Appendix H: Geology and Soil Technical Report

- **Slope Stability Investigation (CHJ, updated 2017)**
- **Geology and Soil Report (SLR, 2013)**

Appendix H-1: Slope Stability Investigation

(CHJ, updated 2017)

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July 20, 2012

Omya California
a Division of Omya, Incorporated
7225 Crystal Creek Road
Lucerne Valley, California 92356
Attention: Mr. Howard Brown

Job No. 12399-8

Dear Mr. Brown:

This letter transmits six copies of the Slope Stability Investigation report, prepared for the proposed Sentinel and Butterfield Mine Reclamation project, located south of Lucerne Valley, California.

We appreciate this opportunity to provide geotechnical services for this project. If you have questions or comments concerning this report, please contact us at your convenience.

Respectfully submitted,
CHJ CONSULTANTS

John S. McKeown

John S. McKeown, E.G.
Project Geologist

JMc:lb

Distribution: Omya California (6)

SLOPE STABILITY INVESTIGATION
PROPOSED AMENDED PLAN OF OPERATIONS
FOR THE
SENTINEL AND BUTTERFIELD QUARRIES
LUCERNE VALLEY, CALIFORNIA

PREPARED FOR
OMYA CALIFORNIA
A DIVISION OF OMYA, INC.
JOB NO. 12399-8

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Attention: Mr. Howard Brown

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Dear Mr. Brown:

Attached herewith is the Slope Stability Investigation report, prepared for the proposed Sentinel and Butterfield Mine Reclamation project, located south of Lucerne Valley, California.

This report was based upon a scope of services generally outlined in our existing agreement, dated May 1, 2012, and other written and verbal communications.

We appreciate this opportunity to provide geotechnical services for this project. If you have questions or comments concerning this report, please contact this firm at your convenience.

Respectfully submitted,
CHJ CONSULTANTS

John S. McKeown

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SLOPE STABILITY INVESTIGATION
PROPOSED AMENDED PLAN OF OPERATIONS
FOR THE
SENTINEL AND BUTTERFIELD 3 QUARRIES
LUCERNE VALLEY, CALIFORNIA
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INTRODUCTION

During June and July, 2012, a slope stability investigation for the proposed Omya California a Division of Omya Incorporated (Omya California) Sentinel and Butterfield 3 (Butterfield) Amended Plan of Operations mine reclamation project was performed by this firm. The purpose of this study was to explore and evaluate the geotechnical/geological engineering conditions at the subject quarries and to provide slope stability evaluation for existing and future cut slopes and overburden embankments.

A Slope Stability Investigation report, prepared for a proposed south and west quarry expansion of the Sentinel quarry, dated July 8, 2003, was previously prepared by C.H.J., Incorporated. Information from the 2003 study was utilized to the extent possible for the current investigation.

To orient our investigation, a draft Reclamation Plan and Amended Mining Plan (AMP) dated July 16, 2012, and Existing Conditions Plan, dated April 17, 2012, prepared by Omya California, were furnished for our use.

The approximate location of the site is shown on the attached Index Map (Enclosure "A-1").

The results of our slope stability investigation, together with our conclusions and recommendations, are presented in this report.

SCOPE OF SERVICES

The scope of services provided during this investigation included the following:

- Review of published and unpublished literature and maps including geologic mapping by Mr. Howard Brown, Omya California's geologist
- Review of aerial imagery dated 1995, 2002, 2003, 2005, 2006, 2007 and 2009
- Review of Omya California mine plans
- Review of previous CHJ studies for the Sentinel quarry and White Knob quarry
- Geologic mapping of the quarry areas
- Geologic (kinematic) evaluation of the proposed rock slopes and slope stability calculations of the proposed rock and fill slopes under static and seismic conditions
- Slope stability analysis of the proposed reclamation slopes
- Slope stability analysis of the proposed overburden embankments
- Evaluation of geologic hazards to the project including seismic shaking hazard

PROJECT CONSIDERATIONS

It is our understanding that the existing mine excavation may be expanded westward and southward and deepened relative to previously-permitted limits/elevations. The mine excavation is anticipated to expose rock materials of similar nature as those addressed in the currently-approved reclamation plan. This study was performed in order to evaluate the slope stability of the proposed excavated mine slopes and overburden embankments for the amended mine reclamation project.

Rock (limestone) slopes will be up to a maximum of approximately 625 feet high and inclined with an overall slope of approximately 48 degrees to 50 degrees. Mining will be conducted with approximately 60-foot high inter-bench slope faces inclined at 70 degrees in the Sentinel quarry and approximately 50-foot high inter-bench slope faces inclined at 70 degrees in the Butterfield 3 quarry. An intervening bench approximately 30 feet wide and 25 feet wide for the Sentinel and Butterfield 3

quarries, respectively, will be created. The placement of haulage roads across some slopes and the proposed benching plan will yield the approximate 48- to 50-degree overall slope angle. Our slope stability calculations for the proposed rock slopes are based upon the above slope configurations and are considered a conservative evaluation of final reclamation conditions.

In addition to rock slopes, overburden stockpile slopes were evaluated with regard to slope stability for several heights and bench configurations yielding overall reclaimed slope gradients of 2(h) to 1(v). These data were utilized in planning the final stockpile configurations for the subject quarries.

SITE DESCRIPTION

The Sentinel and Butterfield quarries are located along the range crest of the northern San Bernardino Mountains, approximately 7 miles south of the town of Lucerne Valley. The quarries occupy portions of sections 23 and 24, T3N, R1W, S.B.B.&M. Access to the quarries is by a haul road extending southerly from the Omya California processing plant along Crystal Creek Road. The Sentinel and Butterfield quarries produce high-purity limestone used for numerous commercial and industrial applications. The high-purity limestone deposits required for these applications are typically white in color and very high-purity calcium carbonate.

The subject quarries are located at the northeast edge of a relatively flat geomorphic surface that characterizes the higher elevations of the San Bernardino Mountains. As such, local natural topography and relief are much less than the adjacent steep north range front slopes.

A steep natural slope descends from the east side of the Sentinel quarry approximately 600 feet into Furnace Canyon at an inclination slightly flatter than 2(h) to 1(v). Remaining natural slopes to the northwest, west and south are flatter, consisting of the rolling hills that typify the higher elevations of the San Bernardino Mountains.

Mine slopes at the Sentinel quarry are inclined overall at approximately 1(h) to 1(v) and up to approximately 360 feet in height. The total area of the existing Sentinel quarry is approximately 40

acres. The south expansion includes an additional 6.5 acres, and the west expansion includes an additional 1.2 acres of currently disturbed ground. The west quarry expansion is minimal in scope, and will entail cutting back an existing slope to relocate an existing haul road. Since the existing quarry will be partially backfilled to approximately Elevation 7,305 feet, the reclaimed (ultimate) height of the quarry slopes will be reduced to a total height of less than 325 feet. Our rock slope stability analyses are conservative in that they utilize the full depth (maximum anticipated excavated slope heights) of the mined quarry prior to backfill.

Existing mine slopes at the Butterfield quarry consist of vertical to steep benched cut slopes inclined overall at 1(h) to 1(v) and up to approximately 55 feet in height. The maximum proposed benched mining slope height of the Butterfield quarry slope is approximately 250 feet including adjacent native slopes. Mining at the Butterfield quarry will be conducted with approximately 50-foot-high inter-bench faces (slopes) inclined at 70 degrees. An intervening terrace (bench) approximately 25 feet wide will be provided above each slope face, yielding the approximate 1(h) to 1(v) overall slope angle. Some slopes will include haulage roads. Overall finished slopes are anticipated to exhibit angles of 48 degrees to 50 degrees. The eastern half of the Butterfield quarry is planned to be backfilled with waste rock to elevations that approximate pre-mining topography.

The proposed mining and reclaimed configurations of the subject quarries are depicted on Enclosure "A-2.2".

Vegetation at the quarries consists of a moderate growth of mature trees and brush in the undisturbed areas. Vegetation is generally absent on the mine slopes.

FIELD INVESTIGATION

A Certified Engineering Geologist conducted geologic mapping of the existing mines slopes in the Sentinel and Butterfield quarries on June 7 and 8, 2012. Geologic structures were mapped in the field, including measurement of bedding/foliation, joint and fault orientations and geometry using a Brunton compass. Our focus in the field was on continuous features that might affect kinematic

stability of local slope faces. General material descriptions were also recorded; however, detailed field mapping of named geologic units was not within the scope of our investigation. We utilized prior mapping by Miller et al. (2001) based on unpublished geologic maps by Mr. Howard Brown, Exploration and Mining Geologist of Omya California. Mr. James Rogers, Geologist of Omya California, identified major and minor structural features of the subject quarries and provided an overview of the various geologic units in the field. Aerial imagery and prior geologic mapping by Mr. Howard Brown of Omya California was reviewed in our office. A Geologic Map (Enclosure "A-2.1") based on data collected during the field investigation and mapping review are provided in Appendix A.

SITE GEOLOGY

The Sentinel and Butterfield quarries are located in the northern portion of the San Bernardino Mountains. The San Bernardino Mountains are part of the Transverse Ranges Geomorphic Province. The San Bernardino Mountains are characterized by remnants of a relatively flat, uplifted geomorphic surface as old as Miocene in age. These discontinuous remnants are separated by steep-walled canyons and prominent peaks. The subject quarries are located along the northeast margin of a remnant of this surface. The view from the highlands above the quarries looks out over Lucerne Valley and the Mojave Desert Geomorphic Province to the north.

Most of the northern San Bernardino Mountains are underlain at a shallow depth by crystalline bedrock of plutonic composition. However, remnants of Paleozoic metamorphic rocks are present in the northern San Bernardino Mountains (Geologic Index Map, Enclosure "A-3"). These remnants consist of moderate- to high-grade metamorphosed sandstones, shales, limestones, and dolomites originally deposited in broad marine basins. The sequence of correlatable marine rocks has been identified throughout the western United States, extending to Utah through Nevada and eastern California.

The Sentinel and Butterfield quarries are located on a large roof pendant of Paleozoic marine rocks. The oldest unit in the Paleozoic sequence present in the Sentinel quarry is the Cambrian Nopah

Formation. The Nopah Formation consists of moderately to thickly bedded, fine- to coarse-grained dolomite and dolomitic marble. The color is variable, but is generally light shades of gray, brown and yellow. The Nopah Formation was observed in the west Sentinel quarry area. Bedding is variable, but generally dips moderately to steeply toward the east.

The Mississippian Monte Cristo Limestone comprises the primary ore body of the Sentinel quarry and is separated from the Nopah Formation by a well-exposed north-northeast trending west-dipping high-angle reverse fault. The Monte Cristo Limestone includes several members, with the Bullion Member forming the majority of rock exposed in the Sentinel quarry. The Yellowpine Member comprises a small exposure in the southwest portion of Sentinel quarry. The Monte Cristo Limestone consists of white to yellowish marble in thin to thick beds. Bedding is variable and exhibits little structural control relative to joints in the Monte Cristo units. Generally, bedding in the Monte Cristo Formation dips westward at moderate angles.

The Pennsylvanian Bird Spring Formation is exposed at the ground surface across most of the south Sentinel quarry area and is shown to be in thrust fault contact with the Monte Cristo Limestone members to the north. The location of this thrust fault as depicted on the Geologic Map herein (Enclosure "A-2.1") is adopted from Miller et al. (2001). This mapping was conducted prior to quarry excavation; thus, the actual location of the thrust fault is to the southwest. Rock exposures in the southern portion of Sentinel quarry were generally poor due to an abundance of fill and surficial rock debris; therefore, this fault was not observed during field mapping. Bird Spring Formation exposed at the Sentinel quarry area is the lower part of the formation and generally consists of gray marble with chert nodules. Based on surface exposures, this unit is folded on a small and large scale. Variability in bedding orientation can be observed within individual outcrops. Upper Bird Spring Formation comprises the white calcite marble ore of the Butterfield quarry.

The lithologic units at the Sentinel and Butterfield quarries consist of sedimentary rocks that have been subjected to high-grade metamorphism. While bedding is generally well developed in these materials, no potentially weak primary clay or silt beds were observed. Therefore, bedding is not considered to be a dominant factor in the stability of the quarry walls.

Fill observed at the site is associated with material and debris stockpiles in the area of quarrying, as well as with roadways and general work areas. The more significant areas of fill are indicated on the Geologic Map (Enclosure "A-2.1").

FAULTING AND SEISMICITY

REGIONAL FAULTING:

The tectonics of the Southern California area are dominated by the interaction of the North American and Pacific tectonic plates, which are sliding past each other in a transform motion. Although some of the motion may be accommodated by rotation of crustal blocks such as the western Transverse Ranges (Dickinson, 1996), the San Andreas fault zone is thought to represent the major surface expression of the tectonic boundary and to be accommodating most of the transform motion between the Pacific Plate and the North American Plate. However, some of the plate motion is apparently also accommodated by other northwest-trending strike-slip faults that are related to the San Andreas system, such as the San Jacinto fault and the Elsinore fault. Local compressional or extensional strain resulting from the transform motion along this boundary is accommodated by left-lateral, reverse, and normal faults such as the Cucamonga fault and the nearby North Frontal fault zone.

The most significant fault to the site from a ground shaking standpoint is the North Frontal fault zone, exposed approximately 2 miles north of the site along the range front of the San Bernardino Mountains. This fault is a complex zone of left-lateral, thrust and reverse faults and forms the boundary between the Mojave Desert Geomorphic Province and the Transverse Ranges Geomorphic Province to the south. Since this fault dips at a moderate angle to the south, the fault plane is probably less than 2 miles beneath the site.

The Eastern California Shear Zone (ECSZ) is a zone of regional deformation traversing the Mojave Desert that includes a system of predominantly northwest-trending strike-slip faults. The ECSZ accommodates strain along the Pacific/North American Plate boundary across a zone approximately 65 miles wide and is thought to transfer as much as 15 percent of the total plate boundary shear into

the Great Basin area (Shermer and others, 1996). A number of faults of this system ruptured in combination during the 1992 Landers earthquake east of the site. Rupture of that event extended within approximately 25 miles of the mine area and included several faults (Hauksson, 1992). An earthquake of **M** 6.4, known as the Big Bear earthquake, occurred a few hours later. The Big Bear quake and its aftershocks occurred along a northeast-trending alignment located approximately 12 miles southeast of the site. The Hector Mine earthquake of 1999 occurred on the Lavic Lake and Bullion faults of the ECSZ. The Helendale fault, Lenwood-Lockhart fault, and Johnson Valley fault of this system are located approximately 4.9 miles northeast, 15-1/2 miles northeast, and 19 miles east-northeast of the site, respectively. These faults are major components of the ECSZ and are considered Holocene active.

The northwest-trending San Andreas fault is located approximately 18 miles southwest of the site. The toe of the mountain front in the San Bernardino area roughly demarcates the presently active trace of the San Bernardino mountains segment. Youthful fault scarps, vegetational lineaments, springs and offset drainages, characterizes both segments. The Working Group on California Earthquake Probabilities (1995) tentatively assigned a 28 percent (±13 percent) probability to a major earthquake occurring on the San Bernardino Mountains segment of the San Andreas fault between 1994 and 2024.

LOCAL FAULTING:

No evidence of active faulting traversing the mapped area was found during our review of published and unpublished literature and maps, during our review of stereoscopic aerial photographs, or during the field mapping. Ground rupture due to primary fault slip in the mapped area is not anticipated.

Various faults were observed in the quarry walls. In the mapped areas, both high-angle and low angle faults were observed. Such faulting is typical of the northern San Bernardino Mountains, and most or all of these are likely to predate or be associated with uplift of the San Bernardino Mountains. Quaternary activity along these faults is unlikely.

In the west Sentinel quarry area, the Cambrian Nopah Formation is in reverse fault contact with the ore (Mississippian Monte Cristo Limestone). This fault strikes about N30E and dips steeply (70 degrees) toward the northwest.

A thrust fault is exposed in the southern portion of the existing Sentinel quarry. The thrust dips toward the south-southwest at a moderate angle (45 degrees) and places the Pennsylvanian Bird Spring Formation over the older Monte Cristo Limestone. In the south Sentinel quarry, the dark gray limestone of the Bird Spring Formation represents a significant overburden on the ore body.

Various high-angle faults of limited continuity are exposed in the existing Butterfield quarry walls. These faults include intruded fault zones that exhibit thick gouge zones and limited exposure.

SEISMIC ACCELERATION PARAMETERS

The 2010 California Building Code (CBC) Design Acceleration Parameters for structures were determined from latitude/longitude coordinates N34.3303, W116.9413 using the web-based U.S. Geologic Survey application - http://earthquake.usgs.gov/hazards/designmaps/javacalc.php - and are summarized in the following table. These data are provided for reference only since no CBC structures are addressed by this report. The corresponding value of peak ground acceleration (PGA) from the design acceleration spectrum according to the 2010 CBC is 0.52g.

2010 CBC - Seismic Parameters	
Mapped Spectral Acceleration Parameters	$S_s = 1.94$ and $S_1 = 0.75$
Site Coefficients	$F_a = 1.0$ and $F_v = 1.0$
Adjusted Maximum Considered Earthquake (MCE) Spectral Response Parameters	$S_{MS} = 1.94$ and $S_{M1} = 0.75$
Design Spectral Acceleration Parameters	$S_{DS} = 1.29$ and $S_{D1} = 0.50$

GROUNDWATER

No evidence for springs or perched groundwater conditions was observed at the site during the geologic mapping or on the aerial photographs reviewed. The rock materials of the quarry areas are generally tight and are not readily susceptible to infiltration of precipitation. However, tension cracks created at the top of the working bench after blasting may collect water during periods of heavy or prolonged precipitation. Removal of loose materials from the intra-bench face during excavation of ore mitigates tension features from the bench and leaves tight rock in place.

Depth-to-groundwater data are not available for the site vicinity from the California Department of Water Resources (2011) or the U.S. Geological Survey (2011). The closest data available are from wells in the town of Lucerne Valley, north of the site and are not representative of site conditions.

Groundwater has not been encountered in exploratory borings drilled to 550 feet below ground surface (Howard Brown, personal communication). The current depth to groundwater at the site is not known but is expected to be greater than 550 feet below the ground surface. Based on the planned excavation depths, the expected depth to groundwater, and the presence of non-liquefiable bedrock, the potential for liquefaction and other shallow groundwater-related hazards at the site is considered to be non-existent.

SLOPE STABILITY

The term "landslide", as used in this report, refers to deep-seated slope failures that involve inter-bench-scale features that have the potential to reduce the long-term stability of finished quarry reclamation slopes. Landslides are typically related to the structure of the parent material. Surficial failures refer to shallow failures that affect limited inter-bench zones and may result in localized raveling of rock material. No evidence for deep-seated landsliding was observed in the quarry walls or on the aerial photographs reviewed. Minor surficial failures typically involving small rock falls or talus accumulations were observed in the quarry walls during this investigation. These surficial failures are considered a mining management/maintenance issue.

The susceptibility of a geologic unit to landsliding is dependent upon various factors, primarily: 1) the presence and orientation of weak structures, such as fractures, faults or clay beds; 2) the height and steepness of the pertinent natural or cut slope; 3) the presence and quantity of groundwater and 4) the occurrence of strong seismic shaking.

Given the steepness of natural slopes at the site and vicinity and the close proximity to the active North Frontal fault, the geologic materials at the site exhibit a low susceptibility to deep-seated landsliding.

GEOLOGIC STRUCTURE:

Geologic mapping of the subject quarries included observation of lithologic distribution and measurement of the orientation of bedrock structures in the quarry exposures that influence kinematic rock slope stability. We also included information from the geologic map by Miller et al. (2001) that is based on work by Mr. Howard Brown in the mine areas. The orientation of joints, bedding/ foliation, dikes, and shear zones were mapped and recorded in tabular format (Tables "B-1.1" through "B-2"). Observations of potential failure modes for each mapping area were noted. Structural data were grouped into areas defined as domains that exhibit similar rock type and structural characteristics. Five domains were defined for the Sentinel quarry and one domain was defined for the Butterfield quarry based on a relative uniformity of structure and material.

Sentinel Quarry

The limestone and dolomite exposed within the Sentinel quarry are relatively pure from a slope stability standpoint. The predominant bedrock structures within the Sentinel quarry include faults, bedding/foliation, and poorly- to moderately-developed joint systems. A major west-dipping high-angle reverse fault exposed in the west wall of Sentinel quarry results in locally-daylighted east-dipping bedding/foliation of the Cambrian Nopah dolomite in its hanging wall. Localized intra-bench failures have formed in this structural system. Bedding/foliation is well-developed in the rock materials that comprise the hanging wall of this fault. Bedding/foliation exhibiting a consistent steep easterly dip was observed from the haul road cut slope down to the level of the exposed reverse fault

plane at approximately elevation 7,490 feet amsl on the working bench. This bedding/foliation in the Nopah provides structural control of a recent slope failure and incipient tension crack feature observed near Location 21. However, this condition is confined to the Nopah dolomite unit exposed by current mining of the final quarry limits in the northern portion of the Sentinel quarry. With regard to potential future slides, this condition is mitigated by the proposed bench configuration and truncation of east-dipping hanging wall features by the west-dipping reverse fault that separates the Nopah and Bullion units. In the remaining areas of the Sentinel quarry, bedding/foliation is poorly defined and secondary to pervasive fracture or jointing with regard to discontinuities.

A low-angle shear zone that forms a relatively flat-lying, undulating, tight contact was observed near the current base of the Sentinel quarry at approximately elevation 7,290 feet amsl. This feature locally includes a brownish red gouge material that varies from very thin millimeter-thick to about 1 inch in thickness. Zones of dark gray to black dirty graphite or manganese oxide were also present locally within this zone. The orientation of this feature as measured on the east quarry wall is N73W, 27SW (strike north 73 degrees west, dipping 27 toward the southwest).

Other faults included on the map by Miller et al. (2001) are shown on Enclosure "A-2.1". These were not directly observed during mapping due to the presence of slough on existing slopes or location outside of the area of field mapping. These features were considered in our slope stability evaluation.

The majority of the rock mass in the Sentinel quarry exhibits pervasive (very closely spaced) random fractures (fractures not belonging to a defined joint set). The random fracture fabric forms a tight, well-healed and hard rock mass with respect to global stability. Jointing within the Sentinel quarry is generally characterized by closely-spaced, discontinuous joint sets (less than 3 feet) that only locally exhibit slightly- to moderately-continuous lengths (3 to 10 feet). Where present, joint sets were observed to form small faces and wedges and columnar blocks cut by orthogonal cross joints. Joint surfaces were generally moderately rough to rough and undulating as is common in carbonate materials. We focused our investigation on the more continuous structures as these have a greater potential to define kinematic behavior in rock masses.

Sentinel Quarry - Existing Slope Failure

Bedding/foliation in the hanging wall of a west-dipping fault formed in dolomite of the Nopah Formation exposed in the west wall of the Sentinel quarry dips steeply toward the east and forms several face-forming dip slopes locally. These bedding/foliation-defined slope faces range from about 3 square feet to 90 square feet in area as observed during our observations of the northwest portion of the Sentinel working bench. This geologic structural domain (described in the Kinematic Analysis section) is confined to the northwestern portion of the quarry excavation above the west-dipping fault that separates Nopah Formation overburden from Bullion Member ore.

During winter 2011-2012, an approximately 250-foot-long segment of rock slope adjacent to a working bench slid along this bedding/foliation-defined dip slope system generating a shallow slope failure confined to a single cut slope, resulting in accumulation of debris on the working bench. This shallow failure occurred along a clay-rich east-dipping bedding plane fault and essentially scaled the slope back along a dip slope (a slope of the surface of the land determined by and conforming approximately to the dip of the underlying rocks). The resulting slope does not exhibit day-lighted bedding/foliation or joint structures. Adjacent to this area of slope failure, a section of bench approximately 150 feet long with an incipient tension crack remained north of the original failure section. We understand that mitigation of the remaining shallow feature, including scaling of loose material, is ongoing. Finished bench widths below the failure area will be adjusted as necessary to result in the desired overall slope angle during creation of final quarry slopes. Recurrence of deep-seated failures after mining is completed in this area is not anticipated based on the relation of proposed bench configurations to the geologic structure.

Due to the purity of the limestone and dolomite, no significant clay or silt layers are expected to be exposed in the proposed cut slopes. Fracturing/jointing is significant, and may reduce the effective cohesion of individual blocks of rock in proposed slopes. However, the closely-spaced and random jointing also effectively limits the depth and areal extent of any slope failures that could occur. Based on these data and the results of our investigation, deep-seated landsliding is not anticipated in the proposed slopes. Further analyses of the proposed slopes is presented later as slope stability calculations.

Butterfield Quarry

The limestone and dolomite exposed within the Butterfield quarry are relatively simple from a slope stability standpoint, with no adversely-oriented weak clay or silt beds observed in natural or mined exposures. The rock mass exposed in the Butterfield quarry exhibits much less pervasive fracture and forms larger volumes of intact rock between structures. Structural features observed in the Butterfield exposures include faults, joints, shear zones and bedding.

Bedding in the Butterfield quarry exhibits low to moderate dips to the east and north east.

The Butterfield quarry exposes thick bedded metamorphosed Upper Bird Spring generally white calcium carbonate marble units that are characterized by moderately- to well-developed joints exhibiting generally steep orientations. Jointing within the Butterfield quarry is generally characterized by regularly-spaced discontinuous joint sets (less than 3 feet) and more-continuous joints that exhibit moderately continuous lengths (3 to 10 feet). The fracture fabric forms a tight, well-healed and hard rock mass. The steep joint structure results in few daylighted planar features with potential to form slope failures. The dominant potential failure mode in the Butterfield quarry is topple-type failure of columnar joint systems. These blocks or columns are of limited volume and are easily mitigated by scaling with excavation equipment during recovery of ore following blasting. Joint surfaces were generally moderately rough to rough and undulating as is common in carbonate materials. We focused our investigation on the more continuous structures as these have a greater potential to estimate kinematic behavior in rock masses.

Faults within the Butterfield quarry are generally high angle or favorably-oriented, steeply-dipping structures, resulting in no out-of-slope fault orientations that could act as slip surfaces for large landslides or failures.

Proposed Overburden Stockpiles

Overburden stockpiles with maximum heights up to 165 feet above adjacent grade and 215 feet above adjacent grade are proposed for the Butterfield and Sentinel quarries, respectively. These stockpiles

are constructed at gradients of 2(h) to 1(v) with overburden material that exhibits variable grain size from silt- to boulder-size material. The variability in grain size results in a slope that forms a network of interlocking coarse-grained clasts infilled with finer-grained sediments. For purposes of slope stability calculation for the proposed overburden stockpile slopes, we have utilized a cohesion value of 100 psf to account for the apparent cohesion generated due to grain to grain contacts and a phi angle of 35 degrees. The actual values for materials of this type are typically greater than the modeled values so our calculations are considered conservative with respect to stability.

SLOPE STABILITY CALCULATIONS:

We evaluated the kinematic (potential failure modes) and global slope stability of the proposed reclamation slopes for Sentinel and Butterfield quarries for representative material types. Rock strength properties for global stability calculations were modeled using Hoek Brown criteria and the ultimate mining depths (highest slopes) anticipated in each quarry. Final quarry bottom elevations in the Sentinel quarry and eastern portion of the Butterfield quarry include backfill that will result in shorter overall slope heights. A discussion and summary of these analyses is presented below. Slope stability data and calculations are presented in Appendices "B" and "C".

Global Stability Calculations

We evaluated proposed mining rock slopes for the Sentinel and Butterfield quarries for native-over-cut and overburden-over-cut rock slopes. We also evaluated several configurations of proposed overburden stockpile (fill) slopes including heights of 250 feet, 400 feet and 560 feet.

The global (rotational) stability of proposed mining slopes as depicted in the Amended Mining Plan and proposed reclamation stockpiles as depicted in the Reclamation Plan was analyzed using Spencer's method under both static and seismic conditions for rotational failures utilizing the SLIDE computer program, version 6.0 (Rocscience, Inc., 2011). Selection of the AMP slope configurations for the analysis of excavated slopes, which depicts the tallest anticipated excavated/native slopes proposed for mining at the Sentinel and Butterfield quarries, is based on a most-conservative analysis approach. Reclamation is planned to fill portions of the quarry bottoms so that ultimate reclaimed slope heights will be shorter and the fill will be confined within the enclosed quarry pit.

Representative slope sections of the excavated rock slopes and overburden stockpiles derived from the AMP were modeled as follows:

- 730-foot high native-over-cut slope (Section A)
- 725-foot high fill-over-cut slope (Section C)
- 250-foot high native-over-cut slope (Section E)
- Various overburden slope configurations as presented in Table 4.

The seismic stability calculations were performed using a lateral pseudostatic coefficient "k" of 0.20 due to the proximity of the North Frontal fault zone. Groundwater was not considered in the global stability evaluation due to the lack of seepage or groundwater anticipated in the generally arid site environment.

The rock strength was modeled utilizing the Generalized Hoek-Brown criteria (Hoek, 2000 and Hoek, Carranza-Torres & Corkum, 2002), and the program's built-in parameter calculator with the following input values:

Table 1: Sentinel Quarry - Monte Cristo and Bird Spring Bedrock Units Slope Stability Parameters

	Value	Description
Unit Weight (pcf*)	150	--
Intact UCS[1] (psf**)	1,500,000	Specimen requires more than one blow of a geological hammer to fracture it
Geological Strength Index	65	Very blocky with good surface conditions
Intact Rock Constant (mi***)	9	Marble
Disturbance Factor	1	Production blasting

[1] Uniaxial Compressive Strength test result
* pcf = pounds per cubic foot
** psf = pounds per square foot
*** mi = unitless constant

Table 2: Butterfield Quarry - Bird Spring Bedrock Units Slope Stability Parameters		
	Value	**Description**
Unit Weight (pcf*)	150	--
Intact UCS[1] (psf**)	1,500,000	Specimen requires more than one blow of a geological hammer to fracture it
Geological Strength Index	65	Blocky with good surface conditions
Intact Rock Constant (mi***)	9	Marble
Disturbance Factor	1	Production blasting

[1] Uniaxial Compressive Strength test result
* pcf = pounds per cubic foot
** psf = pounds per square foot
*** mi = unitless constant

The rock strength parameters were obtained from laboratory analysis of samples from the White Knob quarry that exposes similar carbonate rocks (CHJ, 2008). The Hoek-Brown criteria allows for estimation of rock mass properties based on field criteria such as how easily rock can be broken with a hammer.

The shear strength of overburden stockpiles is based on our direct shear testing results performed on relatively undisturbed samples collected during a prior investigation in the White Knob quarry that generates a similar-type overburden. An internal frictional angle of φ=35 degrees, a cohesive strength of C=100 psf, and a unit weight of 125 pcf were utilized to model the shear strength of overburden fill materials. An internal frictional angle of φ=38 degrees, a cohesive strength of C=200 psf, and a unit weight of 130 pcf were utilized to model the shear strength of native subgrade beneath overburden stockpiles.

