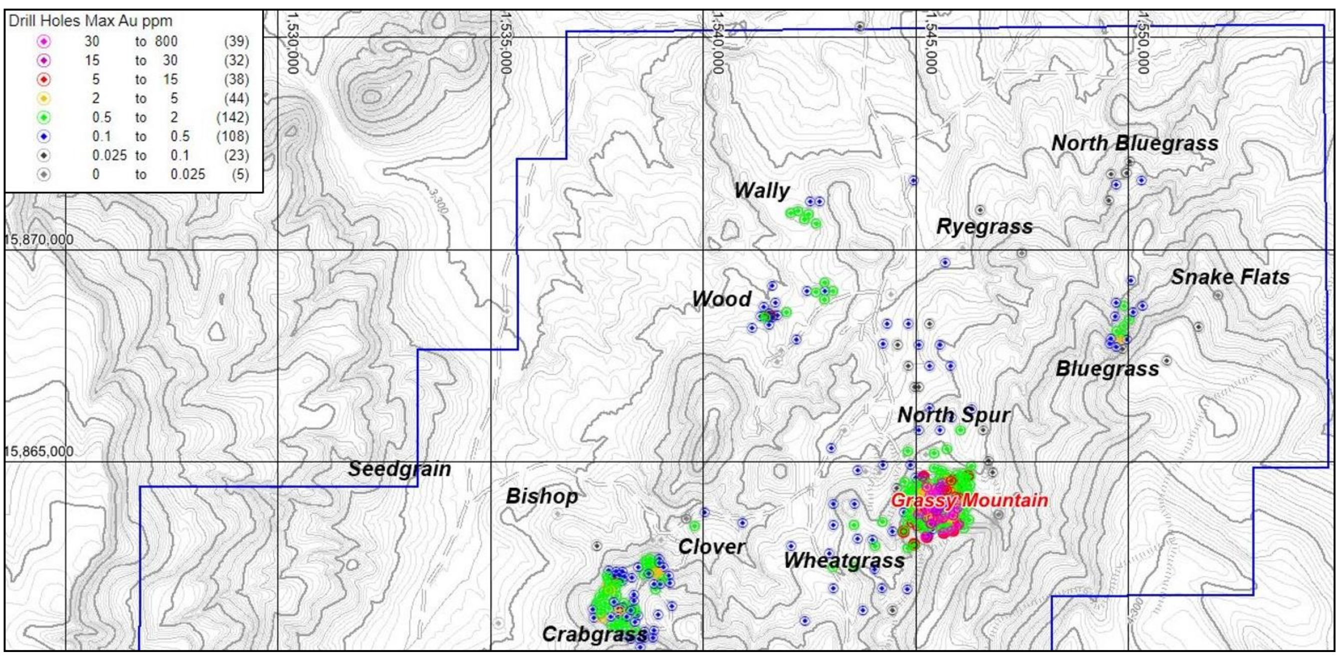
Grassy Mountain Project

Stability Analysis of the Portal Design

Submitted to

Calico Resources USA Corp.



Report prepared by

GEOTECHNICAL
MINE SOLUTIONS

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Grassy Mountain Project

Stability Analysis of the Portal Design

Rev3

Geotechnical Mine Solutions
Mardoqueo Fernández 128, of 503.
Providencia - Santiago
Chile

e-mail: contacto@gms-engineering.cl
Website: www.gms-engineering.cl

Phone :(+56-2) 2297 5377

Authors

Andrés Torres y Gabriel Valdés

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1. INTRODUCTION

Calico Resources USA Corp (Calico) has requested Geotechnical Mine Solutions (GMS) carried out the mine portal stability analysis for the Grassy Mountain Gold Project (Grassy Mountain), Malheur County, Oregon. The portal has been designed during the Pre-Feasibility Study (PFS).

To carried out the stability analysis, GMS evaluated each cut slope at the portal and incorporated the empirical support design carried out during the PFS (Mine Development Associates, 2019) by Ausenco (2018). GMS also evaluated the available information, including geological mapping and drill core (GM 16-04). GMS believes that drill hole GM 16-04 is the most representative hole based on its location.

2. SCOPE

The scope of the study includes the following:

- Stability analysis of portal design, considering rock mass strength properties and geotechnical characteristics.
- Stability analysis of portal design, incorporating empirical support elements defined during the PFS of the project.

3. OVERALL TERMS

The geological and geotechnical characteristics in the portal area were estimated from a geological cross section of the decline ramp provided by Calico geologists, and from an evaluation of cores from drill hole GM16-04. These characteristics were evaluated according to the Rock Mass Rating system (Bieniawski, 1989).

The results of this study are considered preliminary and should be re-evaluated upon receipt of additional information from work recommended in this report.

The results of the stability analysis will ensure the stability of the portal slopes, depending on the resulting safety factor and complying with the acceptability criteria established for the project.

4. AVAILABLE INFORMATION

The available background information used in this study:

- NI 43-101 - Preliminary Feasibility Study and Technical Report for the Grassy Mountain Gold and Silver Project, Malheur County, Oregon, USA. July 9, 2018 (Mine Development Associated, 2018).

- Grassy Mountain Project, Consolidated Permits, Geotechnical Design. May 23, 2019 (Geotechnical Mine Solutions, 2019).

- Grassy Mountain Project, Main Access Portal, Excavation Design and Support Plan, General Plan and Sections GM022019-01. April 11, 2019 (Geotechnical Mine Solutions, 2019).

- Grassy Mountain Project, Main Access Portal, Excavation Design and Support Plan GM022019-03. April 11, 2019 (Geotechnical Mine Solutions, 2019).

- Site Layout Map, Calico Resource USA Corp. Grassy Mountain Project. August 2, 2019.

- Geological cross section of the decline ramp axis in the portal area. May 15, 2019 (Calico Resources USA Corp, 2019).

- Topography "Updated Grassy Site Plan" (contour 10 ft). March 13, 2019.

5. GENERAL OVERVIEW

The portal is designed to allow access to the underground mine facilities while providing adequate space for equipment and vehicles.

The portal is located uphill and approximately 750 feet south of the primary crusher at an approximate elevation of 3749 fasl. The portal pad has been designed with a 1% inclination towards the outside, to allow the flow of stormwater away from the portal and towards the stormwater drainage ditches. The portal pad will have sufficient area for installation of the required ventilator infrastructure to be used during the excavation of the decline ramp and to allow the safe transit of the development equipment. The portal will have a waste rock excavation volume of 2,283,146 tons.

Figure 5-1 shows a plan view of the portal general layout related to the main infrastructure that surrounds it and Figure 5-2 shows a plan view (a) and a frontal perspective (b) of the portal location as example.

UTM coordinates and the dimensions of the entry portal are indicated in Table 5.1.

