



STATE OF
COLORADO

Cazier - DNR, Tim <tim.cazier@state.co.us>

M-1997-054 / Parkdale Quarry AM-2 Revised Geotechnical Stability Exhibit

1 message

David Bieber <David.Bieber@martinmarietta.com>
To: "Cazier - DNR, Tim" <tim.cazier@state.co.us>

Tue, Dec 21, 2021 at 8:54 PM

Hi Tim.

The Parkdale Geotechnical Stability Exhibit with the input and output screens from Rockpack III included as Appendix A is appended.

Dave

David W. Bieber, PG

Manager of Geology/Survey | West Division

Martin Marietta

1627 Cole Blvd Suite 200

Lakewood, CO 80401

t. 720-245-6423 m. 916-870-6635 f. 303-657-4351

e. david.bieber@martinmarietta.com

www.martinmarietta.com



Parkdale 2021 Geotechnical Stability Exhibit with attachments - 12-21-2021.pdf

2834K

RULE 6.5 GEOTECHNICAL STABILITY EXHIBIT
FRONT RANGE AGGREGATES
PARKDALE QUARRY
FREMONT COUNTY, COLORADO

Prepared by David W. Bieber, PG, PGP, CEG, CHG
Martin Marietta Manager of Geology/Survey

December 21, 2021

Introduction

The Parkdale Quarry is located in Fremont County, Colorado, approximately 12 miles west of Canon City and was permitted in 1998. Aggregate reserves mined from the Parkdale Quarry site include those derived from Quaternary alluvium (alluvial deposit) and Precambrian granite (granite deposit). An approximate five-acre area of Cretaceous Dakota sandstone (sandstone deposit) is also permitted for mining on the Parkdale Quarry. However, there are no current plans to mine the sandstone deposit.

The Parkdale Quarry was initially owned and mined by Agile Stone, who operated the quarry from 1998 until 2002. The quarry was purchased by CIG (now a wholly-owned subsidiary of Martin Marietta) in 2003, and mining of the site resumed in 2004. The quarry is currently operated by Front Range Aggregates, LLC (FRA), also a wholly-owned subsidiary of Martin Marietta. The alluvial deposit was the initial deposit mined at the Parkdale Quarry, and provided the majority of the material being mined on the site until 2017. Mining transitioned to the granite deposit in 2017, and material produced from the granite deposit now accounts for the majority of the material mined at the Parkdale Quarry.

Mining of the alluvial deposit was initially limited to the material above high groundwater. In 2008 the mine permit for the Parkdale Quarry was amended to allow the alluvial deposit to be excavated to bedrock, to allow for additional mining of the granite deposit, and to change the mine reclamation end use for the granite and alluvial deposits from agriculture/grazing to water storage. A geotechnical stability report was prepared by Lyman Henn, Inc. (LHI) for the 2008 Parkdale Quarry permit amendment (LHI report).

FRA submitted a 2021 application to amend the Parkdale Quarry mining permit to expand the mining area of the granite deposit north and west onto land owned by the Bureau of Land Management (BLM). As part of that amendment process, the Colorado Department of Reclamation, Mining and Safety (DRMS) requires that the geotechnical stability report for the quarry be updated to reflect the additional mining area and changes to stability requirements since the 2008 amendment. This 2021 exhibit is intended to serve as an update to the LHI report, meeting the requirements of Rule 6.5 of the Mineral Rules and Regulations of the Colorado Mined Land Reclamation Board for the Extraction of Construction Materials as amended in 2019 (Rule 6.5). This update addresses the following issues:

- Geologic hazards that have the potential to affect any proposed impoundment, slope, embankment, highwall, or waste pile within the affected area;
- Engineering stability analyses for proposed final reclaimed slopes, highwalls, waste piles and embankments;
- Operational slope configurations; and
- Information to demonstrate that off-site areas will not be adversely affected by blasting.

Site Geology

The Parkdale Quarry is located at the north end of Webster Park, approximately 12 miles west of Canon City, Colorado. Webster Park is an intermountain sedimentary basin with an area of approximately 10 square miles that is approximately seven miles long in the north-south direction, and ranges from approximately one-half to two miles wide in the east-west direction. The overall surficial geology of the Parkdale Quarry site is comprised of Mesozoic sedimentary rock units overlain by Quaternary alluvium in the southern portion of the property, bounded on the west by Precambrian intrusive igneous/metamorphosed igneous rock, and on the north and east sides by Precambrian granitic intrusive rock (granite). The Mesozoic sedimentary rocks on the site occur in a fault-bounded syncline.

The Precambrian intrusive igneous/metamorphosed igneous rock unit in the Parkdale Quarry vicinity was described by Schaefer (1969) as Parkdale Gneiss, but is shown and described as Precambrian Quartz Diorite correlating to the Boulder Creek Granodiorite by Taylor, et. al. (1975). The primary rock type making up the granite deposit is described in Schaefer (1969) as granite correlating to, or possibly a part of the Pikes Peak Granite pluton, but is shown on Map I-869 as Precambrian Granodiorite. The granitic rock is also described as granite in a 2004 report by J.A. Cesare Associates (Cesare). In 2014, R.J. Lee Group performed a petrographic analysis of the granitic rock currently mined by Front Range Aggregates. R.J. Lee Group characterized the granitic rock on the site as a pink, coarse-grained, alkali granite containing gray and black minerals. Orthoclase feldspar (K-spar) is the dominant mineral, along with quartz and biotite mica. Accessory minerals reported include plagioclase feldspar, calcite, gibbsite, muscovite, kaolinite, and unidentified opaque minerals. The granite is the primary material currently being mined and proposed for future mining. Rare chlorite and epidote were observed on fracture faces in core samples from the granite. The granite is intruded by veins of dark gray, fine-grained, mafic intrusive rock generally ranging from 6 to 24 inches thick. Examples of these mafic intrusive veins are visible in quarry faces and in road cut and cliff exposures along Highway 50 approximately one-mile east of the site. Based on visual evaluation of rock cores and mining faces in the granite deposit, the petrology of the granitic rock in the mining area is relatively homogenous across the site.

The Mesozoic sedimentary complex on the Parkdale Quarry includes the permitted sandstone deposit, and is not currently mined. The Mesozoic sedimentary rocks underlie most of the Quaternary alluvium on the site. The Mesozoic sedimentary complex is composed of Cretaceous Niobrara Formation shale, Cretaceous Graneros Formation shale and shaley limestone, Cretaceous Dakota Formation sandstone and shale, and Jurassic Morrison Formation sandstone and shale. The Mesozoic sedimentary units on the site are separated from the Precambrian intrusive igneous/metamorphosed igneous rock on the west side of the quarry site by the Ilse Fault. Though not mapped as such, drilling results demonstrated that the contact between the Mesozoic sedimentary units and the granitic rock on the east side of the site is a generally north-south trending high-angle reverse fault.

Quaternary alluvium unconformably overlies the other rock units on the property, but primarily occurs overlying the Mesozoic units in the southern portion of the property. Remnant deposits of quaternary alluvium are present overlying the Precambrian rocks on the east and west sides of the property. The Quaternary alluvium is interpreted to be a series of flood deposits resulting from the breaching of a series of glacial ice dams that formed at the west end of Sheep Canyon, west of Parkdale. The Quaternary alluvium was the initial source for materials mined at the Parkdale Quarry.

Five faults are present on or within one mile of the Parkdale Quarry and the BLM expansion area, as shown on the maps by Wobus, et. al (1979) and Taylor, et. al. (1975). The faults include the previously mentioned north-northwest trending Ilse Fault on the west side of the area that forms the western boundary of Webster

Park, the east-southeast trending Parkdale Fault that forms the north and east boundary of Cactus Mountain, the northeast trending Mikesell Fault which Highway 50 approximately follows from the Arkansas River Bridge to the Highway 50/Route 9 junction, an unnamed north trending fault which Currant Creek approximately follows, and the previously mentioned unnamed north-northeast trending fault that cuts through the southeastern part of the site and is the boundary between the Mesozoic sedimentary rocks and the granitic rock.

Geologic Hazards

Rule 6.5 requires the identification of geologic hazards that have the potential to affect any proposed impoundment, slope, embankment, highwall, or waste pile within the affected area. A geologic hazard as defined in Rule 6.5 is one of several types of adverse geologic conditions capable of causing damage or loss of property and life. Geologic hazards that may be considered include landslides and debris flows, subsidence, earthquakes and seismicity, tsunamis and seiches, and volcanic activity.

Landslides and Debris Flows

We visually evaluated landslide and debris flow hazards that have the potential to affect any proposed impoundment, slope, embankment, highwall, or waste pile within the affected area. The geologic materials present on slopes at the Parkdale Quarry and adjacent BLM area proposed for mining include Precambrian granite and Cretaceous-age sedimentary rocks. Some localized natural rockfalls occur in the area due to weathering and erosion. However, no evidence of natural landslides or debris flows were observed within or adjacent to the mining area that would be indicative of a potential hazard to proposed structures. If improperly designed, failures of mine slopes can affect proposed impoundments, embankments, highwalls, or waste piles. Mine slopes are being designed with ultimate factors of safety appropriate to minimize potential adverse impacts. Reclamation slopes are being designed with a static factor of safety of 1.5 or greater, and a seismic factor of safety of 1.3 or greater. Working slopes are being designed with a static factor of safety of 1.3 or greater, and a seismic factor of safety of 1.1 or greater. Mining activities are unlikely to decrease global stability outside of the mining area.

Earthquakes and Seismicity

There is no evidence that the five faults on or within one-mile of the Parkdale Quarry and expansion area are active (evidence of movement in the past 10,000 years) or potentially active (evidence of movement in the last 1.6-million years). The design Peak Ground Acceleration (PGA) for the site was derived from the 2021 USGS online Unified Hazard Tool and was compared to the 1997 Uniform Building Code (UBC) map. According to the UBC map, the Parkdale Quarry is located in Seismic Zone 1 defined by a PGA Range of 0.05g to 0.08g. The USGS Unified Hazard Tool predicted a PGA of 0.0801g for an earthquake with a return period of 975 years (5% chance of occurrence in 50 years). The predicted PGAs are unlikely to affect proposed impoundments, slopes, embankments, highwalls, or waste pile within the affected area.

Volcanic Activity

There are no known active volcanic features in the region with the potential to affect any proposed impoundment, slope, embankment, highwall, or waste pile within the affected area.

Tsunamis and Seiches

Tsunamis and seiches are not a potential hazard since there are no bodies of water in the vicinity of the site large enough to generate those phenomena.

Subsidence

There has not been documented underground mining under the site, and the subsurface geology is not conducive to the formation of karst features, so subsidence is unlikely.

Engineering stability analyses

The 2008 engineering stability analysis was reviewed and additional engineering stability analysis was performed to evaluate current and proposed quarry slopes based on current conditions, observed rock properties, and the proposed mining and reclamation slopes shown in Figure 1. The additional analysis was compared with and incorporated the analysis performed by LHI for the 2008 Reclamation Permit amendment. Additional measurements of discontinuities were taken in July, 2021 at 22 locations on the currently permitted granite mining area and on the proposed BLM mining area to determine whether rock properties differ significantly between the two areas.

Findings from the 2008 Slope Stability Memo

2008 Rock Slope Assessment

In 2008, LHI evaluated the Parkdale Quarry rock slopes based on the kinematic stability of rock blocks, slabs, and ledges defined by the rock joint patterns. LHI incorporated geotechnical and geological data collected at the Parkdale Quarry by Cesare in 2004 into their evaluation. Evaluation of rock mapping data by LHI and Cesare showed that the most prevalent joints are vertical to sub-vertical in two to three sets. Additionally, several sets of random joints at different strike orientations and dip angles were noted to be present. Most of the joints were determined to be fresh to slightly weathered, and moderately rough to stepped. These observations are consistent with those from the 2021 observations. Based on the joint characteristics, LHI used a friction angle of between 39 and 50 degrees. A typical friction angle for joints in granite is 40 degrees (Barton, 1974), which does not account for joint roughness. The friction angle should be modified to account for a joint roughness coefficient of 8 to 12, based on field observations. Based on the work of Williams, 1980, an appropriate modified friction angle for the rock accounting for the joint roughness is 45 degrees.

For the vertical and sub-vertical jointing, LHI stated that there is the potential for toppling and sliding of slivers, but these are expected to be limited to individual benches and highwalls. Large scale instabilities involving multiple benches and the overall quarry slopes are not expected as a result of these vertical and sub-vertical joints. For the non-vertical random jointing, LHI stated that there is the potential for sliding of blocks, slabs, and wedges in situations where the potential slide angle is steeper than the joint friction angle. Based on the then current mine plan, they concluded that this condition is not likely in the upper portion of the quarry, above elevation 5,800 feet where the quarry walls are inclined at a planned dip angle of 39 degrees; which is the lower bound of the likely joint friction angle they used. However, for the lower portion of the quarry, below elevation 5,800 feet where the quarry walls are steeper, with a planned dip angle of 51 degrees, LHI stated that rock instabilities are kinematically possible. However, LHI also stated that for a slide to occur, the joint would have to be relatively continuous and connected to other release joints to isolate a free block or wedge. Because the joints are random, it is not expected that these conditions would be persistent throughout the quarry. As such, LHI stated that there could be isolated areas of slope instability, but it is not expected that the random joints would result in slope instabilities on a large scale that would cause persistent problems. The observations of joints are consistent with those from the 2021 observations. However, as part of the 2021 amendment FRA proposes to modify reclamation slopes to generally be 45 degrees or flatter, equal or less than the calculated friction angle, except in isolated areas totaling less than 10-percent of the slope area, where

near-vertical slopes up to 80 feet in height will be maintained.

LHI stated that for any rock mass there is the possibility of large-scale random joints with a low strength such as from historic sliding, weathering, or clay infilling. If such a joint or several joints exist and if these joints have a disadvantageous orientation and location, then there could be a large-scale slope instability. However, field observations by LHI and by Cesare did not reveal any such joints. Based on the information available in 2008, LHI had no reason to believe that there would be a high risk for such events. Nothing was observed during the 2021 investigation that would alter that conclusion.

LHI did not perform factor of safety analysis for granite rock slopes. As verification for the 2008 slope stability evaluations, LHI recommended that an Observational Approach to slope stability be used to develop the quarry. Using that approach, a small area of the mine in the first phase and away from the limit of mining was excavated first and used to observe actual ground conditions and rock slope behavior. The observed conditions are consistent with the assumptions used for the LHI slope stability evaluation and the rock slopes do not show unexpected behavior.

2008 Soil Backfill Slope Assessment

Soil is placed on benches as part of mine reclamation. LHI expected this soil to be overburden removed from above mineable rock, weathered rock, and unsaleable rock and fines as a byproduct of rock processing. They further expected that this soil would receive a low to moderate degree of compaction, and would contain waste rock containing large particles which is impractical to compact. LHI assumed that the reclamation soils are all granular with angular to sub-angular particles and no more than approximately 25 percent fines (material finer than the number 200 sieve).

LHI's soil slope stability calculations were based on a purely frictional analysis neglecting cohesion, which is a conservative assumption. Soil friction angles were estimated from correlations based on soil type and density. A safety factor of 1.1 was chosen by LHI to be the design criteria. Based on these analyses, they calculated that fill derived from overburden and unsaleable material could be placed on slopes of 1.75 Horizontal (H) to 1 Vertical (V) or flatter, and that weathered rock could be placed on slopes of 1.5H to 1V or flatter. With a high level of compaction and with laboratory testing to verify the soil strength, LHI expected that any of these materials could meet the design safety factor on a slope with an inclination of 1.5H to 1V.

2021 Additional Stability Analysis

Additional stability analysis was performed to assess stability of proposed rock and soil slopes in the Parkdale Quarry BLM expansion area and to reassess existing quarry and fill slopes. Two slope stability conditions were investigated for rock and soil slopes: a static stability state condition and stability assuming the maximum predicted 0.08g PGA based on the seismic zonation. Condition 1 assumes the slope is in a steady state condition and that the minimum acceptable factor of safety is 1.5. Condition 2 assumes that the slope is subject to a PGA of 0.08g, and that the minimum factor of safety is 1.3.

Additional Rock Slope Stability Analysis

LHI evaluated the rock slopes based on the kinematic stability of rock blocks, slabs, and wedges defined by the rock joint patterns. Evaluation of rock mapping data by LHI and, also by Cesare showed that the most prevalent joints are vertical to sub-vertical. Additionally, several sets of random joints at different strike orientations and dip angles were noted to be present. As previously stated, most of the joints were

determined to be fresh to slightly weathered, and moderately rough to stepped equal to a joint roughness coefficient of 8 to 12.

Exploratory mining of the granite was initiated by Agile Stone in 2001, and production-scale mining of the granite was initiated in 2017, subsequent to the observations made by LHI and by Cesare. Approximately 160,000 square feet of bench face have been exposed over the course of the mining, and large-scale random joints with a low strength such as from historic sliding, weathering, or clay infilling have not been observed.

Additional joint orientation data was collected in July, 2021 from quarry faces at eight locations in the active quarry and from 15 outcrop locations within the proposed mining area on the BLM expansion area. Information on jointing characteristics was also obtained from granite cores recovered from exploratory borings on the current mining area and BLM lands drilled by FRA in 2015 and 2018. The cores were not oriented so joint dip azimuth was not available, but the joints were generally steeply dipping. Based on observations from cores, outcrop exposures, and quarry faces in fresh rock, the joint spacing decreases with depth to an average spacing greater than 15 feet. Joints observed in quarry faces are generally discontinuous with average lengths of less than 20 feet.

No large-scale random joints with a low strength such as from historic sliding, weathering, or clay infilling were observed by during the 2021 investigation, or reported by LHI, and J. A. LHI's data on joint orientation and characteristics are consistent with the July, 2021 measurements and observations of joints in the active granite quarry area and on the BLM expansion area. The correlation between the July, 2021 data and that reported by Cesare and LHI is demonstrated by the Stereonet plots from the 2008 analysis (Figures 2A and 2B) versus Stereonet plots of data collected in July 2021 (Figures 3A, 3B, and 3C), and a Stereonet plot of the combined 2008 and 2021 date (Figure 4). Two main joint set orientations show up in each of the three (Martin Marietta, LHI, and Cesare) data sets. Three other joint sets were observed in two of the three data sets. The joint set orientations from each data set and the interpreted average orientation for each joint set are shown in Table 1. The Table I data summarizes the five interpreted major joint orientations present on the site based on evaluation of the individual mapped joints, each of which is represented by one of the poles shown on figures 2A through 4. The poles representing the individual joints making up each joint set and the interpreted joint set are shown on Figure 4.

Table 1 - Joint Set Orientations - Parkdale Quarry Area Granite

Joint Set	Dip Azimuth				Dip			
	Martin Marietta	Lyman Henn Inc.	J. A. Cesare	Average	Martin Marietta	Lyman Henn Inc.	J. A. Cesare	Average
1	322	323	315	320	69	29	Near Vertical ⁽¹⁾	61
2	242	242	228	237	56	81	49	62
3	57	--	40	49	74	--	69	72
4	144	141	--	143	88	86	--	87
5	--	29	35	32	--	81	Near Vertical ⁽¹⁾	83

(1) - A dip value of 85 degrees was assigned to Near Vertical joints for purposes of assigning the average dip for a set.

-- No joint set falling into this approximate range measured/reported.

The current and proposed mining and reclamation rock slopes were analyzed using the RockPack III computer program. RockPack III uses the stability analysis methodology developed by Hoek and Brown, 1997, as modified in 1988, and was designed to analyze the slope stability of a rock slope subjected to several critical situations that may occur during the life of the slope. The program uses stereonet plots to evaluate the joint orientations likely to result in rock slope failure along joint plans, either as wedge failures, topple failures, or sliding failures. Once discontinuities having unfavorable orientations are identified, safety factors against translational sliding may be determined by calculating the ratio of resisting forces to driving forces along discontinuities. A detailed explanation of the use of stereonets for failure analysis and factor of safety analysis is presented in the appended RockPack III user's Manual. The critical zones indicating the potential failure mechanisms are shaded in gray in Figures 5 through 26 and explained on Figure 5. The Table I data summarizes the five interpreted major joint orientations

The rock properties used for the modeling are as follows:

- Density of the Granite - 163 pounds per cubic foot (Based on laboratory measurements of samples from cores and produced materials)
- Friction Angle Modified to Account for Joint Roughness - 45 degrees (from Williams, 1980, and based on an angle of friction of 40 degrees for joints in granite with a sandy loam fracture filling after Barton, 1974, and a joint roughness coefficient of 8 to 12 based on field observations).
- Joint Cohesion - 5,000 pounds per Square Foot (from Barton, 1974 and Wyllie, 1992).
- Unconfined Compressive Strength - 18,020 psi (based on 2002 laboratory testing performed by Colorado School of Mines for Agile Stone)
- Confined Compressive Strength - 52,530 psi (based on 2002 laboratory testing performed by Colorado School of Mines for Agile Stone)
- Maximum Observed Discontinuity Length - 20 feet (Excludes two observed fault/shear zones on the site)
- Average Joint Spacing – 15 feet (Based on observations of quarry faces and from cores)

An evaluation of likely failure mechanisms for each of the mining highwall and reclamation slope orientations was performed using standard stereonet techniques (Figures 5 through 26).

As seen in stereonet plots of jointing verses reclamation slope orientations for each of the final reclamation slopes (Figures 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, and 26), only three joints intercepted the critical zone for wedge or planar failures in any orientation, therefore large-scale wedge and planar failures are unlikely to occur. Some joints did intercept the critical zone for topple failure, but if they occurred, topple failures would be localized for the reasons stated above. Based on current information there is no reason to believe that there would be a significant risk for large scale failures of rock slopes.

Potential failure mechanisms for active mining bench slopes were analyzed as shown in the stereonet plots of jointing verses mining slope orientations for each of the final mining slope orientations (Figures 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, and 25). The 2021 analysis indicates that there is a low potential for toppling and sliding of slivers associated with vertical and sub-vertical jointing on mining highwalls. The analysis does indicate that there is the potential for sliding of blocks, slabs, and wedges associated with non-vertical random jointing on mining highwalls in situations where the potential slide angle is steeper than the joint friction angle, which based on joint properties is assumed to be 45 degrees. Where quarry walls are steeper,

and the joint angle exceeds the joint friction angle rock instabilities are kinematically possible. However, for a slide to occur, the joint would have to be relatively continuous and connected to other release joints to isolate a free block or wedge. Because the observed joints are random and joints are generally discontinuous, it is not expected that these conditions would be persistent throughout the quarry. As such, there could be isolated and localized areas of slope instability on mining benches, but it is not expected that the random joints would result in slope instabilities on a large scale that would cause persistent problems.

Large scale instabilities involving multiple benches and the overall quarry slopes are not expected as a result of the observed joint orientations. The limited joint spacing and joint length observed during the 2021 measurements, as well as observation of quarry slopes excavated between 2001 and 2021 support the conclusion that instability is limited to sliding and toppling of localized small-scale slivers and blocks

Though the stereonet analysis indicates that mining and reclamation slopes are expected to be globally stable, slope stability factor of safety analysis were performed for mining and reclamation slopes. Slope stability factor of safety analysis was performed for the anticipated tallest mining bench and the anticipated average and maximum reclamation slope angles for each planned final reclamation slope. The factor of safety analysis factors of safety used are the minimum factors of safety for critical structures as set forth in Policy 30, Table 1 for generalized, assumed, or single test strength measurements. RockPack III calculates Factors of Safety based on the conventional analysis of the ratio of forces resisting movement of a block on an inclined plane to the forces driving movement as assumed in Mined Land Reclamation Board Policy No. 30. The input data used to determine the Factor of Safety for potential failure types is shown in the following screen captures from the program:

RockPack III Input Screen – Planer Failure

Standard Input Data

(H) Height	0	ft
(SF) Inclination of Slope Face	0	°
(SS) Inclination of Upper Slope	0	°
(SP) Inclination of Failure Plane	0	°
(CO) Cohesive Strength of Failure Surface	0	lb(f)
(PH) Friction Angle of Failure Surface	0	°
(GR) Density of Rock	0	lb(f)/ft ³
(GW) Density of Water	0	lb(f)/ft ³

Bolt Data

(AB) Starting Rock Bolt Angle	0	°	(T1) Starting Bolt Tension	0	lb(f)
(AR) Ending Rock Bolt Angle	0	°	(T2) Ending Bolt Tension	0	lb(f)
(AA) Bolt Angle Increment	0	°	(T3) Bolt Tension Increment	0	lb(f)

Optional Input Data

(AC) Horizontal Acceleration	0	G
(TZ) Amount of Discontinuity Saturated	0	decimal%
(VSUR) Vertical Surcharge	0	lb(f)
(HSUR) Horizontal Surcharge	0	lb(f)

Tension Crack Data

☒ No Tension Crack

☐ Tension Crack Location Known

☐ Tension Crack Location Unknown

(B) Horizontal Distance of Tension Crack from Crest	0	ft
(DZ) Relative Height of Water in Tension Crack	0	decimal%

☒ Dry Slope ☐ Tension Crack filled with Water

RockPack III Input Screen – Topple Failure

Input Data

☒ Calculate Sum of Moments
☐ Calculate the tension required to bolt in place
☐ Calculate the thickness required to prevent toppling

Height of the Block ft
 Width of the Block 0 ft
 Angle of the Block 0 °
 Density of Water 0 lb(f)/ft³
 Density of Rock 0 lb(f)/ft³
 Tension of the Rock Bolt 0 lb(f)
 Height of Water in Tension Crack 0 ft
 Height of Rock Bolt in Block 0 ft

Results

CALCULATE

RockPack III Input Screen – Wedge Failure

Orientation Data for Planes (1-4)

Plane 1: (D1) Dip Value 0 ° (E1) Dip Direction 0 °
 Plane 2: (D2) Dip Value 0 ° (E2) Dip Direction 0 °
 Plane 3: (D3) Dip Value 0 ° (E3) Dip Direction 0 °
 Plane 4: (D4) Dip Value 0 ° (E4) Dip Direction 0 °

Cohesion and Friction Data

Plane 1: (C1) Cohesion 0 lb(f)/ft² (F1) Friction Angle 0 °
 Plane 2: (C2) Cohesion 0 lb(f)/ft² (F2) Friction Angle 0 °

Water Pressure Data

☒ Dry Slope
☐ Cracks Completely Filled (Free Draining)

☐ Alternate Overall Wedge Height Method

(GW) Density of Water 0 lb(f)/ft³
 (HW) Overall Vertical Height of Wedge 0 ft
 (INTTRND) Trend of line of intersection 0
 (INTPLNG) Plunge of line of intersection 0

☐ Other

(U1) Pressure on Plane 1 0 lb(f)/ft²
 (U2) Pressure on Plane 2 0 lb(f)/ft²

CALCULATE FACTOR OF SAFETY

Preliminary Data

(GR) Density of Rock 0 lb(f)/ft³
 (H) Height of Crest Above Intersection 0 ft

Slope Undercutting

Does the slope face overhang the toe of the slope?

☐ Yes ☒ No

Inputs to the Factor of Safety models are as per the rock properties listed above, the joint orientations listed in Table 1, the slope dips and dip directions shown on Figure 1, slope heights and characteristics, as applicable, listed in the reclamation plan for the site, and the height and width of blocks for the topple model based on the maximum observed discontinuity length.

Factors of safety for planar failure were modeled for slopes up to 80 feet tall and with an 80-degree face angle. Planar failure factors of safety equaled or exceeded 3.21 for static conditions, and 1.67 for seismic conditions. Since the major joint sets dip steeper than the overall 45-degree reclamation mine slope, potential failure surfaces for planar failures would not intercept the slope face so factor of safety analysis is not applicable to reclamation slopes. The observed joint sets did not exceed the proposed reclamation bench height of 35 feet so wedge failures are unlikely to affect overall reclamation slopes. Therefore, wedge failure factor of safety analysis for the final reclamation slopes was performed based on analysis for individual benches. Based on that analysis, the minimum factor of safety for the static condition was 7.69 or greater, except that the factor of safety for a wedge formed by joint sets 3 and 5 on the northeast slope on the BLM property was 1.54. Six of the 110 wedge failure analytical models yielded a factor of safety result of zero because the joint orientation relative to the applicable slope face resulted in a floating wedge in the model. Since zero is not a valid factor of safety, modeling runs resulting in a factor of safety of zero were ignored for purposes of this analysis. The results of the Factor of Safety Modeling are summarized in Tables 2 and 3 and the input and output screens are presented in Appendix A.

Table 2 – Summary of Factor of Safety Results, Planar and Topples Failures

Saturated Fractures	Joint Set	Static FOS	Seismic FOS
Planar Failure	1	3.21	1.67
	2	3.3	1.75
	3	6.03	4.15
	4	Dip Angle > Slope Angle	
	5	Dip Angle > Slope Angle	
Topples Failure	1	Safe at block base angle < or = 45°	
	2		
	3		
	4		
	5		

Table 3 – Summary of Factor of Safety Results, Wedge Failures

Slope Orientation Shown on Figure 1	Factor of Safety Wedge Failure
Southeast Limit - Private	20.2
South Limit Private	20.08
West Limit - Private	12.84
North Limit - Private	7.93
East Limit - BLM	19.72
Northeast Limit - BLM	1.54
North Limit - BLM	7.69
Northwest Limit - BLM	9.09
South-central Limit - BLM	20.17
Southwest Limit - BLM	10.81
South Limit - BLM	18.87

Since the observed jointing in the granite is discontinuous, an observational approach to slope stability is being used to supplement the stability modeling used to develop the quarry. Using the observational approach, a small area of the mine away from the limit of mining was excavated first and used to observe actual ground conditions and rock slope behavior. The observed conditions are consistent with the behavior predicted as part of the 2008 slope stability evaluation and as predicted by the 2021 modeling. The observations to date support the development of the mine as proposed in the 2021 mine plan and show that the rock slopes are stable using the proposed design parameters. Slope observations will continue throughout the mining process and if indications of instability are observed appropriate changes to the rock slopes will be made.

Additional Soil Slope Stability Analysis

Approximately 3,200 linear feet of mining benches have been reclaimed at the Parkdale Quarry since 2017. Soil is being placed on benches as part of mine reclamation. This soil is a mixture of overburden removed from above mineable rock, weathered rock, and unsaleable rock and fines as a byproduct of rock processing. During placement, this soil is tracked in with a bulldozer and receives a moderate degree of compaction. These soils are generally granular with angular to sub-angular particles and approximately 25 to 35 percent fines (material finer than the number 200 sieve) and are characterized as GC-GL (clayey gravel with many fines) using the unified soils classification system (USCS). Soil slope stability calculations performed in 2008 were based on a purely frictional analysis neglecting cohesion, which is a conservative assumption. Soil friction angles were estimated from correlations based on soil type and density. Observation of reclamation slopes indicates that cohesion is playing a significant role in stability the backfill. The following soil parameters were used for the stability analysis:

- Unified Soils Classification System GM to GC (Silty Gravels to Clayey Gravels) with cobble-size inclusions of waste rock.
- Estimated Shear Strength 12 kPa
- Effective Friction Angle 35 degrees
- Poisson's Ratio 0.25

- Young's Modulus 150 MPa
- Unit Weight of soil (90% compaction) 103 pounds per cubic foot (16 kN/m³)
- Cohesion 20 psi (3,100 psf)

Soil slope stability was evaluated using the online slope stability calculator developed by the WISE Uranium Project for the evaluation of tailings dam slopes. The WISE program uses the Modified Bishop analysis method (Bishop, 1955). Two slope types were evaluated, reclamation bench fill slopes and excess overburden stockpile slopes. Each slope type was evaluated for static conditions and seismic conditions assuming a 0.08g acceleration.

Reclamation Slopes: Reclamation bench fill slopes were modeled assuming that a slope failure in a reclamation fill slope is constrained by mining benches in rock with a bench height of 35 feet, a bench face angle of 80 degrees, a horizontal bench width of approximately 30 feet, and a soil slope face angle of 45 degrees. As shown in Figure 27, the modeled failure plane assumed a worst-case scenario for a bench fill with failure initiated at the base of the fill and extending to the head of the fill. The calculated factor of safety for the seismic condition was found to be 4.930 indicating that reclamation slopes are stable. The slope was not modeled for the static condition since the seismic factor of safety exceeded 1.5. The finding that reclamation slopes are stable is consistent with four years of observation of fill slopes at the Parkdale Quarry and over 20 years of observation of similarly constructed fill slopes at the Martin Marietta Specification Aggregates Quarry in Golden, Colorado, where no stability-related failures of reclamation slopes have been observed though slopes are subject to accelerations in excess of 0.08g due to blasting on adjacent mining benches. To date, the failures observed on the existing reclamation slopes are generally caused by erosion. Rare raveling of saturated soils in areas generally less than 1,000 square feet have been observed in unvegetated or thinly vegetated areas after heavy rainfall events, but the raveling does not affect the overall stability of the slopes.

Overburden Stockpile Slopes: Overburden stockpile slopes were modeled to determine the maximum slope angle for a 35-foot tall stockpile that meets the minimum factor of safety requirements for the site. As shown in Figures 28A and 28B, the modeled failure plane assumed a worst-case scenario with failure initiated at the base of the fill and extending to the head of the fill. Based on the modeling, stockpile slopes of 1.5H to 1V or flatter will have a static factor of safety of 1.55 or greater and a seismic factor of safety of 1.34 or greater.

The soil slope factors of safety for stockpile slopes determined through the current analysis are higher than that determined by HLA. These soil parameters used for the current analysis are based on observed soil properties, and differ from those used in the LHI report which were overly conservative assumed values. The Modified Bishop method of analysis is an inherently conservative approach to stability modeling. Additionally, Irfan and Tang (1992) found that conventional strength analysis underestimates the strength of block in matrix soils (BIM soils) by 30 percent or more. Therefore, the soil parameters used for the current analysis should also be considered as conservative based on the waste rock blocks present in the materials and thus the results of the analysis should also be viewed as conservative.