The results of our global slope stability analyses are summarized below in Tables 3 and 4. Details of stability calculations including material type boundaries, strength parameters utilized, and the minimum factor of safety and critical slip surface are included in Enclosures "C-1.1" through "C-7.2".

Table 3: Summary of Slope Stability Results - Bedrock Mine Slopes

Cross Section	Material	Slope Configuration	Static F.S.	Seismic F.S. (k=0.2)
Section A - Sentinel	Bullion	Native-over-cut	2.63	1.97
Section C - Sentinel	Bullion	Overburden-over-cut	2.72	2.19
Section E - Butterfield	Bird Spring	Native-over-cut	5.72	4.84

Table 4: Summary of Slope Stability Results Overburden Stockpile Study

Slope Configuration		Static F.S.	Seismic F.S. (k=0.2)
continuous slope at 2:1	26.6° overall H = 250 feet	1.52	1.17
continuous slope at 2:1	26.6° overall H = 400 feet	1.48	1.13
3 segments at 26.6° 2 benches at 50-foot width*	24.7° overall H = 560 feet	1.70	0.99*
4 segments at 26.6° 3 benches at 50-foot width	23.8° overall H = 560 feet	1.53	1.16

*Slope configuration not utilized in proposed reclamation slope design.

As shown in Tables 3 and 4, sufficient static factors of safety in excess of 1.5 and seismic factors of safety in excess of 1.1 were indicated for the modeled proposed rock and overburden slope configurations and satisfy Office of Mine Reclamation (OMR) guidelines.

KINEMATIC ANALYSIS:

Kinematic analysis involves the evaluation of bedrock stability based on the presence of structural discontinuities including joints, faults, shear zones, bedding and foliations. Kinematic analysis addresses only the potential failure mode(s) and does not consider mass or force in a limit-equilibrium analysis. Structurally-controlled kinematic failure modes include planar, wedge, and topple failures. Circular failure of highly fractured rock masses is also feasible and is considered in a global stability analysis (as presented previously).

Stereonet analysis for selected representative rock slopes was performed utilizing the data from mapped geologic structures within the site (Tables "B-1.1" through "B-2"). Rock slopes in the Sentinel quarry were evaluated for slopes with dip azimuths oriented at 45°, 90°, 110°, 130°, 225°, 270° and 315° and for Butterfield quarry at 90°, 180°, 270°, and 360° representing the suite of proposed slope aspects. The stereonet data are presented in Appendix "B". Locations of geologic structural mapping areas (domains) are indicated on the attached Geologic Map and Site Plan (Enclosure "A-2.1").

The proposed 70-degree intra-bench rock slopes were analyzed for wedge and plane failure modes where kinematic evaluation using Markland's Test indicated a potential failure mode. Appendix "B" presents the detailed kinematic analysis data. A cohesion value of 800 psi, a friction angle of 50°, and a rock density of 150 lbs/ft^3 were utilized in the wedge and plane analyses based on typical values for site bedrock and the degree of surface roughness exhibited in the site bedrock. Results of these analyses are presented in Appendix "B".

The results of the planar and wedge failure mode analysis for individual structures indicate overall suitable intra-bench stability (factors of safety) of proposed mining and reclamation slopes in all domains and aspects.

CONCLUSIONS

On the basis of our field investigation and slope stability analyses, it is the opinion of this firm that the proposed mine excavation, stockpile placement, and reclamation of the Omya California Sentinel and Butterfield quarries is feasible from geotechnical engineering and engineering geologic standpoints, provided the recommendations contained in this report are implemented during mining.

In general, it appears that past quarry operations at both the Sentinel and Butterfield quarries have resulted in formation of grossly stable slopes.

Based upon our analyses, the proposed overall approximate 48- to 50-degree mine cut-slopes up to approximately 625 feet in height formed in limestone and marble rock are suitably stable against gross failure for the anticipated long-term conditions, including the effects of seismic shaking. The proposed 2(h):1(v) fill slopes meet the factor of safety criteria for static and seismic conditions.

Subsequent to blasting of the final rock slope walls, quarry operations may include the use of a scaling chain or mechanical equipment to assist in removal of loose or precarious blocks during removal of the ore. Adherence to the slope benching plan and consideration of newly-exposed adverse structural features (if present) during future quarry work can result in stable slopes after completion of quarry reclamation.

No evidence of active faulting was observed on the site during this investigation. Several inactive faults traverse the quarry areas.

The current depth to groundwater is expected to be greater than 550 feet bgs, and the proposed slopes are entirely within non-liquefiable bedrock. Therefore, the potential for liquefaction and other shallow groundwater hazards within the reclamation area is considered to be remote.

Moderate seismic shaking of the site can be expected to occur during the lifetime of the proposed mining and reclamation. This potential has been considered in our analyses and evaluation of slope stability.

Raveling processes during and after quarry operation, with time, will result in deposition of talus on benches. Talus left on the benches can facilitate revegetation and lend a more natural appearance to the reclaimed slopes. It is anticipated that any resulting boulders will be angular and relatively resistant to rolling.

Seepage or other indications of water in the rock mass were not visible during our field mapping. Existing finished excavated rock slopes in the northeastern wall of the Sentinel quarry exhibit angles consistent with planned finished slope angles. Over a period of approximately 40 years raveling of small rock clasts has formed accumulations of talus on bench surfaces creating a more continuous and natural slope appearance.

The arid environment of the site and non-porous, non-fractured nature of the site bedrock precludes significant groundwater in the proposed slopes, except on a very limited basis where water may be concentrated by geologic structures such as faults following periods of precipitation. Groundwater has never been encountered in exploratory borings drilled to at least 550 feet below ground surface (Howard Brown, personal communication).

RECOMMENDATIONS

Overall final cut slopes in the rock materials should be no steeper than approximately 1(h):1(v) up to a maximum height of approximately 625 feet.

Natural raveling processes will result in accumulation of talus on the excavated benches. This process has already occurred along many of the existing mine slopes. The talus will be left on the slopes to facilitate revegetation and to give the reclaimed slopes a relatively natural appearance. It is anticipated that any resulting boulders will be angular and relatively resistant to rolling. Any large, unstable, rounded boulders on slopes steeper than approximately 2(h) to 1(v) should be removed or stabilized where accessible. Areas below loose rock should be restricted and indicated by means of signage or fencing.

Geotechnical evaluation and design, management of mine bench geometry based on encountered conditions, or use of mechanical support systems can enhance the safety of or mitigate hazards in mining; however, monitoring of slope conditions for failure warning signs is the most important means for protecting mine workers (Girard and McHugh, 2000) as it can prevent exposure of personnel to potentially hazardous conditions. As is typical for any surface mining location, we recommend that the ongoing practice of periodic observation of mine benches above working areas for indications of potential instability continue during mine operations.

Final reclaimed fill slopes composed of overburden materials should be no steeper than 2(h):1(v) to the maximum proposed heights.

Slopes should be protected with berms and/or levees as necessary to prevent slope erosion in the areas where natural slopes drain onto the reclaimed slopes.

LIMITATIONS

CHJ Consultants has striven to perform our services within the limits prescribed by our client, and in a manner consistent with the usual thoroughness and competence of reputable geotechnical engineers and engineering geologists practicing under similar circumstances. No other representation, express or implied, and no warranty or guarantee is included or intended by virtue of the services performed or reports, opinion, documents, or otherwise supplied.

This report reflects the testing conducted on the site as the site existed during the study, which is the subject of this report. However, changes in the conditions of a property can occur with the passage of time, due to natural processes or the works of man on this or adjacent properties. Changes in applicable or appropriate standards may also occur whether as a result of legislation, application, or the broadening of knowledge. Therefore, this report is indicative of only those conditions tested at the time of the subject study, and the findings of this report may be invalidated fully or partially by changes outside of the control of CHJ Consultants. This report is therefore subject to review and should not be relied upon after a period of one year.

The conclusions and recommendations in this report are based upon observations performed and data collected at separate locations, and interpolation between these locations, carried out for the project and the scope of services described. It is assumed and expected that the conditions between locations observed and/or sampled are similar to those encountered at the individual locations where observation and sampling was performed. However, conditions between these locations may vary significantly. Should conditions be encountered in the field, by the client or any firm performing services for the client or the client's assign, that appear different than those described herein, this firm should be contacted immediately in order that we might evaluate their effect.

If this report or portions thereof are provided to contractors or included in specifications, it should be understood by all parties that they are provided for information only and should be used as such.

The report and its contents resulting from this study are not intended or represented to be suitable for reuse on extensions or modifications of the project, or for use on any other project.

CLOSURE

We appreciate this opportunity to be of service and trust this report provides the information desired at this time. Should questions arise, please do not hesitate to contact this office.

Respectfully submitted,

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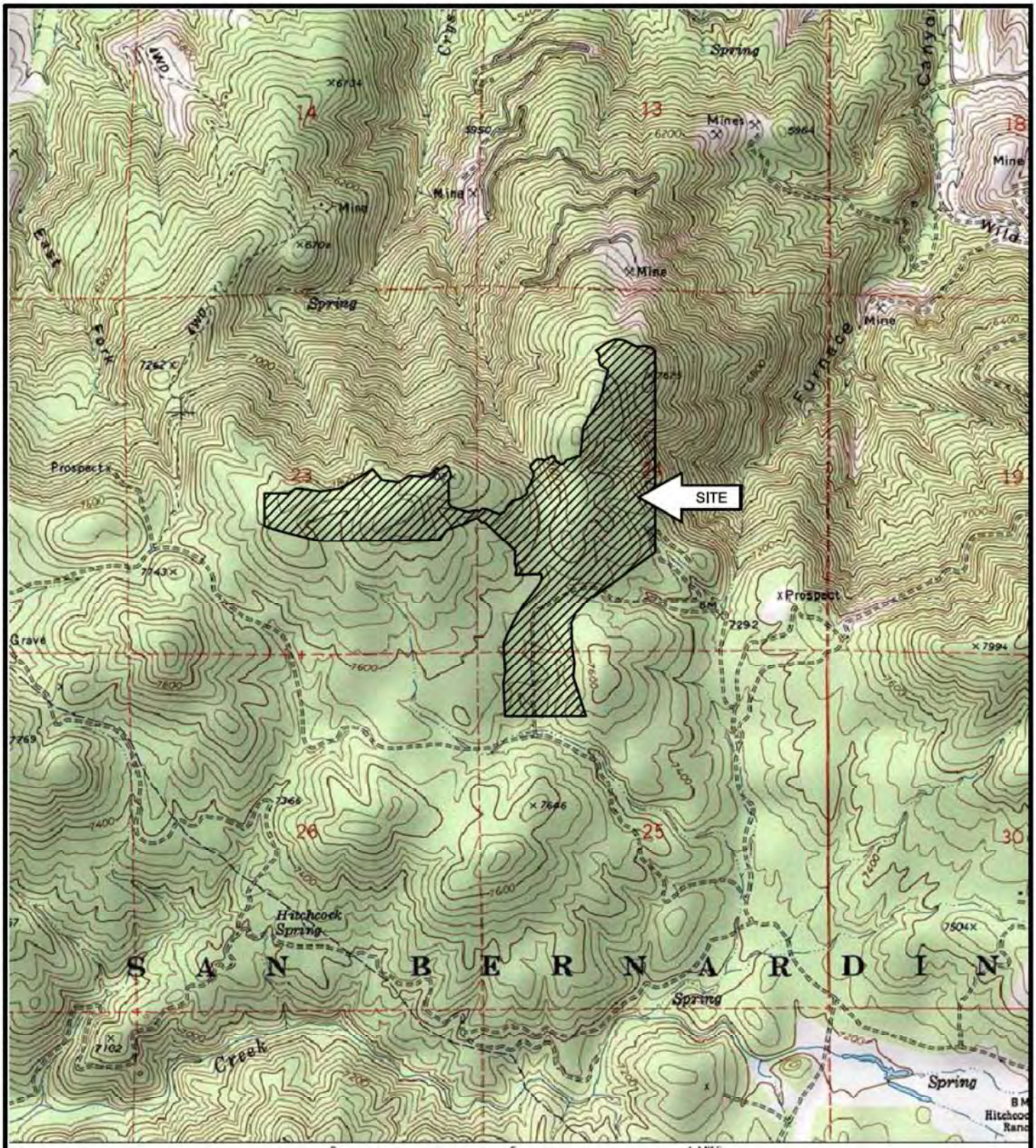
APPENDIX "A"

GEOTECHNICAL MAPS



0 .5 1 MILE

0 1000 FEET 0 500 1000 METERS

-N-

SCALE: 1" = 2000'

INDEX MAP

FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "A-1"
DATE: JULY 2012		JOB NUMBER 12399-8

CHJ Consultants

GEOLOGIC UNITS: *(from Miller et al. 2001 & Brown 1978-82)*

dg - disturbed ground, Includes areas lacking vegetation, roadways & associated fills & overburden embankment fills.
native - areas where vegetation appears undisturbed, mature and dense.

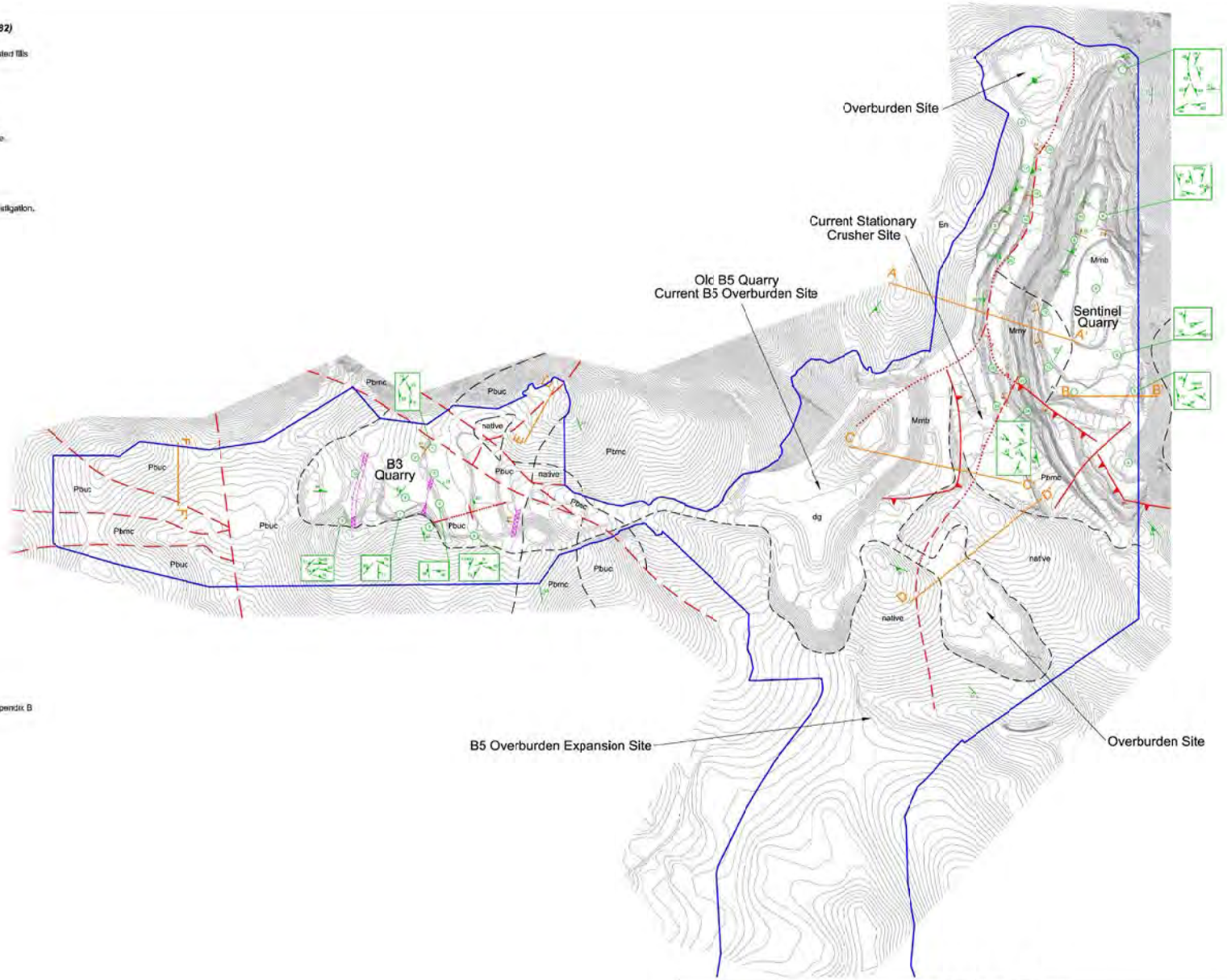
Bird Spring Formation:
Pbuc - Upper Carbonate Member
Pbmc - Middle Carbonate Member

Monte Cristo Limestone:
Mmy - Yellowpine Member, medium-to thick-bedded calcite & dolomite marble
Mmb - Bullion Member, thick-to very thick-bedded calcite marble.
Mml - Lower Member, thin-to thick-bedded calcite marble.
En - Nopah Formation, texturally massive, locally laminated dolomite

Note:
Lithologic contacts & unit names from Miller et al. (2001)
Structural geology from Miller et al. (faults in red) & field mapping for this investigation.
Bedrock units not shown in overburden placement areas.

LEGEND:

- thrust fault, barbs on upper plate
- fault with arrow indicating dip direction dotted where concealed/inferred
- Geologic Contact, queried where uncertain, dotted where inferred or concealed
- Geologic Cross Sections
- strike and dip of bedding
- strike and dip of joint
- shear zone vertical
- shear zone
- vertical foliation
- strike and dip of metamorphic foliation
- (26) location of observations corresponding to tables in Appendix B
- altered intrusive dike/shear zone mapped in field



-N-

SCALE: 1"=250'
0 250 500

GEOLOGIC MAP

FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "A-2.1"
DATE: JULY 2012		JOB NUMBER 12399-3

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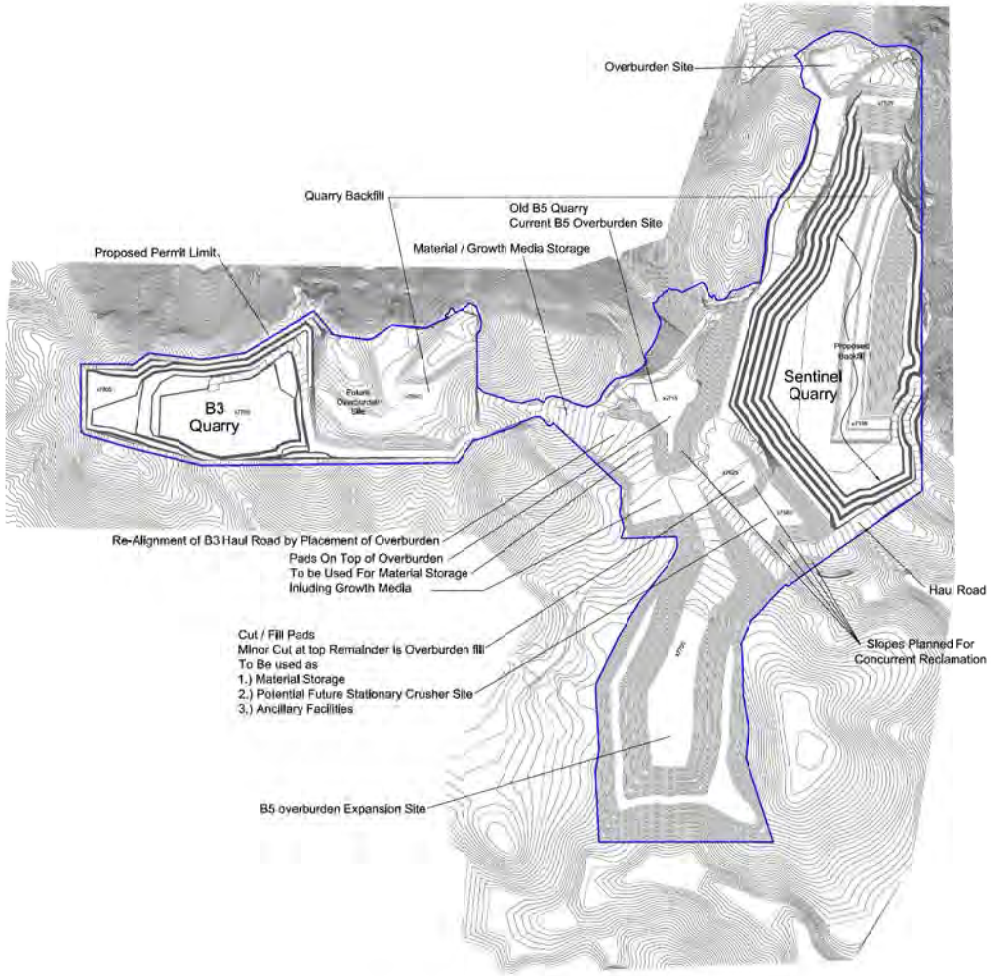
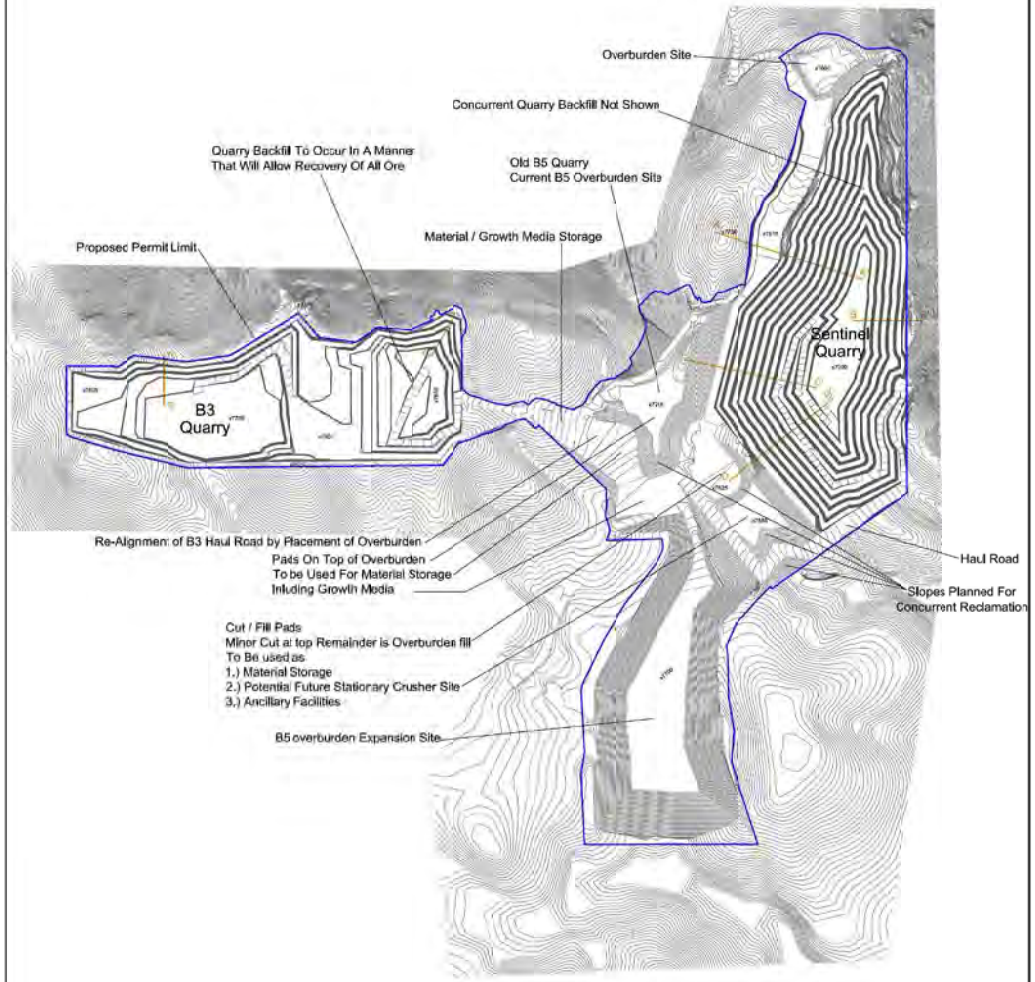


Omya California
Sentinel and B3 Reclamation Plan

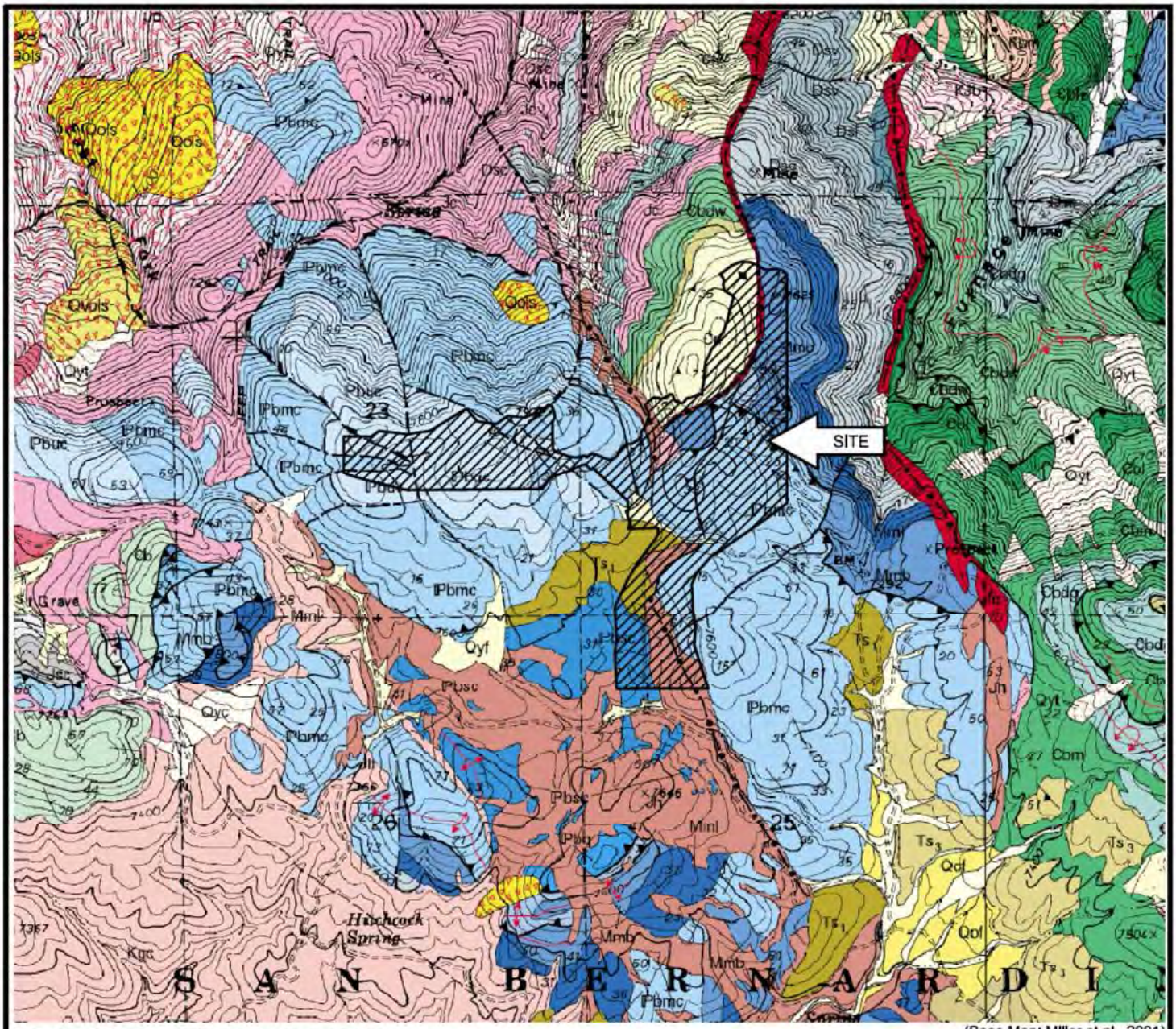


Omya California
Sentinel and B3 Mining Plan

LEGEND:

F F
Geologic Cross Section

RECLAMATION AND MINING PLAN		
FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "A-2.2"
DATE: JULY 2012		JOB NUMBER 12399-3
		CHJ Consultants



(Base Map: Miller et al., 2001)

GEOLOGIC UNITS IN MINE AREAS:

Qyt - talus deposits
Ts - sedimentary rocks of Holcomb Valley
Jc - quartz monzonite
Pbuc, Pbmc, Pblc, Pbsc - carbonate members of Bird Spring Formation
Mmy, Mmb, Mml - carbonate members of Monte Cristo Limestone
Dsc, Dsv, Dsl - members of Sultan Limestone
Єn - Nopah Formation
Єn - Dunderburg Shale
Єbdw, Єbdg - Bonanza King Formation

geologic contact
thrust fault
fault - intruded
fault - high angle
61 strike and dip of bedding
36 strike and dip of foliation

-N-

SCALE: 1" = 2000'

GEOLOGIC INDEX MAP

FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "A-3"
DATE: JULY 2012		JOB NUMBER 12399-8

CHJ Consultants

APPENDIX "B"

KINEMATIC EVALUATION

Table B-1.1: Domain No. 1					
Includes Sentinel Location 1					
Discontinuity No.	**Continuity***	**Geologic Unit**	**Structure Type**	**Dip Direction**	**Dip Value**
1	slightly cont.	Bullion	joint	160	84
2	slightly cont.		joint	162	83
3	slightly cont.		joint	358	81
4	slightly cont.		joint	80	82
5	slightly cont.		joint	250	63
6	slightly cont.		joint	297	49
7	slightly cont.		joint	78	51
8	slightly cont.		joint	281	48
9	slightly cont.		joint	296	76
10	slightly cont.		joint	63	49
11	highly cont.		bedding	270	17

*based on Department of the Interior - Bureau of Reclamation, Engineering Geology Field Manual (2nd edition 1998)

Table B-1.2: Domain No. 2					
Includes Sentinel Locations 2,3, and 16 - 21					
Discontinuity No.	**Continuity**	**Geologic Unit**	**Structure Type**	**Dip Direction**	**Dip Value**
1	slightly cont.	Nopah Fm.	joint	110	60
2	slightly cont.		joint	288	51
3	slightly cont.		fault	308	63
4	moderately cont.		foliation	108	74
5	moderately cont.		foliation	90	63
6	slightly cont.		joint	226	37
7	slightly cont.		joint	165	62
8	slightly cont.		joint	130	49
9	very continuous		fault	270	38
10	slightly cont.		joint	111	51
11	slightly cont.		joint	111	64
12	moderately cont.		foliation	130	90