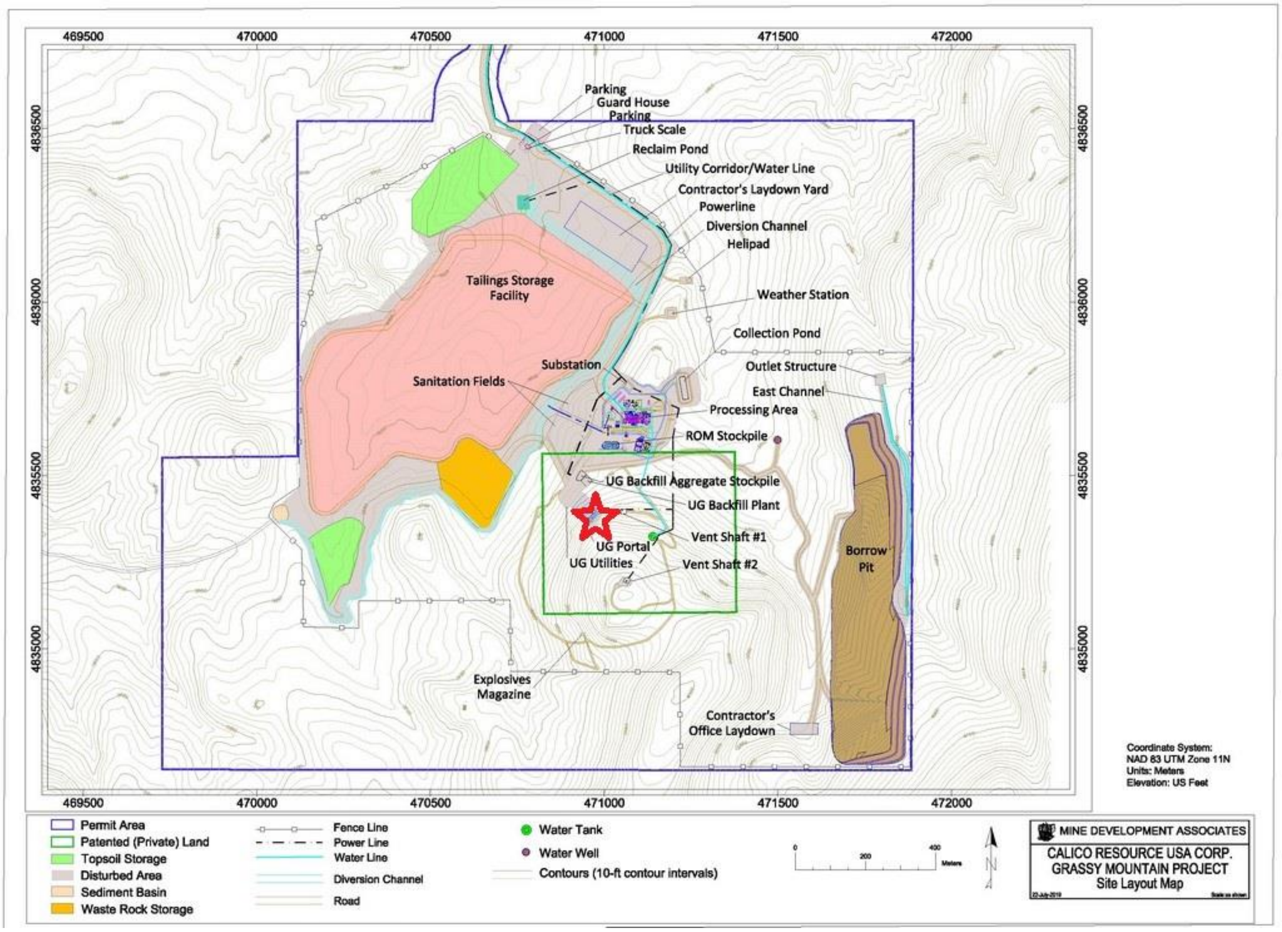


Figure 5-1 General site layout - portal related to the main infrastructure.

Figure 5-2 Plan view (a) and frontal perspective (b) of the portal location.

Table 5.1 Portal location (UTM NAD83, Zone 11).

Portal	Coordinates		Elevation [fasl]	Pad Area [ft^2]
	North	East		
Entry	15864312	1544950	3750	3.322,293

The preliminary design shown in drawing GM022019-03 shows a bench height of 32.81 feet and berm width of 13.12 feet for the slope face at the portal opening. The upper bench will have a bench height of 22.97 feet and berm width of 6.56 feet. The bench face slope angle is 72º, and 59º global slope angle (see Figure 5-3).

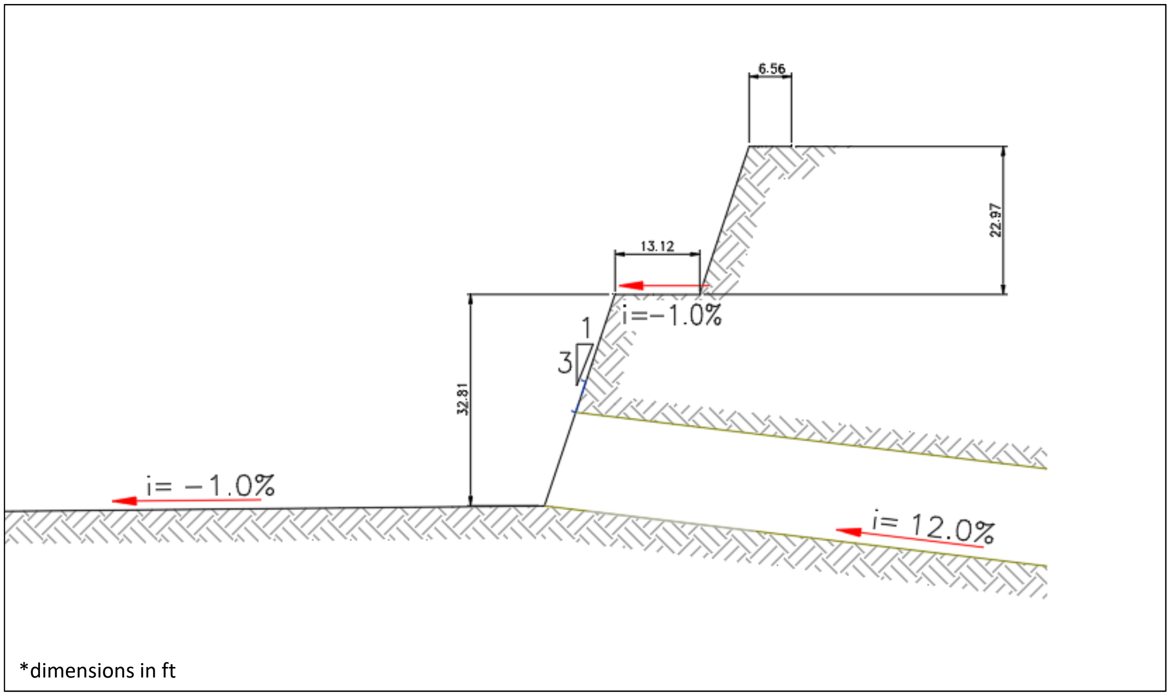


Figure 5-3 Geometric configuration of the portal slopes.

6. GEOTECHNICAL CHARACTERIZATION

The site geology was studied by Calico geologists using a cross section in the decline ramp location (Figure 6-1). The results of the study provided the lithologies present in the portal area according to:

- Colluvium (Non-consolidated material present on surface);
- Sandstone/Arkose;
- Siltstone;
- Clay and;
- Sinter