Off-site Impacts from Blasting

Blasting is currently being performed at the Parkdale Quarry. All blasting is currently performed by a United States Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATFE) licensed third-party blasting contractor. A blast plan prepared in accordance with Code of Federal Regulations (CFR) 30, Part 56 Subpart E - Explosives and Office of Surface Mining Reclamation and Enforcement (OSM) Blasting Performance Standards is in place for blasting operations. Only one off-site structure is located within ½-mile of the

active mining area. Front Range Aggregates had performed 181 monitored blasts on the site as of November 1, 2021, with no reports of offsite damage and no recorded exceedances of allowable vibration limits.

General Blasting Procedures

Blast holes are typically loaded the day a blast is scheduled. Explosives are transported to the site by the blasting contractor on the day a blast is scheduled, any excess explosives are transported from the site after all blast holes are loaded, and no explosives are stored on the site. Personnel at the quarry prepare each area to be drilled and blasted according to the mining plan for the quarry development. The quarry manager works with the blasting contractor to design an appropriate drill pattern to ensure safe and efficient production in each area of the quarry. The drill pattern design includes burden and spacing, hole depth, number of holes, explosive densities, shot sequencing, stemming, and other factors. Drilling is performed using a rotary hammer shothole drill using either a top-hammer or down-hole-hammer. Drilling is conducted using a Martin Marietta employed driller and drill or an outside drilling contractor. Blasting is performed using conventional mining-type bulk explosives to include ammonium nitrate and fuel oil (ANFO); an emulsion of liquid ammonium nitrate and diesel fuel; or a blend of the two. Blasts are initiated using computer-controlled electronic detonators that are programable and require that a unique code be sent to them to detonate.

Blasting at the Parkdale Quarry is currently permitted from 10:00 AM to 5:00 PM, not more than five days per week. No change to the currently permitted blasting schedule is anticipated at this time. The quarry operator reached out to neighbors and other interested parties, including the local fire department, and all interested parties are notified prior to a blast. A blast notification sign is present at the quarry entrance to notify personnel entering the site as to whether a blast is scheduled for that day. On days when a blast is scheduled, onsite personnel are notified as to the scheduled blast time.

Prior to a blasting, quarry personnel, visitors, vendors, and customers are removed from the mining area and stationed at a designated assembly point. The site manager or lead blaster inspect the mining area to confirm all personnel have cleared from the blast area. Blast guards are posted at the quarry entrance to make sure that access corridors through the active mining area are secure during the blast process. Blast guards are in contact with the lead blaster via radio on a channel to be determined at the time the blasting operation begins. Blast guards have the authority to stop the blast at any time, up to the time when the blast is initiated. Audible blast signals are utilized prior to the blast according to the following schedule:

- 2 minutes before the blast
- 30 seconds before blast

Once all personnel are accounted for, all blast guards are in place, and the blast area has been confirmed to be clear, the lead blaster initiates the blast.

After the blast, the lead blaster re-enters the blast area to inspect it and verify that all holes were detonated. No one is allowed back into the mining area until the lead blaster has inspected the blast and confirmed that it is safe to resume work. At that time the 'All Clear' audible signal sounds and the blast guards release their blocks. Personnel are then be allowed back into the mining area and operations return to normal.

A misfire is the complete or partial failure of a blast hole to detonate as planned. Due to advancements in blast technology, misfires rarely happen. However, in the event of a misfire the lead blaster will not allow normal activities to resume in the blast area. The lead blaster will wait 30 minutes before completing a more thorough investigation of the cause of the misfire. Depending on the location of the blast, the lead blaster,

at their discretion, can release areas not in the immediate area of the blast while waiting the required 30 minutes.

If it is found that the misfired detonator can be re-shot, the blast area will be cleared again, blast guards reestablished, the blast warning procedure will be reinitiated, and the detonator blasted. If the detonator cannot be blasted, the area will be secured, and all mining personnel warned of the hazard. The area will be carefully excavated under the supervision of the lead blaster or Quarry Manager until the blasting cap and booster is located and rendered safe.

Vibration Monitoring

Regulatory limits have been set for ground vibration, expressed as peak particle velocity (PPV) to control potential damage to offsite structures due to blasting. Blasts are monitored to verify that these limits are not exceeded. Each blast at the Parkdale Quarry is monitored through a combination of a drone equipped with a video camera and a pair of seismic monitoring stations located at the Parkdale Quarry property boundary between the mining area and the residences closest to the quarry at the locations shown on Figure 29. The two seismic monitors are monitored by VibraTech, a third-party consultant. Vibra-Tech recorded the results of 181 blasts between January 11, 2018 and November 1, 2021. To date, no blast has exceeded allowable PPV limits. The blasting limits established for the site as per Martin Marietta company policy are as follows:

Limits on ground vibration (i.e., peak particle velocity) – 0.50 inches per second

Limit on air blast (i.e., peak air pressure) – 127 decibels

Pre-Blast Survey

Blasting is currently being conducted on the site. Prior to the start of blasting, Front Range Aggregates contacted the neighbors within one-mile of the quarry and met with those who were interested, to provide information on the blasting program and determine what their concerns were. Only one neighbor lives within one-half mile of the mining area where blasting occurs, and no pre-blast surveys were conducted. However, those neighbors wanting to be notified before blasts receive an e-mail prior to each blast notifying them of the blasting schedule. As part of the 2021 amendment, Martin Marietta will administratively alter the limit of mining further north, which will move the associated blasting north and west, further from off-site structures, thus reducing the potential for offsite damage to structures.

Blast Reports

FRA will generate and file blast reports for each blast performed at the quarry. The blasting report will be prepared by the blasting contractor or Martin Marietta blaster, and will be filed by the Parkdale Quarry Manager within two business days after the blast. At a minimum, the blast report will include the following:

- Blast number, blast date, and blast time;
- Location of the blast within the quarry;
- Weather at the time of the blast;
- Location of nearest non-owned structure;
- Seismograph data for the blast; and
- Blast data to include number of blast holes, hole depth, amount and type of explosives used, and cubic yards of material blasted.

References

- Barton, N. R. 1974. A Review of the Shear Strength of Filled Discontinuities in Rock. Publication 105, Norwegian Geotechnical Institute, Oslo, 38 pp.
- Bishop, A. W. 1955. The Use of the Slip Circle in the Stability Analysis of Slopes. *Geotechnique* 5, pp 7-17
- Hoek, E. and Brown, E.T. 1997. Practical Estimates of Rock Mass Strength. *International Journal Rock Mechanics Mining Science*, 34, pp 1165-1186
- Hoek, E., and E.T. Brown. 1988. The Hoek-Brown Failure Criterion-A 1988 Update. In *Proc., 15th Canadian Rock Mechanics Symposium*, University of Toronto, Canada.
- Irfan, T. Y. and Tang, K. Y. 1992. Effect of the Coarse Fractions on the Shear Strength of Colluvium. Special Project Report, SR 15/92 (GEO 23) Geotechnical Engineering Office, Hong Kong. 223 pp
- J.A. Cesare Associates. 2001. Aggregate Resource Investigation, Parkdale Project, Fremont County, Colorado. Unpublished Consulting Report.
- Lyman Henn, Inc. 2008. Parkdale Quarry Slope Stability Summary. Unpublished Consultant's Technical Memorandum.
- R. J. Lee Group. 2014. Petrographic Examination of Ledge Rock Sample from Parkdale Quarry. Unpublished Consultant's Technical Memorandum.
- Schaefer, W. A. 1969. Geology and Petrology of the Parkdale Gneiss, Fremont County, Colorado. Texas Tech University Unpublished Master's Thesis
- Taylor, R. B., Scott, G. R., Wolus, R. A., and Epus, R. C. 1975. Reconnaissance Geologic Map of the Royal Gorge Quadrangle, Fremont and Custer Counties, Colorado. United States Geological Survey. Miscellaneous Investigation Series Map I-869
- United States Geological Survey Online Unified Hazard Tool. 2021.
<https://earthquake.usgs.gov/hazards/interactive>
- United States Nuclear Regulatory Commission. 2015. 1997 UBC United States Seismic Zones Map. NRC-070. <https://www.nrc.gov/docs/ML1513/ML1513A128.pdf>
- Watts, C.F. 2003. Users Manual, Rockpack III for Windows.
- Williams, A. F. 1980. Principles of Slide Resistance Development in Rock Socketed Piles. *Proceedings of the 3rd Australia-New Zealand Conference on Geomechanics*, Vol 1, Wellington. pp 87-94
- WISE Uranium Project (<https://www.wise-uranium.org/csst.html>)
- Wobus, R.A., Epis, R.C., and Scott, G. R. 1979. Geologic Map of the Cover Mountain Quadrangle, Fremont, Park, and Teller Counties, Colorado. United States Geological Survey Miscellaneous Investigation Series Map I-1179

Wyllie, D. C. 1992. Foundations on Rock. Chapman and Hall, London, 331 pp.

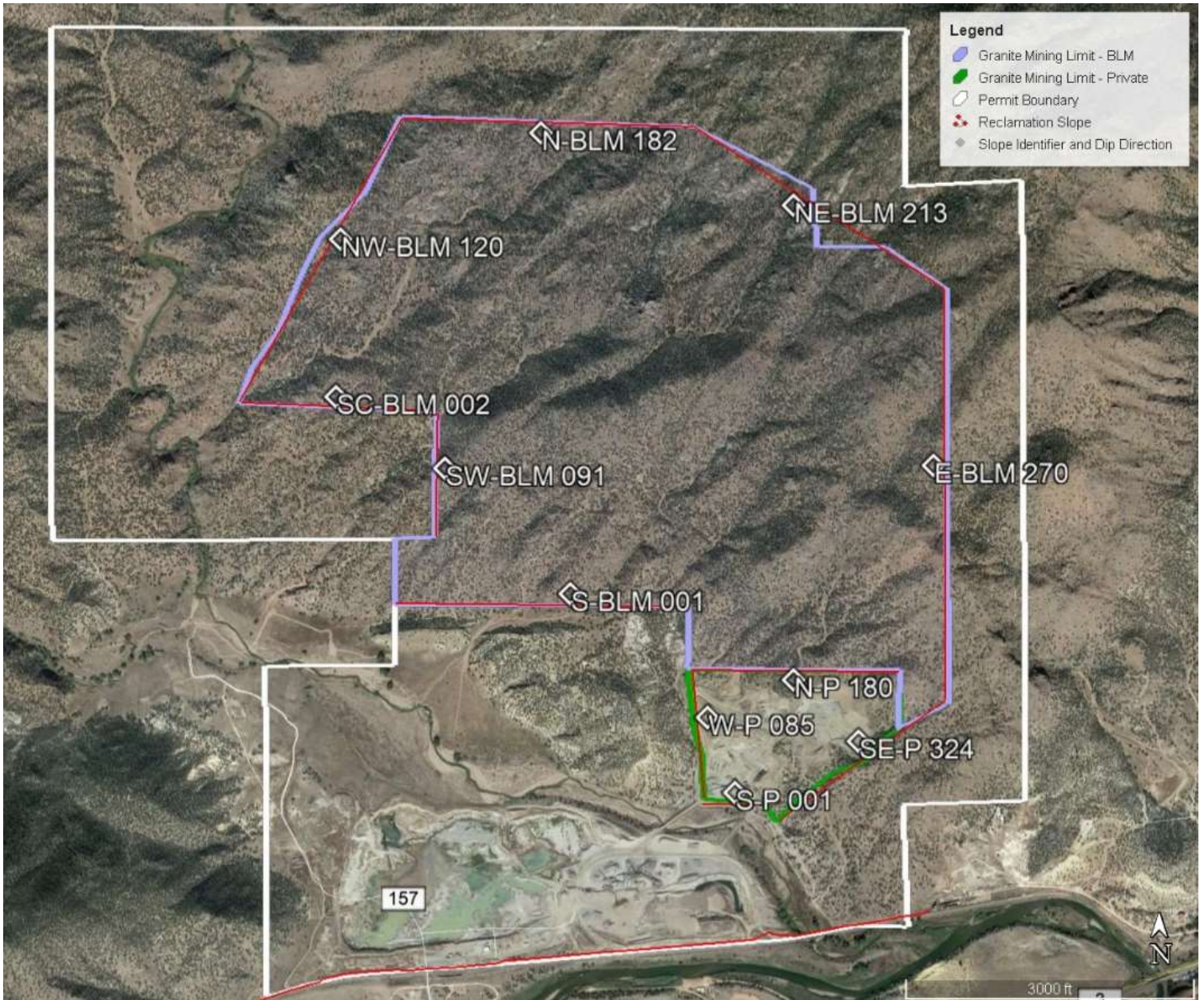


Figure 1 – Parkdale Granite Quarry Reclamation Slopes

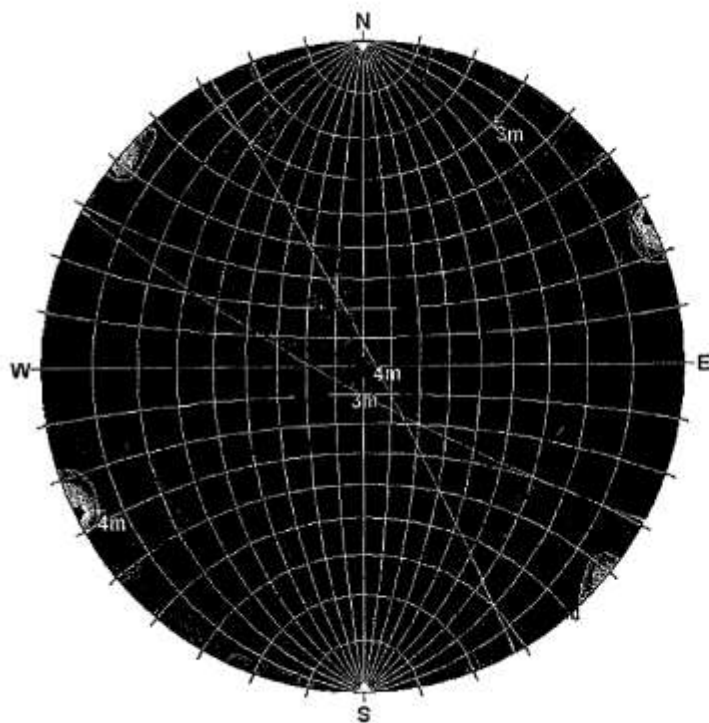
Front Range Aggregates, LLC

Parkdale Quarry

Fremont County, Colorado

DRMS Mining Permit M1997-054

Lyman Henn Data
Vectors perpendicular
to joints and
joint planes



Orientations		
ID		Trend / Plunge
1	m	323 / 61
2	m	141 / 04
3	m	029 / 09
4	m	242 / 04

Equal Angle
Lower Hemisphere
48 Poles
48 Entries

Figure 2A - Stereonet Plot – 2008 Stability Report

Lyman Henn, Inc. Data

Front Range Aggregates, LLC

Parkdale Quarry

Fremont County, Colorado

DRMS Mining Permit M1997-054

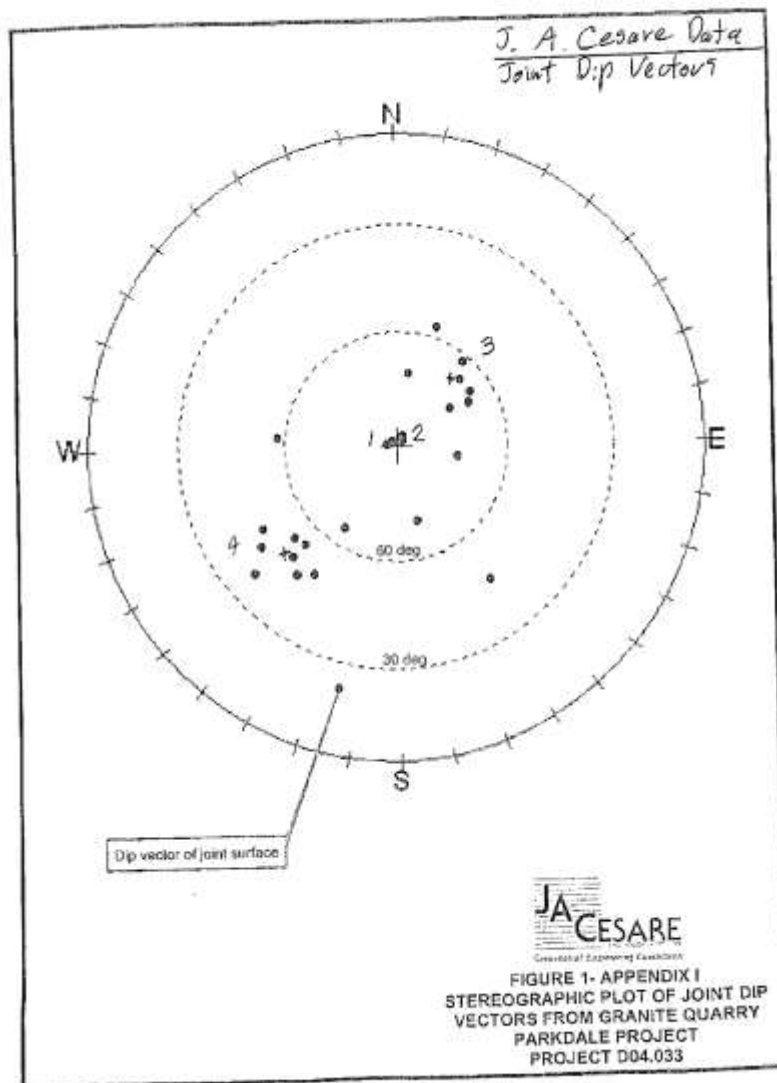


Figure 2B - Stereonet Plot – 2008 Stability Report

J. A. Cesare Data

Front Range Aggregates, LLC

Parkdale Quarry

Fremont County, Colorado

DRMS Mining Permit M1997-054

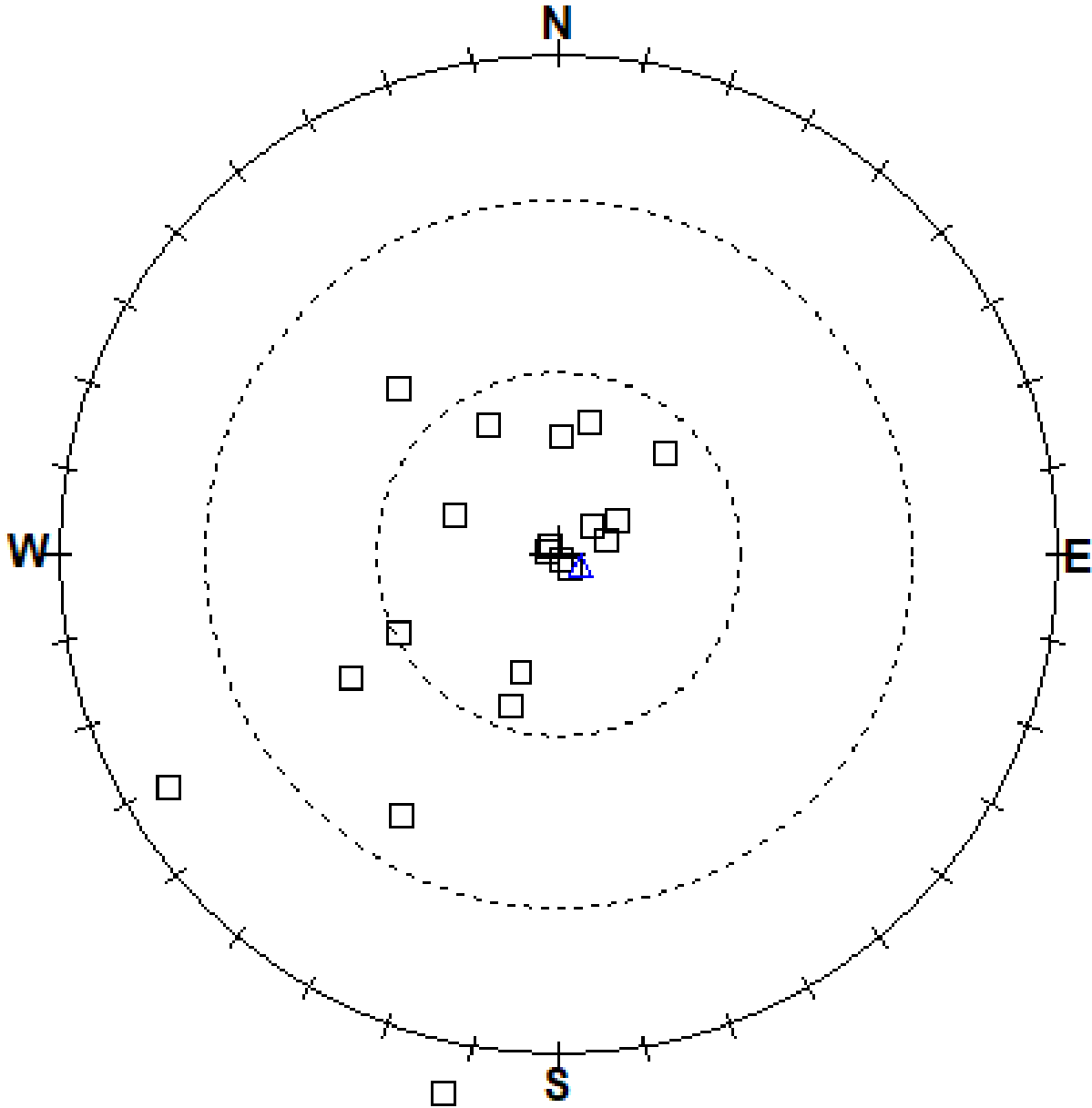


Figure 3A - Stereonet Plot – 2021 Granite Quarry Data
Combined BLM and Private
Front Range Aggregates, LLC
Parkdale Quarry
Fremont County, Colorado
DRMS Mining Permit M1997-054

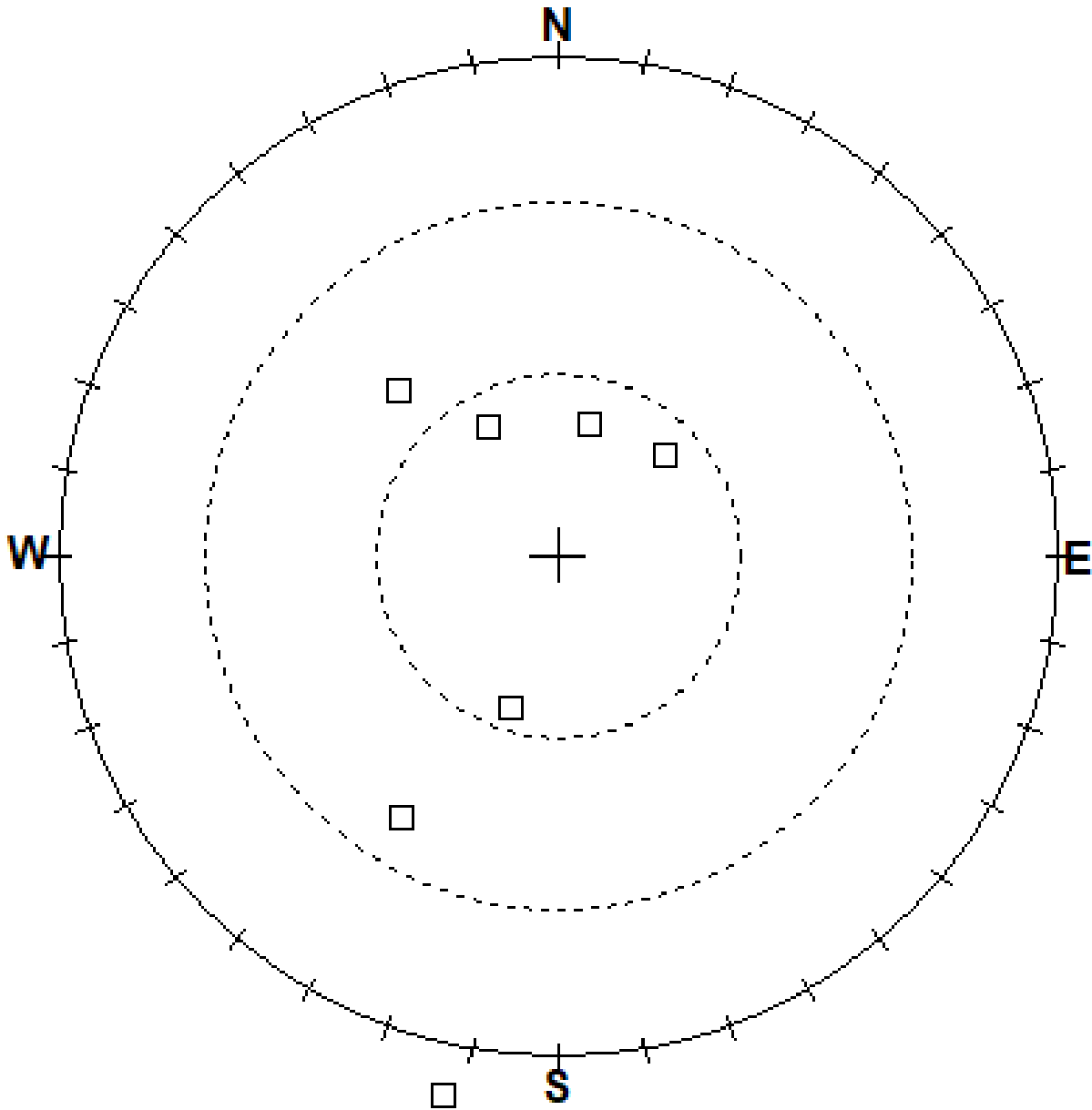


Figure 3B - Stereonet Plot – 2021 Granite Quarry Data

Private Land Granite Quarry Data

Front Range Aggregates, LLC

Parkdale Quarry

Fremont County, Colorado

DRMS Mining Permit M1997-054

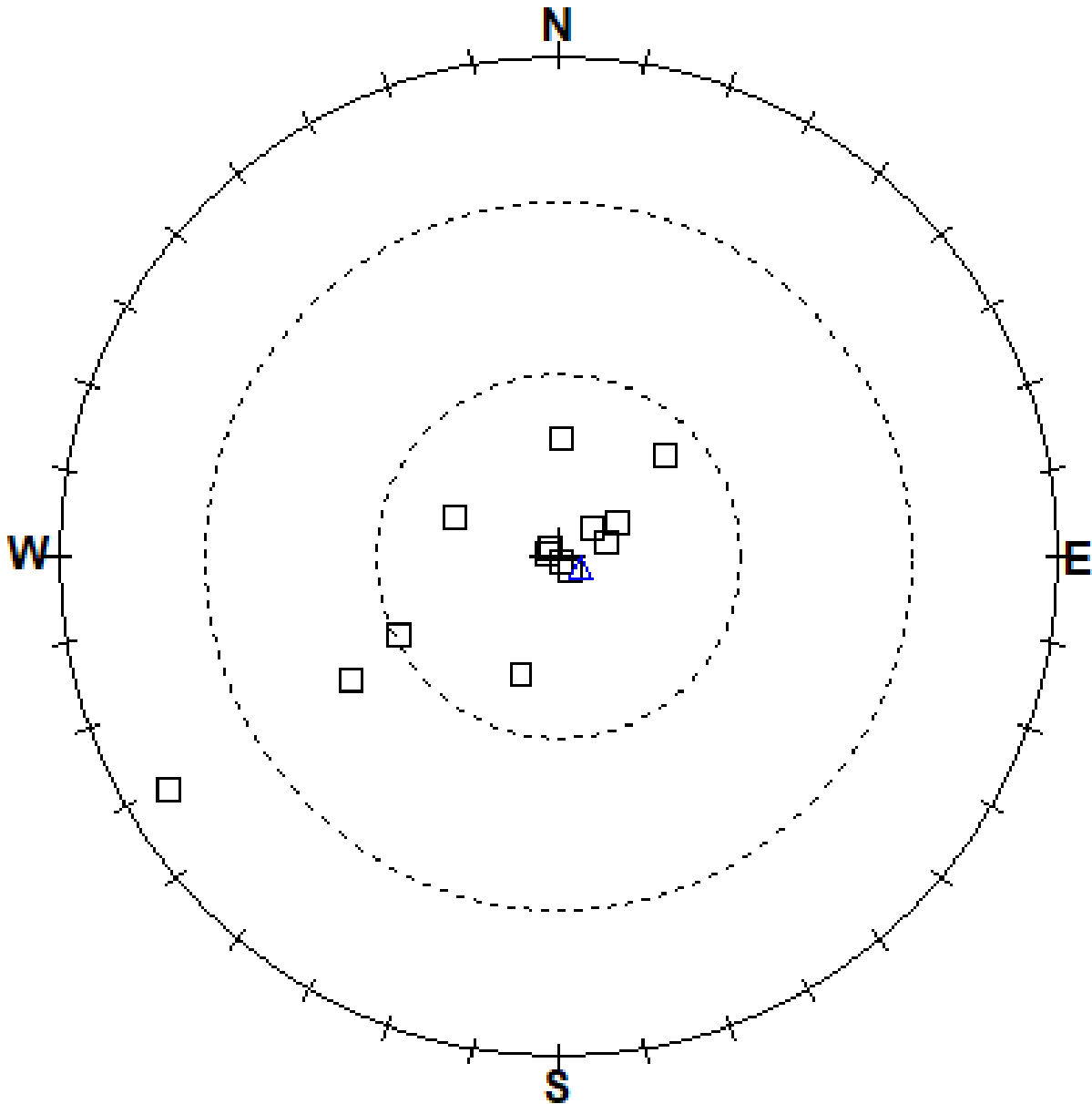


Figure 3C - Stereonet Plot – 2021 Granite Quarry Data

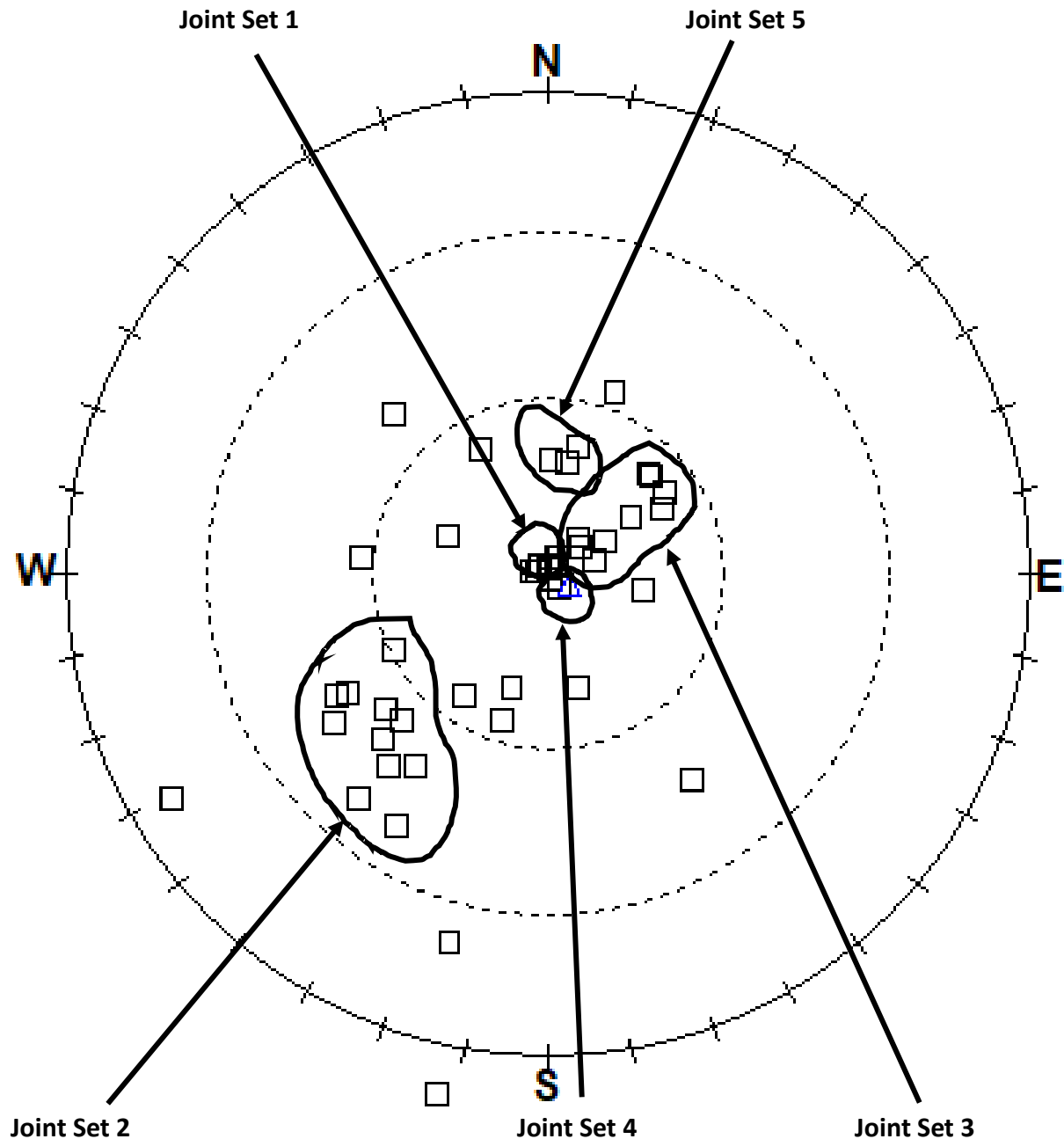
BLM Expansion Area Data

Front Range Aggregates, LLC

Parkdale Quarry

Fremont County, Colorado

DRMS Mining Permit M1997-054



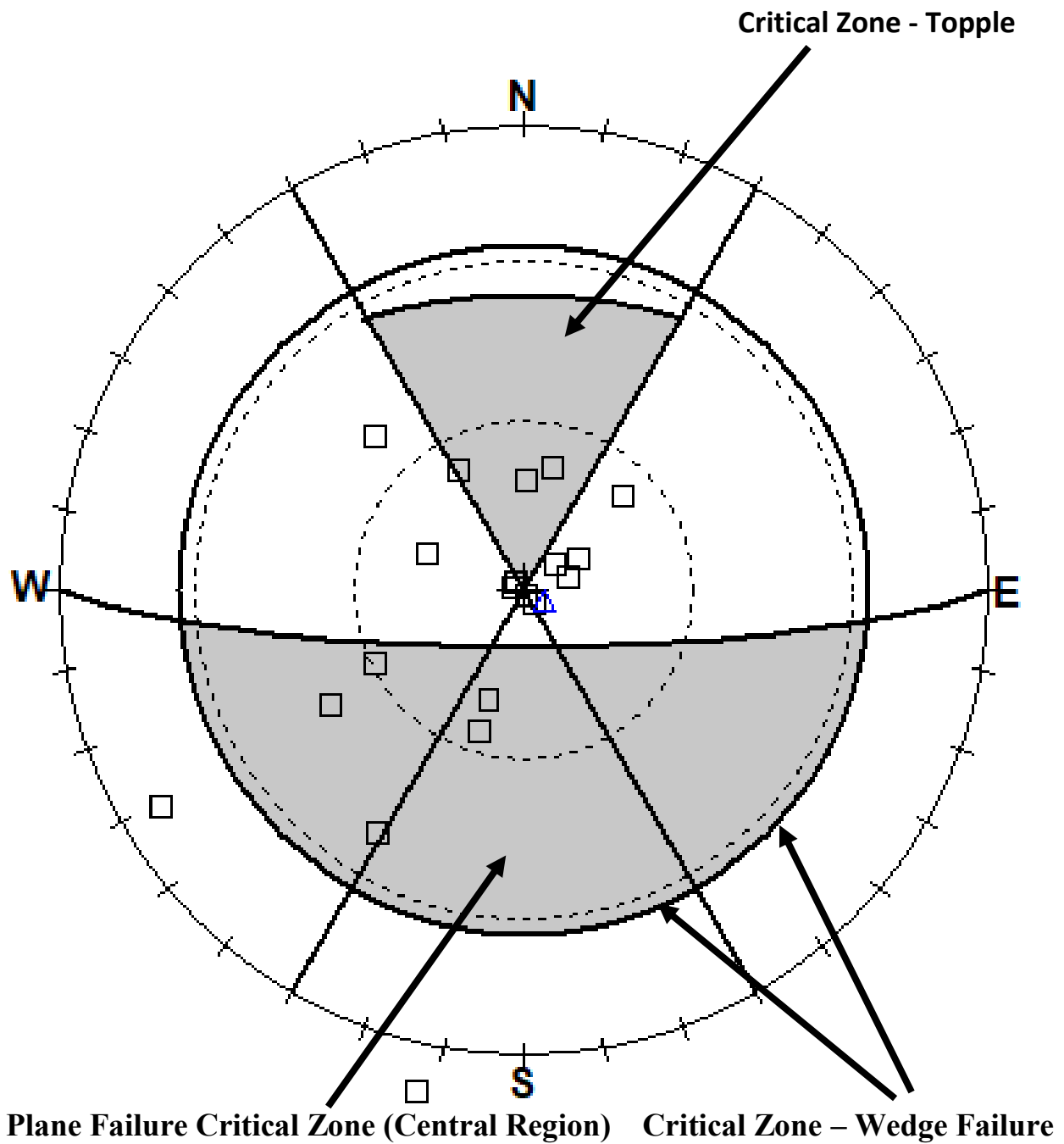
**Figure 4- Stereonet Plot – 2008 and 2021 Data
Private and BLM Areas**