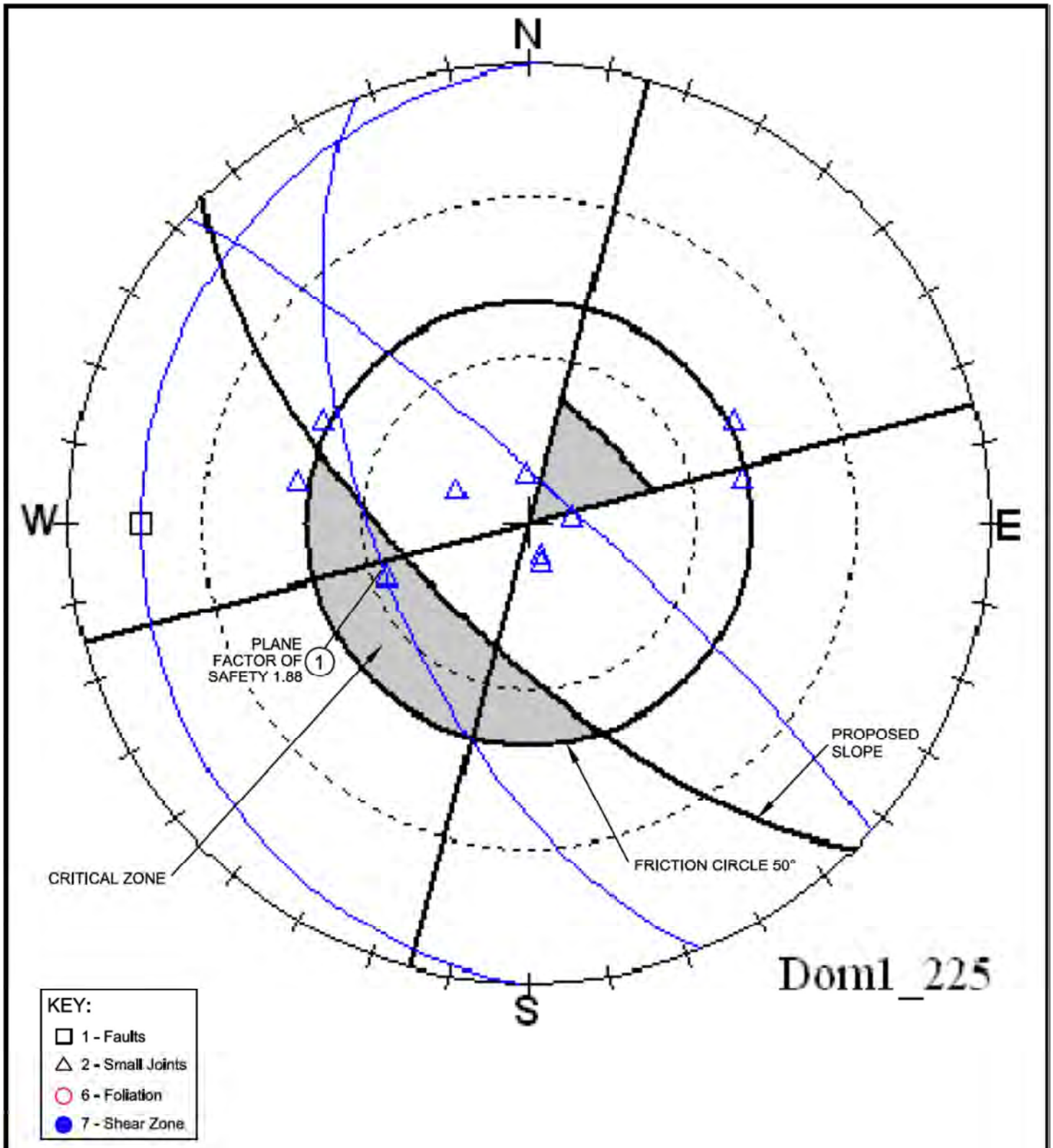
Table B-1.3: Domain No. 3					
Includes Sentinel Locations 8 - 11					
Discontinuity No.	**Continuity**	**Geologic Unit**	**Structure Type**	**Dip Direction**	**Dip Value**
1	highly cont.	Bullion	shear zone	197	27
2	slightly cont.		joint	74	87
3	slightly cont.		joint	259	85
4	slightly cont.		joint	203	86
5	slightly cont.		joint	284	35
6	slightly cont.		joint	284	52
7	slightly cont.		joint	334	43
8	slightly cont.		joint	334	49
9	moderately cont.		shear zone	40	10
10	slightly cont.		joint	95	51
11	slightly cont.		joint	220	73
12	slightly cont.		joint	10	89

Table B-1.4: Domain No. 4					
Includes Sentinel Locations 4 - 7					
Discontinuity No.	**Continuity**	**Geologic Unit**	**Structure Type**	**Dip Direction**	**Dip Value**
1	slightly cont.	Bullion	joint	86	72
2	slightly cont.		joint	30	56
3	slightly cont.		joint	342	36
4	slightly cont.		joint	342	65
5	slightly cont.		joint	288	84
6	slightly cont.		joint	37	57
7	slightly cont.		joint	240	76
8	slightly cont.		joint	259	81
9	slightly cont.		joint	170	73
10	slightly cont.		joint	170	85
11	slightly cont.		joint	357	50
12	slightly cont.		joint	155	68
13	slightly cont.		joint	155	87
14	slightly cont.		joint	168	89
15	slightly cont.		joint	273	74
16	moderately cont.	Bird Spring	foliation	235	25

Table B-1.5: Domain No. 5					
Includes Sentinel Locations 12, 13, 23 - 26					
Discontinuity No.	**Continuity**	**Geologic Unit**	**Structure Type**	**Dip Direction**	**Dip Value**
1	moderately cont.	Bird Spring	foliation	255	30
2	moderately cont.		shear zone	301	38
3	slightly cont.		joint	29	81
4	slightly cont.		joint	305	79
5	slightly cont.		joint	287	82
6	slightly cont.		joint	60	41
7	slightly cont.		joint	240	74
8	slightly cont.		joint	126	57
9	slightly cont.		joint	265	47
10	slightly cont.		joint	245	64
11	highly cont.	Yellowpine	bedding	300	50
12	moderately cont.		shear zone	340	11
13	moderately cont.		shear zone	343	14
14	very continuous	Bird Spring	fault	210	45
15	very continuous	Bird Spring	fault	240	45

Table B-2: Domain No. 6					
Butterfield 3 Quarry					
Discontinuity No.	**Continuity***	**Geologic Unit**	**Structure Type**	**Dip Direction**	**Dip Value**
1	slightly cont.	Bird Spring	joint	318	77
2	slightly cont.		joint	69	25
3	slightly cont.		joint	86	88
4	slightly cont.		joint	93	81
5	slightly cont.		shear zone	312	67
6	moderately cont.		shear zone	314	89
7	slightly cont.		joint	267	78
8	slightly cont.		joint	180	46
9	slightly cont.		joint	75	89
10	slightly cont.		joint	278	70
11	slightly cont.		joint	278	80
12	slightly cont.		joint	347	79
13	slightly cont.		joint	308	79
14	slightly cont.		joint	22	80
15	slightly cont.		joint	315	72
16	slightly cont.		joint	30	78
17	highly cont.		bedding	90	12
18	slightly cont.		joint	313	81
19	slightly cont.		joint	304	76
20	slightly cont.		joint	360	75
21	moderately cont.		shear zone	270	72
22	moderately cont.		shear zone	285	86
23	moderately cont.		shear zone	158	89
24	slightly cont.		joint	80	85
25	slightly cont.		joint	320	78
26	slightly cont.		shear	10	85
27	slightly cont.		joint	10	79
28	slightly cont.		joint	359	76
29	slightly cont.		joint	359	89

*based on Department of the Interior - Bureau of Reclamation, Engineering Geology Field Manual (2nd edition 1998)



SENTINEL - DOMAIN 1 DIP AZIMUTH 225°		
FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "B-1.0"
DATE: JULY 2012		JOB NUMBER 12399-8
		CHJ Consultants

Domain 1 Azimuth 225 degrees

Plane Failure Analysis Input Data - Plane 1

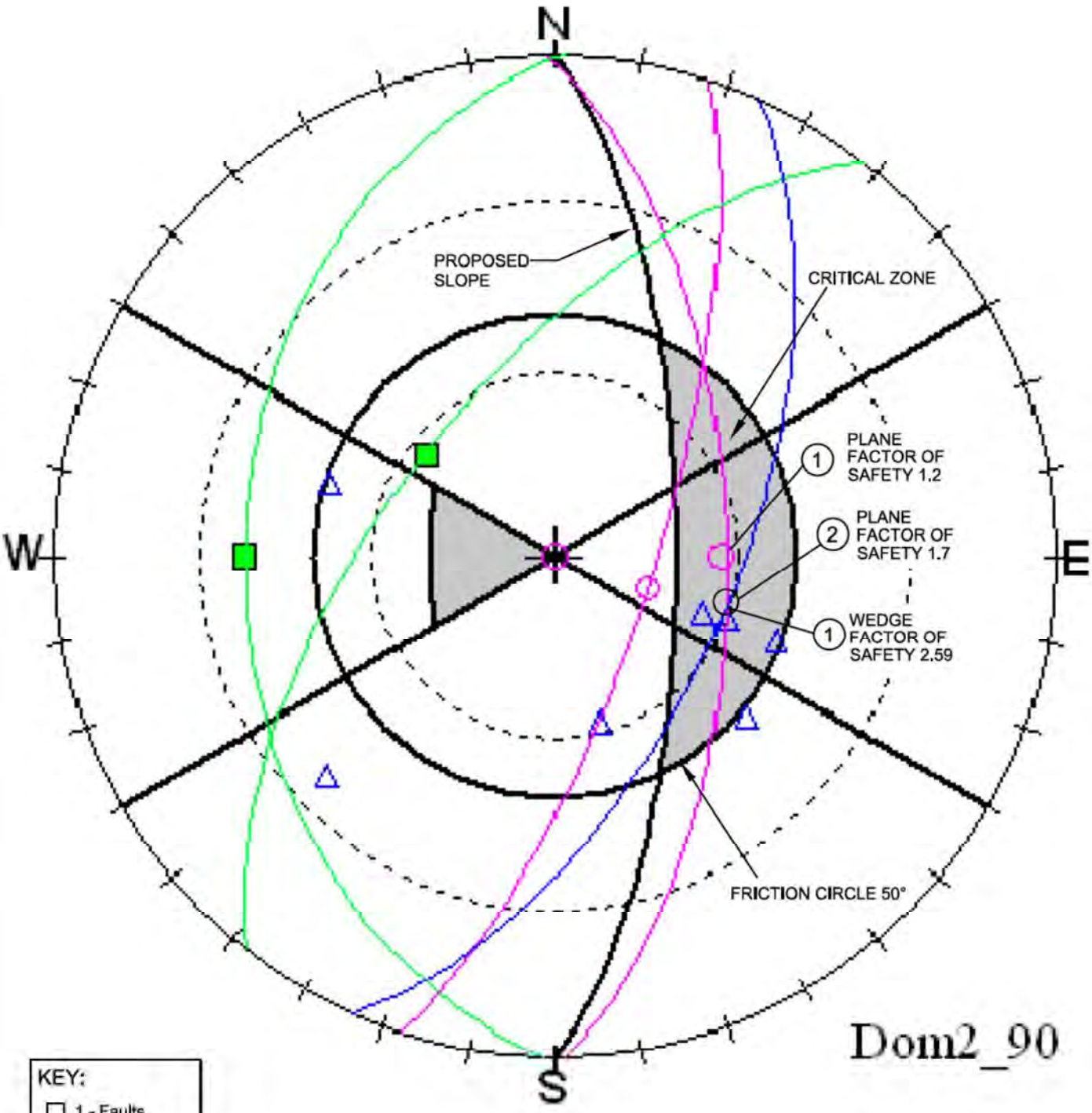
(H) Height = 50 ft
(SF) Inclination of Slope Face = 70 °
(SS) Inclination of Upper Slope = 1 °
(SP) Inclination of Failure Plane = 63 °
(CO) Cohesive Strength of Failure Surface = 800 lb(f)
(PH) Friction Angle of Failure Surface = 50 °
(GR) Density of Rock = 150 lb(f)/ft ^{3}
(GW) Density of Water = 62.4 lb(f)/ft ^{3}
(AB) Starting Rock Bolt Angle = 0 °
(AR) Ending Rock Bolt Angle = 0 °
(AA) Bolt Angle Increment = 0 °
(T1) Starting Bolt Tension = 0 lb(f)
(T2) Ending Bolt Tension = 0 lb(f)
(T3) Bolt Tension Increment = 0 lb(f)
(AC) Horizontal Acceleration = 0.2 G
(TZ) Amount of Discontinuity = 0 decimal%
(VSUR) Vertical Surcharge = 0 lb(f)
(HSUR) Horizontal Surcharge = 0 lb(f)

Tension Crack Location Unknown: Dry Slope

Plane Failure Analysis Output Data

(A) Contact Area = 47.43 ft ^{2}
(W) Weight of Slice = 25016.27 lb(f)
(U) Water Force Normal to Failure Plane = 0 lb(f)
(V) Horizontal Water Force on Tension Crack = 0 lb(f)
(B) Worst Location, Horizontal Distance = 3.33 ft
(Z) Tension Crack Depth = 7.8 ft
(ZW) Depth of Water in Crack = 0 ft
(TH) Bolt Angle = 0 °
(T) Tension = 0 lb(f)
(F) Factor of Safety = 1.88

SENTINEL - DOMAIN 1 DIP AZIMUTH 225°		
FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "B-1.1"
DATE: JULY 2012		JOB NUMBER 12399-8
		CHJ Consultants



KEY:
- 1 - Faults
- 2 - Small Joints
- 6 - Foliation
- 7 - Shear Zone

SENTINEL - DOMAIN 2 DIP AZIMUTH 90°		
FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "B-2.0"
DATE: JULY 2012		JOB NUMBER 12399-8
		CHJ Consultants

Domain 2 Azimuth 90 degrees

Plane Failure Analysis Input Data - Plane 1

(H) Height = 50 ft
(SF) Inclination of Slope Face = 70 °
(SS) Inclination of Upper Slope = 1 °
(SP) Inclination of Failure Plane = 63 °
(CO) Cohesive Strength of Failure Surface = 450 lb(f)
(PH) Friction Angle of Failure Surface = 50 °
(GR) Density of Rock = 150 lb(f)/ft ³
(GW) Density of Water = 62.4 lb(f)/ft ³
(AB) Starting Rock Bolt Angle = 0 °
(AR) Ending Rock Bolt Angle = 0 °
(AA) Bolt Angle Increment = 0 °
(T1) Starting Bolt Tension = 0 lb(f)
(T2) Ending Bolt Tension = 0 lb(f)
(T3) Bolt Tension Increment = 0 lb(f)
(AC) Horizontal Acceleration = 0.2 G
(TZ) Amount of Discontinuity = 0 decimal%
(VSUR) Vertical Surcharge = 0 lb(f)
(HSUR) Horizontal Surcharge = 0 lb(f)

Tension Crack Location Unknown: Dry Slope

Plane Failure Analysis Output Data

(A) Contact Area = 47.43 ft ²
(W) Weight of Slice = 25016.27 lb(f)
(U) Water Force Normal to Failure Plane = 0 lb(f)
(V) Horizontal Water Force on Tension Crack = 0 lb(f)
(B) Worst Location, Horizontal Distance = 3.33 ft
(Z) Tension Crack Depth = 7.8 ft
(ZW) Depth of Water in Crack = 0 ft
(TH) Bolt Angle = 0 °
(T) Tension = 0 lb(f)
(F) Factor of Safety = 1.2

Domain 2 Azimuth 90 degrees

Plane Failure Analysis Input Data - Plane 2

(H) Height = 50 ft
(SF) Inclination of Slope Face = 70 °
(SS) Inclination of Upper Slope = 1 °
(SP) Inclination of Failure Plane = 62 °
(CO) Cohesive Strength of Failure Surface = 800 lb(f)
(PH) Friction Angle of Failure Surface = 50 °
(GR) Density of Rock = 150 lb(f)/ft ³
(GW) Density of Water = 62.4 lb(f)/ft ³
(AB) Starting Rock Bolt Angle = 0 °
(AR) Ending Rock Bolt Angle = 0 °
(AA) Bolt Angle Increment = 0 °
(T1) Starting Bolt Tension = 0 lb(f)
(T2) Ending Bolt Tension = 0 lb(f)
(T3) Bolt Tension Increment = 0 lb(f)
(AC) Horizontal Acceleration = 0.2 G
(TZ) Amount of Discontinuity = 0 decimal%
(VSUR) Vertical Surcharge = 0 lb(f)
(HSUR) Horizontal Surcharge = 0 lb(f)

Tension Crack Location Unknown: Dry Slope

Plane Failure Analysis Output Data

(A) Contact Area = 46.85 ft ²
(W) Weight of Slice = 28498.68 lb(f)
(U) Water Force Normal to Failure Plane = 0 lb(f)
(V) Horizontal Water Force on Tension Crack = 0 lb(f)
(B) Worst Location, Horizontal Distance = 3.8 ft
(Z) Tension Crack Depth = 8.7 ft
(ZW) Depth of Water in Crack = 0 ft
(TH) Bolt Angle = 0 °
(T) Tension = 0 lb(f)
(F) Factor of Safety = 1.7

SENTINEL - DOMAIN 2 DIP AZIMUTH 90°		
FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "B-2.1"
DATE: JULY 2012		JOB NUMBER 12399-8
		CHJ Consultants

Domain 2 Azimuth 90 degrees

Rapid Wedge Failure Analysis Input Data - Wedge 1

(GR) Density of Rock = 150 lb(f)/ft ^{3}
(H) Height of Crest Above Intersection = 40 ft

Plane 1 : (D1) Dip Value = 62 °
(E1) Dip Direction = 111 °
Plane 2 : (D2) Dip Value = 63 °
(E2) Dip Direction = 89 °
Plane 3 : (D3) Dip Value = 1 °
(E3) Dip Direction = 90 °
Plane 4 : (D4) Dip Value = 70 °
(E4) Dip Direction = 90 °

Plane 1 : (C1) Cohesion = 500 lb(f)/ft ^{2}
(P1) Friction Angle = 50 °
Plane 2 : (C2) Cohesion = 450 lb(f)/ft ^{2}
(P2) Friction Angle = 50 °

Water Pressure : Cracks Completely Filled (Free Draining)

(GW) Density of Water = 62.4 lb(f)/ft ^{3}

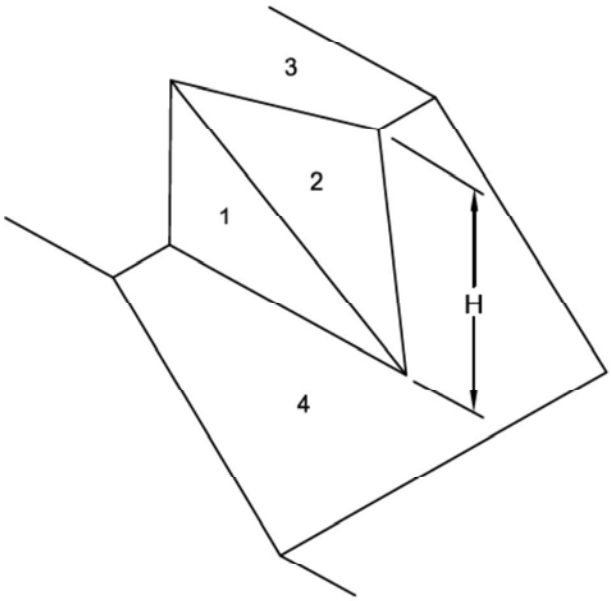
(HW) Overall Vertical Height of Wedge = 0 ft

The slope face DOES NOT hang over the toe of the slope.

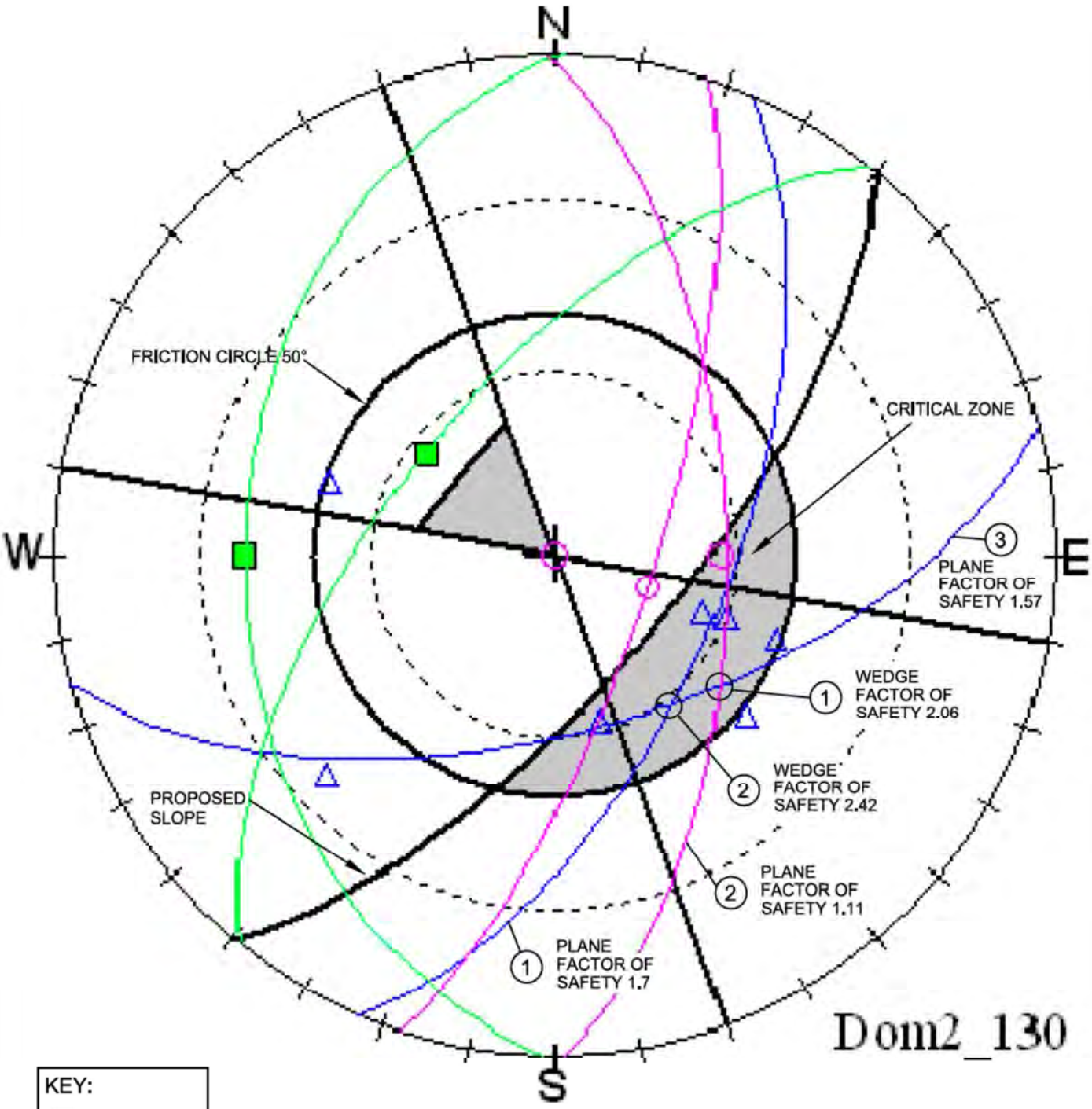
Rapid Wedge Failure Analysis Output Data

(F) Factor of Safety = 2.59
Water Pressure on both planes = 0 lb(f)/ft ^{2}

THERE IS CONTACT ON BOTH PLANES.



SENTINEL - DOMAIN 2 DIP AZIMUTH 90°		
FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "B-2.2"
DATE: JULY 2012		JOB NUMBER 12399-8
		CHJ Consultants



KEY:
- 1 - Faults
- 2 - Small Joints
- 6 - Foliation
- 7 - Shear Zone

SENTINEL - DOMAIN 2 DIP AZIMUTH 130°		
FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "B-3.0"
DATE: JULY 2012		JOB NUMBER 12399-8
		CHJ Consultants

Domain 2 Azimuth 130 degrees

Plane Failure Analysis Input Data - Plane 1

(H) Height = 50 ft
(SF) Inclination of Slope Face = 70 °
(SS) Inclination of Upper Slope = 1 °
(SP) Inclination of Failure Plane = 62 °
(CO) Cohesive Strength of Failure Surface = 800 lb(f)
(PH) Friction Angle of Failure Surface = 50 °
(GR) Density of Rock = 150 lb(f)/ft ³
(GW) Density of Water = 62.4 lb(f)/ft ³
(AB) Starting Rock Bolt Angle = 0 °
(AR) Ending Rock Bolt Angle = 0 °
(AA) Bolt Angle Increment = 0 °
(T1) Starting Bolt Tension = 0 lb(f)
(T2) Ending Bolt Tension = 0 lb(f)
(T3) Bolt Tension Increment = 0 lb(f)
(AC) Horizontal Acceleration = 0.2 G
(TZ) Amount of Discontinuity = 0 decimal%
(VSUR) Vertical Surcharge = 0 lb(f)
(HSUR) Horizontal Surcharge = 0 lb(f)

Tension Crack Location Unknown: Dry Slope

Plane Failure Analysis Output Data

(A) Contact Area = 46.85 ft ²
(W) Weight of Slice = 28498.68 lb(f)
(U) Water Force Normal to Failure Plane = 0 lb(f)
(V) Horizontal Water Force on Tension Crack = 0 lb(f)
(B) Worst Location, Horizontal Distance = 3.8 ft
(Z) Tension Crack Depth = 8.7 ft
(ZW) Depth of Water In Crack = 0 ft
(TH) Bolt Angle = 0 °
(T) Tension = 0 lb(f)
(F) Factor of Safety = 1.7

Domain 2 Azimuth 130 degrees

Plane Failure Analysis Input Data - Plane 2

(H) Height = 50 ft
(SF) Inclination of Slope Face = 70 °
(SS) Inclination of Upper Slope = 1 °
(SP) Inclination of Failure Plane = 62 °
(CO) Cohesive Strength of Failure Surface = 450 lb(f)
(PH) Friction Angle of Failure Surface = 50 °
(GR) Density of Rock = 150 lb(f)/ft ³
(GW) Density of Water = 62.4 lb(f)/ft ³
(AB) Starting Rock Bolt Angle = 0 °
(AR) Ending Rock Bolt Angle = 0 °
(AA) Bolt Angle Increment = 0 °
(T1) Starting Bolt Tension = 0 lb(f)
(T2) Ending Bolt Tension = 0 lb(f)
(T3) Bolt Tension Increment = 0 lb(f)
(AC) Horizontal Acceleration = 0.2 G
(TZ) Amount of Discontinuity = 0 decimal%
(VSUR) Vertical Surcharge = 0 lb(f)
(HSUR) Horizontal Surcharge = 0 lb(f)

Tension Crack Location Unknown: Dry Slope

Plane Failure Analysis Output Data

(A) Contact Area = 46.85 ft ²
(W) Weight of Slice = 28498.68 lb(f)
(U) Water Force Normal to Failure Plane = 0 lb(f)
(V) Horizontal Water Force on Tension Crack = 0 lb(f)
(B) Worst Location, Horizontal Distance = 3.8 ft
(Z) Tension Crack Depth = 8.7 ft
(ZW) Depth of Water In Crack = 0 ft
(TH) Bolt Angle = 0 °
(T) Tension = 0 lb(f)
(F) Factor of Safety = 1.11

SENTINEL - DOMAIN 2 DIP AZIMUTH 130°		
FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "B-3.1"
DATE: JULY 2012		JOB NUMBER 12399-8
		CHJ Consultants

Domain 2 Azimuth 130 degrees

Plane Failure Analysis Input Data - Plane 3

(H) Height = 50 ft
(SF) Inclination of Slope Face = 70 °
(SS) Inclination of Upper Slope = 1 °
(SP) Inclination of Failure Plane = 61 °
(CO) Cohesive Strength of Failure Surface = 800 lb(f)
(PH) Friction Angle of Failure Surface = 50 °
(GR) Density of Rock = 150 lb(f)/ft ³
(GW) Density of Water = 62.4 lb(f)/ft ³
(AB) Starting Rock Bolt Angle = 0 °
(AR) Ending Rock Bolt Angle = 0 °
(AA) Bolt Angle Increment = 0 °
(T1) Starting Bolt Tension = 0 lb(f)
(T2) Ending Bolt Tension = 0 lb(f)
(T3) Bolt Tension Increment = 0 lb(f)
(AC) Horizontal Acceleration = 0.2 G
(TZ) Amount of Discontinuity = 0 decimal%
(VSUR) Vertical Surcharge = 0 lb(f)
(HSUR) Horizontal Surcharge = 0 lb(f)

Tension Crack Location Unknown: Dry Slope

Plane Failure Analysis Output Data

(A) Contact Area = 46.32 ft ²
(W) Weight of Slice = 31972.96 lb(f)
(U) Water Force Normal to Failure Plane = 0 lb(f)
(V) Horizontal Water Force on Tension Crack = 0 lb(f)
(B) Worst Location, Horizontal Distance = 4.26 ft
(Z) Tension Crack Depth = 9.56 ft
(ZW) Depth of Water in Crack = 0 ft
(TH) Bolt Angle = 0 °
(T) Tension = 0 lb(f)
(F) Factor of Safety = 1.57

Domain 2 Azimuth 130 degrees

Rapid Wedge Failure Analysis Input Data - Wedge 1

(GR) Density of Rock = 150 lb(f)/ft ³
(H) Height of Crest Above Intersection = 62.4 ft

Plane 1 : (D1) Dip Value = 61 °
(E1) Dip Direction = 166 °
Plane 2 : (D2) Dip Value = 62 °
(E2) Dip Direction = 91 °
Plane 3 : (D3) Dip Value = 1 °
(E3) Dip Direction = 130 °
Plane 4 : (D4) Dip Value = 70 °
(E4) Dip Direction = 130 °

Plane 1 : (C1) Cohesion = 800 lb(f)/ft ²
(P1) Friction Angle = 50 °
Plane 2 : (C2) Cohesion = 450 lb(f)/ft ²
(P2) Friction Angle = 50 °

Water Pressure : Cracks Completely Filled (Free Draining)

(GW) Density of Water = 0 lb(f)/ft ³

(HW) Overall Vertical Height of Wedge = 0 ft

The slope face DOES NOT hang over the toe of the slope.

Rapid Wedge Failure Analysis Output Data

(F) Factor of Safety = 2.06
Water Pressure on both planes = 0 lb(f)/ft ²

THERE IS CONTACT ON BOTH PLANES.