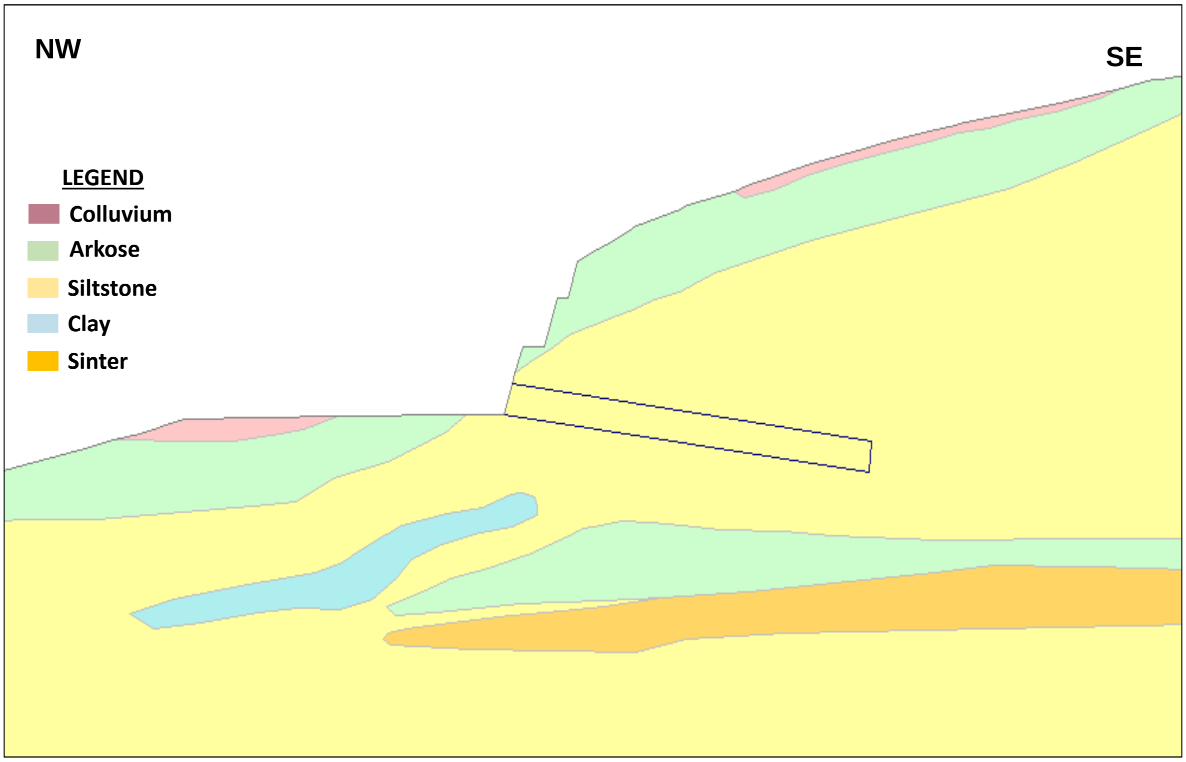


Figure 6-1 Geological cross section, decline ramp at portal.

In order to characterize the rock mass in the portal area, the available geotechnical drilling in the vicinity of the portal site was evaluated. The closest and most representative drill hole in the area is GM16-04, which is a diamond drill hole. The cores were re-logged (quicklog) for geotechnical parameters and then compared with the available Calico drill database to define the geotechnical qualities.

The re-logging methodology consisted of recording the physical characteristics of each structural discontinuity such as the spacing of the fractures, frequency, thickness, type of filling, estimated resistance, presence of water, etc. These were used for the subsequent geotechnical characterization of the rock mass at the portal area.

Due to the lack of outcrops and the strong weathering of the surface rock in the portal area, it was not possible to define the surface structural pattern. Therefore, this variable was not assessed in the stability analysis.

6.1. Rock Mass Classification

The use of geotechnical classification systems for technical support allows estimation of the geotechnical parameters that characterize the rock mass. This estimation, along with the experience of the authors in materials and projects with similar characteristics, allow the definition of the parameters to be adopted in the subsequent stability analysis.

The characterization of the rock mass utilized the RMR (Rock Mass Rating) system (Bieniawski, 1989), which is approximately equivalent to the GSI (Geological Strength Index) system (Hoek, 1995). The use of this system allows inclusion of geological information in the Hoek - Brown generalized failure criterion (Hoek – Brown, 1980) for rock mass, as shown in Equation 1.

$$GSI = RMR_{1989} - 5$$ (Equation 1)

The relevant physical characteristics considered in the classification and definition of the rock mass parameters, are as follow:

- **Non-Weathered Rock Strength:** Field estimation for non-weathered rock strength (Table 6.1) is based on analysis of triaxial tests results of intact rock samples (Hoek, 1983; Doruk, 1991; and Hoek et al, 1992).

- **RQD:** The Rock Quality Designation is an approximation of the degree of jointing or fracture in a rock mass. It is measured as the percentage of the drill core in lengths of 10 cm or more, therefore, the RQD is defined in Equation 2**.**

$$\mathrm{RQD}\,(\%) = \frac{\sum \mathrm{Rock\ Pieces} > 100\,(\mathrm{mm})}{\mathrm{Core\ Run\ Total\ Length}} \times 100$$ (Equation 2)

On surface exposures the measurement of the RQD is estimated by extending a measuring tape along the exposed surface, "simulating" a drill core and estimating the length of the pieces that would be obtained if it was a drill core.

Table 6.1 Field estimation of compressive strength for intact rock samples.

Grade (*)	Term	Uniaxial Comp. Strength [MPa]	Point Load Index [MPa]	Field estimate of strength	Examples
R6	Extremely Strong	> 250	>10	Specimen can only be chipped with a geological hammer	Fresh basalt, chert, diabase, gneiss, granite, quartzite
R5	Very strong	100 - 250	4 - 10	Specimen requires many blows of a geological hammer to fracture it	Amphibolite, sandstone, basalt, gabbro, gneiss, granodiorite, limestone, marble, rhyolite, tuff
R4	Strong	50-100	2-4	Specimen requires more than one blow of a geological hammer to fracture it.	Limestone, marble, phyllite, sandstone, schist, shale
R3	Medium strong	25-50	1-2	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with a single blow from a geological hammer.	Claystone, coal, concrete, schist, shale, siltstone
R2	Weak	5-25	(***)	Can be peeled with a pocket knife with difficulty, shallow indentation made by firm blow with point of a geological hammer	Chalk, rocksalt, potash
R1	Very weak	1-5	(***)	Crumbles under firm blows with point of a geological hammer, can be peeled by a pocket knife.	Highly weathered or altered rock
R0	Extremely weak	0.25-1	(***)	Indented by thumbnail	Stiff fault gouge

(*) Grade according to Brown (1981).
(**) Point load tests on rocks with a uniaxial compressive strength below 25 MPa are likely to yield highly ambiguous results.

- **Spacing Discontinuities:** The spacing of fractures can be characterized both in drill core and in exposed rock surfaces by measuring the distance between the fractures.

- **Condition of Discontinuity:** The condition of the discontinuities can have a significant impact on the behavior of the rock mass. This parameter includes evaluation of the length between fractures, type of fracture filling and the roughness and alteration of the discontinuity surfaces.

- **Water Condition:** Evaluation of the influence of the flow of water on the stability. It considers the flow observed, the relationship between the water pressure in the discontinuities and the field stress. It also considers the general qualitative observation related to groundwater.

Figure 6-2 shows the Rock Mass Rating (RMR `89), classification parameters and their ratings.

