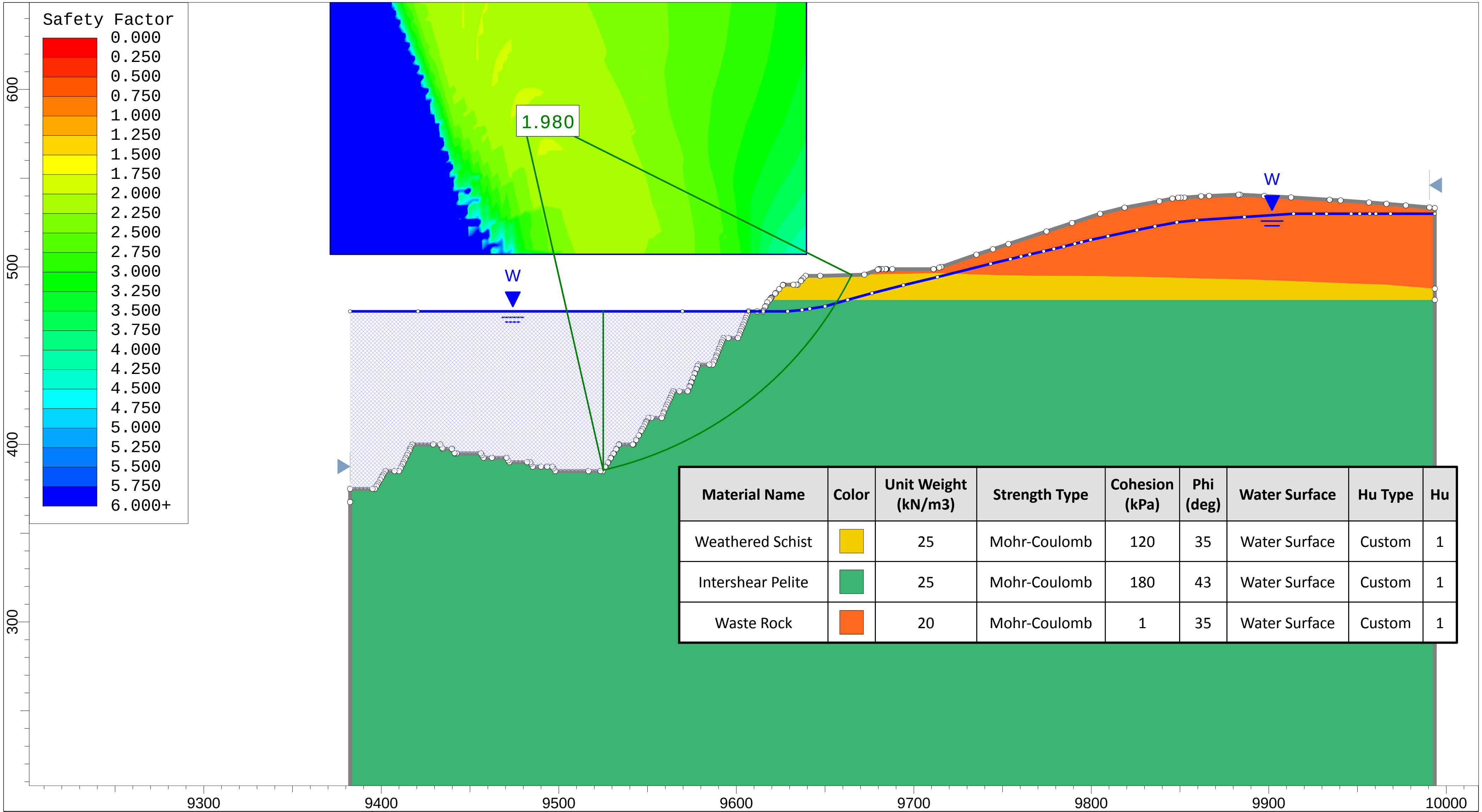
Project	Macraes Mine - Deepdell Closure
Analysis Description	East Wall - Closure Scenario 1
Drawn By	GF
Scale	1:3000
Company	OceanaGold Corporation
Date	23.05.2019
File Name	Section C - Closure Scenario 1.slmd



Intershear Pelite : Cohesion (kN/m2)   Intershear Pelite : Phi (deg)   Intershear Pelite : Unit Weight (kN/m3)

Project	Macraes Mine - Deepdell Closure		
Analysis Description	East Wall - Closure Scenario 1		
Drawn By GF	*Scale*	*Company*	OceanaGold Corporation
Date 23.05.2019		*File Name*	Section C - Closure Scenario 1.slmd

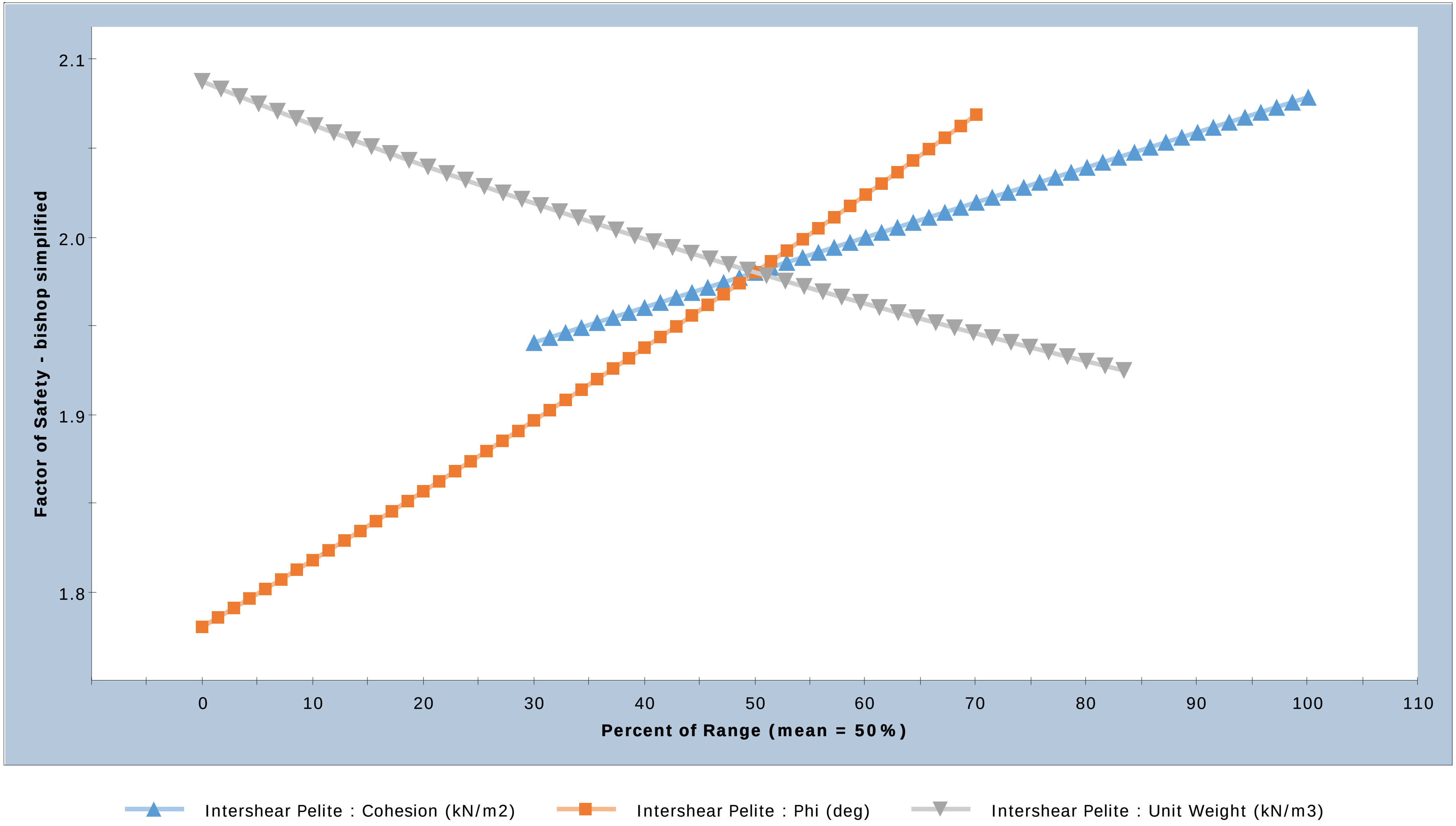
SLIDEINTERPRET 8.010



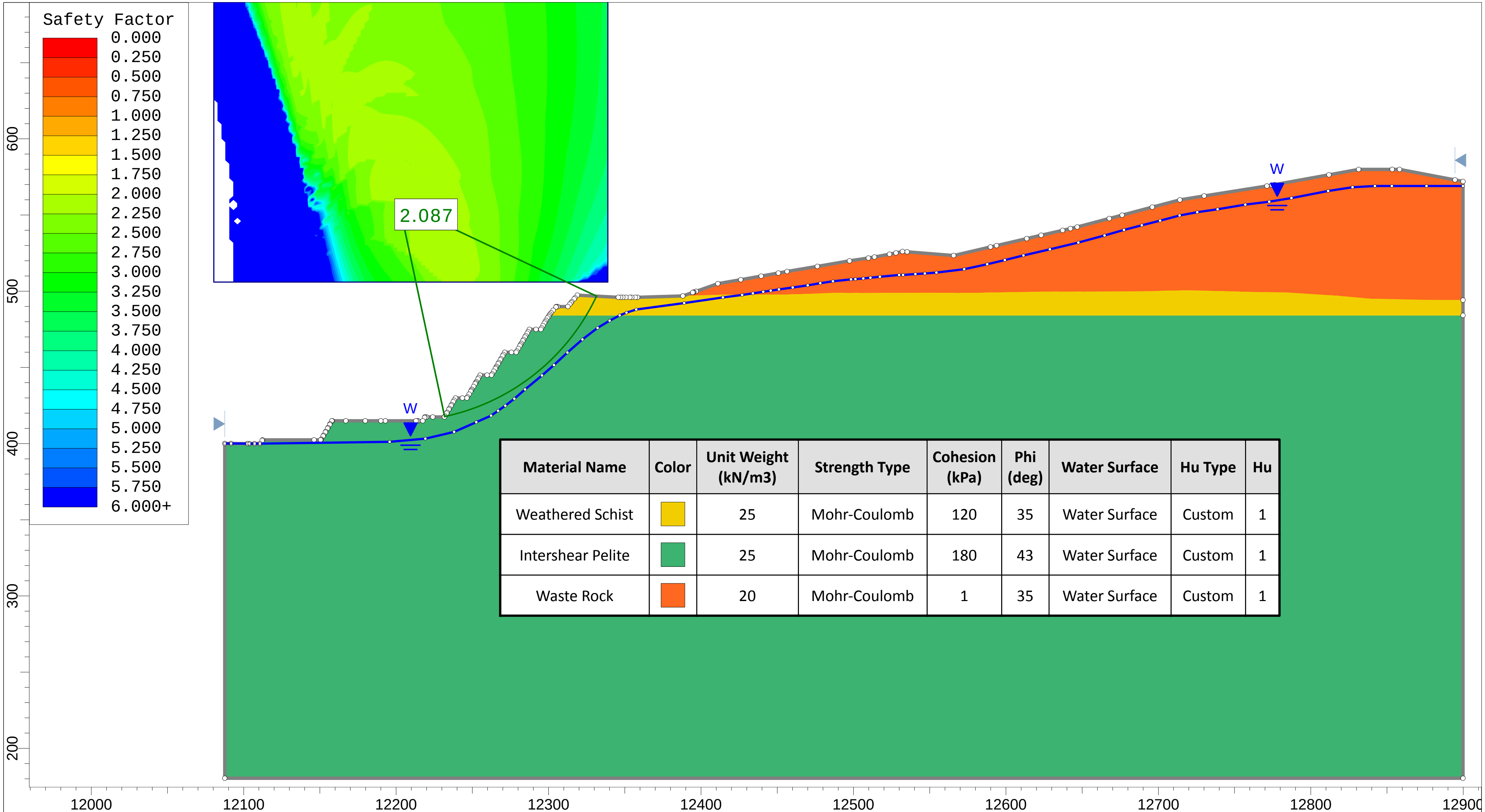
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Weathered Schist		25	Mohr-Coulomb	120	35	Water Surface	Custom	1
Intershear Pelite		25	Mohr-Coulomb	180	43	Water Surface	Custom	1
Waste Rock		20	Mohr-Coulomb	1	35	Water Surface	Custom	1

SLIDEINTERPRET 8.010

Project	Macraes Mine - Deepdell Closure		
Analysis Description	East Wall - Closure Scenario 2		
Drawn By	GF	*Scale*	1:3000
Company	OceanaGold Corporation		
Date	23.05.2019	*File Name*	Section C - Closure Scenario 2.slmd



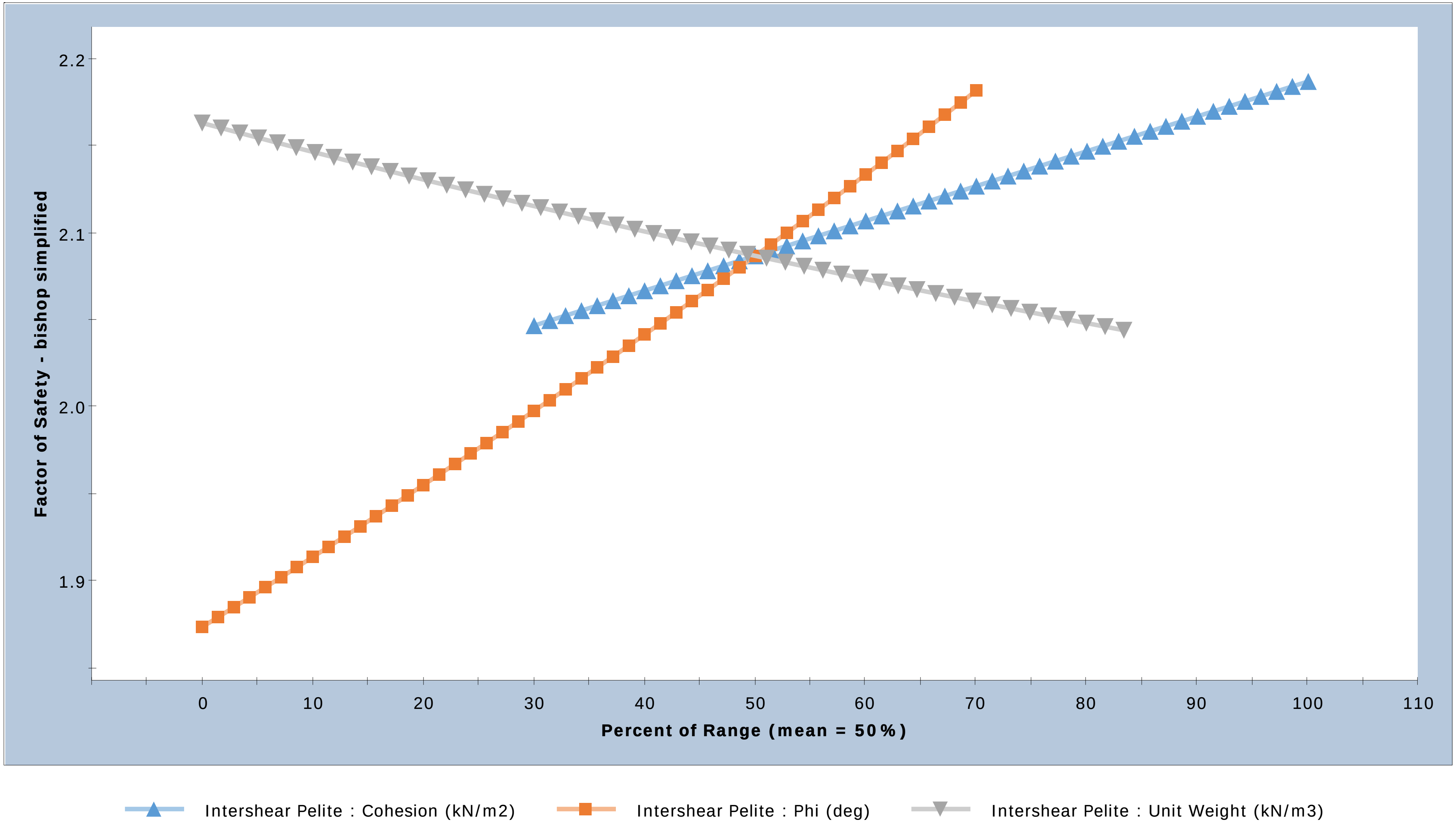
PSM	*Project* Macraes Mine - Deepdell Closure		
	Analysis Description East Wall - Closure Scenario 2		
	Drawn By GF	*Scale*	*Company* OceanaGold Corporation
SLIDEINTERPRET 8.010	*Date* 23.05.2019		*File Name* Section C - Closure Scenario 2.slmd



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Weathered Schist		25	Mohr-Coulomb	120	35	Water Surface	Custom	1
Intershear Pelite		25	Mohr-Coulomb	180	43	Water Surface	Custom	1
Waste Rock		20	Mohr-Coulomb	1	35	Water Surface	Custom	1

Project	Macraes Mine - Deepdell Closure
Analysis Description	East Wall - Operational Stability
Drawn By	GF
Scale	1:3500
Company	OceanaGold Corporation
Date	23.05.2019
File Name	Section D - Operational Stability.slmd

SLIDEINTERPRET 8.010



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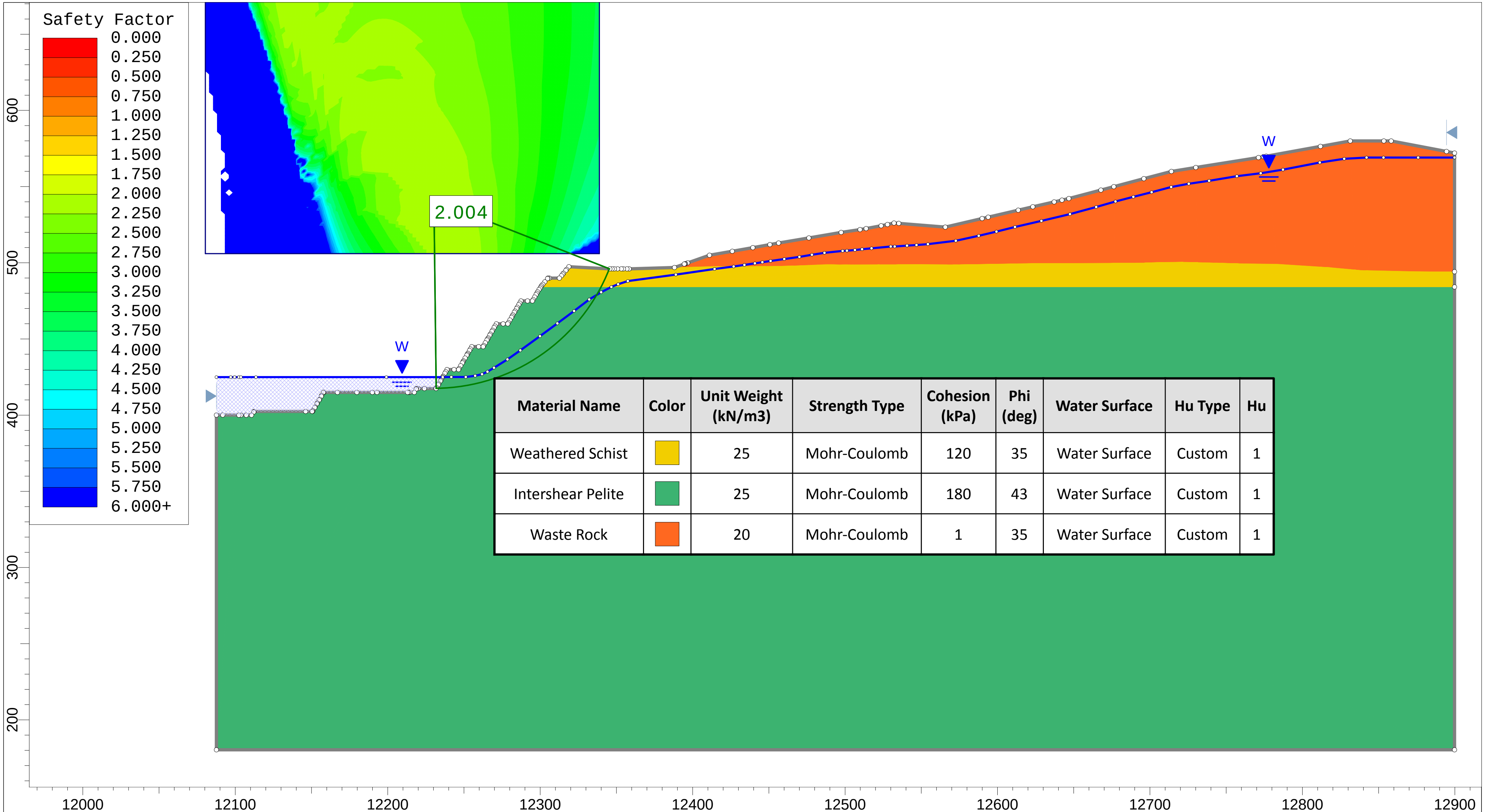
Analysis Description	East Wall - Operational Stability		
Drawn By: GF	Scale	Company: OceanaGold Corporation	
Date: 23.05.2019		File Name: Section D - Operational Stability.slmd	

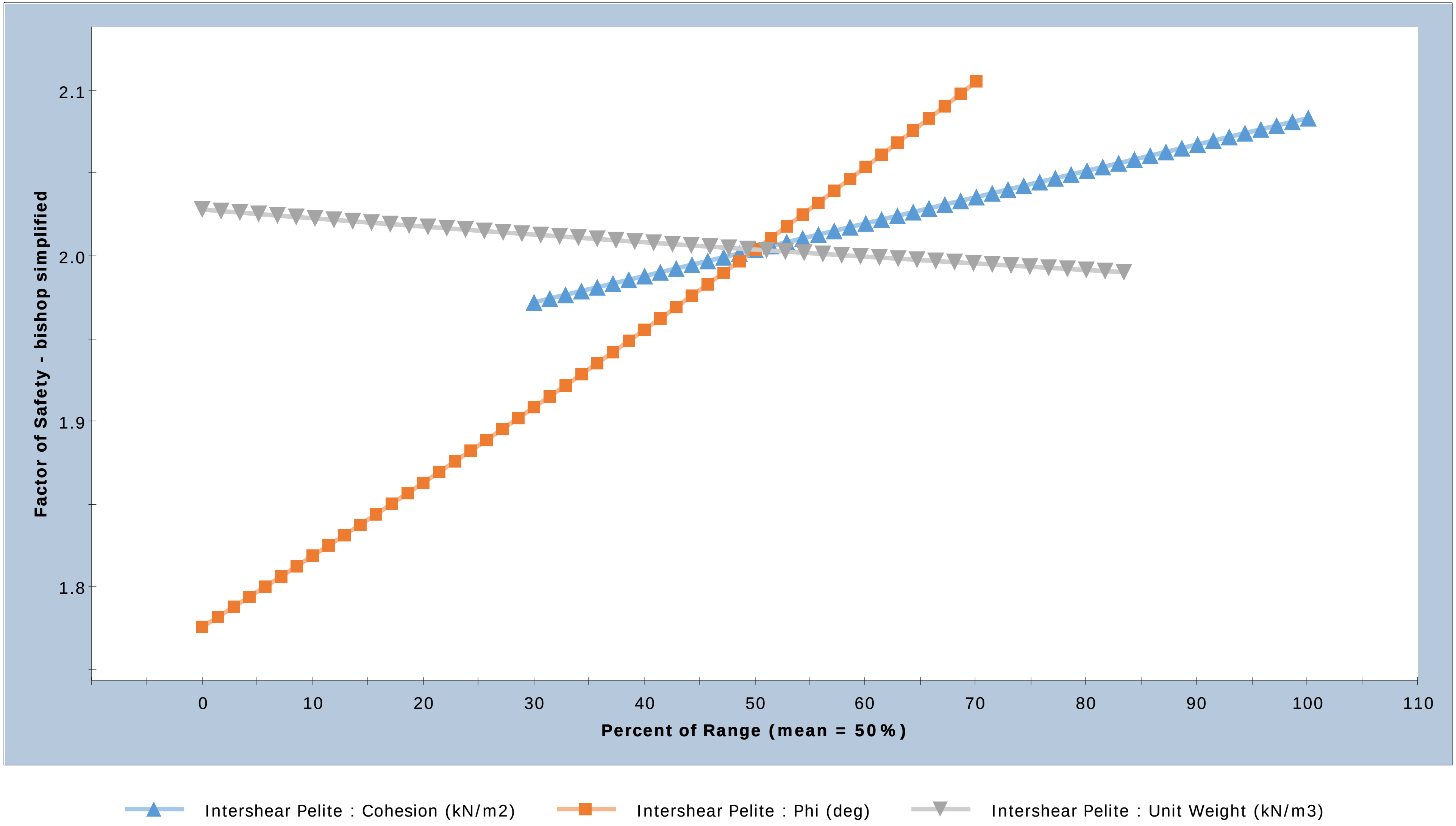
SLIDEINTERPRET 8.010



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Weathered Schist		25	Mohr-Coulomb	120	35	Water Surface	Custom	1
Intershear Pelite		25	Mohr-Coulomb	180	43	Water Surface	Custom	1
Waste Rock		20	Mohr-Coulomb	1	35	Water Surface	Custom	1

SLIDEINTERPRET 8.010

Project	Macraes Mine - Deepdell Closure
Analysis Description	East Wall - Closure Scenario 1
Drawn By	GF
Scale	1:3500
Company	OceanaGold Corporation
Date	23.05.2019
File Name	Section D- Closure Scenario 1.slmd



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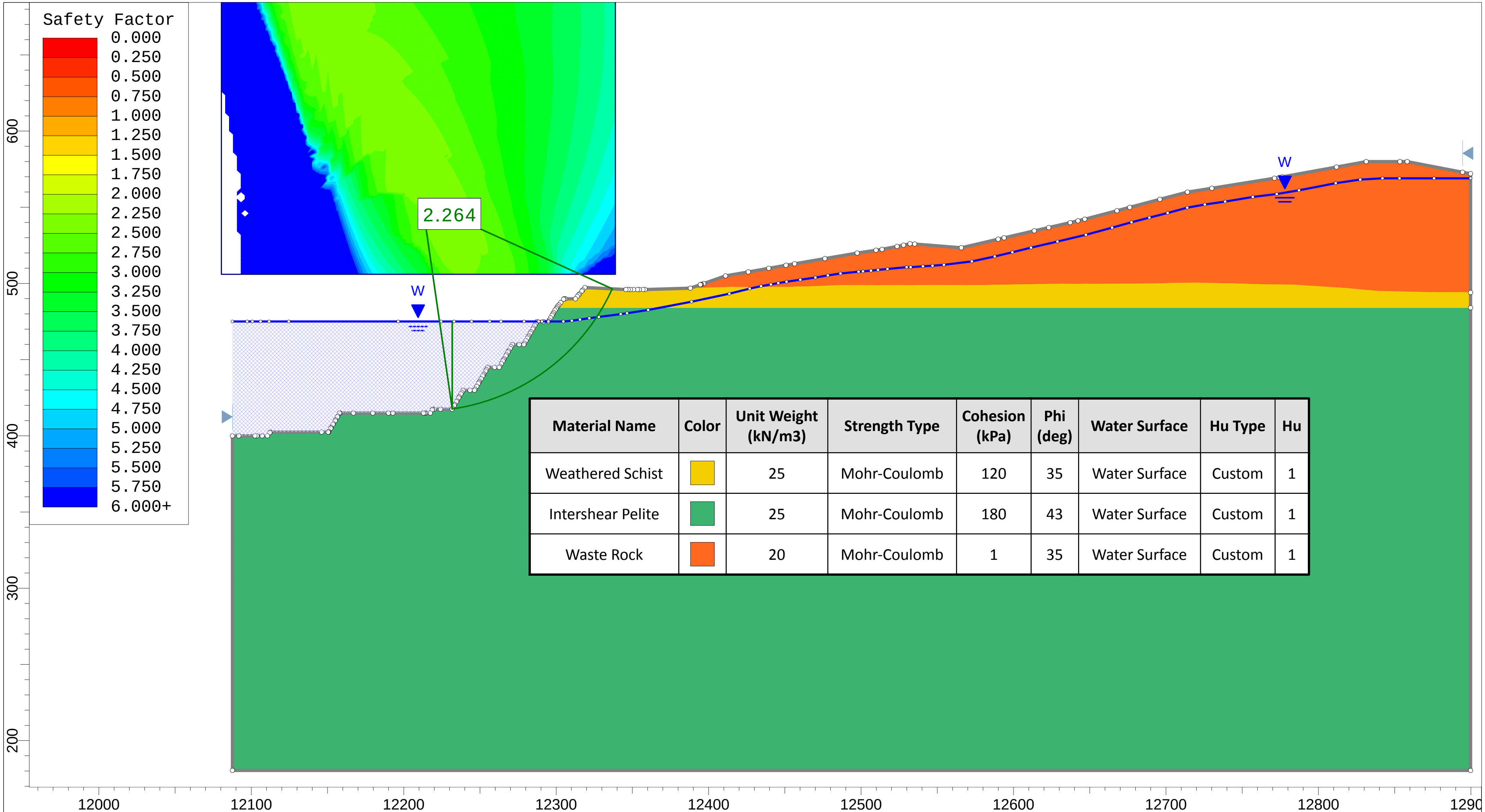
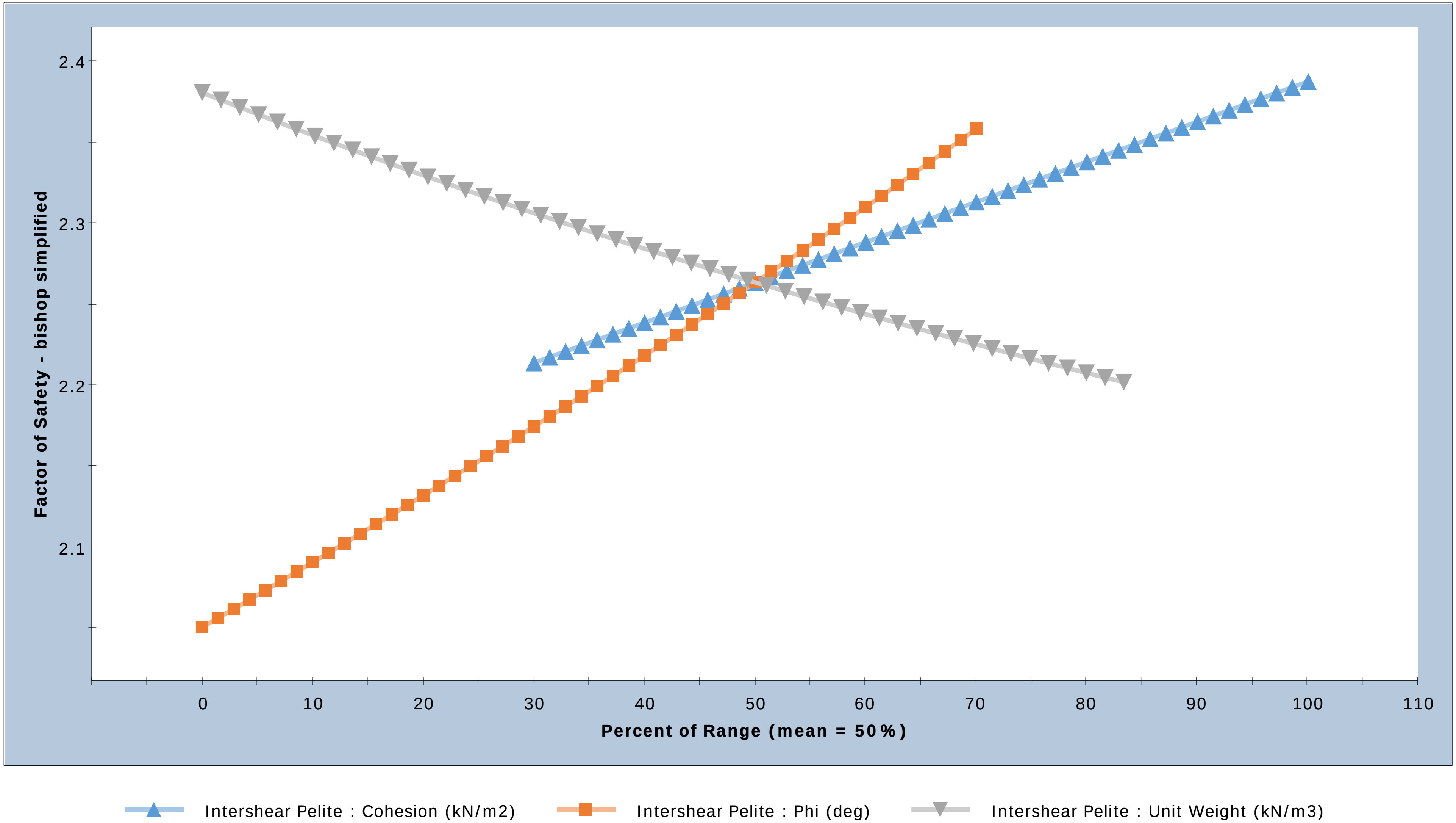
	Analysis Description: East Wall - Closure Scenario 1		
	Drawn By: GF	Scale:	Company: OceanaGold Corporation
SLIDEINTERPRET 8.010	Date: 23.05.2019		File Name: Section D- Closure Scenario 1.slmd



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Weathered Schist		25	Mohr-Coulomb	120	35	Water Surface	Custom	1
Intershear Pelite		25	Mohr-Coulomb	180	43	Water Surface	Custom	1
Waste Rock		20	Mohr-Coulomb	1	35	Water Surface	Custom	1

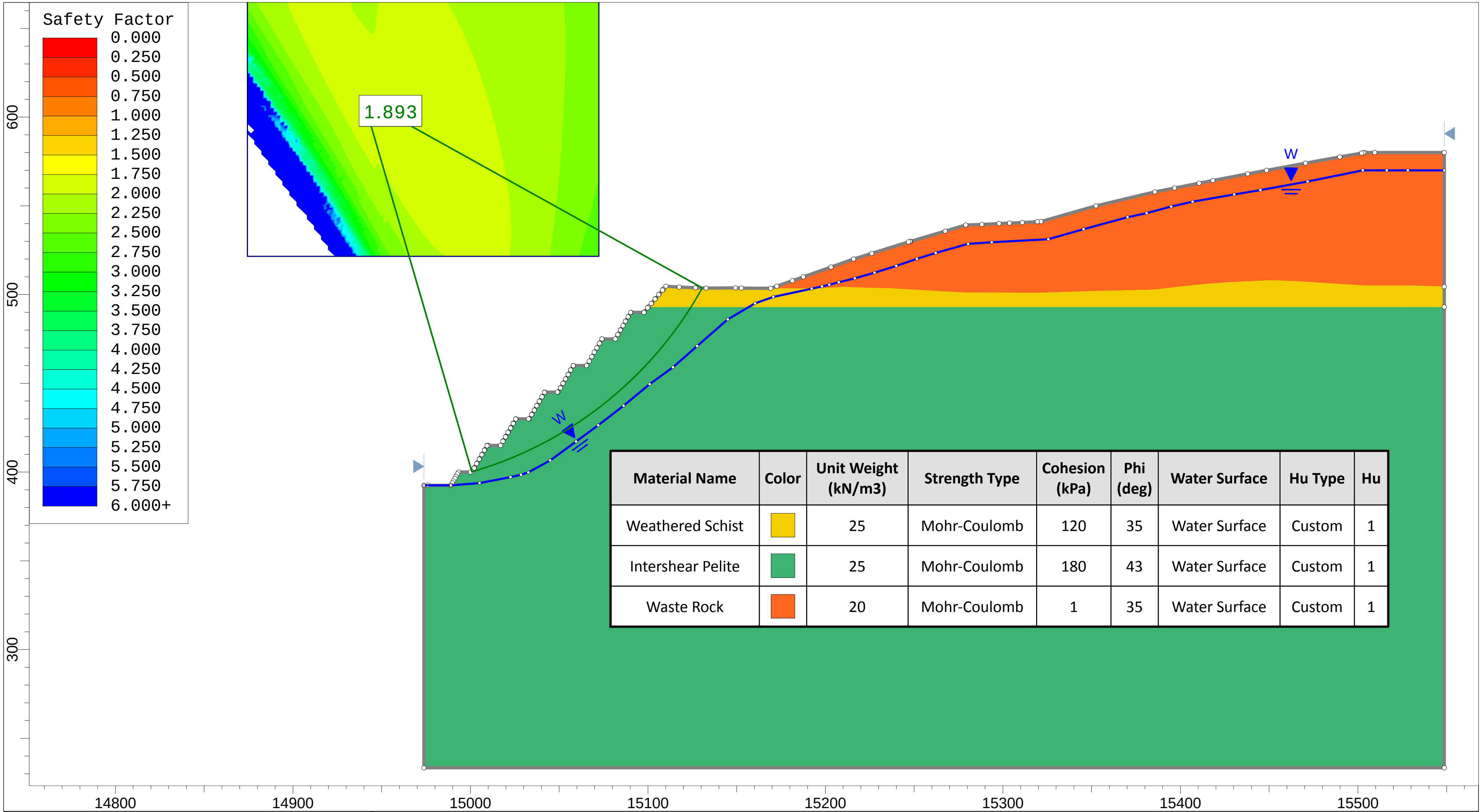
Project	Macraes Mine - Deepdell Closure		
Analysis Description	East Wall - Closure Scenario 2		
Drawn By	GF	*Scale*	1:3500
Company	OceanaGold Corporation		
Date	23.05.2019	*File Name*	Section D- Closure Scenario 2.slmd

SLIDEINTERPRET 6.010



Project	Macraes Mine - Deepdell Closure		
Analysis Description	East Wall - Closure Scenario 2		
Drawn By	GF	Scale	
Company	OceanaGold Corporation		
Date	23.05.2019	File Name	Section D- Closure Scenario 2.slmd

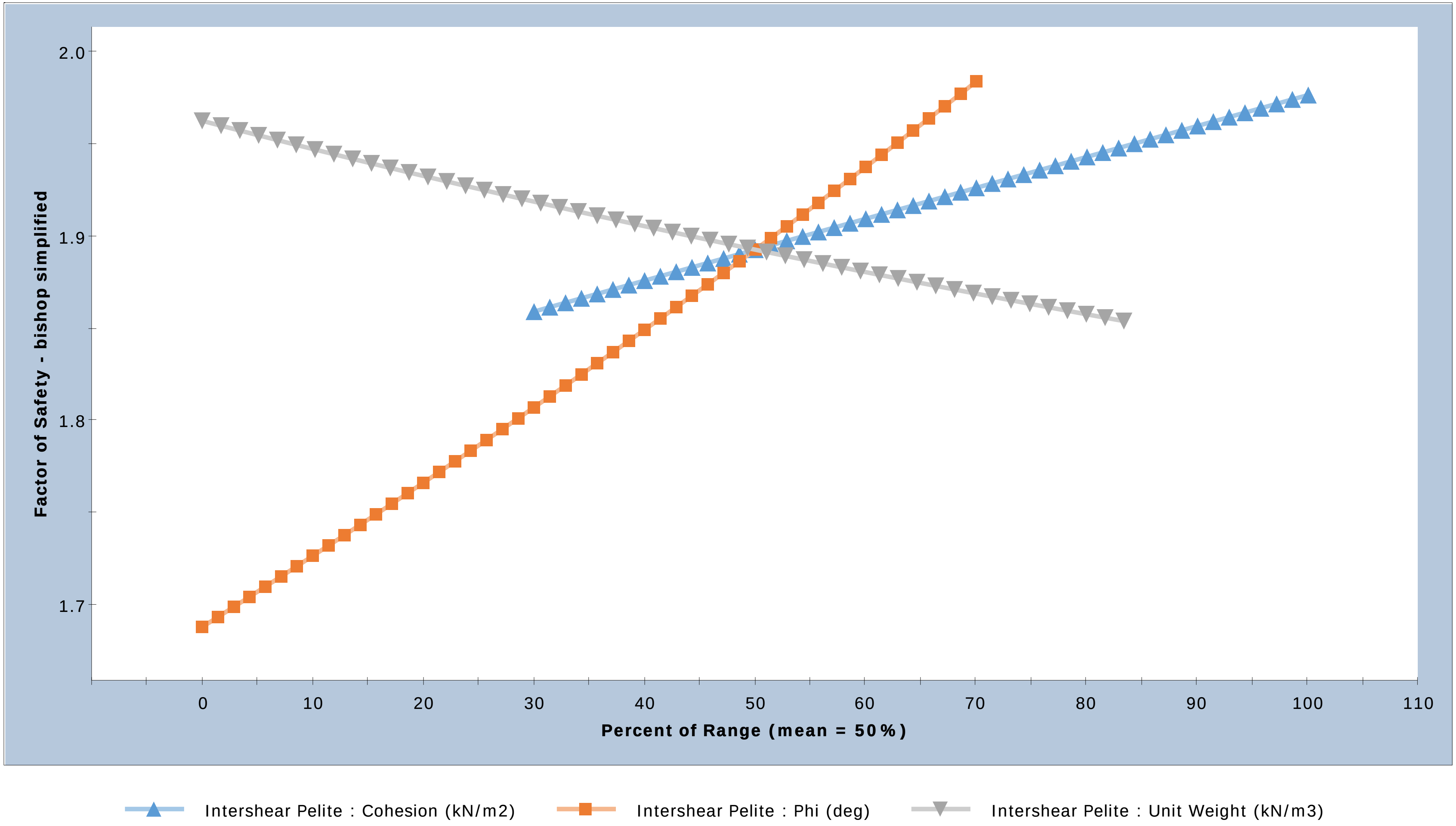
SLIDEINTERPRET 8.010



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Weathered Schist		25	Mohr-Coulomb	120	35	Water Surface	Custom	1
Intershear Pelite		25	Mohr-Coulomb	180	43	Water Surface	Custom	1
Waste Rock		20	Mohr-Coulomb	1	35	Water Surface	Custom	1