SENTINEL - DOMAIN 2 DIP AZIMUTH 130°		
FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "B-3.2"
DATE: JULY 2012		JOB NUMBER 12399-8
		CHJ Consultants

Domain 2 Azimuth 130 degrees

Rapid Wedge Failure Analysis Input Data - Wedge 2

(GR) Density of Rock = 150 lb(f)/ft ³
(H) Height of Crest Above Intersection = 62.4 ft

Plane 1 : (D1) Dip Value = 61 °
(E1) Dip Direction = 166 °
Plane 2 : (D2) Dip Value = 62 °
(E2) Dip Direction = 113 °
Plane 3 : (D3) Dip Value = 1 °
(E3) Dip Direction = 130 °
Plane 4 : (D4) Dip Value = 70 °
(E4) Dip Direction = 130 °

Plane 1 : (C1) Cohesion = 800 lb(f)/ft ²
(P1) Friction Angle = 50 °
Plane 2 : (C2) Cohesion = 800 lb(f)/ft ²
(P2) Friction Angle = 50 °

Water Pressure : Cracks Completely Filled (Free Draining)

(GW) Density of Water = 0 lb(f)/ft ³

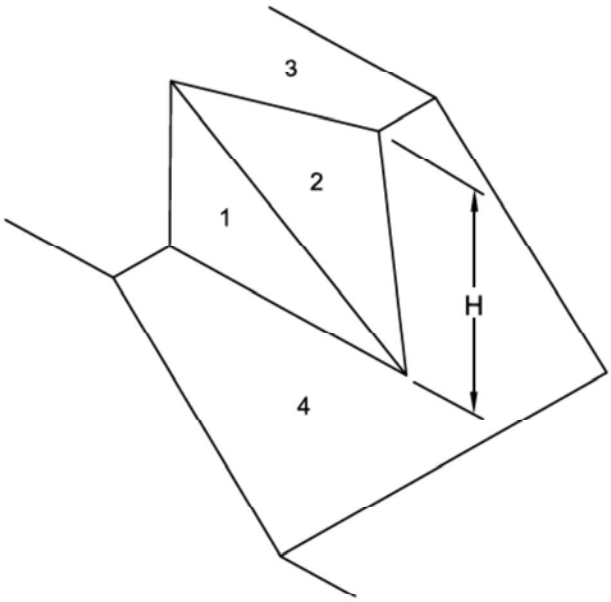
(HW) Overall Vertical Height of Wedge = 0 ft

The slope face DOES NOT hang over the toe of the slope.

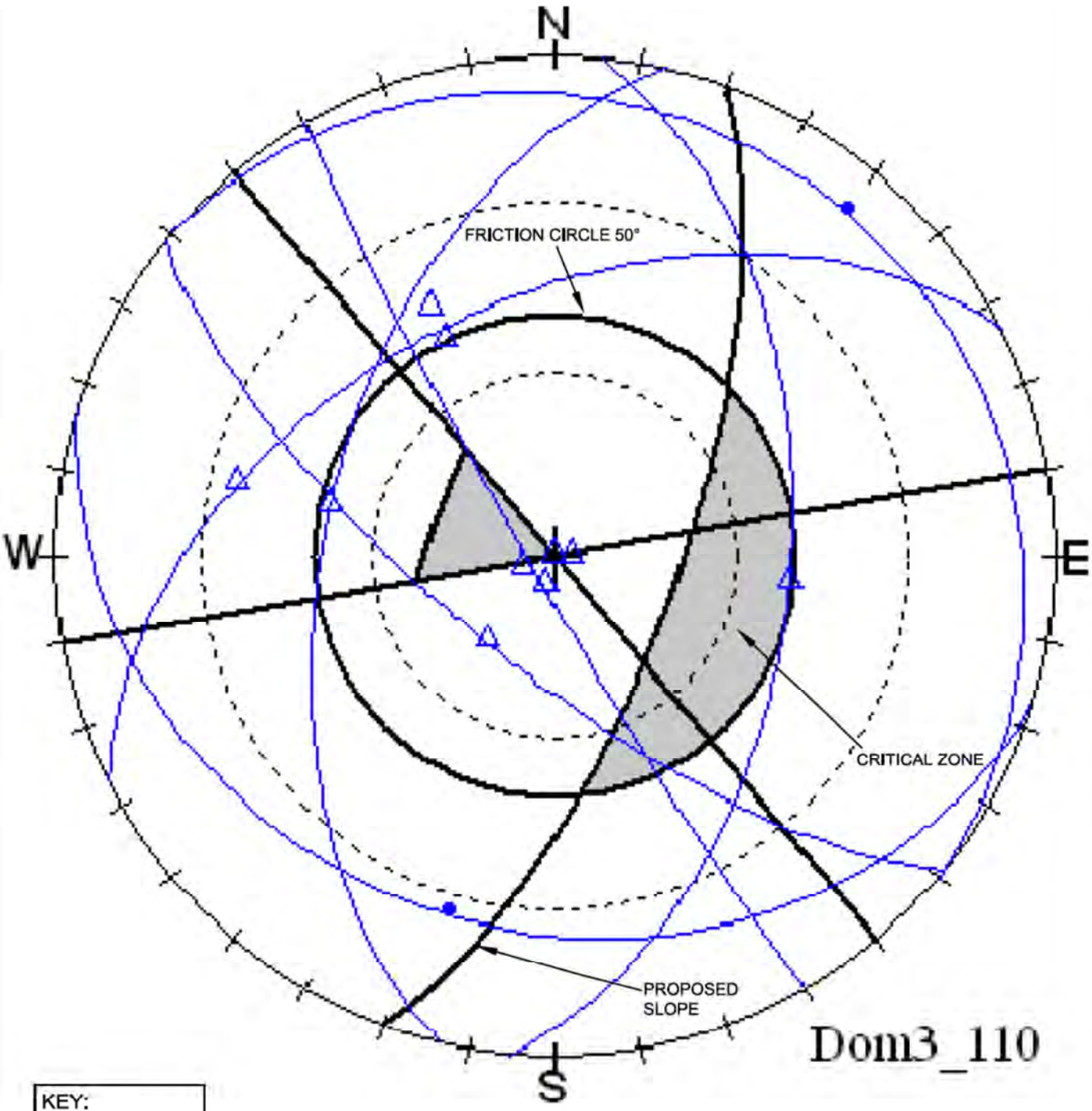
Rapid Wedge Failure Analysis Output Data

(F) Factor of Safety = 2.42
Water Pressure on both planes = 0 lb(f)/ft ²

THERE IS CONTACT ON BOTH PLANES.

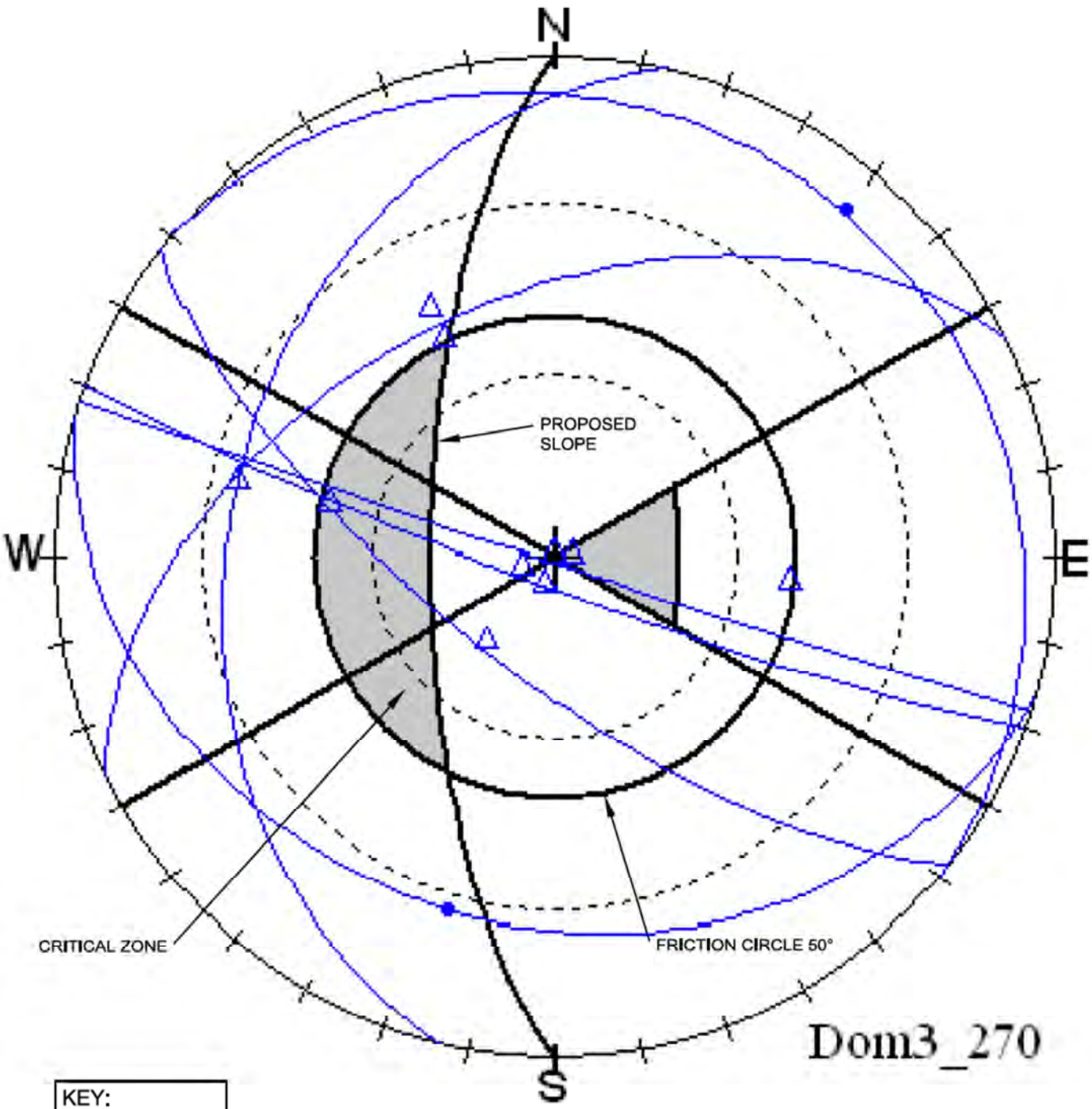


SENTINEL - DOMAIN 2 DIP AZIMUTH 130°		
FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "B-3.3"
DATE: JULY 2012		JOB NUMBER 12399-8
		CHJ Consultants



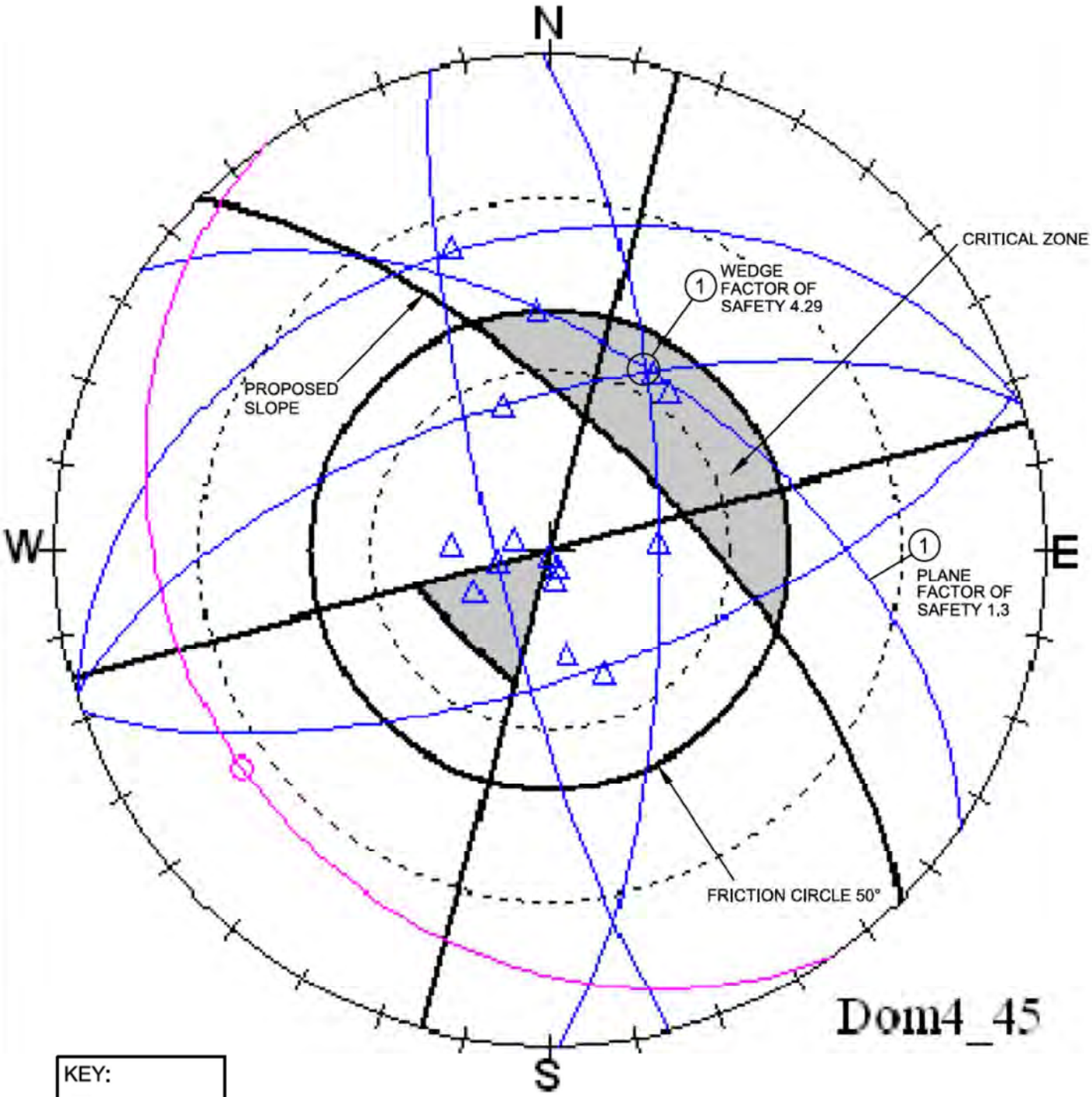
KEY:
- 1 - Faults
- 2 - Small Joints
- 6 - Foliation
- 7 - Shear Zone

SENTINEL - DOMAIN 3 DIP AZIMUTH 110°		
FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "B-4.0"
DATE: JULY 2012		JOB NUMBER 12399-8
		CHJ Consultants



KEY:
- 1 - Faults
- 2 - Small Joints
- 6 - Foliation
- 7 - Shear Zone

SENTINEL - DOMAIN 3 DIP AZIMUTH 270°		
FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "B-5.0"
DATE: JULY 2012		JOB NUMBER 12399-8
		CHJ Consultants



KEY:
- 1 - Faults
- 2 - Small Joints
- 6 - Foliation
- 7 - Shear Zone

SENTINEL - DOMAIN 4 DIP AZIMUTH 45°		
FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "B-6.0"
DATE: JULY 2012		JOB NUMBER 12399-8
		CHJ Consultants

Domain 4 Azimuth 45 degrees

Plane Failure Analysis Input Data - Plane 1

(H) Height = 50 ft
(SF) Inclination of Slope Face = 70 °
(SS) Inclination of Upper Slope = 1 °
(SP) Inclination of Failure Plane = 57 °
(CO) Cohesive Strength of Failure Surface = 800 lb(f)
(PH) Friction Angle of Failure Surface = 50 °
(GR) Density of Rock = 150 lb(f)/ft ³
(GW) Density of Water = 62.4 lb(f)/ft ³
(AB) Starting Rock Bolt Angle = 0 °
(AR) Ending Rock Bolt Angle = 0 °
(AA) Bolt Angle Increment = 0 °
(T1) Starting Bolt Tension = 0 lb(f)
(T2) Ending Bolt Tension = 0 lb(f)
(T3) Bolt Tension Increment = 0 lb(f)
(AC) Horizontal Acceleration = 0.2 G
(TZ) Amount of Discontinuity = 0 decimal%
(VSUR) Vertical Surcharge = 0 lb(f)
(HSUR) Horizontal Surcharge = 0 lb(f)

Tension Crack Location Unknown: Dry Slope

Plane Failure Analysis Output Data

(A) Contact Area = 44.63 ft ²
(W) Weight of Slice = 45875.24 lb(f)
(U) Water Force Normal to Failure Plane = 0 lb(f)
(V) Horizontal Water Force on Tension Crack = 0 lb(f)
(B) Worst Location, Horizontal Distance = 6.11 ft
(Z) Tension Crack Depth = 12.67 ft
(ZW) Depth of Water in Crack = 0 ft
(TH) Bolt Angle = 0 °
(T) Tension = 0 lb(f)
(F) Factor of Safety = 1.3

Domain 4 Azimuth 45 degrees

Rapid Wedge Failure Analysis Input Data - Wedge 1

(GR) Density of Rock = 150 lb(f)/ft ³
(H) Height of Crest Above Intersection = 40 ft

Plane 1 : (D1) Dip Value = 72 °
(E1) Dip Direction = 89 °
Plane 2 : (D2) Dip Value = 65 °
(E2) Dip Direction = 342 °
Plane 3 : (D3) Dip Value = 1 °
(E3) Dip Direction = 45 °
Plane 4 : (D4) Dip Value = 70 °
(E4) Dip Direction = 45 °

Plane 1 : (C1) Cohesion = 800 lb(f)/ft ²
(P1) Friction Angle = 50 °
Plane 2 : (C2) Cohesion = 800 lb(f)/ft ²
(P2) Friction Angle = 50 °

Water Pressure : Cracks Completely Filled (Free Draining)

(GW) Density of Water = 0 lb(f)/ft ³

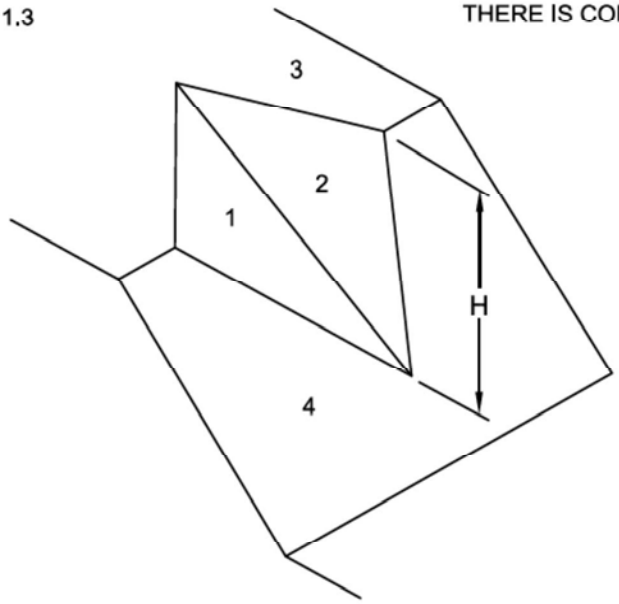
(HW) Overall Vertical Height of Wedge = 0 ft

The slope face DOES NOT hang over the toe of the slope.

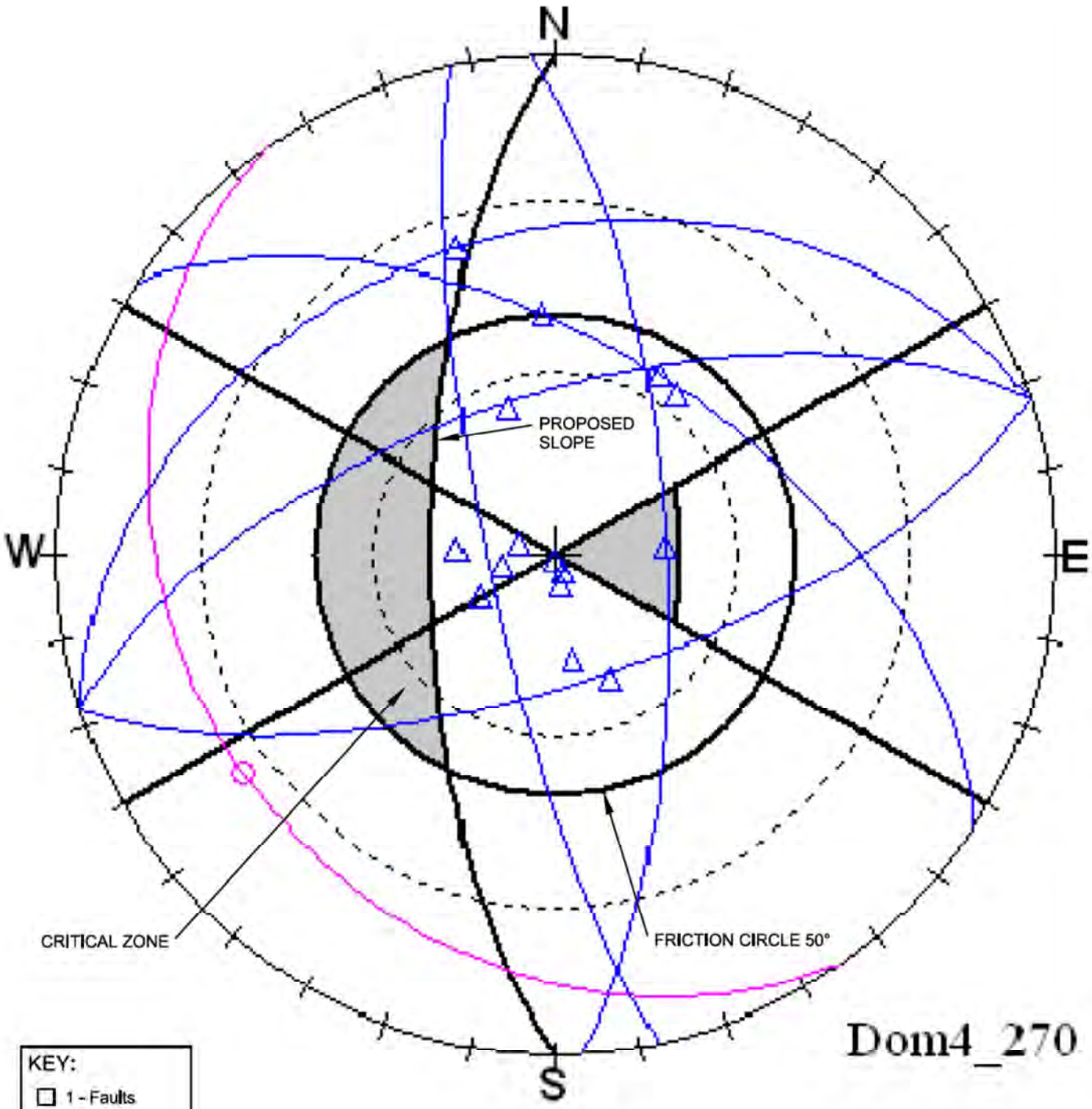
Rapid Wedge Failure Analysis Output Data

(F) Factor of Safety = 4.29
Water Pressure on both planes = 0 lb(f)/ft ²

THERE IS CONTACT ON BOTH PLANES.

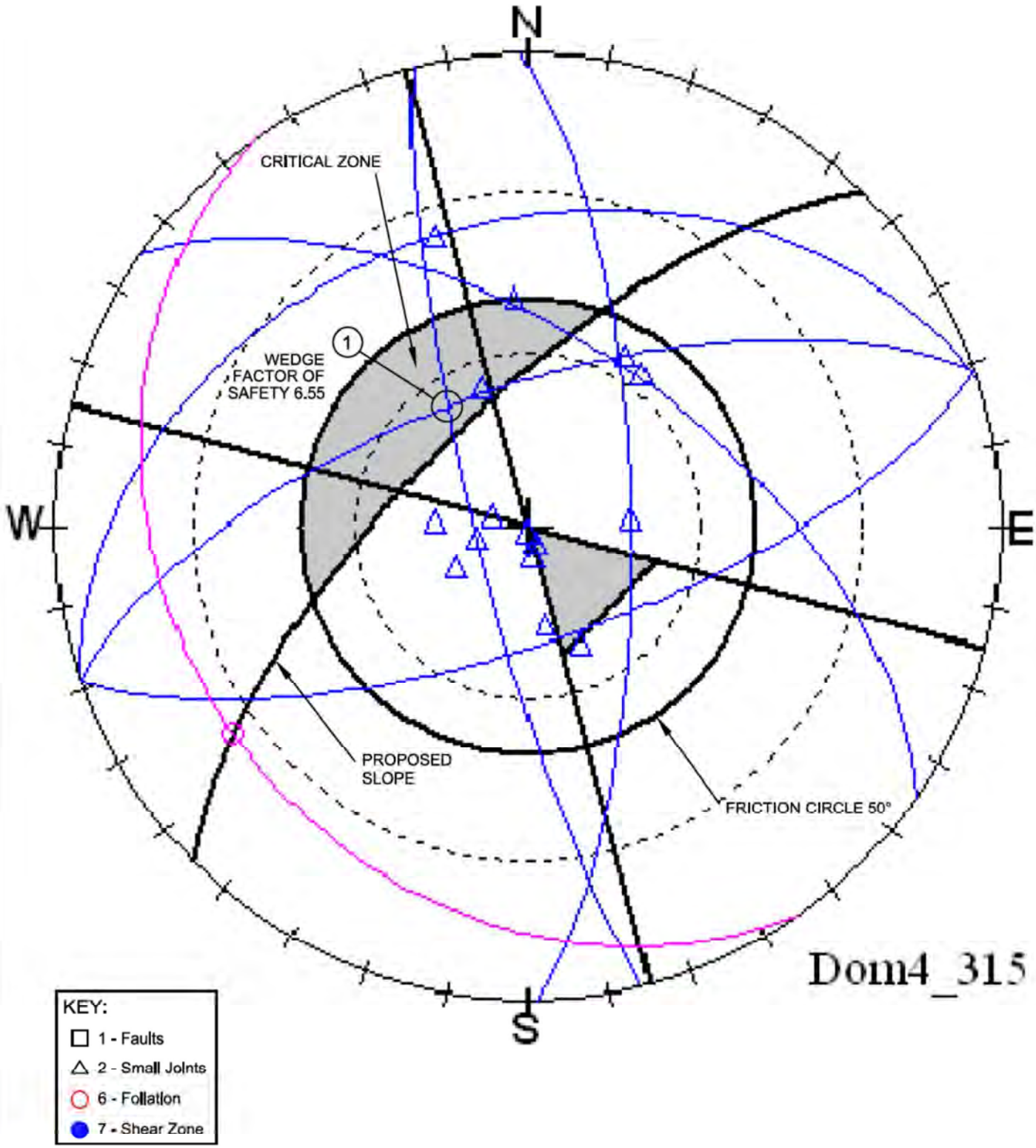


SENTINEL - DOMAIN 4 DIP AZIMUTH 45°		
FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "B-6.1"
DATE: JULY 2012		JOB NUMBER 12399-8
		CHJ Consultants



KEY:
- 1 - Faults
- 2 - Small Joints
- 6 - Foliation
- 7 - Shear Zone

SENTINEL - DOMAIN 4 DIP AZIMUTH 270°		
FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "B-7.0"
DATE: JULY 2012		JOB NUMBER 12399-8
		CHJ Consultants



SENTINEL - DOMAIN 4 DIP AZIMUTH 315°		
FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "B-8.0"
DATE: JULY 2012		JOB NUMBER 12399-8
		CHJ Consultants

Domain 4 Azimuth 315 degrees

Rapid Wedge Failure Analysis Input Data - Wedge 1

(GR) Density of Rock = 150 lb(f)/ft ³
(H) Height of Crest Above Intersection = 40 ft

Plane 1 : (D1) Dip Value = 66 °
(E1) Dip Direction = 341 °
Plane 2 : (D2) Dip Value = 80 °
(E2) Dip Direction = 253 °
Plane 3 : (D3) Dip Value = 1 °
(E3) Dip Direction = 315 °
Plane 4 : (D4) Dip Value = 70 °
(E4) Dip Direction = 315 °

Plane 1 : (C1) Cohesion = 800 lb(f)/ft ²
(P1) Friction Angle = 50 °
Plane 2 : (C2) Cohesion = 800 lb(f)/ft ²
(P2) Friction Angle = 50 °

Water Pressure : Cracks Completely Filled (Free Draining)

(GW) Density of Water = 0 lb(f)/ft ³

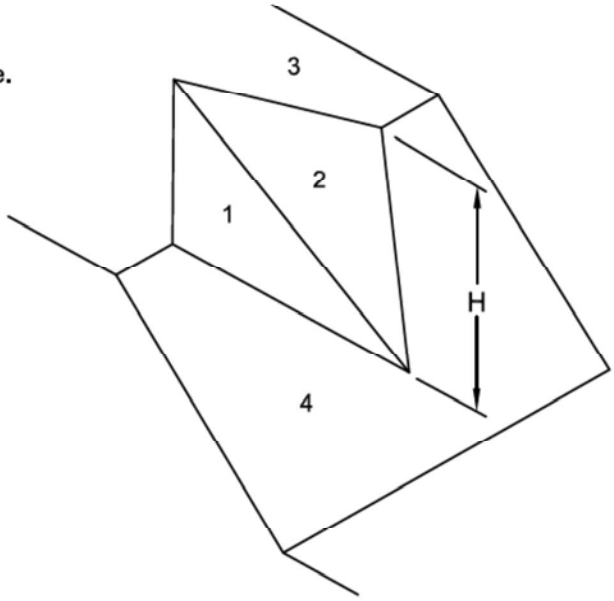
(HW) Overall Vertical Height of Wedge = 0 ft

The slope face DOES NOT hang over the toe of the slope.