A. CLASSIFICATION PARAMETERS AND THEIR RATINGS

	Parameter		Range of values				
1	Strength of intact rock material	Point-load strength index	>10 MPa	4-10 MPa	2-4 MPa	1-2 MPa	For this low range - uniaxial compressive test is preferred
		Uniaxial comp. strength	>250 MPa	100-250 MPa	50-100 MPa	25-50 MPa	5-25 MPa / 1-5 MPa / < 1 MPa
	Rating		15	12	7	4	2 / 1 / 0
2	Drill core Quality *RQD*		90%-100%	75%-90%	50%-75%	25%-50%	< 25%
	Rating		20	17	13	8	3
3	Spacing of discontinuities		> 2 m	0.6-2 . m	200-600 mm	60-200 mm	< 60 mm
	Rating		20	15	10	8	5
4	Condition of discontinuities (See E)		Very rough surfaces Not continuous No separation Unweathered wall rock	Slightly rough surfaces Separation < 1 mm Slightly weathered walls	Slightly rough surfaces Separation < 1 mm Highly weathered walls	Slickensided surfaces or Gouge < 5 mm thick or Separation 1-5 mm Continuous	Soft gouge >5 mm thick or Separation > 5 mm Continuous
	Rating		30	25	20	10	0
5	Ground water	Inflow per 10 m tunnel length (l/m)	None	< 10	10-25	25-125	> 125
		(Joint water press)/(Major principal σ)	0	< 0.1	0.1,-0.2	0.2-0.5	> 0.5
		General conditions	Completely dry	Damp	Wet	Dripping	Flowing
	Rating		15	10	7	4	0

RMR BIENAWSKI (1989) = Sum of Scores 1 + 2+ 3+ 4+ 5

Class	I	II	III	IV	V
Quality	Very Good Rock	Good Rock	Fair Rock	Poor Rock	Very Poor Rock
Rating	100 - 81	80 - 61	60 - 41	40 - 21	20 - 0

Figure 6-2 Rock mass classification Bieniawski 1989 (RMR`89).

Therefore, based on the parameters evaluated and applied to the GM16-04 drill core, the geotechnical quality of the rock mass in the portal area is estimated using a depth between 117 and 182 feet in the referenced drill hole.

Table 6.2 shows the estimated geotechnical qualities compared with the available Calico drill database and Table 6.3 shows the rock mass classification for the geotechnical qualities estimated in the portal area.

Table 6.2 RMR '89, GM16-04 drill hole.

Calico, 2017				GMS, 2019			
From [ft]	To [ft]	RMR	Class	From [ft]	To [ft]	RMR	Class
117	122	61	II	115	126	70	II
122	127	37	IV	126	127	10	V
127	132	36	IV	127	137	50	III
132	135	38	IV	137	139	10	V
135	140	27	IV	139	145	65	II
140	145	74	II	145	158	85	I
145	150	63	II	158	169.8	55	III
150	152	82	I	169.8	179.5	65	II
152	157	77	II	177	189	70	II
157	160	41	III				
160	162	82	I				
162	167	50	III				
167	172	35	IV				
172	177	50	III				
177	182	36	IV				

Table 6.3 Classification of rock mass, RMR '89 of portal area.

Classification	Median Score	Minimum Score	Maximum Score	Rock Quality
RMR	65	10	85	Good to Fair

From the estimated RMR'89 values presented in Table 6.3, and using Equation 1, the GSI of the portal area was calculated (determined empirically). (Table 6.4).

Table 6.4 Classification of rock mass, GSI of portal area.

Classification	Median Score	Minimum Score	Maximum Score	Rock Quality
GSI	60	5	80	B-VB/G-F(*)

B: Blocky; VB: Very Blocky; G: Good; F: Fair.

6.2. Estimation of Rock Mass Properties

The estimation of the strength properties was made based on the geotechnical characteristics, the technical literature and the experience of the authors in materials with similar characteristics.

Table 6.5 indicates the estimated strength properties for the portal stability study.

Table 6.5 Strength properties estimated for stability analysis.

Lithology	Friction Angle[°]	Cohesion [kPa]	Unit Weight [ton/m3]
Sandstone/Arkose	37	350	2.3
Siltstone	39	400	2.5
Clay	35	200	2.2
Sinter	35	350	2.2
Coluvium	37	50	2.0

7. SUPPORT DESIGN

The support design was carried out during the PFS study (Mine Development Associates, 2018), by Ausenco, using the empirical methodology proposed by Barton (1974 and 1980) and base on their experience with similar projects.

The proposed support for the portal slopes and the initial stretch of the decline ramp is presented in Table 7.1.

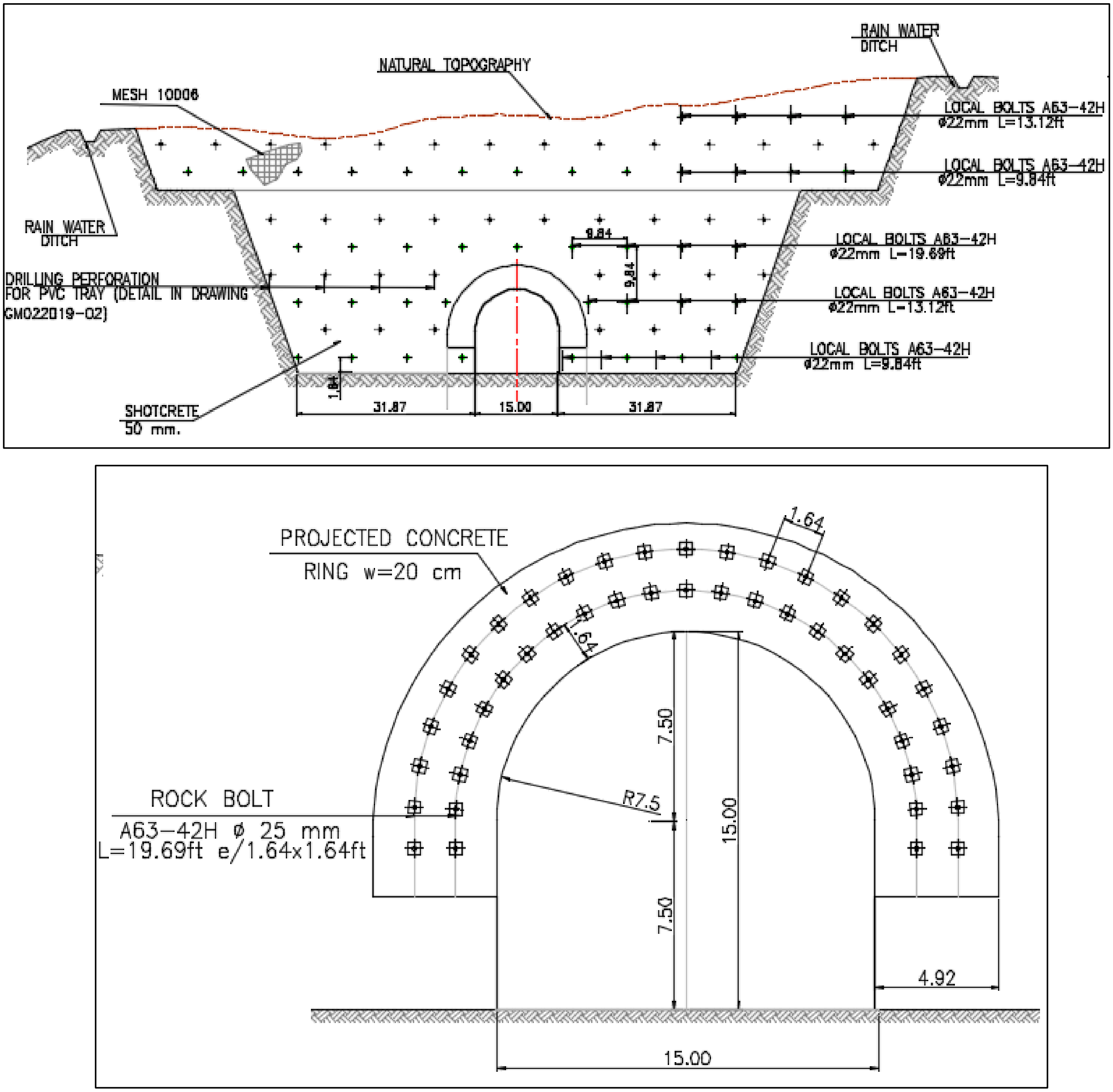
Table 7.1 Support design of the portal entry.