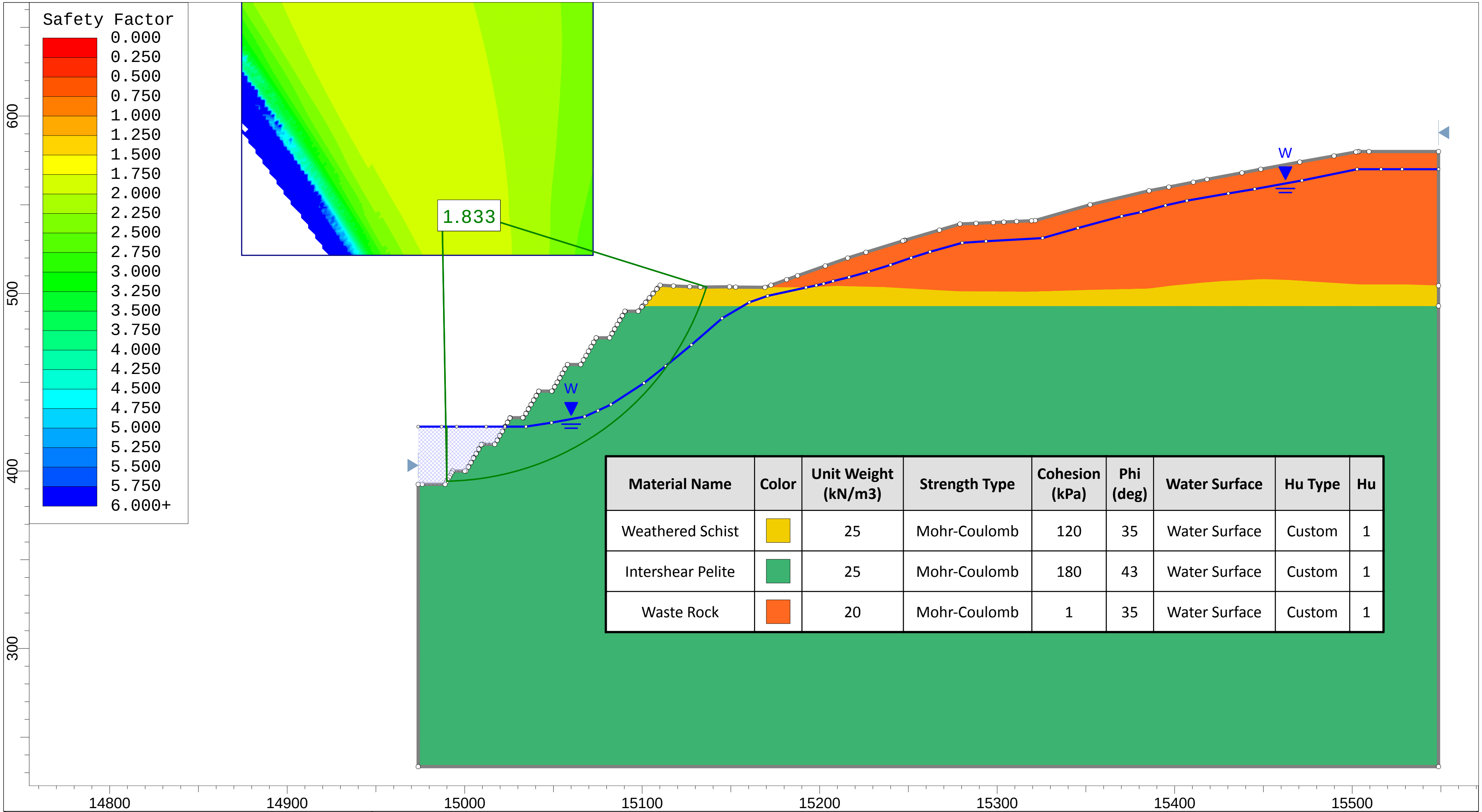
Project	Macraes Mine - Deepdell Closure		
Analysis Description	East Wall - Operational Stability		
Drawn By GF	*Scale* 1:3000	*Company*	OceanaGold Corporation
Date	23.05.2019	*File Name*	Section E - Operational Stability.slmd

SLIDEINTERPRET 8.010



Project	Macraes Mine - Deepdell Closure		
Analysis Description	East Wall - Operational Stability		
Drawn By GF	*Scale*	*Company*	OceanaGold Corporation
Date	23.05.2019	*File Name*	Section E - Operational Stability.slmd

SLIDEINTERPRET 8.010



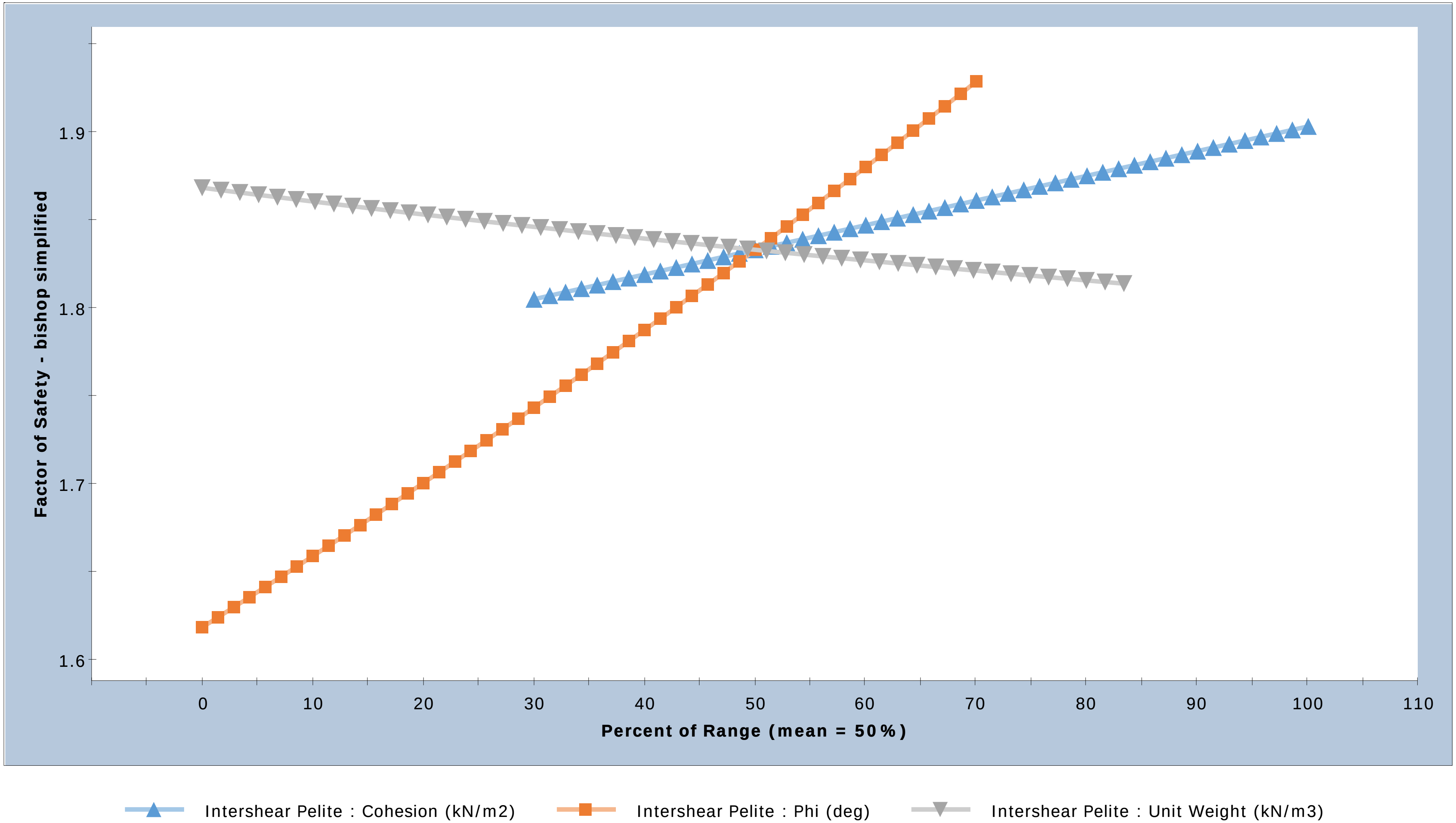
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Weathered Schist		25	Mohr-Coulomb	120	35	Water Surface	Custom	1
Intershear Pelite		25	Mohr-Coulomb	180	43	Water Surface	Custom	1
Waste Rock		20	Mohr-Coulomb	1	35	Water Surface	Custom	1

SLIDEINTERPRET 8.010

Project
Macraes Mine - Deepdell Closure

Analysis Description
East Wall - Closure Scenario 1

Drawn By	GF	*Scale*	1:3000	*Company*	OceanaGold Corporation
Date	23.05.2019			*File Name*	Section E - Closure Scenario 1.slmd



SLIDEINTERPRET 8.010	Project	Macraes Mine - Deepdell Closure		
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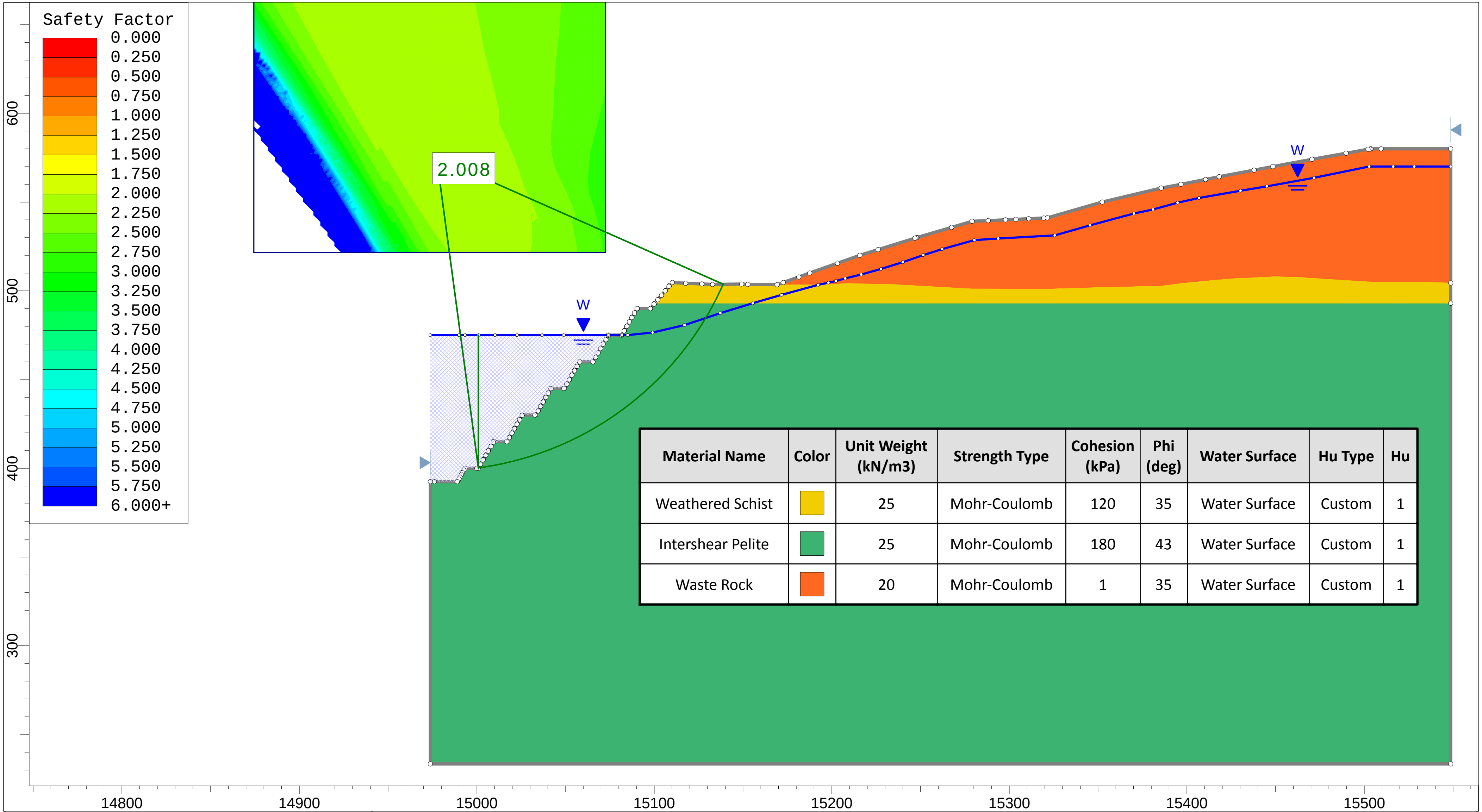
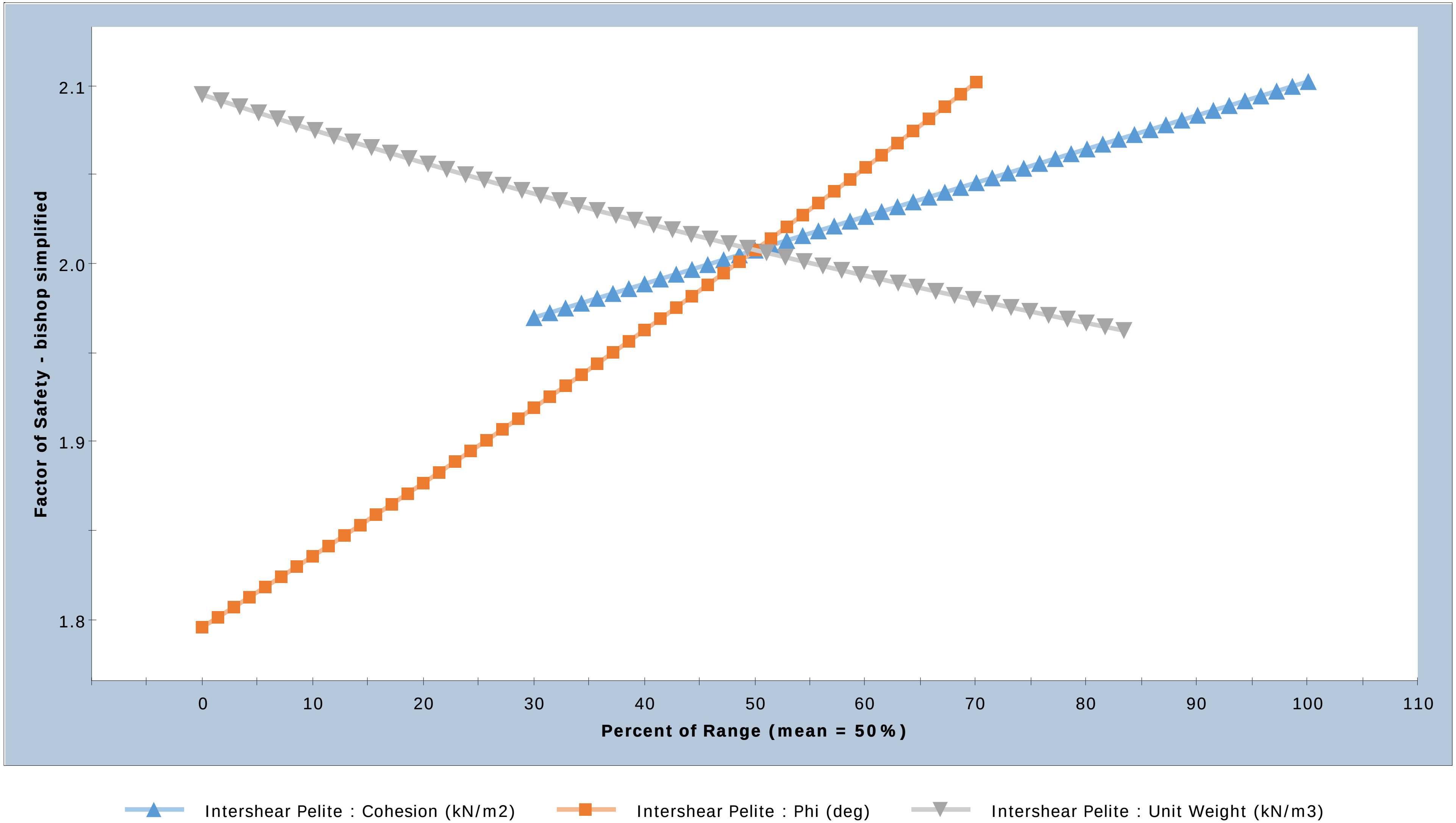
	Drawn By	GF	Scale	Company: OceanaGold Corporation
	Date	23.05.2019	File Name	Section E - Closure Scenario 1.slmd



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Weathered Schist		25	Mohr-Coulomb	120	35	Water Surface	Custom	1
Intershear Pelite		25	Mohr-Coulomb	180	43	Water Surface	Custom	1
Waste Rock		20	Mohr-Coulomb	1	35	Water Surface	Custom	1

Project	Macraes Mine - Deepdell Closure
Analysis Description	East Wall - Closure Scenario 2
Drawn By	GF
Scale	1:3000
Company	OceanaGold Corporation
Date	23.05.2019
File Name	Section E - Closure Scenario 2.slmd

SLIDEINTERPRET 8.010



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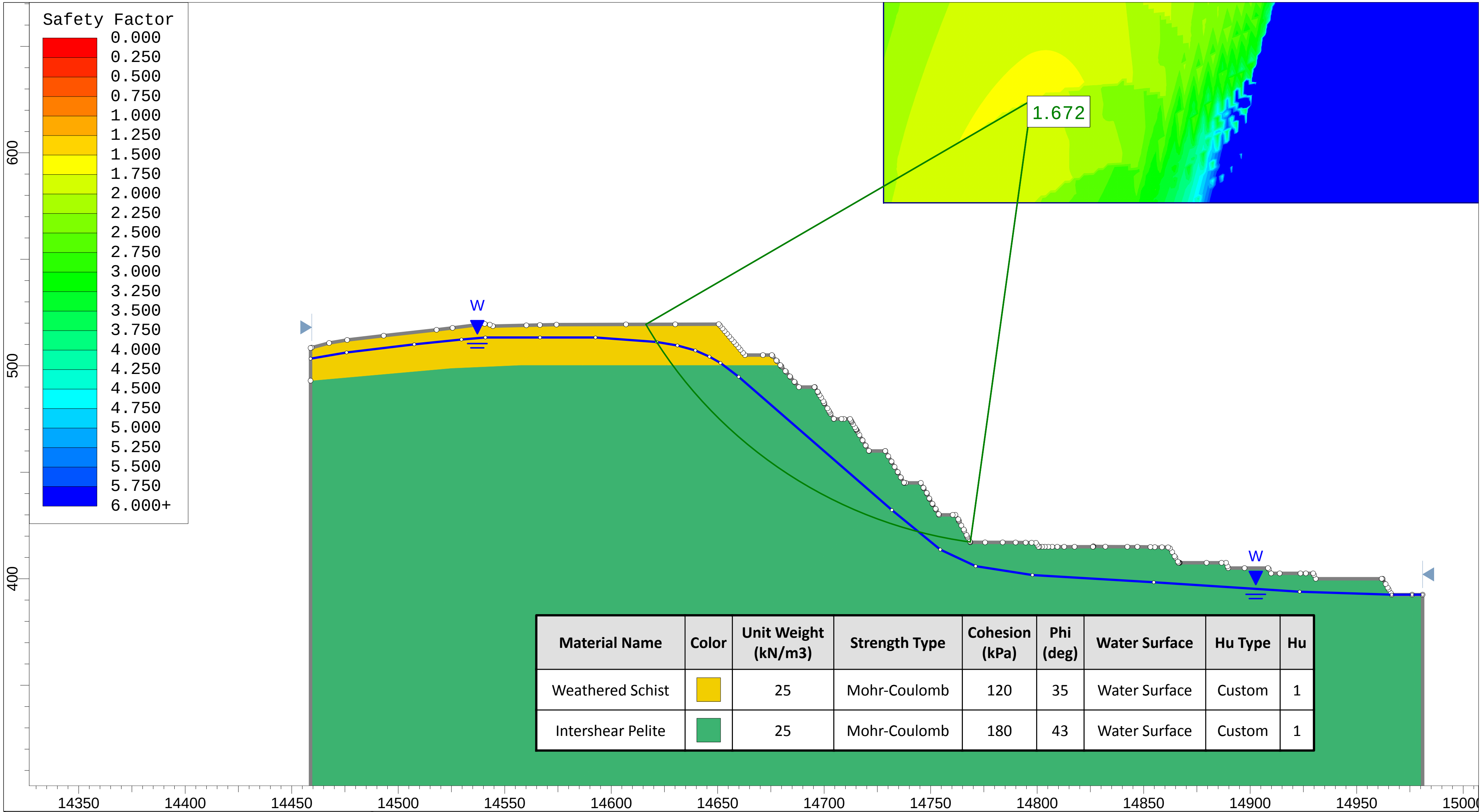
Analysis Description	East Wall - Closure Scenario 2		
Drawn By GF	*Scale*	*Company*	OceanaGold Corporation
Date 23.05.2019		*File Name*	Section E - Closure Scenario 2.slmd

SLIDEINTERPRET 8.010

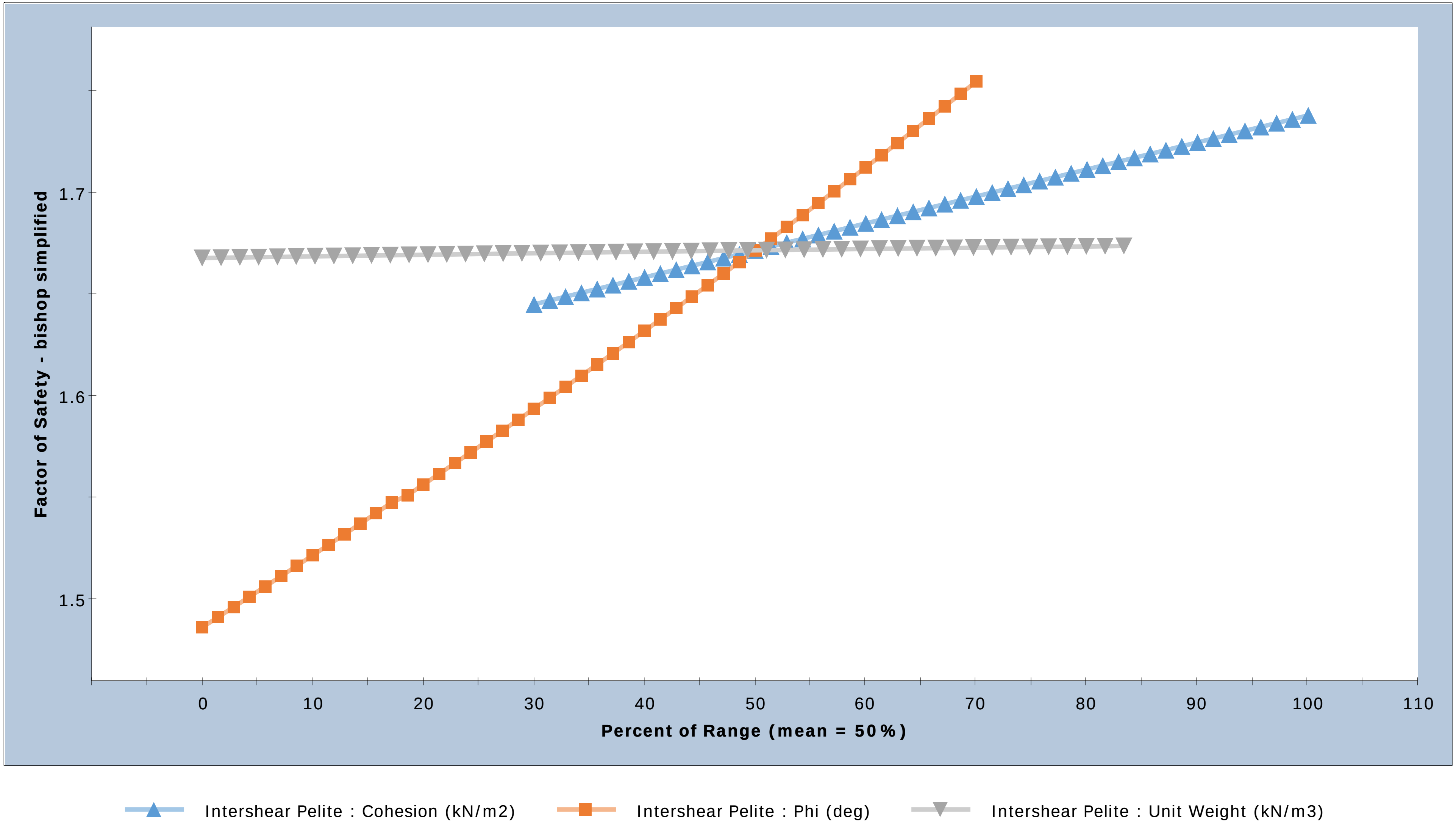


Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Weathered Schist		25	Mohr-Coulomb	120	35	Water Surface	Custom	1
Intershear Pelite		25	Mohr-Coulomb	180	43	Water Surface	Custom	1

PSM

SLIDEINTERPRET 8.010

Project	Macraes Mine - Deepdell Closure		
Analysis Description	West Wall - Operational Stability		
Drawn By GF	*Scale* 1:2500	*Company*	OceanaGold Corporation
Date	24.05.2019	*File Name*	Section E West - Operational Stability.slmd



Project	Macraes Mine - Deepdell Closure		
Analysis Description	West Wall - Operational Stability		
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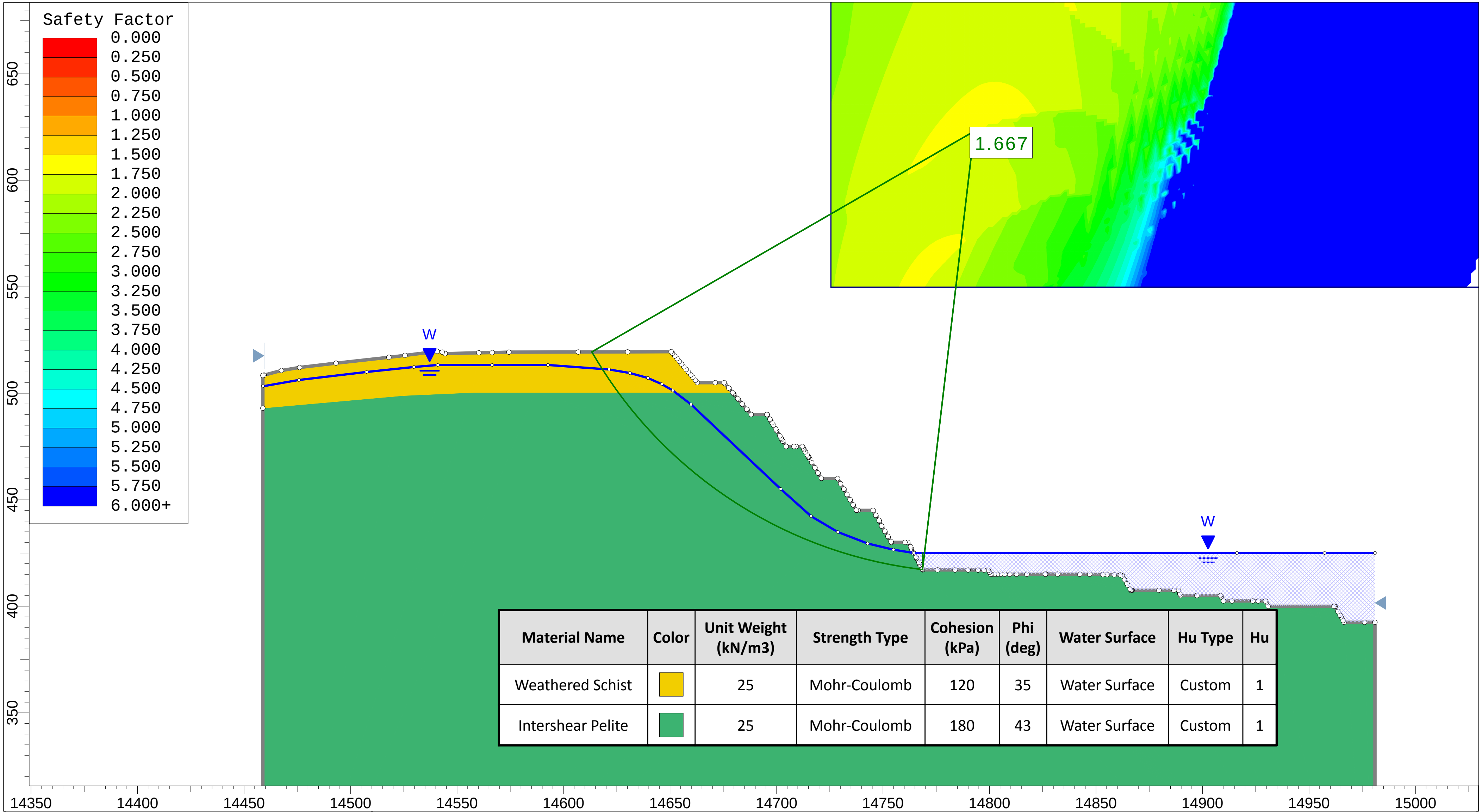
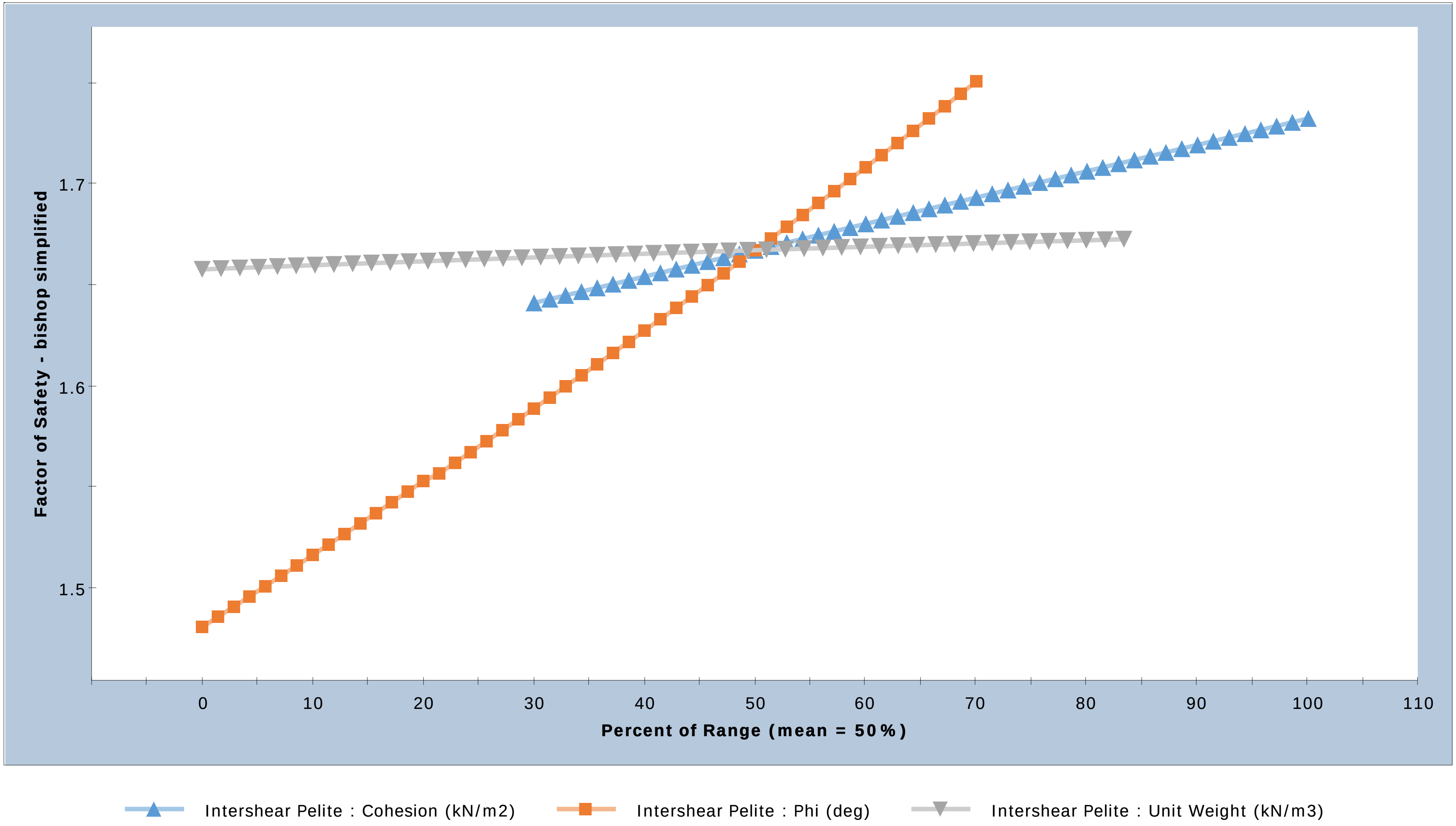
SLIDEINTERPRET 8.010



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Weathered Schist		25	Mohr-Coulomb	120	35	Water Surface	Custom	1
Intershear Pelite		25	Mohr-Coulomb	180	43	Water Surface	Custom	1

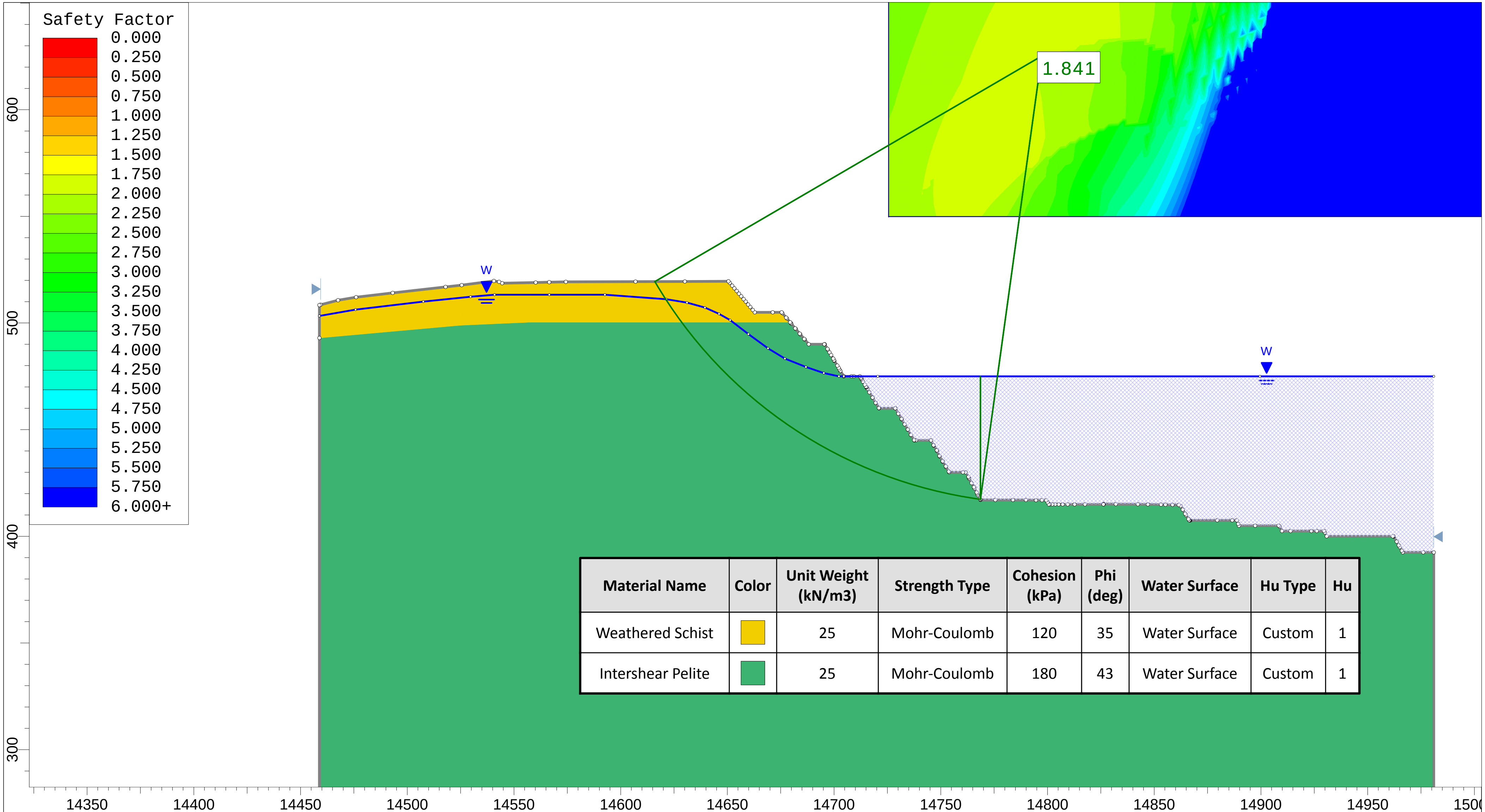
SLIDEINTERPRET 8.010

Project	Macraes Mine - Deepdell Closure		
Analysis Description	West Wall - Closure Scenario 1		
Drawn By GF	*Scale* 1:2500	*Company*	OceanaGold Corporation
Date	24.05.2019	*File Name*	Section E West - Closure Scenario 1.slmd



Project	Macraes Mine - Deepdell Closure		
Analysis Description	West Wall - Closure Scenario 1		
Drawn By GF	*Scale*	*Company*	OceanaGold Corporation
Date 24.05.2019		*File Name*	Section E West - Closure Scenario 1.slmd

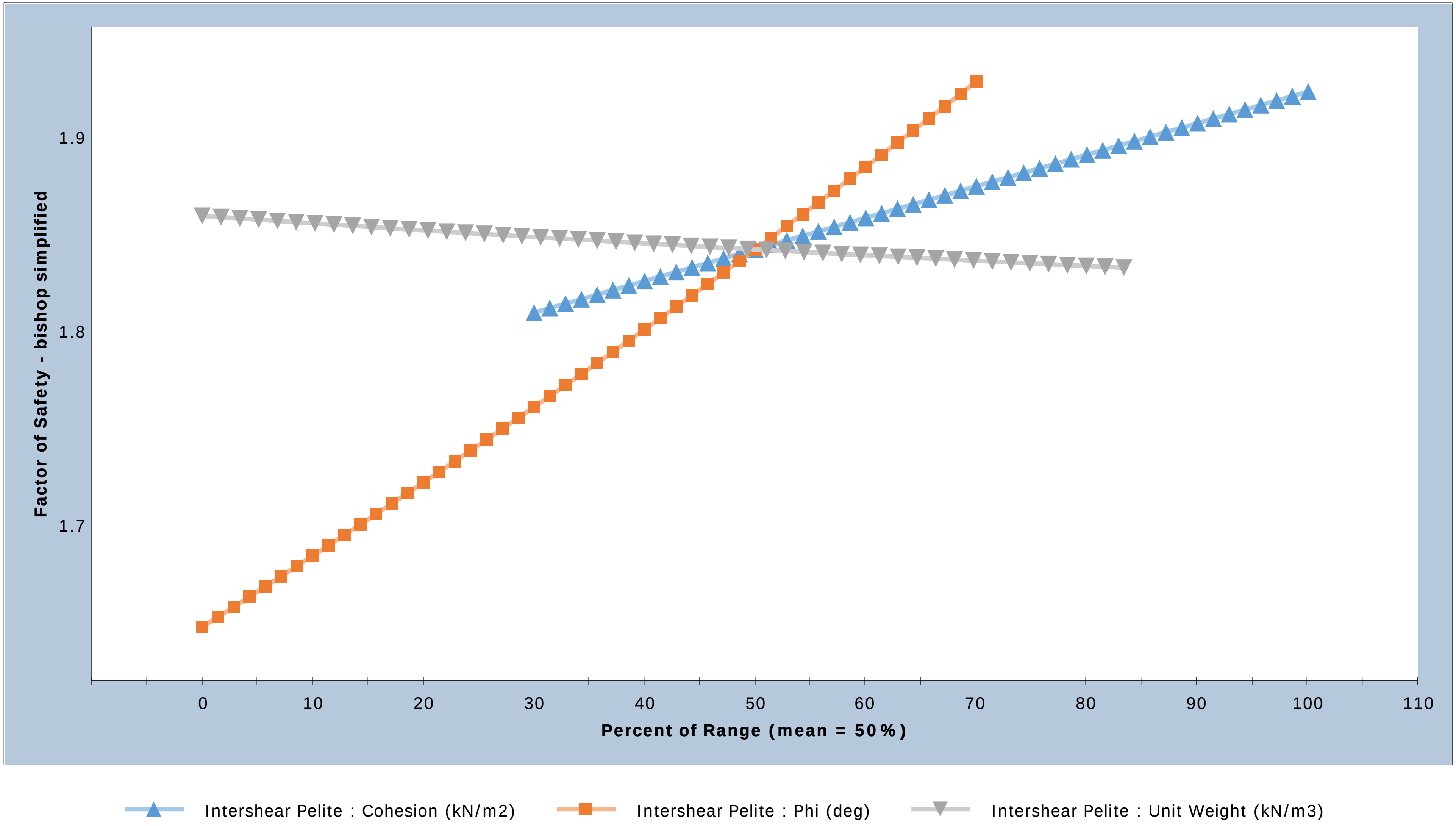
SLIDEINTERPRET 8.010



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Weathered Schist		25	Mohr-Coulomb	120	35	Water Surface	Custom	1
Intershear Pelite		25	Mohr-Coulomb	180	43	Water Surface	Custom	1

Project	Macraes Mine - Deepdell Closure
Analysis Description	West Wall - Closure Scenario 2
Drawn By	GF
Scale	1:2500
Company	OceanaGold Corporation
Date	24.05.2019
File Name	Section E West - Closure Scenario 2.slmd

SLIDEINTERPRET 8.010



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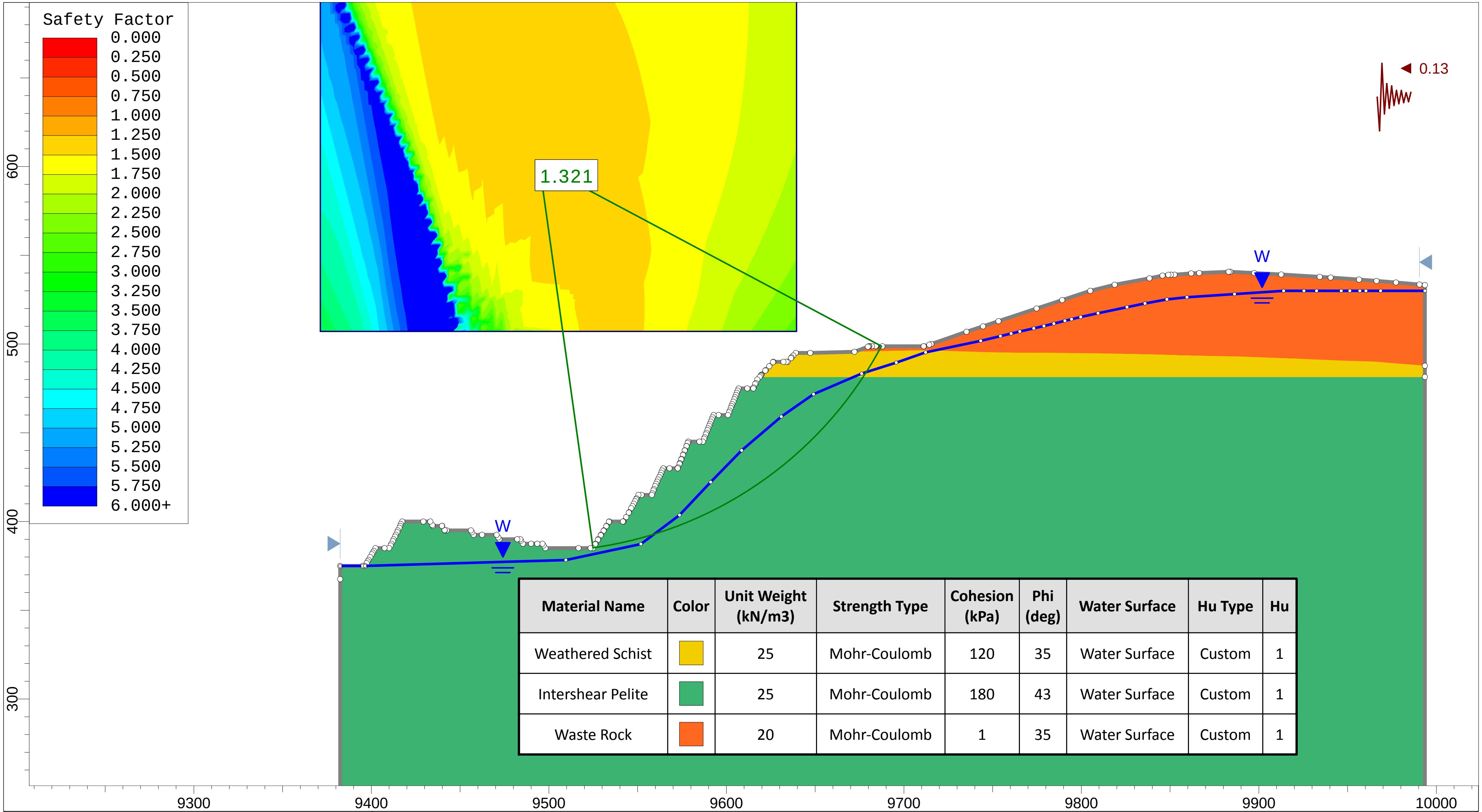
	Analysis Description West Wall - Closure Scenario 2		
	Drawn By GF	*Scale*	*Company* OceanaGold Corporation
SLIDEINTERPRET 8.010	*Date* 24.05.2019		*File Name* Section E West - Closure Scenario 2.slmd