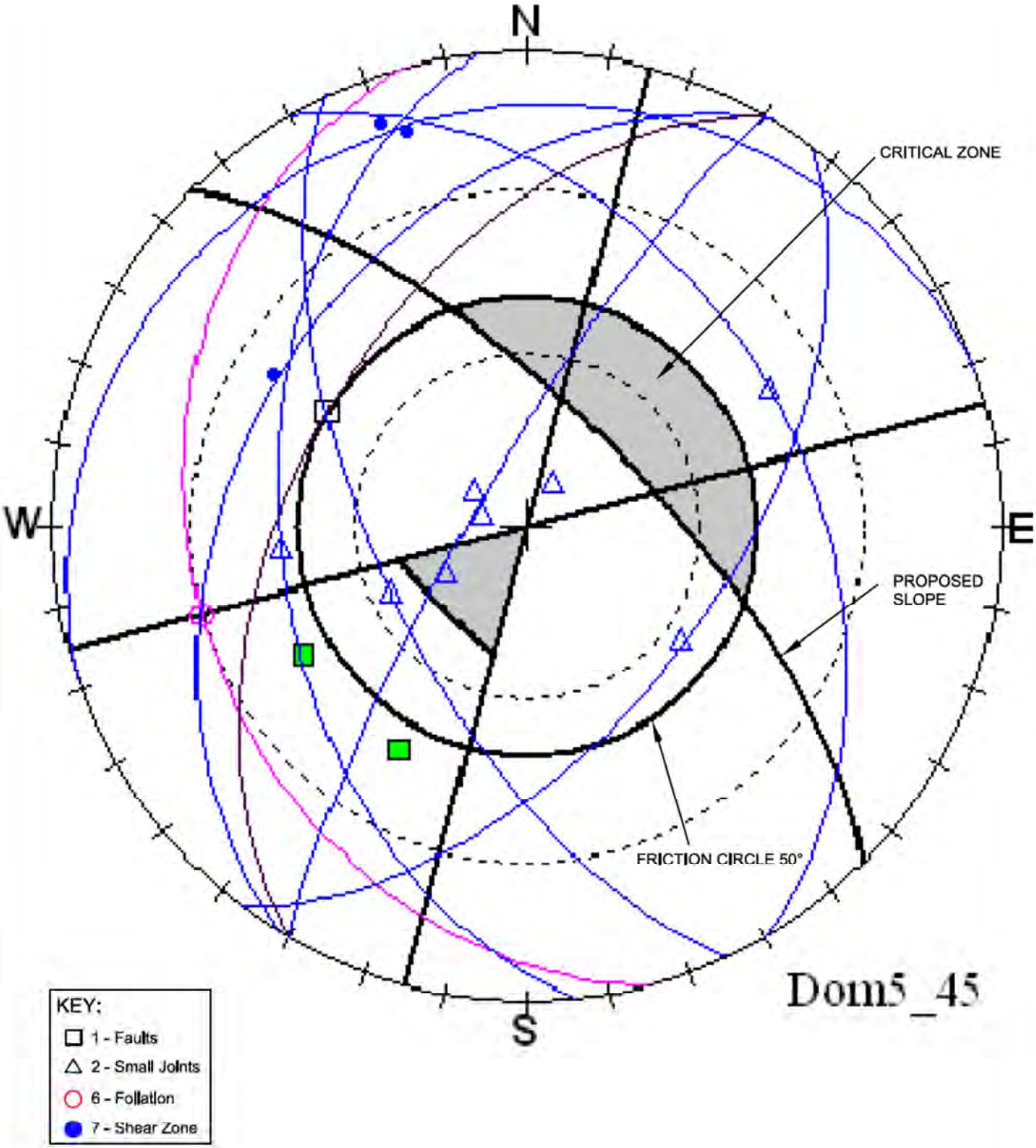
Rapid Wedge Failure Analysis Output Data

(F) Factor of Safety = 6.55
Water Pressure on both planes = 0 lb(f)/ft ²

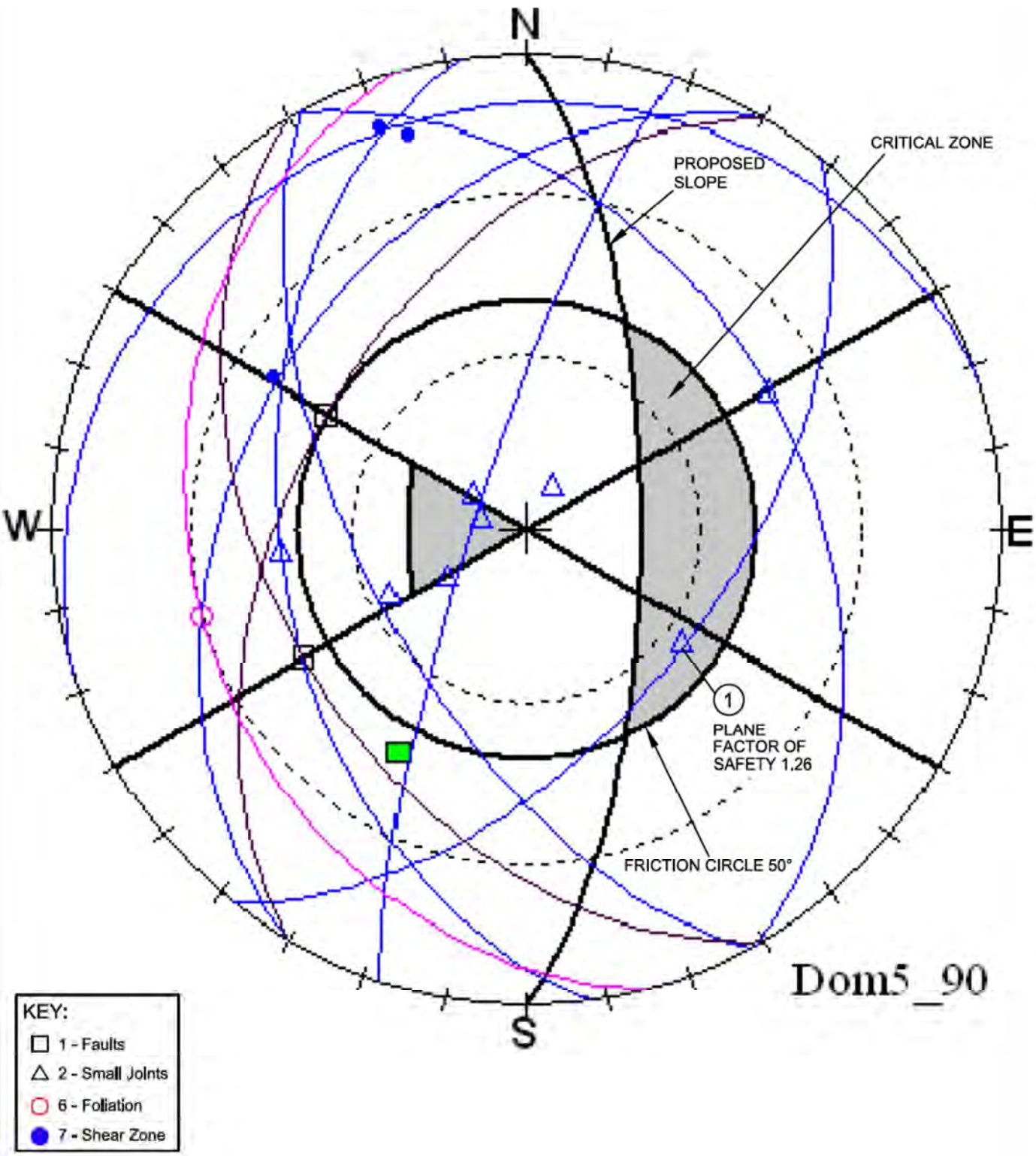
THERE IS CONTACT ON BOTH PLANES.



SENTINEL - DOMAIN 4 DIP AZIMUTH 315°		
FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "B-8.1"
DATE: JULY 2012		JOB NUMBER 12399-8
		CHJ Consultants



SENTINEL - DOMAIN 5 DIP AZIMUTH 45°		
FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "B-9.0"
DATE: JULY 2012		JOB NUMBER 12399-8
		CHJ Consultants



SENTINEL - DOMAIN 5 DIP AZIMUTH 90°		
FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "B-10.0"
DATE: JULY 2012		JOB NUMBER 12399-8
		CHJ Consultants

Domain 5 Azimuth 90 degrees

Plane Failure Analysis Input Data - Plane 1

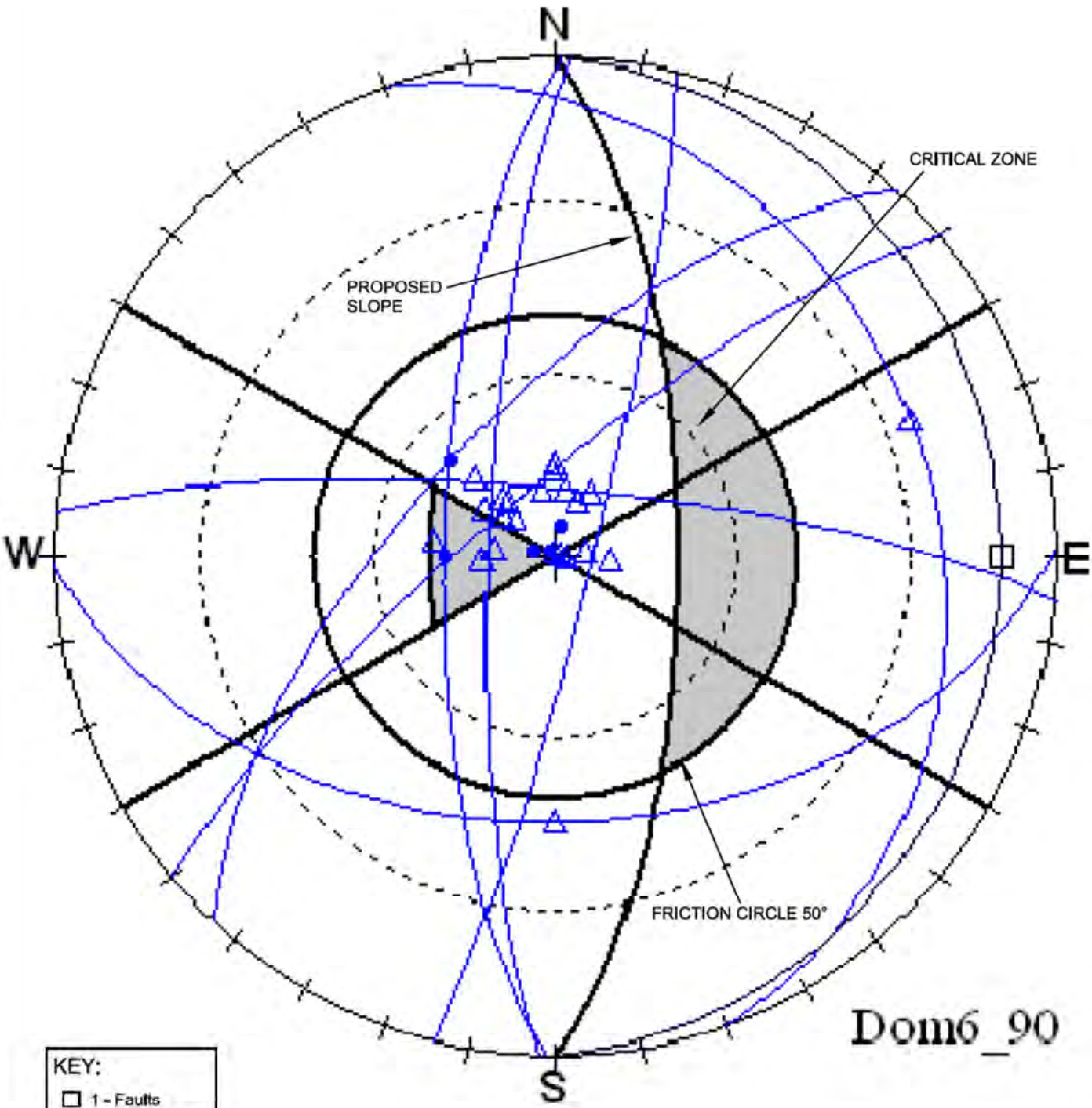
(H) Height = 50 ft
(SF) Inclination of Slope Face = 70 °
(SS) Inclination of Upper Slope = 1 °
(SP) Inclination of Failure Plane = 56 °
(CO) Cohesive Strength of Failure Surface = 800 lb(f)
(PH) Friction Angle of Failure Surface = 50 °
(GR) Density of Rock = 150 lb(f)/ft ^{3}
(GW) Density of Water = 62.4 lb(f)/ft ^{3}
(AB) Starting Rock Bolt Angle = 0 °
(AR) Ending Rock Bolt Angle = 0 °
(AA) Bolt Angle Increment = 0 °
(T1) Starting Bolt Tension = 0 lb(f)
(T2) Ending Bolt Tension = 0 lb(f)
(T3) Bolt Tension Increment = 0 lb(f)
(AC) Horizontal Acceleration = 0.2 G
(TZ) Amount of Discontinuity = 0 decimal%
(VSUR) Vertical Surcharge = 0 lb(f)
(HSUR) Horizontal Surcharge = 0 lb(f)

Tension Crack Location Unknown: Dry Slope

Plane Failure Analysis Output Data

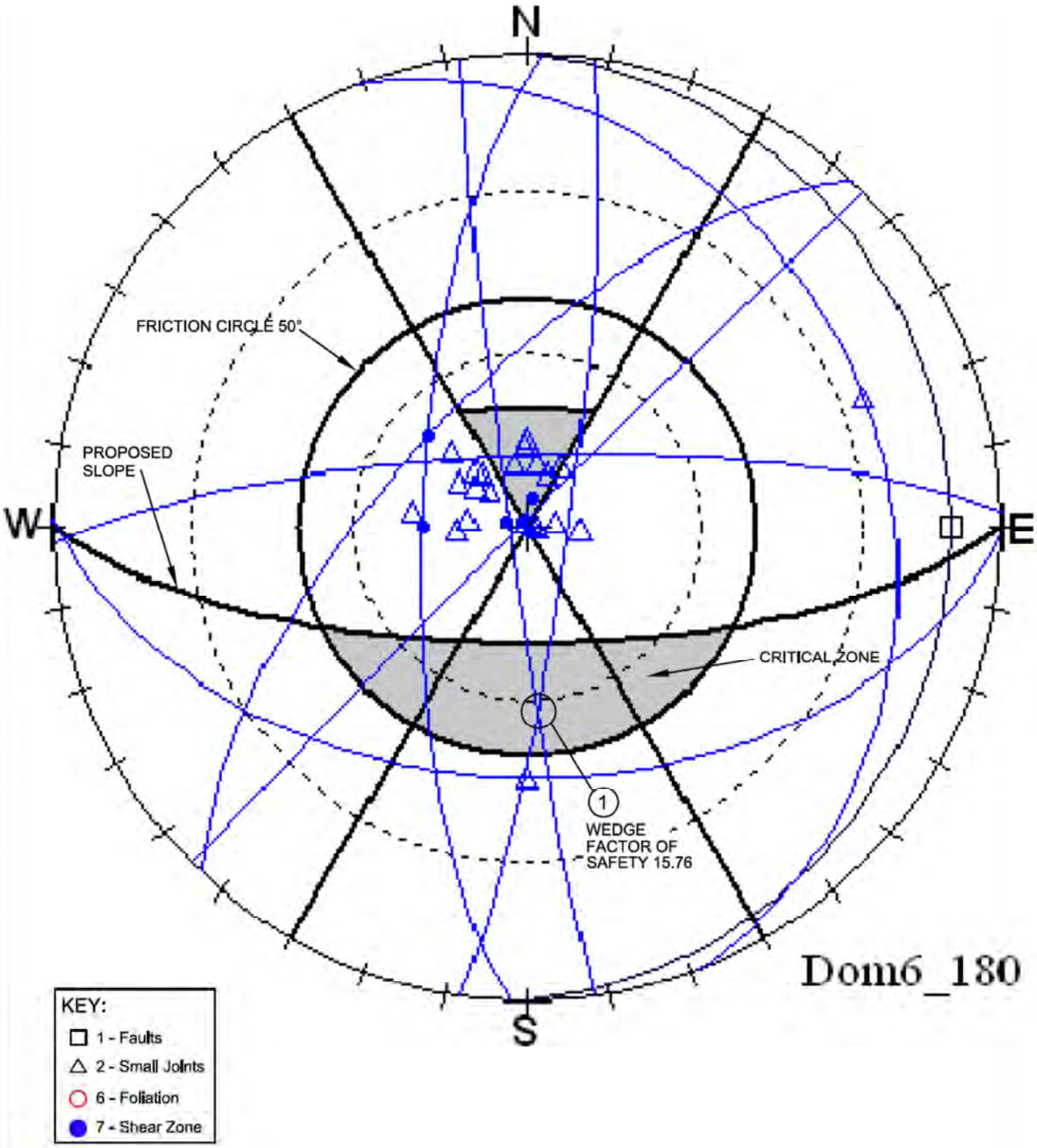
(A) Contact Area = 44.3 ft ^{2}
(W) Weight of Slice = 49372.99 lb(f)
(U) Water Force Normal to Failure Plane = 0 lb(f)
(V) Horizontal Water Force on Tension Crack = 0 lb(f)
(B) Worst Location, Horizontal Distance = 6.58 ft
(Z) Tension Crack Depth = 13.39 ft
(ZW) Depth of Water in Crack = 0 ft
(TH) Bolt Angle = 0 °
(T) Tension = 0 lb(f)
(F) Factor of Safety = 1.26

SENTINEL - DOMAIN 5 DIP AZIMUTH 90°		
FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "B-10.1"
DATE: JULY 2012		JOB NUMBER 12399-8
		CHJ Consultants



KEY:
- 1 - Faults
- 2 - Small Joints
- 6 - Foliation
- 7 - Shear Zone

BUTTERFIELD 3 - DOMAIN 6 DIP AZIMUTH 90°		
FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "B-11.0"
DATE: JULY 2012		JOB NUMBER 12399-8
		CHJ Consultants



BUTTERFIELD 3 - DOMAIN 6 DIP AZIMUTH 180°		
FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "B-12.0"
DATE: JULY 2012		JOB NUMBER 12399-8
		CHJ Consultants

Domain 6 Azimuth 180 degrees

Rapid Wedge Failure Analysis Input Data - Wedge 1

(GR) Density of Rock = 150 lb(f)/ft ³
(H) Height of Crest Above Intersection = 40 ft

Plane 1 : (D1) Dip Value = 79 °
(E1) Dip Direction = 265 °
Plane 2 : (D2) Dip Value = 83 °
(E2) Dip Direction = 97 °
Plane 3 : (D3) Dip Value = 1 °
(E3) Dip Direction = 180 °
Plane 4 : (D4) Dip Value = 70 °
(E4) Dip Direction = 180 °

Plane 1 : (C1) Cohesion = 800 lb(f)/ft ²
(P1) Friction Angle = 50 °
Plane 2 : (C2) Cohesion = 800 lb(f)/ft ²
(P2) Friction Angle = 50 °

Water Pressure : Cracks Completely Filled (Free Draining)

(GW) Density of Water = 0 lb(f)/ft ³

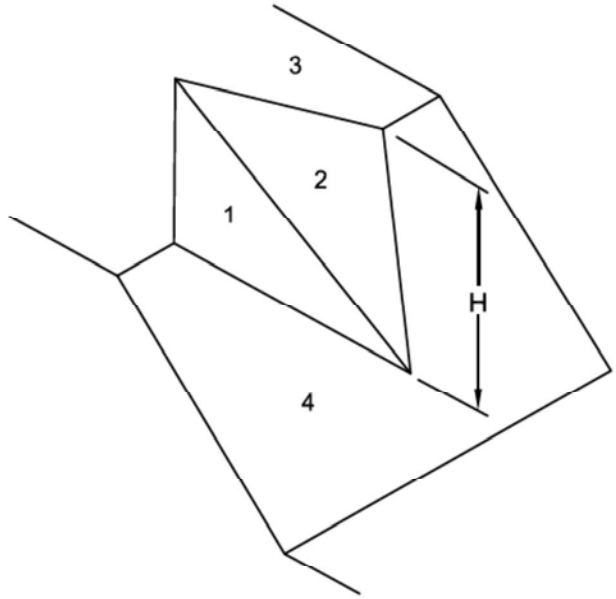
(HW) Overall Vertical Height of Wedge = 0 ft

The slope face DOES NOT hang over the toe of the slope.

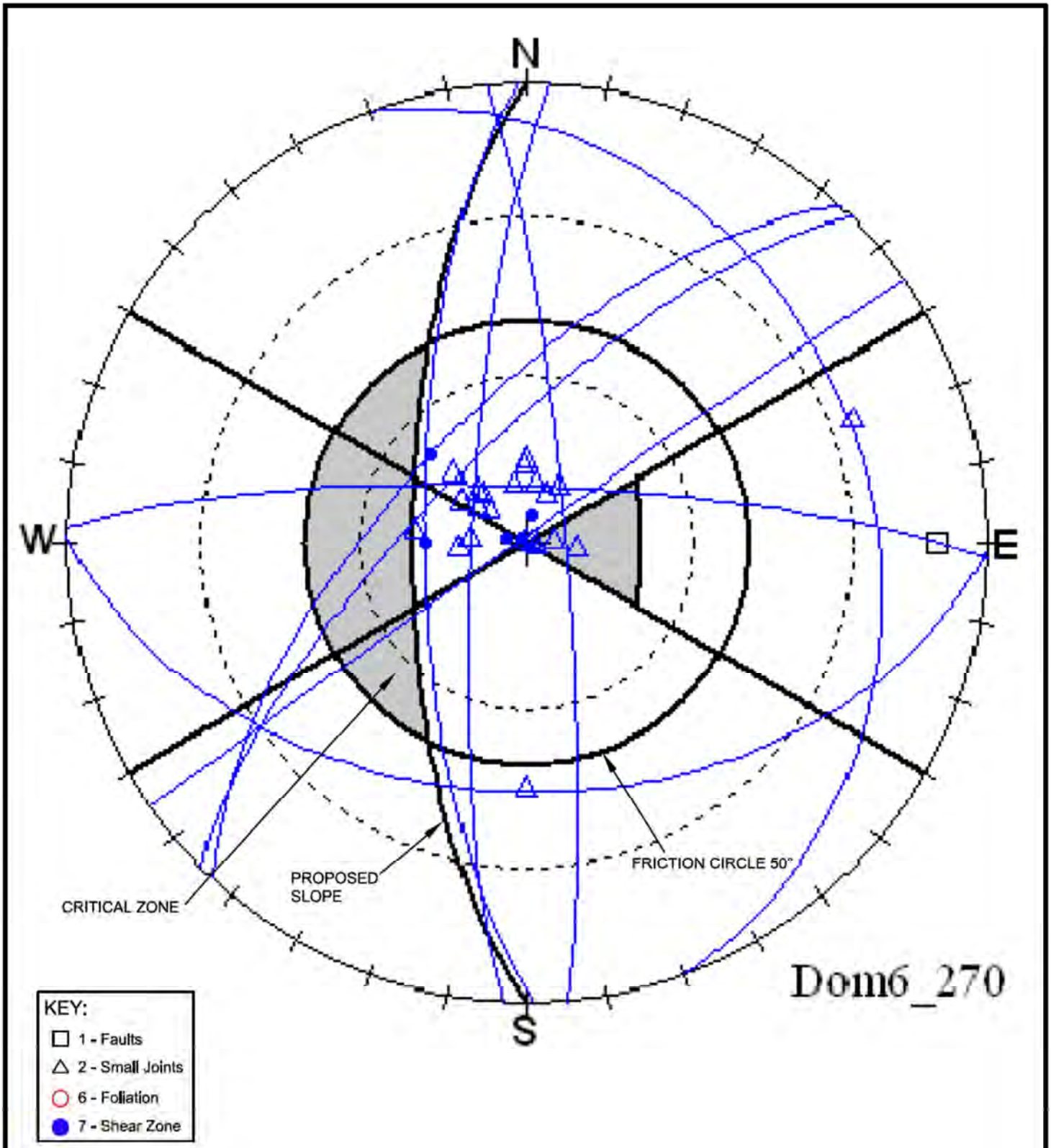
Rapid Wedge Failure Analysis Output Data

(F) Factor of Safety = 15.76
Water Pressure on both planes = 0 lb(f)/ft ²

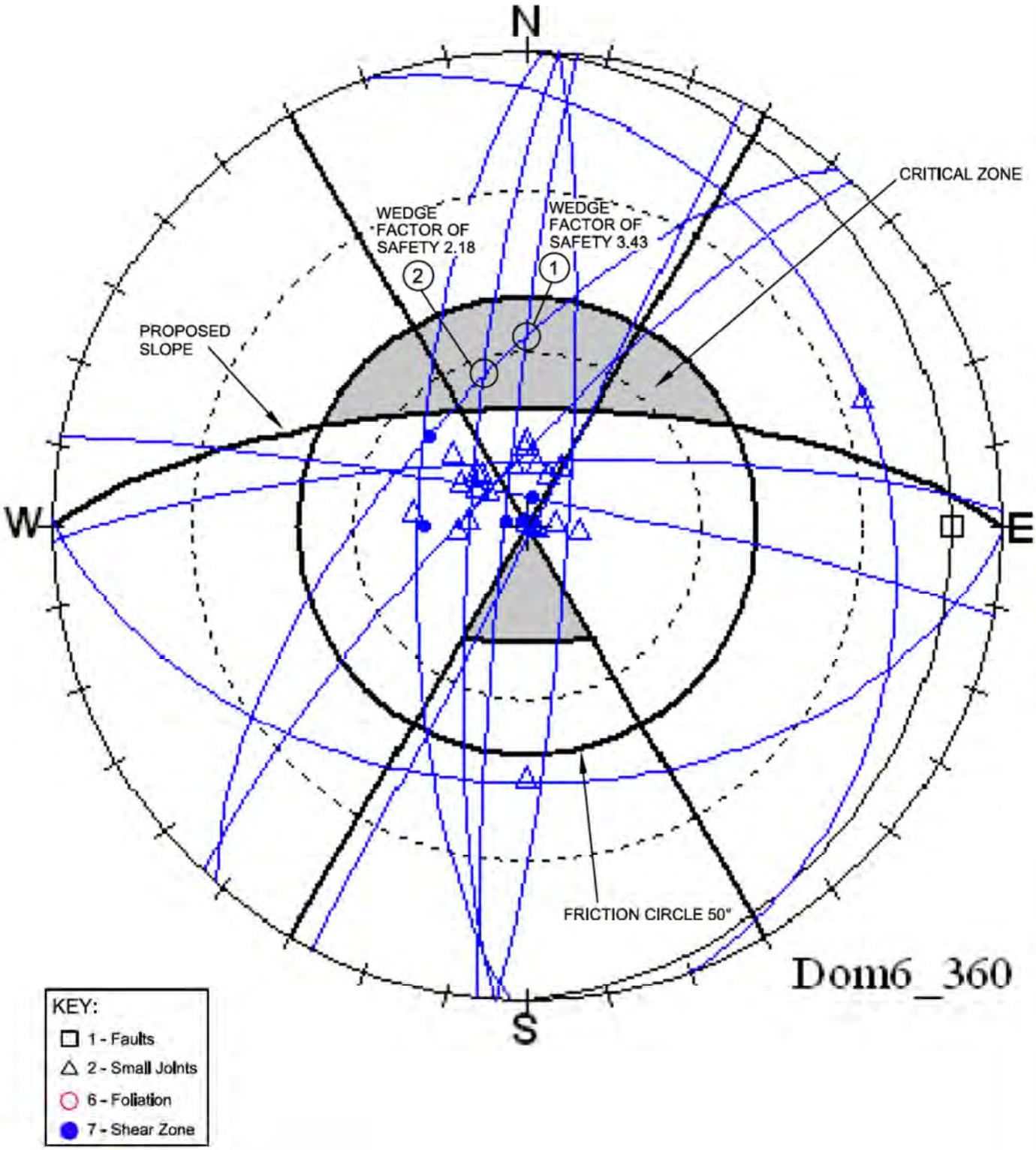
THERE IS CONTACT ON BOTH PLANES.



BUTTERFIELD 3 - DOMAIN 6 DIP AZIMUTH 180°		
FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "B-12.1"
DATE: JULY 2012		JOB NUMBER 12399-8
		CHJ Consultants



BUTTERFIELD 3 - DOMAIN 6 DIP AZIMUTH 270°		
FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "B-13.0"
DATE: JULY 2012		JOB NUMBER 12399-8
		CHJ Consultants



BUTTERFIELD 3 - DOMAIN 6 DIP AZIMUTH 360°		
FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "B-14.0"
DATE: JULY 2012		JOB NUMBER 12399-8
		CHJ Consultants

Domain 6 Azimuth 360 degrees

Rapid Wedge Failure Analysis Input Data - Wedge 1

(GR) Density of Rock = 150 lb(f)/ft ^{3}
(H) Height of Crest Above Intersection = 40 ft

Plane 1 : (D1) Dip Value = 86 °
(E1) Dip Direction = 277 °
Plane 2 : (D2) Dip Value = 67 °
(E2) Dip Direction = 313 °
Plane 3 : (D3) Dip Value = 1 °
(E3) Dip Direction = 180 °
Plane 4 : (D4) Dip Value = 70 °
(E4) Dip Direction = 180 °

Plane 1 : (C1) Cohesion = 800 lb(f)/ft ^{2}
(P1) Friction Angle = 50 °
Plane 2 : (C2) Cohesion = 800 lb(f)/ft ^{2}
(P2) Friction Angle = 50 °

Water Pressure : Cracks Completely Filled (Free Draining)

(GW) Density of Water = 0 lb(f)/ft ^{3}

(HW) Overall Vertical Height of Wedge = 0 ft

The slope face DOES NOT hang over the toe of the slope.

Rapid Wedge Failure Analysis Output Data

(F) Factor of Safety = 3.43
Water Pressure on both planes = 0 lb(f)/ft ^{2}

THERE IS CONTACT ON BOTH PLANES.

Domain 6 Azimuth 360 degrees

Rapid Wedge Failure Analysis Input Data - Wedge 2

(GR) Density of Rock = 150 lb(f)/ft ^{3}
(H) Height of Crest Above Intersection = 40 ft

Plane 1 : (D1) Dip Value = 79 °
(E1) Dip Direction = 263 °
Plane 2 : (D2) Dip Value = 67 °
(E2) Dip Direction = 313 °
Plane 3 : (D3) Dip Value = 1 °
(E3) Dip Direction = 180 °
Plane 4 : (D4) Dip Value = 70 °
(E4) Dip Direction = 180 °

Plane 1 : (C1) Cohesion = 800 lb(f)/ft ^{2}
(P1) Friction Angle = 50 °
Plane 2 : (C2) Cohesion = 800 lb(f)/ft ^{2}
(P2) Friction Angle = 50 °

Water Pressure : Cracks Completely Filled (Free Draining)

(GW) Density of Water = 0 lb(f)/ft ^{3}

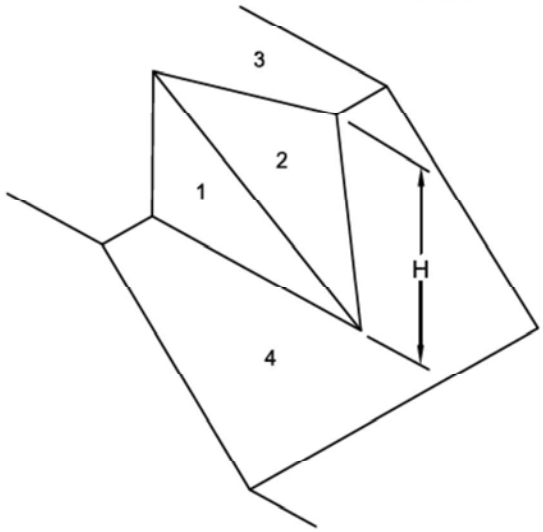
(HW) Overall Vertical Height of Wedge = 0 ft

The slope face DOES NOT hang over the toe of the slope.

Rapid Wedge Failure Analysis Output Data

(F) Factor of Safety = 2.18
Water Pressure on both planes = 0 lb(f)/ft ^{2}

THERE IS CONTACT ON BOTH PLANES.