Infrastructure	Support	Diameter [mm]	Length [ft] (*)	Shotcrete [mm]
Portal Slopes	Bolt A63-42H	22	9.84 (3 m); 13.12 (4 m); 19.69 (6 m)	50
Decline Ramp (**)	Bolt A63-42H	25	9.84 (3 m)	200
	Reticulated Frames	22	61.58 (19 m)	25

(*) According to drawing GM022019-03.
(**) Support for the initial 61.58 ft. length.

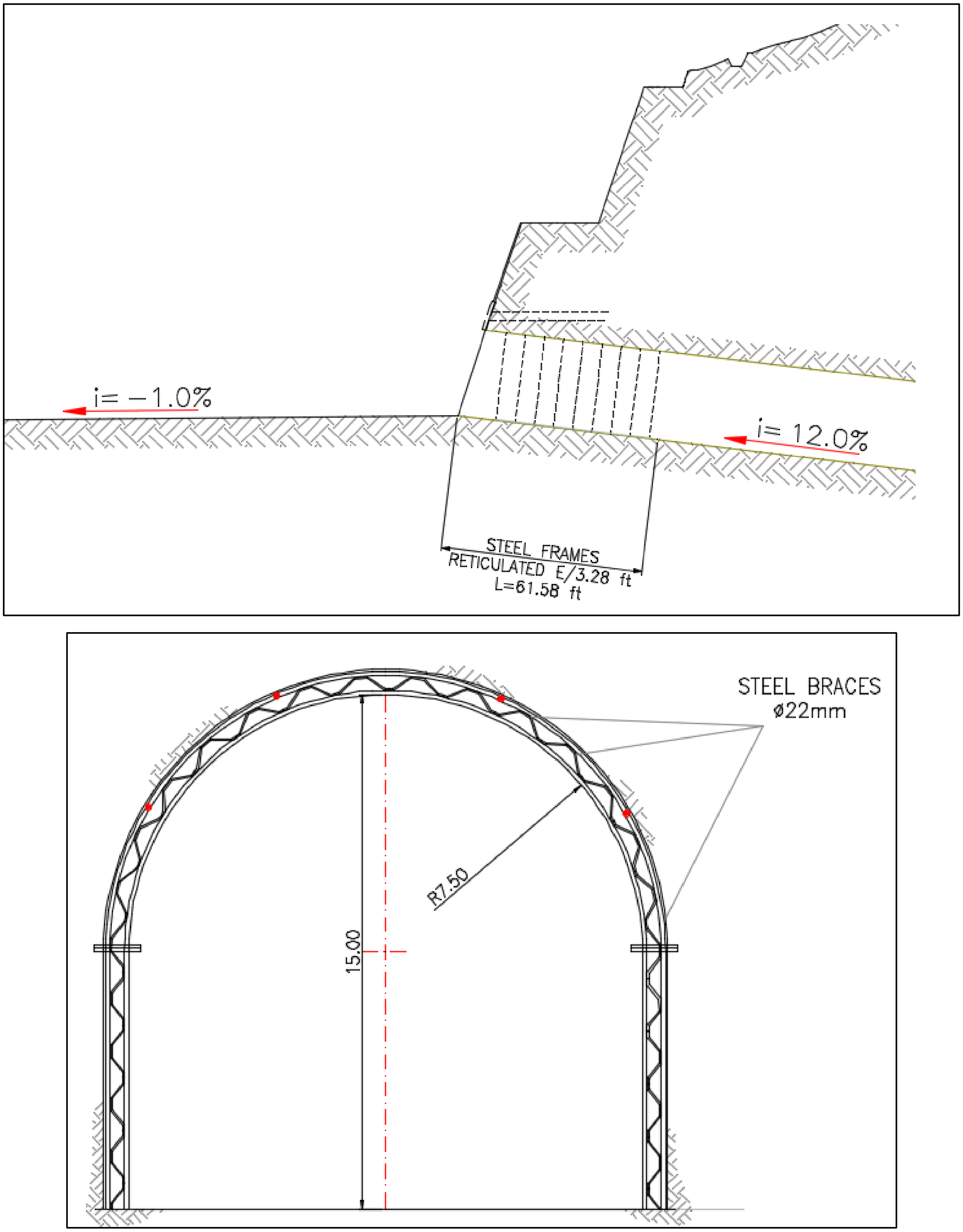
The performance of the proposed bolts will be evaluated in the current stability analysis of the portal slopes.

Figure 7-1 is a frontal view of the portal slopes support, Figure 7-2 is a side view of the bolts and reticulated frames in the decline ramp and Figure 7-3 is a 3D frontal perspective of the portal slopes and the proposed support elements.



Source: GM022019-02.

Figure 7-1 Support design of the portal slopes and portal entry.



Source: GM022019-03.

Figure 7-2 Support design of the initial stretch of the decline ramp.

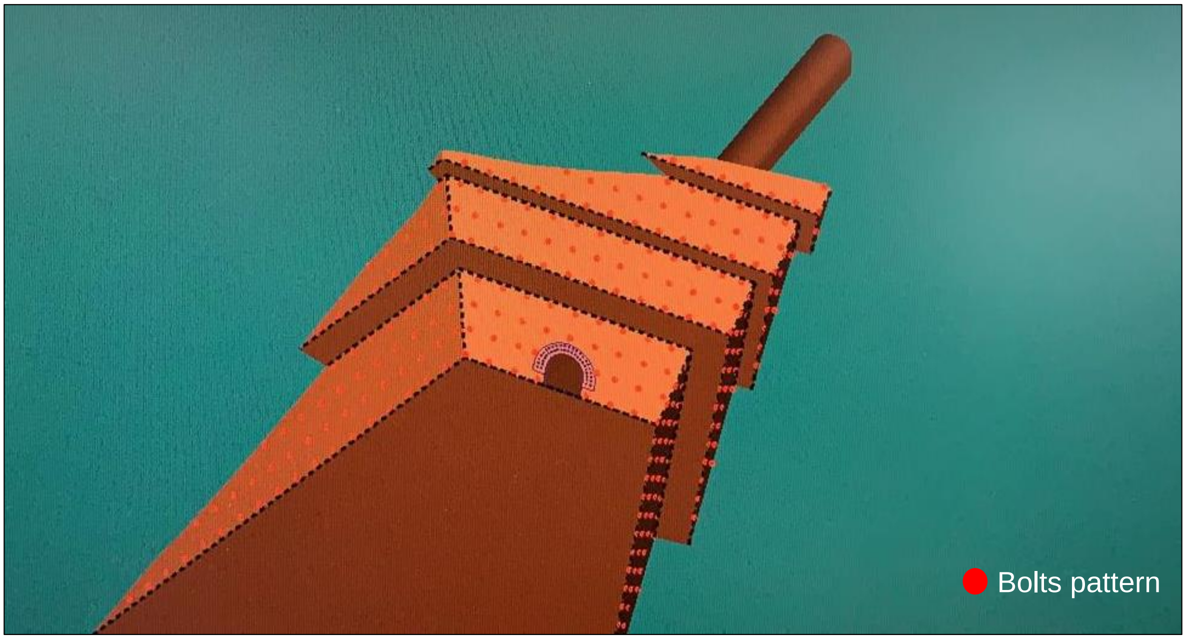
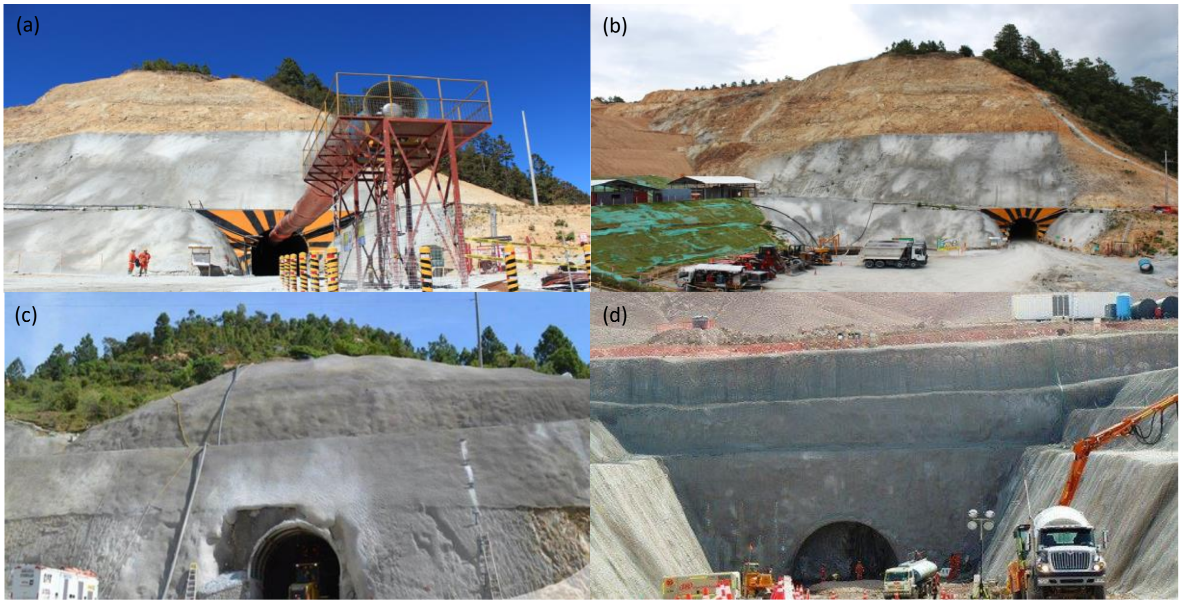