Front Range Aggregates, LLC

Parkdale Quarry

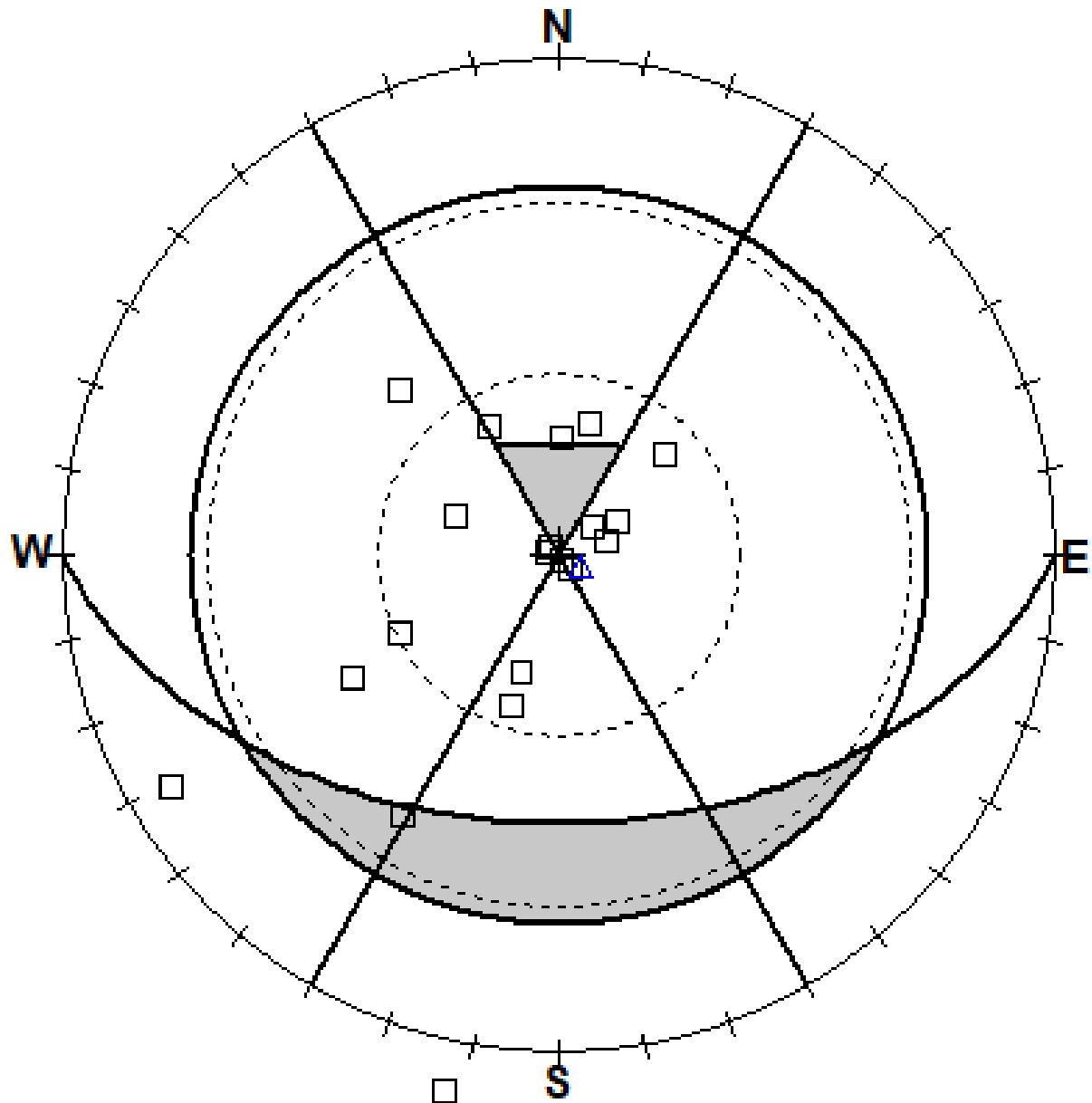
Fremont County, Colorado

DRMS Mining Permit M1997-054

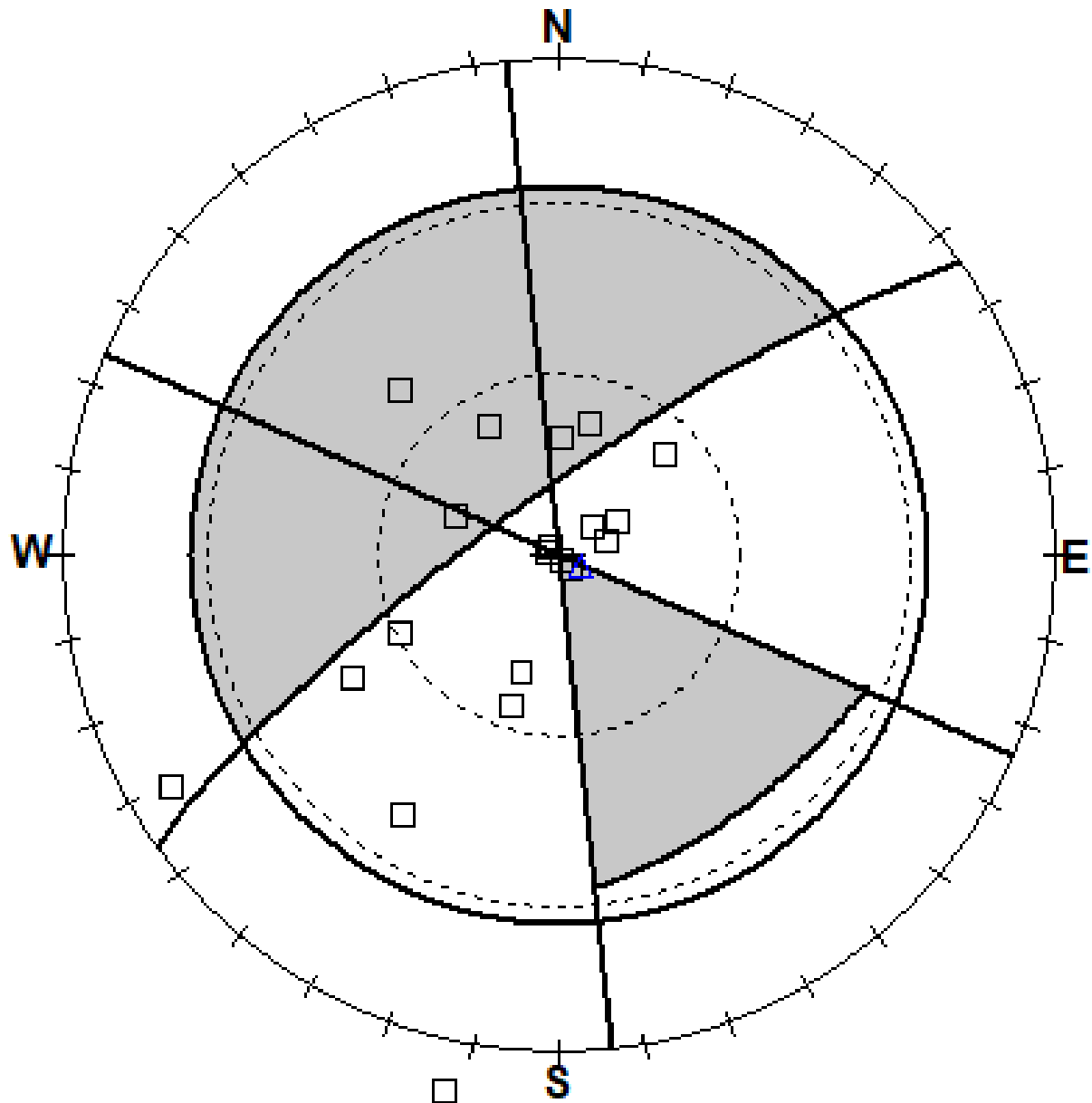


**Figure 5 - Stereonet Plot – North Highwall
Granite Quarry - Private Land (N-P)**
Front Range Aggregates, LLC
Parkdale Quarry

Fremont County, Colorado
DRMS Mining Permit M1997-054



**Figure 6 - Stereonet Plot – North Reclamation Slope
Granite Quarry - Private Land (N-P)**
Front Range Aggregates, LLC
Parkdale Quarry
Fremont County, Colorado
DRMS Mining Permit M1997-054



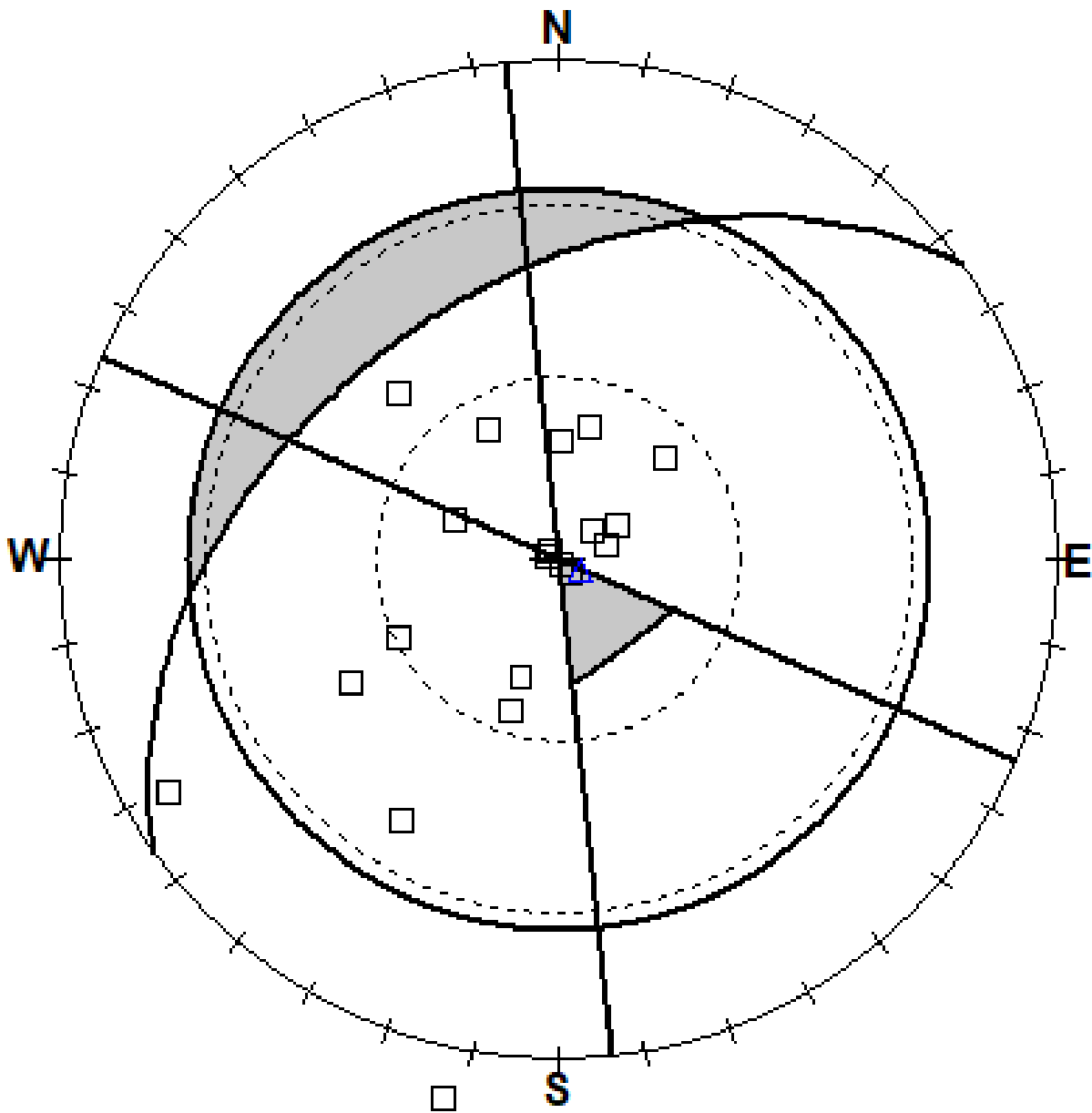
**Figure 7 - Stereonet Plot – Southeast Highwall
Granite Quarry - Private Land (SE-P)**

Front Range Aggregates, LLC

Parkdale Quarry

Fremont County, Colorado

DRMS Mining Permit M1997-054



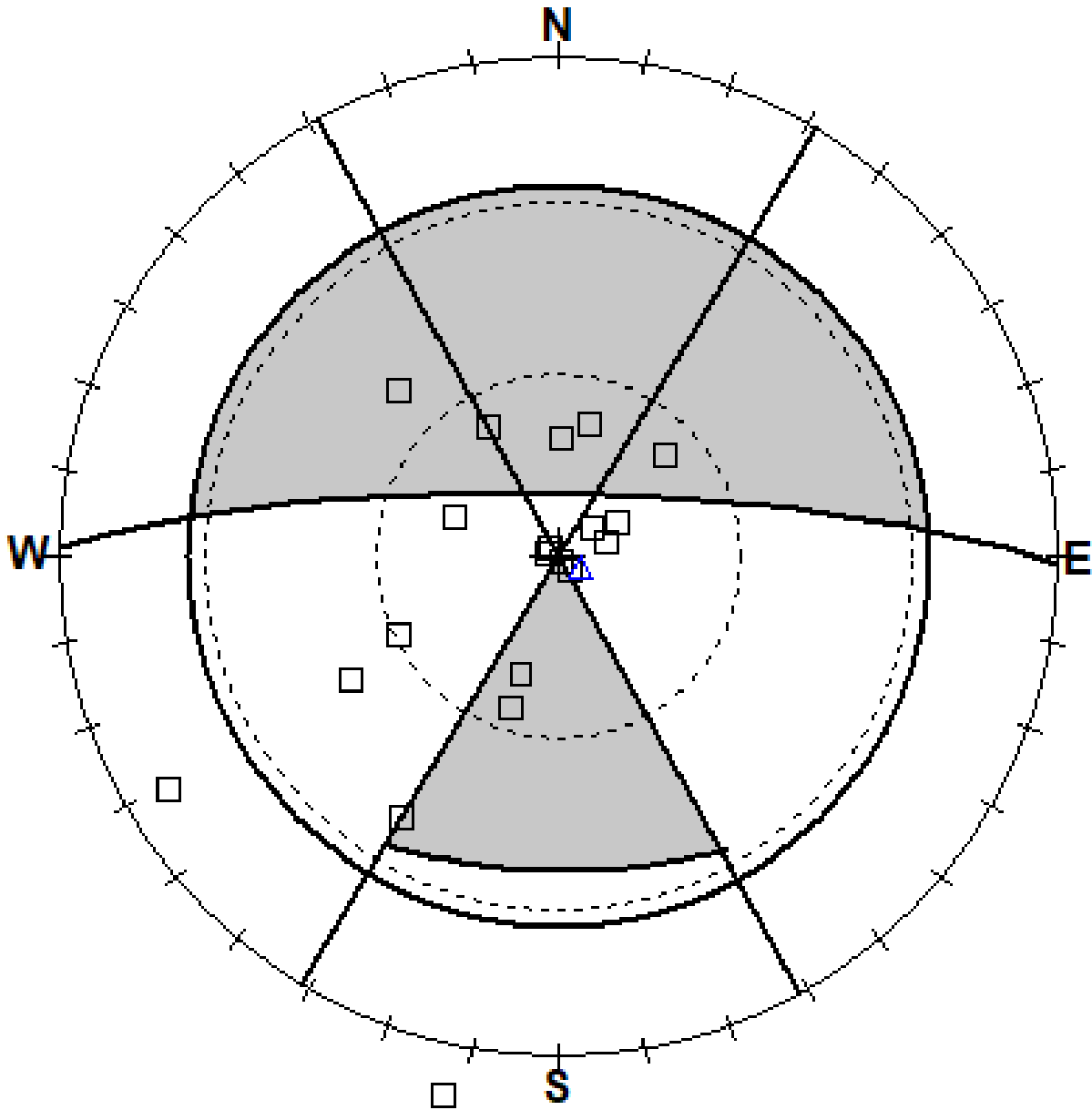
**Figure 8 - Stereonet Plot – Southeast Reclamation Slope
Granite Quarry - Private Land (SE-P)**

Front Range Aggregates, LLC

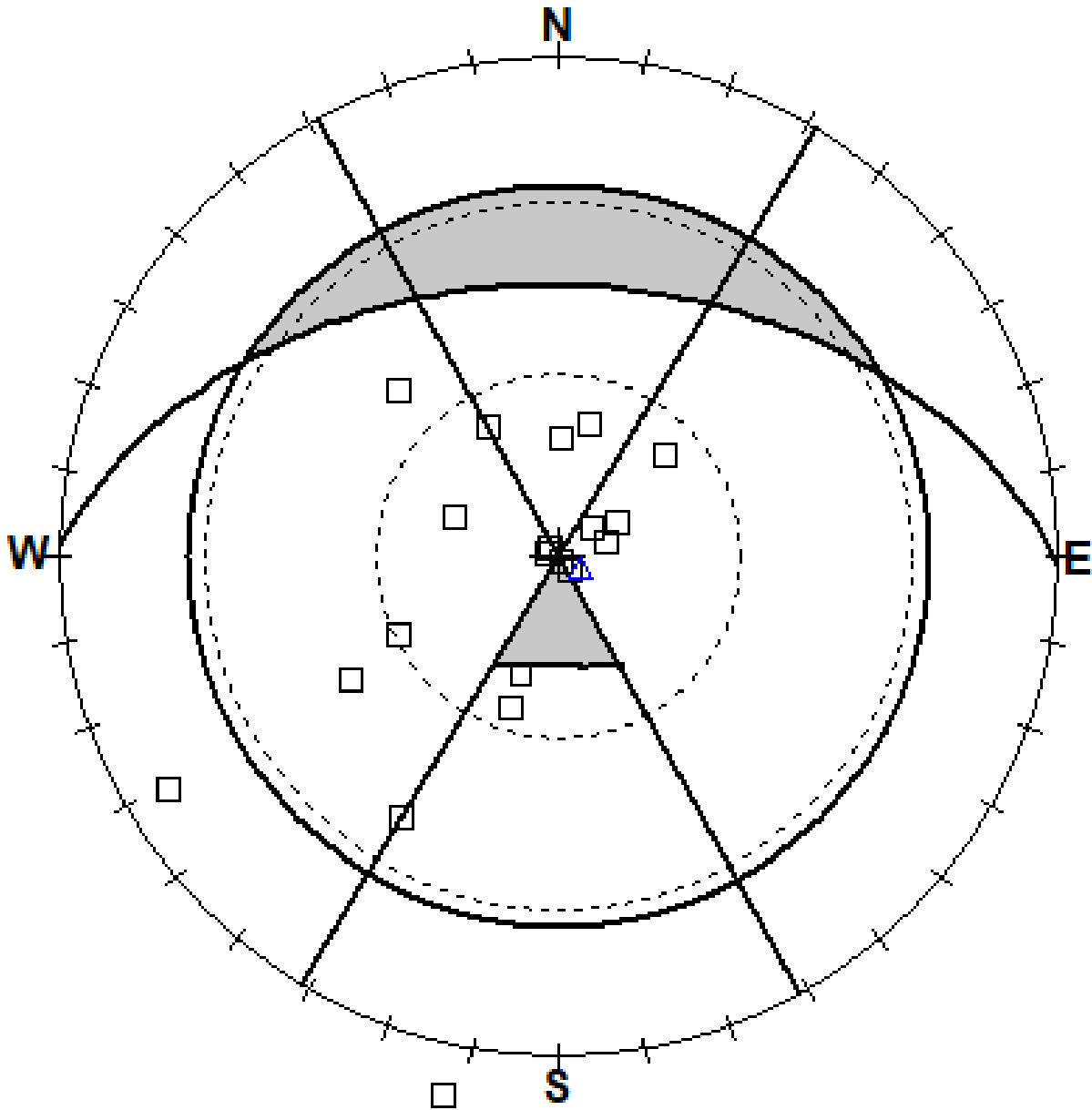
Parkdale Quarry

Fremont County, Colorado

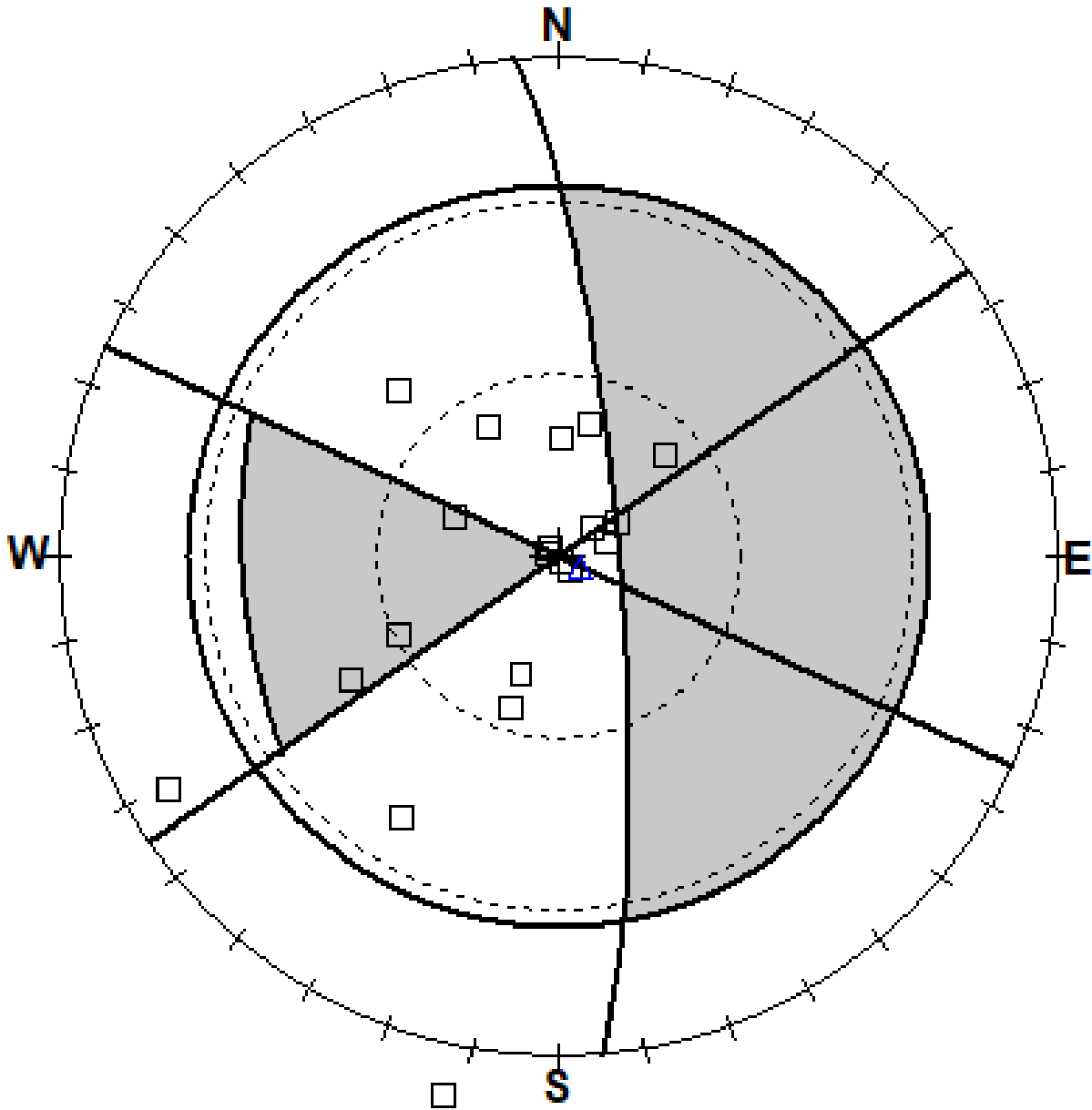
DRMS Mining Permit M1997-054



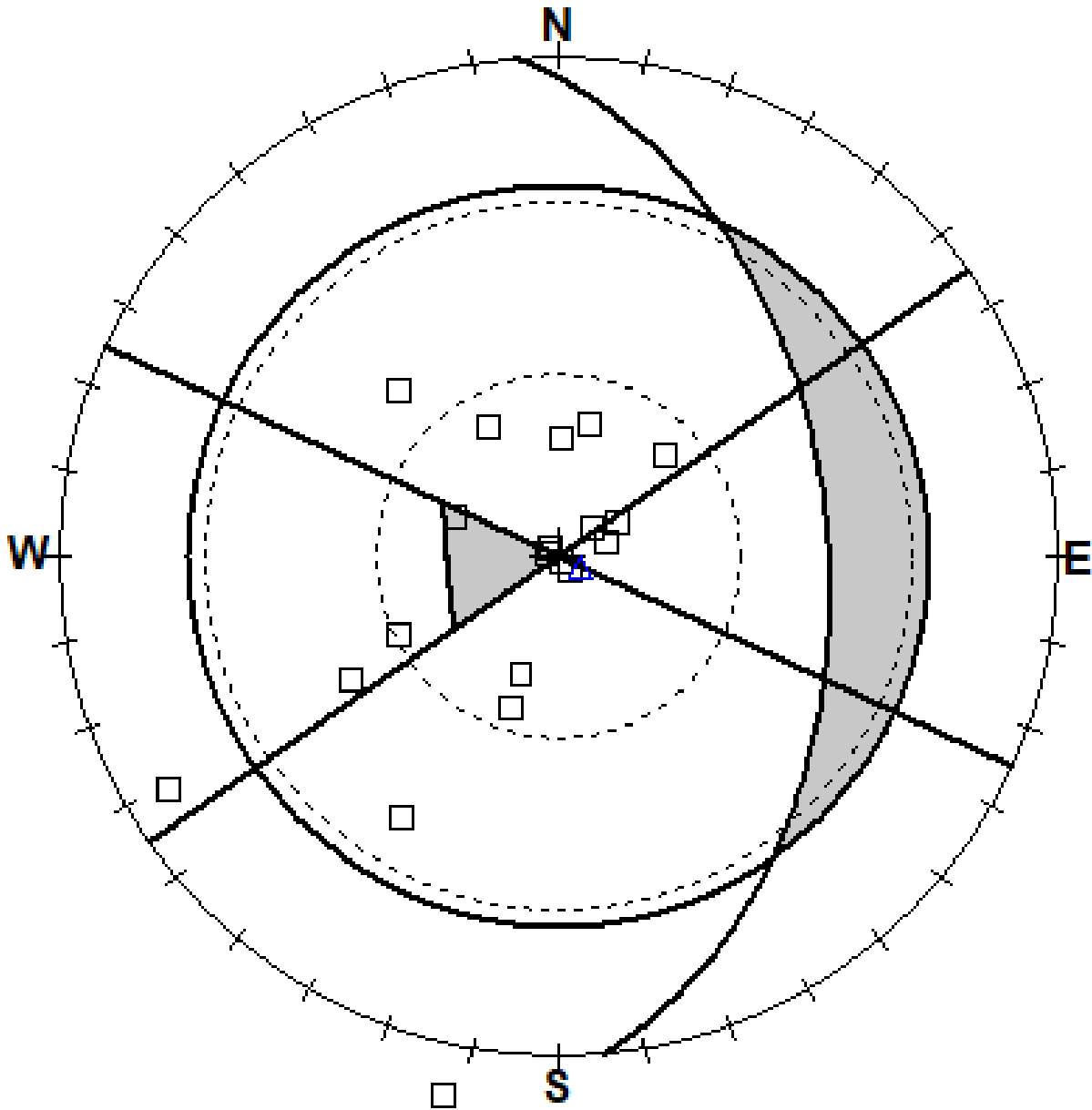
**Figure 9 - Stereonet Plot – South Highwall
Granite Quarry - Private Land (S-P)**
Front Range Aggregates, LLC
Parkdale Quarry
Fremont County, Colorado
DRMS Mining Permit M1997-054



**Figure 10 - Stereonet Plot – South Reclamation Slope
Granite Quarry - Private Land (S-P)**
Front Range Aggregates, LLC
Parkdale Quarry
Fremont County, Colorado
DRMS Mining Permit M1997-054



**Figure 11 - Stereonet Plot – West Highwall
Granite Quarry - Private Land (W-P)**
Front Range Aggregates, LLC
Parkdale Quarry
Fremont County, Colorado
DRMS Mining Permit M1997-054