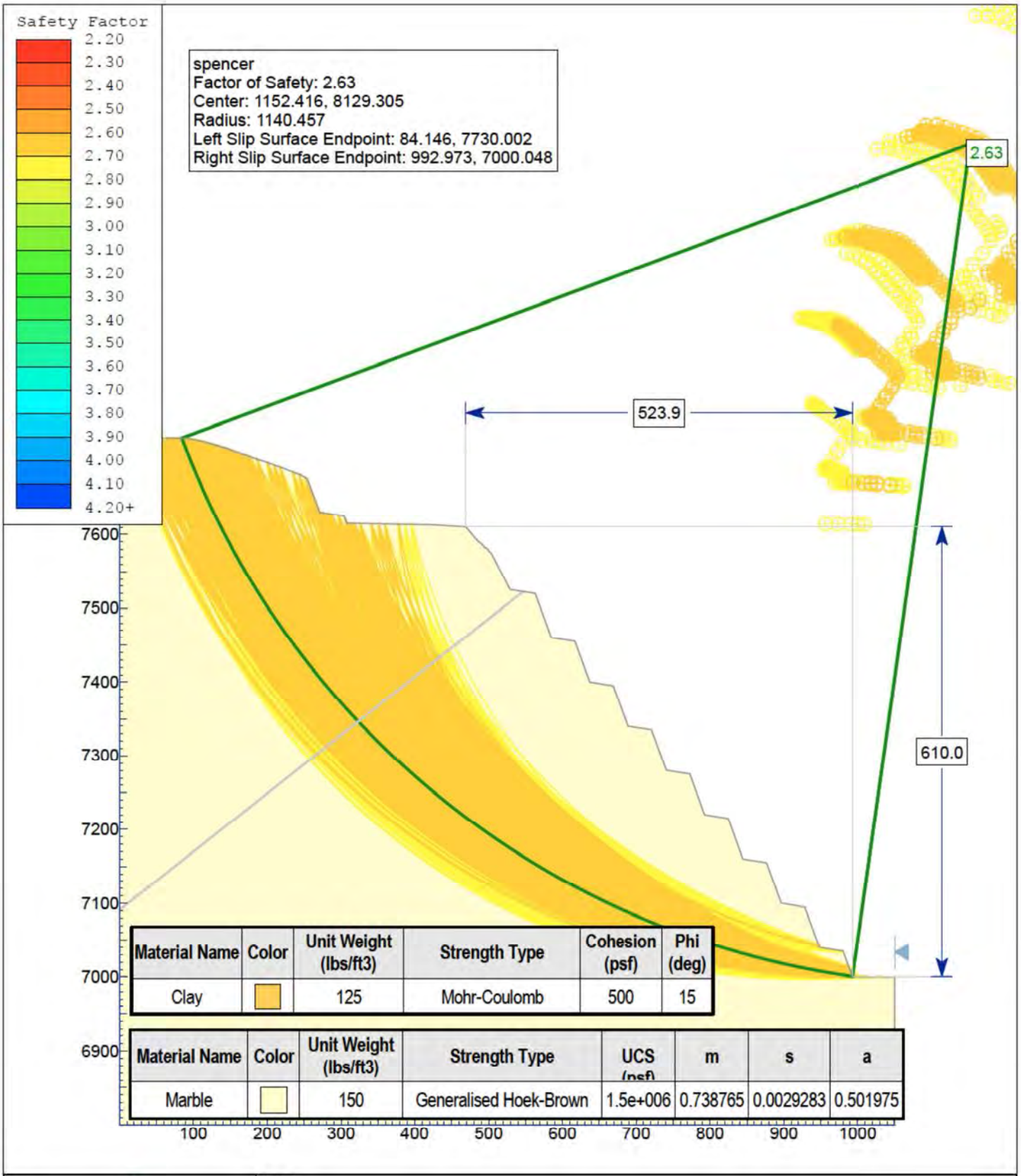
BUTTERFIELD 3 - DOMAIN 6 DIP AZIMUTH 360°

FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "B-14.1"
DATE: JULY 2012		JOB NUMBER 12399-8

CHJ Consultants

APPENDIX "C"

SLOPE STABILITY CALCULATIONS

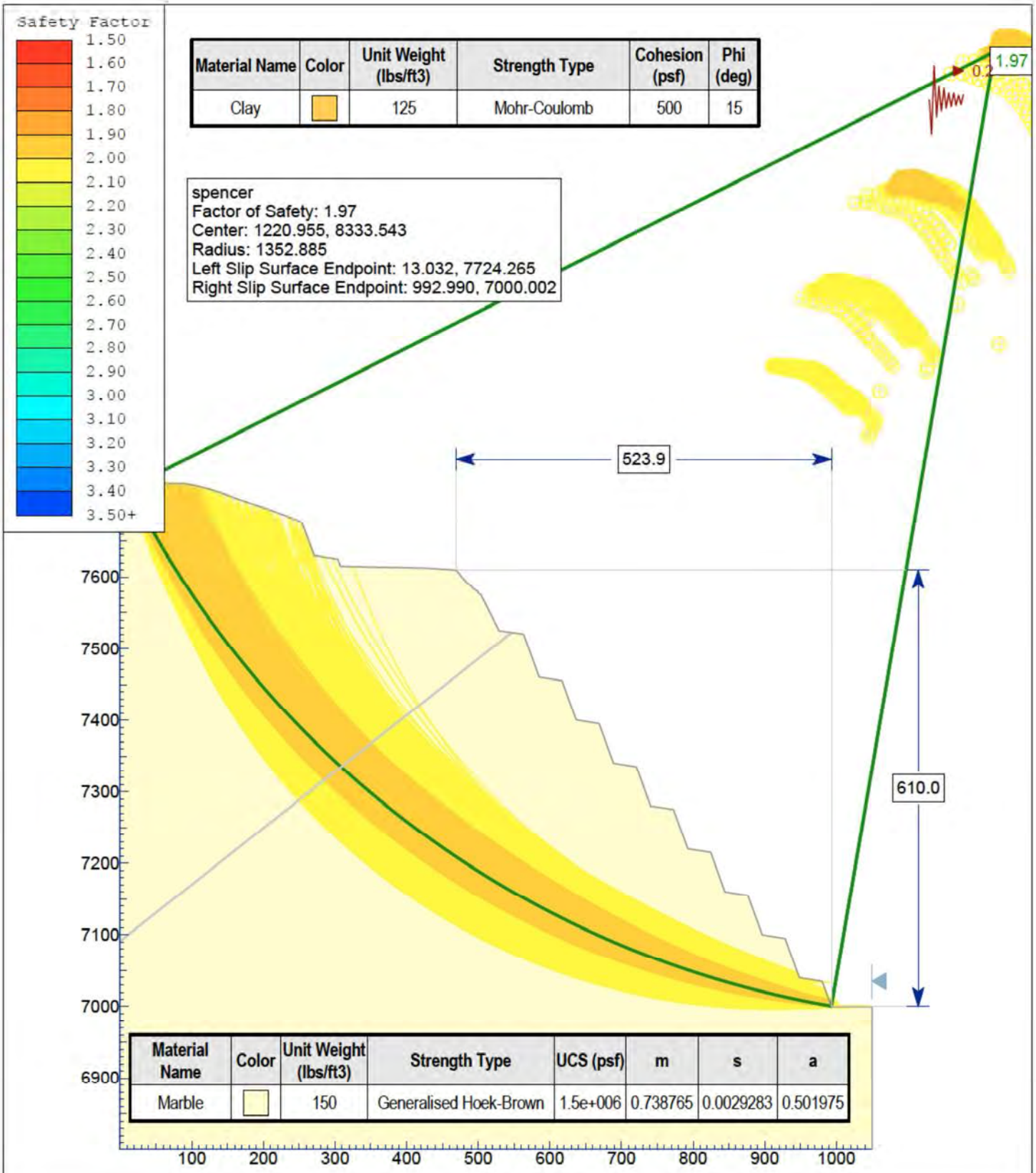


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Clay		125	Mohr-Coulomb	500	15

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	UCS (psf)	m	s	a
Marble		150	Generalised Hoek-Brown	1.5e+006	0.738765	0.0029283	0.501975

SLIDEINTERPRET 6.017

Project	Proposed Sentinel and Butterfield 3 Mine Reclamation Project		
Analysis Description	Slope Stability Analysis - Section A-A'		
Drawn By	CHJ Consultants	Author Fred Yi, PhD, GE	Scale 1:2200
File Name	12399-8 sec A.slim	Date 7/13/2012	Enclosure C-1.1

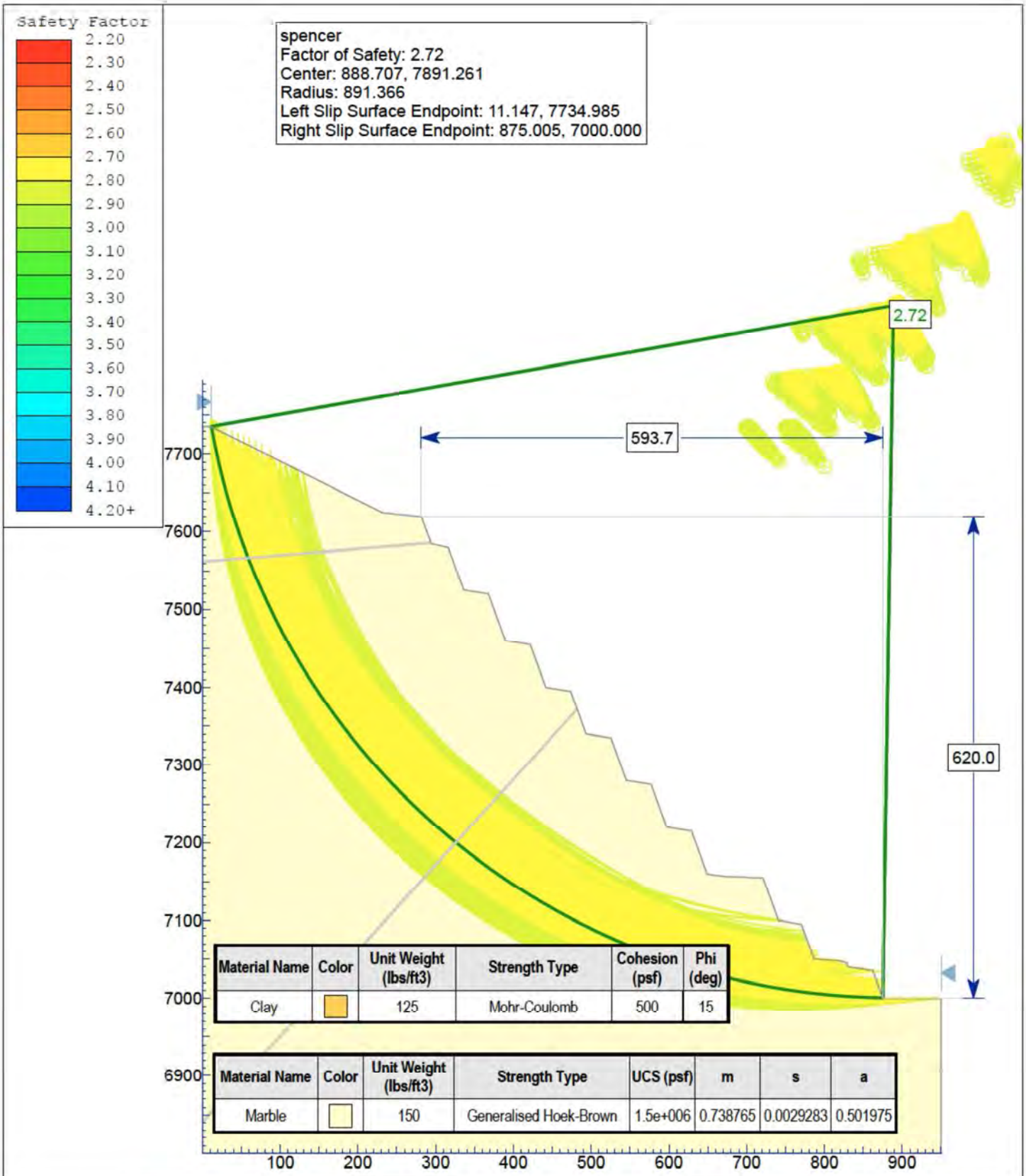


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Clay		125	Mohr-Coulomb	500	15

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	UCS (psf)	m	s	a
Marble		150	Generalised Hoek-Brown	1.5e+006	0.738765	0.0029283	0.501975

SLIDEINTERPRET 6.017

Project	Proposed Sentinel and Butterfield 3 Mine Reclamation Project		
Analysis Description	Slope Stability Analysis - Section A-A'		
Drawn By	CHJ Consultants	Author Fred Yi, PhD, GE	Scale 1:2300
File Name	12399-8 sec A_sei.slim	Date 7/13/2012	Enclosure C-1.2

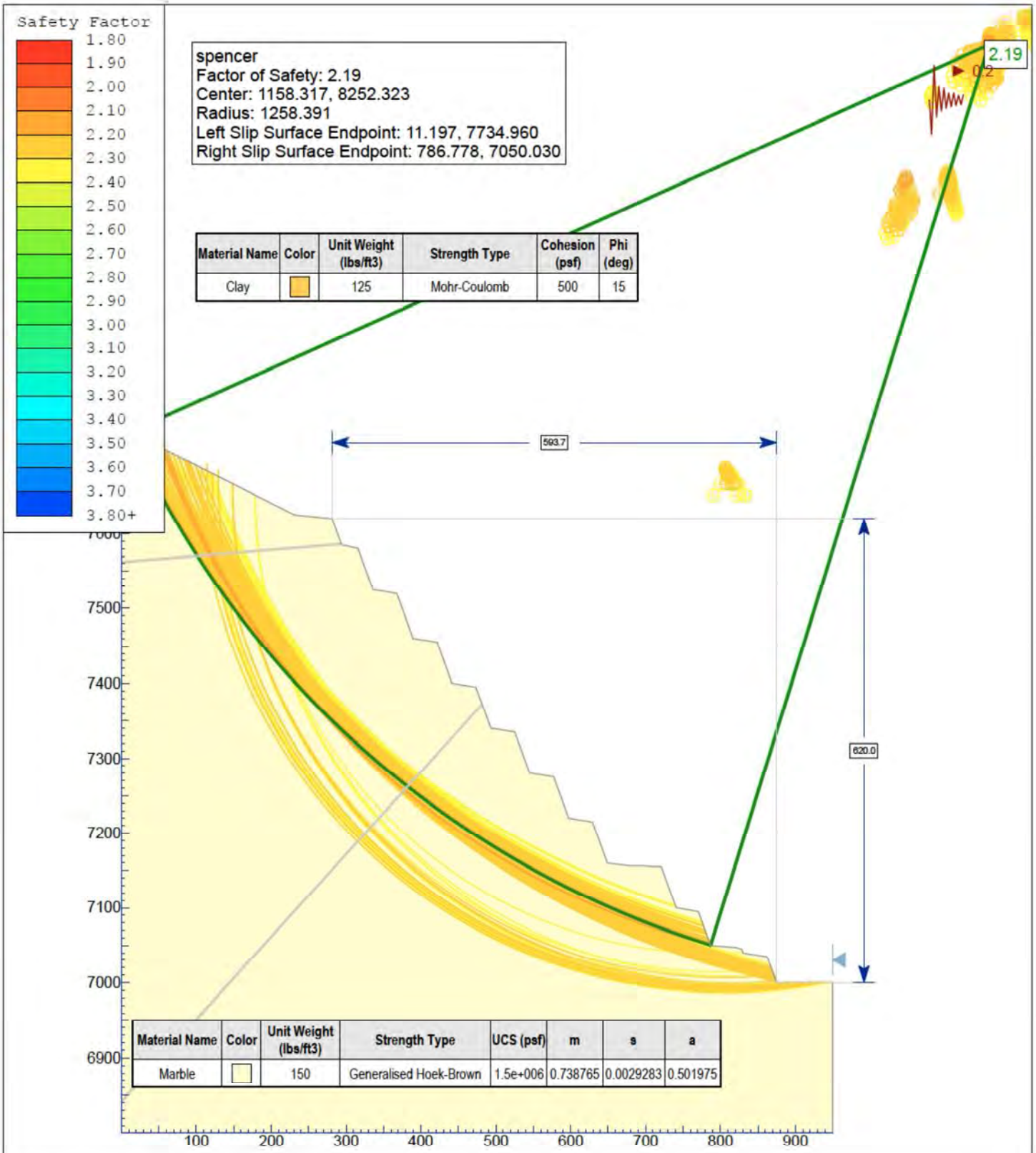


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Clay		125	Mohr-Coulomb	500	15

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	UCS (psf)	m	s	a
Marble		150	Generalised Hoek-Brown	1.5e+006	0.738765	0.0029283	0.501975

SLIDEINTERPRET 6.017

Project	Proposed Sentinel and Butterfield 3 Mine Reclamation Project		
Analysis Description	Slope Stability Analysis - Section C-C'		
Drawn By	CHJ Consultants	Author Fred Yi, PhD, GE	Scale 1:2100
File Name	12399-8 sec C.slim	Date 7/13/2012	Enclosure C-2.1

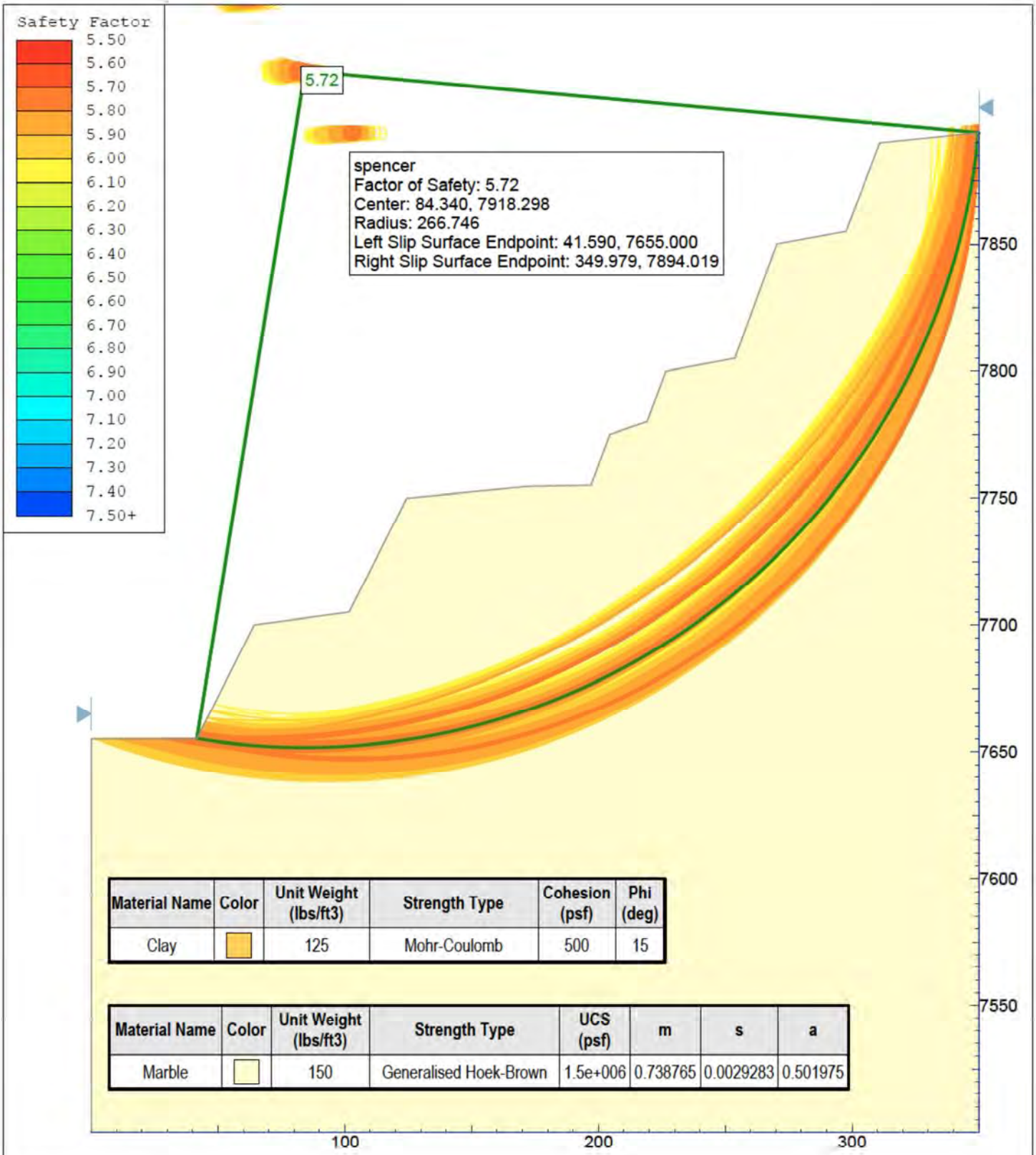


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Clay		125	Mohr-Coulomb	500	15

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	UCS (psf)	m	s	a
Marble		150	Generalised Hoek-Brown	1.5e+006	0.738765	0.0029283	0.501975

SLIDEINTERPRET 6.017

Project	Proposed Sentinel and Butterfield 3 Mine Reclamation Project		
Analysis Description	Slope Stability Analysis - Section C-C'		
Drawn By	CHJ Consultants	Author Fred Yi, PhD, GE	Scale 1:2200
File Name	12399-8 sec C_sei.slim	Date 7/13/2012	Enclosure C-2.2

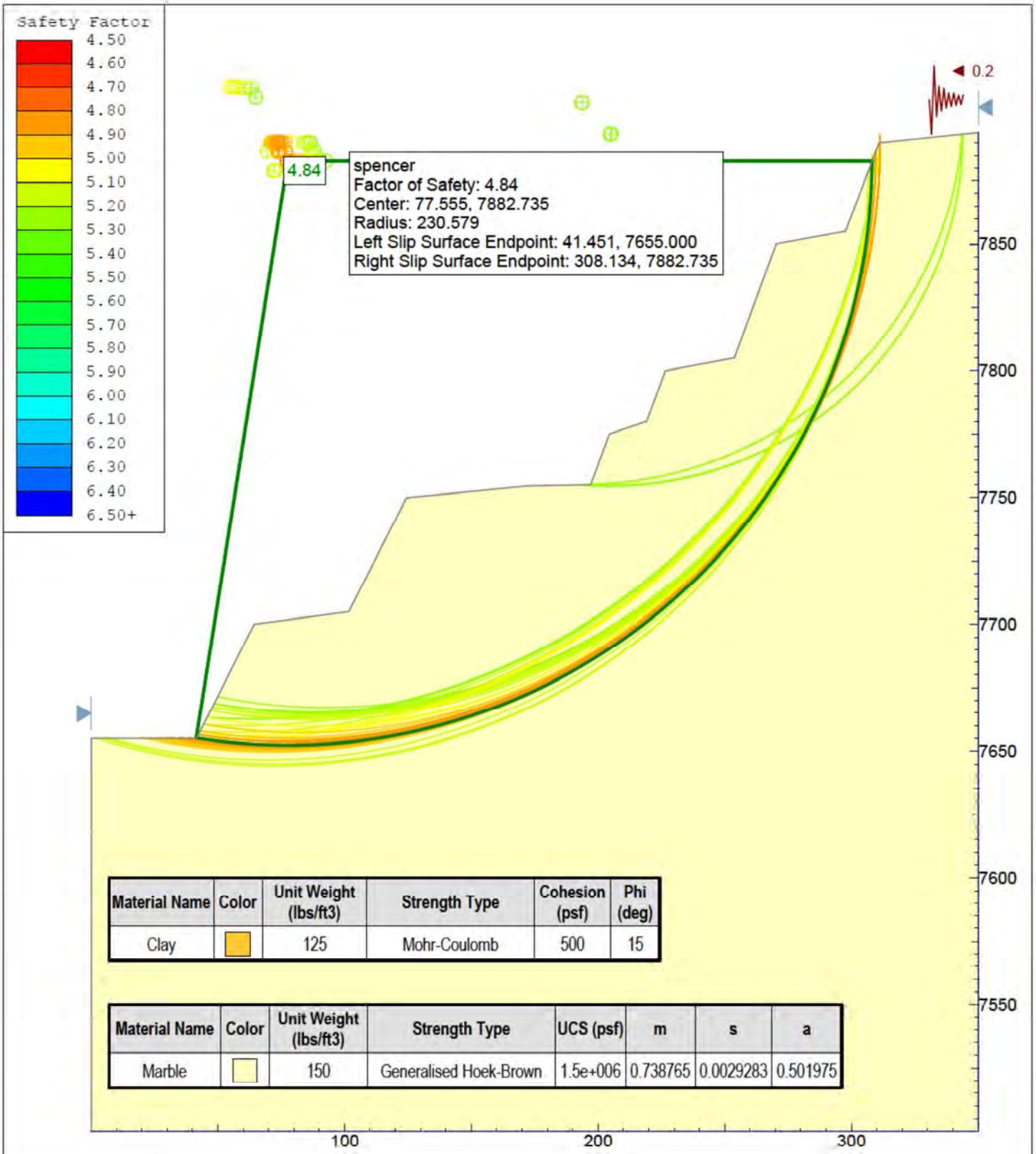


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Clay		125	Mohr-Coulomb	500	15

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	UCS (psf)	m	s	a
Marble		150	Generalised Hoek-Brown	1.5e+006	0.738765	0.0029283	0.501975

SLIDEINTERPRET 6.017

Project	Proposed Sentinel and Butterfield 3 Mine Reclamation Project		
Analysis Description	Slope Stability Analysis - Section E-E'		
Drawn By	CHJ Consultants	Author Fred Yi, PhD, GE	Scale 1:650
File Name	12399-8 sec E.slim	Date 7/13/2012	Enclosure C-3.1

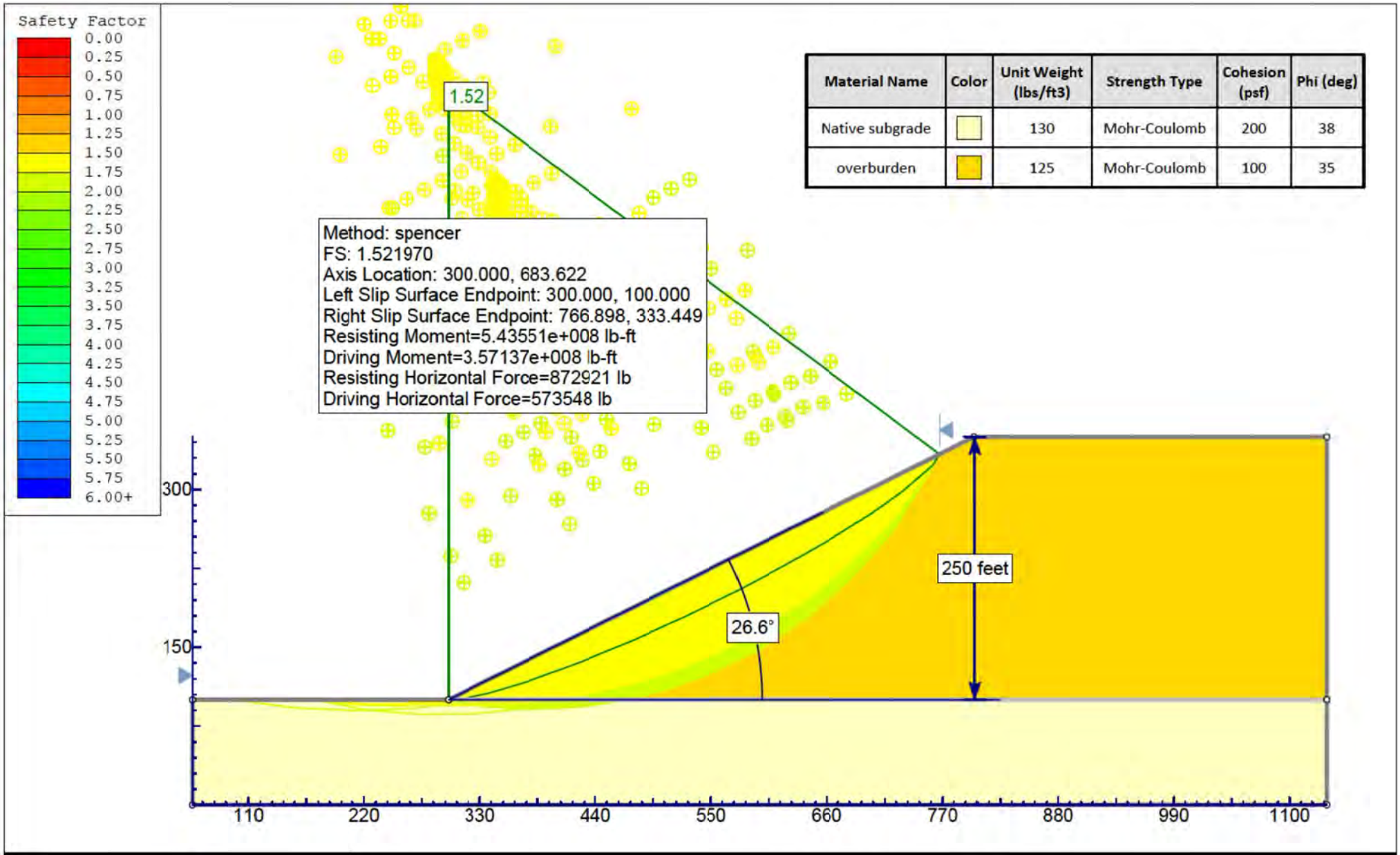


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Clay		125	Mohr-Coulomb	500	15

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	UCS (psf)	m	s	a
Marble		150	Generalised Hoek-Brown	1.5e+006	0.738765	0.0029283	0.501975

SLIDEINTERPRET 6.017

Project	Proposed Sentinel and Butterfield 3 Mine Reclamation Project		
Analysis Description	Slope Stability Analysis - Section E-E'		
Drawn By	CHJ Consultants	Author Fred Yi, PhD, GE	Scale 1:650
File Name	12399-8 sec E_sei.slim	Date 7/13/2012	Enclosure C-3.2