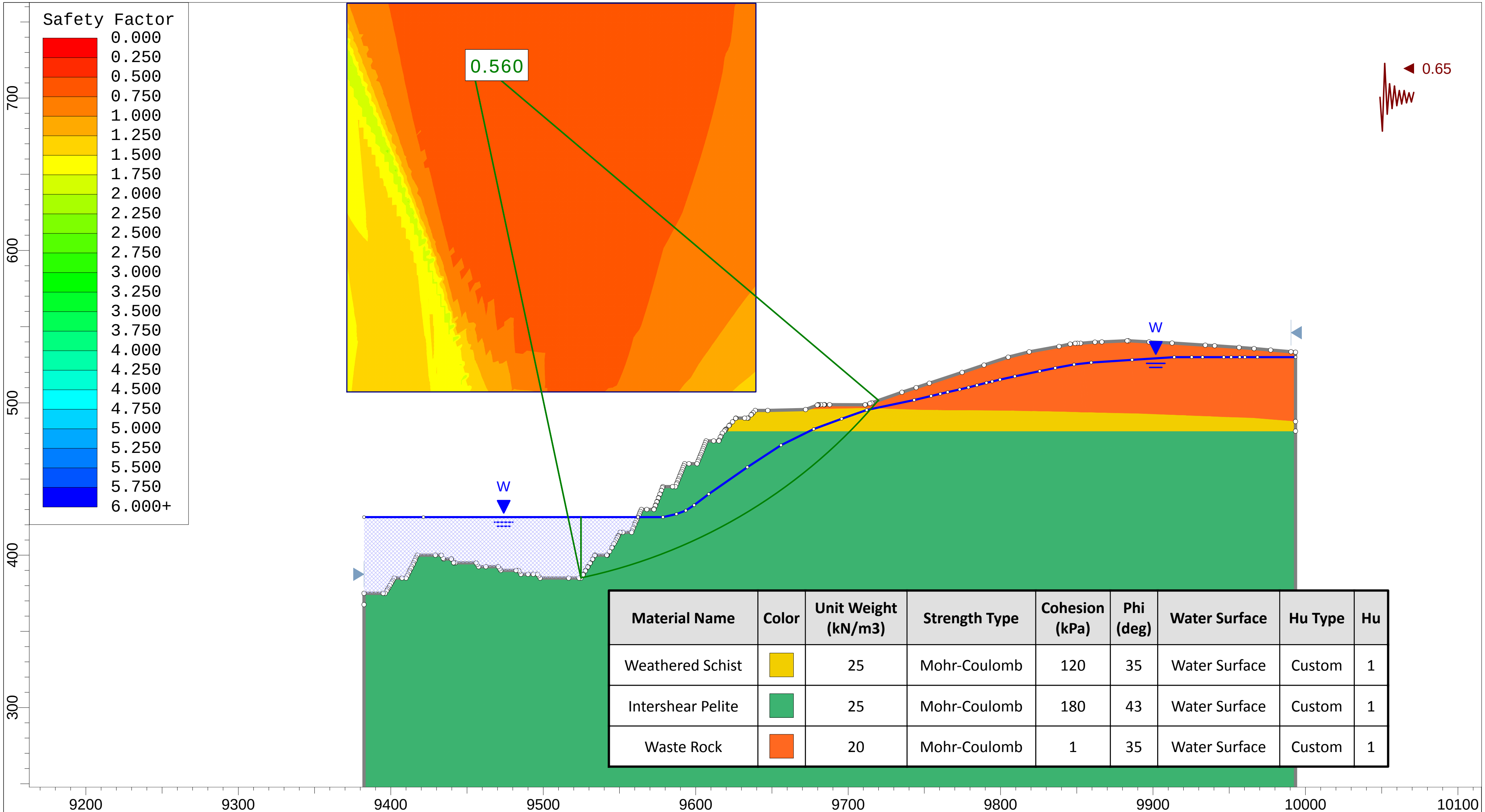
Appendix B
Results of Slide Analyses – Earthquake Cases



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Weathered Schist		25	Mohr-Coulomb	120	35	Water Surface	Custom	1
Intershear Pelite		25	Mohr-Coulomb	180	43	Water Surface	Custom	1
Waste Rock		20	Mohr-Coulomb	1	35	Water Surface	Custom	1

Project	Macraes Mine - Deepdell Closure		
Analysis Description	East Wall - Operational Stability with M5.0 Earthquake		
Drawn By	GF	*Scale*	1:3000
Company	OceanaGold Corporation		
Date	24.05.2019	*File Name*	Section C - Operational Stability (Seismic M4.5).slmd

SLIDEINTERPRET 8.010

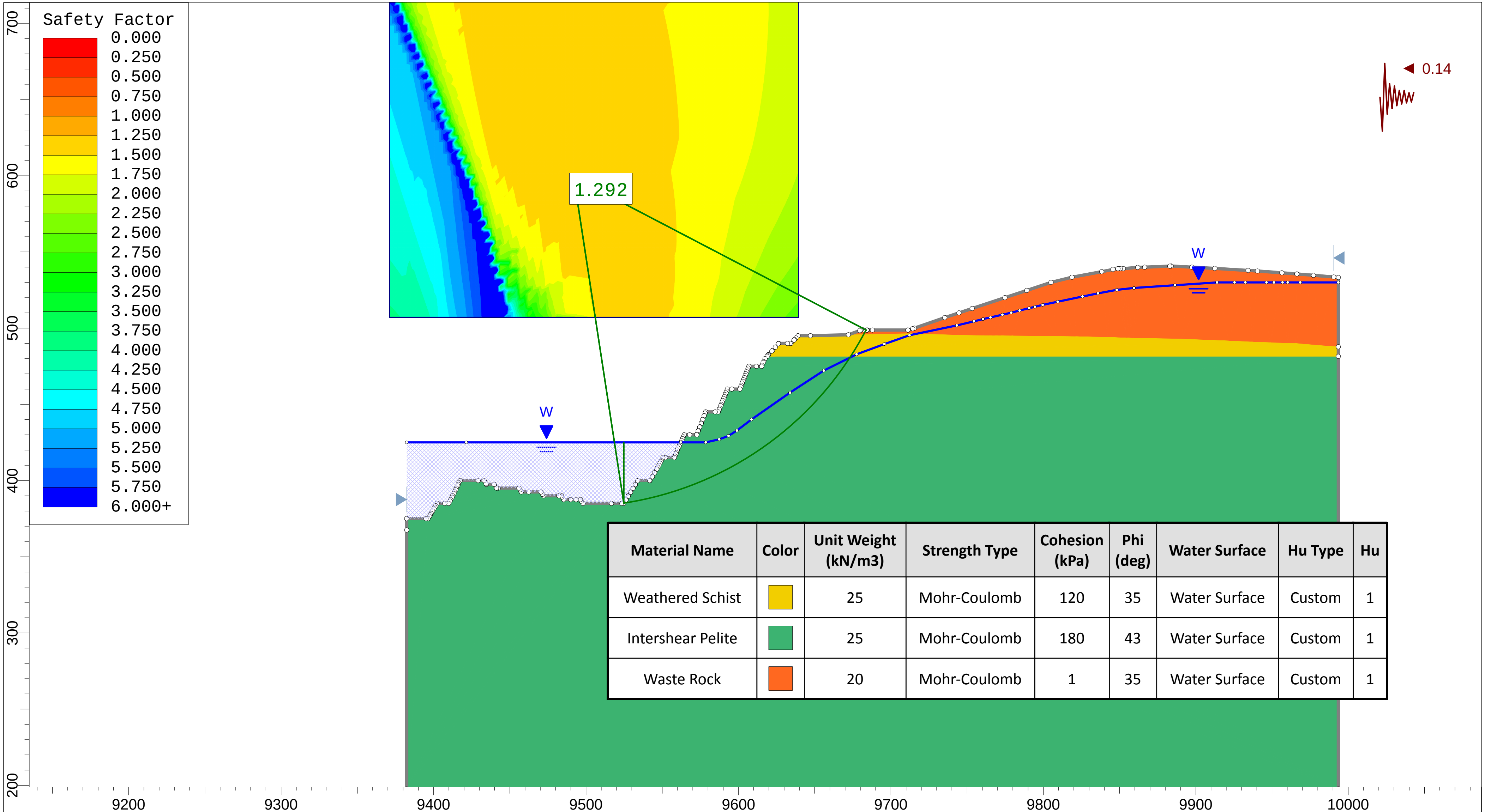


Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Weathered Schist		25	Mohr-Coulomb	120	35	Water Surface	Custom	1
Intershear Pelite		25	Mohr-Coulomb	180	43	Water Surface	Custom	1
Waste Rock		20	Mohr-Coulomb	1	35	Water Surface	Custom	1

PSM

SLIDEINTERPRET 8.010

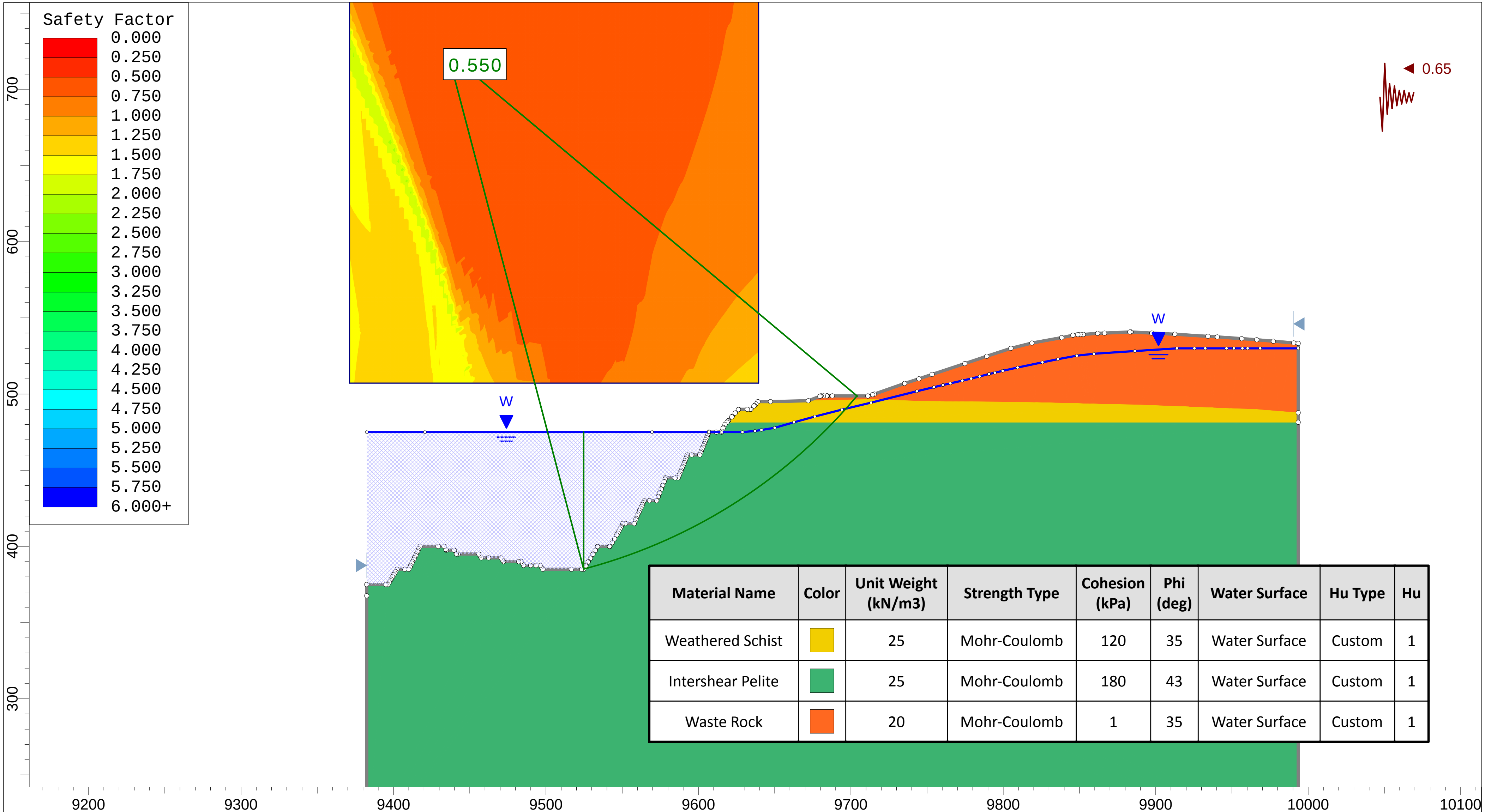
Project	Macraes Mine - Deepdell Closure
Analysis Description	East Wall - Closure Scenario 1 with PGA of 0.65g
Drawn By	GF
Scale	1:3500
Company	OceanaGold Corporation
Date	05.06.2019
File Name	Section C - Closure Scenario 1 (Seismic 0.65g).slmd



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Weathered Schist		25	Mohr-Coulomb	120	35	Water Surface	Custom	1
Intershear Pelite		25	Mohr-Coulomb	180	43	Water Surface	Custom	1
Waste Rock		20	Mohr-Coulomb	1	35	Water Surface	Custom	1

Project	Macraes Mine - Deepdell Closure
Analysis Description	East Wall - Closure Scenario 1 with PGA of 0.14g
Drawn By	GF
Scale	1:3500
Company	OceanaGold Corporation
Date	05.06.2019
File Name	Section C - Closure Scenario 1 (Seismic 0.14g).slmd

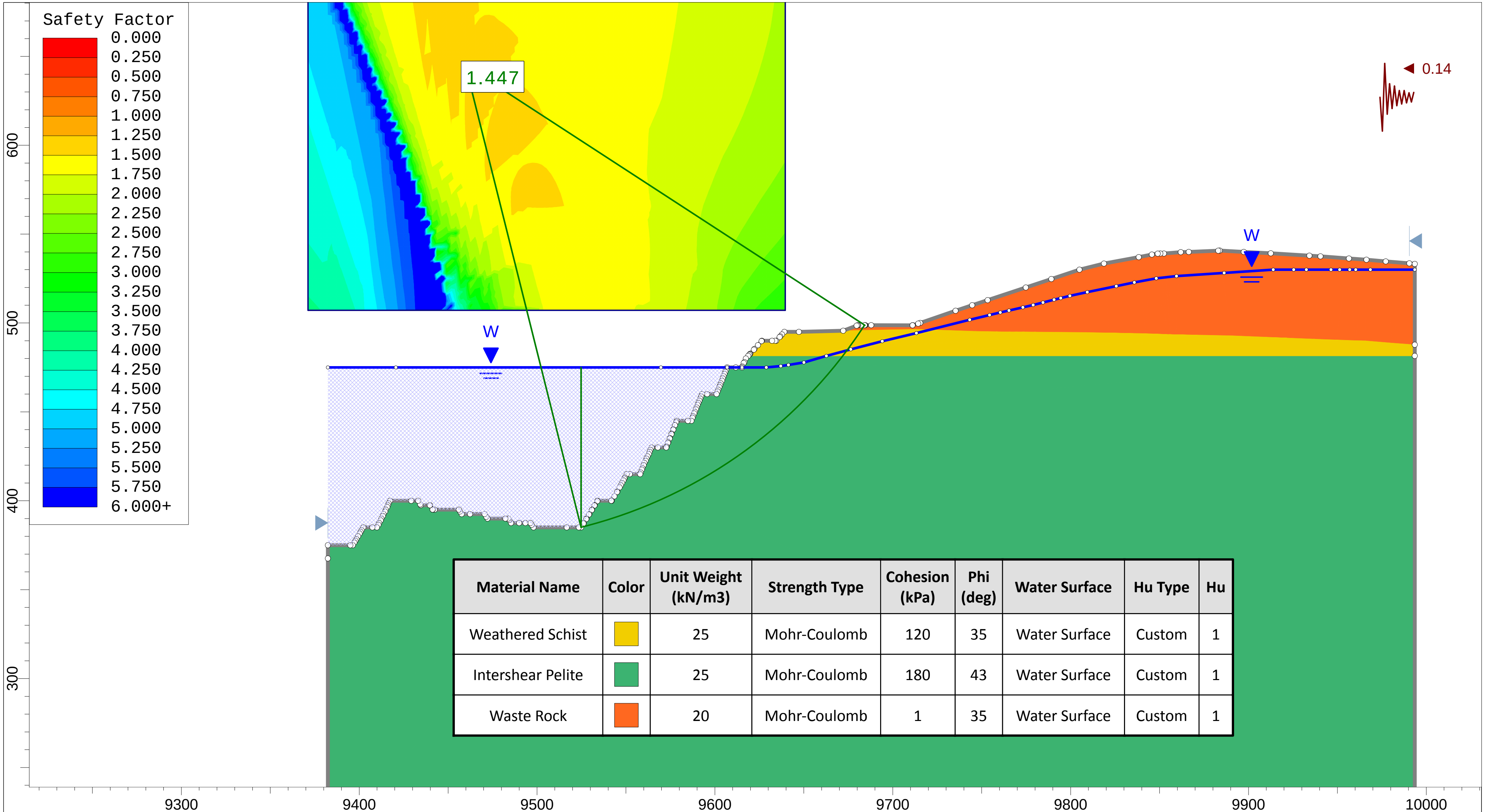
SLIDEINTERPRET 8.010



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Weathered Schist		25	Mohr-Coulomb	120	35	Water Surface	Custom	1
Intershear Pelite		25	Mohr-Coulomb	180	43	Water Surface	Custom	1
Waste Rock		20	Mohr-Coulomb	1	35	Water Surface	Custom	1

SLIDEINTERPRET 8.010

Project	Macraes Mine - Deepdell Closure		
Analysis Description	East Wall - Closure Scenario 2 with PGA of 0.65g		
Drawn By	GF	*Scale*	1:3500
Company	OceanaGold Corporation		
Date	05.06.2019	*File Name*	Section C - Closure Scenario 2.slmd



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Weathered Schist		25	Mohr-Coulomb	120	35	Water Surface	Custom	1
Intershear Pelite		25	Mohr-Coulomb	180	43	Water Surface	Custom	1
Waste Rock		20	Mohr-Coulomb	1	35	Water Surface	Custom	1

Project	Macraes Mine - Deepdell Closure		
Analysis Description	East Wall - Closure Scenario 2 with PGA of 0.14g		
Drawn By	GF	*Scale*	1:3000
Company	OceanaGold Corporation		
Date	05.06.2019	*File Name*	Section C - Closure Scenario 2 (Seismic 0.14g).slmd

SLIDEINTERPRET 8.010

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EGL Ref: 8528

MACRAES GOLD PROJECT
DEEPDELL EAST WASTE ROCK STACK
DESIGN REPORT

Prepared for:

8 November 2019

Oceana Gold (New Zealand) Ltd
PO Box 5442
DUNEDIN 9058

CONTENTS

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EGL
Geotechnical, Earthquake and Dam Engineers

EGL Ref: 8528

8 November 2019

MACRAES GOLD PROJECT
DEEPDELL EAST WASTE ROCK STACK
DESIGN REPORT

1.0 INTRODUCTION

Oceana Gold (New Zealand) Ltd (OceanaGold) operates the gold mine, known as the Macraes Gold Project (MGP), at Macraes Flat in East Otago. The mine is located between Middlemarch and Palmerston as shown in Figure 1. Gold extraction from the current mining operation involves mining of open pits and underground (Frasers Underground). Associated with the MGP are waste rock stacks for disposal of pit overburden material and tailings storage facilities for disposal of tailings.

The Deepdell North Stage III project is located on the northern side of Deepdell Creek as shown in Figure 2. The project involves the following:

- Re-mining of an extension of the Deepdell North Pit located immediately south of Horse Flat Road, to be known as Deepdell North Stage III Pit.
- Construction of a new waste rock stack, to be known as Deepdell East Waste Rock Stack (WRS), immediately south of Horse Flat Road. This will include backfill of the Deepdell South Pit.
- Partial realignment of Horse Flat Road past the WRS.

There is an existing haul road between the Coronation North Project to the north and the MGP Process Plant located on the southern side of Deepdell Creek. The haul road is on the western side of Deepdell North Stage III project (refer Figure 3) and will provide access to the new pit and WRS. No significant length of new haul road will therefore be required for the project other than a short length to access the WRS.

Details of the proposed Deepdell North Project III comprises:

- Deepdell North Stage III Pit will produce 3.5Mt of ore and 53.3Mt of waste rock. The new pit comprises an extension to the existing Deepdell North Pit (Stage 2). The footprint will be 38ha of which 18.7ha was previously disturbed by mining.
- Deepdell East WRS comprises backfilling of the existing Deepdell South Pit and will approximately re-establish the original ground contours, before raising the ground profile to the north. At the WRS northern extent the WRS crosses Horse Flat Road and the road is to be realigned. Overall the WRS has a footprint of 70.8ha and a storage capacity of 21.6Mm^3, to a crest height of RL540. The design crest level for consent is RL580 and this is the level has been used for design in this report

This design report by Engineering Geology Limited (EGL) is for the Deepdell East WRS. Pells Sullivan Meynink is carrying out the design for Deepdell North Stage III Pit and their design considers the impact of the open pit on the stability of the WRS and Pit Backfill (Ref. 2). The analyses covered by this report therefore only consider the shallow stability of the WRS and excludes analyses of potential shear failure into the new pit.

All plans grids, references and geological orientations referred to in this report are to mine north, which is approximately 45 degrees anti-clockwise from true north.

2.0 RESOURCE CONSENTS

Consents held for the existing Coronation North Project are listed in Table 2.1 below and in the Macraes Water Quality Management Plan. It is anticipated that similar consent conditions will apply to the proposed Deepdell East WRS and the design has been carried out on this basis.

Table 2.1: Consent Conditions for Existing Coronation North WRS

Consent	Description
Land Use Consent – 201.2016.779, 201.2013.360.1, LUC-2016-234 and LUC-2013-225A	Land Use Consent for Coronation and Coronation North gold mining operations
Land Use Consent - RM16.138.01	To disturb, deposit and reclaim the bed of unnamed tributaries of Maori Hen Creek, Trimbells Gully, Mare Burn and Coal Creek for the purpose of constructing the Coronation North Waste Rock Stack
Discharge Permit - RM16.138.03	To discharge silt and sediment to water for the purpose of constructing the Coronation North Waste Rock Stack
Discharge Permit - RM16.138.04	To discharge contaminants and water from silt ponds to unnamed tributaries of Maori Hen Creek, Trimbells Gully, Mare Burn and Coal Creek for the purpose of operating silt ponds for Coronation North Pit and the Coronation North Waste Rock Stack.
Discharge Permit - RM16.138.05	To discharge water from the base and toe of the Coronation North Waste Rock Stack for the purpose of operating Coronation North Waste Rock Stack.
Discharge Permit - RM16.138.06	To discharge water containing contaminants from Coronation North Pit Lake to unnamed tributaries of Maori Hen Creek, Trimbells Gully, Mare Burn and Coal Creek for the purpose of pit lake overflow
Discharge Permit - RM16.138.09	To discharge waste rock and contaminants from waste rock to land, or into land in circumstances which may result in contaminants entering water for the purpose of constructing the Coronation North Waste Rock Stack.

Discharge Permit - RM16.138.10	To discharge waste rock to land within the Coronation North Pit for the purpose of disposing of waste rock
Water Permit - RM16.138.11	To take surface water for the purpose of dewatering Coronation North Pit and use for the purpose of dust suppression
Water Permit - RM16.138.12	To take surface water for the purpose of creating the Coronation North Pit Lake
Water Permit - RM16.138.13	To take groundwater for the purpose of dewatering Coronation North Pit and use for the purpose of dust suppression
Water Permit - RM16.138.14	To take groundwater for the purpose of creating the Coronation North Pit Lake
Water Permit - RM16.138 .15	To divert water around the open pit known as Coronation North Pit Pit and into unnamed tributaries of Maori Hen Creek, Trimbells Gully, Mare Burn and Coal Creek for the purpose of preventing surface water ingress and managing the surface water runoff
Water Permit – RM16.138.17	To dam water in Coronation North Pit for the purpose of creating the Coronation North Pit Lake
Discharge Permit – RM16.138.19	To discharge contaminants from mining operations and post mining rehabilitation to air for the purpose of undertaking mining operations
Water Permit – RM16.138.20	To permanently divert water around the Coronation North Waste Rock Stack and into Maori Hen Creek, Trimbells Gully, Mare Burn and Coal Creek the for the purpose of preventing surface water ingress and managing stormwater runoff

Condition 11.2 of land use consent 201.2016.779, 201.2013.360.1, LUC-2016-234 and LUC-2013-225A requires the consent holder to engage a suitably qualified geotechnical engineer to design the waste rock stack and submit a Design Report prior to the construction of the new rock stack.

> *Condition 11.2.*
> *The consent holder shall engage a suitably qualified geotechnical engineer to design the waste rock stack. A construction report shall be prepared for the waste rock stack and this report provided to the Councils prior to the commencement of construction of the waste rock stack. The report shall include details of site formation, design construction, appearance, and testing for stability of the waste rock stack, and shall include evaluation of the long-term stability and performance of the waste rock stack.*

Condition 3 of Resource Consent RM16.138.01 relates to the requirement to construct underdrains in the watercourses that underlie the waste rock stack unless the "Best Practicable Options Report" identifies otherwise.

- *Condition 3.*
  Underdrains shall be constructed in the natural channels that form the unnamed tributaries of Maori Hen Creek, Trimbells Gully, Mare Burn and Coal Creek beneath the footprint of the Coronation North Waste Rock Stack by placement of large rocks covered by appropriately graded material to provide sufficient filtering to prevent blockage of the drains by finer material unless it is identified in the "Best Practicable Options Report" required by Condition 5 of Consent RM16.136.02 that underdrains should be constructed differently or not be constructed at all.

Condition 11.1 of Land Use Consent 201.2016.779, 201.2013.360.1, LUC-2016-234 and LUC-2013-225A relates to the seismic requirements for the waste rock stack and is addressed within this report.

- *Condition 11.1*
  The Coronation North waste rock stack shall be designed for operating basis earthquake (OBE) with a recurrence interval of 150 years and maximum design earthquake (MDE) with a recurrence interval of 2,500 years and otherwise shall otherwise be designed in accordance with sound engineering practice.

3.0 SITE AND PROJECT DESCRIPTION

Deepdell North Stage III is located on a relatively flat plain running east west, which is approximately 1km wide. Deepdell Creek meanders down the southern side of the plain and is incised about 130m lower. The northern side of the plain comprises a mountain range rising up about 200m.

The existing Deepdell South Pit is located on the southern edge of the plain as shown in Figure 3 and extends partway down the steep slope to Deepdell Creek. The sloping ground varies between about 1v:4h to 1v:1.3h. The existing south pit is to be backfilled and merges with the waste rock to be placed north of the pit, on Horse Flat, to form the proposed Deepdell East WRS. On Horse Flat, a local high point lies beneath the centre of the WRS with ground sloping to the east, west and south. To the west of the WRS, the ground slopes relatively gently at approximately 1v:30h to 1v:15h. To the east the ground also slopes relatively gently at 1v:30h to 1v:10h which steepens into the gully side slopes of approximately 1v:3h, down to Deepdell Creek. The northern toe of the WRS approaches the toe of the hills to the north of Horse Flat.

The new Deepdell North Stage III Pit is north west of the existing Deepdell South Pit and located over the central southern area of the plain, immediately south of Horse Flat Road, east of the existing haul road and west of the Deepdell East WRS as shown in Figure 3. This area has been previously mined in part for Deepdell North Pit Stage II. The new pit is to be excavated deeper and extended further than the previous pit.

All stormwater runoff from Deepdell North Stage III project will drain via a series of gullies and creeks to Deepdell Creek, that forms part of the Shag Catchment.

The batter slopes of the WRS have been designed to blend as naturally as possible with the natural landscape. The maximum height of the WRS is approximately 200m and the outer shoulders have an overall slope of about 1(v):3(h). The WRS and Deepdell South Pit are shown in Figure 4 with the underlying topography and the location of the cross sections. The design profile of Deepdell East WRS is shown on cross sections (X1-X1’ and X2-X2’) in Figure 5 and the long sections (L1-L1’ and L2-L2’) in Figure 6.

4.0 GEOLOGY AND GEOTECHNICAL INVESTIGATION

4.1. Regional Geology

The basement rock in Central and East Otago comprises Otago schist. The Otago schist is primarily composed of psammitic and pelitic grey schist derived from metamorphism of Mesozoic age sandstone and mudstone. In the area of Macraes Flat, the rocks have been metamorphosed to green schist metamorphic facies, giving a strongly foliated fabric of dark grey micaceous and light grey quartz-rich laminations.

From previous geotechnical investigations for the MGP, it is apparent that the prominent geological structure includes a well-developed schistosity with two dominant fault sets. West of the Footwall Fault, that defines the footwall of the Hyde – Macraes Shear Zone (HMSZ). The schistosity is folded and has a varying trend over the project area revealing a series of anticlines and synclines. Foliation dips either to the northwest, north, west or south west. East of the Footwall Fault (Hanging wall) the schistosity has more of an easterly trend. At Coronation the Footwall Fault position is inferred as a subtle feature on the landscape. The WRS is located to the south of the proposed Coronation North Pit and east of the both the Footwall Fault and the Hanging Wall Shear.

The major set of faults has an eastern trend. They exhibit Miocene (recent tectonic) deformations and are related to the formation of the Alpine Fault. This deformation has faulted and folded the surface within Central and East Otago to produce the present-day basin and range topography.

The second set of faults has a northern trend, and the most significant of these is the Hyde-Macraes Shear Zone.

The Hyde–Macraes Shear Zone (HMSZ) comprises a mineralised shear zone which has been mapped for at least 25km by OceanaGold geologists. The HMSZ represents the principal gold bearing ore body exploited by OceanaGold and generally strikes north and dips at about 15° to the east. Tectonic displacement associated with the HMSZ is inferred to be in the order of hundreds of metres, with this movement initiating some 120 to 150 million years ago. The ore-schist zone of the HMSZ consists of predominantly pelite and semipelite, but includes blocks of psammite, typically well foliated and containing mineralised quartz veins.

4.2. Geotechnical Investigation

Specific geotechnical investigation for Deepdell East WRS comprised field mapping and test pits. Test pits were excavated on Horse Flat where the schist is mantled by a layer of loess.

4.2.1. Fieldwork

The fieldwork was carried out on the 27th and 28th of June 2019. The fieldwork comprised a walkover survey, mapping and the excavation and logging of test pits by a senior engineering geologist. The results of the field mapping are shown in Figure 7. The test pit logs are in Appendix A.

4.2.2. Soils

The prevalent rock outcrops and head scarps of shallow slips observed on the sides of gullies and farm tracks, show that there is generally only a thin layer of soil overlying the bedrock on Horse Flat. Soil depths over the extent of the WRS was typically 0.3 to 0.5m with one location (TP4) with 4m of soil and another location (TP3) with 1.3m of soil. The soil comprises loess or residual soil (of the underlying schist) and comprises layers of silt with varying amounts of clay, sand and gravel.

Particle size distributions and Atterberg limit tests were undertaken on three loess soil samples (results are in Appendix B). The results of the three loess samples comprised silt with some clay with a Plasticity Index (PI) of 3 and 12.

4.2.3. Schist

The schist observed on site comprises well foliated, highly to moderately jointed semi-psammitic schist.

The foliation is well developed. A recent walk over survey and testpits show that the foliation generally dipping between 10° and 30° mine south east on Horse Flat. On the northern end of the Deepdell South Pit Backfill, the dip of the foliation varies between 10° and 20° towards the mine north. On the southern side of the existing Deepdell South Pit Backfill, the foliation dips about 25° to the south.

The schist is moderately to highly jointed with joints generally steeply dipping between 60° and 80° in multiple directions around the Deepdell East WRS. The joints dip between 60° and 80° to the northwest to northeast on the southern end of the Deepdell South Pit and to the south on the northern end of the Deepdell South Pit (Figure 7). Large tension cracks were observed on the eastern pit wall of the existing pit which were dipping steeply to the north west. Toppling failure was observed across the pit wall in this area.

No strength testing has been undertaken on schist in the Deepdell North Stage III area. However, elsewhere on the Macraes Gold Project, the typical unconfined compressive strength of unweathered schist is between about 20MPa and 40MPa, normal to the foliation. Schist typically has a lower unconfined compressive strength along the direction of foliation. This is reflective of the layered nature of the rock and the presence of weak, mica-rich laminations. It is anticipated that the strength of the schist underlying the proposed WRS will be consistent with that found elsewhere in the Macraes Gold Project area.

4.2.4. Inferred Areas of Instability

No areas of significant historical or incipient instability were observed on site.

Where the creeks dissect the underlying schist bedrock the steepness of the slopes generally vary depending on the local dip of the foliation and discontinuities. Typically, the side slopes to the creeks are steeper where the foliation is dipping into the slope (i.e. governed by block failures) and gentler sloping where the foliation is dipping out of the slope (i.e. governed by block sliding on the foliations and the slopes are typically parallel to the dip).

Localised shallow slumping/instability is evident on the hills to the north of Horse Flat, more than the slopes to the south down to Deepdell Creek. This shallow instability is considered to be associated with erosion and undercutting at the toe of the slopes during heavy rainfall and flow within the creeks.

Soil creep was also inferred on some of the steeper slopes on the hills however this does not effect the WRS. Where localised soil creep was evident, the soil mantle is reasonably thin and can be cleared as part of the foundation stripping.

5.0 DESIGN

5.1. Design Life

The estimated duration of the operation and rehabilitation of the Deepdell East WRS is about 5 years (2020 – 2025) and will remain in place in perpetuity.

5.2. Stability

5.2.1. General

Engineering Geology Ltd (EGL) has carried out both static and seismic stability analyses for the WRS. The analyses do not include the stability of potential shear failures into the new Deepdell North Stage III Pit. This has been covered by Pells Sullivan Meynink in their design for the pit (Ref.2). They conclude in their report that the eastern offset to the WRS is sufficient that no additional loads will be placed on the adjacent pit wall; as such this will not have an effect on stability.

The stability of the WRS has been analysed using the same design approach and parameters as that used for the existing consented Coronation Project WRS (Ref.3 and Ref.12).

Analyses of long-term static stability of the shoulders of the waste rock stack and stability when subjected to design earthquake loads have been undertaken. Limit equilibrium analyses of the slope have been undertaken using the SLOPE/W program, Geostudio 2012 (Ref.4). The Spencer solution method (Ref 5.) has been used for the analyses of circular potential failure surfaces. The Janbu simplified method (Ref.6) has been used for the analyses of potential block/non- circular failure surfaces.

Limit equilibrium analyses have been undertaken to calculate the Factor of Safety (FoS) for static and seismic loading conditions. Where seismic loading results in a FoS less than one it has also been used to determine the yield coefficient (k_y) to calculate co-seismic displacement.

The possibility of failure through the foundation soils has been considered. The seismic stability of the Deepdell East WRS complies with Condition 11.1 of DCC and WDC Consents (No. 201.2016.779, 201.2013.360.1, LUC-2016-234 and LUC-2013-225A (Ref.3). This condition requires that "*the waste rock stacks shall be designed for operating basis earthquake (OBE) with a recurrence interval of 150 years and maximum design earthquake (MDE) with a recurrence interval of 2,500 years and otherwise shall be designed in accordance with sound engineering practice"*. The WRS profile maybe subjected to settlement and horizontal displacement in an earthquake, however, the profile is stable post-earthquake.

Stability analyses have been undertaken for four cross sections through the WRS. These are representative of the critical cross sections in terms of loading, topography and rock foliation/discontinuities. The location of the cross-sections is shown in Figure 4 and the cross sections are shown in the stability analyses included in Appendix C.

5.2.2. Waste Rock Characteristics

The waste rock is anticipated to consist of a mixture of psammitic and pelitic schist. It is to be excavated from the new Deepdell North Stage III Pit. The schist rock varies from completely to slightly weathered, depending on the relative depth of excavation.

Physical characteristics of the excavated rockfill were assessed during the design phase for the tailings embankments and were based on tests conducted on samples of rockfill, schist and other various rock types used for similar projects.

The waste rock to be placed in the WRS and Pit Backfill will be end-tipped, so it is assumed to be non-structural fill. The waste rock segregates when end-tipped, such that each lift (approximately 10-20m high) varies from coarse rock at the bottom to silty sandy rockfill at the top. Consequently, the WRS consists of layers of rockfill of varying permeability. Generally, the rockfill could be expected to be free draining, except at the top of each lift where a thin low permeability layer is created by the trafficking of the dump trucks.

The following shear strength function has been adopted for waste rock which is consistent with that previously used for WRS at MGP and Coronation WRS (Ref.3 and Ref 12):

Shear strength (τ) = 1.29 $\sigma'^{\,0.91}$ (kPa), where σ' is the effective overburden pressure.

The design unit weight used is 21.5kN/m^3.

5.2.3. Foundation Material Characteristics

The *in-situ* rock beneath the proposed Deepdell East WRS is similar to that beneath the existing Coronation WRS (Ref.3 and Ref.12), so the same foundation shear strength parameters have been adopted for design. They are summarised below:

Intact rock

Effective cohesion	=	50 kPa
Effective friction	=	40 degrees

The above shear strength parameters are based on shearing through relatively intact rock at about right angles to the foliation dip. As discussed in Section 4.2.3, the measured foliation dips between about 10° and 30° to mine south east around Horse Flat. On the northern end of the existing Deepdell South Pit, the dip of the foliation varies between 10° and 20° towards mine north. On the southern side of the Deepdell South Pit the foliation dips about 25° to mine south (Figure 7).

A second set of shear strength parameters has therefore been adopted for the rock where failure could potentially occur along the rock foliation and any minor faults/shear zones dipping to the north east. The shear strength parameters are the same as those adopted in similar circumstances for the stability analysis of the existing Coronation WRS (Ref.3 and Ref.12) and given below.

Shear along foliations and minor faults/shear zones

Effective cohesion	=	47 kPa

Effective friction = 23 degrees

5.2.4. Ground Water Conditions

The stability analyses for the WRS assume that the natural ground is saturated and the waste rock is fully drained. The WRS will be comprised of rockfill and the gullies beneath the WRS are to be infilled with coarse rockfill to ensure good drainage. Some localised perched groundwater may occur on the thin low permeability trafficked layers within the WRS (refer Section 5.2.2), but due to the 10 to 20m vertical spacing between these layers is unlikely to significantly affect the overall stability of the WRS.

Similarly, in the existing Deepdell South Pit, the rockfill material in the pit is assumed to be drained and the natural ground is assumed to be saturated.

5.2.5. Static Stability

The results of the static stability analyses are presented in Appendix C and are summarised in Table 5.1 below. Static stability analyses considered potential failure conditions using circular and block type failure surfaces which passed through the rockfill material and/or original ground foundation. Only the critical failure slip surfaces are presented in this report.

Two key variables in the setup of the stability analysis were the inclusion of the overlying loess soil between the rockfill and the foundation rock around Cross Section A-A' and the potential for unfavourable foliations in the schist rock (i.e. in the direction of slope movement). Table 5.1 summarises which cross sections these conditions are applied to.

Cross Sections A-A' and B-B' (refer to Figure 4 for plan and Appendix C for cross sections) check the stability of the Deepdell East WRS on Horse Flat.

Cross Section A-A' (refer to Figure A05 in Appendix C) is through the greatest thickness of rock fill where the deepest overlying soil is found. For stability analysis, the overlying soils in the area of Section A-A' are assumed to be continuous and 4m thick and a foliation dip of zero degrees. In reality, test pitting has demonstrated the thickness of overlying soils is much less than 4m on average and this assumption is just for the stability analyses.

Cross Section B-B' cuts through the steepest topography with a foliation dip direction that is more unfavourable than Cross Section A-A'. A downslope dip of 15 degrees has been applied.

Cross Sections C-C' and D-D' (refer to Figure 4 for plan and Appendix C for cross sections) have been used to check the stability of the Deepdell South Pit area with the addition of the East WRS.

For Cross Section D-D' the dip direction of the foliations is assumed to be at zero degrees. For Cross Section C-C' it is assumed the dip direction of the foliations is at 10 degrees, as the dip of 25 degrees noted in this area is not directly downslope.

In the model, we have applied the reduced strength along the foliations to plus and minus 5 degrees from that indicated in Table 5.1.

Table 5.1. Summary of Static Slope Stability Analyses

Figure	Cross Section	Over lying loess soil	Unfavourable foliation dip considered	Critical Failure Surface	FoS
A01a	A-A’	Yes	0 degrees	Block slide along schist foliation	2.0
A02a	B-B’	No	15 degrees	Block slide along schist foliation	2.1
A03b	C-C’	No	10 degrees	Block slide along schist foliation	1.7
A04a	D-D’	No	0 degrees	Block slide along schist foliation	1.8

Based on the above analyses, the performance of the WRS under static loading is satisfactory, as all the calculated FoS are above 1.5, a typical minimum value applied for long-term static stability and considered suitable for the WRS.

5.2.6. Seismic Stability

Seismic stability analyses of the WRS have been undertaken for the following two levels of earthquake shaking;

- Operating Basis Earthquake (OBE) - 150 year return period
- Safety Evaluation Earthquake (SEE) – 2,500 year return period.

Note that the SEE was previously referred to as the Maximum Design Earthquake (MDE) but has been changed to SEE to follow the terminology used in the latest NZSOLD New Zealand Dam Safety Guidelines (2015). The WRS is not a dam, however, and therefore the NZSOLD definitions are used only as reference. For the WRS the OBE earthquake is a design limit state which aims to have minor damage and the SEE earthquake would look to prevent collapse so not to cause a hazard.