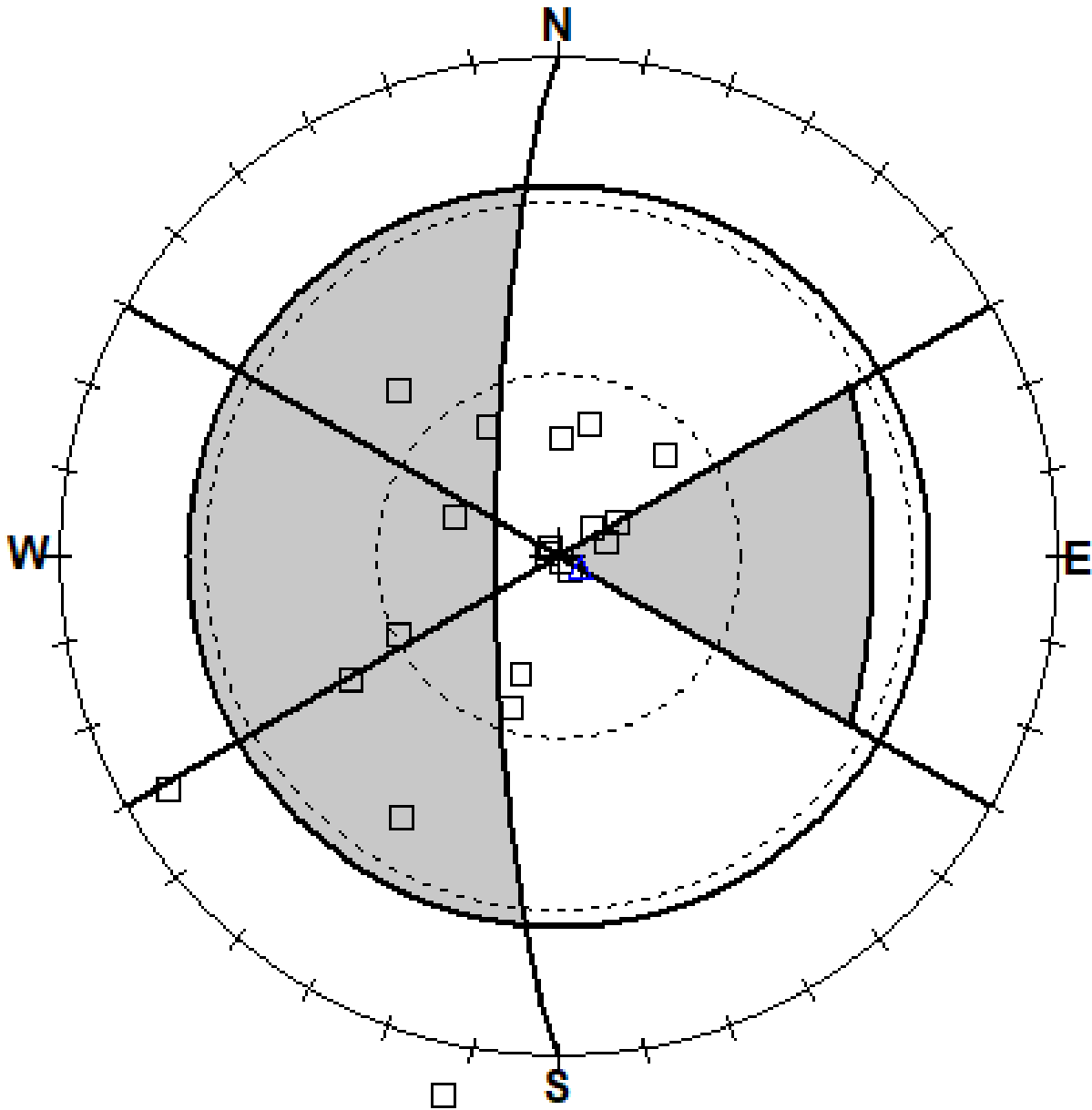
**Figure 12 - Stereonet Plot – West Reclamation Slope
Granite Quarry - Private Land (W-P)**

Front Range Aggregates, LLC

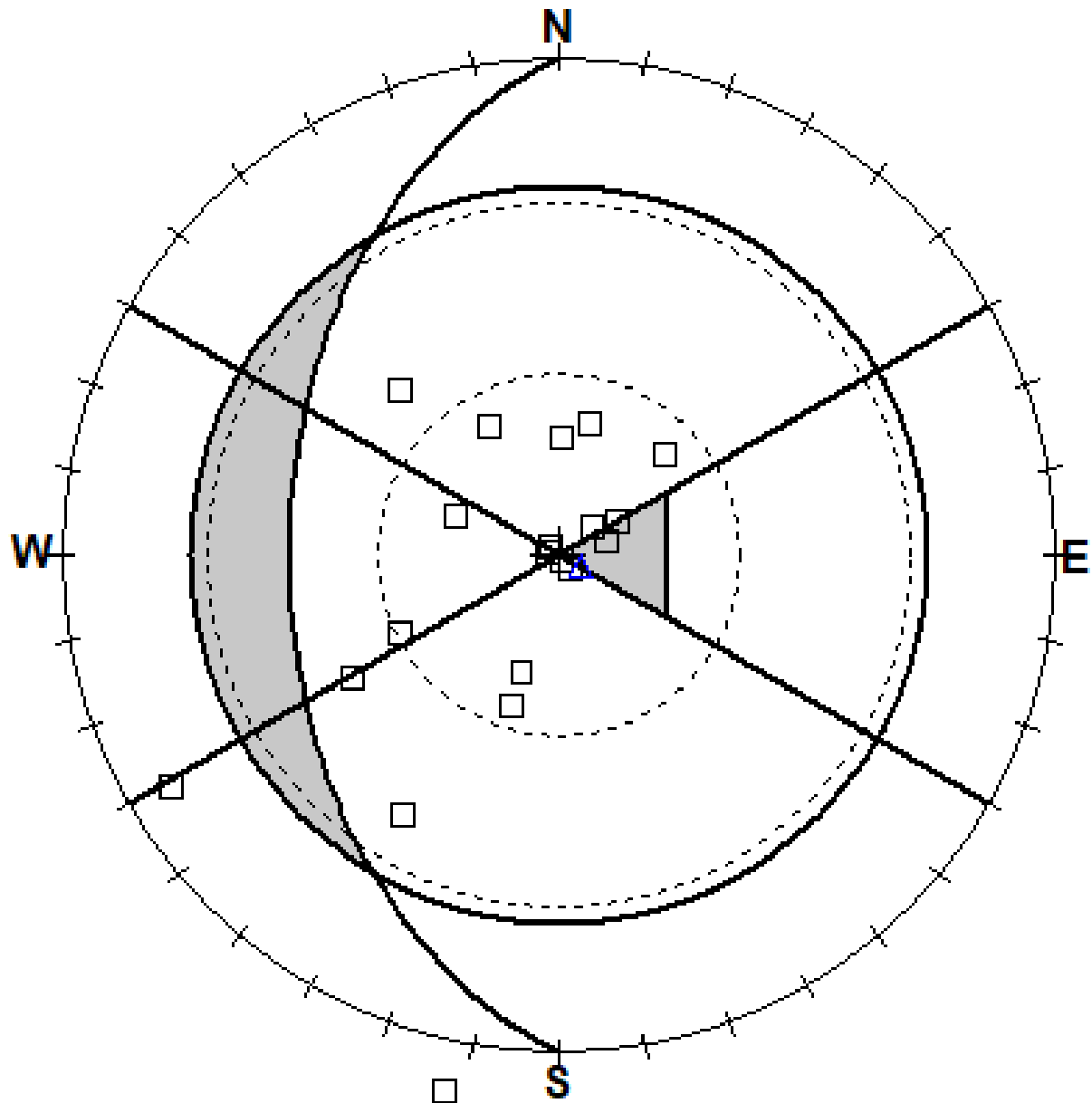
Parkdale Quarry

Fremont County, Colorado

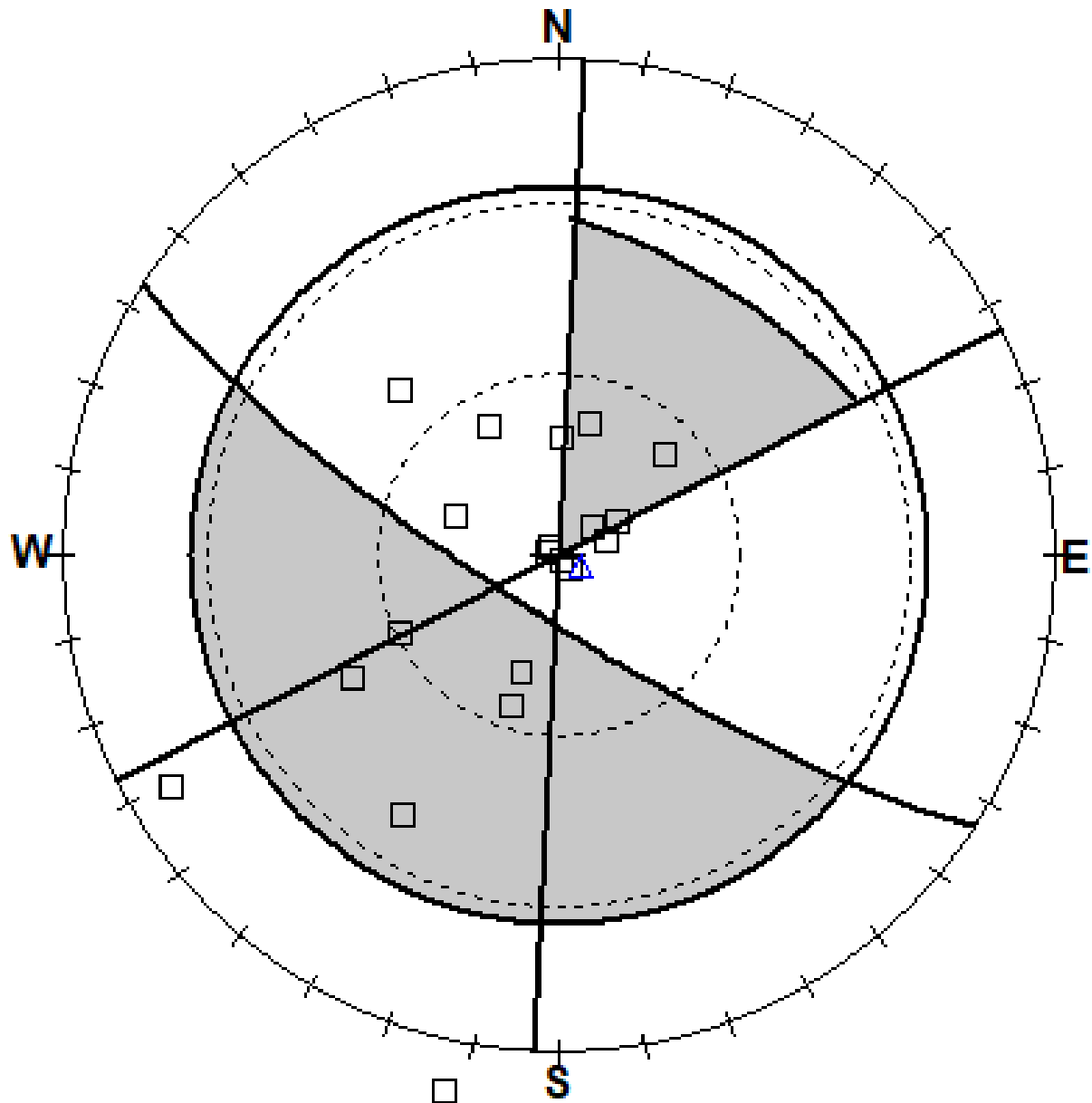
DRMS Mining Permit M1997-054



**Figure 13 - Stereonet Plot – East Highwall
Granite Quarry - BLM Area (E-BLM)**
Front Range Aggregates, LLC
Parkdale Quarry
Fremont County, Colorado
DRMS Mining Permit M1997-054



**Figure 14 - Stereonet Plot – East Reclamation Slope
Granite Quarry - BLM Area (E-BLM)**
Front Range Aggregates, LLC
Parkdale Quarry
Fremont County, Colorado
DRMS Mining Permit M1997-054



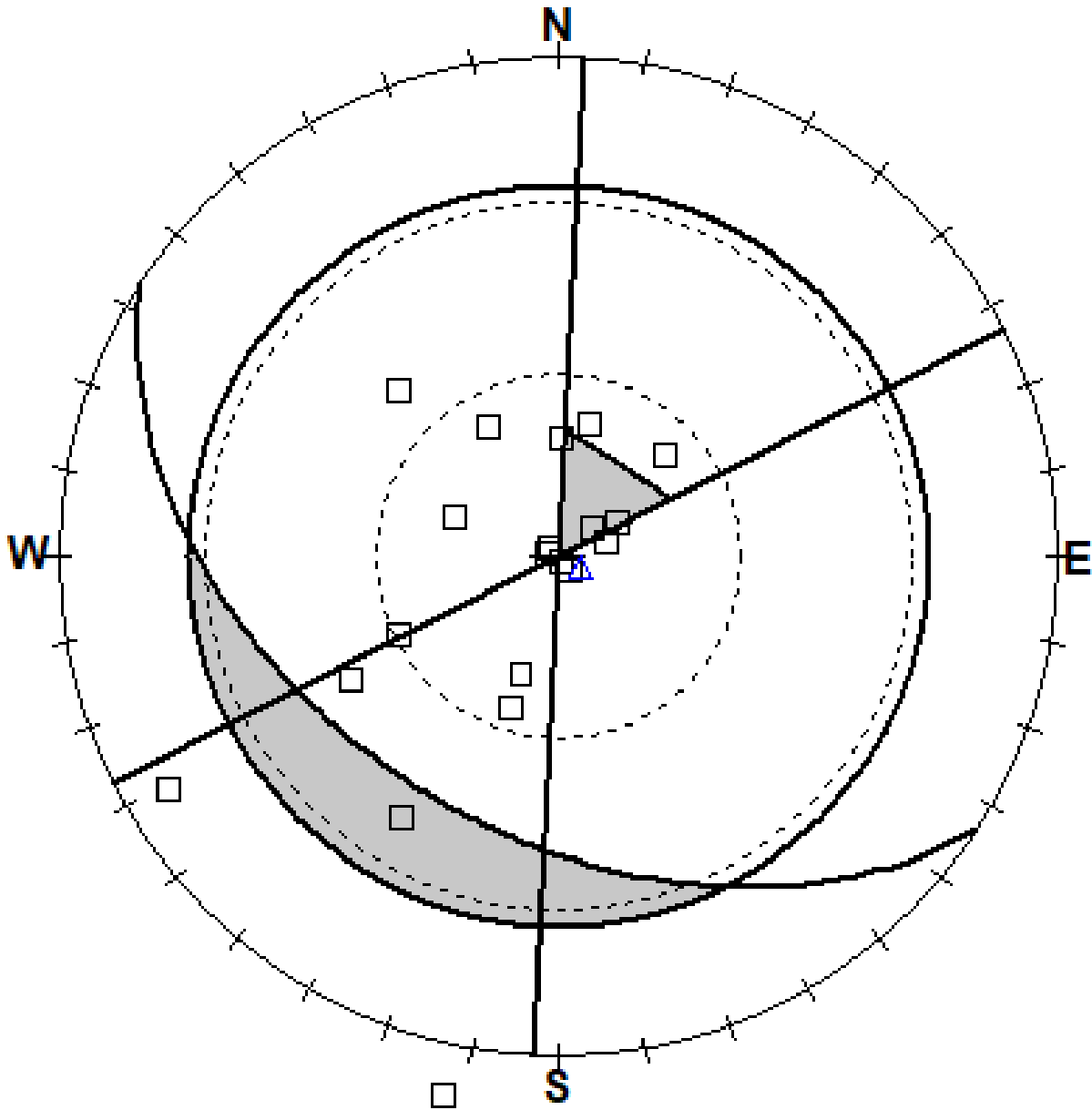
**Figure 15 - Stereonet Plot – Northeast Highwall
Granite Quarry - BLM Area (NE-BLM)**

Front Range Aggregates, LLC

Parkdale Quarry

Fremont County, Colorado

DRMS Mining Permit M1997-054



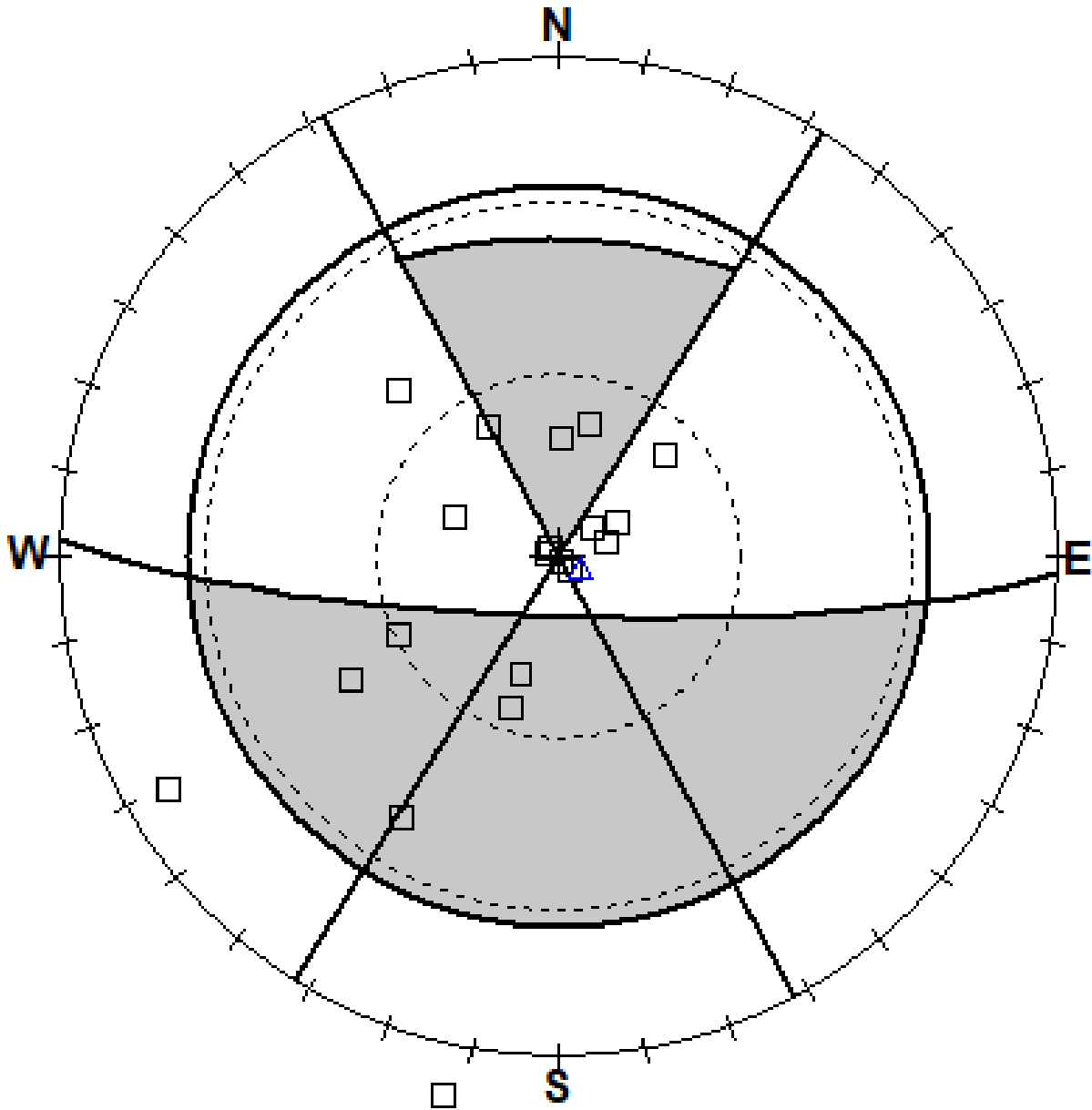
**Figure 16 - Stereonet Plot – Northeast Reclamation Slope
Granite Quarry - BLM Area (NE-BLM)**

Front Range Aggregates, LLC

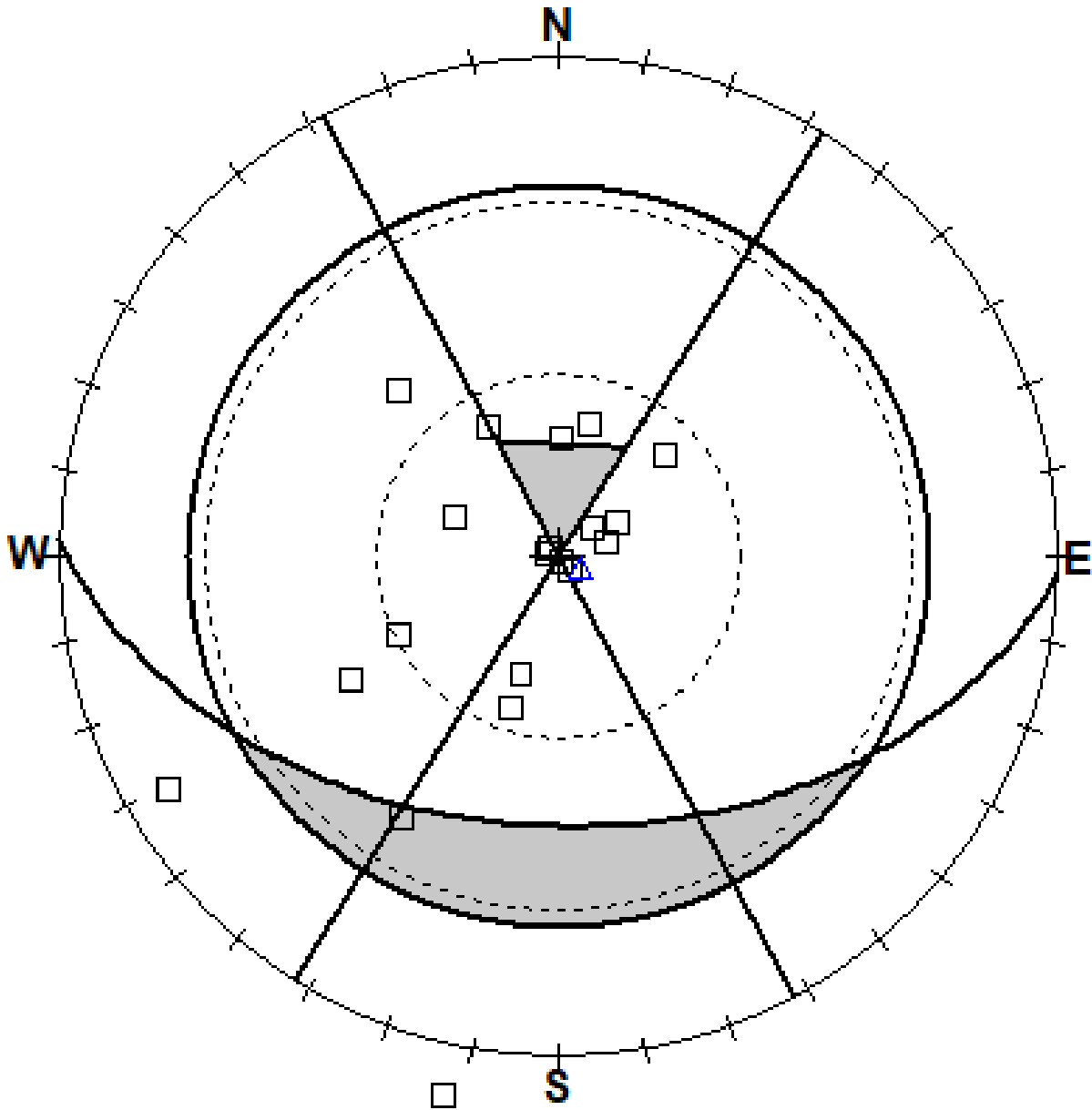
Parkdale Quarry

Fremont County, Colorado

DRMS Mining Permit M1997-054



**Figure 17 - Stereonet Plot – North Highwall
Granite Quarry - BLM Area (N-BLM)**
Front Range Aggregates, LLC
Parkdale Quarry
Fremont County, Colorado
DRMS Mining Permit M1997-054



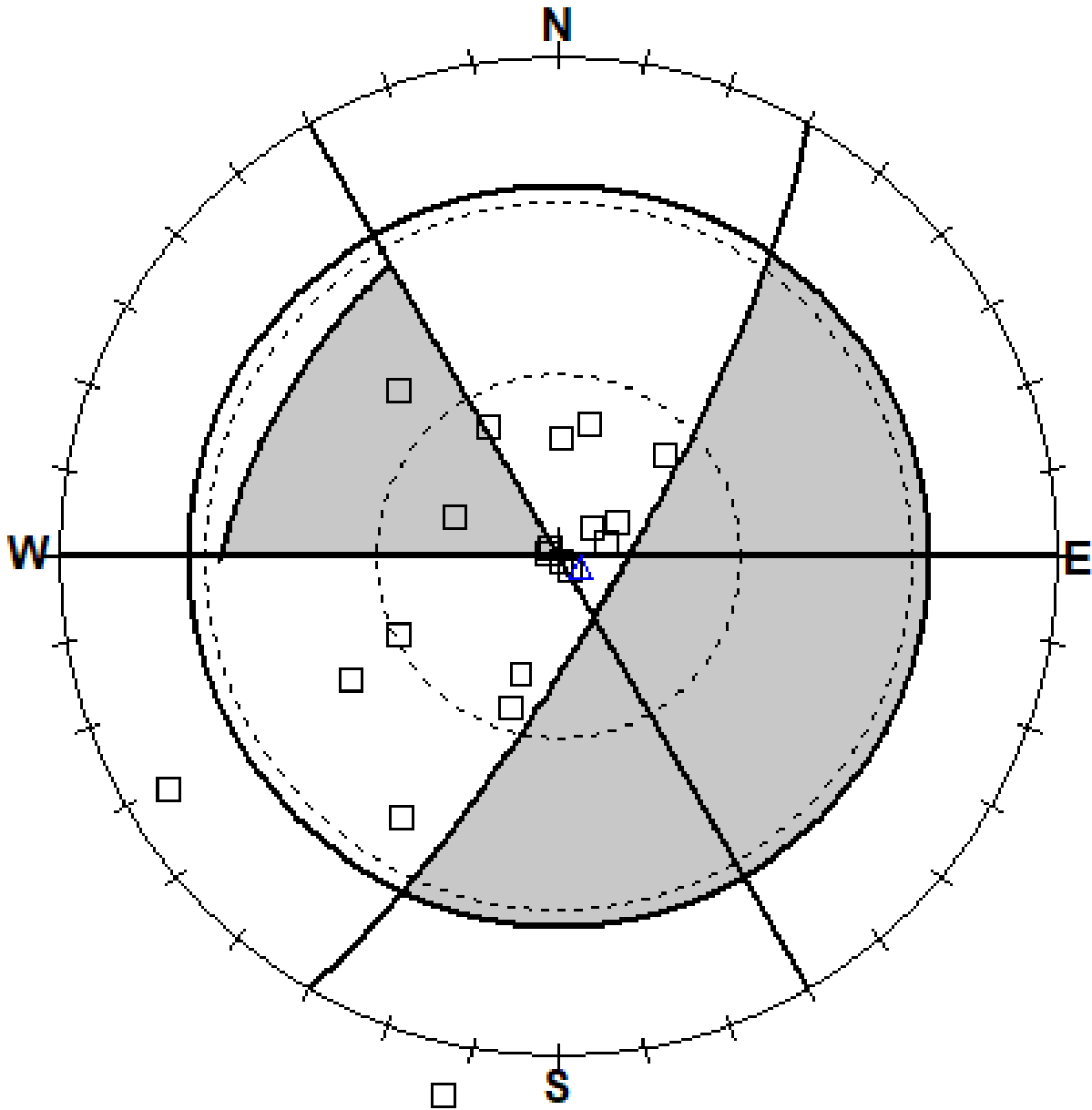
**Figure 18 - Stereonet Plot – North Reclamation Slope
Granite Quarry - BLM Area (N-BLM)**

Front Range Aggregates, LLC

Parkdale Quarry

Fremont County, Colorado

DRMS Mining Permit M1997-054



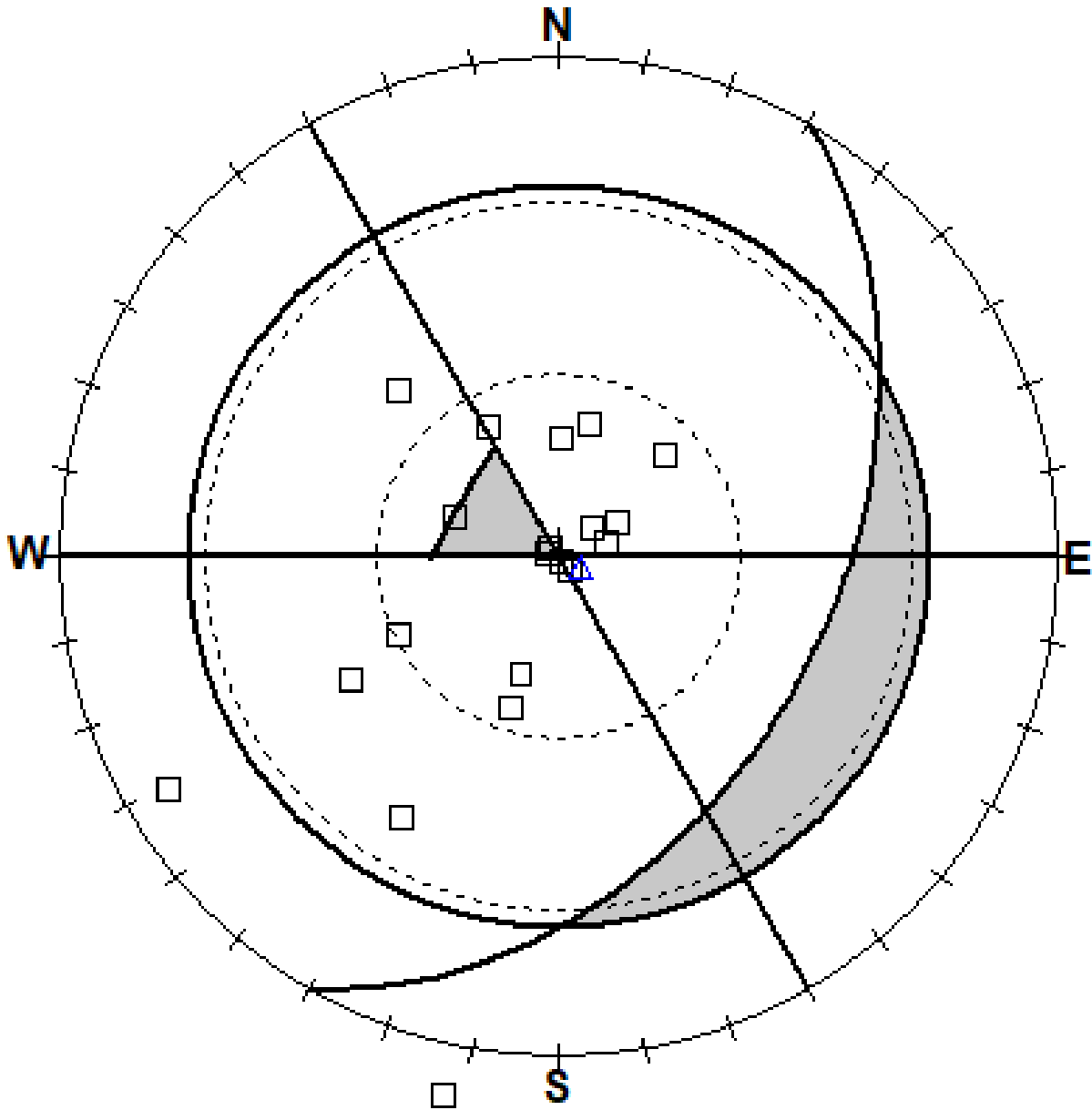
**Figure 19 - Stereonet Plot – Northwest Highwall
Granite Quarry - BLM Area (NW-BLM)**

Front Range Aggregates, LLC

Parkdale Quarry

Fremont County, Colorado

DRMS Mining Permit M1997-054



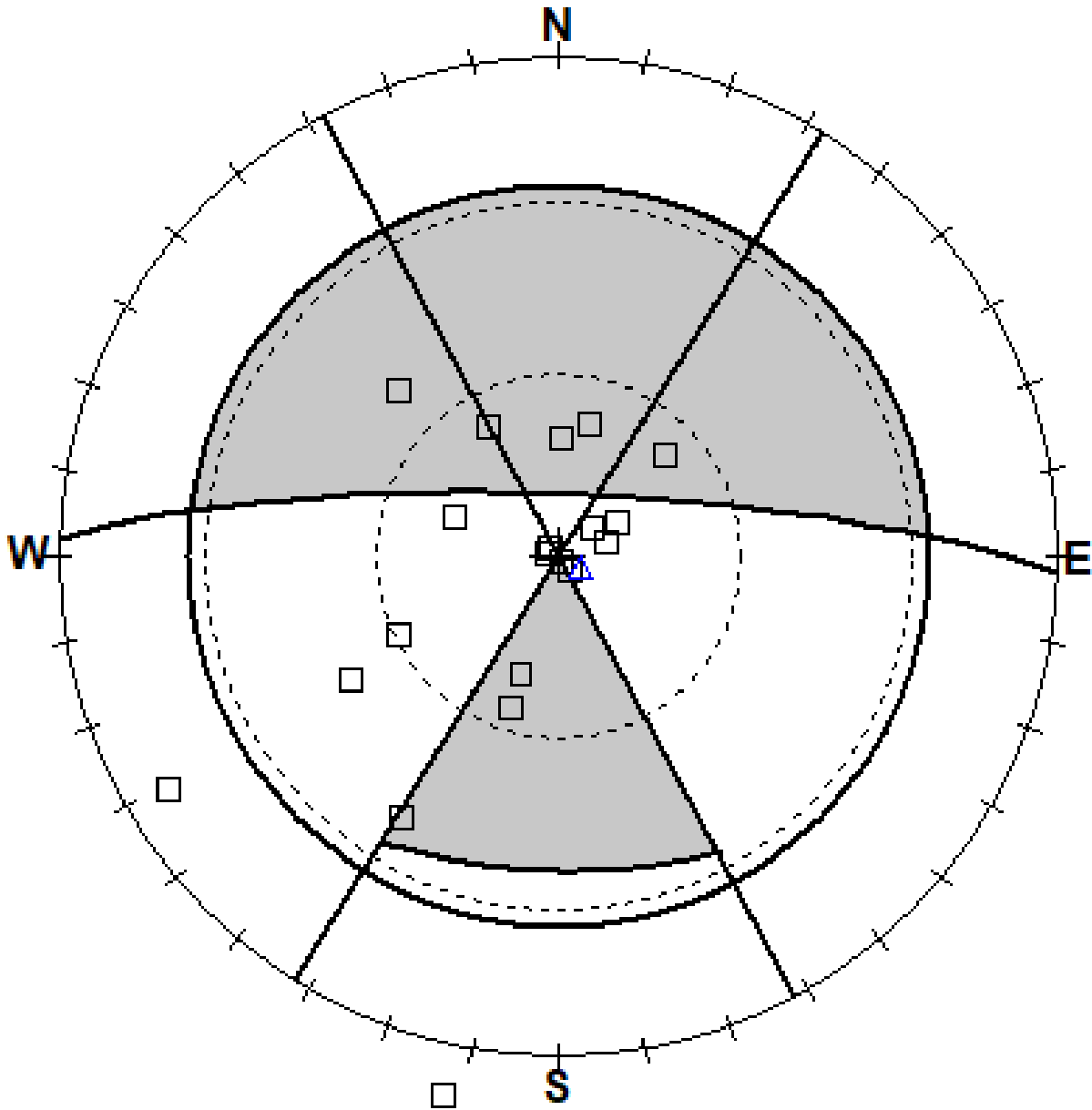
**Figure 20 - Stereonet Plot – Northwest Reclamation Slope
Granite Quarry - BLM Area (NW-BLM)**