Figure 7-3 Supported portal slopes – Frontal perspective (3D).



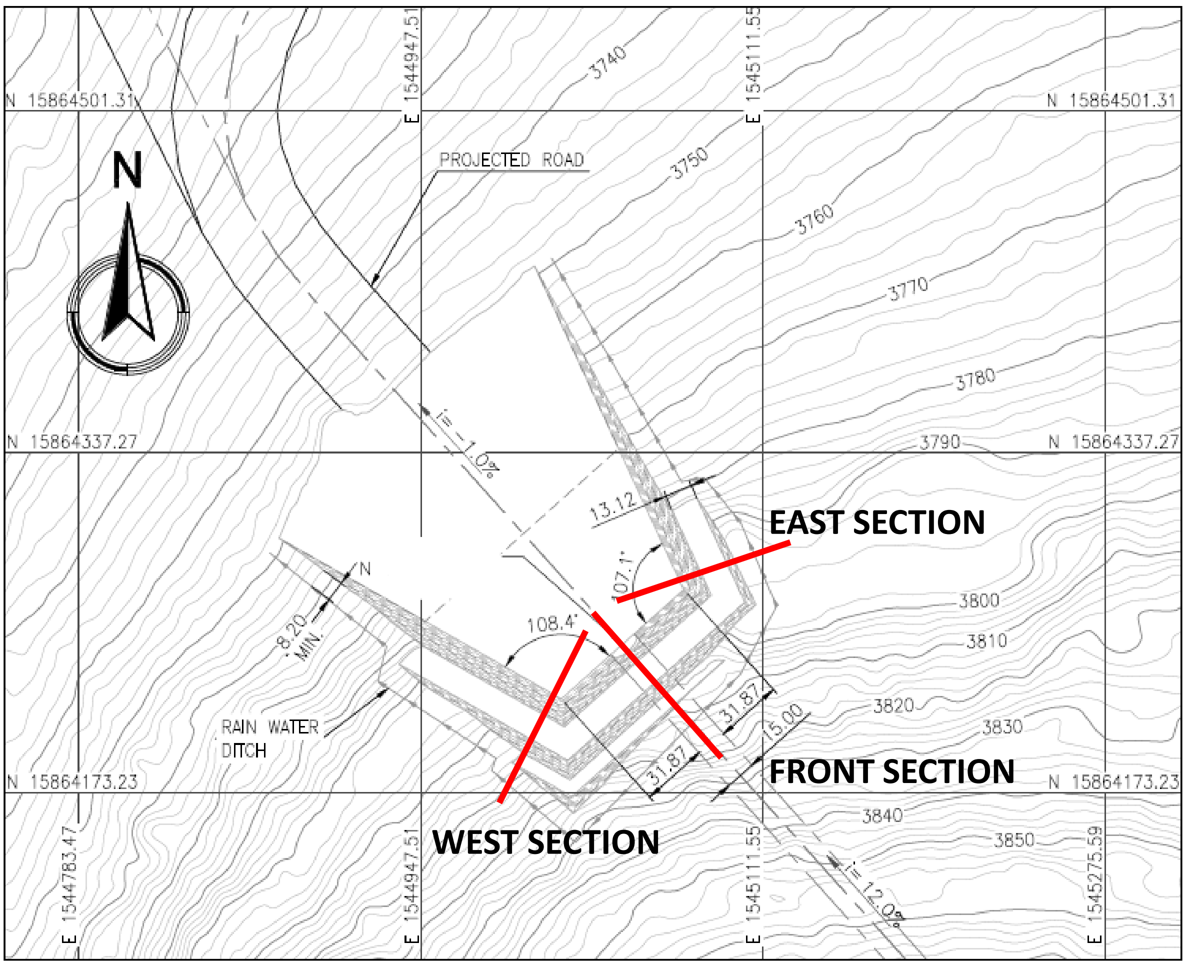
Source: (a), (b), (c) www.grupoemo.com; (d) www.portalminero.com

Figure 7-4 Examples of mine portals constructed; (a) and (b) Cochise Mine, Guatemala; (c) La Hamaca Mine, Guatemala; (d) Chuquicamata Underground, Chile.

8. STABILITY ANALYSIS

The portal area stability is based on the estimated geotechnical characterization and the degree of fractured rock mass present in the portal area. The stability analysis has considered modes of instability that occur at rock mass level; without structural control.

To carry out the analysis, three representative perpendicular and transversal sections were selected in the portal as shown in Figure 8-1.



Source: GM022019-01, 2019.

Figure 8-1 Location of analysis sections.

The stability analysis is based on the geology shown in Figure 6-1. The geological cross section was provided by Calico.

The stability analyses were completed using limit equilibrium methods, which assigns a safety factor for a potential slip surface based on a defined geometry. The safety factor depends on the geometry of the potential slip surface, on the strength properties of the materials and on the site conditions analyzed (pore pressures, surface loads and seismic forces).

Calculations were carried out using the Slide v6.0 program of Rocscience, which allows for determination of safety factors associated with a large number of potential slide surfaces. The safety factors were calculated using the Morgenstern-Price method (Generalized Limit Equilibrium, GLE), which is based on an analysis that considers the balance of forces and moments.

A Safety Factor ≥ 1.8 was assumed as acceptability criterion for the static analysis.

The results of the stability analyses are presented in Table 8.1, considering the frontal, east and west slope orientations, with and without the support design.

Table 8.1 Slope stability analyses results.