The cross-section geometry used for static stability has been used to assess seismic stability.

Peak horizontal ground accelerations for the OBE and SEE were obtained from acceleration response spectra determined in a site specific seismic hazard study by the Institute of Geological and Nuclear Science (GNS) for the MGP (Ref.7). The spectra were generated from a model which combines earthquakes associated with the three closest faults to the MGP (Billy’s Ridge, Taieri Ridge, and Hyde faults).

The levels of peak ground acceleration used for analysis of the seismic stability are:

- OBE (150 yr) = 0.13 g
- SEE (2,500 yr) = 0.65 g

The ground motion amplification (ratio of crest acceleration to PGA) relationship given by Harder et al. (Ref.8) has been used to determine the peak motion at the crest of the WRS. This method is based on actual measurements of ground motions recorded at the crests of embankments relative to those recorded near the base. Crest accelerations using this method are 3.3 and 1.4 times the base ground acceleration for the OBE and SEE. Accelerations will vary throughout the WRS and this needs to be accounted for in the stability analyses. The estimated average horizontal accelerations for both OBE and SEE levels of earthquake shaking applied to each potential failure surface (kmax) are given in Table 5.2.

Stability has been assessed for potential failure surfaces located at 1/3H, 2/3H and 1H below the top of the WRS, where H is the full height of the WRS. Where yielding is predicted, permanent co-seismic (during an earthquake) slope deformations are estimated using the Bray and Travasarou (2007) displacement calculation (Ref.9). Spectral accelerations used for this calculation are reported in Table 5.2. The development of the calculation approach considered the dynamic response of the potential failure sliding mass.

The overlying loess soils around Cross Section A-A' are potentially susceptible to liquefaction if saturated. The test pit logs and the laboratory testing indicate that the loess layers are low-plastic silt with PI less than 12 and therefore are susceptible to liquefaction under the PI criteria of Bray and Sancio (2006) (Ref.13). We have not been able to use the water content over liquid limit criteria as the ground water conditions are currently dry in these layers.

As a perched ground water table beneath the WRS could potentially occur and saturate the loess soils, triggering of liquefaction from shaking equivalent to OBE and SEE, using Idriss and Boulanger (2008) (Ref.14), has been considered. A 35% or greater fines content has been assumed for the loess material. The cyclic stress ratio for the OBE earthquake beneath the WRS indicates that liquefaction is unlikely for the OBE earthquake, however, if the material is susceptible to liquefaction, triggering would have occurred with shaking less than the SEE. The stability analyses have, therefore, used non-liquefied strengths for the loess under the OBE and an undrained liquefied strength, based Olson and Stark (2002) (Ref.15), of 0.06 multiplied by the vertical effective stress for the SEE.

The limit equilibrium stability analyses are presented in Appendix C and summarised in Table 5.2 on the following page.

For the OBE cases, the seismic Factor of Safety is generally 1.0 or greater except for Figure A07 and A19 where small co-seismic displacements occur are estimated. For OBE cases with FoS greater than 1, limited horizontal displacements are expected, however, some vertical consolidation of the WRS, due to shake down, may occur.

With liquefaction of a continuous loess layer beneath the WRS, stability would not be maintained in the post-earthquake (SEE) case as shown in the analysis in Figure A05 in Appendix C with a FoS equal to 0.8. This is predominantly a consideration at the northern toe which the thickest covering of loess. The width of loess that would need to be removed, or waste rock contact directly on the bedrock that would need to be proven, has been determined to be 30m. A 30m wide shear key starting at the WRS toe achieves a post-earthquake FoS of 1.1. This width has been shown as a shear key area in Figure 8. This extends over the Horse Flat area however in many locations to the South East rock is outcropping anyway.

Cross Section A-A' has the greatest co-seismic displacements in the analyses with 12 to 46cm (16%ile to 84%ile) of displacement estimated. Of the other cross-sections, B-

B' had the greatest estimated displacements of 11 to 41cm. For these to section the greatest displacement is associated with a shallow slip mechanism along the embankment slope face. With the higher shaking of the SEE, greater vertical shake down (consolidation) settlement of the WRS can be expected. Settlement associated with shake down may be in the order of a tens of centimetres to possibly a meter. In the SEE, these displacements are acceptable as there are no critical elements which would be affected, and the post-earthquake stability has been shown to achieve a FoS of 1.1.

To achieve a stable profile post-earthquake, the extent of loess is to be determined and material removed to match the design assumptions. This will require monitoring at the construction stage.

Table 5.2. Summary of Seismic Slope Stability Analyses and Co-seismic Displacement Estimates

Figure No.	Cross section	Loading condition	Failure surface location	Topographical Amp. Factor	Seismic FoS[1]					Co-seismic displacement estimates[3]	
					H (m)	T (s)	Sa(1.5T)	Sa(1.5T) x Amp. Factor[2]	FoS	ky (g) -	Estimated co-seismic displacements using Bray and Travasarou (2007) (cm)
A05	**A-A' (No shear keys)**	Post EQ – Su_{liq}=0.06	H						0.8	-	-
A06		Post EQ – Su_{liq}=0.06	H						1.1	-	-
A07			1/3H	3.3	30	0.26	0.28	0.92	<1.0	0.46	0 - 5.1
A08			2/3H	2.2	50	0.43	0.17	0.36	1.1	-	-
A09	**A-A' (30m shear keys)**	OBE	H	1.0	80	1.07	0.07	0.07	1.7	-	-
A10			1/3H	1.4	20	0.17	1.59	2.23	<1.0	0.44	**12.4 - 46.2**
A11			2/3H	1.2	50	0.43	0.74	0.88	<1.0	0.42	0 - 7.6
A12		SEE	H	1.0	70	0.93	0.35	0.35	<1.0	0.12	7.3 - 27.8
A13			1/3H	3.3	20	0.17	0.36	1.19	<1.0	0.48	1.8 - 8.8
A14			2/3H	2.2	40	0.35	0.21	0.46	<1.0	0.44	<1.0
A15		OBE	H	1.0	70	0.93	0.08	0.08	1.2	-	-
A16	**B-B'**		1/3H	1.4	20	0.17	1.59	2.23	<1.0	0.48	**11.0 – 41.0**
A17			2/3H	1.2	40	0.35	0.92	1.10	<1.0	0.44	2.5 - 11.5
A18		SEE	H	1.0	125	1.67	0.19	0.19	<1.0	0.14	0 - 9.9
A19			1/3H	3.3	60	0.80	0.09	0.31	<1.0	0.31	<1.0
A20			2/3H	2.2	70	0.93	0.08	0.17	1.2	-	-
A21		OBE	H	1.0	100	1.33	0.05	0.05	1.4	-	-
A22	**C-C'**		1/3H	1.4	60	0.80	0.42	0.58	<1.0	0.32	0 - 7.8
A23			2/3H	1.2	70	0.93	0.35	0.42	<1.0	0.26	0 - 6.0
A24		SEE	H	1.0	100	1.33	0.24	0.24	<1.0	0.17	0 - 6.4
A25			1/3H	3.3	60	0.80	0.09	0.31	1.1	-	-
A26		OBE	2/3H	2.2	100	1.33	0.05	0.12	1.6	-	-
A27			H	1.0	125	1.67	0.04	0.04	1.5	-	-
A28	**D-D'**		1/3H	1.4	80	1.07	0.30	0.43	<1.0	0.33	0 - 3
A29		SEE	2/3H	1.2	100	1.33	0.24	0.29	<1.0	0.29	0 - 2.7
A30			H	1.0	125	1.67	0.19	0.19	<1.0	0.15	0 - 3.9

1. H is the total height of the slip mass. Slide mass fundamental period (T) is estimated using 4H/Vs for deep block failure slips and 2.6H/Vs for shallow circular failure slips.
2. The amplified spectral accelerations at the degraded slide period are applied as pseudostatic horizontal acceleration in seismic stability analysis.
3. Co-seismic displacement calculation is only undertaken when seismic FoS, using full pseudostatic horizontal coefficient equal to SA(1.5T)xAmp, is less than 1. Co-seismic displacements are calculated for a mean magnitude of 7.2.

5.3. Surface Drainage

A perimeter drain or bund will be constructed around the toe of the WRS to collect stormwater runoff and divert it into silt ponds. Runoff flows are expected to be quite small because a high proportion of rainfall is expected to infiltrate the rock fill. This is consistent with what has been observed on site for the existing WRS.

Where necessary, perimeter drains are to be constructed largely by excavating into the natural ground. Some short sections may be located in fill. Drains will be sized to have sufficient capacity to carry the peak runoff from the 10-minute, 5 percent AEP (20 year storm) whilst retaining 0.25m freeboard.

Temporary clean water diversion drains and diversion culvert will be constructed at the early stages of the WRS to reduce the catchments contributing to the silt ponds.

5.4. Subsurface Drainage

Existing ephemeral gullies beneath the WRS footprint are to be filled with coarse free draining waste rock material either through high tip-head segregation or direct placement. This will enable subsurface drainage of gullies which are filled downstream by waste rock.

5.5. Silt Control

Runoff from the WRS during construction will be directed to silt ponds located in the gullies immediately downstream, as discussed in the erosion and sediment control report (Ref.10). Temporary silt ponds may also be constructed upstream of the main silt ponds in the early stages of development of the WRS as required. The WRS will be constructed with the working surface sloping down away from the outside shoulder. The runoff will then infiltrate the rockfill and percolate through the coarse fill subsurface drainage system before discharging as seepage downstream of the WRS. Experience to date indicates that not much silt is generated during waste rock stack construction due to a combination of the material used and the progressive nature of stripping and rehabilitation as the waste rock stack is constructed. Most of the runoff infiltrates the rockfill and the silt is removed before the seepage emerges from the toe of the rock stack.

5.6. Rehabilitation

The final contoured surface of the WRS is to be rehabilitated by spreading 1.65m of weathered rock plus 0.2m of topsoil, excavated from the foundations, and then grassed. Once the grass is established, any runoff from the WRS is generally of good quality.

6.0 CONSTRUCTION AND QUALITY CONTROL

Construction of the WRS will be undertaken by OceanaGold, or in part by contractors under the direct supervision of OceanaGold employees. OceanaGold is responsible for setting out the works, ensuring that the rock stack is constructed to the design profile, that foundation stripping and preparation is properly carried out, subsurface drainage material is suitably placed, surface drainage is properly constructed and maintained, and that rehabilitation (i.e. topsoil and grassing) is to high standards. The proposed construction methods and rehabilitation strategies are similar to those employed on the existing tailing storage facilities and waste rock stacks, and these have been successful during the 25 years of operation at the MGP.

The design requirement for shear keys beneath WRS can be reviewed with additional ground investigation information. Shear keys would be constructed of waste rock and would need to extend through the soils and contact the schist rock over the areas shown in Figure 8.

It is anticipated that similar consent conditions to those for the existing Coronation North WRS will apply to the Deepdell East WRS, such as the specific requirements affecting construction as summarised below:

Conditions 8 and 9 of RM16.138.01, Condition 8 of RM16.138.15 and Condition 12 of RM16.138.20 refer to the requirement for cleaning of construction plant to avoid spreading didymo and the need to minimise work in waterways.

Condition 14a of RM16.138.01, condition 15a of RM16.138.15, condition 16a of RM16.138.20 and condition 14.6a of 201.2016.779, 201.2013.360.1, LUC-2016-234 and LUC-2013-225A requires if there is discovery of koiwi tangata (human skeletal remains) or Maori artefact material that the Consent Holder shall without delay:

i. Notify the Consent Authority, Tangata whenua and New Zealand Historical Society, in the case of skeletal remains, the New Zealand Police and
ii. Stop work within the immediate vicinity
iii. Any koiwi tangata discovered shall be handled and removed by tribal elders responsible for the tikanga (custom) appropriate to its removal or preservation

Condition 14b of RM16.138.01, Condition 15b of RM16.138.15, Condition 16b of RM16.138.20 and Condition 14.6b of 201.2016.779, 201.2013.360.1, LUC-2016-234 and LUC-2013-225A requires if there is discovery of any features or archaeological features that pre-dates 1900, or heritage material, or disturbs a previously unidentified archaeological or history site that the Permit Holder shall without delay:

i. Stop work within the immediate vicinity
ii. Advise the New Zealand Historical Places Trust, and in the case of Maori features or materials, the Tangata whenua, and if required, shall make an application for an Archaeological Authority pursuant to the Historic Places Act 1993
iii. Arrange for a suitably qualified archaeologist to undertake a survey of the site.

7.0 CONCLUSIONS

The Deepdell East WRS is designed in accordance with accepted engineering practices. Existing WRS have been designed to similar standards and their performance to date has been satisfactory. Construction procedures, including supervision and quality control practices for the Deepdell WRS will meet accepted engineering standards.

All final slopes of the WRS have been designed for a long term static factor of safety against instability exceeding 1.5 for the expected water levels.

The WRS has been designed for an operating basis earthquake (OBE) with a recurrence interval of 150 years and maximum design earthquake (SEE) with a recurrence interval of 2,500 years. Minor deformation is expected from the OBE and satisfactory performance is shown for the post-earthquake case and the SEE and settlement and slope deformation will not affect any critical elements of the WRS.

Based on the results of the static and seismic stability analyses conducted it is concluded that the WRS is sufficiently stable for the intended long-term use of pastoral farming post-rehabilitation and mine closure.

OceanaGold will ensure short and long term stability of the WRS, associated works, and surrounds at all time during the operational life of the structure. This will be achieved through construction, rehabilitation and ongoing monitoring in accordance with the controlling documents:

Deepdell East WRS Design Report (i.e. this report);
Deepdell North Stage III Erosion and Sediment Control Report (Ref 10);
Macraes Water Quality Management Plan (Ref.11)

ENGINEERING GEOLOGY LTD

Report prepared by

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BE (Hons) Civil
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Reviewed by:

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Principal Geotechnical Engineer
CPEng

N Tan
Geotechnical Engineer
BE (Hons) Civil

FIGURES
1 TO 8

REFERENCES

1. Oceana Gold (New Zealand) Limited (2014) 'Coronation Waste Rock Stack Operations and Management Plan, June 2014'.

2. Pells Sullivan Meynink (2019) Geotechnical Review Updated Deepdell Stability Stage 3 Pit. Report Ref PSM71-238L, dated 5 June 2019.

3. Engineering Geology Ltd (2014) 'Macraes Gold Project, Coronation Waste Rock Stack, Design Report'.

4. GEO-SLOPE International Ltd (2012) 'Stability Modelling with SLOPE/W: An Engineering Methodology', GEO-SLOPE International Ltd.

5. Spencer, E. (1967) 'A Method of Analyses of the Stability of Embankments Assuming Parallel Inter-Slice Forces', Geotechnique, Vol. 17, No. 1, pp 11-26.

6. Janbu, N. (1954) Applications of Composite Slip Surfaces for Stability Analysis. In Proceedings of the European Conference on the Stability of Earth Slopes, Stockholm, Vol. 3, pp. 39-43.

7. Litchfield N, McVerry G H, Smith W, Berryman K R and Stirling M (2005) 'Seismic Hazard Study for Tailings Embankments at Macraes Gold Project' GNS Client Report 2005/135.

8. Harder, L.F., Bray, J.D., Volpe, R.L. and Rodda, K.V. (1998) 'performance of Earth Dams during the Loma Prieta Earthquake' US Geological Survey Professional Paper 1552-D, pp D3-D26.

9. Bray, J.D. and Travasarou, T. (2007) 'Simplified Procedure for Estimating Earthquake-Induced Deviatoric Slope Displacements', Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 133(4): 381-39277

10. Engineering Geology Ltd (2019) 'Oceana Gold (New Zealand) Ltd, Macraes Gold Project, Deepdell North Stage III, Erosion and Sediment Control Report'

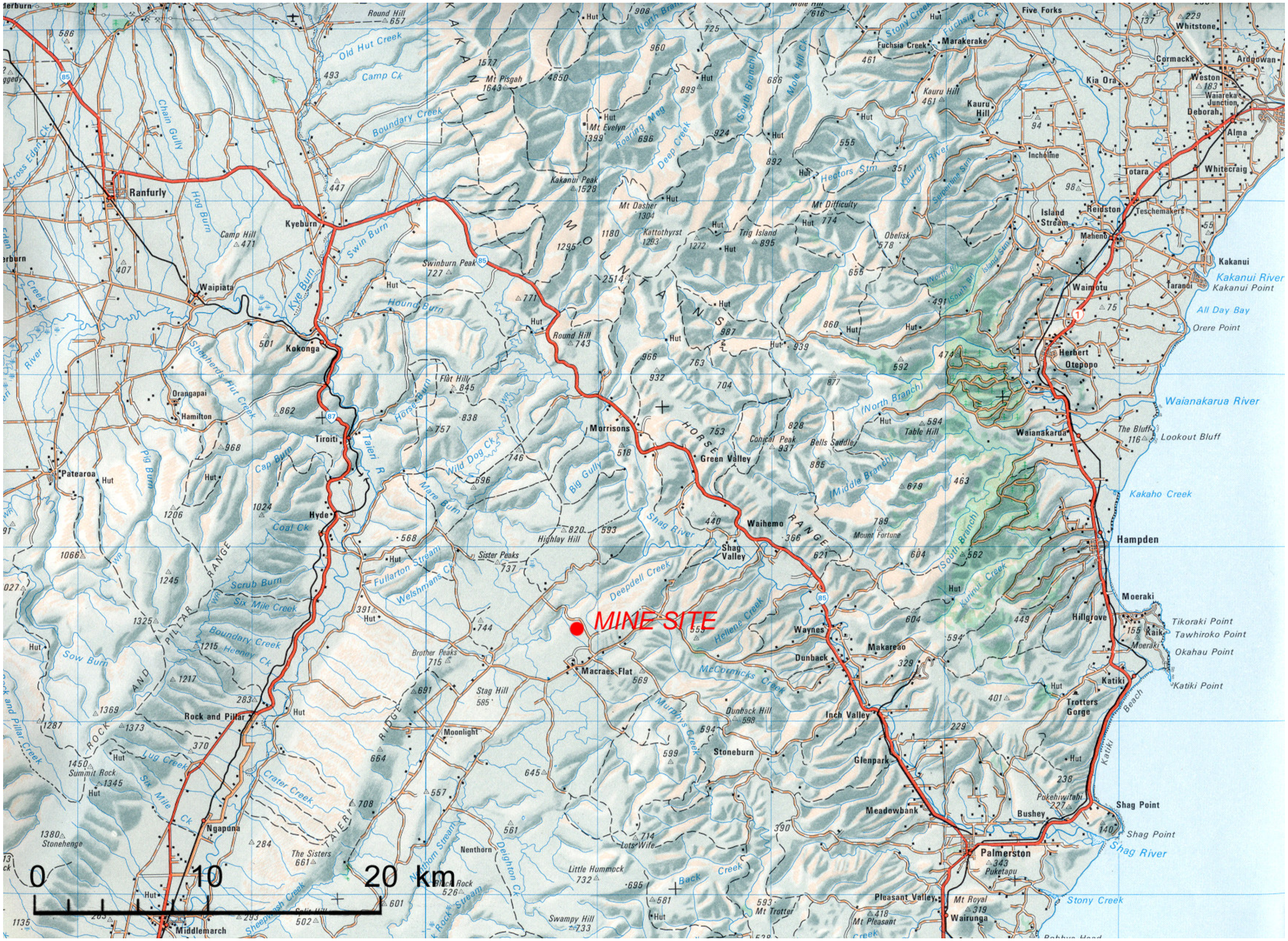
11. Oceana Gold (New Zealand) Limited (2018) 'Macraes Water Quality Management Plan 2018'.

12. Engineering Geology Limited (2016) 'Macraes Gold Project Coronation Waste Rock Stack Design Report (Rev. A)'

13. Bray, J. D., & Sancio. (2006). Assessment of the Liquefaction Susceptibility of Fine Grained Soil.

14. Idriss, I. M., & Boulanger, R. W. (2008). Soil liquefaction during earthquakes (Vol. Monograph MNO-12). Oakland, CA: Earthquake Engineering Research Institute.

15. Olson, S., & Stark, T. (2002). Liquefied strength ratio from liquefaction flow case histories. Can. Geotech. J., 39, 629–647.



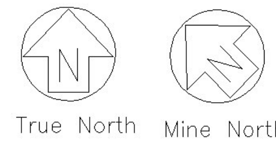


Figure 1

Source: NZMS Sheet 15 Waitaki.

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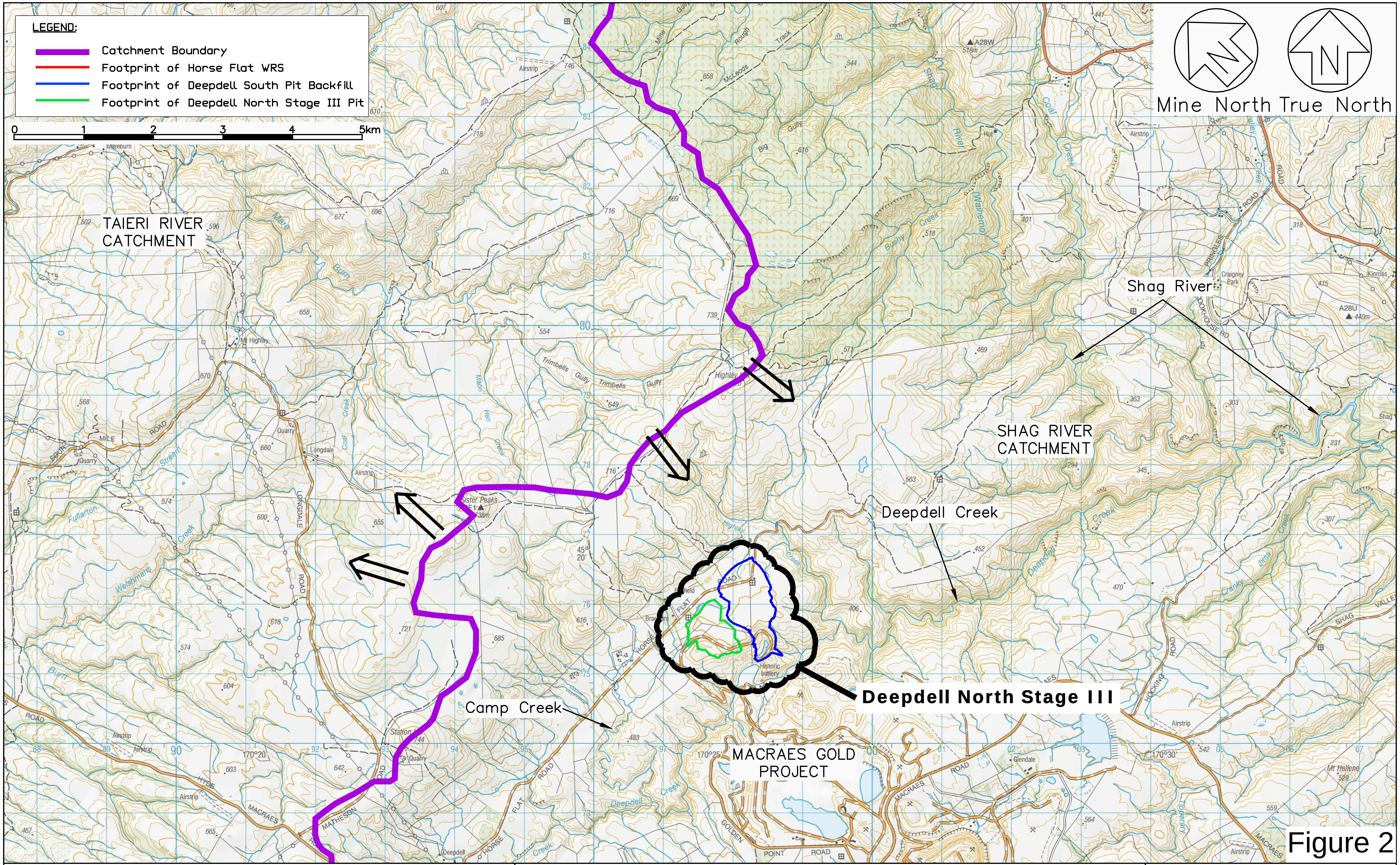
OCEANA GOLD (NEW ZEALAND) LTD
Macraes Gold Project
Locality Plan

Ref. No.: 1410
Date: 26 June 2002
Drawn: SP
File: local.grf



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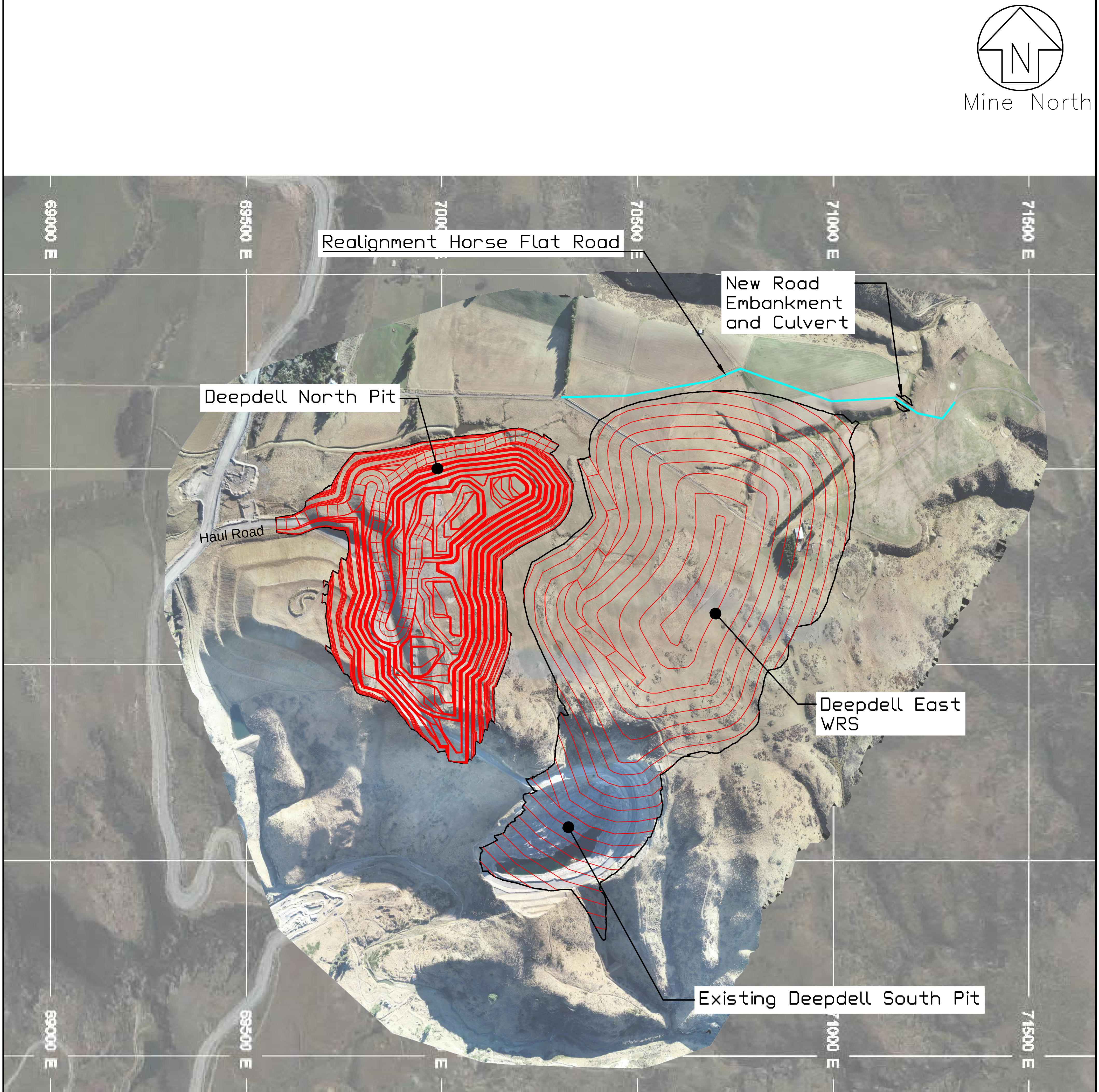
OCEANA GOLD NZ LTD
MACRAES GOLD PROJECT- Deepdell North Stage III
Site Plan

Drawing No.	8528-Fig 2
Date:	Jul 2019
Drawn:	NT
Scale:	1:50000 (@A3)
Filename:	8528-Fig2.dwg



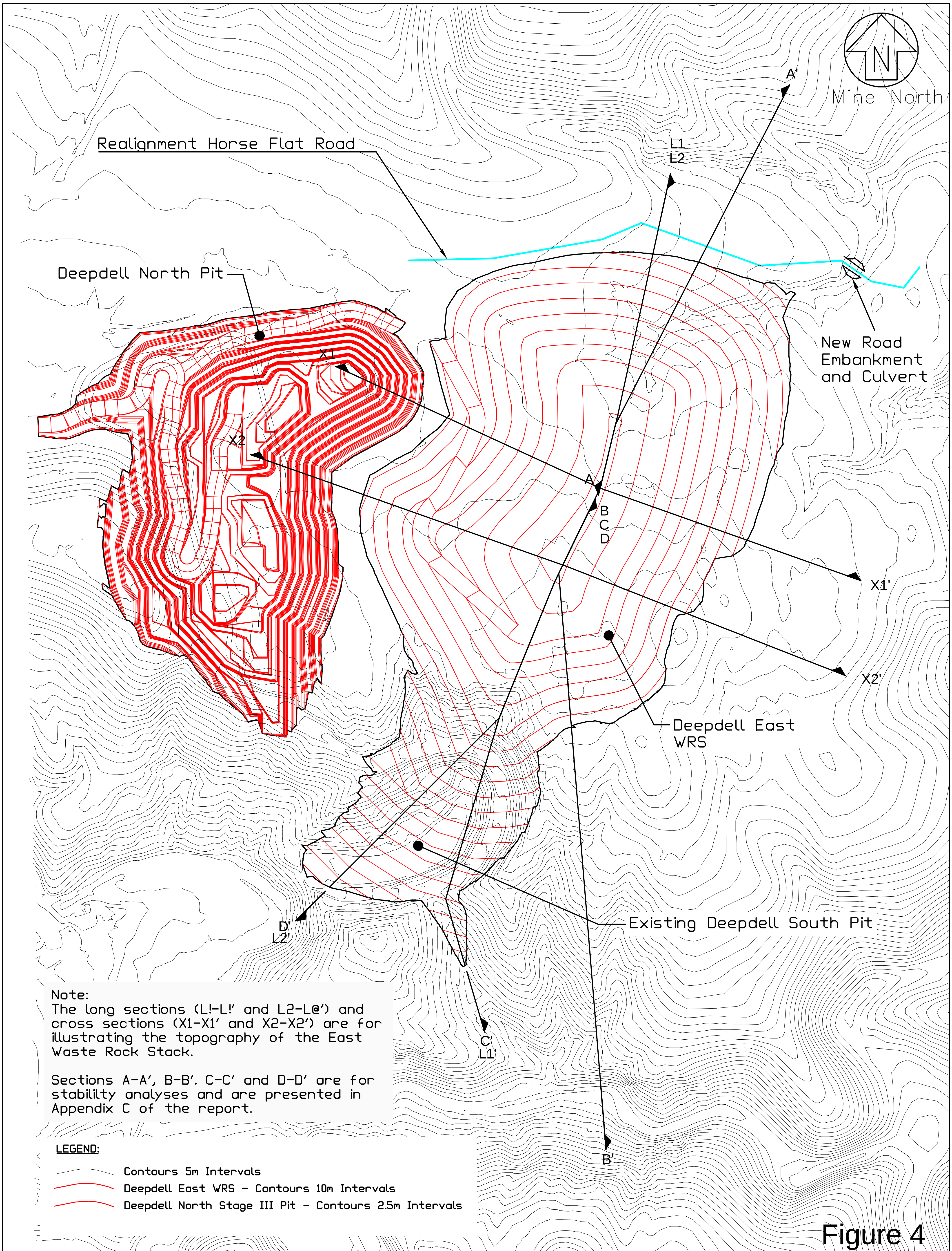
LEGEND:

Deepdell East WRS - Contours 10m Intervals

Deepdell North Stage III Pit - Contours 2.5m Intervals

Figure 3

ENGINEERING GEOLOGY LTD Unit 7C, 331 Rosedale Rd, PO Box 301054, Albany Ph (09)486-2546, Fax (09)486-2556	OCEANA GOLD NZ LIMITED MACRAES GOLD PROJECT- Deepdell North Stage III *Waste Rock Stack Plan*	Drawing No. 8528-Fig3 Date: Jul 2019 Drawn: NT Scale: 1:10,000 (@A3) Filename: 8528-fig3.dwg

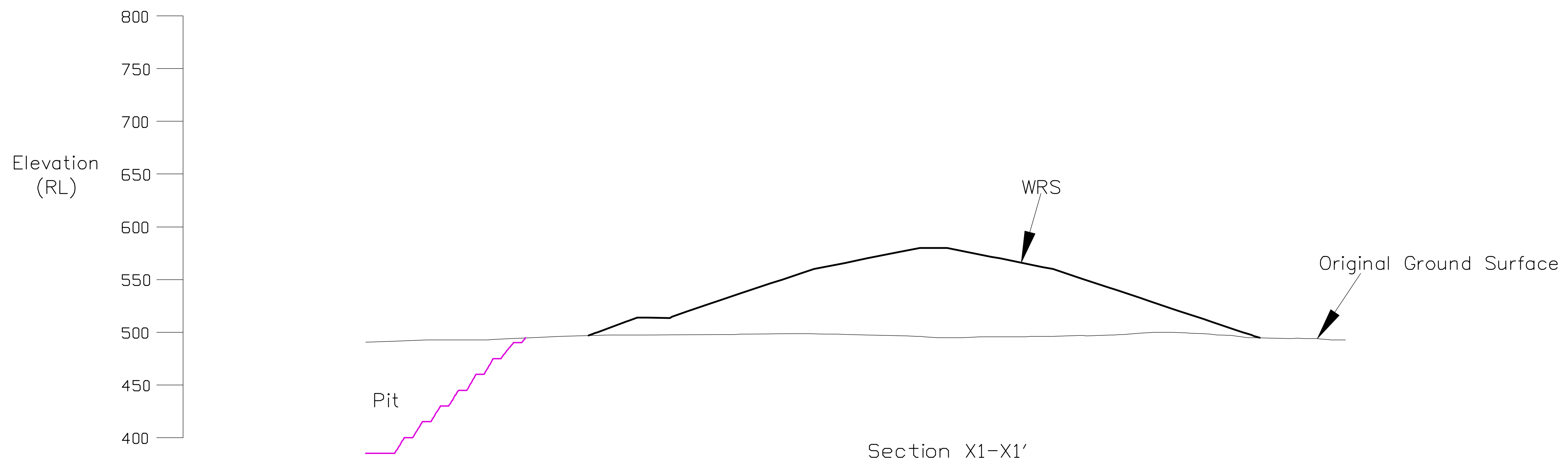


Note:
The long sections (L!-L!' and L2-L@') and cross sections (X1-X1' and X2-X2') are for illustrating the topography of the East Waste Rock Stack.

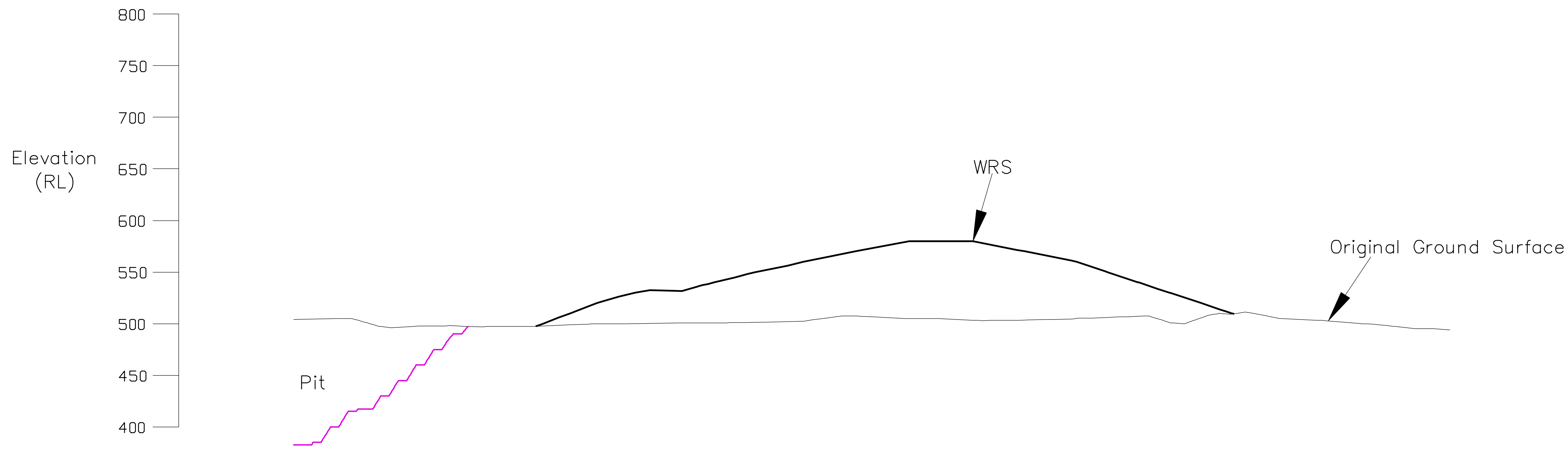
Sections A-A', B-B'. C-C' and D-D' are for stability analyses and are presented in Appendix C of the report.