Front Range Aggregates, LLC

Parkdale Quarry

Fremont County, Colorado

DRMS Mining Permit M1997-054



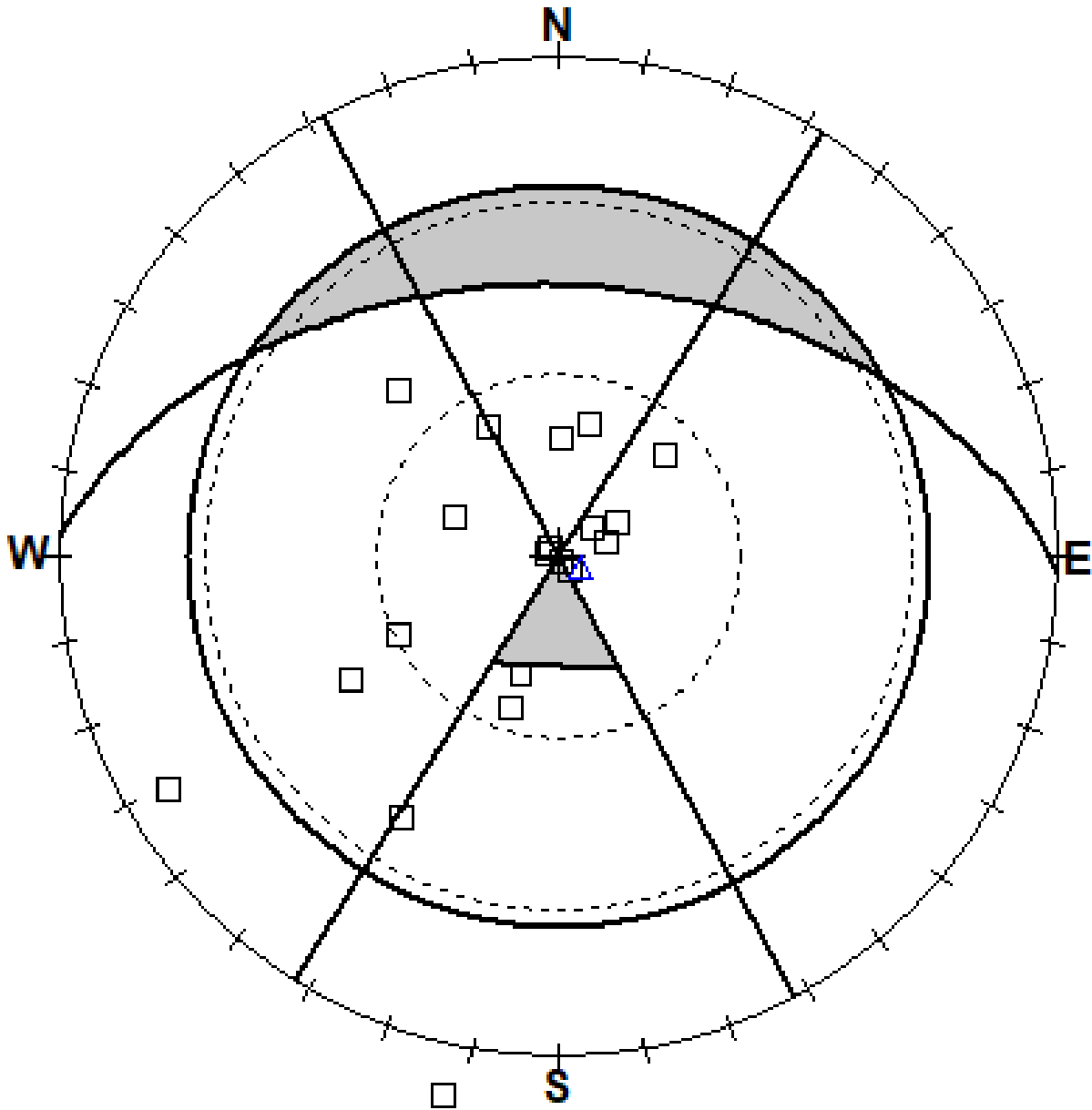
**Figure 21 - Stereonet Plot – South-central Highwall
Granite Quarry - BLM Area (SC-BLM)**

Front Range Aggregates, LLC

Parkdale Quarry

Fremont County, Colorado

DRMS Mining Permit M1997-054



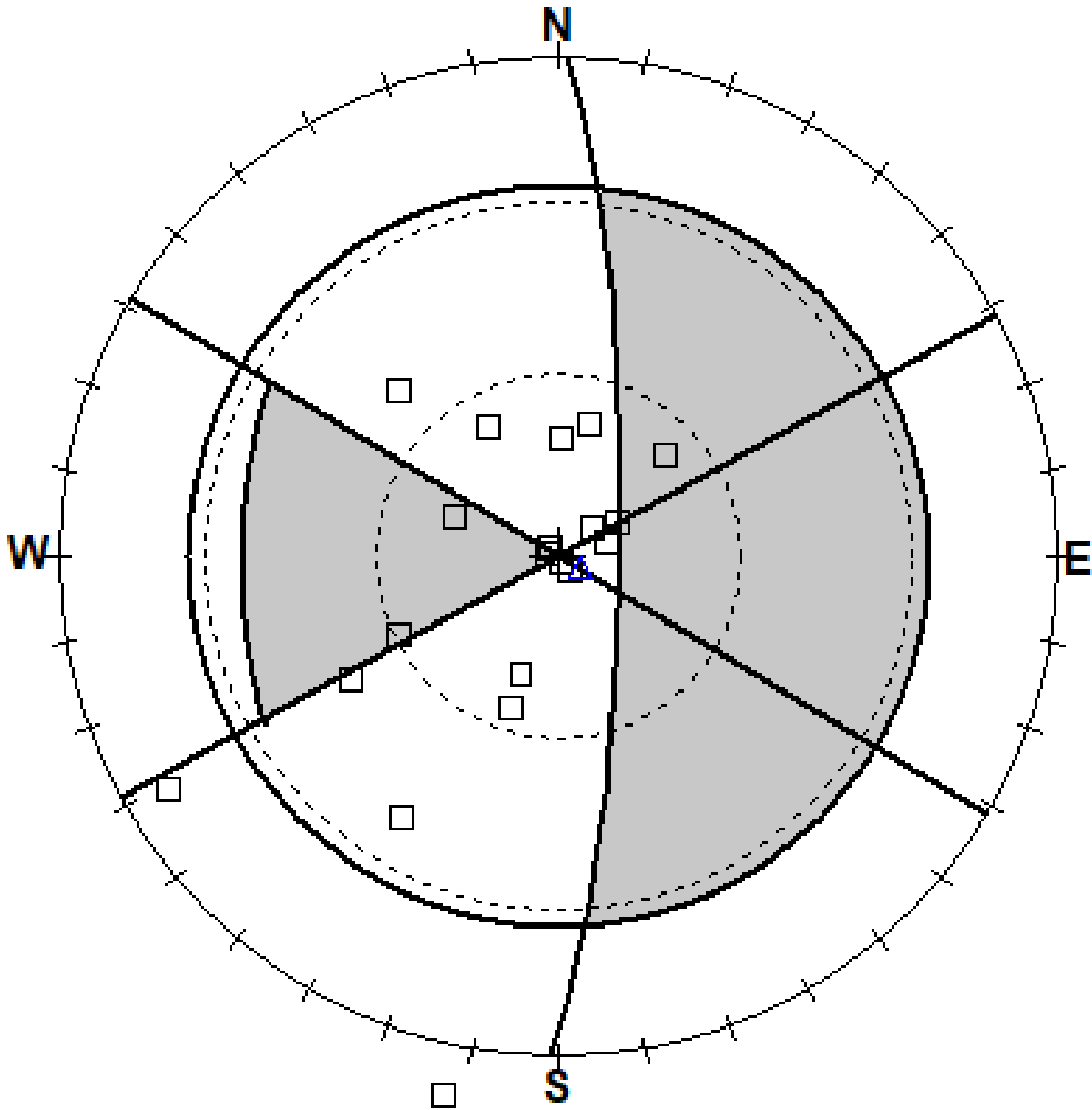
**Figure 22 - Stereonet Plot – South-central Reclamation Slope
Granite Quarry - BLM Area (SC-BLM)**

Front Range Aggregates, LLC

Parkdale Quarry

Fremont County, Colorado

DRMS Mining Permit M1997-054



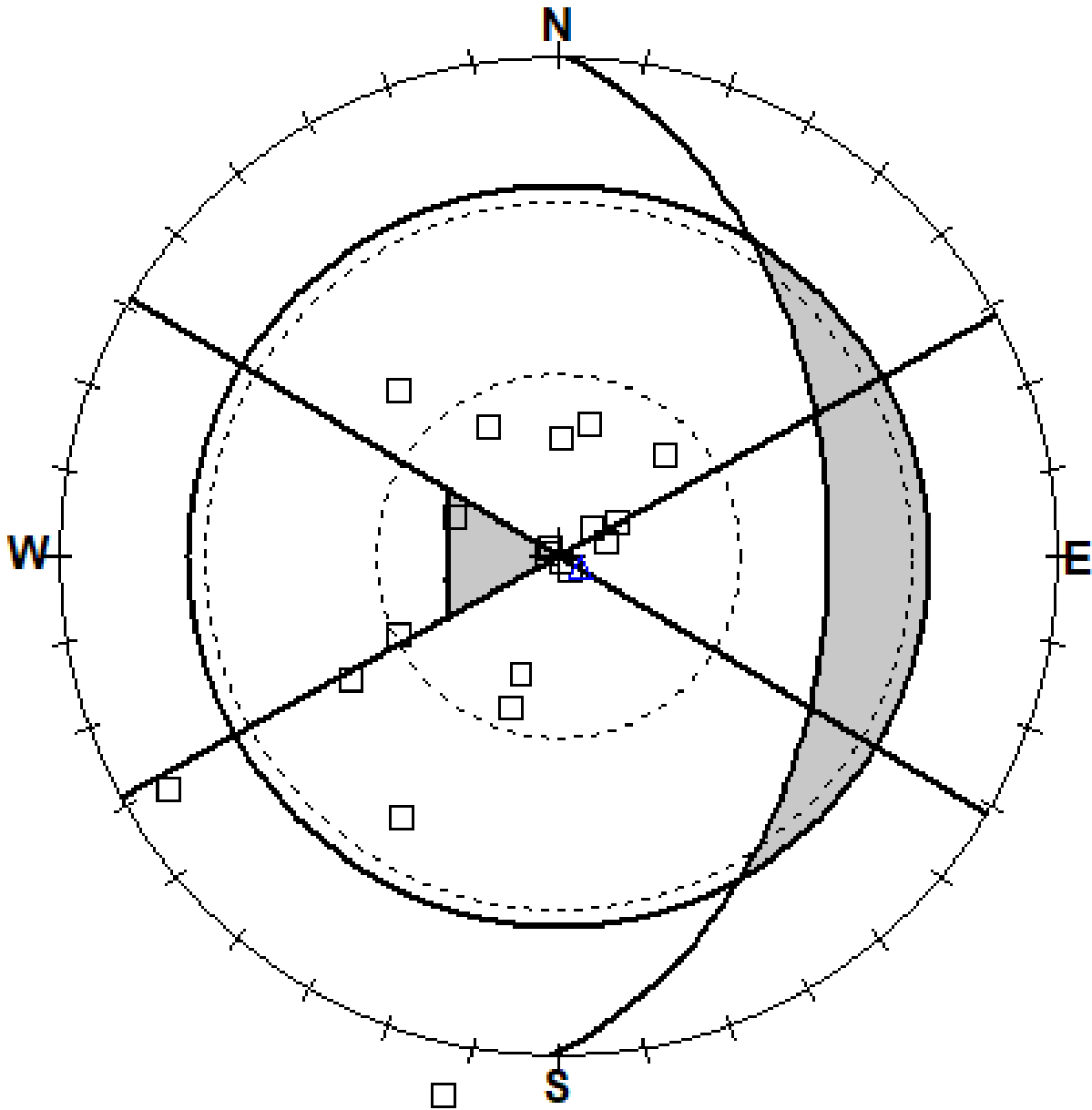
**Figure 23 - Stereonet Plot – Southwest Highwall
Granite Quarry - BLM Area (SW-BLM)**

Front Range Aggregates, LLC

Parkdale Quarry

Fremont County, Colorado

DRMS Mining Permit M1997-054



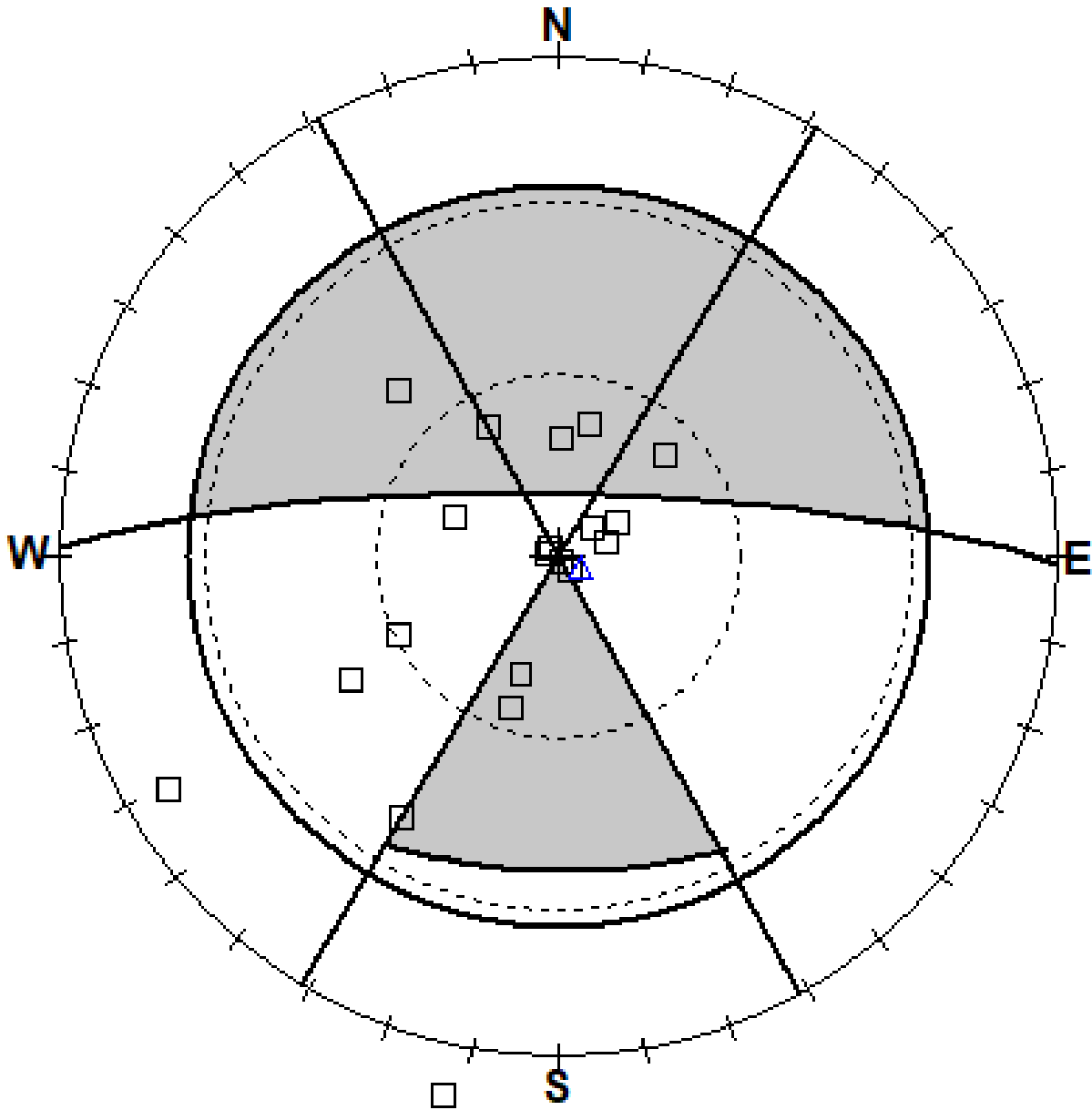
**Figure 24 - Stereonet Plot – Southwest Reclamation Slope
Granite Quarry - BLM Area (SW-BLM)**

Front Range Aggregates, LLC

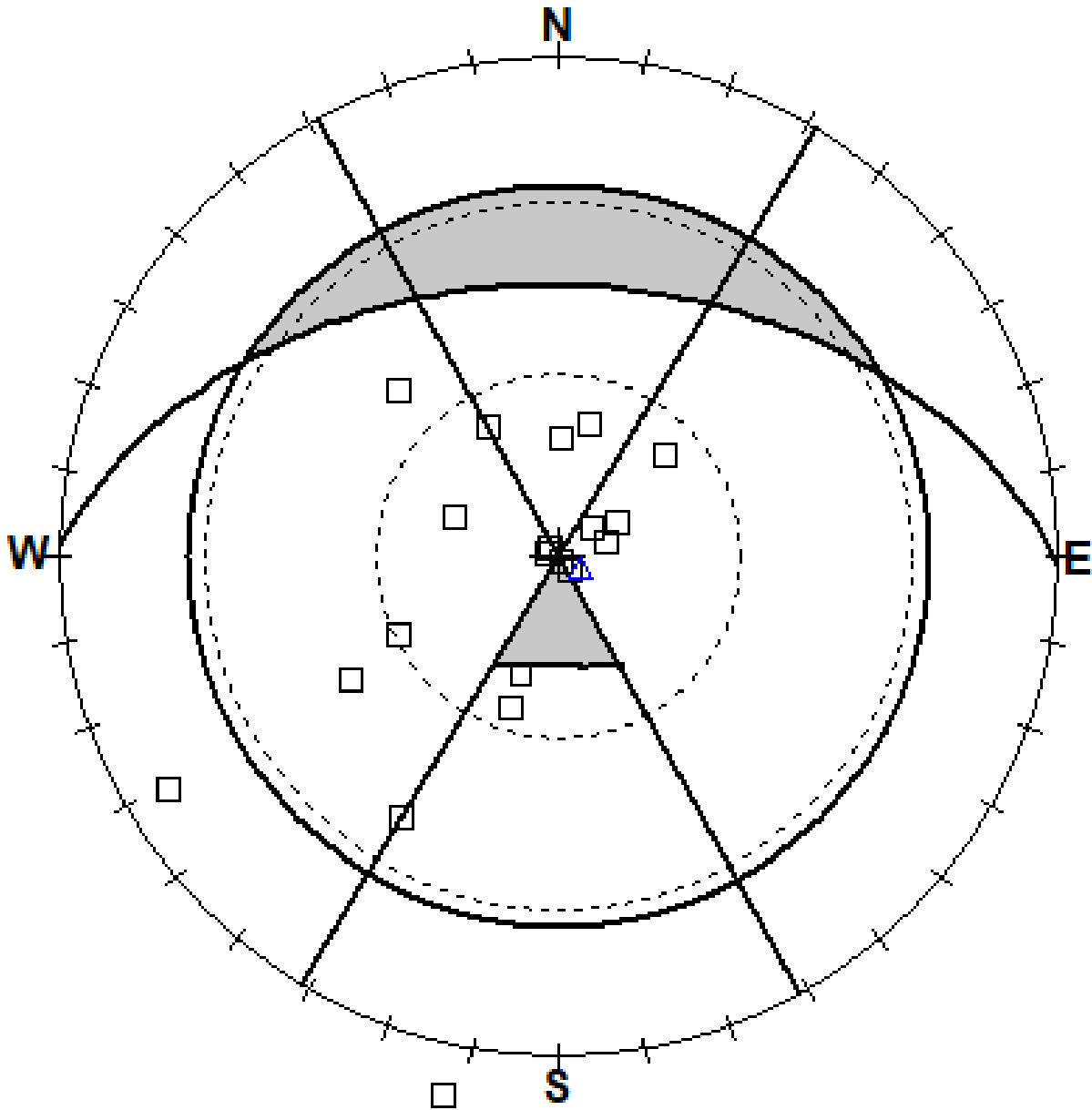
Parkdale Quarry

Fremont County, Colorado

DRMS Mining Permit M1997-054



**Figure 25 - Stereonet Plot – South Highwall
Granite Quarry - BLM Area (S-BLM)**
Front Range Aggregates, LLC
Parkdale Quarry
Fremont County, Colorado
DRMS Mining Permit M1997-054



**Figure 26 - Stereonet Plot – South Reclamation Slope
Granite Quarry - BLM Area (S-BLM)**

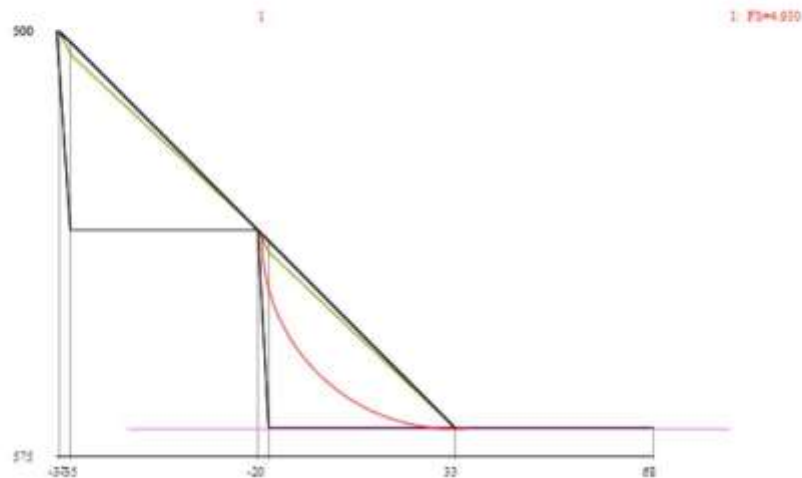
Front Range Aggregates, LLC

Parkdale Quarry

Fremont County, Colorado

DRMS Mining Permit M1997-054

Method:	<input checked="" type="radio"/> Bishop Modified	<input type="radio"/> Ordinary Method of Slices
Seismic Coefficient:	.8 (unitless)	
Seismic Option:	<input checked="" type="radio"/> 1	<input type="radio"/> 2
*) optional		



**Figure 27 - Reclamation Soil Fill Slope
Seismic Stability Failure Analysis Model**

Front Range Aggregates, LLC

Parkdale Quarry

Fremont County, Colorado

DRMS Mining Permit M1997-054

Slip Circle [HELP](#)

Centers		Circumference	
Specified Centers		Search Start Center	
X [ft.]	Y [ft.]	X [ft.]	Y [ft.]
		05	625
- or -		- and -	
		Final Search Grid	
		[ft.]	
		10	
		- or -	
		Toe Point	
		X [ft.]	Y [ft.]
		52.5	600

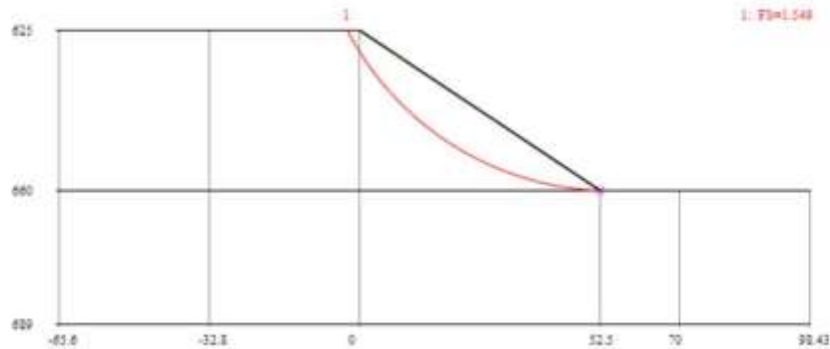
General [HELP](#)

Method: ☒ Bishop Modified ☐ Ordinary Method of Slices

Seismic Coefficient: (unitless)

Seismic Option: ☒ 1 ☐ 2

*) optional



**Figure 28A – Overburden Stockpile Maximum Slope
Static Stability Failure Analysis Model**

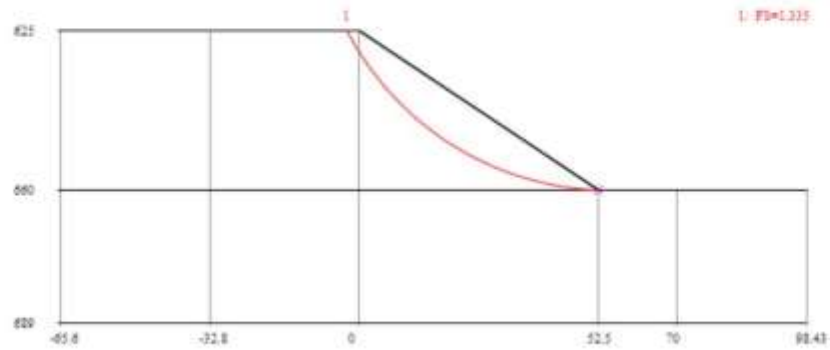
Front Range Aggregates, LLC

Parkdale Quarry

Fremont County, Colorado

DRMS Mining Permit M1997-054

Method:	<input checked="" type="radio"/> Bishop Modified	<input type="radio"/> Ordinary Method of Slices
Seismic Coefficient:	<input type="text" value="08"/> (unitless)	
Seismic Option:	<input checked="" type="radio"/> 1	<input type="radio"/> 2
*) optional		



**Figure 28B – Overburden Stockpile Maximum Slope
Seismic Stability Failure Analysis Model**
Front Range Aggregates, LLC
Parkdale Quarry
Fremont County, Colorado
DRMS Mining Permit M1997-054



Figure 29 – Map Showing Parkdale Quarry Blast Monitor Locations

Front Range Aggregates, LLC
Parkdale Quarry
Fremont County, Colorado
DRMS Mining Permit M1997-054

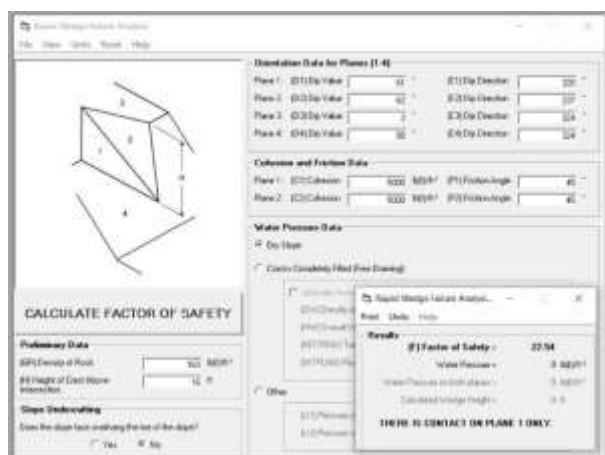
Parkdale Geotechnical Stability Exhibit

Appendix A

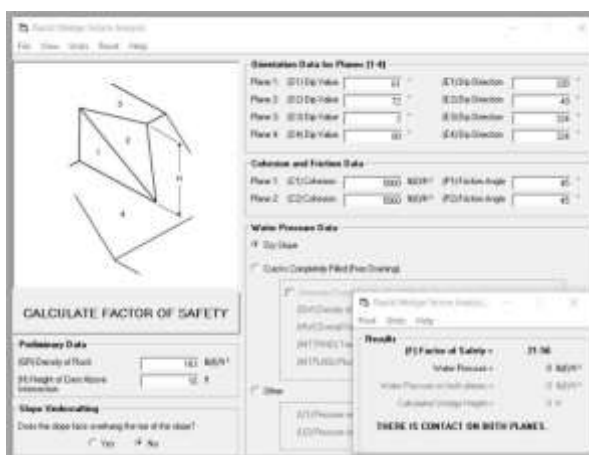
Rockpack III Factor of Safety Analysis Input and Output

Wedge Failure Analysis

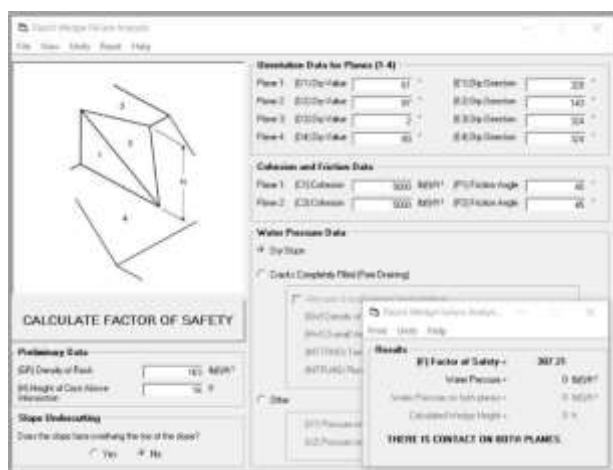
Southeast Slope – Private Land



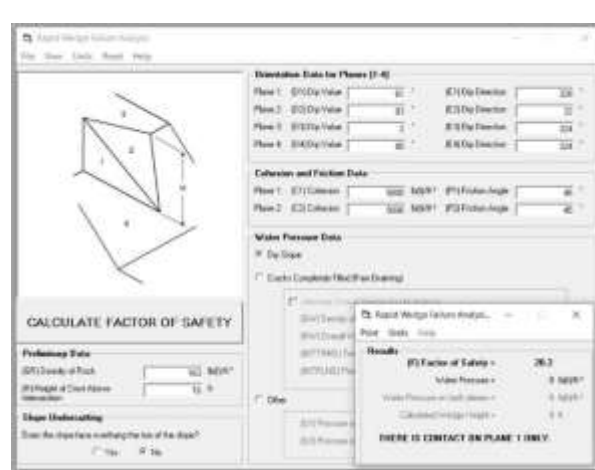
Joint Sets 1, 2



Joint Sets 1, 3



Joint Sets 1, 4



Joint Sets 1, 5



Joint Sets 2, 3



Joint Sets 2, 4

Southeast Slope – Private Land

Observation Data for Planes (1-4)

Plane	J1 Dip Value	J1 Dip Direction	J2 Dip Value	J2 Dip Direction
Plane 1	60	135	60	135
Plane 2	60	135	60	135
Plane 3	60	135	60	135
Plane 4	60	135	60	135

Cohesion and Friction Data

Plane	C1 Cohesion	C1 Friction	C2 Cohesion	C2 Friction
Plane 1	0.000 MPa	0.000 MPa	0.000 MPa	0.000 MPa
Plane 2	0.000 MPa	0.000 MPa	0.000 MPa	0.000 MPa

Water Pressure Data

☒ Dry Slope

☐ Check Completely Filled Free Draining

CALCULATE FACTOR OF SAFETY

Preliminary Data

SPS Density of Rock	SPS Height of Core Above Intersection
155 kg/m ³	15.0

Slope Undercutting

Does the slope face overhang the toe of the slope?

☒ Yes ☐ No

Results

Factor of Safety = 25.35

Water Pressure on Joint Planes = 0.000 MPa

Calculated Bridge Height = 0.0

THERE IS CONTACT ON PLANE 1 ONLY.

Joint Sets 2, 5

Observation Data for Planes (1-4)

Plane	J1 Dip Value	J1 Dip Direction	J2 Dip Value	J2 Dip Direction
Plane 1	60	135	60	135
Plane 2	60	135	60	135
Plane 3	60	135	60	135
Plane 4	60	135	60	135

Cohesion and Friction Data

Plane	C1 Cohesion	C1 Friction	C2 Cohesion	C2 Friction
Plane 1	0.000 MPa	0.000 MPa	0.000 MPa	0.000 MPa
Plane 2	0.000 MPa	0.000 MPa	0.000 MPa	0.000 MPa

Water Pressure Data

☒ Dry Slope

☐ Check Completely Filled Free Draining

CALCULATE FACTOR OF SAFETY

Preliminary Data

SPS Density of Rock	SPS Height of Core Above Intersection
155 kg/m ³	15.0

Slope Undercutting

Does the slope face overhang the toe of the slope?

☒ Yes ☐ No

Results

Factor of Safety = 25.35

Water Pressure on Joint Planes = 0.000 MPa

Calculated Bridge Height = 0.0

THERE IS CONTACT ON PLANE 1 ONLY.

Joint Sets 3, 4

Observation Data for Planes (1-4)

Plane	J1 Dip Value	J1 Dip Direction	J2 Dip Value	J2 Dip Direction
Plane 1	60	135	60	135
Plane 2	60	135	60	135
Plane 3	60	135	60	135
Plane 4	60	135	60	135

Cohesion and Friction Data

Plane	C1 Cohesion	C1 Friction	C2 Cohesion	C2 Friction
Plane 1	0.000 MPa	0.000 MPa	0.000 MPa	0.000 MPa
Plane 2	0.000 MPa	0.000 MPa	0.000 MPa	0.000 MPa

Water Pressure Data

☒ Dry Slope

☐ Check Completely Filled Free Draining

CALCULATE FACTOR OF SAFETY

Preliminary Data

SPS Density of Rock	SPS Height of Core Above Intersection
155 kg/m ³	15.0

Slope Undercutting

Does the slope face overhang the toe of the slope?

☒ Yes ☐ No

Results

Factor of Safety = 25.35

Water Pressure on Joint Planes = 0.000 MPa

Calculated Bridge Height = 0.0

THERE IS CONTACT ON BOTH PLANES.