Slope	Static Safety Factor	Static Safety Factor Supported
Frontal	2.12	2.13
East	2.72	2.74
West	2.32	2.36

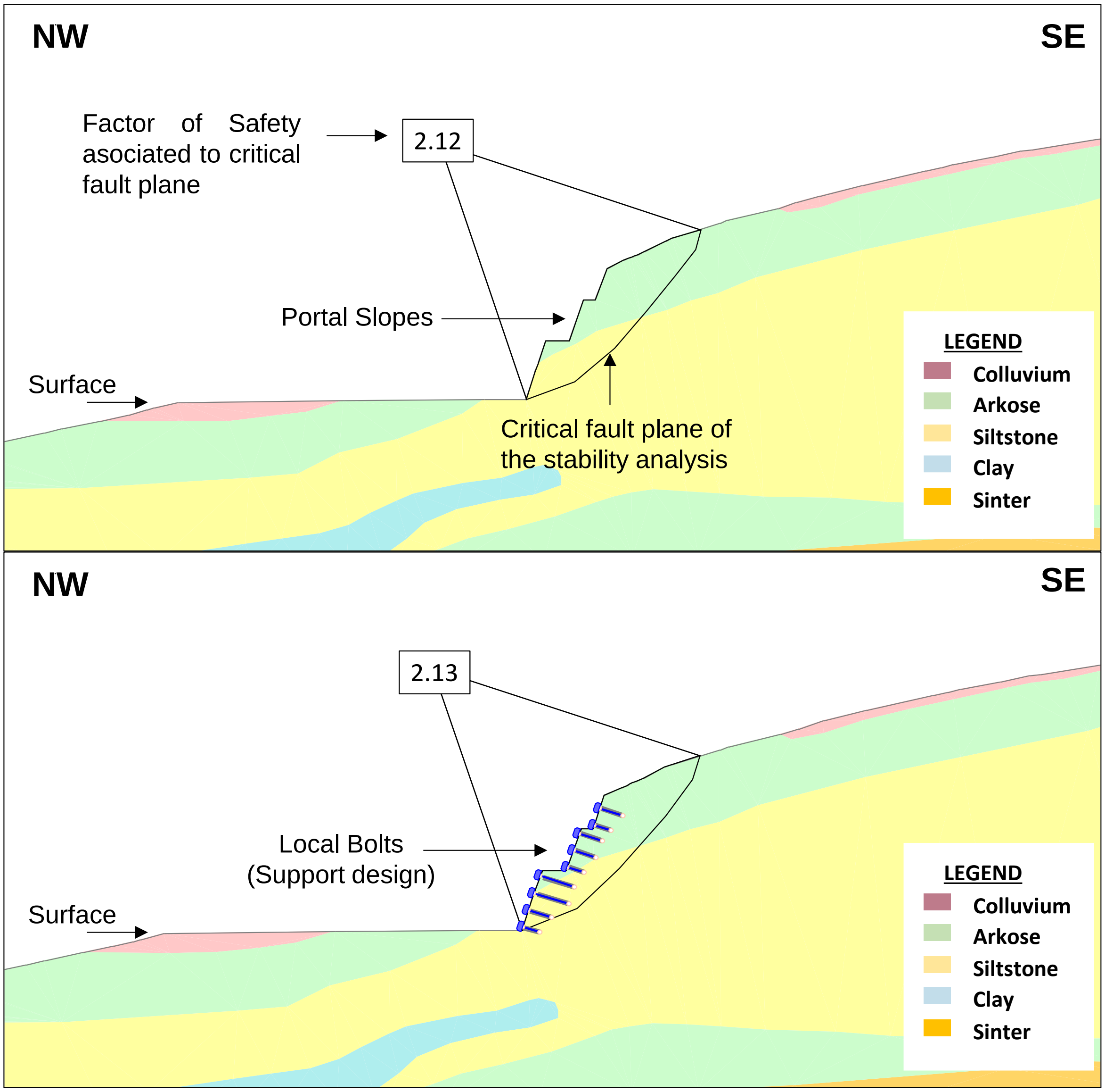


Figure 8-2 Slope stability analyses – Frontal Section.

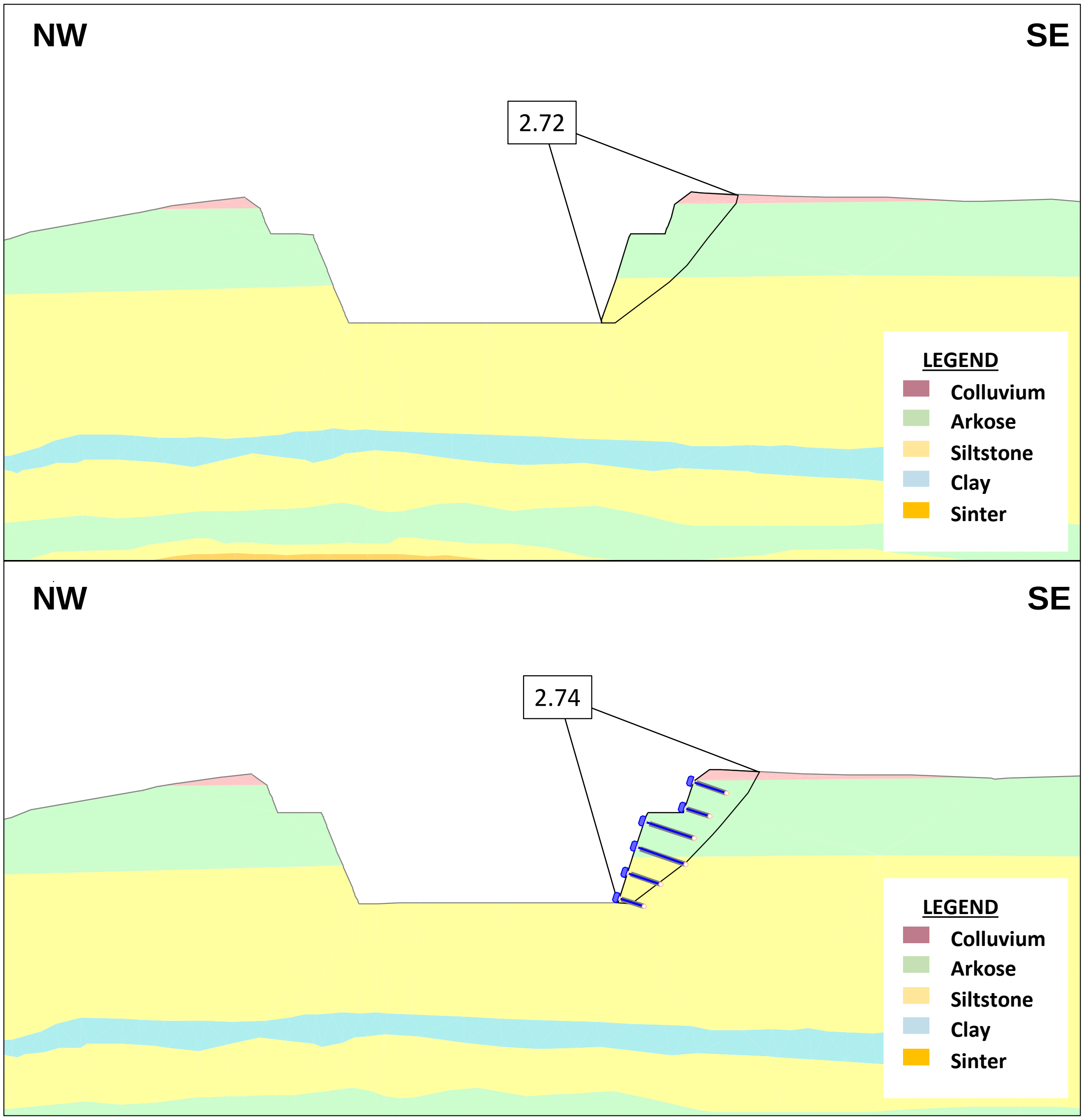


Figure 8-3 Slope stability analyses – East Section.