Figure 4

ENGINEERING GEOLOGY LTD Unit 7C, 331 Rosedale Rd, PO Box 301054, Albany Ph (09)486-2546, Fax (09)486-2556	OCEANA GOLD NZ LIMITED MACRAES GOLD PROJECT- Deepdell North Stage III *Waste Rock Stack Plan*	Drawing No. 8528-Fig4 Date: Jul 2019 Drawn: NT Scale: 1:7,500 (@A3) Filename: 8528-fig4.dwg



Section X1-X1'



Section X2-X2'

Figure 5

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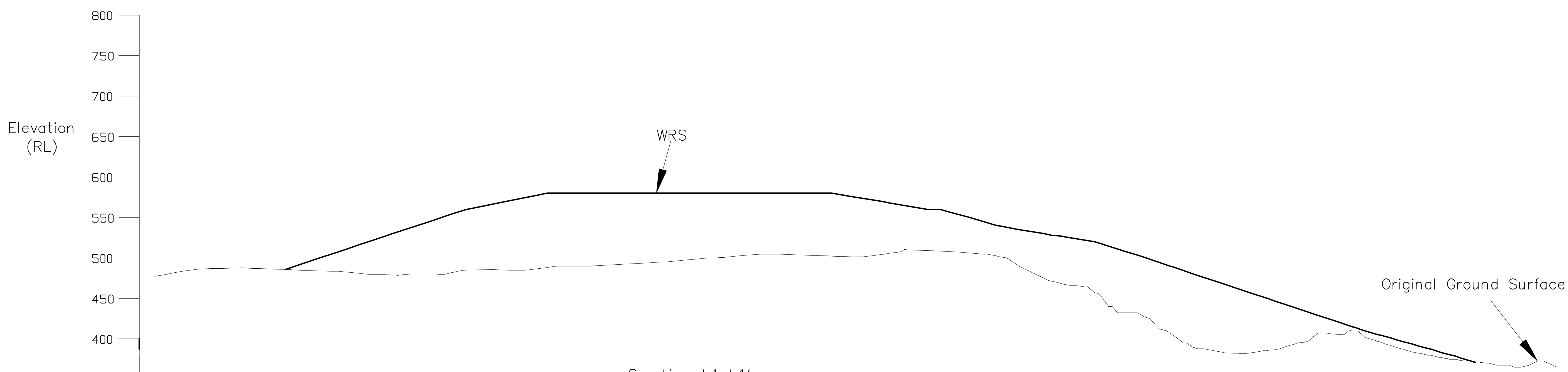
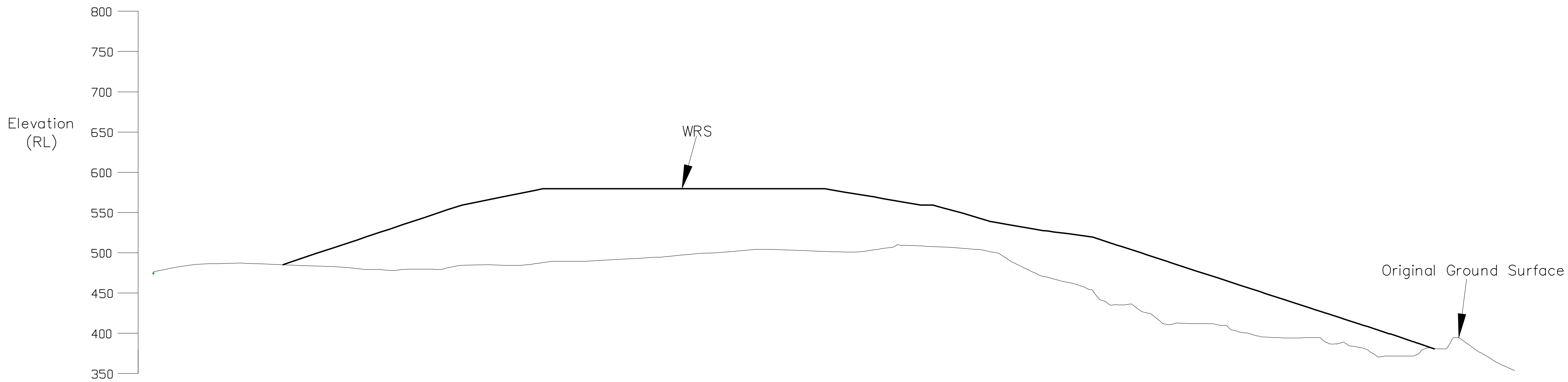
OCEANA GOLD NZ LTD
MACRAES GOLD PROJECT- Deepdell North Stage III
Deepdell East Waste Rock Stack
Cross Sections

Drawing No.	8528-Fig 5
Date:	June 2019
Drawn:	JL
Scale:	1:5000 (@A3)
Filename:	8528-Fig5.dwg



Section L1-L1'



Section L2-L2'

Figure 6

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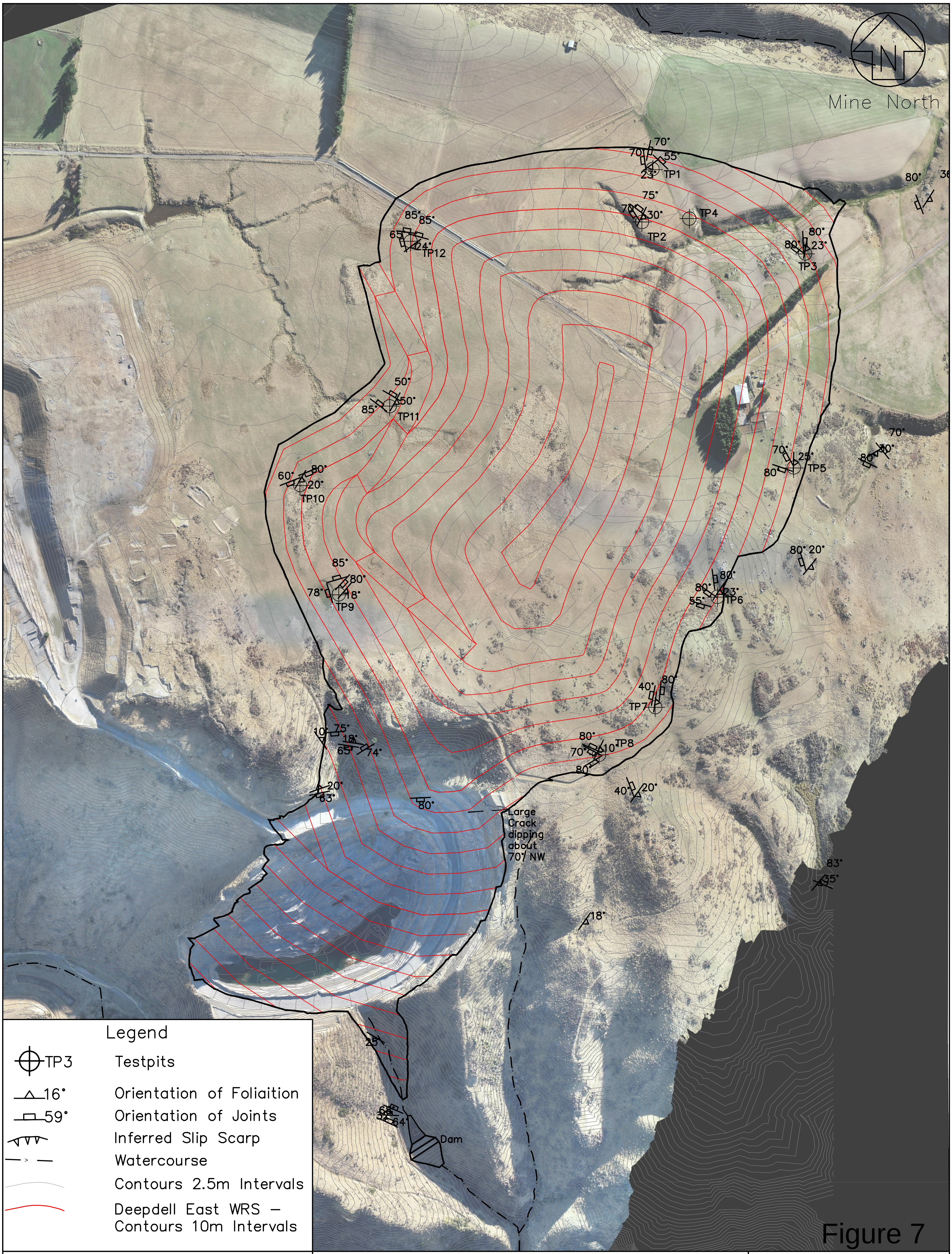
OCEANA GOLD NZ LTD
MACRAES GOLD PROJECT- Deepdell North Stage III
Deepdell East Waste Rock Stack
Long Sections

Drawing No.	8528-Fig 6
Date:	June 2019
Drawn:	JL
Scale:	1:5000 (@A3)
Filename:	8528-Fig6.dwg



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OCEANA GOLD NZ LIMITED
MACRAES GOLD PROJECT-Deepdell North Stage III
Deepdell East Waste Rock Stack
Fieldwork Location Plan

Drawing No.	8528-Fig7
Date:	Jul 2019
Drawn:	NT
Scale:	1:5000 (@A3)
Filename:	8528-Fig7.dwg

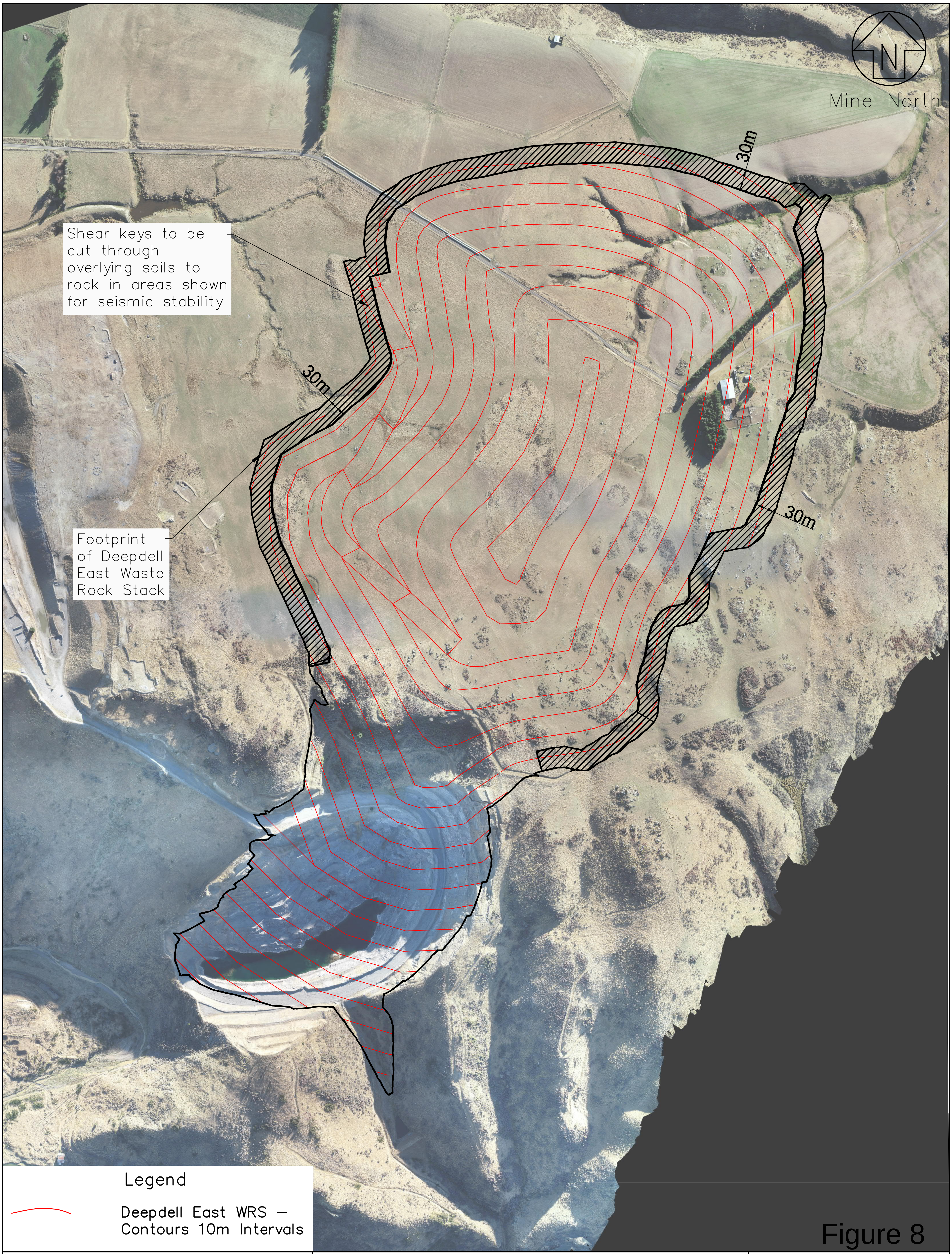

Figure 8

ENGINEERING GEOLOGY LTD
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OCEANA GOLD NZ LIMITED
MACRAES GOLD PROJECT-Deepdell North Stage III
Deepdell East Waste Rock Stack
Shear Key Option

Drawing No.	8528–Fig8
Date:	Jul 2019
Drawn:	NT
Scale:	1:5000 (@A3)
Filename:	8528–Fig8.dwg

APPENDIX A

GROUND INVESTIGATIONS

ENGINEERING GEOLOGY LTD

TEST PIT LOG

TESTPIT No.: TP1

SHEET 1 OF 1

Job No.: 8528

PROJECT: Deepdell East WRS

LOCATION: Deepdell East WRS, Oceana Gold Macraes Mine, Macraes Flat, Otago

COORDINATES: East 70781.4 North 17671.8 **RL GROUND:** 484.4m **DATE:** 27/06/2019

GRID: MMG **DATUM:** Mine **TESTPIT DEPTH:** 0.9m

GEOLOGICAL UNIT	SOIL MATERIAL DESCRIPTION	DEPTH / RL	GRAPHIC LOG	DEPTH (m)	MOISTURE CONDITION	CONSISTENCY / DENSITY	SAMPLES	WATER CONTENT (%)	WATER LEVEL	CORRECTED VANE SHEAR STRENGTH (kPa) ● Field Vane (BS 1377) ○ Remoulded Field Vane 50 100 150	FIELD TESTS
TS	Organic SILT, trace clay; grey brown. Very stiff, moist, low plasticity	484.4 0.2	TS		M	VSt			Groundwater Not Encountered		
Loess	SILT, tr. clay; grey orange brown. V. Stiff, moist, low plasticity	484.2 0.3								●	SV: 0.3m, 114 / - kPa (N/A)
	Bag sample 1, 0.35-0.4m	484.1 0.4									
Rakaia Terrane TZIII Schist	Highly weathered, light grey, orange, SCHIST; extremely weak to very weak	484.0 0.7			D-M	EW-VW					SV: 0.4m, UTP
	mod.-sl. weathered, weak, Foliation 187°/23° E Joints 87°/55° NNW, 145°/70° NE, 306°/70° SW, tight, smooth, discontinuous	483.7 0.9				W					

EOH: 0.90 m

NOTES:
E.O.P. @ 0.9m (Too hard to excavate), Test pit was dry on 27 June 2019.

LOGGED: DLM

CHECKED: ET **EXCAVATOR:** 20 Tonne Excavator

Client Name.	Oceana Gold New Zealand Limited	Job No.	8528		
Engineering Geology Ltd CONSULTING GEOTECHNICAL, GEOLOGICAL AND EARTHQUAKE ENGINEERS		Address	Deepdell East WRS		
		Photographer	DLM	Date:	27-28 June 2019
Title:	**TEST PIT PHOTOGRAPHS**				

Test Pit 1

ENGINEERING GEOLOGY LTD

TEST PIT LOG

TESTPIT No.: TP2

Job No.: 8528

PROJECT: Deepdell East WRS

LOCATION: Deepdell East WRS, Oceana Gold Macraes Mine, Macraes Flat, Otago

COORDINATES: East 70766.0 North 17593.9 | **RL GROUND:** 480.0m | **DATE:** 27/06/2019

GRID: MMG | **DATUM:** Mine | **TESTPIT DEPTH:** 0.8m

GEOLOGICAL UNIT	SOIL MATERIAL DESCRIPTION	DEPTH / RL	GRAPHIC LOG	DEPTH (m)	MOISTURE CONDITION	CONSISTENCY / DENSITY	SAMPLES	WATER CONTENT (%)	WATER LEVEL	CORRECTED VANE SHEAR STRENGTH (kPa) ●Field Vane (BS 1377) ○Remoulded Field Vane 50 100 150	FIELD TESTS
TS	Organic SILT, trace clay, some gravel; grey brown. Very stiff, moist, low plasticity; Bag sample 1, 0.25m	480.0 / 0.3			M	VSt			Groundwater Not Encountered		SV: 0.3m, UTP
Rakaia Terrane TZIII Schist	Completely weathered, orange brown, light grey, SCHIST; extremely weak to very weak; weathered to a clayey gravel	479.8 / 0.4			D-M	EW-VW					
	Moderately weathered, grey, orange brown, SCHIST; very weak	479.6 / 0.6				VW					
	mod.-sl. weathered, weak, Foliation 160°/30° ENE Joints 80°/75° N, 280°/76° S, tight, smooth, discontinuous	479.4 / 0.8				W					

EOH: 0.80 m

NOTES:
E.O.P. @ 0.8m (Too hard to excavate), Test pit was dry on 27 June 2019.

LOGGED: DLM

CHECKED: ET

EXCAVATOR: 20 Tonne Excavator

Client Name.	Oceana Gold New Zealand Limited	Job No.	8528		
Engineering Geology Ltd CONSULTING GEOTECHNICAL, GEOLOGICAL AND EARTHQUAKE ENGINEERS		Address	Deepdell East WRS		
		Photographer	DLM	Date:	27-28 June 2019
Title:	**TEST PIT PHOTOGRAPHS**				

Test Pit 1

Test Pit 2

ENGINEERING GEOLOGY LTD

TEST PIT LOG

TESTPIT No.: TP3

SHEET 1 OF 1

Job No.: 8528

PROJECT: Deepdell East WRS

LOCATION: Deepdell East WRS, Oceana Gold Macraes Mine, Macraes Flat, Otago

COORDINATES: East 71003.1 North 17547.6 **RL GROUND:** 473.2m **DATE:** 27/06/2019

GRID: MMG **DATUM:** Mine **TESTPIT DEPTH:** 2.0m

GEOLOGICAL UNIT	SOIL MATERIAL DESCRIPTION	DEPTH / RL	GRAPHIC LOG	DEPTH (m)	MOISTURE CONDITION	CONSISTENCY / DENSITY	SAMPLES	WATER CONTENT (%)	WATER LEVEL	CORRECTED VANE SHEAR STRENGTH (kPa) ●Field Vane (BS 1377) ○Remoulded Field Vane 50 100 150	FIELD TESTS
TS	Organic SILT, minor clay; grey brown. Very stiff, moist, low plasticity	473.2 / 0.2	TS		M	VSt					
Colluvium/Slopewash	SILT, some clay, gravelly (f-c); orange brown, light grey. Hard, mist, low plasticity	473.0 / 0.4			M	VSt					
	clasts of schist up to 50mm, Bag sample 1, 0.45m	472.8 / 0.7			M	H	■				SV: 0.5m, 200+ kPa
	Bag sample 2, 0.7m	472.5 / 1.3		1	M	H	■				SV: 0.7m, 200+ kPa
Rakaia Terrane TZIII Schist	Completely weathered, orange brown, SCHIST, extremely weak; weathered to a gravelly SILT, hard; Bag sample 3, 1.4m	471.9 / 1.5			M	H	■				SV: 1.4m, 200+ kPa
	Moderately weathered, grey, orange brown, SCHIST; very weak	471.7 / 1.8			M	VW					
	sl. weathered, weak, Foliation 144°/23° NE Joints 260°/80° S, 131°/80° NE, tight, smooth, discontinuous, saturated, seepage at 2.0m	471.4 / 2.0		2	S	W			2.00m, 27/06/2019		

EOH: 2.00 m

NOTES:
E.O.P. @ 2.0m (Too hard to excavate).

LOGGED: DLM

CHECKED: ET **EXCAVATOR:** 20 Tonne Excavator

Client Name.	Oceana Gold New Zealand Limited	Job No.	8528		
Engineering Geology Ltd CONSULTING GEOTECHNICAL, GEOLOGICAL AND EARTHQUAKE ENGINEERS		Address	Deepdell East WRS		
		Photographer	DLM	Date:	27-28 June 2019
Title:	**TEST PIT PHOTOGRAPHS**				

Test Pit 2

Test Pit 3

Test Pit 3

ENGINEERING GEOLOGY LTD

TEST PIT LOG

TESTPIT No.: TP4

SHEET 1 OF 1

Job No.: 8528

PROJECT: Deepdell East WRS

LOCATION: Deepdell East WRS, Oceana Gold Macraes Mine, Macraes Flat, Otago

COORDINATES: East 70835.6 North 17598.8 **RL GROUND:** 477.1m **DATE:** 27/06/2019

GRID: MMG **DATUM:** Mine **TESTPIT DEPTH:** 4.5m

GEOLOGICAL UNIT	SOIL MATERIAL DESCRIPTION	DEPTH / RL	DEPTH (m)	MOISTURE CONDITION	CONSISTENCY / DENSITY	SAMPLES	WATER CONTENT (%)	WATER LEVEL	CORRECTED VANE SHEAR STRENGTH (kPa) ● Field Vane (BS 1377) ○ Remoulded Field Vane (50 100 150)	FIELD TESTS
TS	Organic SILT, trace clay; grey brown. Very stiff, moist, low plasticity	477.1 / 0.2			VSt					
Loess	SILT, trace clay; orange, grey yellow brown, light grey. Hard, moist, low plasticity. Bag sample 1, 0.4m	476.9 / 0.9			H	◣				SV: 0.4m, 200+ kPa
	very stiff, Bag sample 2, 1.0m	476.2 / 1.0			VSt	◣				
	trace gravel (f)	476.1	1						●	SV: 1.0m, 187 / - kPa (N/A)
									●	SV: 1.2m, 106 / - kPa (N/A)
	some clay, Bag sample 3, 2.1m	2.0 / 475.1	2	M		◣		Groundwater Not Encountered		
	Bag sample 4, 3.0m	3.0 / 474.1	3			◣				
Rakaia Terrane TZIII Schist	Completely weathered, grey orange brown, SCHIST; extremely weak; weathered to a SILT with some clay and gravel; Bag sample 5, 4.0m	4.0 / 473.1 / 4.4	4		H	◣				
	Highly weathered, grey, orange brown, SCHIST; very weak	472.7 / 4.5			VW					

EOH: 4.50 m

NOTES:
E.O.P. @ 4.5m (maximum reach of excavator), Test pit was dry on 27 June 2019.

LOGGED: DLM

CHECKED: ET **EXCAVATOR:** 20 Tonne Excavator

Client Name.	Oceana Gold New Zealand Limited	Job No.	8528		
Engineering Geology Ltd CONSULTING GEOTECHNICAL, GEOLOGICAL AND EARTHQUAKE ENGINEERS		Address	Deepdell East WRS		
		Photographer	DLM	Date:	27-28 June 2019
Title:	**TEST PIT PHOTOGRAPHS**				

Test Pit 4

Test Pit 4

ENGINEERING GEOLOGY LTD

TEST PIT LOG

TESTPIT No.: TP5

SHEET 1 OF 1

Job No.: 8528

PROJECT: Deepdell East WRS
LOCATION: Deepdell East WRS, Oceana Gold Macraes Mine, Macraes Flat, Otago
COORDINATES: East 70989.3 North 17232.4 | **RL GROUND:** 492.9m | **DATE:** 28/06/2019
GRID: MMG | **DATUM:** Mine | **TESTPIT DEPTH:** 1.2m

GEOLOGICAL UNIT	SOIL MATERIAL DESCRIPTION	DEPTH / RL	GRAPHIC LOG	DEPTH (m)	MOISTURE CONDITION	CONSISTENCY / DENSITY	SAMPLES	WATER CONTENT (%)	WATER LEVEL	CORRECTED VANE SHEAR STRENGTH (kPa) ●Field Vane (BS 1377) ○Remoulded Field Vane 50 100 150	FIELD TESTS
TS	Organic SILT, tr. clay; grey brown. V. stiff, moist, low plasticity	492.9 / 0.1	TS		M	VSt			Groundwater Not Encountered		
Loess	SILT, minor clay; light grey orange brown, light grey, orange. Very stiff, moist, low plasticity	492.8 / 0.3			M	VSt				● 145	SV: 0.2m, 145 / - kPa (N/A)
Loess	trace gravel (f), light grey, orange brown, hard, Bag sample 1, 0.3m	492.6 / 0.5			M	H	◣				SV: 0.3m, 200+ kPa; SV: 0.5m, UTP
Rakaia Terrane TZIII Schist	Completely to highly weathered, light grey, orange brown, SCHIST; extremely to very weak	492.4 / 0.7			D-M	EW-VW					
Rakaia Terrane TZIII Schist	highly weathered, very weak	492.2 / 0.9			D-M	VW					
Rakaia Terrane TZIII Schist	moderately to slightly weathered, weak Foliation 135°/25° NE Joints 285°/70° S, 242°/80° SSE, tight, smooth, discontinuous	492.0 / 1.2		1	D-M	W					

EOH: 1.20 m

NOTES:
E.O.P. @ 1.2m (Too hard to excavate), Test pit was dry on 28 June 2019.

LOGGED: DLM
CHECKED: ET
EXCAVATOR: 20 Tonne Excavator

Client Name.	Oceana Gold New Zealand Limited	Job No.	8528		
Engineering Geology Ltd CONSULTING GEOTECHNICAL, GEOLOGICAL AND EARTHQUAKE ENGINEERS		Address	Deepdell East WRS		
		Photographer	DLM	Date:	27-28 June 2019

Title:	TEST PIT PHOTOGRAPHS

Test Pit 5

Test Pit 5

ENGINEERING GEOLOGY LTD

TEST PIT LOG

TESTPIT No.: TP6
SHEET 1 OF 1
Job No.: 8528

PROJECT: Deepdell East WRS
LOCATION: Deepdell East WRS, Oceana Gold Macraes Mine, Macraes Flat, Otago
COORDINATES: East 70876.9 North 17042.2 **RL GROUND:** 506.4m **DATE:** 28/06/2019
GRID: MMG **DATUM:** Mine **TESTPIT DEPTH:** 2.0m

GEOLOGICAL UNIT	SOIL MATERIAL DESCRIPTION	DEPTH / RL	GRAPHIC LOG	MOISTURE CONDITION	CONSISTENCY / DENSITY	SAMPLES	WATER CONTENT (%)	WATER LEVEL	FIELD TESTS
TS	Organic SILT, tr. clay; grey brown. V. stiff, moist, low plasticity	506.4 / 0.1	TS	M	VSt			Groundwater Not Encountered	
Loess	SILT, minor clay; light grey orange brown. Very stiff, moist, low plasticity	506.3 / 0.4		M	VSt				SV: 0.3m, 187 / - kPa (N/A)
Loess	some clay, tr. gravel, orange brown, Bag sample 1, 0.4m	506.0 / 0.5		M	VSt	Bag sample 1			SV: 0.4m, 176 / - kPa (N/A)
Rakaia Terrane TZIII Schist	Completely weathered, orange brown, light grey, SCHIST; extremely weak; weathered to a silty GRAVEL; Bag sample 2, 0.5m	505.9 / 0.8		M	H	Bag sample 2			SV: 0.5m, UTP
Rakaia Terrane TZIII Schist	Highly weathered, orange brown, grey, SCHIST; very weak	505.6 / 1.8		D-M	VW				
Rakaia Terrane TZIII Schist	moderately to slightly weathered, weak, Foliation 166°/23° E Joints 259°/80° S, 239°/85° SSE, 126°/80° NE, tight, smooth, discontinuous	504.6 / 2.0		D-M	W				

CORRECTED VANE SHEAR STRENGTH (kPa): ● Field Vane (BS 1377) ○ Remoulded Field Vane — 50 100 150

DEPTH (m): 1 2

EOH: 2.00 m

NOTES:
E.O.P. @ 2.0m (Too hard to excavate), Test pit was dry on 28 June 2019.

LOGGED: DLM
CHECKED: ET **EXCAVATOR:** 20 Tonne Excavator

Client Name.	Oceana Gold New Zealand Limited	Job No.	8528		
Engineering Geology Ltd CONSULTING GEOTECHNICAL, GEOLOGICAL AND EARTHQUAKE ENGINEERS		Address	Deepdell East WRS		
		Photographer	DLM	Date:	27-28 June 2019
Title:	**TEST PIT PHOTOGRAPHS**				

Test Pit 6

Test Pit 6

ENGINEERING GEOLOGY LTD

TEST PIT LOG

TESTPIT No.: TP7

SHEET 1 OF 1

Job No.: 8528

PROJECT: Deepdell East WRS

LOCATION: Deepdell East WRS, Oceana Gold Macraes Mine, Macraes Flat, Otago

COORDINATES: East 70785.5 North 16879.7 **RL GROUND:** 510.0m **DATE:** 28/06/2019

GRID: MMG **DATUM:** Mine **TESTPIT DEPTH:** 1.9m

GEOLOGICAL UNIT	SOIL MATERIAL DESCRIPTION	DEPTH / RL	GRAPHIC LOG	DEPTH (m)	MOISTURE CONDITION	CONSISTENCY / DENSITY	SAMPLES	WATER CONTENT (%)	WATER LEVEL	CORRECTED VANE SHEAR STRENGTH (kPa) ●Field Vane (BS 1377) ○Remoulded Field Vane 50 100 150	FIELD TESTS
TS	Organic SILT, tr. clay; grey brown. Very stiff, moist, low plasticity	510.0 / 0.2	TS		M	VSt			Groundwater Not Encountered		
Loess	SILT, tr. clay; grey orange brown. Hard, moist, low plasticity	509.9 / 0.3				H					SV: 0.3m, UTP
	trace schist gravel and cobbles	509.8 / 0.4									
	Bag sample 1, 0.35m	509.7 / 0.5									
Rakaia Terrane TZII Schist	Completely weathered, light grey, orange, SCHIST; extremely weak; weathered to a gravelly SILT; Bag sample 2, 0.5m	509.5 / 0.7									SV: 0.5m, UTP
	Highly weathered, orange brown, grey, SCHIST; very weak	509.3 / 1.7		1	D-M	VW					
	moderately to slightly weathered, weak, Foliation 142°/20° NE Joints 324°/40° SW, 139°/80° NE, tight, smooth, discontinuous	508.3 / 1.9				W					

EOH: 1.90 m

NOTES:
E.O.P. @ 1.9m (Too hard to excavate), Test pit was dry on 28 June 2019.

LOGGED: DLM

CHECKED: ET **EXCAVATOR:** 20 Tonne Excavator

Client Name.	Oceana Gold New Zealand Limited	Job No.	8528		
Engineering Geology Ltd CONSULTING GEOTECHNICAL, GEOLOGICAL AND EARTHQUAKE ENGINEERS		Address	Deepdell East WRS		
		Photographer	DLM	Date:	27-28 June 2019
Title:	**TEST PIT PHOTOGRAPHS**				

Test Pit 7

Test Pit 7

ENGINEERING GEOLOGY LTD

TEST PIT LOG

TESTPIT No.: TP8

SHEET 1 OF 1

Job No.: 8528

PROJECT: Deepdell East WRS

LOCATION: Deepdell East WRS, Oceana Gold Macraes Mine, Macraes Flat, Otago

COORDINATES: East 70702.6 North 16809.7 | **RL GROUND:** 505.2m | **DATE:** 28/06/2019

GRID: MMG | **DATUM:** Mine | **TESTPIT DEPTH:** 0.9m

GEOLOGICAL UNIT	SOIL MATERIAL DESCRIPTION	DEPTH / RL	GRAPHIC LOG	DEPTH (m)	MOISTURE CONDITION	CONSISTENCY / DENSITY	SAMPLES	WATER CONTENT (%)	WATER LEVEL	CORRECTED VANE SHEAR STRENGTH (kPa) ●Field Vane (BS 1377) ○Remoulded Field Vane 50 100 150	FIELD TESTS
TS	Organic SILT; grey brown. Very stiff, moist, low plasticity	505.2 / 0.2	TS		M	VSt			Groundwater Not Encountered		
Loess	SILT, tr. clay, some gravel; orange brown. Hard, moist, low plasticity	505.1 / 0.3			M	H					SV: 0.2m, UTP
Rakaia Terrane TZIII Schist	Completely weathered, orange brown, grey, SCHIST; extremely weak; weathered to a silty gravel	504.9 / 0.5			D-M	H					
	Moderately weathered, grey, orange brown, SCHIST; very weak	504.7 / 0.7			D-M	VW					
	weak, Foliation 159°/10° ENE Joints 192°/80° E, 68°/80° NNW, 251°/70° SSE, tight, smooth, discontinuous	504.5 / 0.9			D-M	W					

EOH: 0.90 m

NOTES:
E.O.P. @ 0.9m (Too hard to excavate), Test pit was dry on 28 June 2019.

LOGGED: DLM

CHECKED: ET

EXCAVATOR: 20 Tonne Excavator

Client Name.	Oceana Gold New Zealand Limited	Job No.	8528		
Engineering Geology Ltd CONSULTING GEOTECHNICAL, GEOLOGICAL AND EARTHQUAKE ENGINEERS		Address	Deepdell East WRS		
		Photographer	DLM	Date:	27-28 June 2019
Title:	**TEST PIT PHOTOGRAPHS**				

Test Pit 8

Test Pit 8

ENGINEERING GEOLOGY LTD

TEST PIT LOG

TESTPIT No.: TP9

SHEET 1 OF 1

Job No.: 8528

PROJECT: Deepdell East WRS

LOCATION: Deepdell East WRS, Oceana Gold Macraes Mine, Macraes Flat, Otago

COORDINATES: East 17045.9 North 17045.9 **RL GROUND:** 502.5m **DATE:** 27/06/2019

GRID: MMG **DATUM:** Mine **TESTPIT DEPTH:** 1.2m

GEOLOGICAL UNIT	SOIL MATERIAL DESCRIPTION	DEPTH / RL	GRAPHIC LOG	DEPTH (m)	MOISTURE CONDITION	CONSISTENCY / DENSITY	SAMPLES	WATER CONTENT (%)	WATER LEVEL	CORRECTED VANE SHEAR STRENGTH (kPa) ●Field Vane (BS 1377) ○Remoulded Field Vane 50 100 150	FIELD TESTS
TS	Organic SILT; grey brown. Very stiff, moist, low plasticity	502.5 / 0.2	TS		M	VSt			Groundwater Not Encountered		
Loess	SILT, tr. clay; grey orange brown. Hard, moist, low plasticity	502.3 / 0.4			M	H					SV: 0.4m, UTP
Rakaia Terrane TZIII Schist	Highly weathered, grey, orange brown, SCHIST; very weak	502.1 / 0.7			D-M	VW					
	moderately weathered, weak	501.8 / 1.0			D-M	W					
	slightly weathered, Foliation 174°/18° ENE Joints 296°/78°SSW, 177°/80° E, 27°/85° WNW, tight, smooth, discontinuous	501.5 / 1.2		1	D-M	W					

EOH: 1.20 m

NOTES:
E.O.P. @ 1.2m (Too hard to excavate), Test pit was dry on 27 June 2019.

LOGGED: DLM

CHECKED: ET **EXCAVATOR:** 20 Tonne Excavator

Client Name.	Oceana Gold New Zealand Limited	Job No.	8528		
Engineering Geology Ltd CONSULTING GEOTECHNICAL, GEOLOGICAL AND EARTHQUAKE ENGINEERS		Address	Deepdell East WRS		
		Photographer	DLM	Date:	27-28 June 2019
Title:	**TEST PIT PHOTOGRAPHS**				

Test Pit 9

Test Pit 9

ENGINEERING GEOLOGY LTD

TEST PIT LOG

TESTPIT No.: **TP10**

Job No.: 8528

PROJECT: Deepdell East WRS

LOCATION: Deepdell East WRS, Oceana Gold Macraes Mine, Macraes Flat, Otago

COORDINATES: East 70262.6 North 17206.6 **RL GROUND:** 499.8m **DATE:** 27/06/2019

GRID: MMG **DATUM:** Mine **TESTPIT DEPTH:** 1.1m

GEOLOGICAL UNIT	SOIL MATERIAL DESCRIPTION	DEPTH / RL	GRAPHIC LOG	DEPTH (m)	MOISTURE CONDITION	CONSISTENCY / DENSITY	SAMPLES	WATER CONTENT (%)	WATER LEVEL	CORRECTED VANE SHEAR STRENGTH (kPa) ●Field Vane (BS 1377) ○Remoulded Field Vane 50 100 150	FIELD TESTS
TS	Organic SILT, trace clay; grey brown. Very stiff, moist, low plasticity.	499.8 / 0.2	TS		M	VSt			Groundwater Not Encountered		
Loess	SILT, some gravel (f), trace clay; orange brown. Hard, moist, low plasticity.	499.6 / 0.5			M	H					SV: 0.3m, UTP
Rakaia Terrane TZIII Schist	Extremely weathered, orange brown, grey, SCHIST; very weak; weathered to a silty gravel	499.3 / 0.7			D-M	H					
Rakaia Terrane TZIII Schist	Moderately weathered, grey, orange brown, SCHIST; very weak	499.1 / 0.9			D-M	VW					
Rakaia Terrane TZIII Schist	moderate to slightly weathered, weak, Foliation 164°/20° E Joints 202°/60° ESE, 202°/80° ESE, tight, smooth, discontinuous	498.9 / 1.1		1	D-M	W					

EOH: 1.10 m

NOTES:
E.O.P. @ 1.1m (Too hard to excavate), Test pit was dry on 27 June 2019.

LOGGED: DLM

CHECKED: ET

EXCAVATOR: 20 Tonne Excavator

Client Name.	Oceana Gold New Zealand Limited	Job No.	8528		
Engineering Geology Ltd CONSULTING GEOTECHNICAL, GEOLOGICAL AND EARTHQUAKE ENGINEERS		Address	Deepdell East WRS		
		Photographer	DLM	Date:	27-28 June 2019

Title:	TEST PIT PHOTOGRAPHS

Test Pit 10

Test Pit 10

ENGINEERING GEOLOGY LTD

TEST PIT LOG

TESTPIT No.: TP11

SHEET 1 OF 1

Job No.: 8528

PROJECT: Deepdell East WRS

LOCATION: Deepdell East WRS, Oceana Gold Macraes Mine, Macraes Flat, Otago

COORDINATES: East 70394.4 North 17322.7 **RL GROUND:** 497.5m **DATE:** 27/06/2019

GRID: MMG **DATUM:** Mine **TESTPIT DEPTH:** 0.7m

GEOLOGICAL UNIT	SOIL MATERIAL DESCRIPTION	DEPTH / RL	GRAPHIC LOG	DEPTH (m)	MOISTURE CONDITION	CONSISTENCY / DENSITY	SAMPLES	WATER CONTENT (%)	WATER LEVEL	CORRECTED VANE SHEAR STRENGTH (kPa) ●Field Vane (BS 1377) ○Remoulded Field Vane 50 100 150	FIELD TESTS
TS	Organic SILT; grey brown. Very stiff, moist, low plasticity.	497.5 / 0.3	TS		M	VSt			Groundwater Not Encountered		SV: 0.3m, UTP
Terrane TZIII	Extremely weathered, grey, orange brown, SCHIST; very weak	497.2 / 0.5			D-M	VW					
	moderately weathered, weak, Foliation 162°/15° ENE Joints 80°/85° N, 74°/50° N, tight, smooth, discontinuous	497.0 / 0.7				W					

EOH: 0.70 m

NOTES:
E.O.P. @ 0.7m (Too hard to excavate), Test pit was dry on 27 June 2019.

LOGGED: DLM

CHECKED: ET **EXCAVATOR:** 20 Tonne Excavator

Client Name.	Oceana Gold New Zealand Limited	Job No.	8528		
Engineering Geology Ltd CONSULTING GEOTECHNICAL, GEOLOGICAL AND EARTHQUAKE ENGINEERS		Address	Deepdell East WRS		
		Photographer	DLM	Date:	27-28 June 2019
Title:	**TEST PIT PHOTOGRAPHS**				

Test Pit 11

Test Pit 11

ENGINEERING GEOLOGY LTD

TEST PIT LOG

TESTPIT No.: TP12

SHEET 1 OF 1

Job No.: 8528

PROJECT: Deepdell East WRS

LOCATION: Deepdell East WRS, Oceana Gold Macraes Mine, Macraes Flat, Otago

COORDINATES: East 70435.4 North 17565.2 **RL GROUND:** 495.0m **DATE:** 27/06/2019

GRID: MMG **DATUM:** Mine **TESTPIT DEPTH:** 1.1m

GEOLOGICAL UNIT	SOIL MATERIAL DESCRIPTION	DEPTH / RL	GRAPHIC LOG	DEPTH (m)	MOISTURE CONDITION	CONSISTENCY / DENSITY	SAMPLES	WATER CONTENT (%)	WATER LEVEL	CORRECTED VANE SHEAR STRENGTH (kPa) ●Field Vane (BS 1377) ○Remoulded Field Vane 50 100 150	FIELD TESTS
TS	Organic SILT, trace clay; grey brown. Very stiff, moist, low plasticity.	495.0 / 0.2	TS						Groundwater Not Encountered		
Loess	SILT, some gravel, minor clay; orange brown, grey brown; Very stiff, moist, low plasticity.	494.8 / 0.5			M	VSt					SV: 0.3m, UTP
Rakaia Terrane TZIII Schist	Extremely to highly weathered, orange brown, grey, SCHIST; very weak; weathered to a silty gravel	494.5 / 0.7				VW					
	Highly to moderately weathered, grey, orange brown, SCHIST; very weak to weak	494.3 / 0.9			D-M	VW-W					
	Foliation 186°/24° E Joints 59°/85° NNW, 299°/65° SSW, 51°/85° NW, tight, smooth, discontinuous	494.1 / 1.1		1							

EOH: 1.10 m

NOTES:
E.O.P. @ 1.1m (Too hard to excavate), Test pit was dry on 27 June 2019.

LOGGED: DLM

CHECKED: ET **EXCAVATOR:** 20 Tonne Excavator

Client Name.	Oceana Gold New Zealand Limited	Job No.	8528		
Engineering Geology Ltd CONSULTING GEOTECHNICAL, GEOLOGICAL AND EARTHQUAKE ENGINEERS		Address	Deepdell East WRS		
		Photographer	DLM	Date:	27-28 June 2019
Title:	**TEST PIT PHOTOGRAPHS**				

Test Pit 12

Test Pit 12

APPENDIX B

LABORATORY TESTING

Central Testing Services
18 Ngapara St, P.O. Box 397, Alexandra 9340, Central Otago, New Zealand
P: 03 4487644, W: www.centraltesting.co.nz, E: info@centraltesting.co.nz

Reference No: 19/2051

Date: 15 July 2019

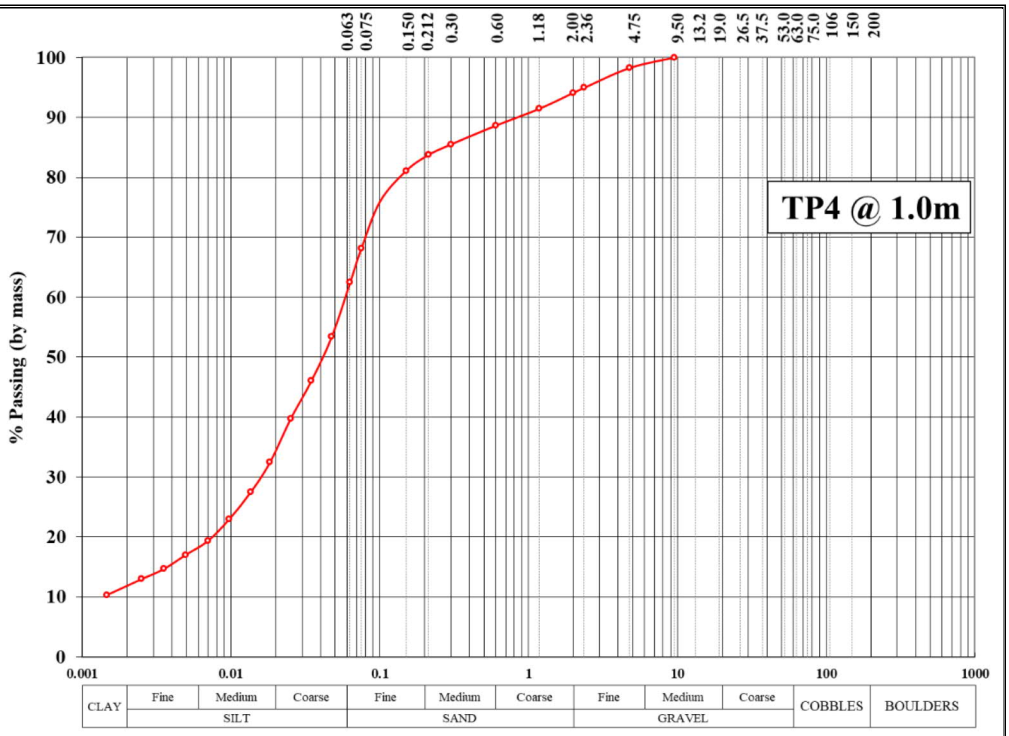
TEST REPORT – OCEANA GOLD INVESTIGATIONS

Client Details:	**Oceana Gold, Golden Point Road, RD3 Macraes Flat, East Otago**	**Attention:**	**M. Hughes**
Job Description:	**Oceana Gold – DDN3; Deep Dell WRS Samples**		
Sample Description:	**Sandy SILT with minor / some clay and minor gravel**	**Client Reference No:**	**8528**
Sample Source:	**Test Pit 4, Sample 2 @ 1.0m**	**Sample Label No:**	**N/A**
Date & Time Sampled:	**27-Jun-19**	**Sampled By:**	**Oceana Gold**
Sample Method:	**Test Pit ***	**Date Received:**	**8-Jul-19**

PARTICLE SIZE ANALYSIS (NZS 4402:1986, Test 2.8.1 & 2.8.4)

Test Sieve (mm)	% Passing (by mass)
37.5	
26.5	
19.0	
13.2	
9.50	100
4.75	98
2.36	95
2.00	94
1.18	91
0.60	89
0.30	86
0.212	84
0.150	81
0.075	68
0.063	62

Fraction Size	Interpolated % Passing
60 µm	61
20 µm	34
6 µm	18
2 µm	12



The sample was received in a natural state. The percentage passing the 63µm test sieve was obtained by difference. The pH of the hydrometer suspension was 9.0. Sodium hexametaphosphate was used as a dispersant.

PARTICLE SIZE ANALYSIS & HYDROMETER ANALYSIS RESULTS - NZS 4402:1986, Test 2.8.1 & 2.8.4

Description	Fraction Range	% Within Range	Description	Fraction Range	% Within Range
Coarse Gravel	60.0mm to 20.0mm	-	Fine Sand	200 µm to 60 µm	22
Medium Gravel	20.0mm to 6.0mm	1	Coarse Silt	60 µm to 20 µm	27
Fine Gravel	6.0mm to 2.00 mm	5	Medium Silt	20 µm to 6 µm	16
Coarse Sand	2.00mm to 600 µm	5	Fine Silt	6 µm to 2 µm	6
Medium Sand	600 µm to 200 µm	6	Clay	< 2 µm	12

WATER CONTENT & PLASTICITY INDEX RESULTS - NZS 4402:1986, Test 2.1, 2.2, 2.3 & 2.4

Water Content: (“All In” As Received)	13.4 %
Liquid Limit: (LL)	25
Plastic Limit: (PL)	22
Plasticity Index: (PI)	3

Note: The sample was received in a natural state. The plasticity index material tested was the fraction passing the 425 µm test sieve.