Joint Sets 3, 5

Observation Data for Planes (1-4)

Plane	J1 Dip Value	J1 Dip Direction	J2 Dip Value	J2 Dip Direction
Plane 1	60	135	60	135
Plane 2	60	135	60	135
Plane 3	60	135	60	135
Plane 4	60	135	60	135

Cohesion and Friction Data

Plane	C1 Cohesion	C1 Friction	C2 Cohesion	C2 Friction
Plane 1	0.000 MPa	0.000 MPa	0.000 MPa	0.000 MPa
Plane 2	0.000 MPa	0.000 MPa	0.000 MPa	0.000 MPa

Water Pressure Data

☒ Dry Slope

☐ Check Completely Filled Free Draining

CALCULATE FACTOR OF SAFETY

Preliminary Data

SPS Density of Rock	SPS Height of Core Above Intersection
155 kg/m ³	15.0

Slope Undercutting

Does the slope face overhang the toe of the slope?

☒ Yes ☐ No

Results

Factor of Safety = 25.35

Water Pressure on Joint Planes = 0.000 MPa

Calculated Bridge Height = 0.0

THERE IS CONTACT ON PLANE 1 ONLY.

Joint Sets 4, 5

South Slope – Private Land

Orientation Data for Planes (1-4)

Plane 1: S1 Dip Value 61° S1 Dip Direction 330°
 Plane 2: S2 Dip Value 32° S2 Dip Direction 220°
 Plane 3: S3 Dip Value 2° S3 Dip Direction 1°
 Plane 4: S4 Dip Value 36° S4 Dip Direction 1°

Cohesion and Friction Data

Plane 1: S1 Cohesion 0.00 kN/m² S1 Friction Angle 45°
 Plane 2: S2 Cohesion 0.00 kN/m² S2 Friction Angle 45°

Water Pressure Data

☒ Dry Slope
☐ Gusher Completely Filled (Free Draining)

Calculate Factor of Safety

Preliminary Data
 SPT Density of Rock 100 kN/m³
 SPT Height of Crest Above Interception 10.0

Slope Undercutting
 Does the slope face overhang the toe of the slope?
☐ Yes ☒ No

Results
 F Factor of Safety = 75.8
 Water Pressure = 0.00 kN/m²
 Calculated Wedge Height = 0.0
 THERE IS CONTACT ON PLANE 2 ONLY.

Joint Sets 1, 2

Orientation Data for Planes (1-4)

Plane 1: S1 Dip Value 61° S1 Dip Direction 330°
 Plane 2: S2 Dip Value 32° S2 Dip Direction 220°
 Plane 3: S3 Dip Value 2° S3 Dip Direction 1°
 Plane 4: S4 Dip Value 36° S4 Dip Direction 1°

Cohesion and Friction Data

Plane 1: S1 Cohesion 0.00 kN/m² S1 Friction Angle 45°
 Plane 2: S2 Cohesion 0.00 kN/m² S2 Friction Angle 45°

Water Pressure Data

☒ Dry Slope
☐ Gusher Completely Filled (Free Draining)

Calculate Factor of Safety

Preliminary Data
 SPT Density of Rock 100 kN/m³
 SPT Height of Crest Above Interception 10.0

Slope Undercutting
 Does the slope face overhang the toe of the slope?
☐ Yes ☒ No

Results
 F Factor of Safety = 24.25
 Water Pressure = 0.00 kN/m²
 Calculated Wedge Height = 0.0
 THERE IS CONTACT ON BOTH PLANES.

Joint Sets 1, 3

Orientation Data for Planes (1-4)

Plane 1: S1 Dip Value 61° S1 Dip Direction 330°
 Plane 2: S2 Dip Value 32° S2 Dip Direction 220°
 Plane 3: S3 Dip Value 2° S3 Dip Direction 1°
 Plane 4: S4 Dip Value 36° S4 Dip Direction 1°

Cohesion and Friction Data

Plane 1: S1 Cohesion 0.00 kN/m² S1 Friction Angle 45°
 Plane 2: S2 Cohesion 0.00 kN/m² S2 Friction Angle 45°

Water Pressure Data

☒ Dry Slope
☐ Gusher Completely Filled (Free Draining)

Calculate Factor of Safety

Preliminary Data
 SPT Density of Rock 100 kN/m³
 SPT Height of Crest Above Interception 10.0

Slope Undercutting
 Does the slope face overhang the toe of the slope?
☐ Yes ☒ No

Results
 F Factor of Safety = 277.41
 Water Pressure = 0.00 kN/m²
 Calculated Wedge Height = 0.0
 THERE IS CONTACT ON BOTH PLANES.

Joint Sets 1, 4

Orientation Data for Planes (1-4)

Plane 1: S1 Dip Value 61° S1 Dip Direction 330°
 Plane 2: S2 Dip Value 32° S2 Dip Direction 220°
 Plane 3: S3 Dip Value 2° S3 Dip Direction 1°
 Plane 4: S4 Dip Value 36° S4 Dip Direction 1°

Cohesion and Friction Data

Plane 1: S1 Cohesion 0.00 kN/m² S1 Friction Angle 45°
 Plane 2: S2 Cohesion 0.00 kN/m² S2 Friction Angle 45°

Water Pressure Data

☒ Dry Slope
☐ Gusher Completely Filled (Free Draining)

Calculate Factor of Safety

Preliminary Data
 SPT Density of Rock 100 kN/m³
 SPT Height of Crest Above Interception 10.0

Slope Undercutting
 Does the slope face overhang the toe of the slope?
☐ Yes ☒ No

Results
 F Factor of Safety = 28.00
 Water Pressure = 0.00 kN/m²
 Calculated Wedge Height = 0.0
 THERE IS CONTACT ON PLANE 1 ONLY.

Joint Sets 1, 5

Orientation Data for Planes (1-4)

Plane 1: S1 Dip Value 61° S1 Dip Direction 330°
 Plane 2: S2 Dip Value 32° S2 Dip Direction 220°
 Plane 3: S3 Dip Value 2° S3 Dip Direction 1°
 Plane 4: S4 Dip Value 36° S4 Dip Direction 1°

Cohesion and Friction Data

Plane 1: S1 Cohesion 0.00 kN/m² S1 Friction Angle 45°
 Plane 2: S2 Cohesion 0.00 kN/m² S2 Friction Angle 45°

Water Pressure Data

☒ Dry Slope
☐ Gusher Completely Filled (Free Draining)

Calculate Factor of Safety

Preliminary Data
 SPT Density of Rock 100 kN/m³
 SPT Height of Crest Above Interception 10.0

Slope Undercutting
 Does the slope face overhang the toe of the slope?
☐ Yes ☒ No

Results
 F Factor of Safety = 151.26
 Water Pressure = 0.00 kN/m²
 Calculated Wedge Height = 0.0
 THERE IS CONTACT ON BOTH PLANES.

Joint Sets 2, 3

Orientation Data for Planes (1-4)

Plane 1: S1 Dip Value 61° S1 Dip Direction 330°
 Plane 2: S2 Dip Value 32° S2 Dip Direction 220°
 Plane 3: S3 Dip Value 2° S3 Dip Direction 1°
 Plane 4: S4 Dip Value 36° S4 Dip Direction 1°

Cohesion and Friction Data

Plane 1: S1 Cohesion 0.00 kN/m² S1 Friction Angle 45°
 Plane 2: S2 Cohesion 0.00 kN/m² S2 Friction Angle 45°

Water Pressure Data

☒ Dry Slope
☐ Gusher Completely Filled (Free Draining)

Calculate Factor of Safety

Preliminary Data
 SPT Density of Rock 100 kN/m³
 SPT Height of Crest Above Interception 10.0

Slope Undercutting
 Does the slope face overhang the toe of the slope?
☐ Yes ☒ No

Results
 F Factor of Safety = 18.97
 Water Pressure = 0.00 kN/m²
 Calculated Wedge Height = 0.0
 THERE IS CONTACT ON BOTH PLANES.

Joint Sets 2, 4

South Slope – Private Land

Orientation Data for Planes (1-4)

Plane	J1 Dip Value	J1 Dip Direction	J2 Dip Value	J2 Dip Direction
Plane 1	87	142	27	32
Plane 2	87	142	27	32
Plane 3	87	142	27	32
Plane 4	87	142	27	32

Cohesion and Friction Data

Plane	C1 Cohesion	C1 Friction Angle	C2 Cohesion	C2 Friction Angle
Plane 1	5000	40	5000	40
Plane 2	5000	40	5000	40

Water Pressure Data

☒ Dry Slope

☐ Double Completely Filled (Free Draining)

CALCULATE FACTOR OF SAFETY

Preliminary Data

Density of Rock: 162 kN/m³

Height of Earth Slope: 10 m

Width of Earth Slope: 10 m

Slope Undercutting

Does the slope have undercutting the top of the slope? ☒ Yes ☐ No

Results

F) Factor of Safety = 25.00

Water Pressure = 0 kN/m²

Water Pressure on both planes = 0 kN/m²

Calculated Wedge Height = 0 m

THERE IS CONTACT ON PLANE 1 ONLY.

Joint Sets 2, 5

Orientation Data for Planes (1-4)

Plane	J1 Dip Value	J1 Dip Direction	J2 Dip Value	J2 Dip Direction
Plane 1	27	32	87	142
Plane 2	87	142	27	32
Plane 3	87	142	27	32
Plane 4	87	142	27	32

Cohesion and Friction Data

Plane	C1 Cohesion	C1 Friction Angle	C2 Cohesion	C2 Friction Angle
Plane 1	5000	40	5000	40
Plane 2	5000	40	5000	40

Water Pressure Data

☒ Dry Slope

☐ Double Completely Filled (Free Draining)

CALCULATE FACTOR OF SAFETY

Preliminary Data

Density of Rock: 162 kN/m³

Height of Earth Slope: 10 m

Width of Earth Slope: 10 m

Slope Undercutting

Does the slope have undercutting the top of the slope? ☒ Yes ☐ No

Results

F) Factor of Safety = 208.57

Water Pressure = 0 kN/m²

Water Pressure on both planes = 0 kN/m²

Calculated Wedge Height = 0 m

THERE IS CONTACT ON PLANE 2 ONLY.

Joint Sets 3, 4

Orientation Data for Planes (1-4)

Plane	J1 Dip Value	J1 Dip Direction	J2 Dip Value	J2 Dip Direction
Plane 1	27	32	87	142
Plane 2	87	142	27	32
Plane 3	87	142	27	32
Plane 4	87	142	27	32

Cohesion and Friction Data

Plane	C1 Cohesion	C1 Friction Angle	C2 Cohesion	C2 Friction Angle
Plane 1	5000	40	5000	40
Plane 2	5000	40	5000	40

Water Pressure Data

☒ Dry Slope

☐ Double Completely Filled (Free Draining)

CALCULATE FACTOR OF SAFETY

Preliminary Data

Density of Rock: 162 kN/m³

Height of Earth Slope: 10 m

Width of Earth Slope: 10 m

Slope Undercutting

Does the slope have undercutting the top of the slope? ☒ Yes ☐ No

Results

F) Factor of Safety = 25.00

Water Pressure = 0 kN/m²

Water Pressure on both planes = 0 kN/m²

Calculated Wedge Height = 0 m

THERE IS CONTACT ON BOTH PLANES.

Joint Sets 3, 5

Orientation Data for Planes (1-4)

Plane	J1 Dip Value	J1 Dip Direction	J2 Dip Value	J2 Dip Direction
Plane 1	87	142	27	32
Plane 2	87	142	27	32
Plane 3	87	142	27	32
Plane 4	87	142	27	32

Cohesion and Friction Data

Plane	C1 Cohesion	C1 Friction Angle	C2 Cohesion	C2 Friction Angle
Plane 1	5000	40	5000	40
Plane 2	5000	40	5000	40

Water Pressure Data

☒ Dry Slope

☐ Double Completely Filled (Free Draining)

CALCULATE FACTOR OF SAFETY

Preliminary Data

Density of Rock: 162 kN/m³

Height of Earth Slope: 10 m

Width of Earth Slope: 10 m

Slope Undercutting

Does the slope have undercutting the top of the slope? ☒ Yes ☐ No

Results

F) Factor of Safety = 25.00

Water Pressure = 0 kN/m²

Water Pressure on both planes = 0 kN/m²

Calculated Wedge Height = 0 m

THERE IS CONTACT ON PLANE 1 ONLY.

Joint Sets 4, 5

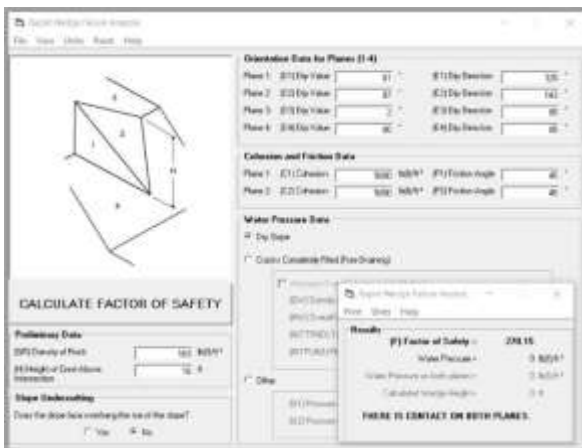
West Slope – Private Land



Joint Sets 1, 2



Joint Sets 1, 3



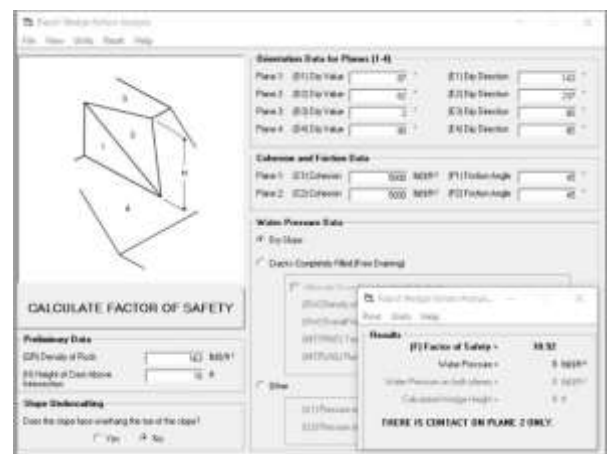
Joint Sets 1, 4



Joint Sets 1, 5



Joint Sets 2, 3



Joint Sets 2, 4

West Slope – Private Land

Orientation Data for Planes (1-4)

Plane	S1 Dip Value	S1 Dip Direction	S2 Dip Value	S2 Dip Direction
Plane 1	27	143		
Plane 2	33	33		
Plane 3	3	45		
Plane 4	45	35		

Collection and Friction Data

Plane	S21 Cohesion	S21 Friction Angle	S22 Cohesion	S22 Friction Angle
Plane 1	0.000 MPa	45		
Plane 2	0.000 MPa	45		

Water Pressure Data

☒ Dry Slope

☐ Check Completely Filled (Free Draining)

Calculate Factor of Safety

Preliminary Data

SPT Density of Rock: 500 kg/m³

SPT Height of Crest Above Intersection: 10 m

Slope Undercutting

Does the slope have undercutting the toe of the slope?

☒ Yes ☐ No

Results

(F) Factor of Safety = 8

Water Pressure on both planes = 0 MPa

Calculated Wedge Height = 0 m

CONTACT IS LOST ON BOTH PLANES. THE WEDGE FLUTS AS A RESULT OF WATER PRESSURE ACTING ON PLANES 1 AND 2.

Joint Sets 2, 5

Orientation Data for Planes (1-4)

Plane	S1 Dip Value	S1 Dip Direction	S2 Dip Value	S2 Dip Direction
Plane 1	12	45		
Plane 2	33	103		
Plane 3	3	45		
Plane 4	45	35		

Collection and Friction Data

Plane	S21 Cohesion	S21 Friction Angle	S22 Cohesion	S22 Friction Angle
Plane 1	0.000 MPa	45		
Plane 2	0.000 MPa	45		

Water Pressure Data

☒ Dry Slope

☐ Check Completely Filled (Free Draining)

Calculate Factor of Safety

Preliminary Data

SPT Density of Rock: 500 kg/m³

SPT Height of Crest Above Intersection: 10 m

Slope Undercutting

Does the slope have undercutting the toe of the slope?

☒ Yes ☐ No

Results

(F) Factor of Safety = 0.2

Water Pressure on both planes = 0 MPa

Calculated Wedge Height = 0 m

THERE IS CONTACT ON BOTH PLANES.

Joint Sets 3, 4

Orientation Data for Planes (1-4)

Plane	S1 Dip Value	S1 Dip Direction	S2 Dip Value	S2 Dip Direction
Plane 1	12	45		
Plane 2	33	33		
Plane 3	3	45		
Plane 4	45	35		

Collection and Friction Data

Plane	S21 Cohesion	S21 Friction Angle	S22 Cohesion	S22 Friction Angle
Plane 1	0.000 MPa	45		
Plane 2	0.000 MPa	45		

Water Pressure Data

☒ Dry Slope

☐ Check Completely Filled (Free Draining)

Calculate Factor of Safety

Preliminary Data

SPT Density of Rock: 500 kg/m³

SPT Height of Crest Above Intersection: 10 m

Slope Undercutting

Does the slope have undercutting the toe of the slope?

☒ Yes ☐ No

Results

(F) Factor of Safety = 18.03

Water Pressure on both planes = 0 MPa

Calculated Wedge Height = 0 m

THERE IS CONTACT ON BOTH PLANES.

Joint Sets 3, 5

Orientation Data for Planes (1-4)

Plane	S1 Dip Value	S1 Dip Direction	S2 Dip Value	S2 Dip Direction
Plane 1	27	143		
Plane 2	33	33		
Plane 3	3	45		
Plane 4	45	35		

Collection and Friction Data

Plane	S21 Cohesion	S21 Friction Angle	S22 Cohesion	S22 Friction Angle
Plane 1	0.000 MPa	45		
Plane 2	0.000 MPa	45		

Water Pressure Data

☒ Dry Slope

☐ Check Completely Filled (Free Draining)

Calculate Factor of Safety

Preliminary Data

SPT Density of Rock: 500 kg/m³

SPT Height of Crest Above Intersection: 10 m

Slope Undercutting

Does the slope have undercutting the toe of the slope?

☒ Yes ☐ No

Results

(F) Factor of Safety = 8

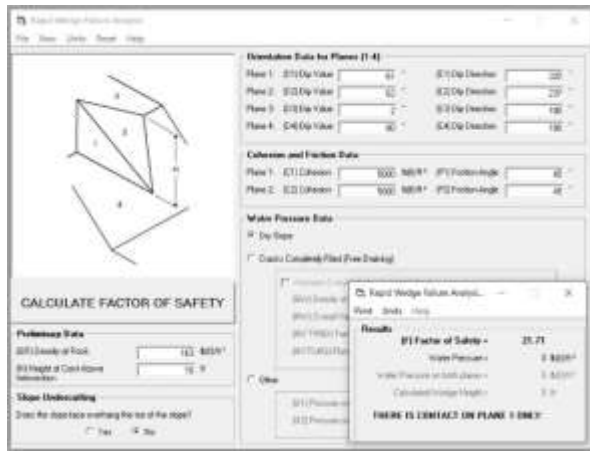
Water Pressure on both planes = 0 MPa

Calculated Wedge Height = 0 m

CONTACT IS LOST ON BOTH PLANES. THE WEDGE FLUTS AS A RESULT OF WATER PRESSURE ACTING ON PLANES 1 AND 2.

Joint Sets 4, 5

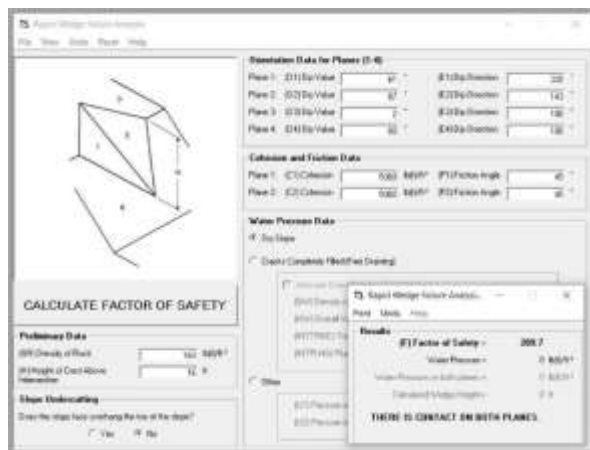
North Slope – Private Land



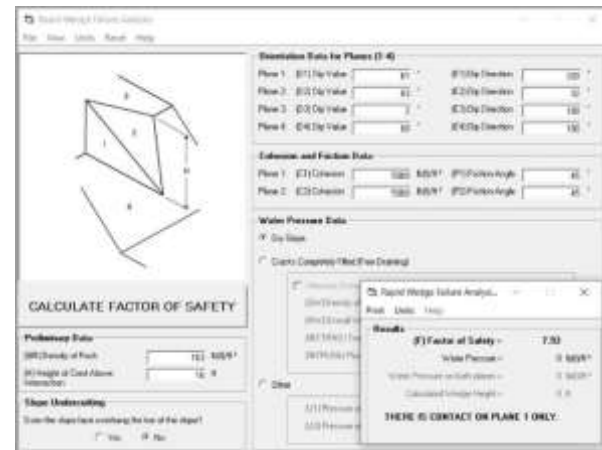
Joint Sets 1, 2



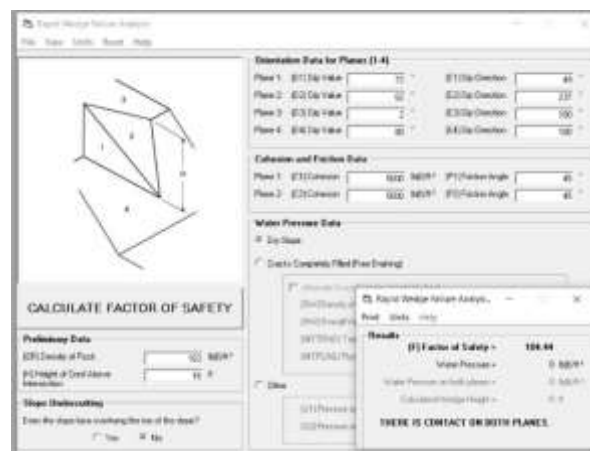
Joint Sets 1, 3



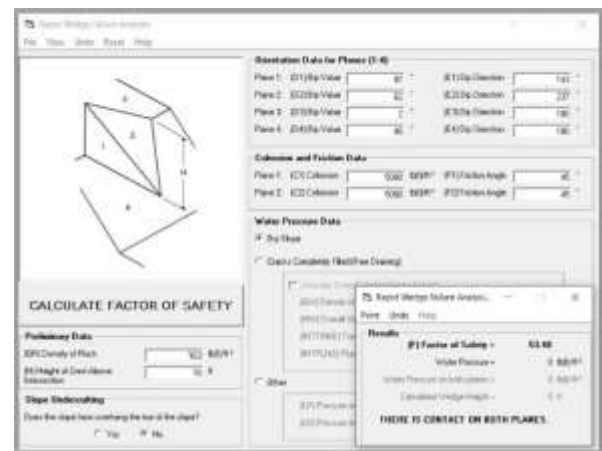
Joint Sets 1, 4



Joint Sets 1, 5



Joint Sets 2, 3



Joint Sets 2, 4

North Slope – Private Land

Orientation Data for Planes (1-4)

Plane	J1/J2/J3/J4/J5	Dip Value	Dip Direction
Plane 1	J2	32	142
Plane 2	J5	32	32
Plane 3	J1	32	142
Plane 4	J4	32	142

Cohesion and Friction Data

Plane	J1/J2/J3/J4/J5	Cohesion	Friction Angle
Plane 1	J2	1000	40°
Plane 2	J5	1000	40°

Water Pressure Data

By Slope ☒ Check Completely Filled (Free Draining)

Calculate Factor of Safety

Preliminary Data

SR Density of Rock: 265 kN/m³
SR Height of Crest Above Intersection: 10 m

Slope Undercutting

Does the slope face overhang the toe of the slope? ☒ Yes ☐ No

Results

Factor of Safety = 10.8
Water Pressure = 0 kN/m²
Calculated Undercut Height = 0 m
THERE IS CONTACT ON PLANE 2 ONLY.

Joint Sets 2, 5

Orientation Data for Planes (1-4)

Plane	J1/J2/J3/J4/J5	Dip Value	Dip Direction
Plane 1	J3	32	40
Plane 2	J4	32	142
Plane 3	J2	32	142
Plane 4	J1	32	142

Cohesion and Friction Data

Plane	J1/J2/J3/J4/J5	Cohesion	Friction Angle
Plane 1	J3	1000	40°
Plane 2	J4	1000	40°

Water Pressure Data

By Slope ☒ Check Completely Filled (Free Draining)

Calculate Factor of Safety

Preliminary Data

SR Density of Rock: 265 kN/m³
SR Height of Crest Above Intersection: 10 m

Slope Undercutting

Does the slope face overhang the toe of the slope? ☒ Yes ☐ No

Results

Factor of Safety = 11.96
Water Pressure = 0 kN/m²
Calculated Undercut Height = 0 m
THERE IS CONTACT ON PLANE 1 ONLY.

Joint Sets 3, 4

Orientation Data for Planes (1-4)

Plane	J1/J2/J3/J4/J5	Dip Value	Dip Direction
Plane 1	J3	32	40
Plane 2	J5	32	32
Plane 3	J2	32	142
Plane 4	J4	32	142

Cohesion and Friction Data

Plane	J1/J2/J3/J4/J5	Cohesion	Friction Angle
Plane 1	J3	1000	40°
Plane 2	J5	1000	40°

Water Pressure Data

By Slope ☒ Check Completely Filled (Free Draining)

Calculate Factor of Safety

Preliminary Data

SR Density of Rock: 265 kN/m³
SR Height of Crest Above Intersection: 10 m

Slope Undercutting

Does the slope face overhang the toe of the slope? ☒ Yes ☐ No

Results

Factor of Safety = 107.87
Water Pressure = 0 kN/m²
Calculated Undercut Height = 0 m
THERE IS CONTACT ON BOTH PLANES.

Joint Sets 3, 5

Orientation Data for Planes (1-4)

Plane	J1/J2/J3/J4/J5	Dip Value	Dip Direction
Plane 1	J4	32	142
Plane 2	J5	32	32
Plane 3	J2	32	142
Plane 4	J1	32	142

Cohesion and Friction Data

Plane	J1/J2/J3/J4/J5	Cohesion	Friction Angle
Plane 1	J4	1000	40°
Plane 2	J5	1000	40°

Water Pressure Data

By Slope ☒ Check Completely Filled (Free Draining)

Calculate Factor of Safety

Preliminary Data

SR Density of Rock: 265 kN/m³
SR Height of Crest Above Intersection: 10 m

Slope Undercutting

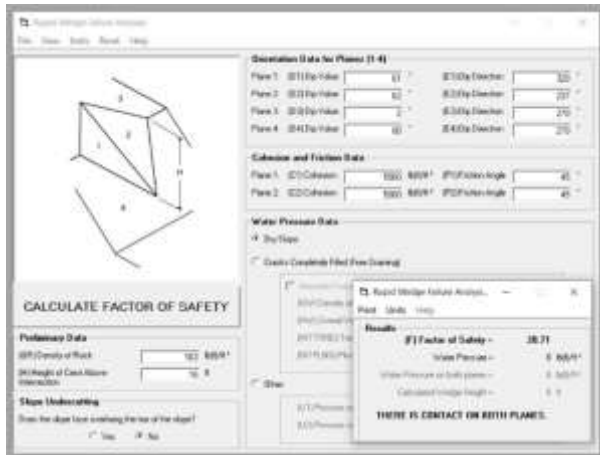
Does the slope face overhang the toe of the slope? ☒ Yes ☐ No

Results

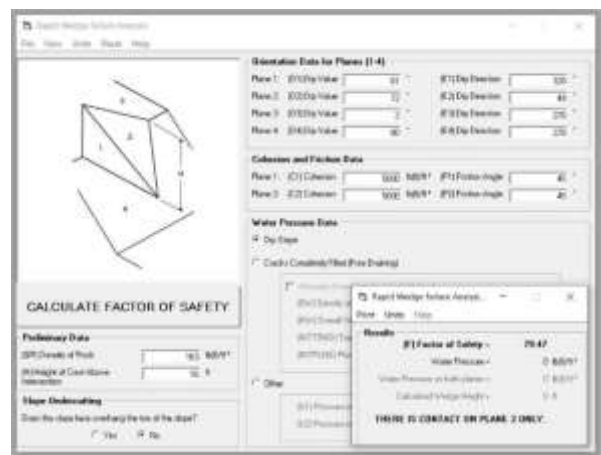
Factor of Safety = 10.8
Water Pressure = 0 kN/m²
Calculated Undercut Height = 0 m
THERE IS CONTACT ON PLANE 1 ONLY.

Joint Sets 4, 5

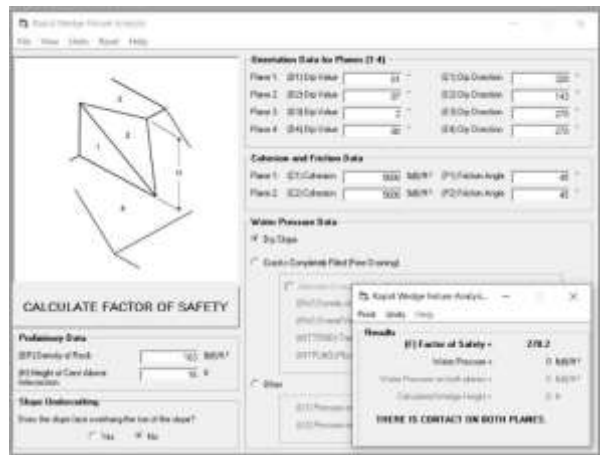
East Slope – BLM Land



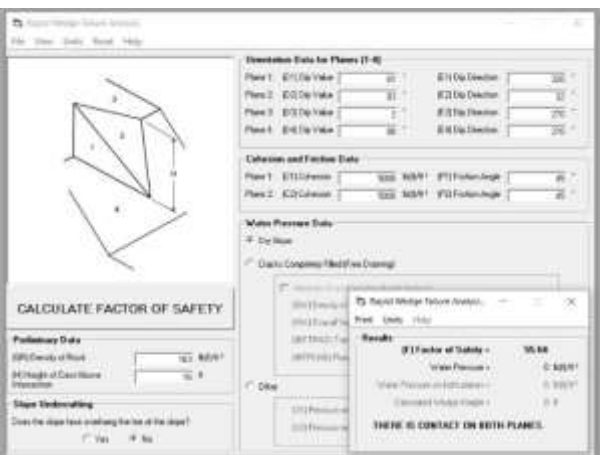
Joint Sets 1, 2



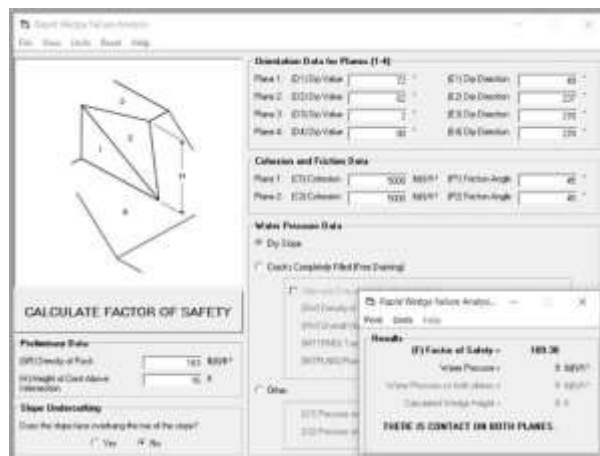
Joint Sets 1, 3



Joint Sets 1, 4



Joint Sets 1, 5



Joint Sets 2, 3



Joint Sets 2, 4

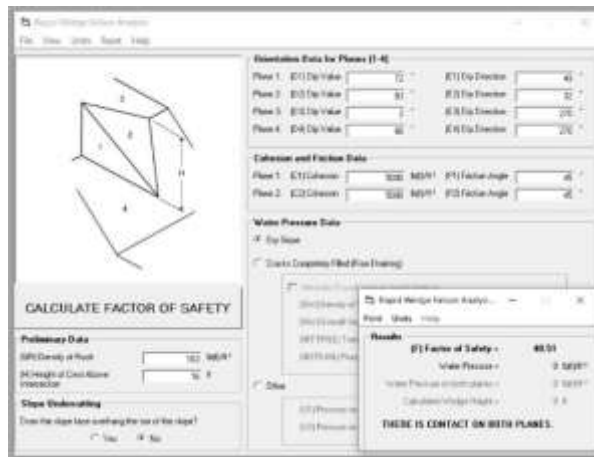
East Slope – BLM Land



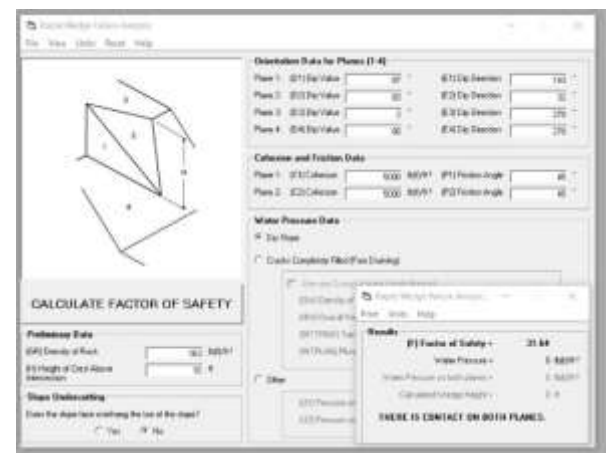
Joint Sets 2, 5



Joint Sets 3, 4



Joint Sets 3, 5



Joint Sets 4, 5

Northeast Slope – BLM Land

Orientation Data for Planes (1-4)

Plane	Dip Value	Dip Direction
Plane 1	61°	200°
Plane 2	62°	207°
Plane 3	63°	213°
Plane 4	64° <td 215°	

Extension and Friction Data

Plane	Cohesion	Friction Angle
Plane 1	5000 N/m²	45°
Plane 2	5000 N/m²	45°

Water Pressure Data

☐ Dip Slope

☒ Check Completely Filled Free Draining

Results

(F) Factor of Safety = **16.85**

Water Pressure = 0 N/m²

Water Pressure on both planes = 0 N/m²

Calculated Wedge Height = 0 ft

There is CONTACT ON PLANE 2 ONLY.