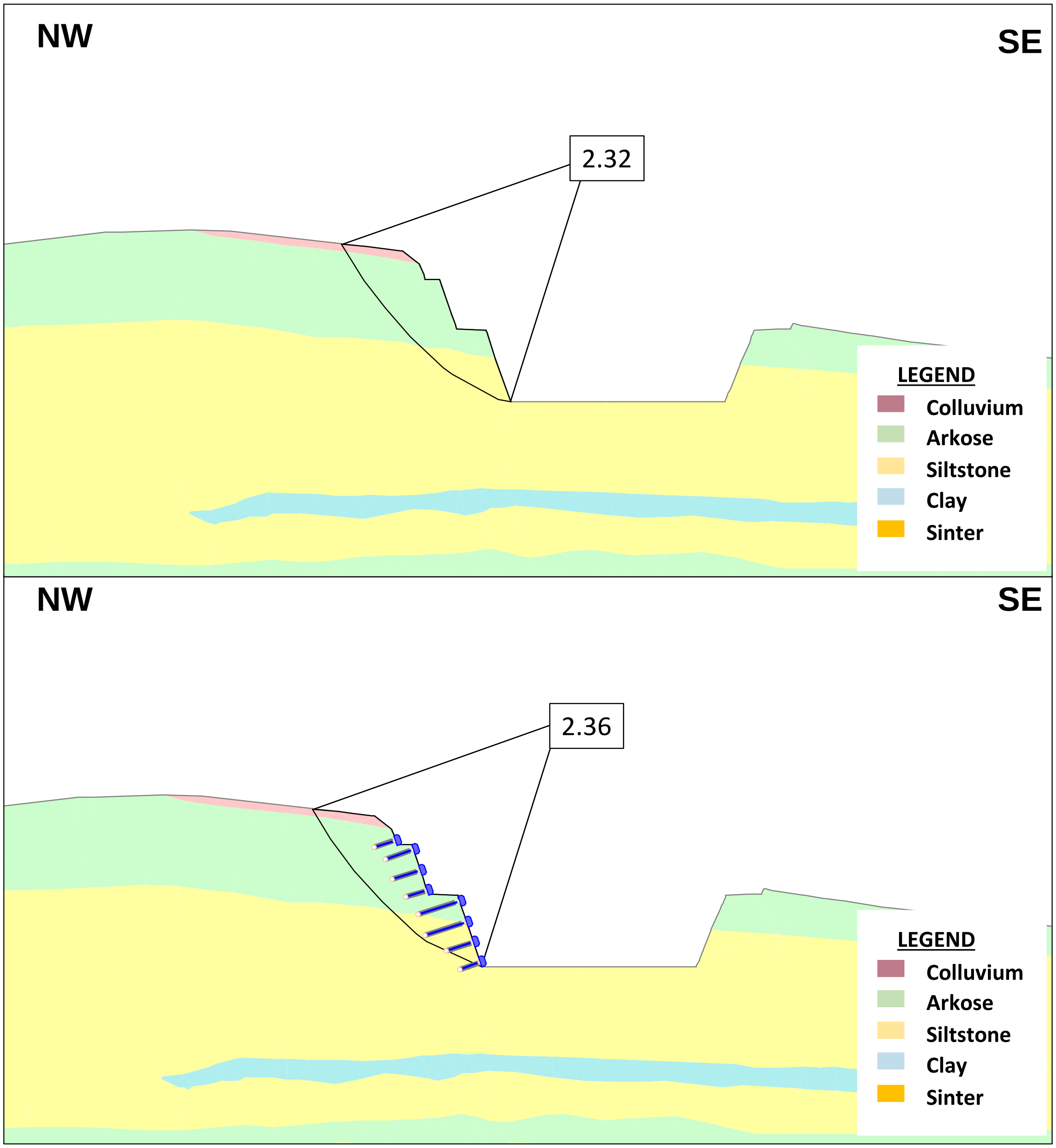


Figure 8-4 Slope stability analyses – West Section.

9. CONCLUSIONS

Based on the results, the most relevant conclusions are:

- Rock mass characterization in the portal area was based on detailed geological interpretation provided by Calico´s geologist and the closest drill hole GM16-04.

- The geotechnical characterization of drill hole GM16-04, using a zone of influence between 117 feet and 182 feet deep, indicates a median of 53 points according to the RMR '89 classification. This corresponds to the geotechnical quality of *Good* rock.

- The estimation of the rock mass strength properties was based on the geotechnical characterization of the drill cores (GM16-04), using technical literature and the experience of the authors in materials of similar characteristics.

- Detailed geological information from surface mapping and nearby drill holes indicates that the front slope of the portal contains almost 50% of colluvium. Therefore, it was necessary to increase the portal excavation size to reduce the amount presence of colluvium in the portal slopes. The portal base evaluation was modified from 3750 feet to 3749 feet.

- Slopes that contain colluvium in their upper bench have been modified to equal the angle for unconsolidated materials.

- Stability analyses were carried out using the Slide v6.0 program from Rocscience. The reported safety factors were calculated using the Morgenstern-Price method (Generalized Limit Equilibrium, GLE), which is based on an analysis that considers the balance of forces and moments.

- Support design for portal stability was made using empirical methods during the PFS and that method was also used in this study.

- The water variable has not been incorporated in the study because there was no water encountered at or near the surface in the portal area.

- The safety factors evaluated for the slopes in the design are adequate for the acceptability criterion adopted for the project.

10. RECOMMENDATIONS

As a result of the present study, the following is recommended:

- Detailed structural geology information should be revised to incorporate wedges, planes and toppling. The design should then be revised if necessary, to ensure stability and safely.

- The portal slopes have a slope angle H: V / 1: 3, a bench height of 32.81 feet and berm width of 13.12 feet for the portal opening and a bench height of 22.97 feet and berm widths of 6.56 feet for the upper benches. The bench face angle is 72° and 59° equivalent global slope angle. Based on the geotechnical conditions, it is recommended that the geometric configuration does not exceed these specifications.

- The support application must be carried out for safety reasons in the excavation process, the sequence must be from top to bottom as the excavation is generated. At the same time, the berms and benches must be cleaned before applying the support elements.

- The following support is recommended for the portal in order to ensure the local and global stability of the slopes during the life of the project:

    - A #10006 mesh is required on the entire slope surface, anchored 5 feet from the slope face and dropping the rest of the mesh, with an overlap of 1 foot, fastened to the berm by bolts 9.84 feet long and spaced at 4,9 feet.

    - A63-42H quality steel bolts, 22 mm in diameter and 9.84, 12.13 and 19.69 feet in length.

    - 200 mm x 200 mm x 4 mm plate and spherical nut.

    - Place 50 mm shotcrete thickness on the entire slope and upper berms.

    - In addition, drainage tubes should be placed in a grid of 9.84 feet x 9.84 feet when shotcrete is placed.

- The following support is recommended for the inner reinforcement section, in order to ensure the stability of the first 32.8 feet of the decline ramp excavation:

    - Reticulated steel frames, spaced every 3.28 feet.

    - A63-42H steel bolts, 25 mm in diameter and 9.84 feet in length, placed on the roof and walls, spaced at 4.9 feet.

    - Shotcrete of 200 mm thickness placed in roof and walls, armed with electro-welded grid mesh 150mm x 150 mm and 9.2 mm wire.

- The portal area is a designed for the mine life, will require constant evaluation and if necessary, revision to ensure stability and safety.

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