Note:

- *Information contained in this report which is Not IANZ Accredited relates to the sample descriptions based on NZ Geotechnical Society Guidelines 2005, the sample method * and sampling.*
- *This report may not be reproduced except in full.*

Tested By: L.T. Smith **Date:** 10 to 12-Jul-19

Checked By: emfalus

Tests indicated as Not Accredited are outside the scope of the laboratory's accreditation

IANZ ACCREDITED LABORATORY
Accreditation No: 434

Central Testing Services
18 Ngapara St, P.O. Box 397, Alexandra 9340, Central Otago, New Zealand
P: 03 4487644, W: www.centraltesting.co.nz, E: info@centraltesting.co.nz

Reference No: 19/2051

Date: 15 July 2019

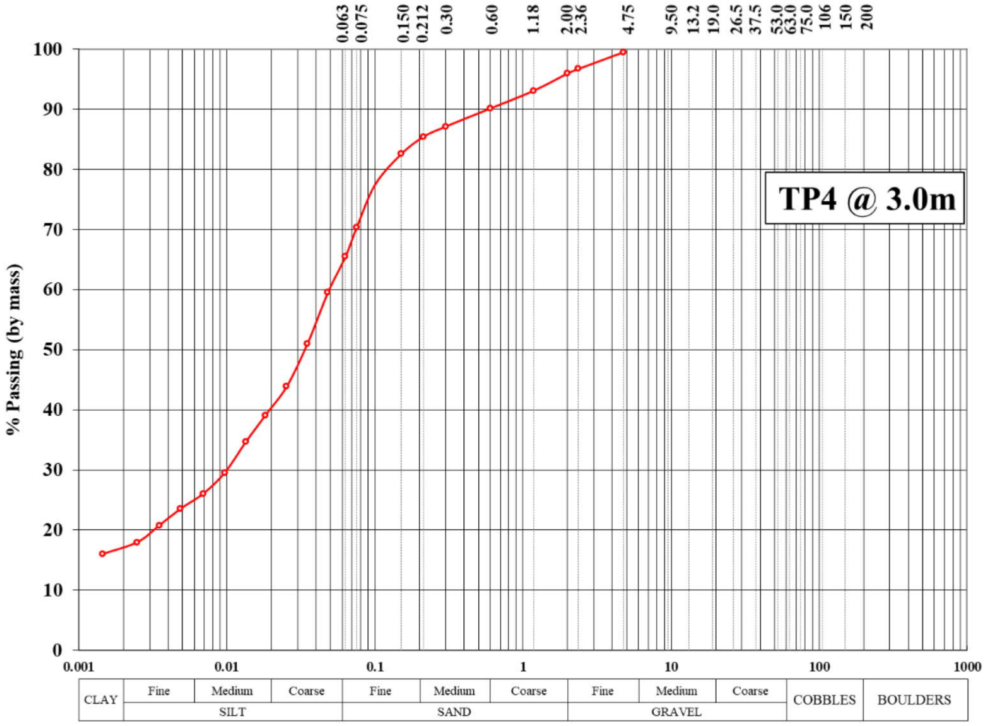
TEST REPORT – OCEANA GOLD INVESTIGATIONS

Client Details:	Oceana Gold, Golden Point Road, RD3 Macraes Flat, East Otago	**Attention:**	M. Hughes
Job Description:	Oceana Gold – DDN3; Deep Dell WRS Samples		
Sample Description:	Sandy SILT with some clay and trace of gravel	**Client Reference No:**	8528
Sample Source:	Test Pit 4, Sample 4 @ 3.0m	**Sample Label No:**	N/A
Date & Time Sampled:	27-Jun-19	**Sampled By:**	Oceana Gold
Sample Method:	Test Pit *	**Date Received:**	8-Jul-19

PARTICLE SIZE ANALYSIS (NZS 4402:1986, Test 2.8.1 & 2.8.4)

Test Sieve (mm)	% Passing (by mass)
37.5	
26.5	
19.0	
13.2	
9.50	
4.75	100
2.36	97
2.00	96
1.18	93
0.60	90
0.30	87
0.212	85
0.150	83
0.075	70
0.063	65

Fraction Size	Interpolated % Passing
60 µm	64
20 µm	40
6 µm	25
2 µm	17



The sample was received in a natural state. The percentage passing the 63µm test sieve was obtained by difference. The pH of the hydrometer suspension was 9.0. Sodium hexametaphosphate was used as a dispersant.

PARTICLE SIZE ANALYSIS & HYDROMETER ANALYSIS RESULTS - NZS 4402:1986, Test 2.8.1 & 2.8.4

Description	Fraction Range	% Within Range	Description	Fraction Range	% Within Range
Coarse Gravel	60.0mm to 20.0mm	-	Fine Sand	200 µm to 60 µm	21
Medium Gravel	20.0mm to 6.0mm	-	Coarse Silt	60 µm to 20 µm	24
Fine Gravel	6.0mm to 2.00 mm	4	Medium Silt	20 µm to 6 µm	15
Coarse Sand	2.00mm to 600 µm	6	Fine Silt	6 µm to 2 µm	8
Medium Sand	600 µm to 200 µm	5	Clay	< 2 µm	17

WATER CONTENT & PLASTICITY INDEX RESULTS - NZS 4402:1986, Test 2.1, 2.2, 2.3 & 2.4

Water Content: ("All In" As Received)	16.6 %
Liquid Limit: (LL)	24
Plastic Limit: (PL)	20
Plasticity Index: (PI)	4

Note: The sample was received in a natural state. The plasticity index material tested was the fraction passing the 425 µm test sieve.

Note:

- *Information contained in this report which is Not IANZ Accredited relates to the sample descriptions based on NZ Geotechnical Society Guidelines 2005, the sample method * and sampling.*
- *This report may not be reproduced except in full.*

Tested By: L.T. Smith **Date:** 10 to 12-Jul-19

Checked By: [signature]

Tests indicated as Not Accredited are outside the scope of the laboratory's accreditation

IANZ ACCREDITED LABORATORY
Accreditation No: 434

Central Testing Services
18 Ngapara St, P.O. Box 397, Alexandra 9340, Central Otago, New Zealand
P: 03 4487644, W: www.centraltesting.co.nz, E: info@centraltesting.co.nz

Reference No: 19/2051

Date: 15 July 2019

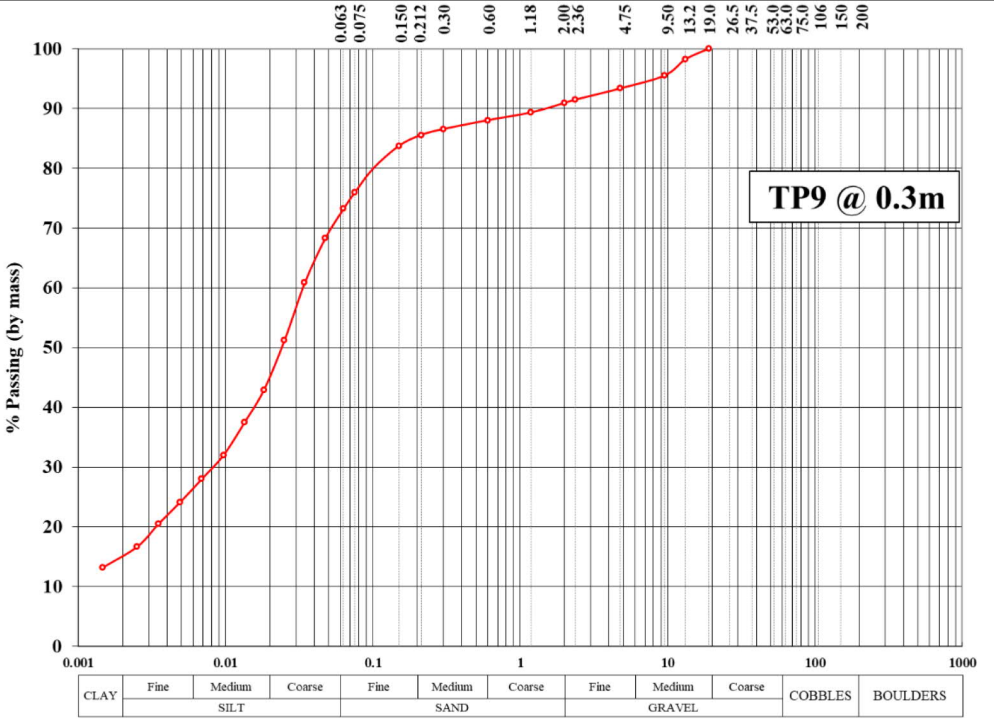
TEST REPORT –OCEANA GOLD INVESTIGATIONS

Client Details:	Oceana Gold, Golden Point Road, RD3 Macraes Flat, East Otago	Attention:	M. Hughes
Job Description:	Oceana Gold – DDN3; Deep Dell WRS Samples		
Sample Description:	SILT with some sand, some clay and minor gravel	Client Reference No:	8528
Sample Source:	Test Pit 9, Sample 1 @ 0.3m	Sample Label No:	N/A
Date & Time Sampled:	27-Jun-19	Sampled By:	Oceana Gold
Sample Method:	Test Pi *	Date Received:	8-Jul-19

PARTICLE SIZE ANALYSIS (NZS 4402:1986, Test 2.8.1 & 2.8.4)

Test Sieve (mm)	% Passing (by mass)
37.5	
26.5	
19.0	100
13.2	98
9.50	96
4.75	93
2.36	91
2.00	91
1.18	89
0.60	88
0.30	87
0.212	86
0.150	84
0.075	76
0.063	73

Fraction Size	Interpolated % Passing
60 µm	72
20 µm	45
6 µm	26
2 µm	15



The sample was received in a natural state. The percentage passing the 63µm test sieve was obtained by difference. The pH of the hydrometer suspension was 8.5. Sodium hexametaphosphate was used as a dispersant.

PARTICLE SIZE ANALYSIS & HYDROMETER ANALYSIS RESULTS - NZS 4402:1986, Test 2.8.1 & 2.8.4

Description	Fraction Range	% Within Range	Description	Fraction Range	% Within Range
Coarse Gravel	60.0mm to 20.0mm	-	Fine Sand	200 µm to 60 µm	13
Medium Gravel	20.0mm to 6.0mm	6	Coarse Silt	60 µm to 20 µm	27
Fine Gravel	6.0mm to 2.00 mm	3	Medium Silt	20 µm to 6 µm	19
Coarse Sand	2.00mm to 600 µm	3	Fine Silt	6 µm to 2 µm	11
Medium Sand	600 µm to 200 µm	3	Clay	< 2 µm	15

WATER CONTENT & PLASTICITY INDEX RESULTS - NZS 4402:1986, Test 2.1, 2.2, 2.3 & 2.4

Water Content: ("All In" As Received)	20.1 %
Liquid Limit: (LL)	45
Plastic Limit: (PL)	33
Plasticity Index: (PI)	12

Note: The sample was received in a natural state. The plasticity index material tested was the fraction passing the 425 µm test sieve.

Note:

- *Information contained in this report which is Not IANZ Accredited relates to the sample descriptions based on NZ Geotechnical Society Guidelines 2005, the sample method * and sampling.*
- *This report may not be reproduced except in full.*

Tested By: L.T. Smith   Date: 10 to 12-Jul-19

Checked By:

Approved Signatory

A.P. Julius
Laboratory Manager

Tests indicated as Not Accredited are outside the scope of the laboratory's accreditation

IANZ ACCREDITED LABORATORY
Accreditation No: 434

Specialist Quality Assurance Service in Aggregate, Concrete and Soils Testing

APPENDIX C

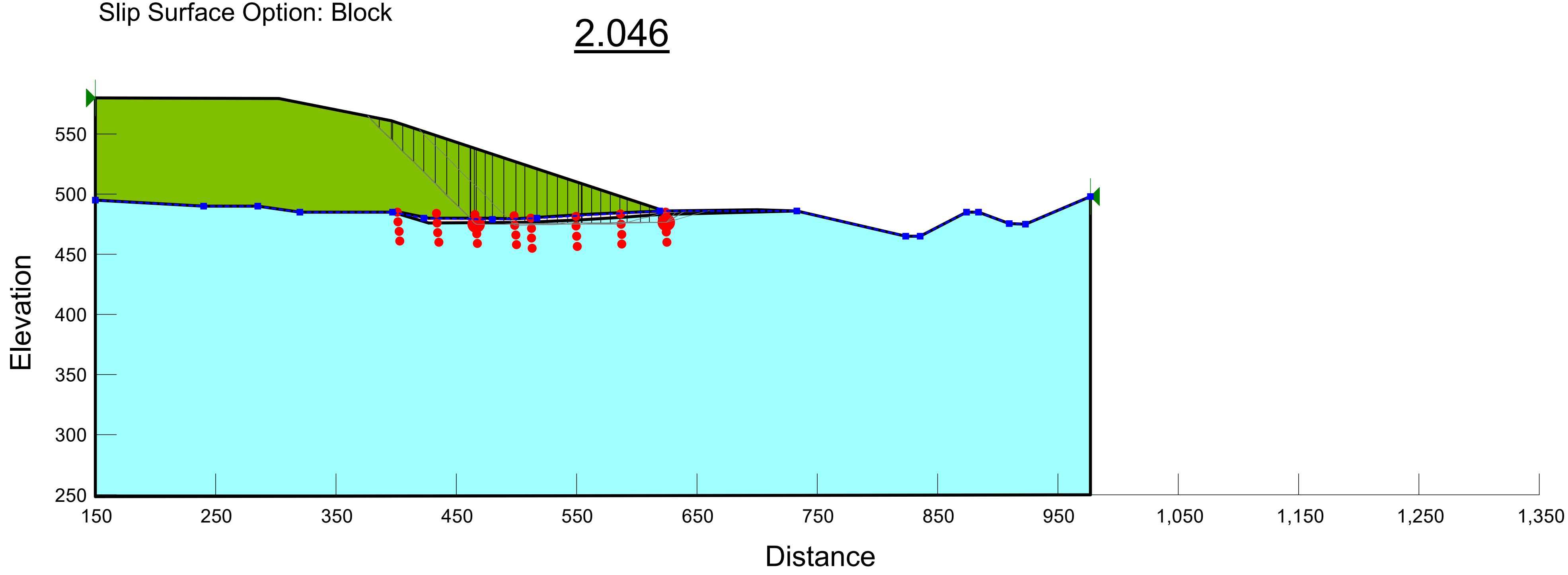
STABILITY ANALYSES

Static Stability Analyses

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste rock stack (Peak)
Piezometric Line: 1

Name: Loess
Model: Mohr-Coulomb
Unit Weight: 18 kN/m³
Cohesion': 0 kPa
Phi': 30 °
Phi-B: 0 °
Piezometric Line: 1

Method: Janbu
Slip Surface Option: Block



Deepdell East WRS

Section A-A'

Name: Figure A01a SLOPE/W Analysis - Static Block Slide

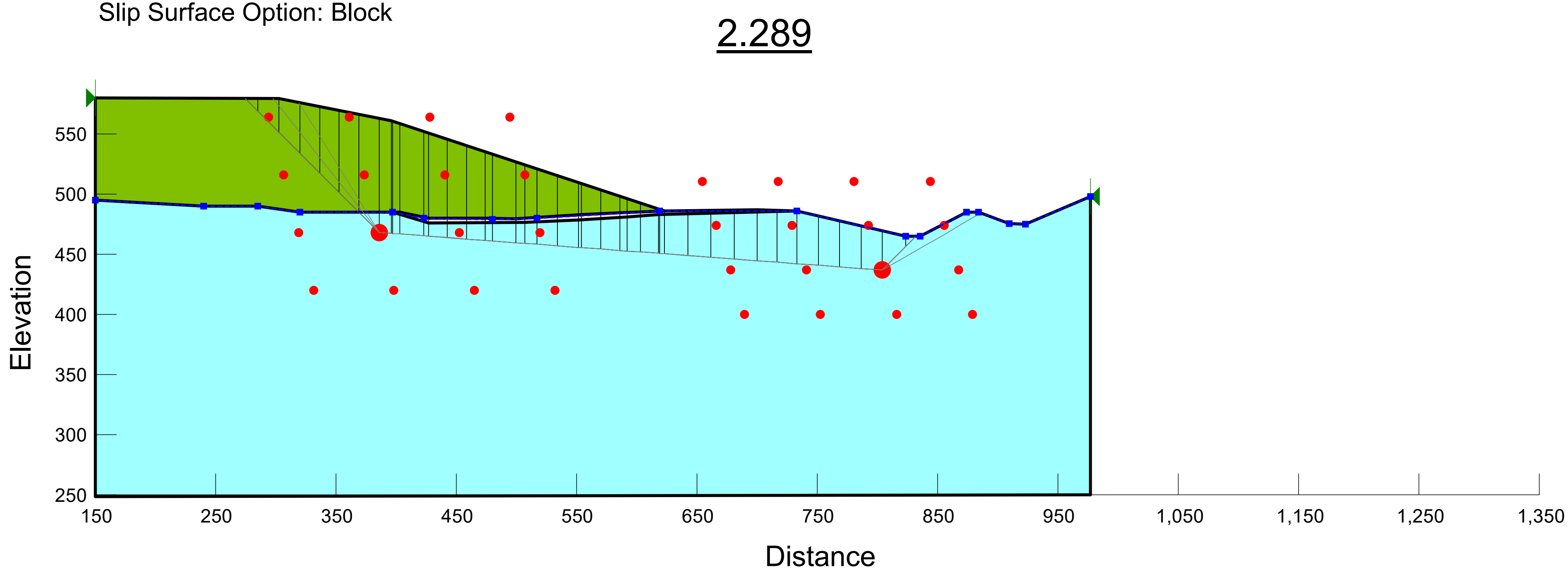
Engineering Geology Limited

Name: Schist (Foliation 0 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Phi-B: 0 °
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste rock stack (Peak)
Piezometric Line: 1

Name: Loess
Model: Mohr-Coulomb
Unit Weight: 18 kN/m³
Cohesion': 0 kPa
Phi': 30 °
Phi-B: 0 °
Piezometric Line: 1

Method: Janbu
Slip Surface Option: Block



Deepdell East WRS

Section A-A'

Name: Figure A01b SLOPE/W Analysis - Static Block Slide

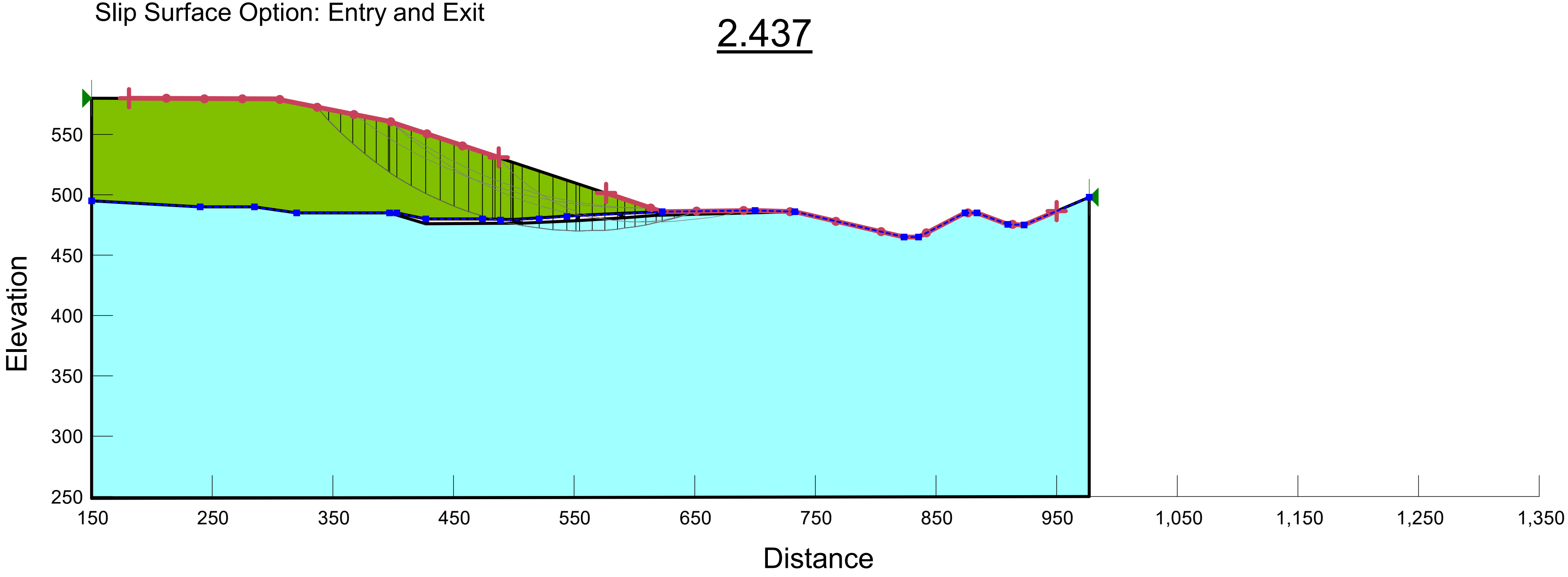
Engineering Geology Limited

Name: Schist (Foliation 0 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Phi-B: 0 °
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste rock stack (Peak)
Piezometric Line: 1

Name: Loess
Model: Mohr-Coulomb
Unit Weight: 18 kN/m³
Cohesion': 0 kPa
Phi': 30 °
Phi-B: 0 °
Piezometric Line: 1

Method: Spencer
Slip Surface Option: Entry and Exit



Deepdell East WRS

Section A-A'

Name: Figure A01c SLOPE/W Analysis - Static Circular Slide

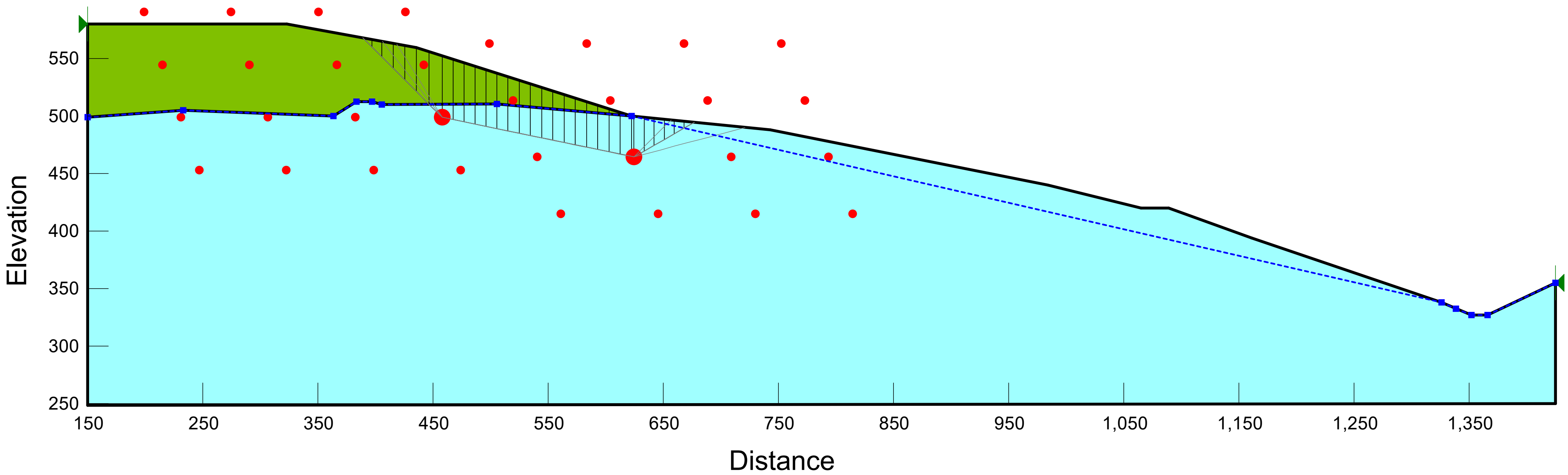
Engineering Geology Limited

Name: Schist (Foliation 0 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Phi-B: 0 °
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste rock stack (Peak)
Phi-B: 0 °
Piezometric Line: 1

2.109

Method: Janbu
Slip Surface Option: Block



Deepdell East WRS

Section B-B'

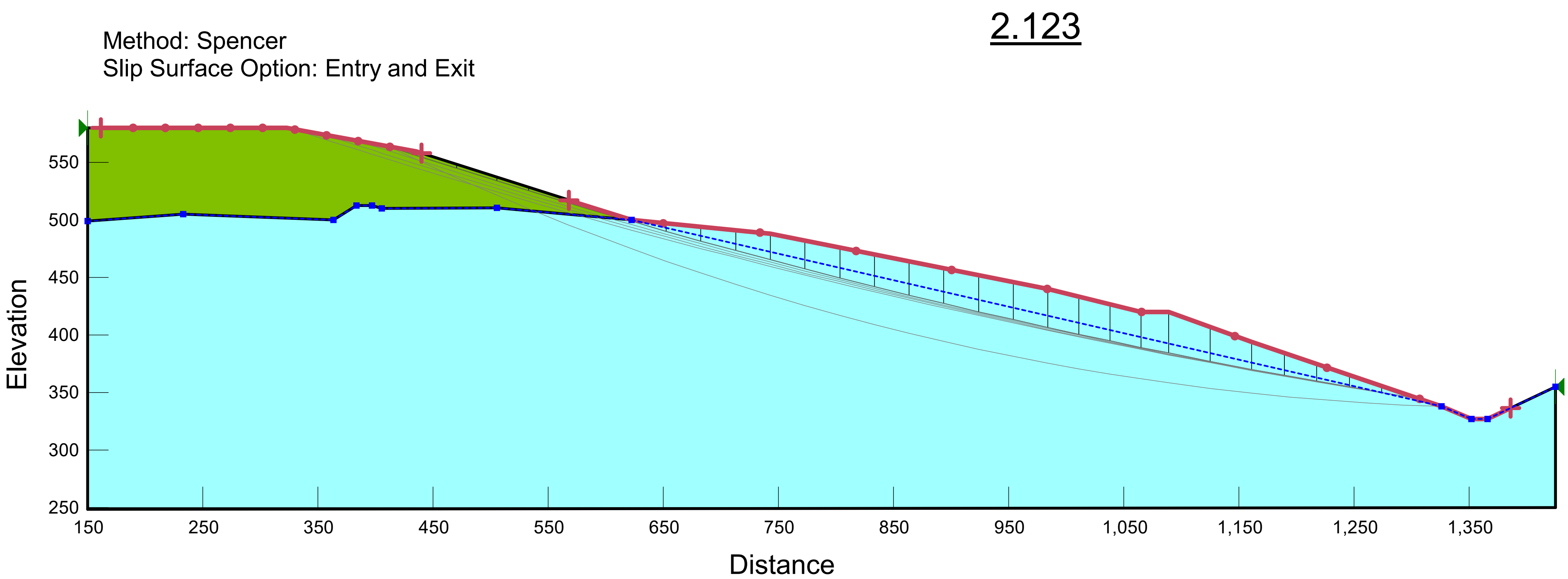
Name: Figure A02a SLOPE/W Analysis - Static Block Slide

Engineering Geology Limited

Name: Schist (Foliation 15 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Phi-B: 0 °
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste rock stack (Peak)
Phi-B: 0 °
Piezometric Line: 1

Method: Spencer
Slip Surface Option: Entry and Exit



Deepdell East WRS

Section B-B'

Name: Figure A02b SLOPE/W Analysis - Static Circular Slide

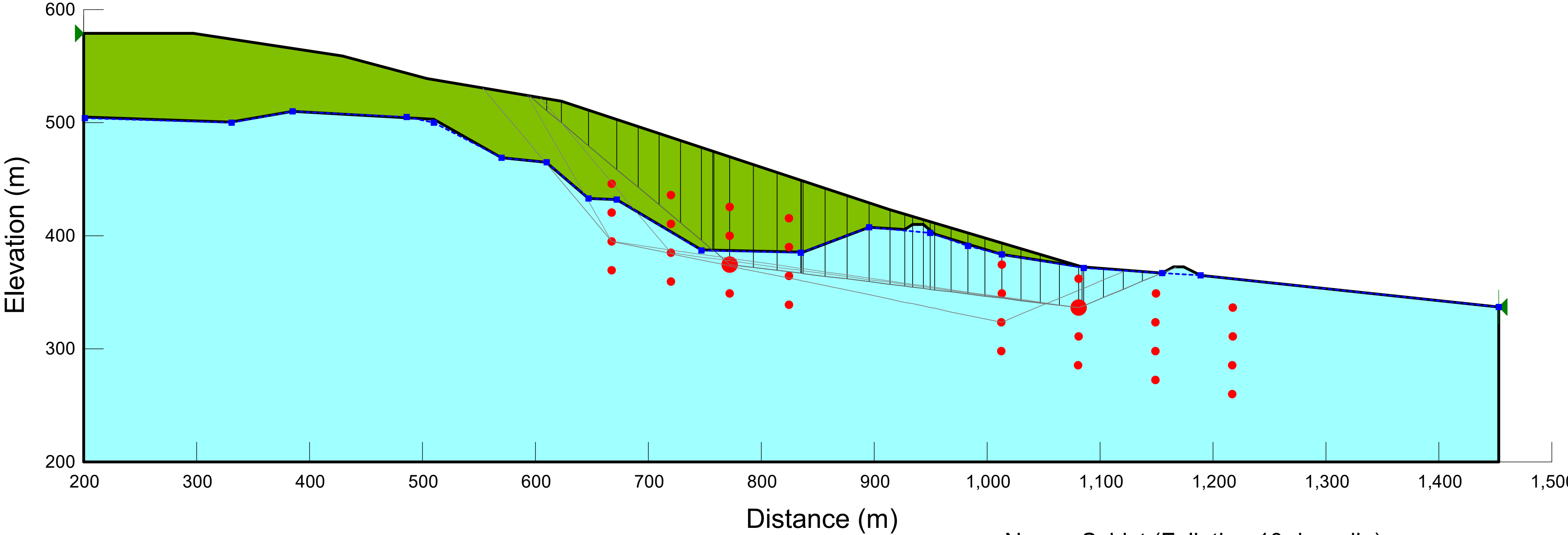
Engineering Geology Limited

Name: Schist (Foliation 15 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Phi-B: 0 °
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste Rock Stack (Peak)
Piezometric Line: 1

Method: Janbu
Slip Surface Option: Block

1.796



Deepdell East WRS

Section C-C'

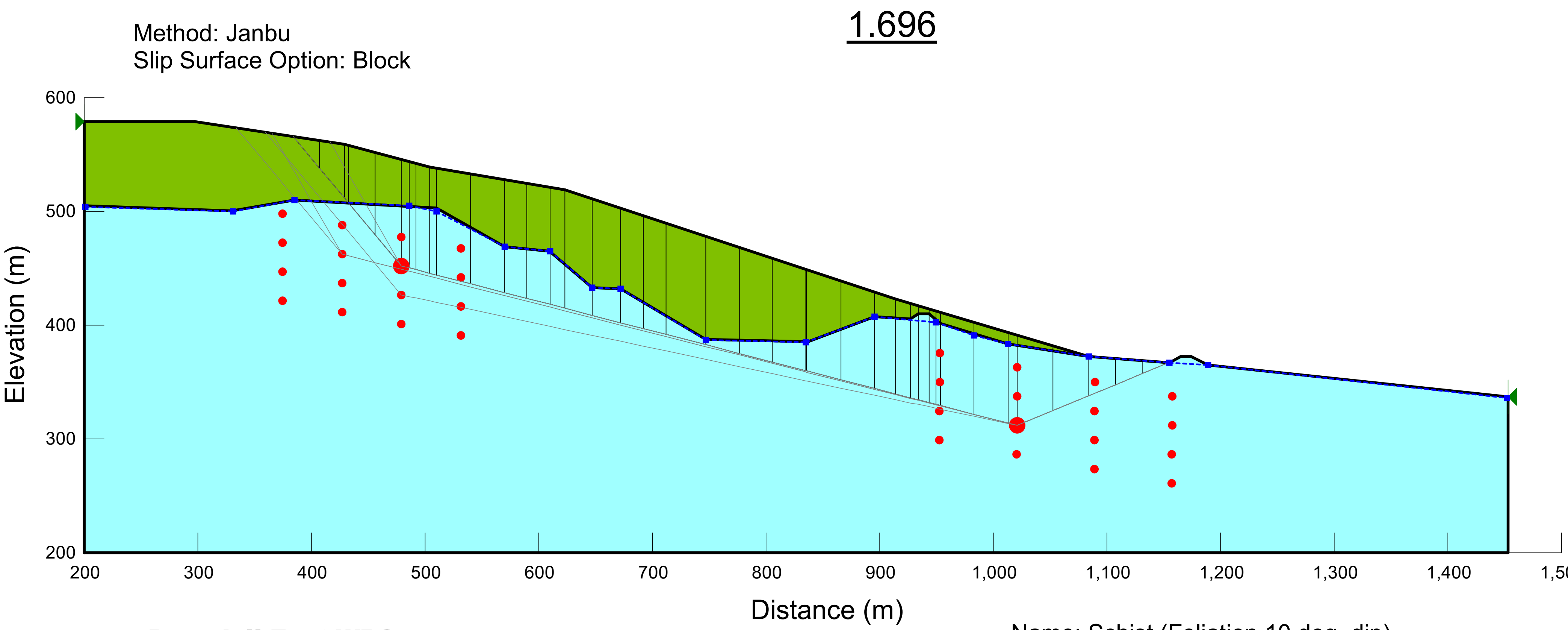
Name: Figure A03a SLOPE/W Analysis - Static Block Slide

Engineering Geology Limited

Name: Schist (Foliation 10 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste Rock Stack (Peak)
Piezometric Line: 1

Method: Janbu
Slip Surface Option: Block



Deepdell East WRS

Section C-C'

Name: Figure A03b SLOPE/W Analysis - Static Block Slide

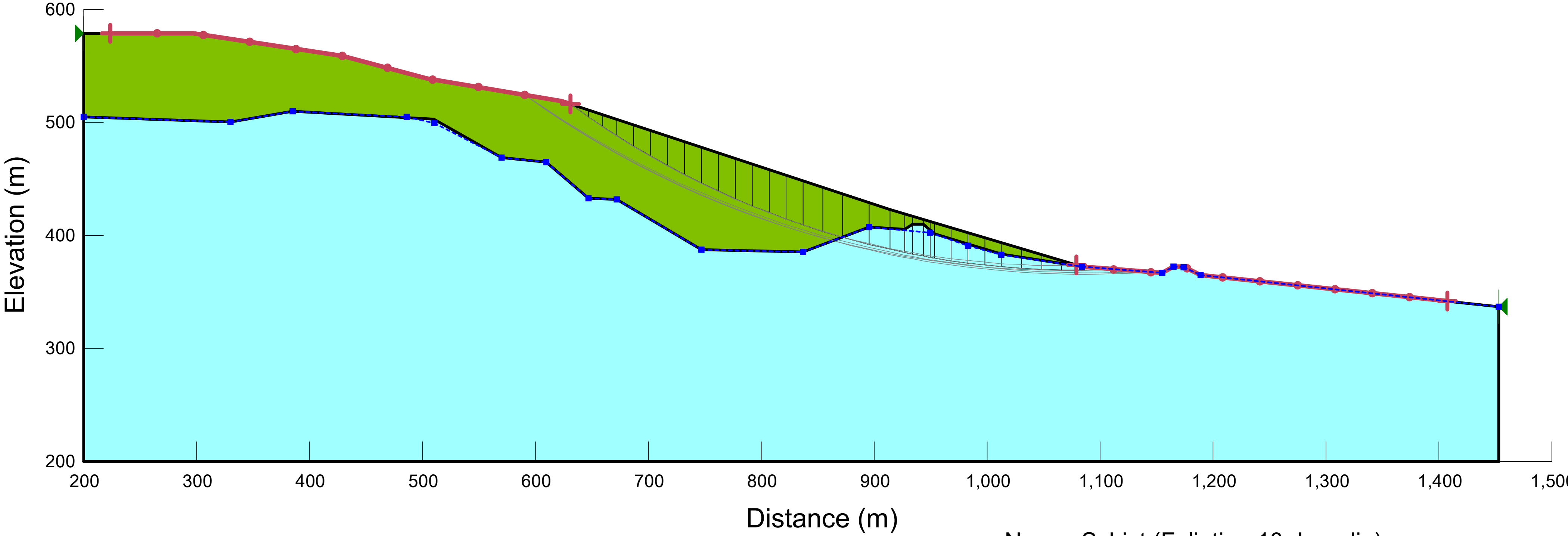
Engineering Geology Limited

Name: Schist (Foliation 10 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste Rock Stack (Peak)
Piezometric Line: 1

Method: Spencer
Slip Surface Option: Entry and Exit

2.028



Deepdell East WRS

Section C-C'

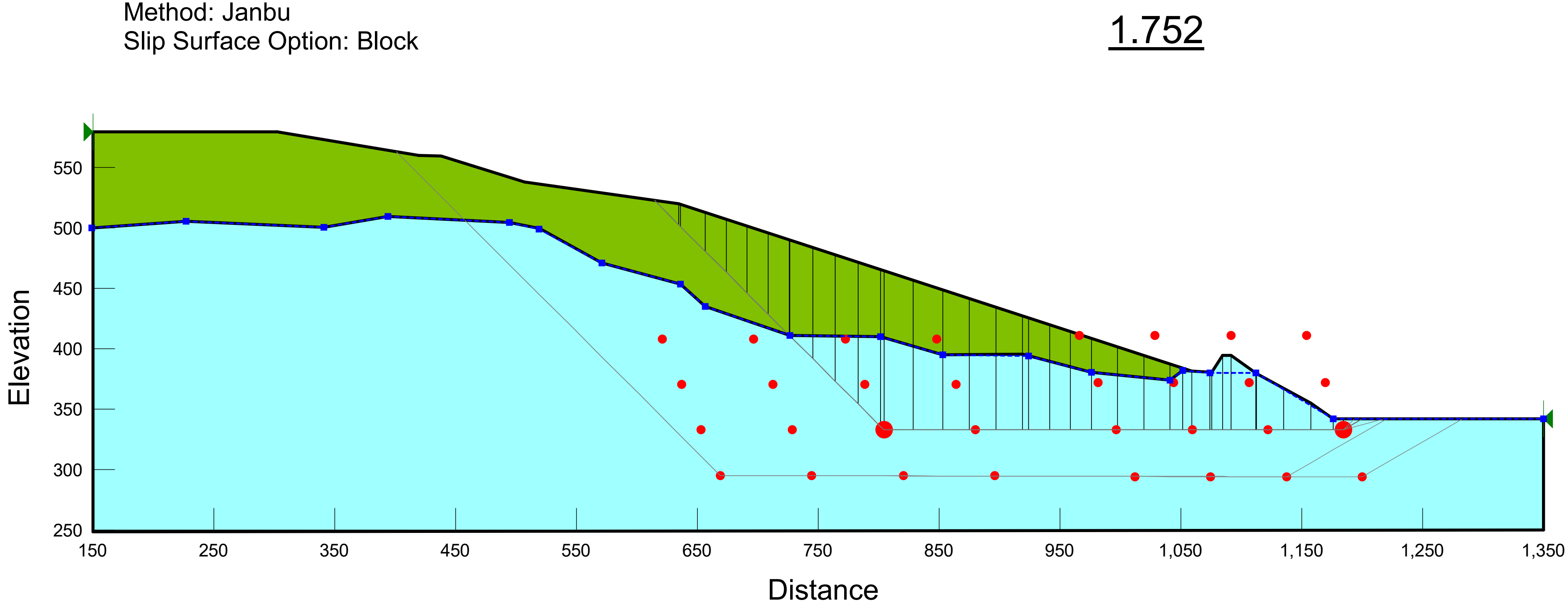
Name: Figure A03c SLOPE/W Analysis - Static Circular Slide

Engineering Geology Limited

Name: Schist (Foliation 10 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste rock stack (Peak)
Phi-B: 0 °
Piezometric Line: 1

Method: Janbu
Slip Surface Option: Block



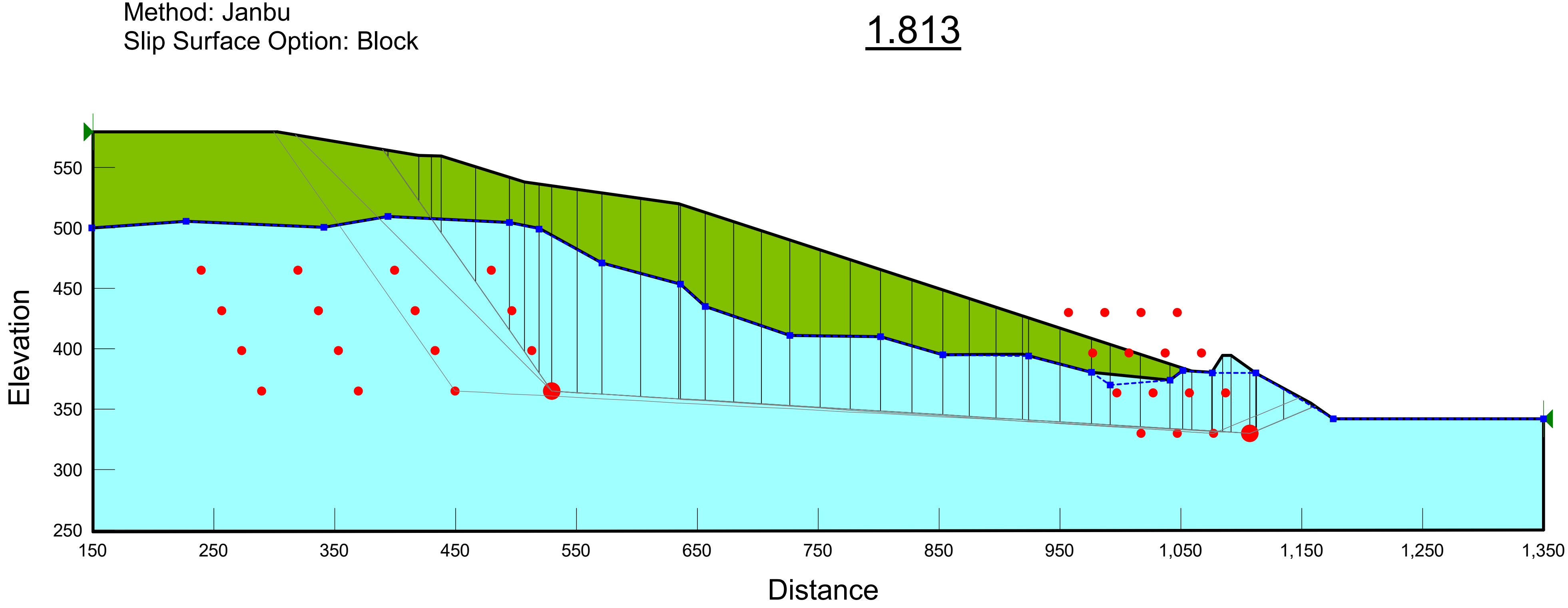
Deepdell East WRS
Section D-D'
Name: Figure A04a SLOPE/W Analysis - Static Block Slide

Engineering Geology Limited

Name: Schist (Foliation 0 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Phi-B: 0 °
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste rock stack (Peak)
Phi-B: 0 °
Piezometric Line: 1

Method: Janbu
Slip Surface Option: Block



Deepdell East WRS

Section D-D'