Joint Sets 1, 2

Orientation Data for Planes (1-4)

Plane	Dip Value	Dip Direction
Plane 1	61°	200°
Plane 2	62°	207°
Plane 3	63°	213°
Plane 4	64°	215°

Extension and Friction Data

Plane	Cohesion	Friction Angle
Plane 1	5000 N/m²	45°
Plane 2	5000 N/m²	45°

Water Pressure Data

☐ Dip Slope

☒ Check Completely Filled Free Draining

Results

(F) Factor of Safety = **14.85**

Water Pressure = 0 N/m²

Water Pressure on both planes = 0 N/m²

Calculated Wedge Height = 0 ft

There is CONTACT ON BOTH PLANES.

Joint Sets 1, 3

Orientation Data for Planes (1-4)

Plane	Dip Value	Dip Direction
Plane 1	61°	200°
Plane 2	62°	207°
Plane 3	63°	213°
Plane 4	64°	215°

Extension and Friction Data

Plane	Cohesion	Friction Angle
Plane 1	5000 N/m²	45°
Plane 2	5000 N/m²	45°

Water Pressure Data

☐ Dip Slope

☒ Check Completely Filled Free Draining

Results

(F) Factor of Safety = **20.28**

Water Pressure = 0 N/m²

Water Pressure on both planes = 0 N/m²

Calculated Wedge Height = 0 ft

There is CONTACT ON PLANE 2 ONLY.

Joint Sets 1, 4

Orientation Data for Planes (1-4)

Plane	Dip Value	Dip Direction
Plane 1	61°	200°
Plane 2	62°	207°
Plane 3	63°	213°
Plane 4	64°	215°

Extension and Friction Data

Plane	Cohesion	Friction Angle
Plane 1	5000 N/m²	45°
Plane 2	5000 N/m²	45°

Water Pressure Data

☐ Dip Slope

☒ Check Completely Filled Free Draining

Results

(F) Factor of Safety = **20.28**

Water Pressure = 0 N/m²

Water Pressure on both planes = 0 N/m²

Calculated Wedge Height = 0 ft

There is CONTACT ON PLANE 2 ONLY.

Joint Sets 1, 5

Orientation Data for Planes (1-4)

Plane	Dip Value	Dip Direction
Plane 1	61°	200°
Plane 2	62°	207°
Plane 3	63°	213°
Plane 4	64°	215°

Extension and Friction Data

Plane	Cohesion	Friction Angle
Plane 1	5000 N/m²	45°
Plane 2	5000 N/m²	45°

Water Pressure Data

☐ Dip Slope

☒ Check Completely Filled Free Draining

Results

(F) Factor of Safety = **20.26**

Water Pressure = 0 N/m²

Water Pressure on both planes = 0 N/m²

Calculated Wedge Height = 0 ft

There is CONTACT ON BOTH PLANES.

Joint Sets 2, 3

Orientation Data for Planes (1-4)

Plane	Dip Value	Dip Direction
Plane 1	61°	200°
Plane 2	62°	207°
Plane 3	63°	213°
Plane 4	64°	215°

Extension and Friction Data

Plane	Cohesion	Friction Angle
Plane 1	5000 N/m²	45°
Plane 2	5000 N/m²	45°

Water Pressure Data

☐ Dip Slope

☒ Check Completely Filled Free Draining

Results

(F) Factor of Safety = **20.48**

Water Pressure = 0 N/m²

Water Pressure on both planes = 0 N/m²

Calculated Wedge Height = 0 ft

There is CONTACT ON BOTH PLANES.

Joint Sets 2, 4

Northeast Slope – BLM Land

Orientation Data for Planes (1-4)

Plane	Dip Value	Dip Direction
Plane 1	87	141
Plane 2	87	35
Plane 3	2	213
Plane 4	85	213

Cohesion and Friction Data

Plane	Cohesion	Friction Angle
Plane 1	5000 lb/ft ²	45°
Plane 2	5000 lb/ft ²	45°

Water Pressure Data

☒ Dry Slope

☐ Check Completely Filled (Free Draining)

Results

(F) Factor of Safety = 26.27

Water Pressure = 0 lb/ft²

Water Pressure at Soil Surface = 0 lb/ft²

Calculated Wedge Height = 0 ft

THERE IS CONTACT ON BOTH PLANES

Preliminary Data

(S) Density of Rock = 153 lb/ft³

(H) Height of Cast Above Intersection = 15 ft

Slope Undercutting

Does the slope face overhang the toe of the slope? ☐ Yes ☒ No

Joint Sets 2, 5

Orientation Data for Planes (1-4)

Plane	Dip Value	Dip Direction
Plane 1	12	45
Plane 2	87	141
Plane 3	87	35
Plane 4	85	213

Cohesion and Friction Data

Plane	Cohesion	Friction Angle
Plane 1	5000 lb/ft ²	45°
Plane 2	5000 lb/ft ²	45°

Water Pressure Data

☒ Dry Slope

☐ Check Completely Filled (Free Draining)

Results

(F) Factor of Safety = 12.12

Water Pressure = 0 lb/ft²

Water Pressure at Soil Surface = 0 lb/ft²

Calculated Wedge Height = 0 ft

THERE IS CONTACT ON PLANE 1 ONLY

Preliminary Data

(S) Density of Rock = 153 lb/ft³

(H) Height of Cast Above Intersection = 15 ft

Slope Undercutting

Does the slope face overhang the toe of the slope? ☐ Yes ☒ No

Joint Sets 3, 4

Orientation Data for Planes (1-4)

Plane	Dip Value	Dip Direction
Plane 1	22	43
Plane 2	83	35
Plane 3	2	213
Plane 4	85	213

Cohesion and Friction Data

Plane	Cohesion	Friction Angle
Plane 1	5000 lb/ft ²	45°
Plane 2	5000 lb/ft ²	45°

Water Pressure Data

☒ Dry Slope

☐ Check Completely Filled (Free Draining)

Results

(F) Factor of Safety = 1.54

Water Pressure = 0 lb/ft²

Water Pressure at Soil Surface = 0 lb/ft²

Calculated Wedge Height = 0 ft

THERE IS CONTACT ON PLANE 1 ONLY

Preliminary Data

(S) Density of Rock = 153 lb/ft³

(H) Height of Cast Above Intersection = 15 ft

Slope Undercutting

Does the slope face overhang the toe of the slope? ☐ Yes ☒ No

Joint Sets 3, 5

Orientation Data for Planes (1-4)

Plane	Dip Value	Dip Direction
Plane 1	87	141
Plane 2	87	35
Plane 3	2	213
Plane 4	85	213

Cohesion and Friction Data

Plane	Cohesion	Friction Angle
Plane 1	5000 lb/ft ²	45°
Plane 2	5000 lb/ft ²	45°

Water Pressure Data

☒ Dry Slope

☐ Check Completely Filled (Free Draining)

Results

(F) Factor of Safety = 26.27

Water Pressure = 0 lb/ft²

Water Pressure at Soil Surface = 0 lb/ft²

Calculated Wedge Height = 0 ft

THERE IS CONTACT ON BOTH PLANES

Preliminary Data

(S) Density of Rock = 153 lb/ft³

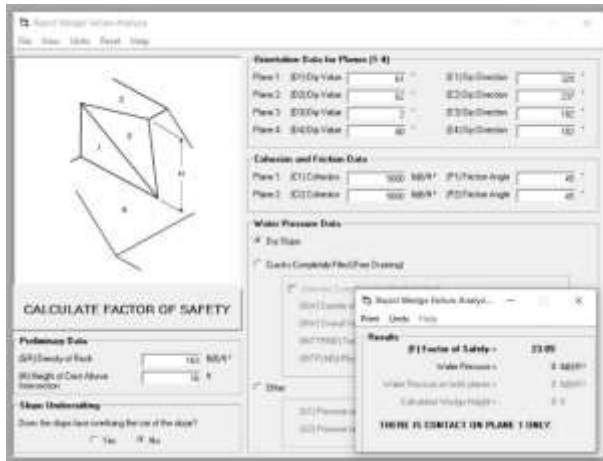
(H) Height of Cast Above Intersection = 15 ft

Slope Undercutting

Does the slope face overhang the toe of the slope? ☐ Yes ☒ No

Joint Sets 4, 5

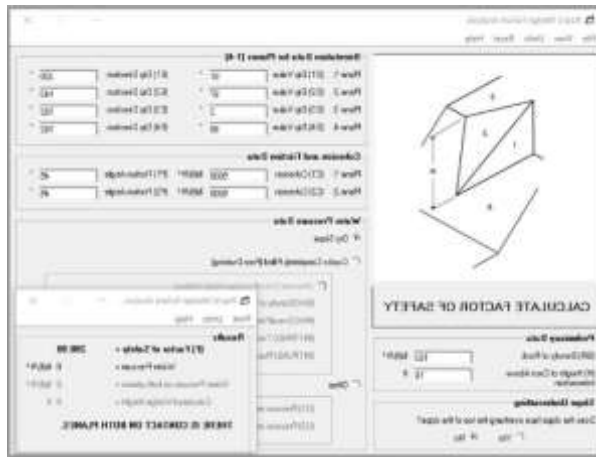
North Slope – BLM Land



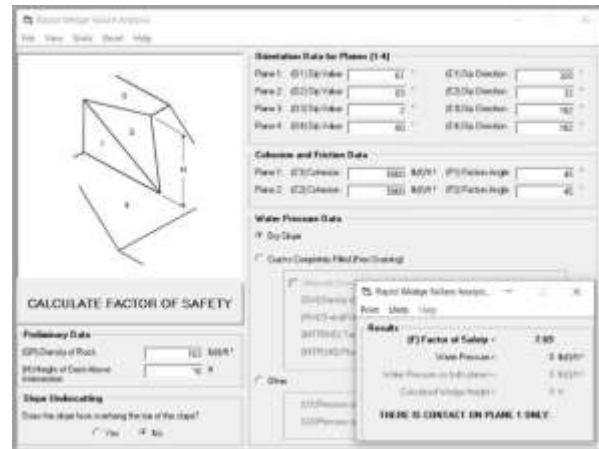
Joint Sets 1, 2



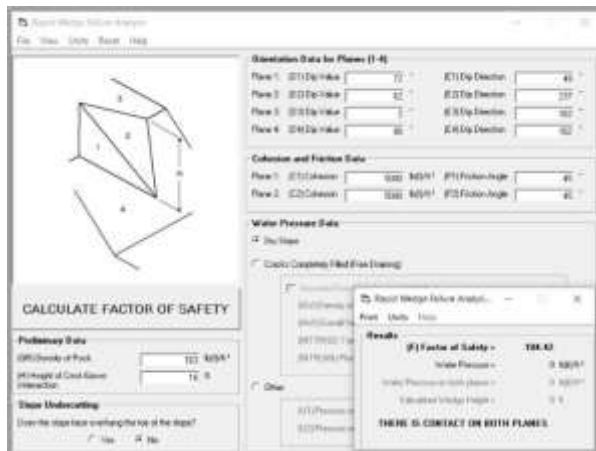
Joint Sets 1, 3



Joint Sets 1, 4



Joint Sets 1, 5



Joint Sets 2, 3



Joint Sets 2, 4

North Slope – BLM Land

Orientation Data for Planes (1-4)

Plane	J2 Dip Value	J2 Dip Direction	J5 Dip Value	J5 Dip Direction
Plane 1	27	143		
Plane 2	33	30		
Plane 3	2	143		
Plane 4	30	143		

Cohesion and Friction Data

Plane	C21 Cohesion	J2/Friction Angle	C22 Cohesion	J5/Friction Angle
Plane 1	3000	45		
Plane 2	3000	45		

Water Pressure Data

Diap. Slope

☒ Check Completely Filled Free Draining

CALCULATE FACTOR OF SAFETY

Preliminary Data

J2 Density of Rock: 163 kN/m³

J5 Height of Crest Above Intersection: 10.0

Slope Undercutting

Does the slope base overhang the toe of the slope? ☐ Yes ☒ No

Results

J2 Factor of Safety = 17.18

Water Pressure = 0 kN/m²

Slope Projection on both planes = 0.0

Calculated bridge height = 0.0

THERE IS CONTACT ON PLANE 2 ONLY.

Joint Sets 2, 5

Orientation Data for Planes (1-4)

Plane	J3 Dip Value	J3 Dip Direction	J4 Dip Value	J4 Dip Direction
Plane 1	11	43		
Plane 2	37	143		
Plane 3	2	143		
Plane 4	30	143		

Cohesion and Friction Data

Plane	C31 Cohesion	J3/Friction Angle	C32 Cohesion	J4/Friction Angle
Plane 1	3000	45		
Plane 2	3000	45		

Water Pressure Data

Diap. Slope

☒ Check Completely Filled Free Draining

CALCULATE FACTOR OF SAFETY

Preliminary Data

J3 Density of Rock: 163 kN/m³

J4 Height of Crest Above Intersection: 10.0

Slope Undercutting

Does the slope base overhang the toe of the slope? ☐ Yes ☒ No

Results

J3 Factor of Safety = 12.80

Water Pressure = 0 kN/m²

Slope Projection on both planes = 0.0

Calculated bridge height = 0.0

THERE IS CONTACT ON PLANE 3 ONLY.

Joint Sets 3, 4

Orientation Data for Planes (1-4)

Plane	J3 Dip Value	J3 Dip Direction	J5 Dip Value	J5 Dip Direction
Plane 1	11	43		
Plane 2	33	30		
Plane 3	2	143		
Plane 4	30	143		

Cohesion and Friction Data

Plane	C31 Cohesion	J3/Friction Angle	C32 Cohesion	J5/Friction Angle
Plane 1	3000	45		
Plane 2	3000	45		

Water Pressure Data

Diap. Slope

☒ Check Completely Filled Free Draining

CALCULATE FACTOR OF SAFETY

Preliminary Data

J3 Density of Rock: 163 kN/m³

J5 Height of Crest Above Intersection: 10.0

Slope Undercutting

Does the slope base overhang the toe of the slope? ☐ Yes ☒ No

Results

J3 Factor of Safety = 427.80

Water Pressure = 0 kN/m²

Slope Projection on both planes = 0.0

Calculated bridge height = 0.0

THERE IS CONTACT ON BOTH PLANES.

Joint Sets 3, 5

Orientation Data for Planes (1-4)

Plane	J4 Dip Value	J4 Dip Direction	J5 Dip Value	J5 Dip Direction
Plane 1	37	143		
Plane 2	33	30		
Plane 3	2	143		
Plane 4	30	143		

Cohesion and Friction Data

Plane	C41 Cohesion	J4/Friction Angle	C42 Cohesion	J5/Friction Angle
Plane 1	3000	45		
Plane 2	3000	45		

Water Pressure Data

Diap. Slope

☒ Check Completely Filled Free Draining

CALCULATE FACTOR OF SAFETY

Preliminary Data

J4 Density of Rock: 163 kN/m³

J5 Height of Crest Above Intersection: 10.0

Slope Undercutting

Does the slope base overhang the toe of the slope? ☐ Yes ☒ No

Results

J4 Factor of Safety = 17.96

Water Pressure = 0 kN/m²

Slope Projection on both planes = 0.0

Calculated bridge height = 0.0

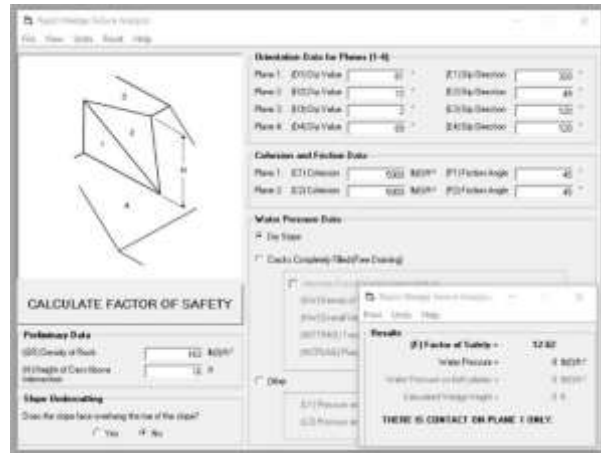
THERE IS CONTACT ON PLANE 2 ONLY.

Joint Sets 4, 5

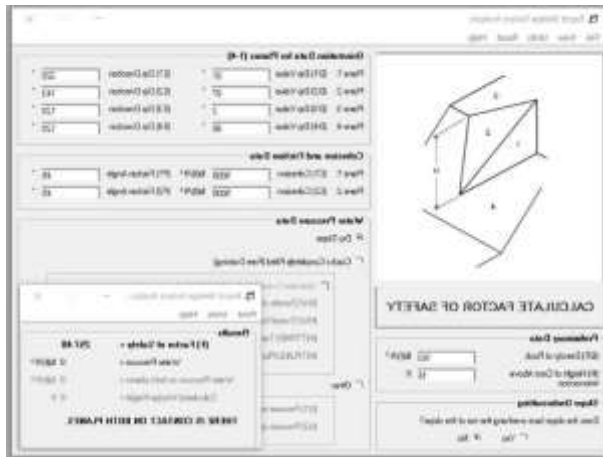
Northwest Slope – BLM Land



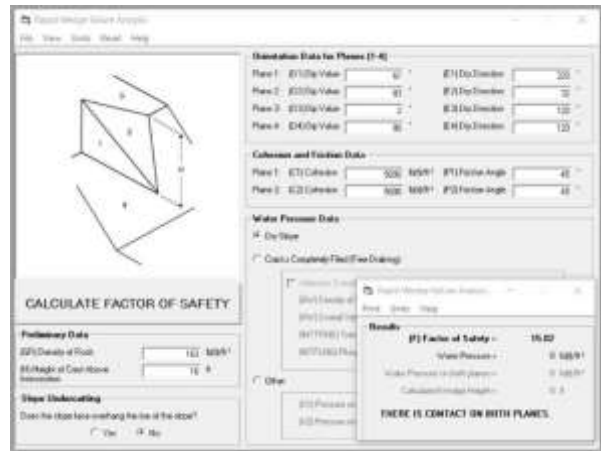
Joint Sets 1, 2



Joint Sets 1, 3



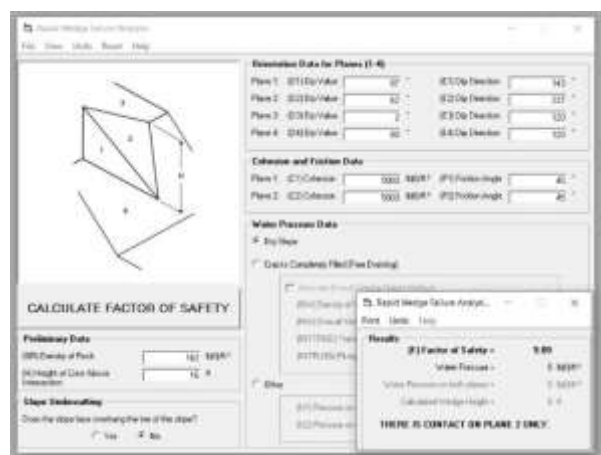
Joint Sets 1, 4



Joint Sets 1, 5



Joint Sets 2, 3



Joint Sets 2, 4

Northwest Slope – BLM Land

Orientation Data for Planes (1-4)

Plane	Dip Value	Dip Direction
Plane 1	27	143
Plane 2	63	32
Plane 3	2	126
Plane 4	65	126

Cohesion and Friction Data

Plane	Cohesion	Friction Angle
Plane 1	500 MBF/ft²	45°
Plane 2	500 MBF/ft²	45°

Water Pressure Data

☒ Dry Slope

☐ Check Completely Flood (Free Draining)

Preliminary Data

SPT Density of Rock: 143 MBF/ft²

Height of Crest Above Intersection: 16 ft

Slope Undercutting

Does the slope face overhang the toe of the slope? ☒ Yes ☐ No

Results

(F) Factor of Safety = 0

Water Pressure = 0 MBF/ft²

Calculated Undercut Height = 0 ft

CONTACT IS LOST ON BOTH PLANES. THE WEDGE FLOATS AS A RESULT OF WATER PRESSURE ACTING ON PLANES 1 AND 2.

Joint Sets 2, 5

Orientation Data for Planes (1-4)

Plane	Dip Value	Dip Direction
Plane 1	27	143
Plane 2	63	147
Plane 3	2	126
Plane 4	65	126

Cohesion and Friction Data

Plane	Cohesion	Friction Angle
Plane 1	500 MBF/ft²	45°
Plane 2	500 MBF/ft²	45°

Water Pressure Data

☒ Dry Slope

☐ Check Completely Flood (Free Draining)

Preliminary Data

SPT Density of Rock: 143 MBF/ft²

Height of Crest Above Intersection: 16 ft

Slope Undercutting

Does the slope face overhang the toe of the slope? ☒ Yes ☐ No

Results

(F) Factor of Safety = 1368.41

Water Pressure = 0 MBF/ft²

Calculated Undercut Height = 0 ft

THERE IS CONTACT ON BOTH PLANES.

Joint Sets 3, 4

Orientation Data for Planes (1-4)

Plane	Dip Value	Dip Direction
Plane 1	27	143
Plane 2	63	32
Plane 3	2	126
Plane 4	65	126

Cohesion and Friction Data

Plane	Cohesion	Friction Angle
Plane 1	500 MBF/ft²	45°
Plane 2	500 MBF/ft²	45°

Water Pressure Data

☒ Dry Slope

☐ Check Completely Flood (Free Draining)

Preliminary Data

SPT Density of Rock: 143 MBF/ft²

Height of Crest Above Intersection: 16 ft

Slope Undercutting

Does the slope face overhang the toe of the slope? ☒ Yes ☐ No

Results

(F) Factor of Safety = 34.38

Water Pressure = 0 MBF/ft²

Calculated Undercut Height = 0 ft

THERE IS CONTACT ON BOTH PLANES.

Joint Sets 3, 5

Orientation Data for Planes (1-4)

Plane	Dip Value	Dip Direction
Plane 1	27	143
Plane 2	63	32
Plane 3	2	126
Plane 4	65	126

Cohesion and Friction Data

Plane	Cohesion	Friction Angle
Plane 1	500 MBF/ft²	45°
Plane 2	500 MBF/ft²	45°

Water Pressure Data

☒ Dry Slope

☐ Check Completely Flood (Free Draining)

Preliminary Data

SPT Density of Rock: 143 MBF/ft²

Height of Crest Above Intersection: 16 ft

Slope Undercutting

Does the slope face overhang the toe of the slope? ☒ Yes ☐ No

Results

(F) Factor of Safety = 0

Water Pressure = 0 MBF/ft²

Calculated Undercut Height = 0 ft

CONTACT IS LOST ON BOTH PLANES. THE WEDGE FLOATS AS A RESULT OF WATER PRESSURE ACTING ON PLANES 1 AND 2.

Joint Sets 4, 5

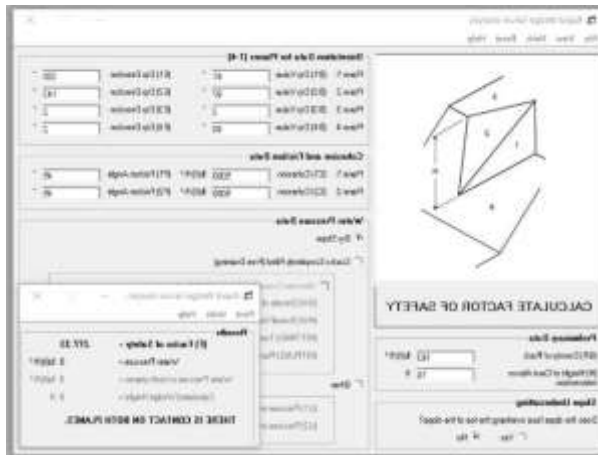
South-central Slope – BLM Land



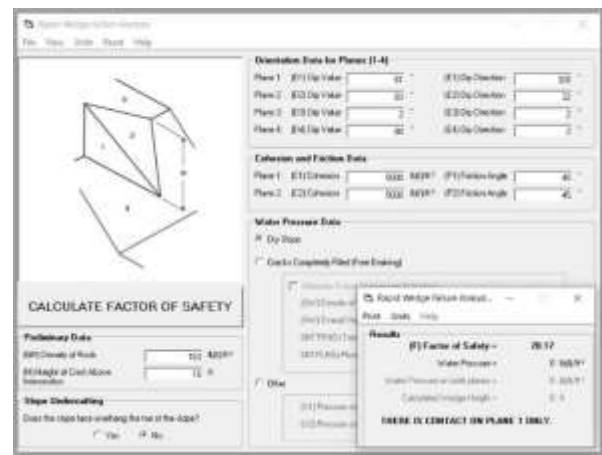
Joint Sets 1, 2



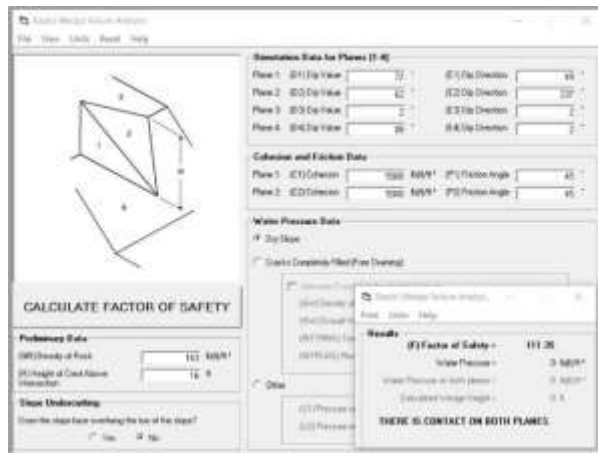
Joint Sets 1, 3



Joint Sets 1, 4



Joint Sets 1, 5



Joint Sets 2, 3



Joint Sets 2, 4

South-central Slope – BLM Land

Observation Data for Planes (1-4)

Plane	D1/D2 Value	D1/D2 Direction	D3/D4 Value	D3/D4 Direction	D5/D6 Value	D5/D6 Direction	D7/D8 Value	D7/D8 Direction
Plane 1	67	142						
Plane 2	93	121						
Plane 3	2	121						
Plane 4	80	19						

Cohesion and Friction Data

Plane	C1 Cohesion	F1 Friction Angle	C2 Cohesion	F2 Friction Angle
Plane 1	5000 kN/m²	45		
Plane 2	5000 kN/m²	45		

Water Pressure Data

☒ By Slope

☐ Cracks Completely Filled (Free Draining)

Preliminary Data

GFI Density of Rock: 161 kN/m³

H: Height of Crest Above Intersection: 16.8

Slope Undercutting

Does the slope face overhang the toe of the slope? ☒ Yes ☐ No

Results

Factor of Safety = 0

Water Pressure = 0 kN/m²

Water Pressure on both planes = 0 kN/m²

Calculated Wedge Height = 0.0

CONTACT IS LOST ON BOTH PLANES. THE WEDGE FLOATS AS A RESULT OF WATER PRESSURE ACTING ON PLANES 1 AND 2.

Joint Sets 2, 5

Observation Data for Planes (1-4)

Plane	D1/D2 Value	D1/D2 Direction	D3/D4 Value	D3/D4 Direction	D5/D6 Value	D5/D6 Direction	D7/D8 Value	D7/D8 Direction
Plane 1	70	43						
Plane 2	67	121						
Plane 3	2	121						
Plane 4	80	19						

Cohesion and Friction Data

Plane	C1 Cohesion	F1 Friction Angle	C2 Cohesion	F2 Friction Angle
Plane 1	5000 kN/m²	45		
Plane 2	5000 kN/m²	45		

Water Pressure Data

☒ By Slope

☐ Cracks Completely Filled (Free Draining)

Preliminary Data

GFI Density of Rock: 161 kN/m³

H: Height of Crest Above Intersection: 16.8

Slope Undercutting

Does the slope face overhang the toe of the slope? ☒ Yes ☐ No

Results

Factor of Safety = 432.77

Water Pressure = 0 kN/m²

Water Pressure on both planes = 0 kN/m²

Calculated Wedge Height = 0.0

THERE IS CONTACT ON PLANE 2 ONLY.

Joint Sets 3, 4

Observation Data for Planes (1-4)

Plane	D1/D2 Value	D1/D2 Direction	D3/D4 Value	D3/D4 Direction	D5/D6 Value	D5/D6 Direction	D7/D8 Value	D7/D8 Direction
Plane 1	72	43						
Plane 2	91	121						
Plane 3	2	121						
Plane 4	80	19						

Cohesion and Friction Data

Plane	C1 Cohesion	F1 Friction Angle	C2 Cohesion	F2 Friction Angle
Plane 1	5000 kN/m²	45		
Plane 2	5000 kN/m²	45		

Water Pressure Data

☒ By Slope

☐ Cracks Completely Filled (Free Draining)

Preliminary Data

GFI Density of Rock: 161 kN/m³

H: Height of Crest Above Intersection: 16.8

Slope Undercutting

Does the slope face overhang the toe of the slope? ☒ Yes ☐ No

Results

Factor of Safety = 25.57

Water Pressure = 0 kN/m²

Water Pressure on both planes = 0 kN/m²

Calculated Wedge Height = 0.0

THERE IS CONTACT ON BOTH PLANES.

Joint Sets 3, 5

Observation Data for Planes (1-4)

Plane	D1/D2 Value	D1/D2 Direction	D3/D4 Value	D3/D4 Direction	D5/D6 Value	D5/D6 Direction	D7/D8 Value	D7/D8 Direction
Plane 1	67	142						
Plane 2	91	121						
Plane 3	2	121						
Plane 4	80	19						

Cohesion and Friction Data

Plane	C1 Cohesion	F1 Friction Angle	C2 Cohesion	F2 Friction Angle
Plane 1	5000 kN/m²	45		
Plane 2	5000 kN/m²	45		

Water Pressure Data

☒ By Slope

☐ Cracks Completely Filled (Free Draining)

Preliminary Data

GFI Density of Rock: 161 kN/m³

H: Height of Crest Above Intersection: 16.8

Slope Undercutting

Does the slope face overhang the toe of the slope? ☒ Yes ☐ No

Results

Factor of Safety = 25.43

Water Pressure = 0 kN/m²

Water Pressure on both planes = 0 kN/m²

Calculated Wedge Height = 0.0

THERE IS CONTACT ON PLANE 1 ONLY.

Joint Sets 4, 5

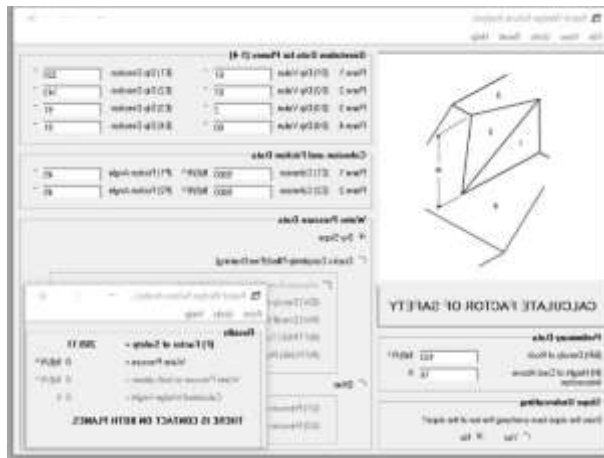
Southwest Slope – BLM Land



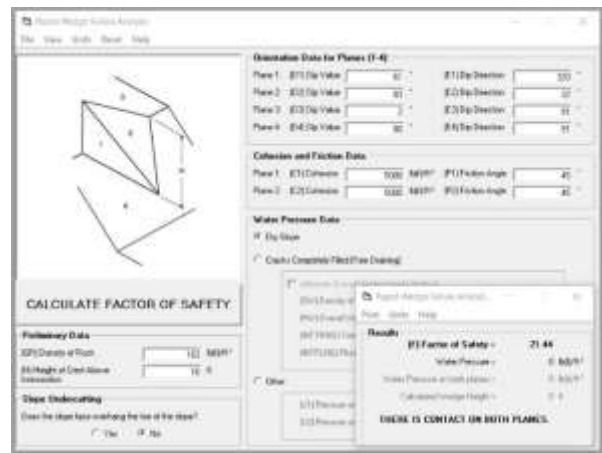
Joint Sets 1, 2



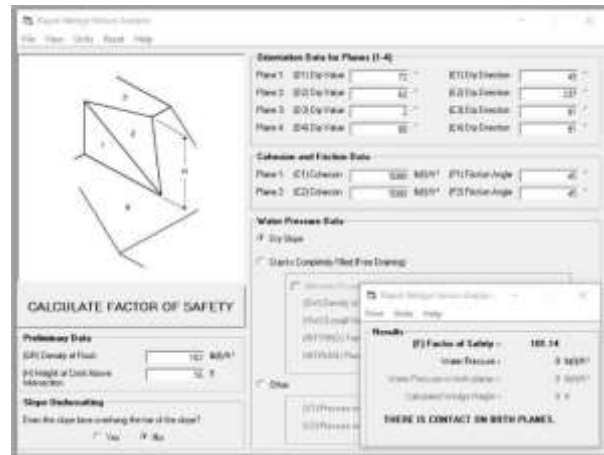
Joint Sets 1, 3



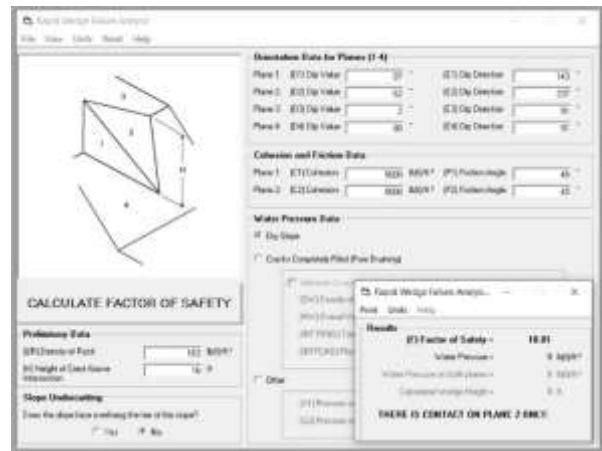
Joint Sets 1, 4



Joint Sets 1, 5



Joint Sets 2, 3



Joint Sets 2, 4

Southwest Slope – BLM Land



Orientation Data for Planes (1-4)

Plane	Strike Value	Strike Direction	Dip Value	Dip Direction
Plane 1	070	045	30	045
Plane 2	030	030	30	030
Plane 3	070	030	30	030
Plane 4	040	030	30	030

Cohesion and Friction Data

Plane	Cohesion	Friction Angle
Plane 1	0.000 kN/m ²	45°
Plane 2	0.000 kN/m ²	45°

Water Pressure Data

☒ Dry Slope

☐ Check Completely Filled (Free Draining)

Results

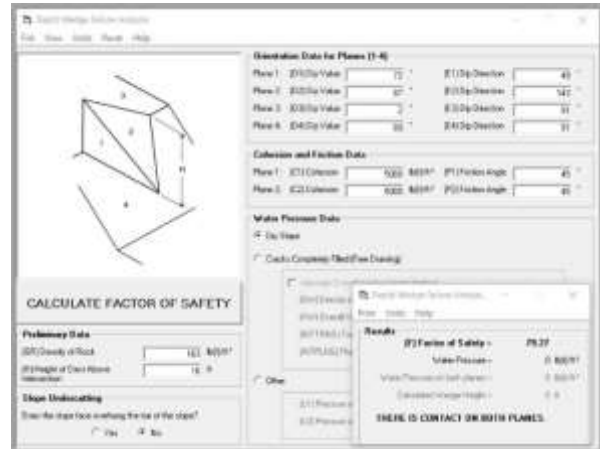
(F) Factor of Safety = 0

Water Pressure on both planes = 0.000 kN/m²

Calculated Wedge Height = 0.0

CONTACT IS LOST ON BOTH PLANES. THE WEDGE FLUATS AS A RESULT OF WATER PRESSURE ACTING ON PLANES 1 AND 2.