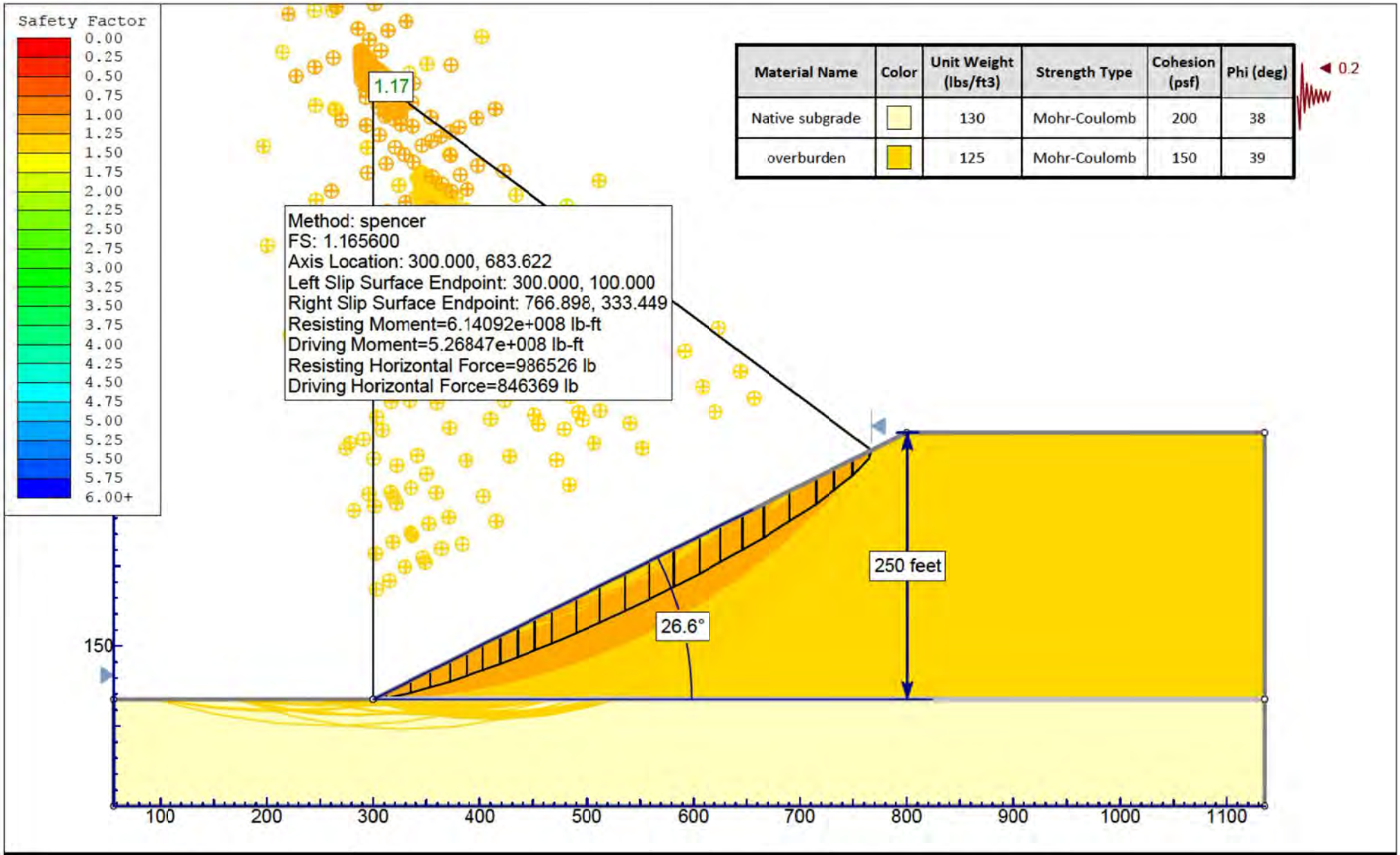


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Native subgrade		130	Mohr-Coulomb	200	38
overburden		125	Mohr-Coulomb	100	35

SLIDEINTERPRET 6.015

OMYA Overburden Stockpile Stability

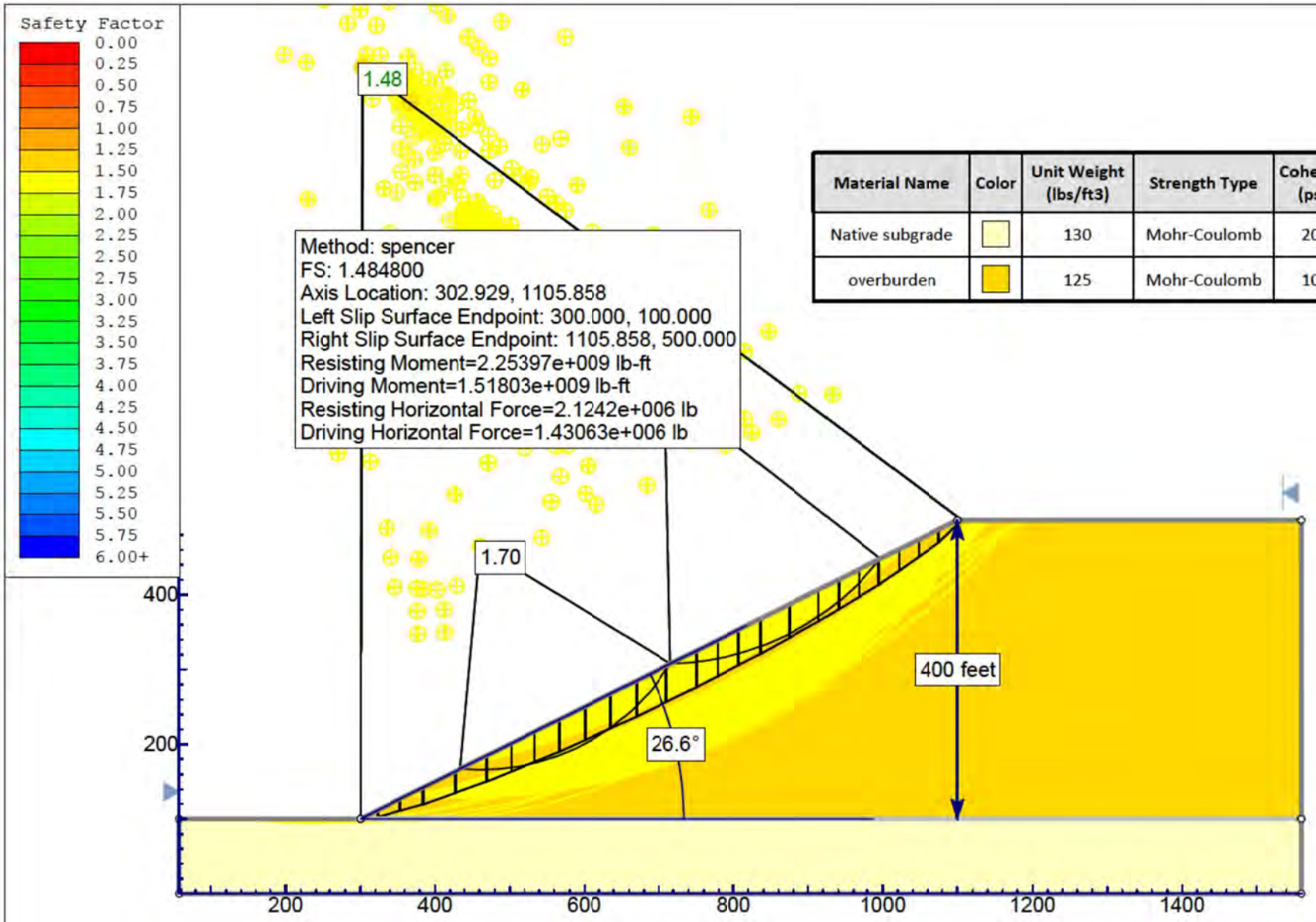
Analysis Description	General Stockpile		
Drawn By	CHJ	Author	J. McKeown	Scale	1:1514
File Name	26d 250H no benches stat.slim	Date	3/12/2012	Enclosure C-4.1



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Native subgrade		130	Mohr-Coulomb	200	38
overburden		125	Mohr-Coulomb	150	39

SLIDEINTERPRET 6.015

OMYA - Overburden Stockpile Stability			
Analysis Description	General Stockpile		
Drawn By	CHJ	Author	J. McKeown	Scale	1:1493
File Name	26d 250H no benches seis 0 2.slim	Date	3/12/2012	Enclosure C-4.2

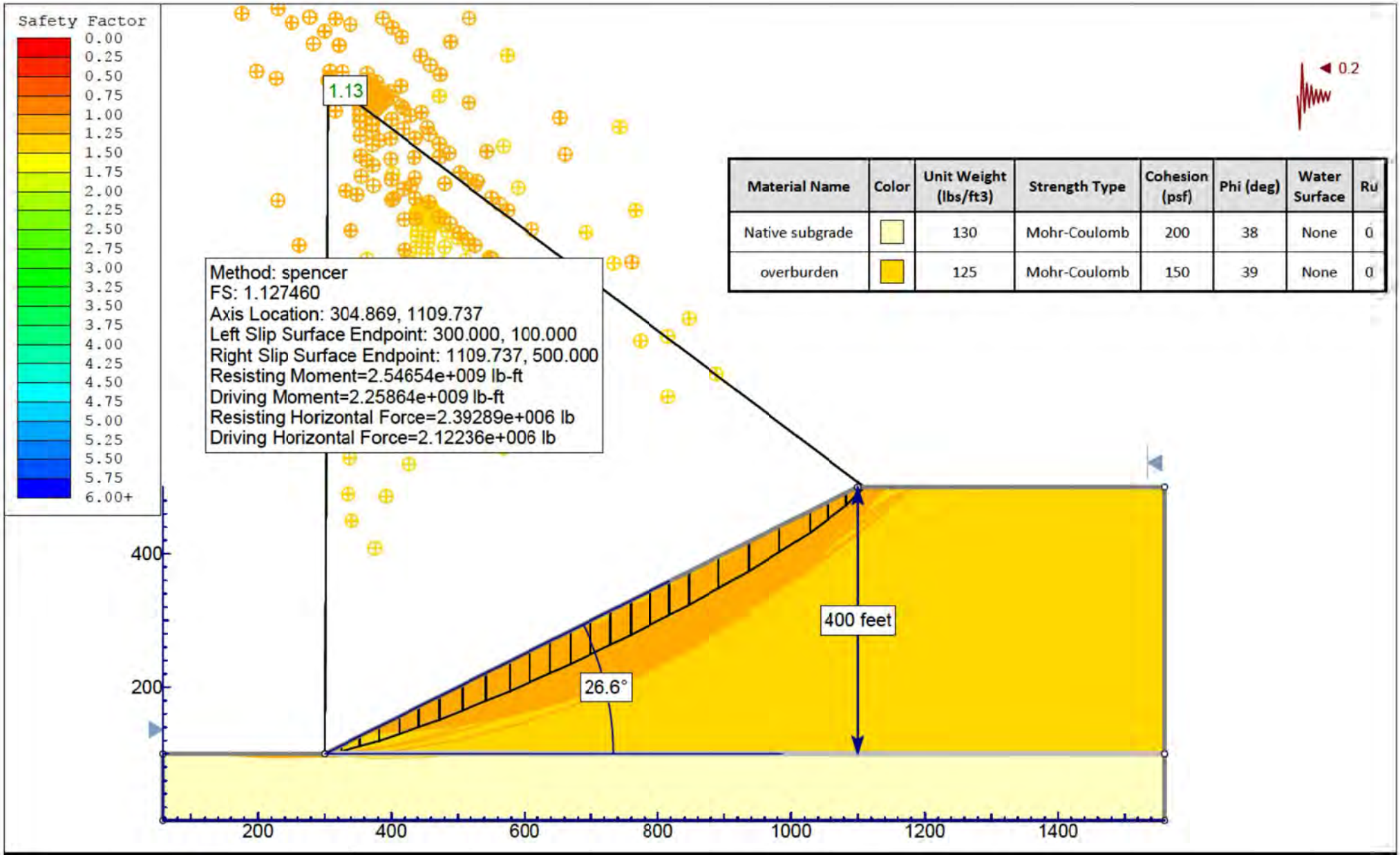


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Native subgrade		130	Mohr-Coulomb	200	38	None	0
overburden		125	Mohr-Coulomb	100	35	None	0

SLIDEINTERPRET 6.015

OMYA - Overburden Stockpile Stability

Analysis Description	General Stockpile		
Drawn By	CHJ	Author	J. McKeown	Scale	1:2388
File Name	26d 400H no benches stat.slim	Date	3/12/2012	Enclosure C-5.1

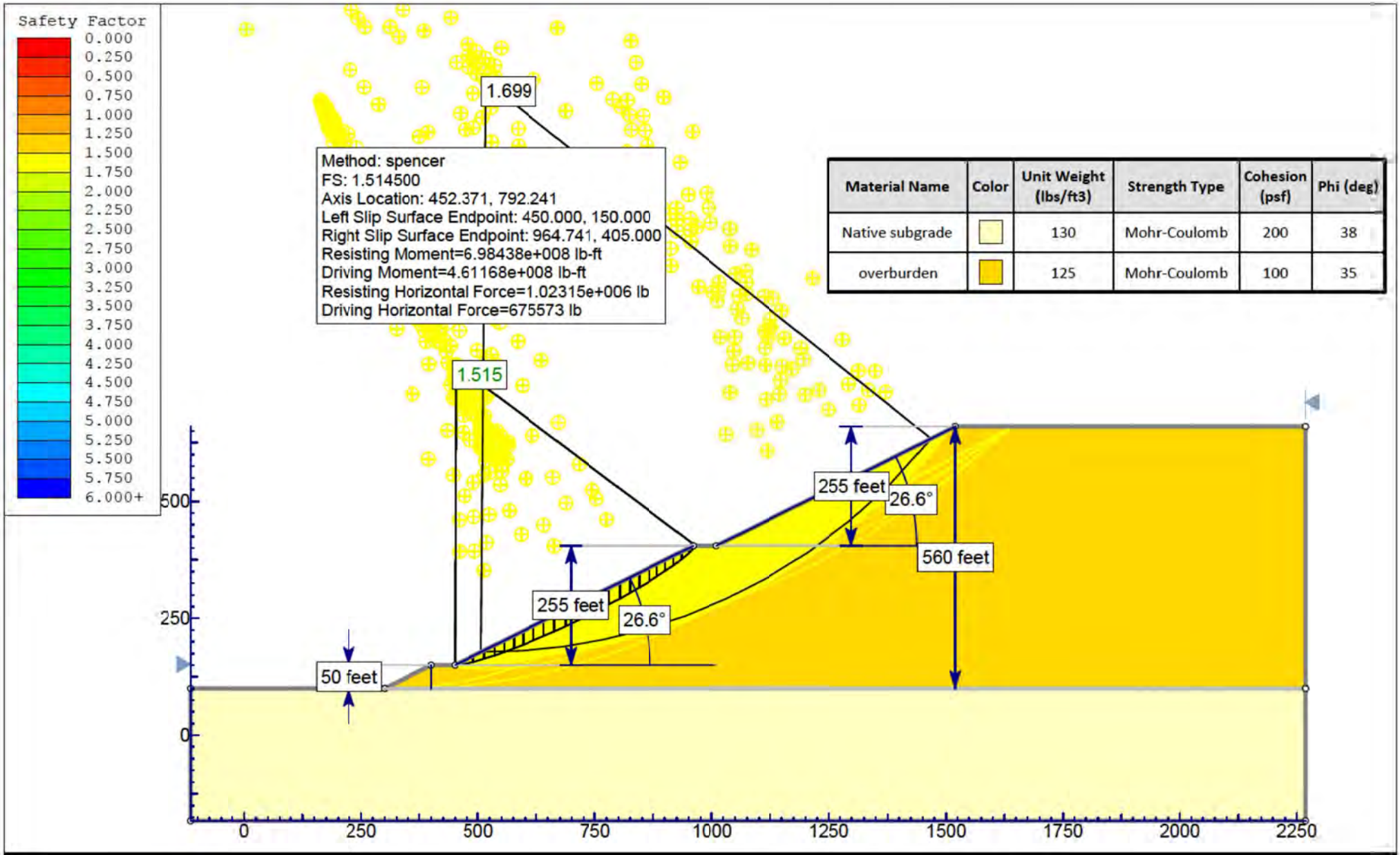


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface	Ru
Native subgrade		130	Mohr-Coulomb	200	38	None	0
overburden		125	Mohr-Coulomb	150	39	None	0

SLIDEINTERPRET 6.015

OMYA - Overburden Stockpile Stability

Analysis Description	General Stockpile		
Drawn By	CHJ	Author	J. McKeown	Scale	1:2388
File Name	26d 400H no benches seis 0 2.slim	Date	3/12/2012	Enclosure C-5.2

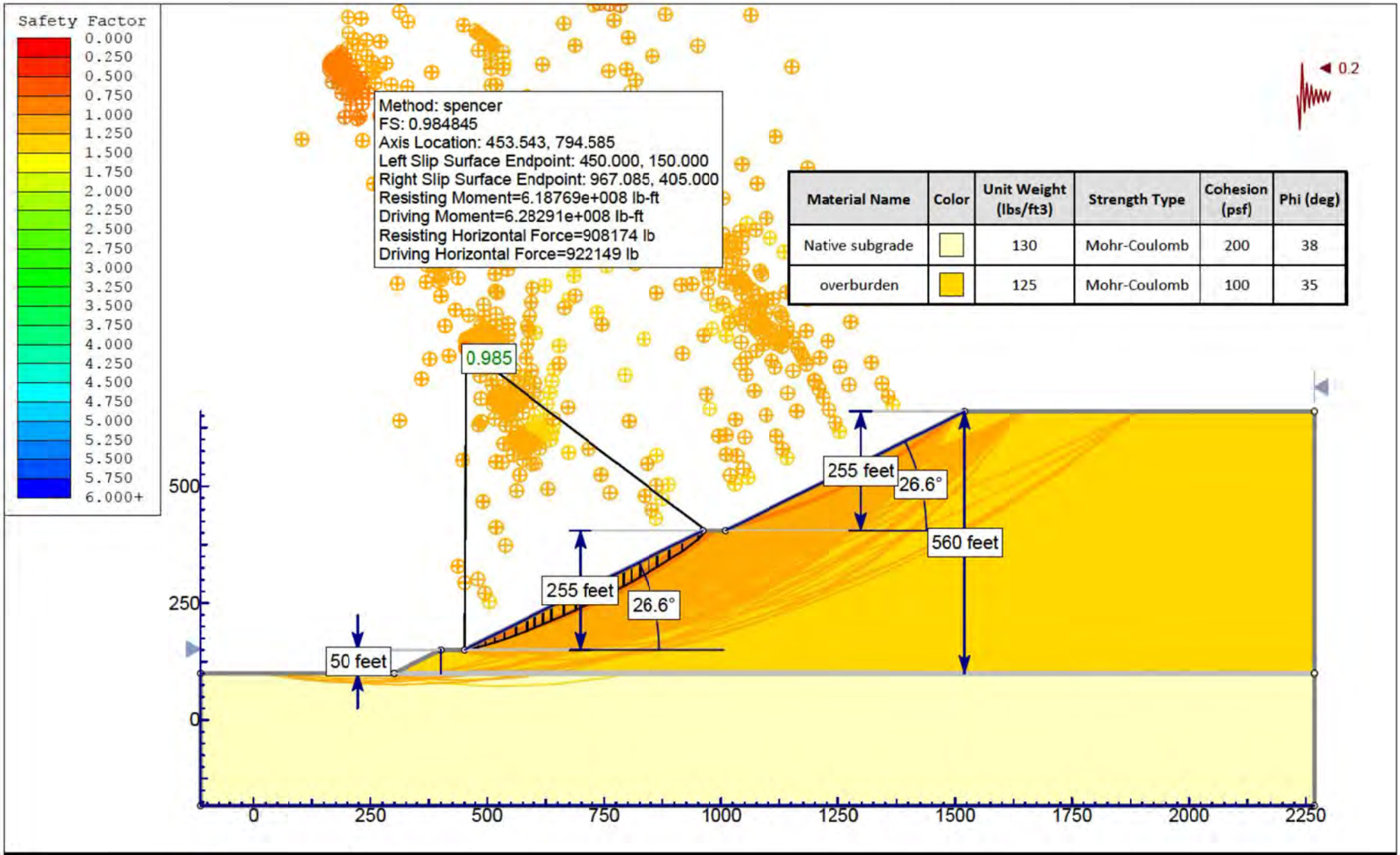


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Native subgrade		130	Mohr-Coulomb	200	38
overburden		125	Mohr-Coulomb	100	35

SLIDEINTERPRET 6.015

OMYA - Overburden Stockpile Stability

Analysis Description	General Stockpile		
Drawn By	CHJ	Author	J. McKeown	Scale	1:3404
File Name	26d 560H 2 benches stat.slim	Date	3/13/2012	Enclosure C-6.1

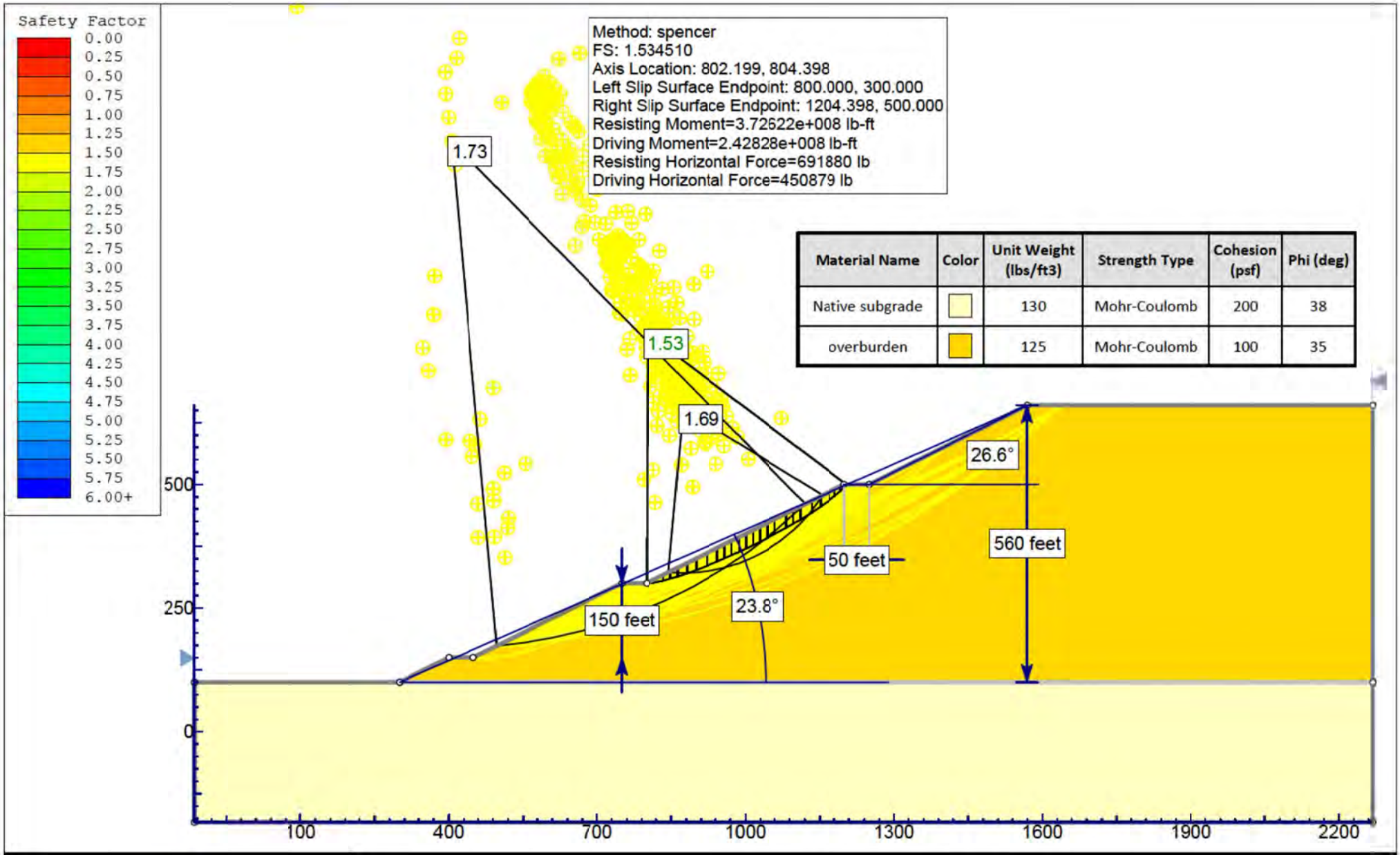


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Native subgrade		130	Mohr-Coulomb	200	38
overburden		125	Mohr-Coulomb	100	35

SLIDEINTERPRET 6.015

OMYA - Overburden Stockpile Stability

Analysis Description	General Stockpile		
Drawn By	CHJ	Author	J. McKeown	Scale	1:3404
File Name	26d 560H 2 benches seis 02.slim	Date	3/13/2012	Enclosure C-6.2

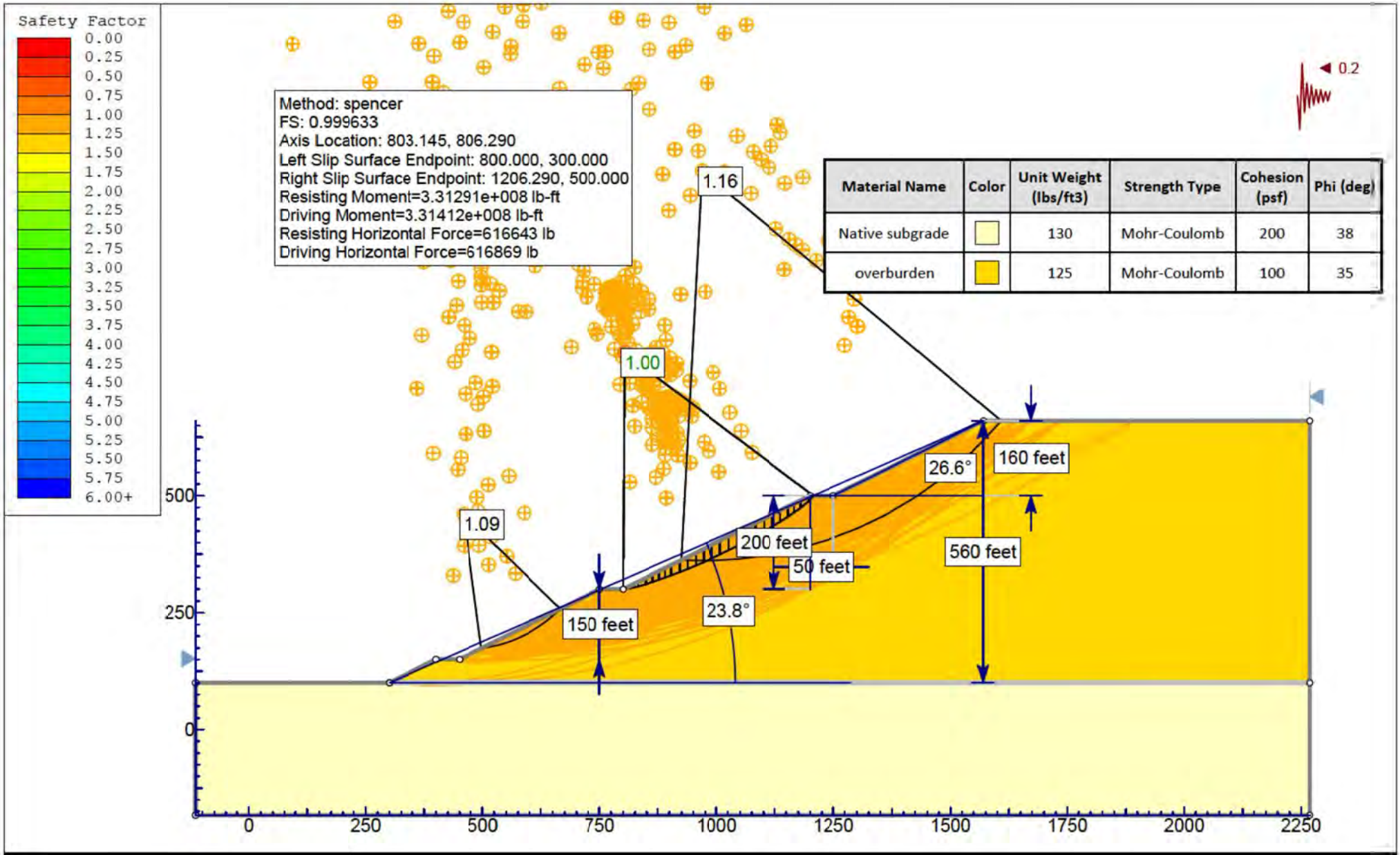


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Native subgrade		130	Mohr-Coulomb	200	38
overburden		125	Mohr-Coulomb	100	35

SLIDEINTERPRET 6.015

OMYA - Overburden Stockpile Stability

Analysis Description	General Stockpile		
Drawn By	CHJ	Author	J. McKeown	Scale	1:3219
File Name	26d 560H ___ benches stat.slim	Date	3/13/2012	Enclosure C-7.1



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Native subgrade		130	Mohr-Coulomb	200	38
overburden		125	Mohr-Coulomb	100	35

SLIDEINTERPRET 6.015

OMYA - Overburden Stockpile Stability

Analysis Description	General Stockpile		
Drawn By	CHJ	Author	J. McKeown	Scale	1:3405
File Name	26d 560H ___ benches seis 02.slim	Date	3/13/2012	Enclosure C-7.2

CHJ Consultants

A Terracon COMPANY

April 6, 2017

OMYA, Inc.
9987 Carver Road, Suite 300
Cincinnati, Ohio 45242
Attention: Ms. Shelby Olsen

Job No. 17077-8

Subject: Response to Comments by OMR Dated August 19, 2013
Slope Stability Investigation
Amended Reclamation of Sentinel and Butterfield Quarries
San Bernardino County, California
CHJ Consultants Report Dated July 20, 2012

Dear Ms. Olsen:

In accordance with a request from Ms. Maya Rohr of Sespe Consulting and with your authorization, we have prepared this response to comments by the State of California Office of Mine Reclamation (OMR) regarding our slope stability investigation report for the Sentinel/Butterfield Quarries (CA Mine ID# 91-36-0052) located in San Bernardino County, California. The slope stability report was prepared to address the proposed reclamation plan slopes. We appreciate the opportunity to receive comments and suggestions from reviewers.

This letter addresses the "geotechnical requirements" comments provided in a letter dated August 19, 2013, addressed to Ms. Channary Leng of San Bernardino County Land Use Services Department. The comments by OMR are presented in italics below, followed by our response.

Comments by OMR

The Geologic Map in the CHJ Consultants (CHJ) study (Enclosure A-2.1) is unclear in its depiction of the geology of the site. Some geologic contacts appear to cross each other; some areas of

adjacent, differing geologic units are not separated by a geologic contact; and geologic units [in] some areas are unlabeled. The maps should be checked for accuracy and revised as necessary. It may help to color the various geologic units.

The Geologic Map (Enclosure A-2.1) has been revised to clarify the various geologic contacts and units areas. The contacts depicted on the original version were produced by overlay of the Fawnskin quadrangle 7.5-minute geologic map that is based on original field mapping by Mr. Howard Brown (unpublished data) conducted prior to the existing mine configuration. Unit contact and fault locations shown on Enclosure A-2.1 are approximate outside the mined exposures. Faults mapped during the 2012 study are shown as located at the time of mapping and are included in the kinematic evaluations for the mine.