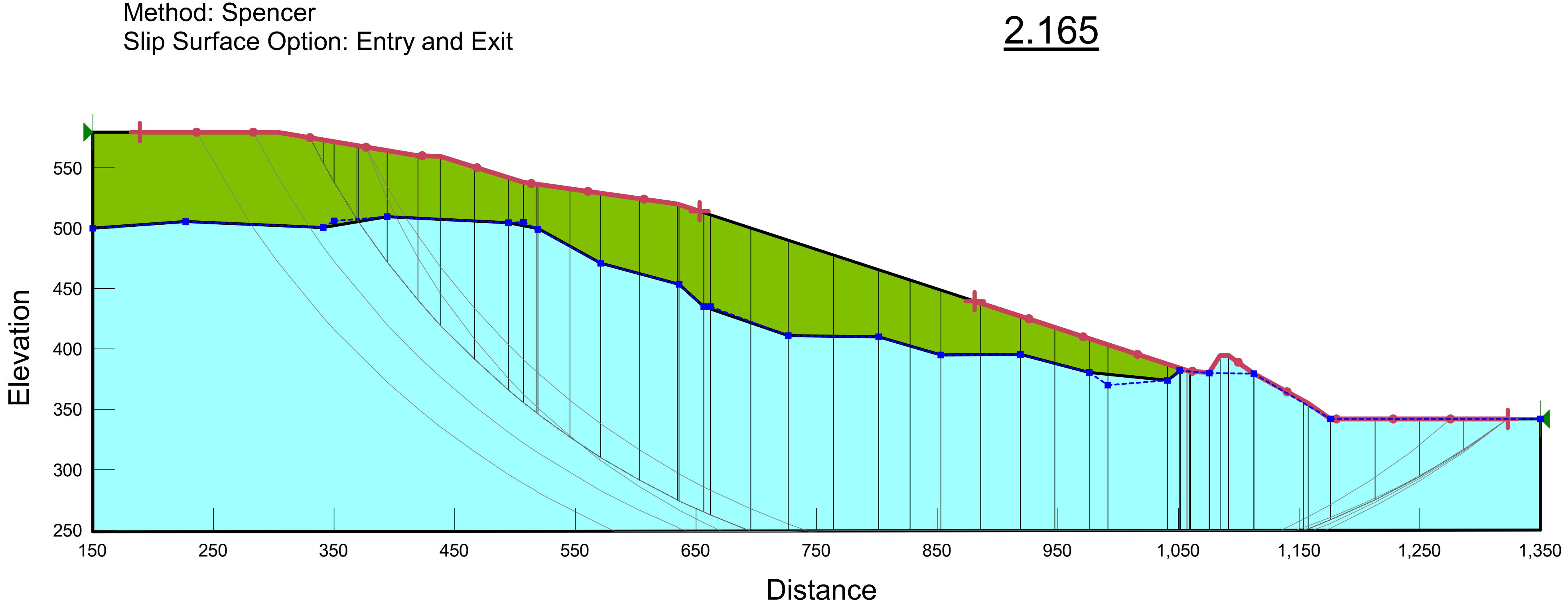
Name: Figure A04b SLOPE/W Analysis - Static Block Slide

Engineering Geology Limited

Name: Schist (Foliation 0 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Phi-B: 0 °
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste rock stack (Peak)
Phi-B: 0 °
Piezometric Line: 1

Method: Spencer
Slip Surface Option: Entry and Exit



Deepdell East WRS

Section D-D'

Name: Figure A04c SLOPE/W Analysis - Static Circular Slide

Engineering Geology Limited

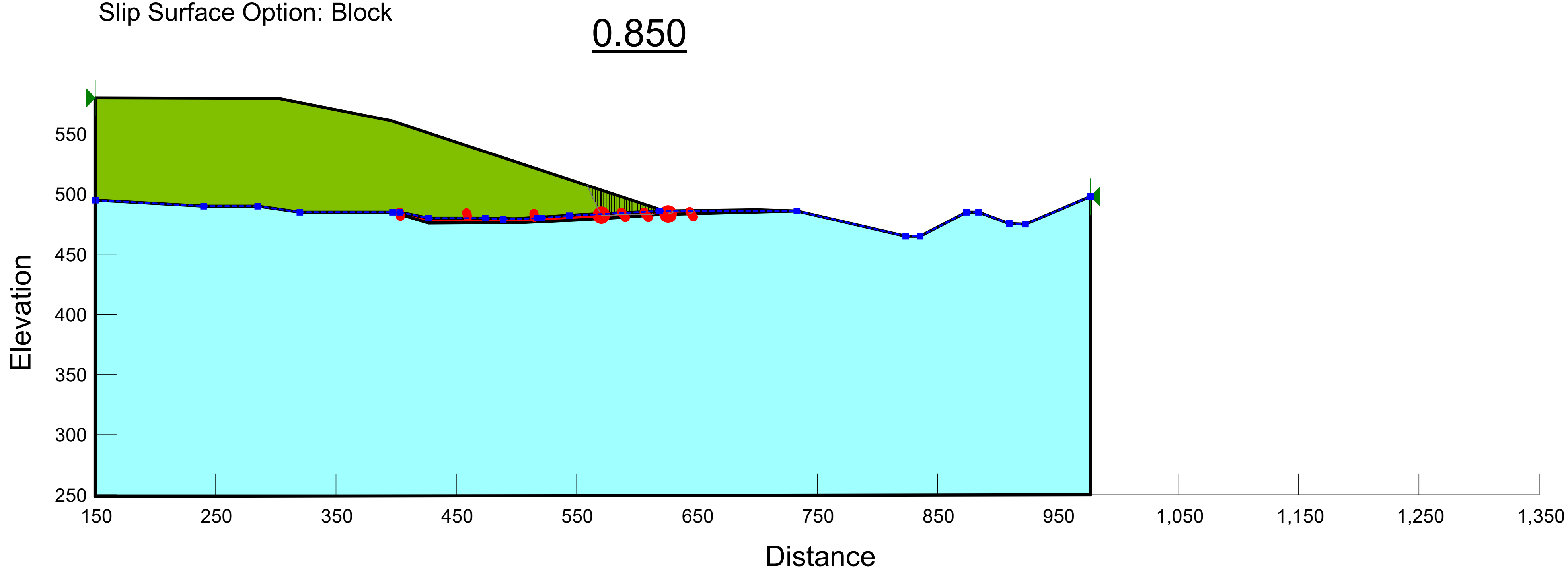
Name: Schist (Foliation 0 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Phi-B: 0 °
Piezometric Line: 1

Seismic Stability Analyses

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste rock stack (Peak)
Piezometric Line: 1

Name: Loess Liquefied
Model: S=f(overburden)
Unit Weight: 18 kN/m³
Tau/Sigma Ratio: 0.06
Minimum Strength: 0
Piezometric Line: 1

Method: Janbu
Slip Surface Option: Block



Deepdell East WRS

Section A-A'

Name: Figure A05 SLOPE/W Analysis - Seismic Post EQ Liq B. Slide

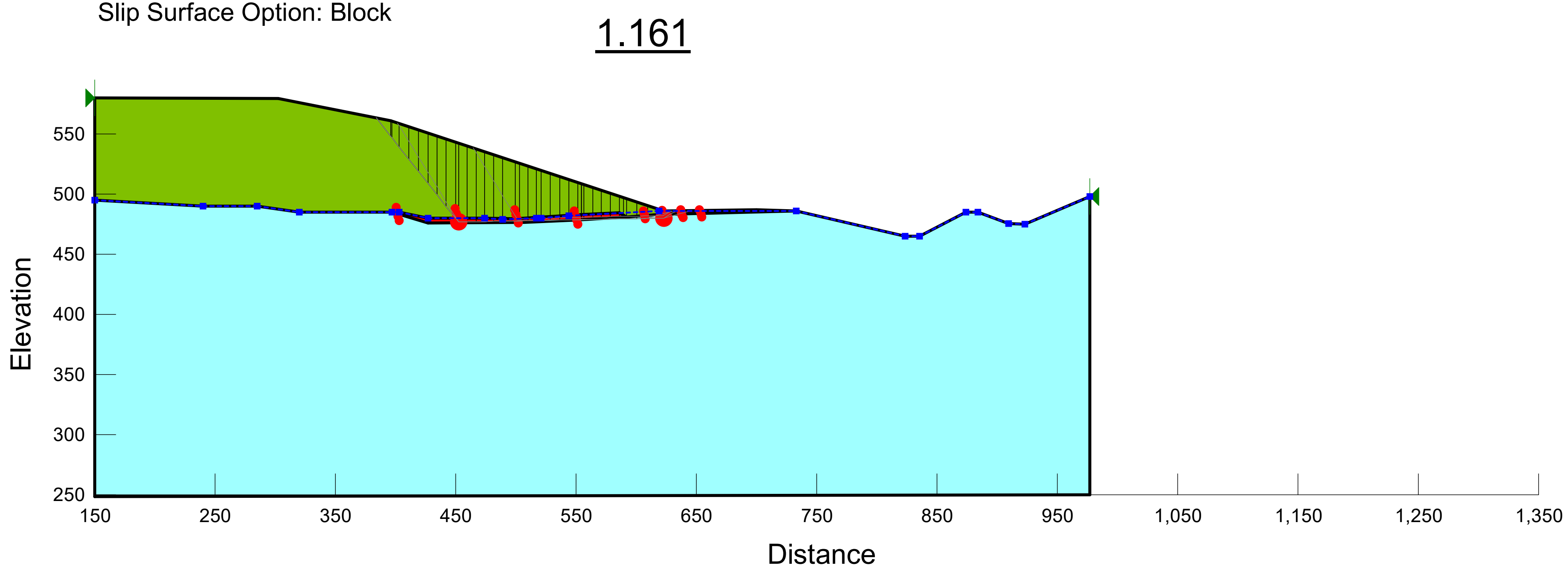
Engineering Geology Limited

Name: Schist (Foliation 0 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Phi-B: 0 °
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste rock stack (Peak)
Piezometric Line: 1

Name: Loess Liquefied
Model: S=f(overburden)
Unit Weight: 18 kN/m³
Tau/Sigma Ratio: 0.06
Minimum Strength: 0
Piezometric Line: 1

Method: Janbu
Slip Surface Option: Block



Deepdell East WRS

Section A-A'

Name: Figure A06 SLOPE/W Analysis - Seismic Post EQ Liq Shear Key B. Slide

Engineering Geology Limited

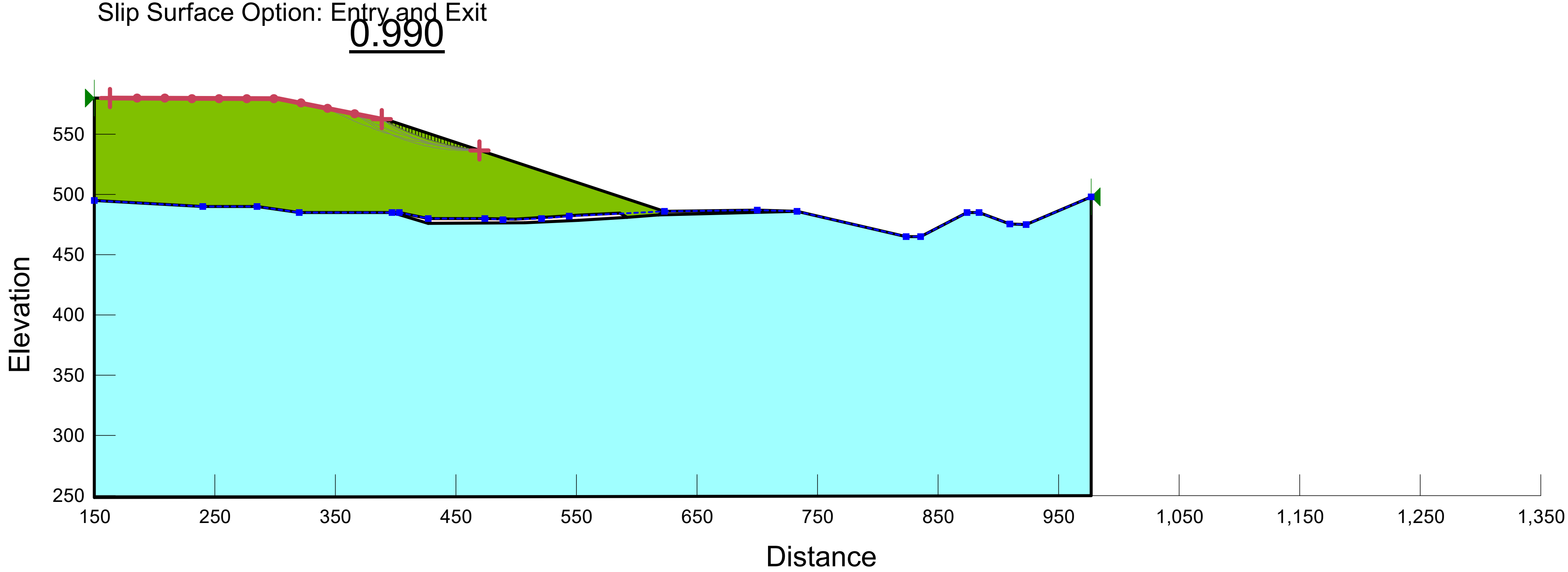
Name: Schist (Foliation 0 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Phi-B: 0 °
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste rock stack (Peak)
Piezometric Line: 1

Name: Loess
Model: Mohr-Coulomb
Unit Weight: 18 kN/m³
Cohesion': 0 kPa
Phi': 30 °
Phi-B: 0 °
Piezometric Line: 1

Horz Seismic Coef.: 0.46
Ignore seismic load in strength: No

Method: Spencer
Slip Surface Option: Entry and Exit



Deepdell East WRS
Section A-A'
Name: Figure A07 SLOPE/W Analysis - OBE 1/3H Circular Slide

Engineering Geology Limited

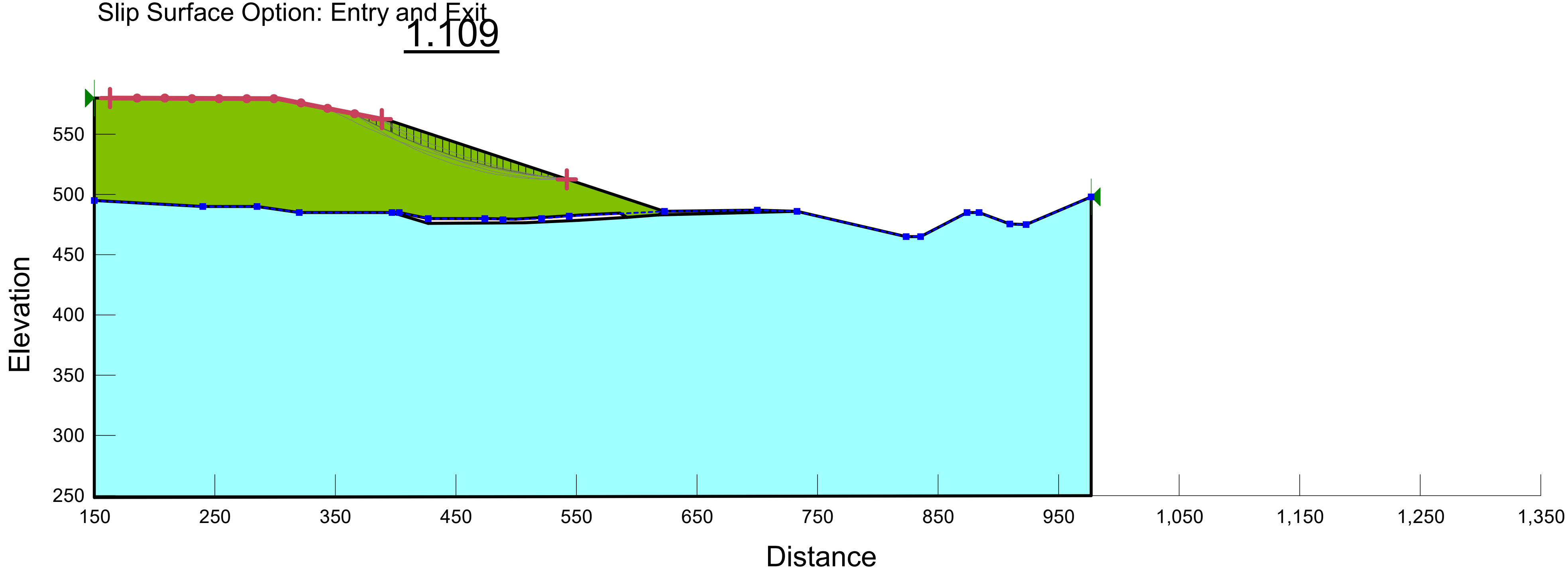
Name: Schist (Foliation 0 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Phi-B: 0 °
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste rock stack (Peak)
Piezometric Line: 1

Name: Loess
Model: Mohr-Coulomb
Unit Weight: 18 kN/m³
Cohesion': 0 kPa
Phi': 30 °
Phi-B: 0 °
Piezometric Line: 1

Horz Seismic Coef.: 0.355
Ignore seismic load in strength: No

Method: Spencer
Slip Surface Option: Entry and Exit



Deepdell East WRS

Section A-A'

Name: Figure A08 SLOPE/W Analysis - OBE 2/3H Circular Slide

Engineering Geology Limited

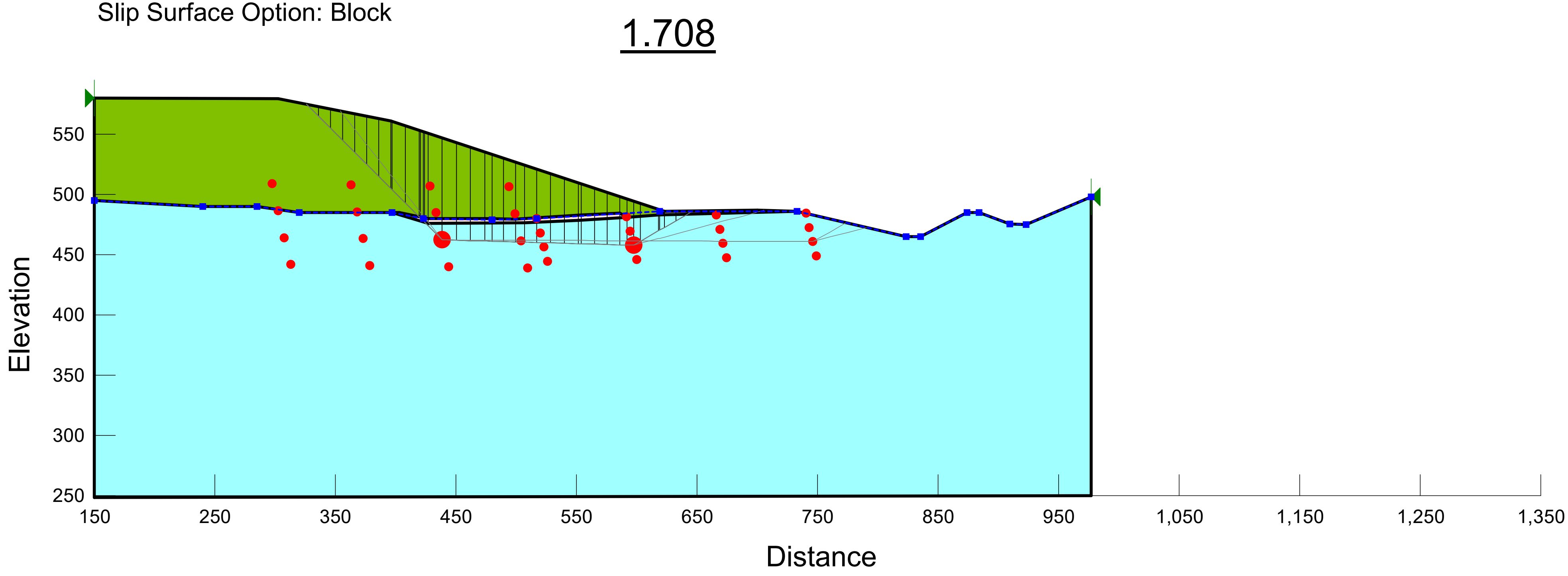
Name: Schist (Foliation 0 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Phi-B: 0 °
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste rock stack (Peak)
Piezometric Line: 1

Horz Seismic Coef.: 0.068
Ignore seismic load in strength: No

Method: Janbu
Slip Surface Option: Block

Name: Loess
Model: Mohr-Coulomb
Unit Weight: 18 kN/m³
Cohesion': 0 kPa
Phi': 30 °
Phi-B: 0 °
Piezometric Line: 1



Deepdell East WRS

Section A-A'

Name: Figure A09 SLOPE/W Analysis - OBE 1H Block Slide

Engineering Geology Limited

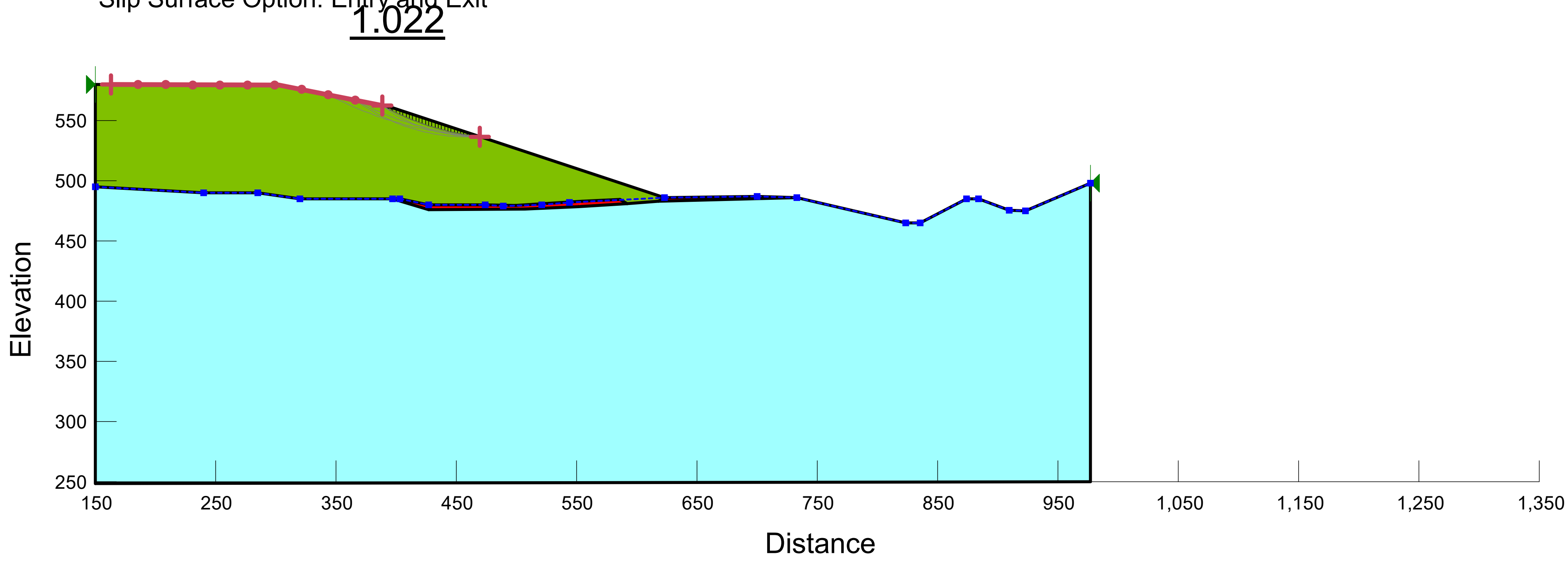
Name: Schist (Foliation 0 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Phi-B: 0 °
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste rock stack (Peak)
Piezometric Line: 1

Horz Seismic Coef.: 0.44
Ignore seismic load in strength: No

Method: Spencer
Slip Surface Option: Entry and Exit

Name: Loess Liquefied
Model: S=f(overburden)
Unit Weight: 18 kN/m³
Tau/Sigma Ratio: 0.06
Minimum Strength: 0
Piezometric Line: 1



Name: Schist (Foliation 0 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Phi-B: 0 °
Piezometric Line: 1

Deepdell East WRS

Section A-A'

Name: Figure A10 SLOPE/W Analysis - SEE 1/3H Circular Slide

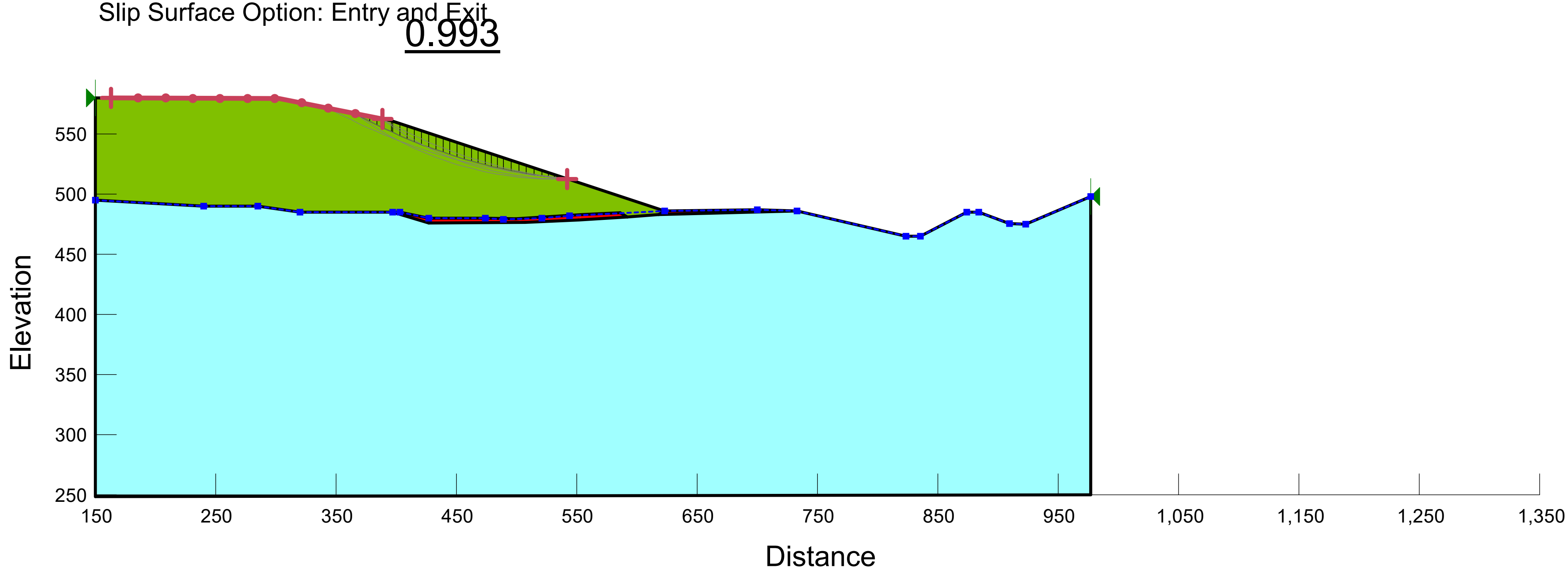
Engineering Geology Limited

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste rock stack (Peak)
Piezometric Line: 1

Name: Loess Liquefied
Model: S=f(overburden)
Unit Weight: 18 kN/m³
Tau/Sigma Ratio: 0.06
Minimum Strength: 0
Piezometric Line: 1

Horz Seismic Coef.: 0.42
Ignore seismic load in strength: No

Method: Spencer
Slip Surface Option: Entry and Exit



Deepdell East WRS

Section A-A'

Name: Figure A11 SLOPE/W Analysis - SEE 2/3H Circular Slide

Engineering Geology Limited

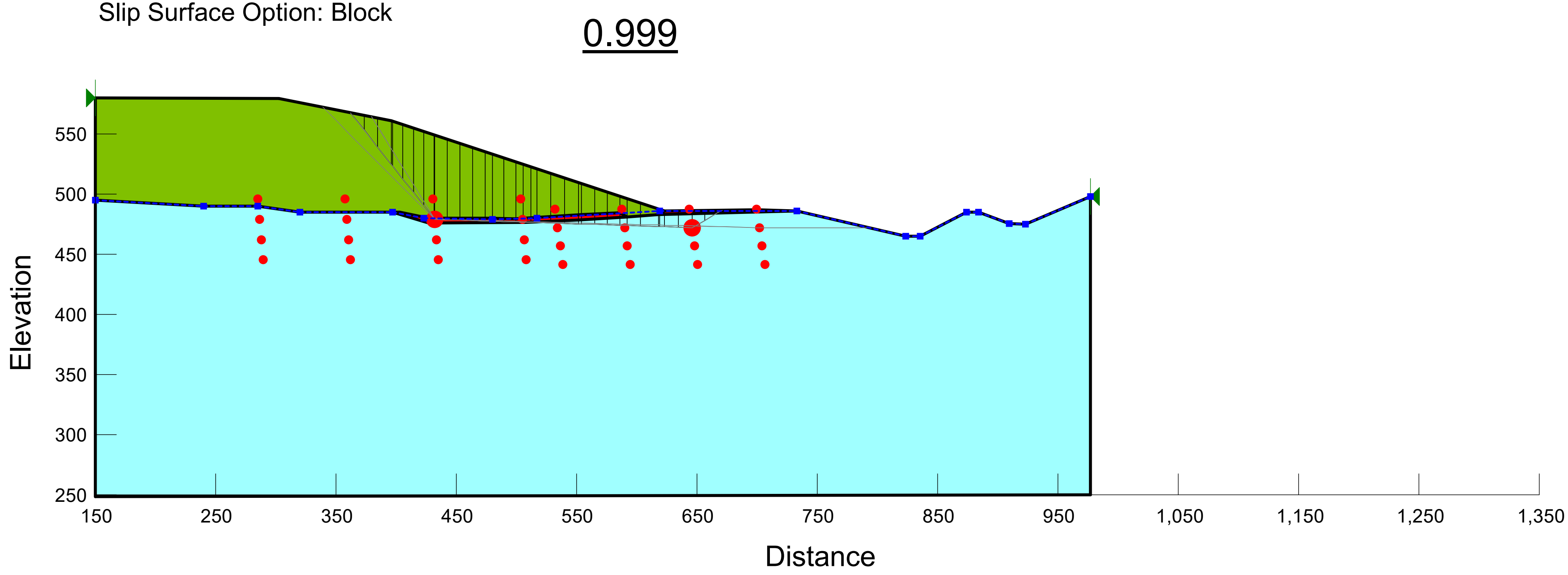
Name: Schist (Foliation 0 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Phi-B: 0 °
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste rock stack (Peak)
Piezometric Line: 1

Horz Seismic Coef.: 0.12
Ignore seismic load in strength: No

Method: Janbu
Slip Surface Option: Block

Name: Loess Liquefied
Model: S=f(overburden)
Unit Weight: 18 kN/m³
Tau/Sigma Ratio: 0.06
Minimum Strength: 0
Piezometric Line: 1



Deepdell East WRS
Section A-A'
Name: Figure A12 SLOPE/W Analysis - SEE 1H Block Slide

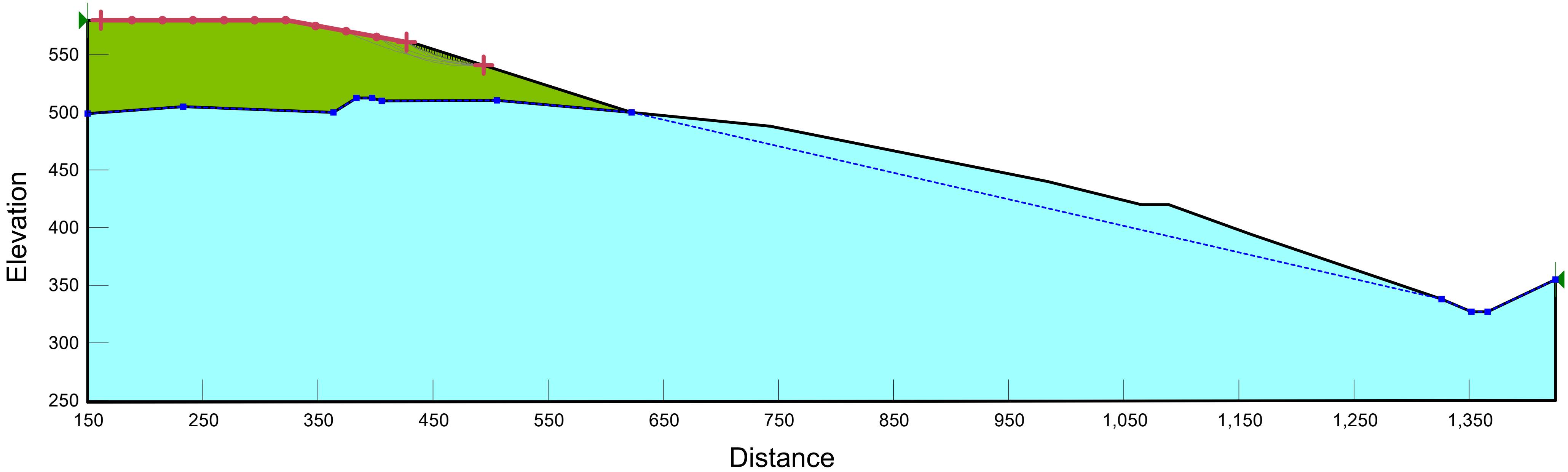
Engineering Geology Limited

Name: Schist (Foliation 0 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Phi-B: 0 °
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste rock stack (Peak)
Phi-B: 0 °
Piezometric Line: 1

Horz Seismic Coef.: 0.48
Ignore seismic load in strength: No

Method: Spencer 0.999
Slip Surface Option: Entry and Exit



Deepdell East WRS
Section B-B'
Name: Figure A13 SLOPE/W Analysis - OBE 1/3H Circular Slide

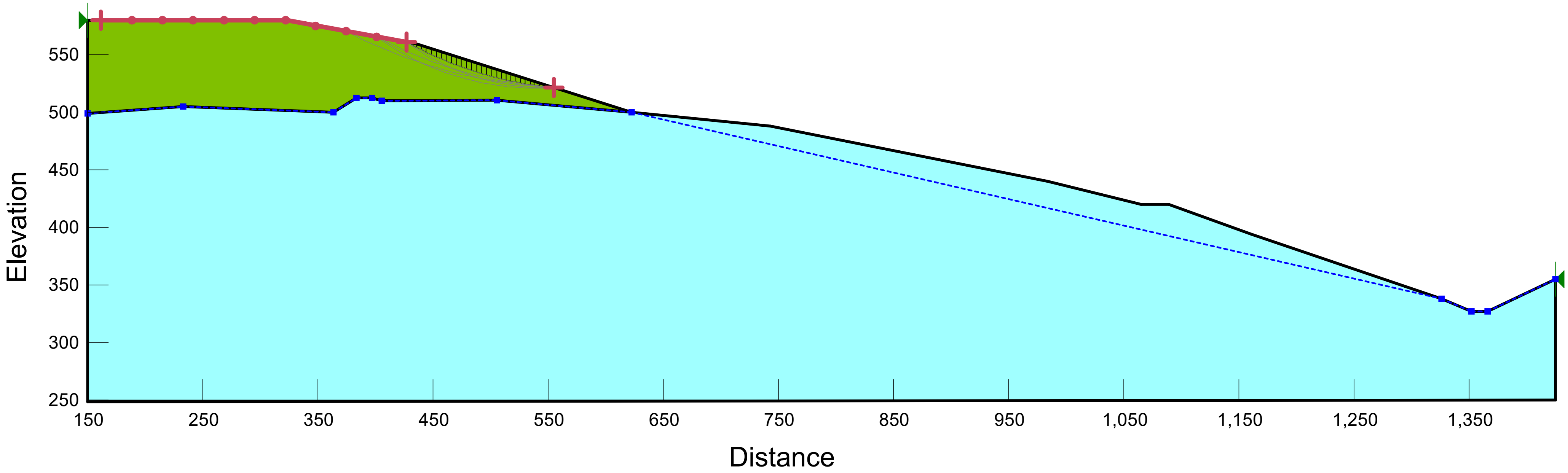
Engineering Geology Limited

Name: Schist (Foliation 15 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Phi-B: 0 °
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste rock stack (Peak)
Phi-B: 0 °
Piezometric Line: 1

Horz Seismic Coef.: 0.44
Ignore seismic load in strength: No

Method: Spencer <u>1.000</u>
Slip Surface Option: Entry and Exit



Deepdell East WRS
Section B-B'
Name: Figure A14 SLOPE/W Analysis - OBE 2/3H Circular Slide

Engineering Geology Limited

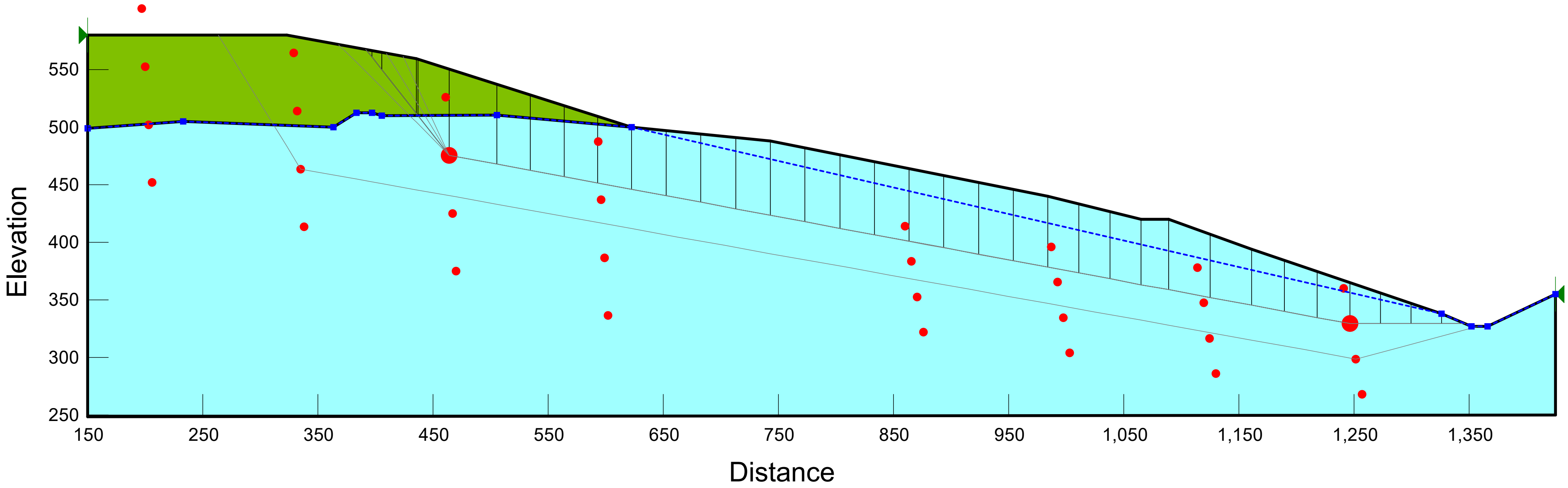
Name: Schist (Foliation 15 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Phi-B: 0 °
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste rock stack (Peak)
Phi-B: 0 °
Piezometric Line: 1

Horz Seismic Coef.: 0.08
Ignore seismic load in strength: No

Method: Janbu
Slip Surface Option: Block

1.188



Deepdell East WRS

Section B-B'

Name: Figure A15 SLOPE/W Analysis - OBE 1H Block Slide

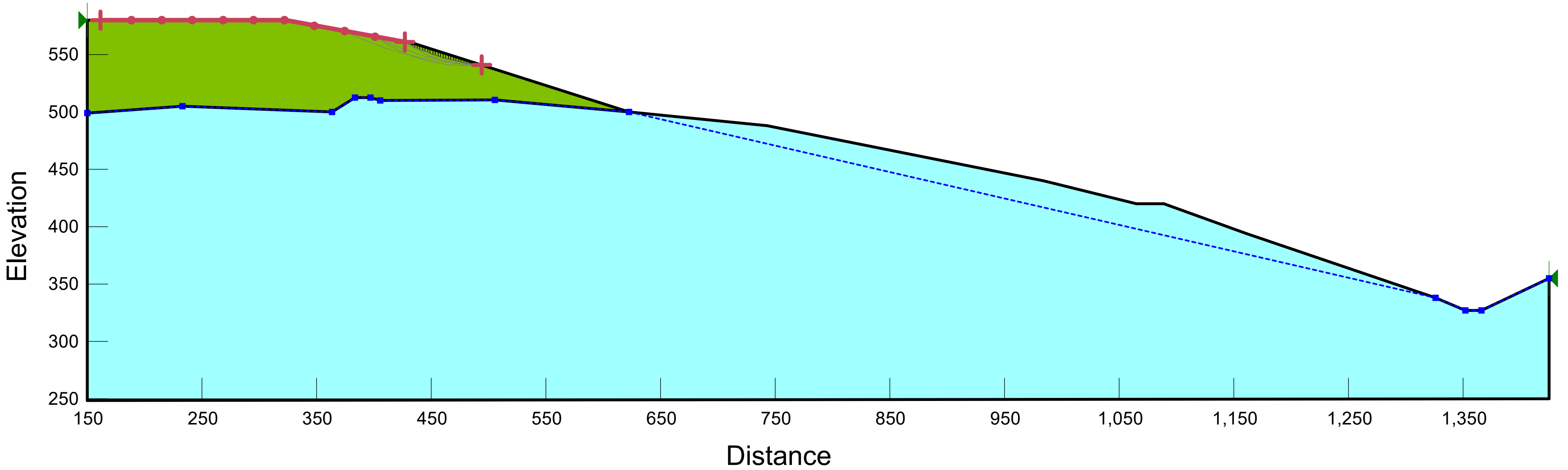
Engineering Geology Limited

Name: Schist (Foliation 15 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Phi-B: 0 °
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste rock stack (Peak)
Phi-B: 0 °
Piezometric Line: 1

Horz Seismic Coef.: 0.48
Ignore seismic load in strength: No

Method: Spencer 0.999
Slip Surface Option: Entry and Exit



Deepdell East WRS

Section B-B'