Joint Sets 2, 5



Orientation Data for Planes (1-4)

Plane	Strike Value	Strike Direction	Dip Value	Dip Direction
Plane 1	070	045	30	045
Plane 2	030	030	30	030
Plane 3	070	030	30	030
Plane 4	040	030	30	030

Cohesion and Friction Data

Plane	Cohesion	Friction Angle
Plane 1	0.000 kN/m ²	45°
Plane 2	0.000 kN/m ²	45°

Water Pressure Data

☒ Dry Slope

☐ Check Completely Filled (Free Draining)

Results


(F) Factor of Safety = 79.77

Water Pressure on both planes = 0.000 kN/m²

Calculated Wedge Height = 0.0

THERE IS CONTACT ON BOTH PLANES.

Joint Sets 3, 4



Orientation Data for Planes (1-4)

Plane	Strike Value	Strike Direction	Dip Value	Dip Direction
Plane 1	070	045	30	045
Plane 2	030	030	30	030
Plane 3	070	030	30	030
Plane 4	040	030	30	030

Cohesion and Friction Data

Plane	Cohesion	Friction Angle
Plane 1	0.000 kN/m ²	45°
Plane 2	0.000 kN/m ²	45°

Water Pressure Data

☒ Dry Slope

☐ Check Completely Filled (Free Draining)

Results


(F) Factor of Safety = 0

Water Pressure on both planes = 0.000 kN/m²

Calculated Wedge Height = 0.0

THERE IS CONTACT ON BOTH PLANES.

Joint Sets 3, 5



Orientation Data for Planes (1-4)

Plane	Strike Value	Strike Direction	Dip Value	Dip Direction
Plane 1	070	045	30	045
Plane 2	030	030	30	030
Plane 3	070	030	30	030
Plane 4	040	030	30	030

Cohesion and Friction Data

Plane	Cohesion	Friction Angle
Plane 1	0.000 kN/m ²	45°
Plane 2	0.000 kN/m ²	45°

Water Pressure Data

☒ Dry Slope

☐ Check Completely Filled (Free Draining)

Results

(F) Factor of Safety = 0

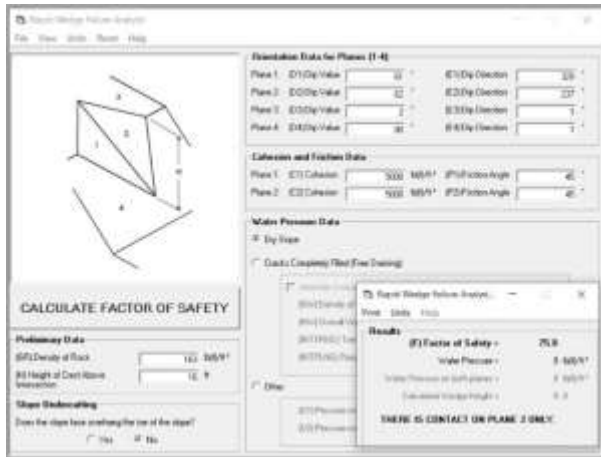
Water Pressure on both planes = 0.000 kN/m²

Calculated Wedge Height = 0.0

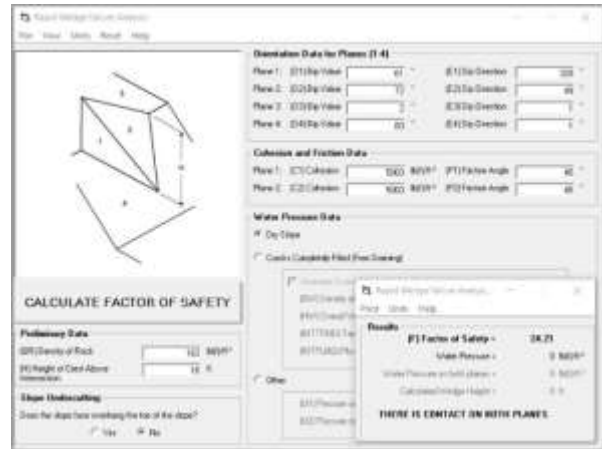
CONTACT IS LOST ON BOTH PLANES. THE WEDGE FLUATS AS A RESULT OF WATER PRESSURE ACTING ON PLANES 1 AND 2.

Joint Sets 4, 5

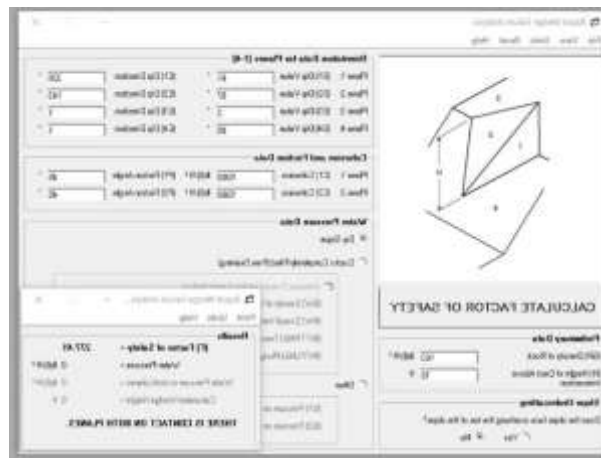
South Slope – BLM Land



Joint Sets 1, 2



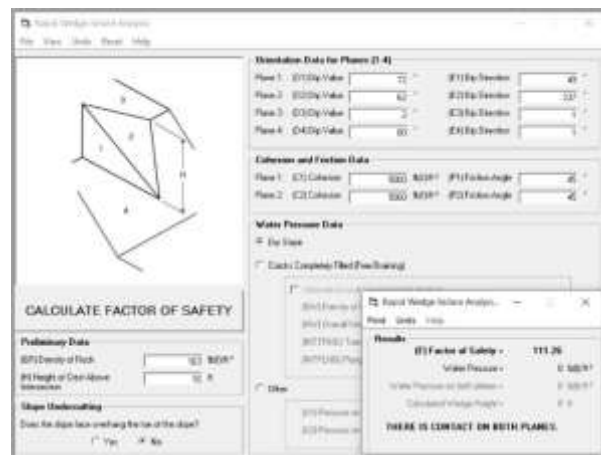
Joint Sets 1, 3



Joint Sets 1, 4



Joint Sets 1, 5



Joint Sets 2, 3

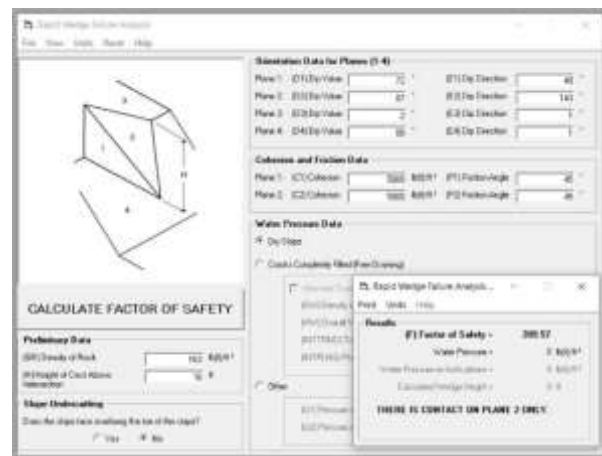


Joint Sets 2, 4

South Slope – BLM Land



Joint Sets 2, 5



Joint Sets 3, 4



Joint Sets 3, 5

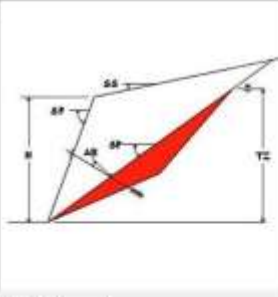


Joint Sets 4, 5

Planar Failure Analysis – Static

Plane Failure Analysis Input Screen

File View Units Reset Help



Status: READY

CALCULATE FACTOR OF SAFETY

Standard Input Data

(H) Height ft
 (SF) Inclination of Slope Face °
 (SS) Inclination of Upper Slope °
 (SP) Inclination of Failure Plane °
 (CD) Cohesive Strength of Failure Surface lb/ft
 (FH) Friction Angle of Failure Surface °
 (GR) Density of Rock lb/ft³
 (GW) Density of Water lb/ft³

Bolt Data

(AB) Starting Rock Bolt Angle ° (T1) Starting Bolt Tension lb
 (AE) Ending Rock Bolt Angle ° (T2) Ending Bolt Tension lb
 (AA) Bolt Angle Increment ° (T3) Bolt Tension Increment lb

Tension Crack Data

☒ No Tension Crack
☐ Tension Crack Location Known
☐ Tension Crack Location Unknown

(B) Horizontal Distance of Tension Crack from Crest ft
 (CC) Relative Height of Water in Tension Crack decimal ft

☒ Dry Slope ☐ Tension Crack Filled with Water

Optional Input Data

(AC) Horizontal Acceleration g
 (TZ) Amount of Discontinuity Separated decimal ft
 (VSR) Vertical Surcharge lb/ft
 (HSUR) Horizontal Surcharge lb/ft

Plane Failure Analysis Output Screen

Print Units Graph Mode Help

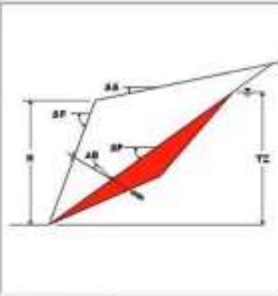
Results

(F) Factor of Safety = 3.21 (T) Tension = 0 lb
 (A) Contact Area = 92.7 ft² (TH) Bolt Angle = 0 °
 (W) Weight of Slice = 19800.15 lb (C) Tension Crack Depth = 0 ft
 (U) Water Force Normal to Failure Plane = 0 lb (CT) Height/Length of Crack = 0 ft
 (M) Horizontal Water Force on Tension Crack = 0 lb (CW) Depth of Water in Crack = 0 ft
 (B) Horizontal Distance of Tension Crack from Crest = 30.94 ft (BL) Water Location, Horizontal Distance = 0 ft

Joint Set 1

Plane Failure Analysis Input Screen

File View Units Reset Help



Status: READY

CALCULATE FACTOR OF SAFETY

Standard Input Data

(H) Height ft
 (SF) Inclination of Slope Face °
 (SS) Inclination of Upper Slope °
 (SP) Inclination of Failure Plane °
 (CD) Cohesive Strength of Failure Surface lb/ft
 (FH) Friction Angle of Failure Surface °
 (GR) Density of Rock lb/ft³
 (GW) Density of Water lb/ft³

Bolt Data

(AB) Starting Rock Bolt Angle ° (T1) Starting Bolt Tension lb
 (AE) Ending Rock Bolt Angle ° (T2) Ending Bolt Tension lb
 (AA) Bolt Angle Increment ° (T3) Bolt Tension Increment lb

Tension Crack Data

☒ No Tension Crack
☐ Tension Crack Location Known
☐ Tension Crack Location Unknown

(B) Horizontal Distance of Tension Crack from Crest ft
 (CC) Relative Height of Water in Tension Crack decimal ft

☒ Dry Slope ☐ Tension Crack Filled with Water

Optional Input Data

(AC) Horizontal Acceleration g
 (TZ) Amount of Discontinuity Separated decimal ft
 (VSR) Vertical Surcharge lb/ft
 (HSUR) Horizontal Surcharge lb/ft

Plane Failure Analysis Output Screen

Print Units Graph Mode Help

Results

(F) Factor of Safety = 3.3 (T) Tension = 0 lb
 (A) Contact Area = 91.75 ft² (TH) Bolt Angle = 0 °
 (W) Weight of Slice = 18771.46 lb (C) Tension Crack Depth = 0 ft
 (U) Water Force Normal to Failure Plane = 0 lb (CT) Height/Length of Crack = 0 ft
 (M) Horizontal Water Force on Tension Crack = 0 lb (CW) Depth of Water in Crack = 0 ft
 (B) Horizontal Distance of Tension Crack from Crest = 28.97 ft (BL) Water Location, Horizontal Distance = 0 ft

Joint Set 2

Planar Failure Analysis – Static

Plane Failure Analysis Input Screen

File View Units Report Help



Status: READY

CALCULATE FACTOR OF SAFETY

Standard Input Data

(H) Height: 80 ft
 (SF) Inclination of Slope Face: 80°
 (SS) Inclination of Upper Slope: 2°
 (SP) Inclination of Failure Plane: 72°
 (CO) Cohesive Strength of Failure Surface: 5000 lb/ft
 (PH) Friction Angle of Failure Surface: 45°
 (GR) Density of Rock: 163 lb/ft³
 (GW) Density of Water: 63 lb/ft³

Bolt Data

(AB) Starting Rock Bolt Angle: 0° (T1) Starting Bolt Tension: 0 lb/ft
 (AP) Ending Rock Bolt Angle: 0° (T2) Ending Bolt Tension: 0 lb/ft
 (AA) Bolt Angle Increment: 0° (T3) Bolt Tension Increment: 0 lb/ft

Tension Crack Data

☒ No Tension Crack
☐ Tension Crack Location Known
☐ Tension Crack Location Unknown

(B) Horizontal Distance of Tension Crack from Crest: 0 ft
 (CZ) Relative Height of Water in Tension Crack: 0 decimal ft

☒ Dry Slope ☐ Tension Crack Filled with Water

Optional Input Data

(AC) Horizontal Acceleration: 0 g
 (TZ) Amount of Discontinuity Saturated: 0 decimal ft
 (VSLR) Vertical Surcharge: 0 lb/ft
 (HSLR) Horizontal Surcharge: 0 lb/ft

Plane Failure Analysis Output Screen

Print Units Graph Mode Help

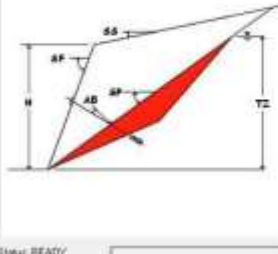
Results

(F) Factor of Safety = 6.83 (T) Tension = 0 lb/ft
 (A) Contact Area = 84.56 ft² (TH) Bolt Angle = 0°
 (W) Weight of Slice = 77962.75 lb/ft (CZ) Tension Crack Depth = 0 ft
 (U) Water Force Normal to Failure Plane = 0 lb/ft (CT) Height/Length of Crack = 0 ft
 (V) Horizontal Water Force on Tension Crack = 0 lb/ft (CW) Depth of Water in Crack = 0 ft
 (B) Horizontal Distance of Tension Crack from Crest = 12.82 ft (B) Water Location, Horizontal Distance = 0 ft

Joint Set 3

Plane Failure Analysis Input Screen

File View Units Report Help



Status: READY

CALCULATE FACTOR OF SAFETY

Standard Input Data

(H) Height: 80 ft
 (SF) Inclination of Slope Face: 80°
 (SS) Inclination of Upper Slope: 2°
 (SP) Inclination of Failure Plane: 87°
 (CO) Cohesive Strength of Failure Surface: 5000 lb/ft
 (PH) Friction Angle of Failure Surface: 45°
 (GR) Density of Rock: 163 lb/ft³
 (GW) Density of Water: 63 lb/ft³

Bolt Data

(AB) Starting Rock Bolt Angle: 0° (T1) Starting Bolt Tension: 0 lb/ft
 (AP) Ending Rock Bolt Angle: 0° (T2) Ending Bolt Tension: 0 lb/ft
 (AA) Bolt Angle Increment: 0° (T3) Bolt Tension Increment: 0 lb/ft

Tension Crack Data

☒ No Tension Crack
☐ Tension Crack Location Known
☐ Tension Crack Location Unknown

(B) Horizontal Distance of Tension Crack from Crest: 0 ft
 (CZ) Relative Height of Water in Tension Crack: 0 decimal ft

☒ Dry Slope ☐ Tension Crack Filled with Water

Optional Input Data

(AC) Horizontal Acceleration: 0 g
 (TZ) Amount of Discontinuity Saturated: 0 decimal ft
 (VSLR) Vertical Surcharge: 0 lb/ft
 (HSLR) Horizontal Surcharge: 0 lb/ft

Plane Failure Analysis Output Screen

Print Units Graph Mode Help

Results

(F) Factor of Safety = -6.15 (T) Tension = 0 lb/ft
 (A) Contact Area = 75.75 ft² (TH) Bolt Angle = 0°
 (W) Weight of Slice = 44258.03 lb/ft (CZ) Tension Crack Depth = 0 ft
 (U) Water Force Normal to Failure Plane = 0 lb/ft (CT) Height/Length of Crack = 0 ft
 (V) Horizontal Water Force on Tension Crack = 0 lb/ft (CW) Depth of Water in Crack = 0 ft
 (B) Horizontal Distance of Tension Crack from Crest = 9.92 ft (B) Water Location, Horizontal Distance = 0 ft

Joint Set 4

Planar Failure Analysis – Static

Plane Failure Analysis Input Screen

File View Units Report Help



Status: READY

CALCULATE FACTOR OF SAFETY

Standard Input Data

(H) Height: 80 ft
 (SF) Inclination of Slope Face: 80 °
 (SS) Inclination of Upper Slope: 2 °
 (SP) Inclination of Failure Plane: 83 °
 (CC) Cohesive Strength of Failure Surface: 3000 lb/ft
 (PH) Friction Angle of Failure Surface: 45 °
 (GR) Density of Rock: 163 lb/ft³
 (GW) Density of Water: 62 lb/ft³

Bolt Data

(AB) Starting Rock Bolt Angle: 0 ° (T1) Starting Bolt Tension: 0 lb
 (AR) Ending Rock Bolt Angle: 0 ° (T2) Ending Bolt Tension: 0 lb
 (BA) Bolt Angle Increment: 0 ° (T) Bolt Tension Increment: 0 lb

Optional Input Data

(AC) Horizontal Acceleration: 0 g
 (TZ) Amount of Discontinuity Submerged: 0 decimal ft
 (VSR) Vertical Surcharge: 0 lb/ft
 (HSUR) Horizontal Surcharge: 0 lb/ft

Tension Crack Data

☒ No Tension Crack
☐ Tension Crack Location Known
☐ Tension Crack Location Unknown

(B) Horizontal Distance of Tension Crack from Crest: 0 ft
 (CZ) Relative Height of Water in Tension Crack: 0 decimal ft

☒ No Tension Crack ☐ Tension Crack Filled with Grout

Plane Failure Analysis Output Screen

Print Units Graph Mode Help

Results

(F) Factor of Safety =	-14.42	(T) Tension =	0 lb
(A) Contact Area =	80.45 ft²	(TH) Bolt Angle =	0 °
(W) Weight of Slice =	27875.28 lb	(C) Tension Crack Depth =	0 ft
(U) Water Force Normal to Failure Plane =	0 lb	(CL) Height/Length of Crack =	0 ft
(H) Horizontal Water Force on Tension Crack =	0 lb	(WD) Depth of Water in Crack =	0 ft
(B) Horizontal Distance of Tension Crack from Crest =	-4.3 ft	(R) Water Location, Horizontal Distance =	0 ft

Joint Set 5

Plane Failure Analysis Input Screen

File View Units Reset Help

Standard Input Data

(H) Height	<input type="text" value="80"/>	'
(SF) Inclination of Slope Face	<input type="text" value="80"/>	"
(SS) Inclination of Upper Slope	<input type="text" value="2"/>	"
(SP) Inclination of Failure Plane	<input type="text" value="67"/>	"
(C) Cohesive Strength of Failure Surface	<input type="text" value="5000"/>	lb/ft
(PH) Friction Angle of Failure Surface	<input type="text" value="45"/>	"
(GR) Density of Rock	<input type="text" value="162"/>	lb/ft ³
(GW) Density of Water	<input type="text" value="62.4"/>	lb/ft ³

Bolt Data

(AR) Starting Rock Bolt Angle	<input type="text" value="0"/>	"	(T1) Starting Bolt Tension	<input type="text" value="0"/>	lb/ft
(AR) Ending Rock Bolt Angle	<input type="text" value="0"/>	"	(T2) Ending Bolt Tension	<input type="text" value="0"/>	lb/ft
(IA) Bolt Angle Increment	<input type="text" value="0"/>	"	(T3) Bolt Tension Increment	<input type="text" value="0"/>	lb/ft

Status: READY

CALCULATE FACTOR OF SAFETY

Optional Input Data

(AC) Horizontal Acceleration	<input type="text" value="0.5"/>	G
(TZ) Amount of Discontinuity Submerged	<input type="text" value="0"/>	decimal%
(VSRU) Vertical Surcharge	<input type="text" value="0"/>	lb/ft
(HSUR) Horizontal Surcharge	<input type="text" value="0"/>	lb/ft

Tension Crack Data

☒ No Tension Crack
☐ Tension Crack Location Known
☐ Tension Crack Location Unknown

(B) Horizontal Distance of Tension Crack from Crest	<input type="text" value="0"/>	'
(SZ) Relative Height of Water in Tension Crack	<input type="text" value="0"/>	decimal%

☐ Dry Slope ☐ Tension Cracks Redefine Slope

Plane Failure Analysis Output Screen

Print Units Graph Mode Help

-Results-

(F) Factor of Safety =	1.67	(T) Tension =	0 lb/ft
(A) Contact Area =	32.7 ft ²	(TH) Bolt Angle =	0 "
(W) Weight of Slice =	19608.15 lb/ft	(Z) Tension Crack Depth =	0 ft
(U) Water Force Normal to Failure Plane =	0 lb/ft	(ZL) Height/Length of Crack =	0 ft
(V) Horizontal/Water Force on Tension Crack =	0 lb/ft	(ZW) Depth of Water in Crack =	0 ft
(B) Horizontal Distance of Tension Crack from Crest =	20.88 ft	(BL) Water Location, Horizontal Distance =	0 ft

Plane Failure Analysis Input Screen

File View Units Result Help

Standard Input Data

(H) Height

80 ft

(S) Inclination of Slope Face

80 °

(SU) Inclination of Upper Slope

2 °

(SF) Inclination of Failure Plane

62 °

(C) Cohesive Strength of Failure Surface

5000 lb/ft

(ϕ) Friction Angle of Failure Surface

45 °

(γ) Density of Rock

163 lb/ft³

(γ_w) Density of Water

62 lb/ft³

Bolt Data

(AB) Starting Rock Bolt Angle

0 °

(T1) Starting Bolt Tension

0 lb/ft

(AR) Ending Rock Bolt Angle

0 °

(T2) Ending Bolt Tension

0 lb/ft

(AV) Bolt Angle Increment

0 °

(T3) Bolt Tension Increment

0 lb/ft

Calculate Factor of Safety

Optional Input Data

(AC) Horizontal Acceleration

0 g

(TZ) Amount of Discontinuity Shear

0 decimal

(VSUR) Vertical Surcharge

0 lb/ft

(HSUR) Horizontal Surcharge

0 lb/ft

Tension Crack Data

☒ No Tension Crack
 ☐ Tension Crack Location Known
 ☐ Tension Crack Location Unknown

(B1) Horizontal Distance of Tension Crack from Crest

0 ft

(B2) Relative Height of Water in Tension Crack

0 decimal

☐ Dry Slope
 ☐ Tension Crack Filled with Grout

Plane Failure Analysis Output Screen

Print Units Graphs/Model Help

Results

(F) Factor of Safety =

1.75

(T) Tension =

0 lb/ft

(A) Contact Area =

91.75 ft²

(TH) Bolt Angle =

0 °

(W) Weight of Slice =

187711.46 lb/ft

(C) Tension Crack Depth =

0 ft

(U) Water Force Normal to Failure Plane =

0 lb/ft

(Z) Height/Length of Crack =

0 ft

(V) Horizontal Water Force on Tension Crack =

0 lb/ft

(D) Depth of Water in Crack =

0 ft

(B) Horizontal Distance of Tension Crack from Crest =

20.97 ft

(H) Water Location, Horizontal Distance =

0 ft

Joint Set 2

Plane Failure Analysis Input Screen

File View Units Reset Help

Standard Input Data

(H) Height	80 ft
(SF) Inclination of Slope Face	80 °
(SS) Inclination of Upper Slope	2 °
(SP) Inclination of Failure Plane	72 °
(C) Cohesive Strength of Failure Surface	5000 lb/ft
(PH) Friction Angle of Failure Surface	40 °
(D) Density of Rock	162 lb/ft ³
(DW) Density of Water	62 lb/ft ³

Bank Data

(AB) Starting Rock Bolt Angle	0 °	(T1) Starting Bolt Tension	0 lb/ft
(AM) Ending Rock Bolt Angle	0 °	(T2) Ending Bolt Tension	0 lb/ft
(AA) Bolt Angle Increment	0 °	(TB) Bolt Tension Increment	0 lb/ft

Status: READY

CALCULATE FACTOR OF SAFETY

Optional Input Data

(AC) Horizontal Acceleration	0.0 G
(TZ) Amount of Discontinuity Stagger	0 decimal
(MSUR) Vertical Surcharge	0 lb/ft
(HSUR) Horizontal Surcharge	0 lb/ft

No Tension Crack

Tension Crack Location Known

Tension Crack Location Unknown

(B) Horizontal Distance of Tension Crack from Crest

(S2) Relative Height of Water in Tension Crack

(T) Slope

Tension Crack Method to Use

Plane Failure Analysis Output Screen

Print Units Graph Mode Help

Results

(F) Factor of Safety =	4.15	(T) Tension =	0 lb/ft
(A) Contact Area =	84.56 ft ²	(TH) Bolt Angle =	0 °
(W) Weight of Slice =	7782.75 lb/ft	(S) Tension Crack Depth =	0 ft
(U) Water Force Normal to Failure Plane =	0 lb/ft	(Z) Height/Length of Crack =	0 ft
(V) Horizontal Water Force on Tension Crack =	0 lb/ft	(DW) Depth of Water in Crack =	0 ft
(B) Horizontal Distance of Tension Crack from Crest =	12.02 ft	(W) Water Location, Horizontal Distance =	0 ft

Joint Set 3

Plane Failure Analysis Input Screen

File View Units Reset Help

Status: READY

Standard Input Data

(H) Height	90 ft
(S) Inclination of Slope Face	80 °
(S1) Inclination of Upper Slope	2 °
(S2) Inclination of Failure Plane	67 °
(C) Cohesive Strength of Failure Surface	9000 lbf/ft
(ϕ) Friction Angle of Failure Surface	45 °
(γ) Density of Rock	163 lbf/ft ³
(γ_w) Density of Water	62 lbf/ft ³

Soil Data

(AR) Starting Rock Bolt Angle	0 °	(T1) Starting Bolt Tension	0 lbf
(AR) Ending Rock Bolt Angle	0 °	(T2) Ending Bolt Tension	0 lbf
(SA) Bolt Angle Increment	0 °	(T3) Bolt Tension Increment	0 lbf

Tension Crack Data

☒ No Tension Crack

☐ Tension Crack Location Known

☐ Tension Crack Location Unknown

(B) Horizontal Distance of Tension Crack from Crest	0 ft
(C2) Relative Height of Water in Tension Crack	0 (decimal)
(F) Fill Slope	0 Tension Crack Width x Height

CALCULATE FACTOR OF SAFETY

Optional Input Data

(AC) Horizontal Acceleration	0.0 G
(T2) Amount of Discontinuity	0 (decimal)
(VSUR) Vertical Surcharge	0 lbf
(HSUR) Horizontal Surcharge	0 lbf

Plane Failure Analysis Output Screen

Print Units Graph Mode Help

Results

(F) Factor of Safety =	6.67	(T) Tension =	0 lbf
(A) Contact Area =	79.75 ft ²	(T4) Bolt Angle =	0 °
(W) Weight of Slice =	64356.02 lbf	(C2) Tension Crack Depth =	0 ft
(B) Water Force Normal to Failure Plane =	0 lbf	(C2) Height/Length of Crack =	0 ft
(V) Horizontal Water Force on Tension Crack =	0 lbf	(C2) Depth of Water in Crack =	0 ft
(B) Horizontal Distance of Tension Crack from Crest =	-8.93 ft	(F) Water Location, Horizontal Distance =	0 ft

Joint Set 4

Planar Failure Analysis – Seismic

Planar Failure Analysis Input Screen

File View Units Report Help



Status: READY

CALCULATE FACTOR OF SAFETY

Standard Input Data

(H) Height = 80 ft
 (SP) Inclination of Slope Face = 60 °
 (SI) Inclination of Upper Slope = 2 °
 (SF) Inclination of Failure Plane = 63 °
 (CO) Cohesive Strength of Failure Surface = 9000 lbf/ft²
 (FH) Friction Angle of Failure Surface = 45 °
 (GR) Density of Rock = 163 lbf/ft³
 (GW) Density of Water = 62 lbf/ft³

Bolt Data

(AB) Starting Rock Bolt Angle = 0 ° (T1) Starting Bolt Tension = 0 lbf
 (AE) Ending Rock Bolt Angle = 0 ° (T2) Ending Bolt Tension = 0 lbf
 (AI) Bolt Angle Increment = 0 ° (T3) Bolt Tension Increment = 0 lbf

Optional Input Data

(AC) Horizontal Acceleration = 0.0 g
 (T2) Amount of Discontinuity Saturated = 0 decimal
 (VSUR) Vertical Surcharge = 0 lbf
 (HSUR) Horizontal Surcharge = 0 lbf

Tension Crack Data

☒ No Tension Crack
☐ Tension Crack Location Known
☐ Tension Crack Location Unknown

(B) Horizontal Distance of Tension Crack from Crest = 0 ft
 (C2) Relative Height of Water in Tension Crack = 0 decimal
☐ Dry Slope ☒ Tension Crack filled with water

Planar Failure Analysis Output Screen

Print Units Graph Mode Help

Results

(F) Factor of Safety = -13.85 (T) Tension = 0 lbf
 (A) Contact Area = 80.45 ft² (TH) Bolt Angle = 0 °
 (W) Weight of Slice = 27575.28 lbf (C) Tension Crack Depth = 0 ft
 (U) Water Force Normal to Failure Plane = 0 lbf (C2) Height/Length of Crack = 0 ft
 (V) Horizontal Water Force on Tension Crack = 0 lbf (C3) Depth of Water in Crack = 0 ft
 (B) Horizontal Distance of Tension Crack from Crest = 4.3 ft (B) Water Location, Horizontal Distance = 0 ft

Joint Set 5

Topple Failure Analysis

Topple Failure Analysis

File Units Reset Help

Input Data

☒ Calculate Sum of Moments
☐ Calculate the tension required to bolt in place
☐ Calculate the thickness required to prevent toppling

Height of the Block: ft
Width of the Block: 16 ft
Angle of the Block: 45 °
Density of Water: 63 lb(f)/ft³
Density of Rock: 163 lb(f)/ft³
Tension of the Rock Bolt: 0 lb(f)
Height of Water in Tension Crack: 0 ft
Height of Rock Bolt in Block: 0 ft

Results

The Sum of the Moments = -0.05 lb(f).ft

This indicates that the slope is SAFE

CALCULATE

Maximum Safe Joint Angle

Topple Failure Analysis

File Units Reset Help

Input Data

☒ Calculate Sum of Moments
☐ Calculate the tension required to bolt in place
☐ Calculate the thickness required to prevent toppling

Height of the Block: 16 ft
Width of the Block: 16 ft
Angle of the Block: 45 °
Density of Water: 63 lb(f)/ft³
Density of Rock: 163 lb(f)/ft³
Tension of the Rock Bolt: 0 lb(f)
Height of Water in Tension Crack: 0 ft
Height of Rock Bolt in Block: 0 ft

Results

The Sum of the Moments = 8239.2 lb(f).ft

This indicates that the slope is UNSAFE

CALCULATE

Minimum Unsafe Joint Angle