Name: Figure A16 SLOPE/W Analysis - SEE 1/3H Circular Slide

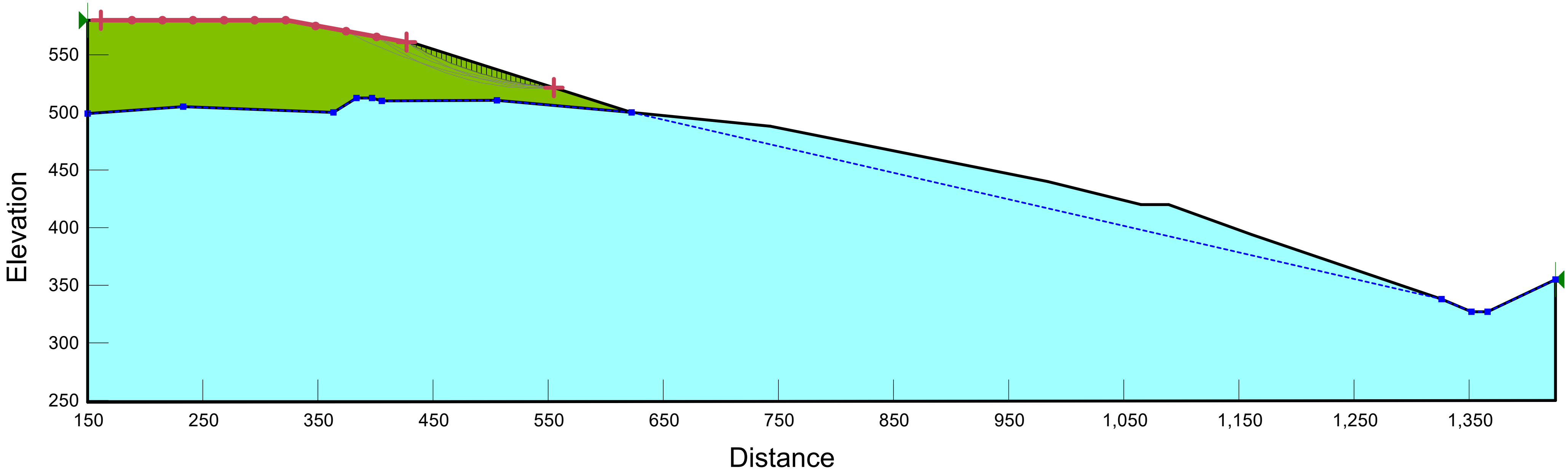
Engineering Geology Limited

Name: Schist (Foliation 15 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Phi-B: 0 °
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste rock stack (Peak)
Phi-B: 0 °
Piezometric Line: 1

Horz Seismic Coef.: 0.44
Ignore seismic load in strength: No

Method: Spencer 1.000
Slip Surface Option: Entry and Exit



Deepdell East WRS

Section B-B'

Name: Figure A17 SLOPE/W Analysis - SEE 2/3H Circular Slide

Engineering Geology Limited

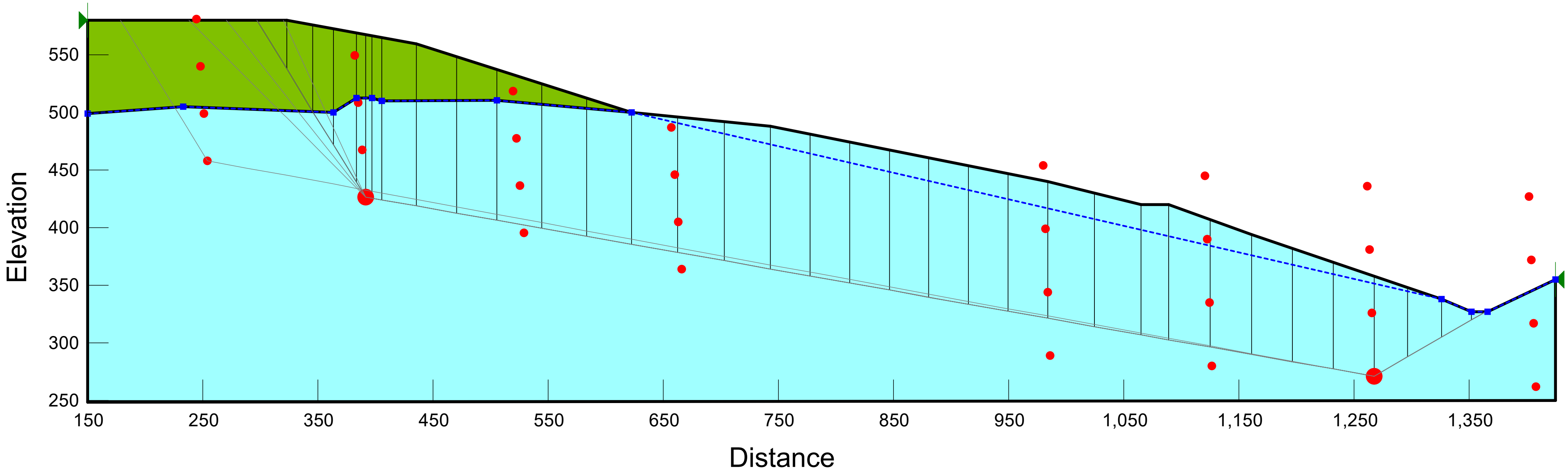
Name: Schist (Foliation 15 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Phi-B: 0 °
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste rock stack (Peak)
Phi-B: 0 °
Piezometric Line: 1

Horz Seismic Coef.: 0.14
Ignore seismic load in strength: No

Method: Janbu
Slip Surface Option: Block

0.998



Deepdell East WRS

Section B-B'

Name: Figure A18 SLOPE/W Analysis - SEE 1H Block Slide

Engineering Geology Limited

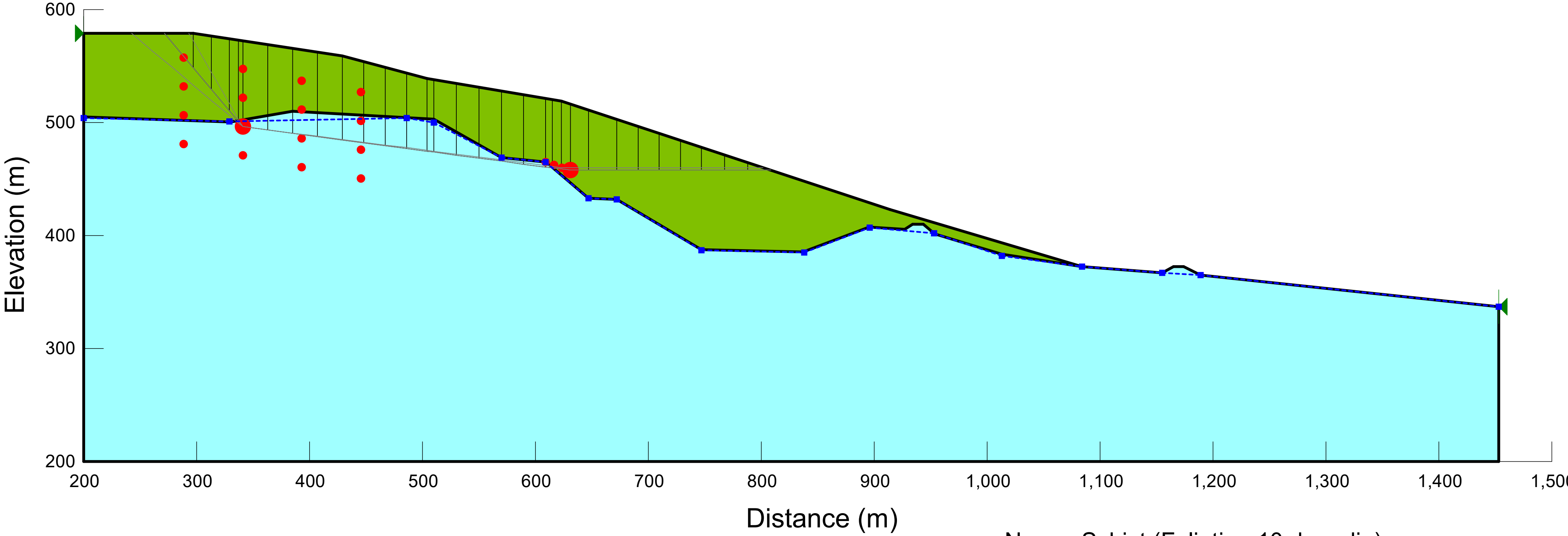
Name: Schist (Foliation 15 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Phi-B: 0 °
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste Rock Stack (Peak)
Piezometric Line: 1

Horz Seismic Coef.: 0.31
Ignore seismic load in strength: No

Method: Janbu
Slip Surface Option: Block

0.998



Deepdell East WRS

Section C-C'

Name: Figure A19 SLOPE/W Analysis - OBE 1/3H Block Slide

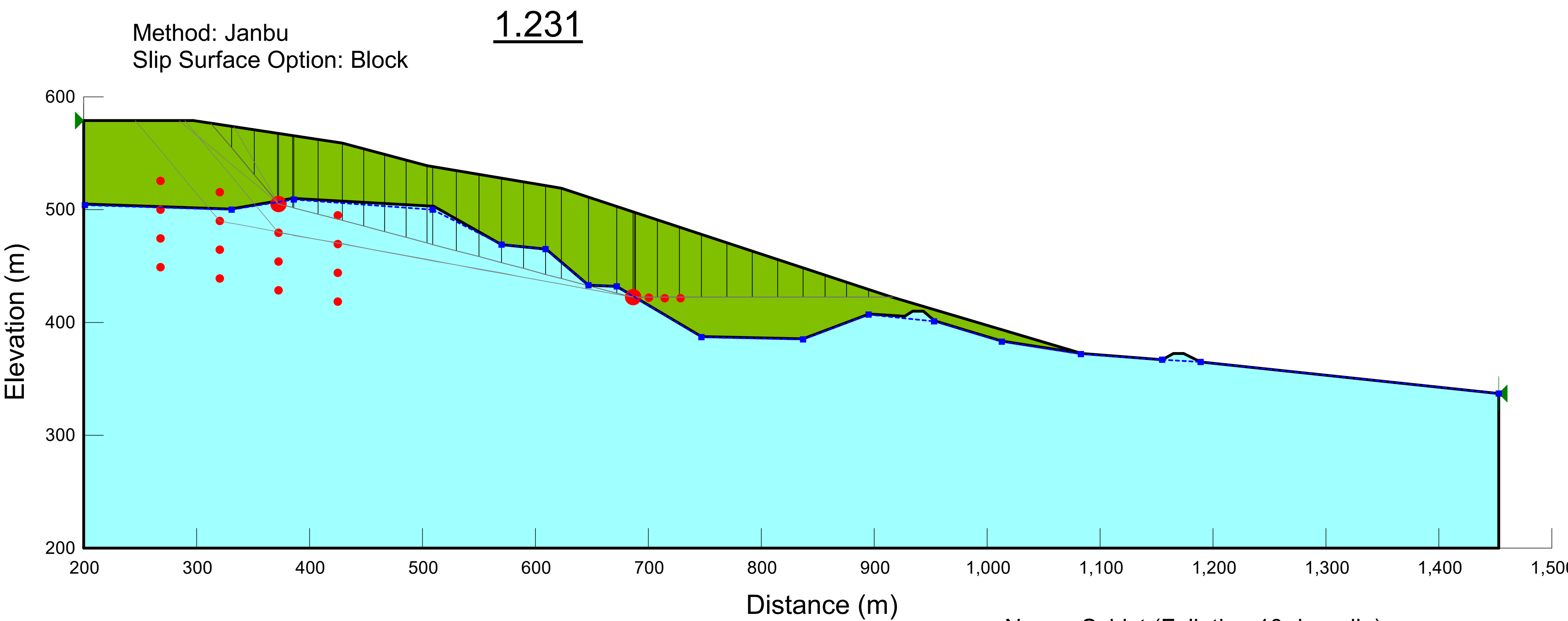
Engineering Geology Limited

Name: Schist (Foliation 10 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste Rock Stack (Peak)
Piezometric Line: 1

Horz Seismic Coef.: 0.171
Ignore seismic load in strength: No

Method: Janbu
Slip Surface Option: Block



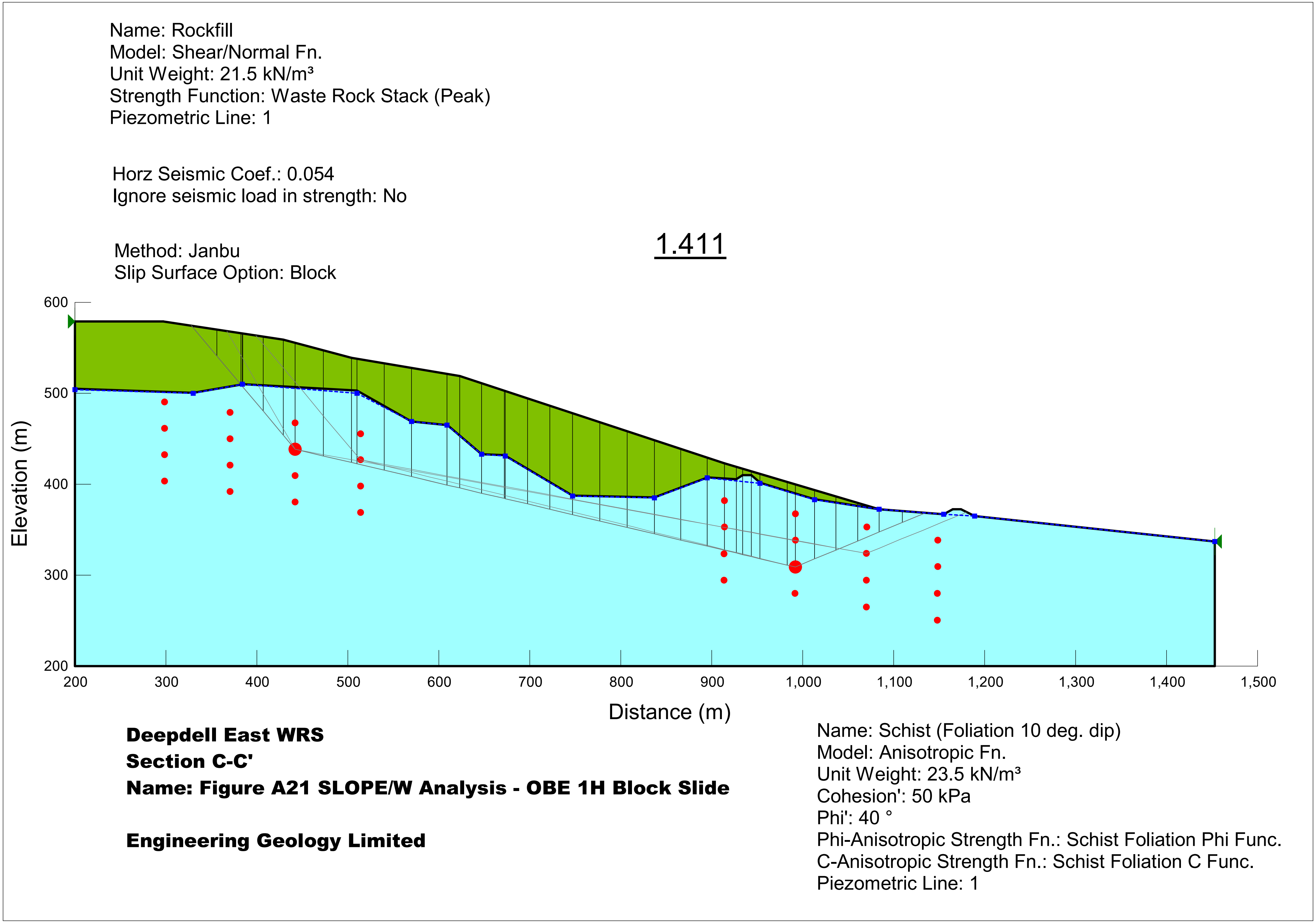
Deepdell East WRS

Section C-C'

Name: Figure A20 SLOPE/W Analysis - OBE 2/3H Block Slide

Engineering Geology Limited

Name: Schist (Foliation 10 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Piezometric Line: 1



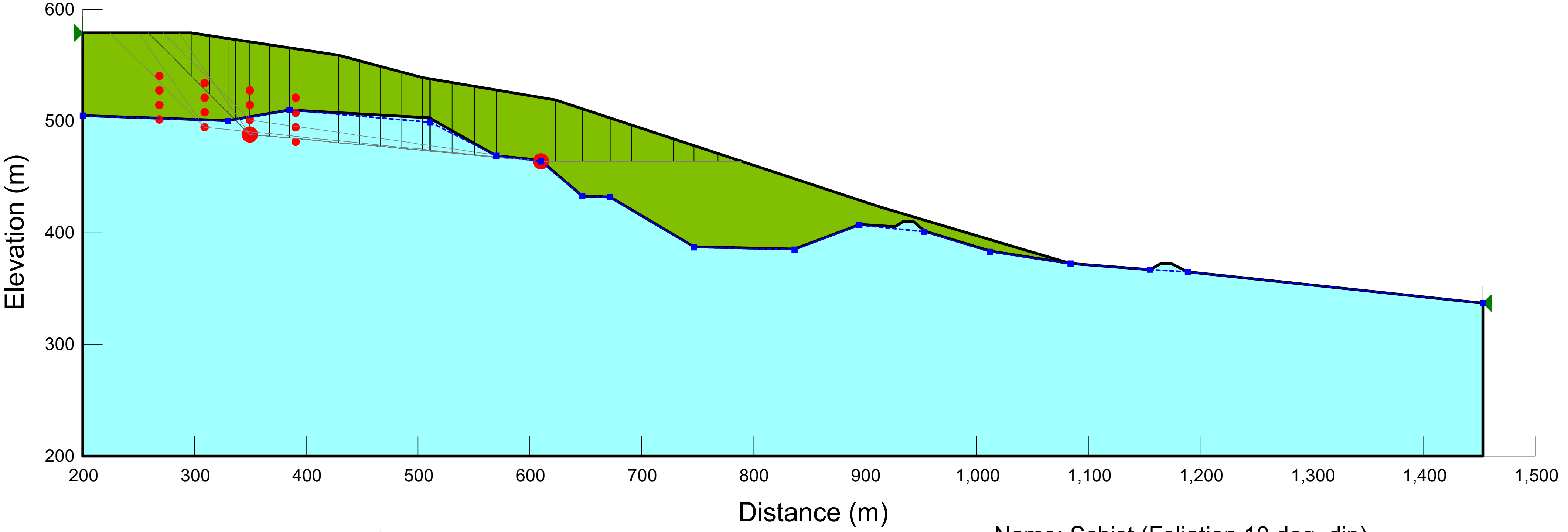
Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste Rock Stack (Peak)
Piezometric Line: 1
Horz Seismic Coef.: 0.054
Ignore seismic load in strength: No
Method: Janbu
Slip Surface Option: Block
1.411
Elevation (m)
600
500
400
300
200
200
300
400
500
600
700
800
900
1,000
1,100
1,200
1,300
1,400
1,500
Distance (m)
Name: Schist (Foliation 10 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Piezometric Line: 1
Deepdell East WRS
Section C-C'
Name: Figure A21 SLOPE/W Analysis - OBE 1H Block Slide
Engineering Geology Limited

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste Rock Stack (Peak)
Piezometric Line: 1

Horz Seismic Coef.: 0.32
Ignore seismic load in strength: No

Method: Janbu
Slip Surface Option: Block

0.993



Deepdell East WRS

Section C-C'

Name: Figure A22 SLOPE/W Analysis - SEE 1/3H Block Slide

Engineering Geology Limited

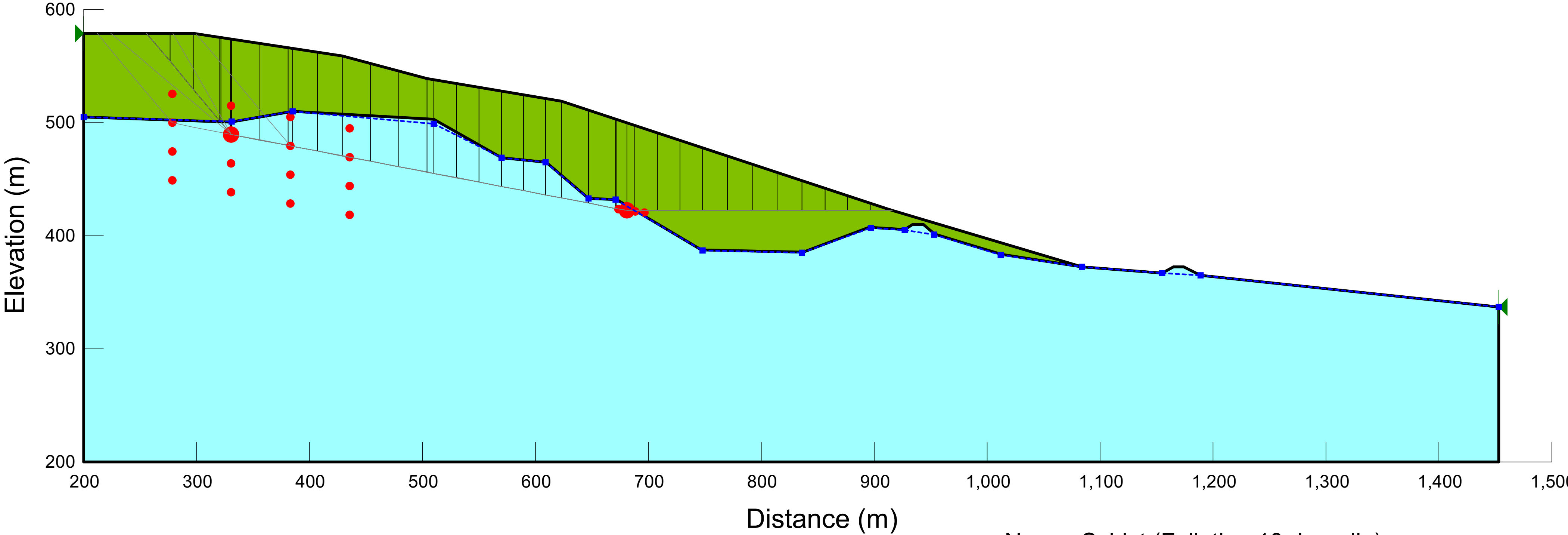
Name: Schist (Foliation 10 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste Rock Stack (Peak)
Piezometric Line: 1

Horz Seismic Coef.: 0.26
Ignore seismic load in strength: No

Method: Janbu
Slip Surface Option: Block

1.000



Deepdell East WRS

Section C-C'

Name: Figure A23 SLOPE/W Analysis - SEE 2/3H Block Slide

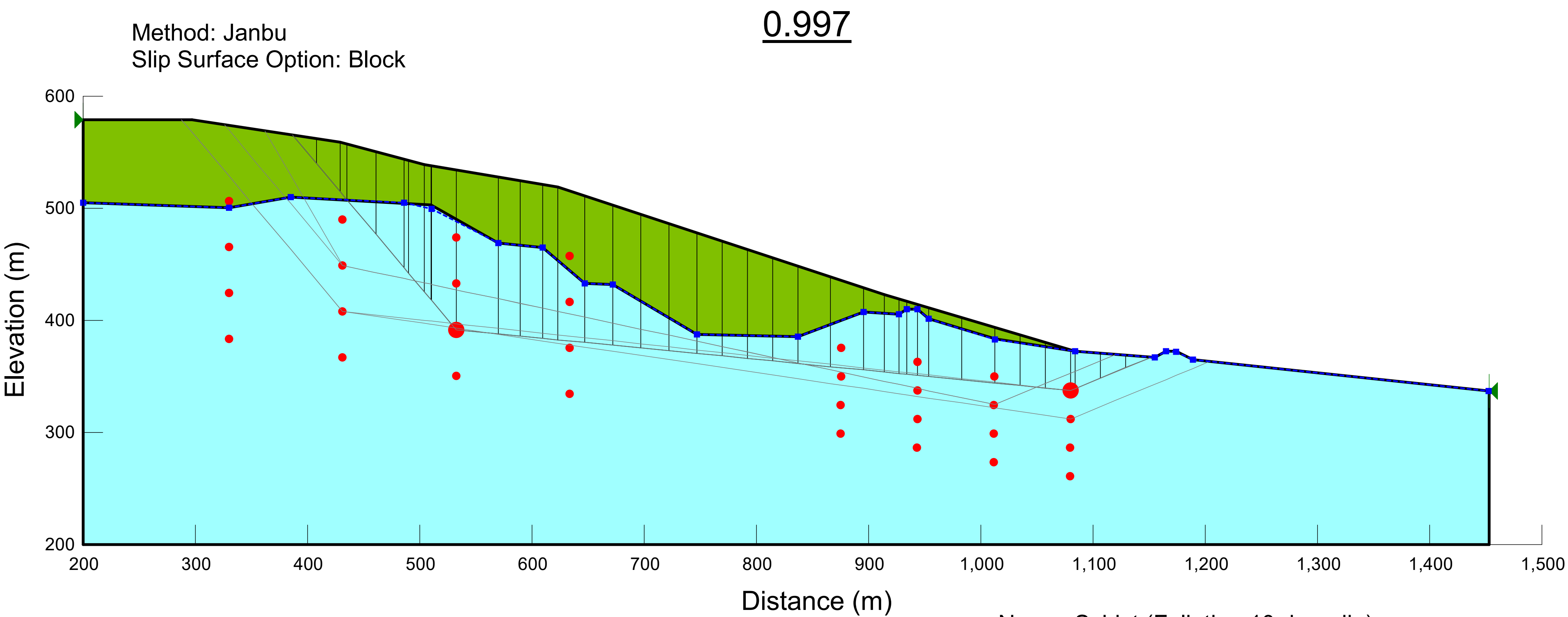
Engineering Geology Limited

Name: Schist (Foliation 10 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste Rock Stack (Peak)
Piezometric Line: 1

Horz Seismic Coef.: 0.17
Ignore seismic load in strength: No

Method: Janbu
Slip Surface Option: Block



Deepdell East WRS

Section C-C'

Name: Figure A24 SLOPE/W Analysis - SEE 1H Block Slide

Engineering Geology Limited

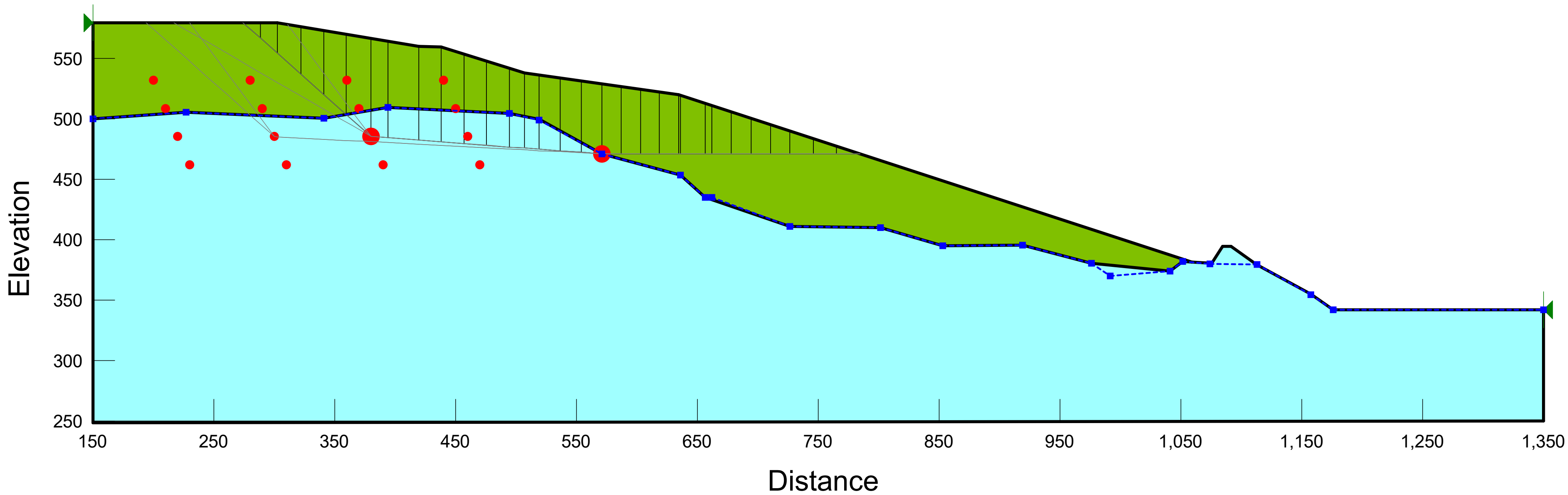
Name: Schist (Foliation 10 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste rock stack (Peak)
Phi-B: 0 °
Piezometric Line: 1

Horz Seismic Coef.: 0.314
Ignore seismic load in strength: No

Method: Janbu
Slip Surface Option: Block

1.080



Deepdell East WRS

Section D-D'

Name: Figure A25 SLOPE/W Analysis - OBE 1/3H Block Slide

Engineering Geology Limited

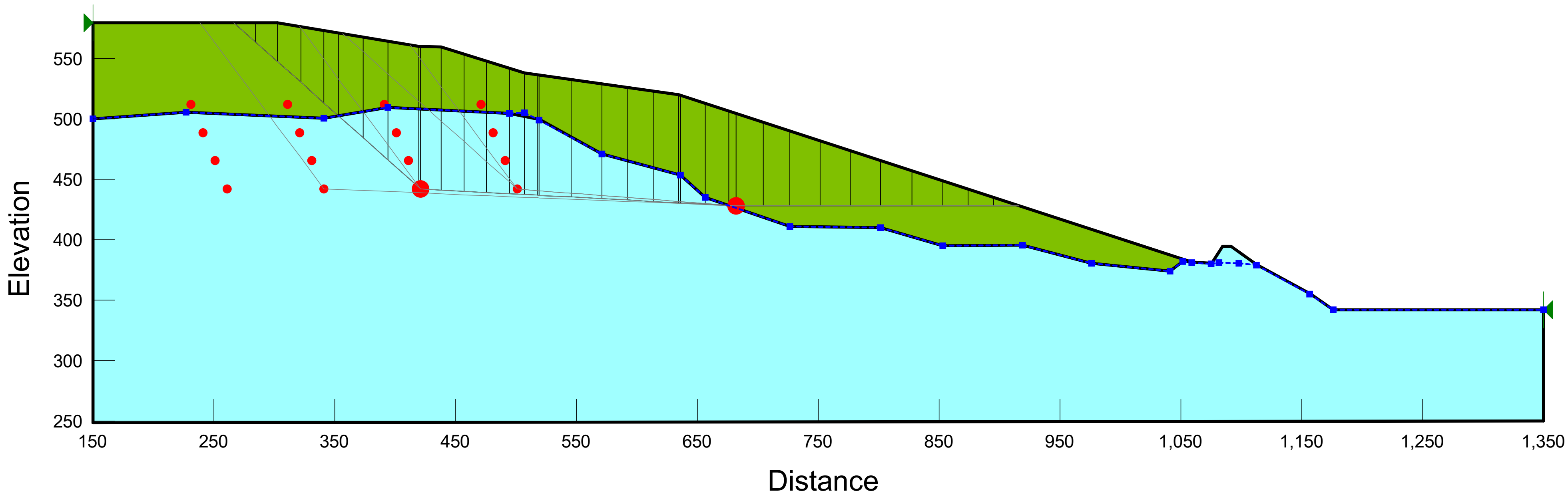
Name: Schist (Foliation 0 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Phi-B: 0 °
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste rock stack (Peak)
Phi-B: 0 °
Piezometric Line: 1

Horz Seismic Coef.: 0.116
Ignore seismic load in strength: No

Method: Janbu
Slip Surface Option: Block

1.607



Deepdell East WRS
Section D-D'
Name: Figure A26 SLOPE/W Analysis - OBE 2/3H Block Slide

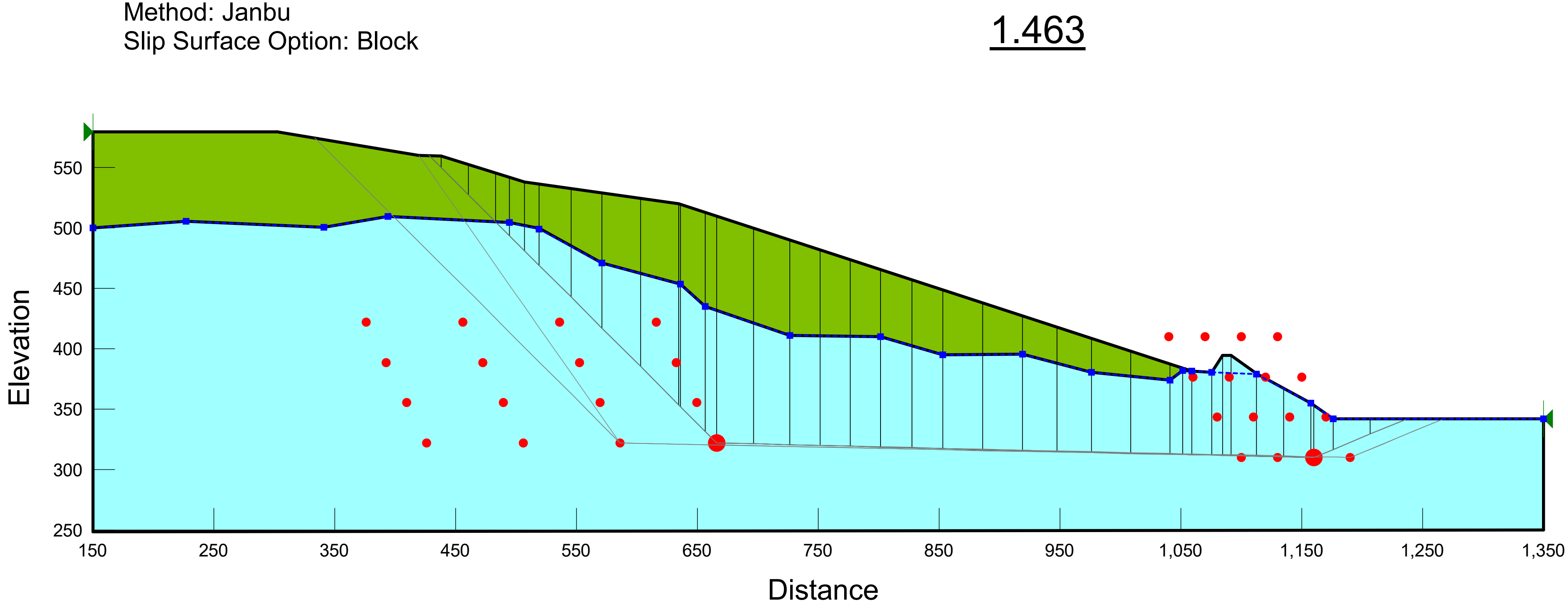
Engineering Geology Limited

Name: Schist (Foliation 0 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Phi-B: 0 °
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste rock stack (Peak)
Phi-B: 0 °
Piezometric Line: 1

Horz Seismic Coef.: 0.043
Ignore seismic load in strength: No

Method: Janbu
Slip Surface Option: Block



Deepdell East WRS
Section D-D'
Name: Figure A27 SLOPE/W Analysis - OBE 1H Block Slide

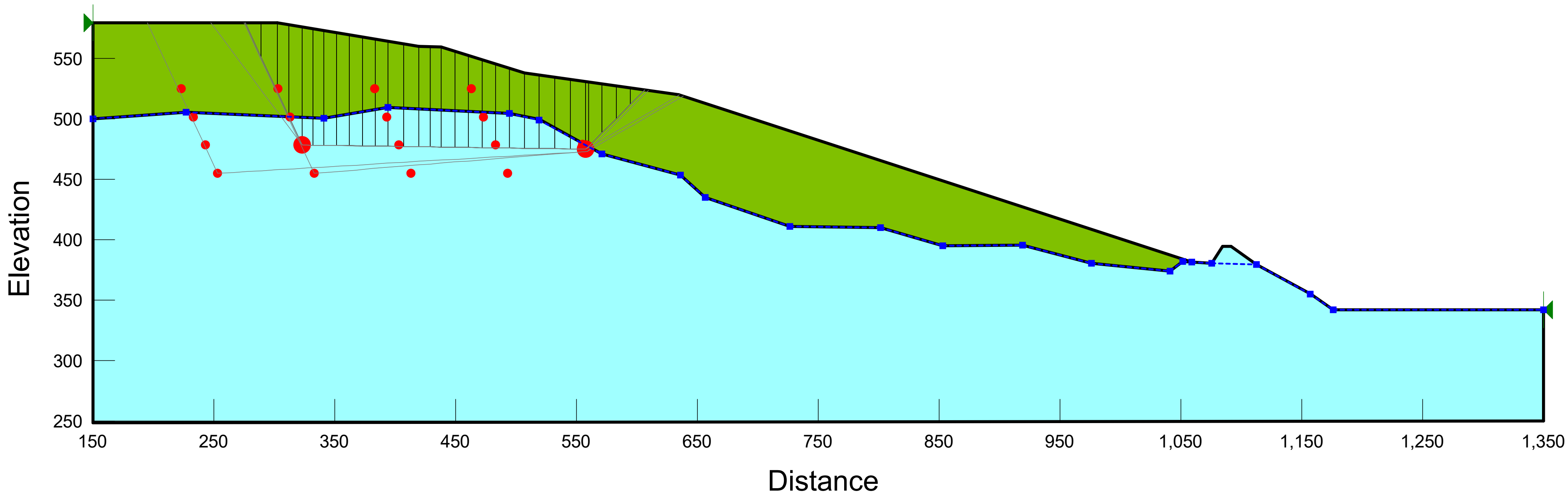
Engineering Geology Limited

Name: Schist (Foliation 0 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Phi-B: 0 °
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste rock stack (Peak)
Phi-B: 0 °
Piezometric Line: 1

Horz Seismic Coef.: 0.33
Ignore seismic load in strength: Yes

Method: Janbu
Slip Surface Option: Block 1.005



Deepdell East WRS
Section D-D'
Name: Figure A28 SLOPE/W Analysis - SEE 1/3H Block Slide

Engineering Geology Limited

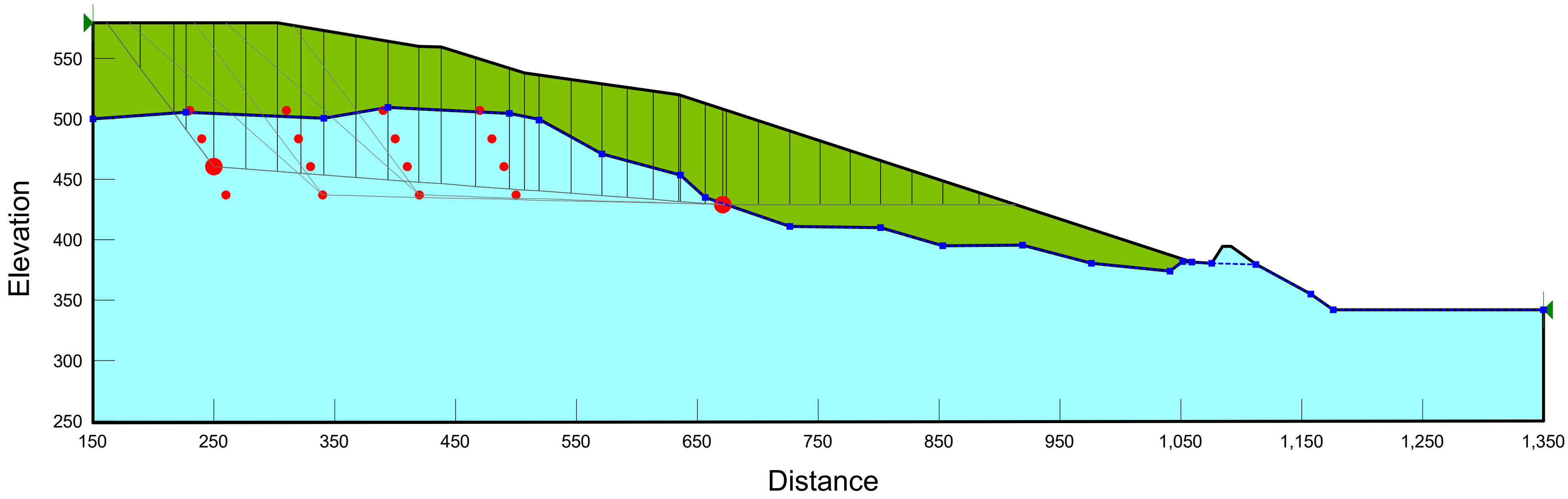
Name: Schist (Foliation 0 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Phi-B: 0 °
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste rock stack (Peak)
Phi-B: 0 °
Piezometric Line: 1

Horz Seismic Coef.: 0.288
Ignore seismic load in strength: No

Method: Janbu
Slip Surface Option: Block

1.010



Deepdell East WRS

Section D-D'

Name: Figure A29 SLOPE/W Analysis - SEE 2/3H Block Slide

Engineering Geology Limited

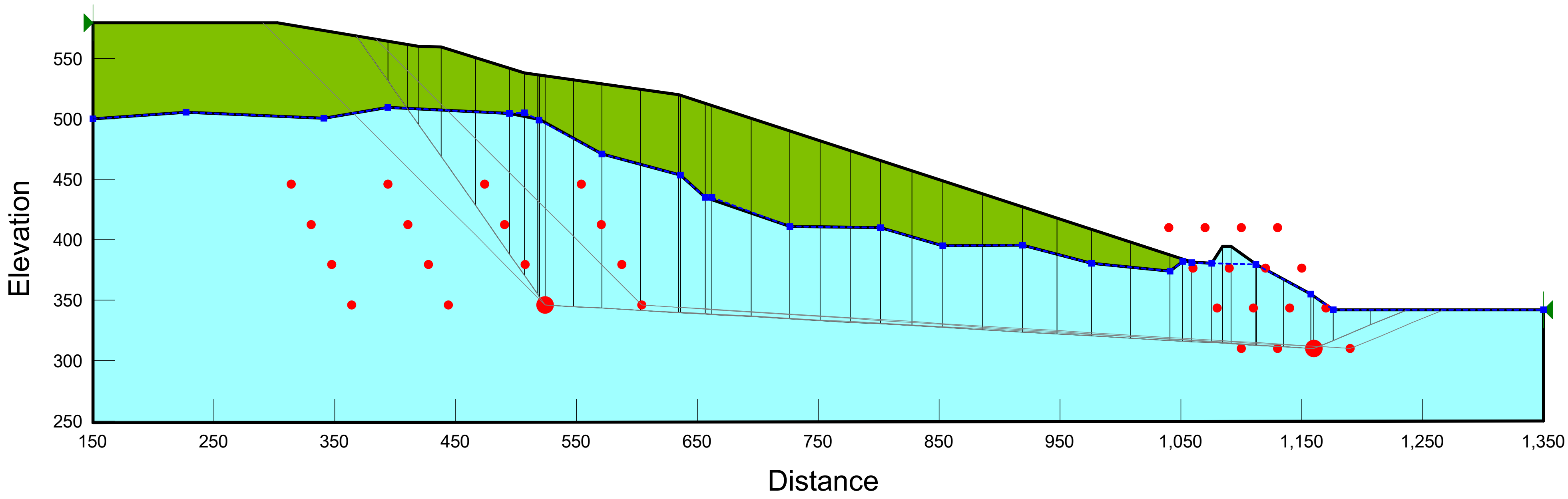
Name: Schist (Foliation 0 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Phi-B: 0 °
Piezometric Line: 1

Name: Rockfill
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: Waste rock stack (Peak)
Phi-B: 0 °
Piezometric Line: 1

Horz Seismic Coef.: 0.15
Ignore seismic load in strength: No

Method: Janbu
Slip Surface Option: Block

1.001



Deepdell East WRS

Section D-D'

Name: Figure A30 SLOPE/W Analysis - SEE 1H Block Slide

Engineering Geology Limited

Name: Schist (Foliation 0 deg. dip)
Model: Anisotropic Fn.
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Phi-Anisotropic Strength Fn.: Schist Foliation Phi Func.
C-Anisotropic Strength Fn.: Schist Foliation C Func.
Phi-B: 0 °
Piezometric Line: 1