The text, the Geologic Map (Enclosure A-2.1), and Appendix B refer to 'location of observation'. These locations appear to be incompletely depicted on maps and text. For example, the text refers to Location 21 being near an existing landslide in the Sentinel Quarry, but that location is not depicted on the map. Similarly, Locations 7, 14, 15 and 22 are not depicted on the Geologic Map.

The locations included on our original Geologic Map (Enclosure A-2.1) presented only those field locations where structural data were collected so as to correspond to domain designations and numbered locations utilized in the kinematic data tables. All of the map locations are included on the revised version of the Geologic Map attached hereto. Note that location 15 was not used.

The landslide referred to in the previous comment is not shown on the Geologic Map (Enclosure A-2.1). The map should be revised to show the location and extent of the landslide.

The subject landslide (map Location 21) consisted of a block-type failure about 100 feet wide formed on daylighted joints intersecting a west-dipping zone of allanite. The block was located in a working face contained in a volume of rock that has been removed by mining subsequent to the mapping we conducted in June 2012. Therefore, the landslide in question no longer exists.

The CHJ study includes no engineering geologic cross sections, although the explanation on the Geologic Map (Enclosure A-2.1) indicates that geologic cross sections exist. Thus, the study is

unclear how well the models utilized in the stability analyses approximate the geology of the final slopes. Engineering geologic cross sections showing existing conditions and final slopes should be included in the study.

A set of cross sections presenting the requested information is attached hereto. We included the existing and final slope surfaces including the benches. Geologic information was obtained from published and unpublished maps by Mr. Howard Brown and our field mapping. Fault geometries are plotted based on information in the Brown maps and from field measurements where obtained. Drill hole data was not available for this investigation. The configuration and geometry of major structural features was considered by the mine engineer in final slope design to mitigate the potential for large-scale slope failure.

The analyses indicate that wedge, planar and/or toppling failures are kinematically possible for certain quarry slope aspects and structural domains. However, CHJ reports that these failure modes appear to have suitably high factors of safety against failure. The analyses were run assuming dry conditions with not earthquake shaking. Infiltration of seasonal rainfall into fractures and earthquakes can exert a substantial destabilizing effect on slopes. The kinematic study should be revised to evaluate the stability of the slopes assuming water-filled fractures and conditions of earthquake loading.

The July 2012 study utilized an approach for evaluation of kinematically-possible failure modes at the bench face scale that relies on identification and limit-equilibrium analysis of individual slope features/zones. This method relied on the user to recognize existing individual features or representative conditions with the potential for kinematic instability; therefore, the predictive ability of the method was limited to available pit exposures. We have since adopted a statistical approach to kinematic evaluation of pit bench faces and bench-scale features that utilizes a stereonet database of global structural data sets to define and evaluate the kinematic conditions for topple, wedge and planar failure potential. A range of values expressed as a percentage of features in the data sets provides a quantitative characterization of the kinematic state for a suite of slope configurations. The statistical method also provides for consideration of structure type. A revised kinematic evaluation for the Sentinel and Butterfield quarries is provided in the following paragraphs. The value for

friction angle was reduced to 30 degrees in consideration of slope conditions with water infiltration and earthquake loading.

Kinematic analysis involves the evaluation of geometrically feasible failure modes in bedrock based on the orientation of structural discontinuities including joints, faults, shear zones, bedding and foliation. Kinematic analysis does not consider mass or force as in a limit-equilibrium analysis. Structurally controlled kinematic failure modes include planar, wedge and topple failures.

We performed stereonet analysis (Rocscience, 2016) for representative slope aspects (slope dip direction) within several "domains" defined based on rock and structural characteristics utilizing the data compiled from mapping and measurement of geologic structures within the quarries (attached Tables B-1.1 through B-1.5 and Table B-2). The proposed maximum bench face angle (70 degrees) was evaluated for selected slope aspects. The slope orientations are listed in azimuth format in Tables 1.1 and 1.2.

Planar analysis considers dip vectors of measured data points. Planar sliding requires a releasing surface—a joint or tension crack—to allow sliding to occur. Kinematic analysis does not consider the geometry of releasing surfaces or the presence of bonded contacts along the sliding plane; therefore actual conditions are typically more stable than indicated by kinematic results. The potential for planar sliding or wedge failure suggested by stereonet analysis should be considered a conservative estimate of probability subject to mitigation by mining practices such as scaling and adjustment of slope face angles to the geometry and conditions encountered during mining. Wedge analysis generates dip vectors for the intersections of all planes; therefore, wedge analysis generates a large number of vectors to evaluate. Topple analysis identifies the potential for columns to form along steeply dipping joint systems or contacts to tilt out of the excavated face along separation surfaces. The stereonet data plots are attached hereto as Enclosures 1.1 through 14.3. Tables 1.1 and 1.2 (below) summarize the results of kinematic evaluation for the Sentinel and Butterfield quarries, respectively.

Table 1.1: Summary of Kinematic Evaluation—Sentinel Quarry			
Domain/Slope Aspect	**Percentage Critical Points**		
	Planar	**Wedge**	**Topple (Direct)**
	70° bench face	70° bench face	70° bench face
Dom1_225	0	20	3.6
Dom2_90	16.7	27.3	0
Dom2_130	33.3	31.8	0
Dom3_110	8.3	7.6	4.6
Dom3_270	8.3	18.2	3.0
Dom4_45	12.5	25.0	15.8
Dom4_270	0	3.3	11.7
Dom4_315	0	15.0	2.5
Dom5_45	6.7	1.9	11.4
Dom5_90	0	2.9	6.7

Table 1.2: Summary of Kinematic Evaluation—Butterfield Quarry			
Domain/Slope Aspect	**Percentage Critical Points**		
	Planar	**Wedge**	**Topple (Direct)**
	70° bench face	70° bench face	70° bench face
Dom6_90	0	3.0	7.9
Dom6_180	3.5	9.1	25.4
Dom6_270	0	6.9	5.9
Dom6_360	0	8.9	3.7

The stereonet evaluation provides results as a percentage of points (structural features) in a data set with a geometrically feasible orientation to undergo a particular failure mode. In general, the percentage value relates to probability of a particular failure mode. Probabilities below 5 percent suggest low potential, 5 percent to 20 percent a low to moderate potential, and values above 20 percent a moderate or higher potential for formation of kinematically feasible failure modes.

Sentinel Quarry – Kinematic Results

The results of the kinematic evaluation for Sentinel suggest a moderate potential for planar sliding in east-facing slopes in Domain 2, southeast- and west-facing slopes in Domain 3, northeast-facing slopes in Domain 4, and northeast-facing slopes in Domain 5. A higher potential for planar sliding is indicated for southeast-facing slopes in Domain 2. Low planar sliding potential is indicated for the remaining domains/aspects. Planar failures are expected to be bench-scale features based on site observations and are mitigatable during mining with removal and scaling and inclusion of benches in the excavations. All Sentinel domains were combined and evaluated in a sensitivity plot of planar sliding versus slope dip direction (aspect). This chart is attached as Enclosure 15.1 and indicates a low potential for planar sliding in all domains, with the higher relative probability in west to northwest-facing slopes.

Wedge formation potential is relatively high for east- and southeast-facing slopes in Domain 2 and northeast-facing slopes in Domain 4. Moderate potential for wedge formation is indicated for southwest-facing slopes in Domain 1, southeast- and west-facing slopes in Domain 3, and northwest-facing slopes in Domain 4. Low potential for wedge formation is indicated for the remaining domains/aspects. Wedge failures are expected to be bench-scale features based on site observations and are mitigatable during mining with removal and scaling and inclusion of benches in the excavations. All Sentinel domains were combined and evaluated in a sensitivity plot of wedge sliding versus slope dip direction (aspect). This chart is attached as Enclosure 15.2 and indicates a low to moderate potential for wedge sliding in most domains, with the higher relative probability in west to northwest-facing slopes.

Topple potential is low to moderate for all slope azimuths and domains. Topple geometries were not noted in the Sentinel pit exposures, and steep joints with columnar volumes were not noted. The potential for topple failures is low. A sensitivity analysis of direct toppling versus dip direction

indicates a low probability for formation of topple geometries across all slope aspects (Enclosure 15.3)

Butterfield Quarry – Kinematic Results

The potential for planar failure geometries are low for the four domains defined for the Butterfield quarry. Wedge formation potential is low to moderate in the Butterfield domains. Topple geometry potential is generally low to moderate for the Butterfield quarry with the exception of south-facing slopes which are indicated as having a moderate to high potential for topple failure. Topple failures were not noted in the mine exposures at the time of our investigation. Topple features are anticipated to be bench-scale and mitigatable by the ongoing operations that include scaling and removal of unstable features during mining and inclusion of safety benches in the wall profile.

All Butterfield data were combined and evaluated in a sensitivity plot of planar sliding versus slope dip direction (aspect). This chart is attached as Enclosure 16.1 and indicates a low potential for planar sliding. The sensitivity plot of wedge sliding versus dip direction indicates a low potential for wedge formation across all aspects (Enclosure 16.2). The sensitivity plot for direct toppling versus dip direction indicates a low to moderate potential for topple in south-facing slopes (Enclosure 16.3).

Continuous-Scale Structure Types

Enclosure 17.1 presents a stereonet lot of orientations of the more continuous structure types (faults and bedding) for the Sentinel and Butterfield quarries. Sensitivity plots of structural data for faults and bedding in the overall slope (angle 50 degrees), are presented as Enclosures 17.2 through 17.4 These figures show the percentage of critical features for a given failure type versus a suite of slope aspects in azimuthal increments of 30 degrees. For planar sliding a low potential is indicated for all structure at all slope aspects. Wedge formation potential is below 13 percent for continuous structure types; therefore, the potential for large-scale wedge failures is anticipated to be low for known fault and bedding planes. Topple potential is typically limited to bench-scale volumes in fractured rock types and the sensitivity plot reflects this with most azimuthal points plotting at or below 8 percent for direct topple.

Based on the results of the revised kinematic evaluation, it is anticipated that structurally-controlled planar, wedge or topple features will be limited to bench scale and can be mitigated by the proposed

benching and excavation scheme. Observations of quarry faces during prior mapping indicated that scaling of loose blocks during excavation provides a suitable mitigation of potential rock fall from planar, wedge or topple structures. The operational bench design allows for adjustments due to areas of deeper raveling on wall faces.

Subsequent to blasting of the final rock slope walls, quarry operations include the use of a scaling chain or mechanical equipment to remove loose or precarious blocks during excavation of the resource. Adherence to the slope benching plan and consideration of newly exposed adverse structural features (if present) during future quarry work will result in stable slopes after completion of reclamation.

Low-damage controlled blasting techniques or other suitable methods of excavating relatively clean and uniform benches and faces are planned to create the final reclamation slopes. Feature-specific mitigation has been used to mitigate adverse geologic conditions discovered during ongoing mining and is a proven method for slope control for the Sentinel and Butterfield quarries.

The analyses of the stability of the overall slope, referred to a 'Global Stability' in the CHJ report, appear to test for only a circular failure mechanism. The descriptions of the geologic units indicated that a circular failure mechanism is unlikely. This is supported by the relatively high calculated factors of safety from the analyses. The report should address the potential for larger block failures, such as planar or wedge failures, of the overall slope.

A potential for global-scale block-type failures was not observed during geologic mapping nor is indicated in the kinematic evaluation for continuous structures such as bedding or faults (Enclosures 17.2 and 17.3). The major faults that might have the potential to act as large-scale slip planes are generally west-dipping features and are situated along the west side of the Sentinel quarry. The location of the resource is determined by the fault structures, which in turn determine the quarry location. The presence of faults and geometry of bedding have been considered in planning the quarry limits and bench geometry; therefore, large block-type slope failures are not anticipated.

CLOSURE

We trust this information is sufficient for your needs at this time. If you should have questions, please contact this firm at your convenience.

Respectfully submitted,
CHJ CONSULTANTS, a Terracon Company

John S. McKeown, E.G. 2396
Senior Geologist

Jay J. Martin, E.G. 1529
Principal Geologist

JMc/JJM:lb

Enclosures: Revised Geologic Map
Geologic Sections
Kinematic Data Tables
Stereonet Plots and Sensitivity Charts

Distribution: OMYA (2 copies + electronic)

GEOLOGIC UNITS: *(from Miller et al. 2001 & Brown 1978-82)*

dg - disturbed ground, includes areas lacking vegetation, roadways & associated fills & overburden embankment fills.
native - areas where vegetation appears undisturbed, mature and dense.

Bird Spring Formation:

Pbuc - Upper Carbonate Member
Pbmc - Middle Carbonate Member

Monte Cristo Limestone:

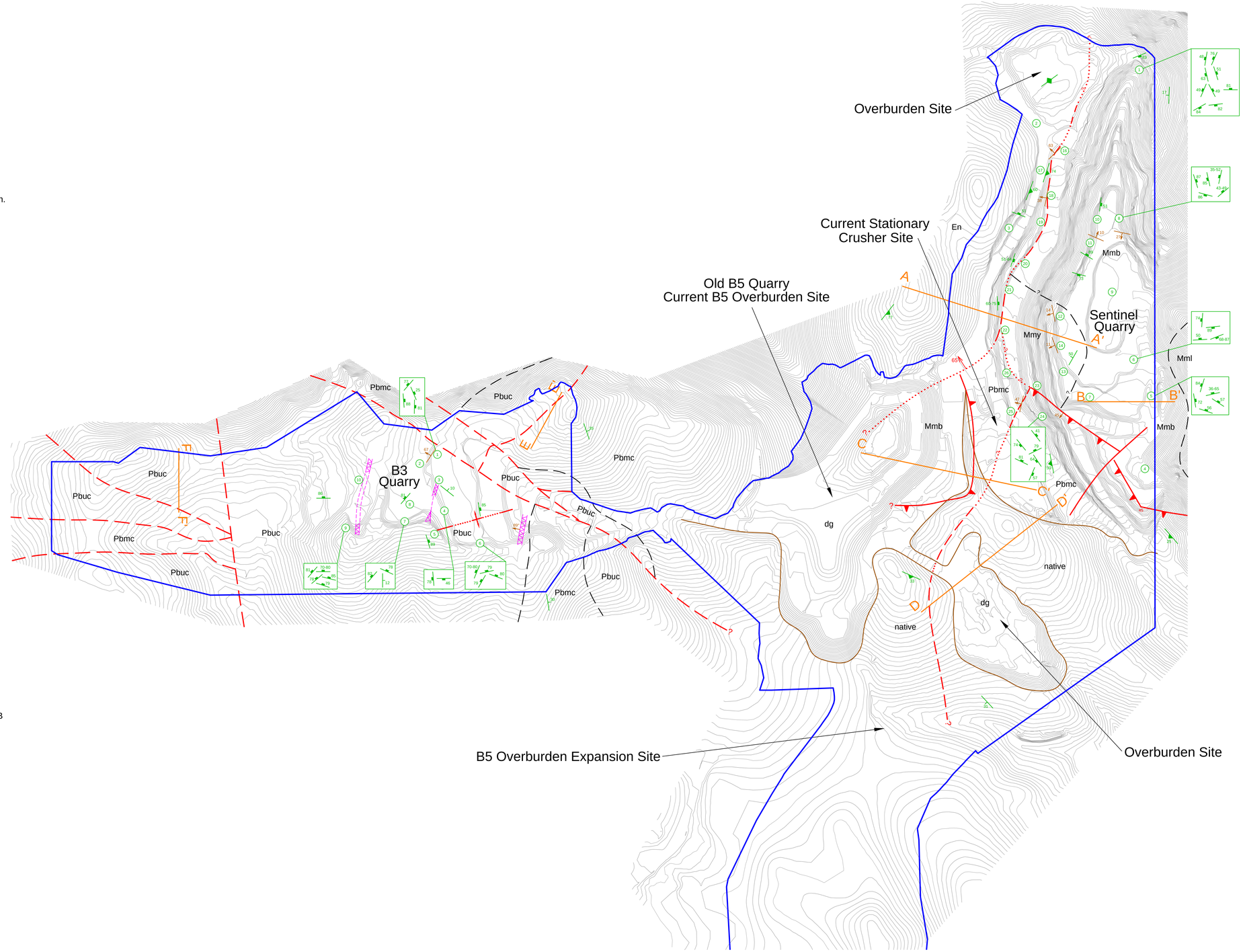
Mmy - Yellowpine Member, medium-to thick-bedded calcite & dolomite marble.
Mmb - Bullion Member, thick-to very thick-bedded calcite marble.
Mml - Lower Member, thin-to thick-bedded calcite marble.
En - Nopah Formation, texturally massive, locally laminated dolomite

Note:

Lithologic conatcts & unit names from Miller et al. (2001)
Structural geology from Miller et al. (faults in red) & field mapping for this investigation.
Bedrock units not shown in overburden placement areas. Geologic Units/Contacts depicted in areas of planned excavation.

LEGEND:

- thrust fault, barbs on upper plate
- 65 — fault with arrow indicating dip direction dotted where concealed/inferred
- ? — Geologic Contact, queried where uncertain, dotted where inferred or concealed.
- Delineates areas of disturbed or undisturbed (native) ground in Sentinel area.
- F — F' Geologic Cross Sections
- 60 — strike and dip of bedding
- 79 — strike and dip of joint
- shear zone vertical
- 27 — shear zone
- vertical foliation
- strike and dip of metamorphic foliation
- 26 — location of observations corresponding to tables in Appendix B
- 15 — not used
- altered intrusive dike/shear zone mapped in field



– N –

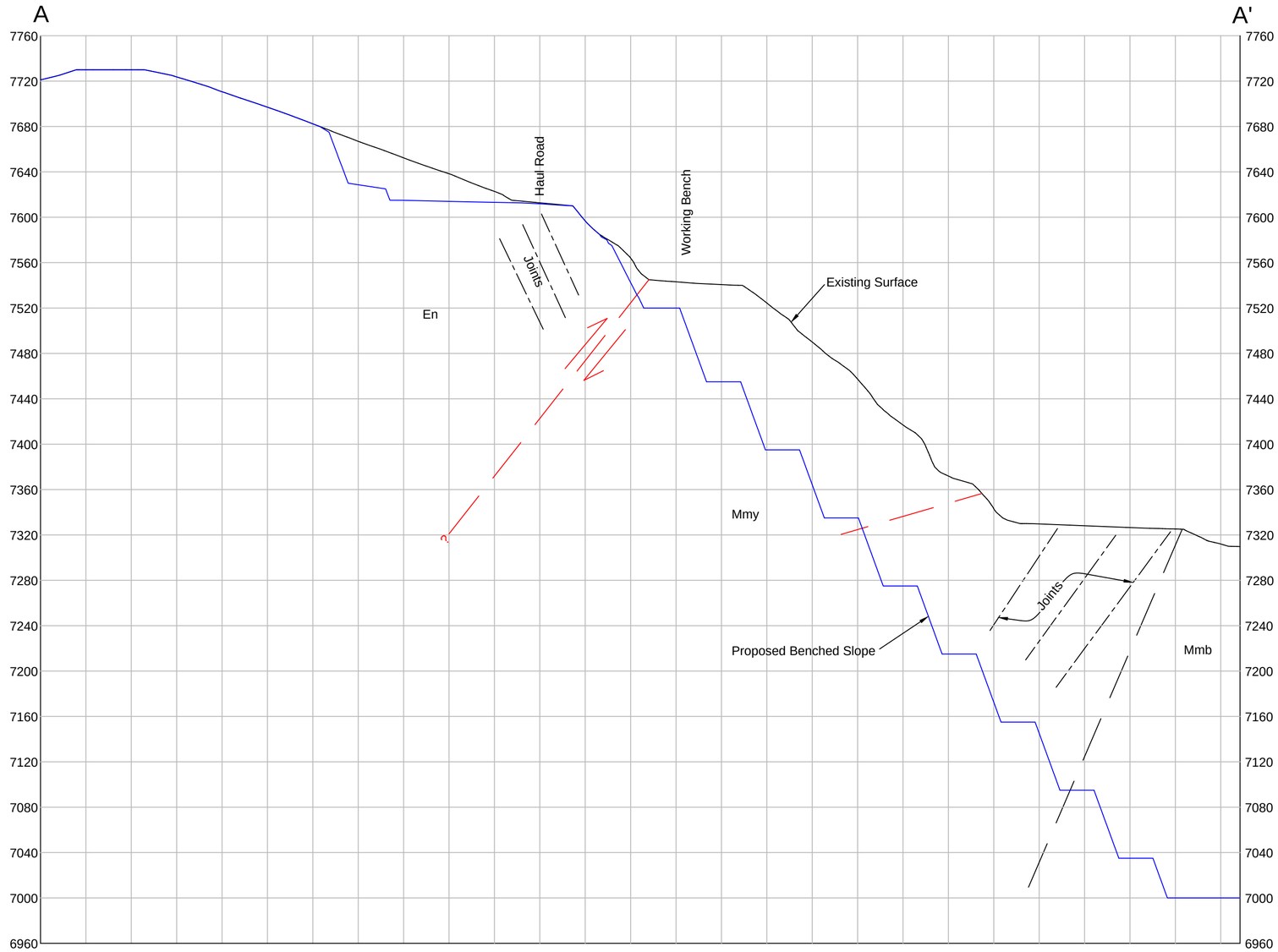
SCALE: 1"=250'

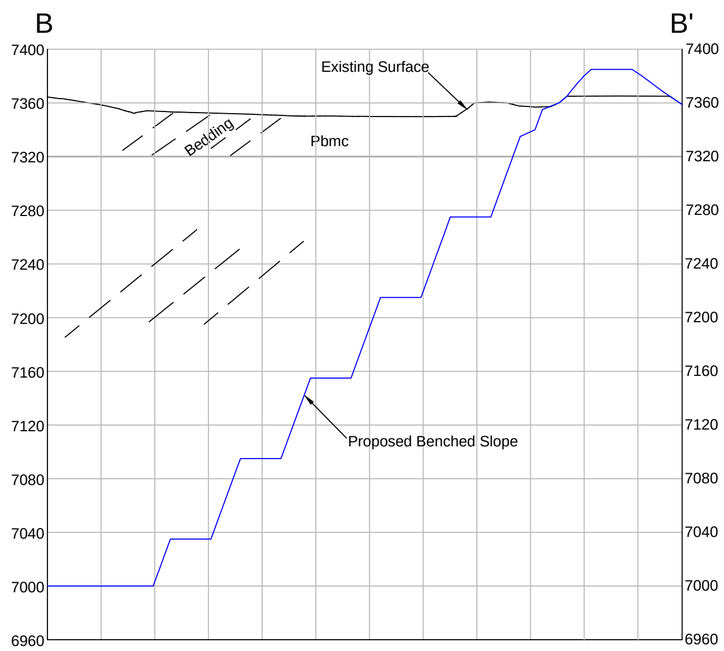
0 250 500

REVISED GEOLOGIC MAP

FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "A-2.1"
DATE: APRIL 2017		JOB NUMBER 17077-8

Terracon

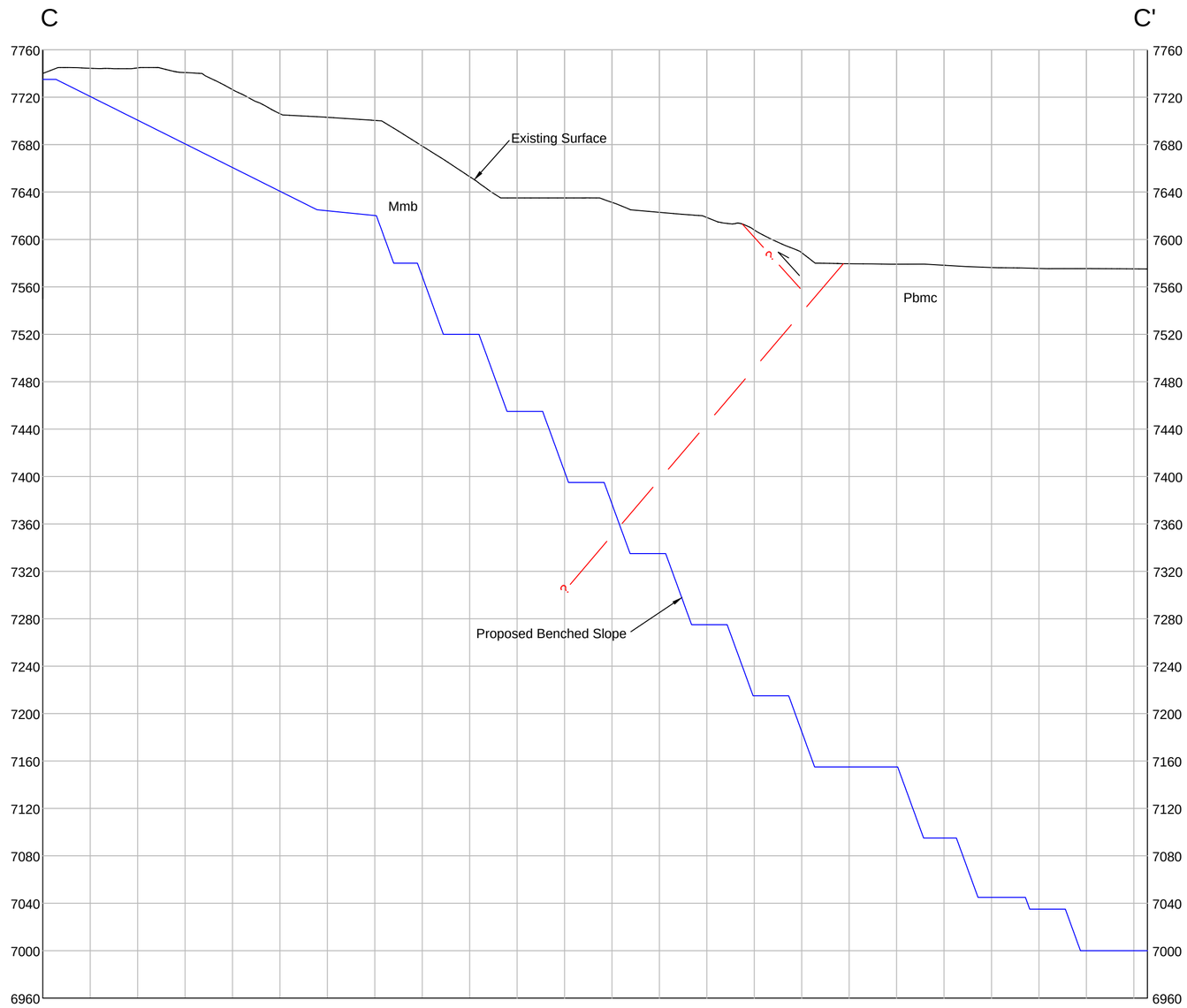




SCALE: 1" = 80'

PG. 1 OF 4

GEOLOGIC CROSS SECTIONS		
FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "A-2.2a"
DATE: MARCH 2017		JOB NUMBER 17077-8
		Terracon

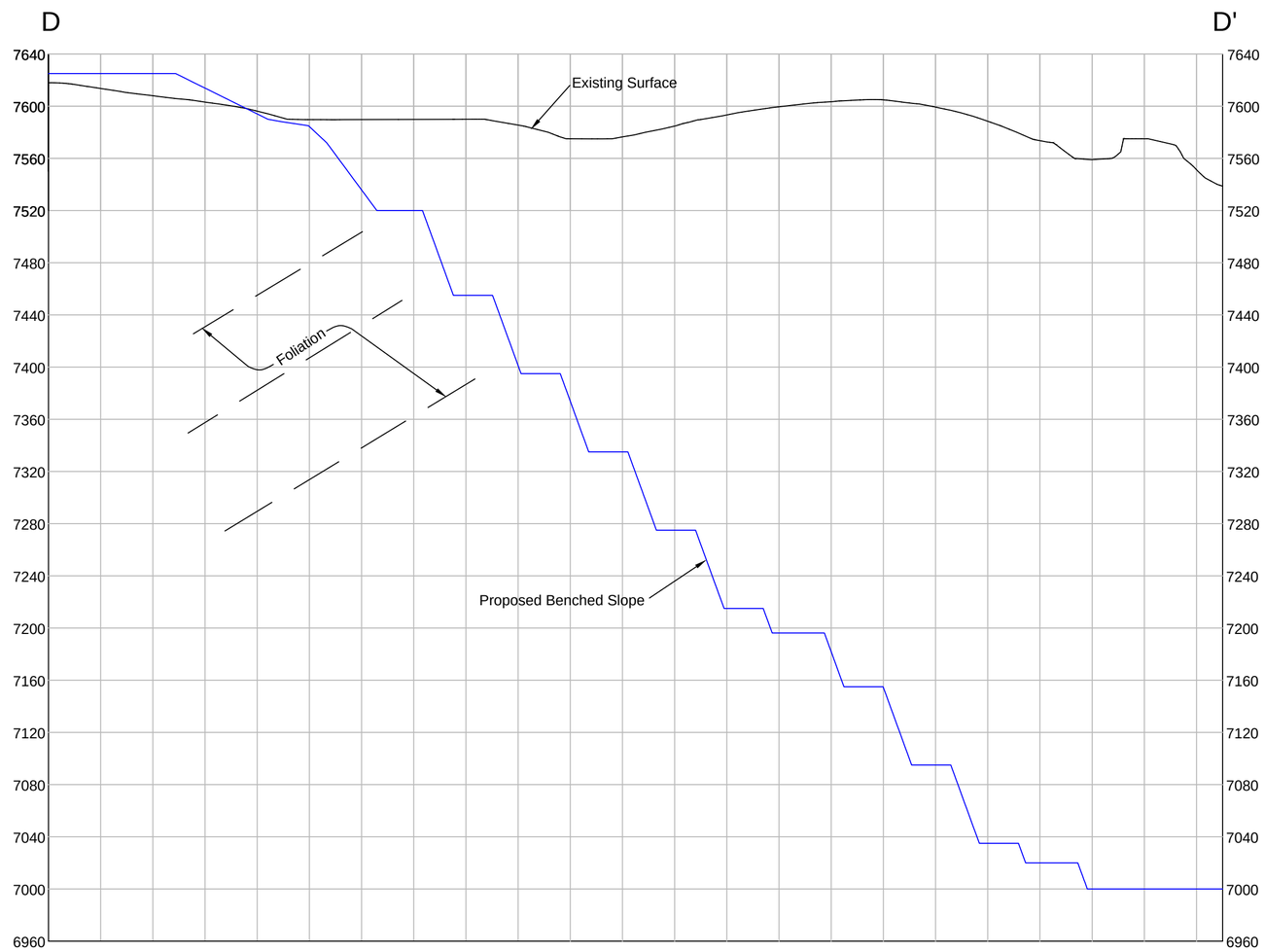


GEOLOGIC CROSS SECTIONS

FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "A-2.2b"
DATE: MARCH 2017		JOB NUMBER 17077-8

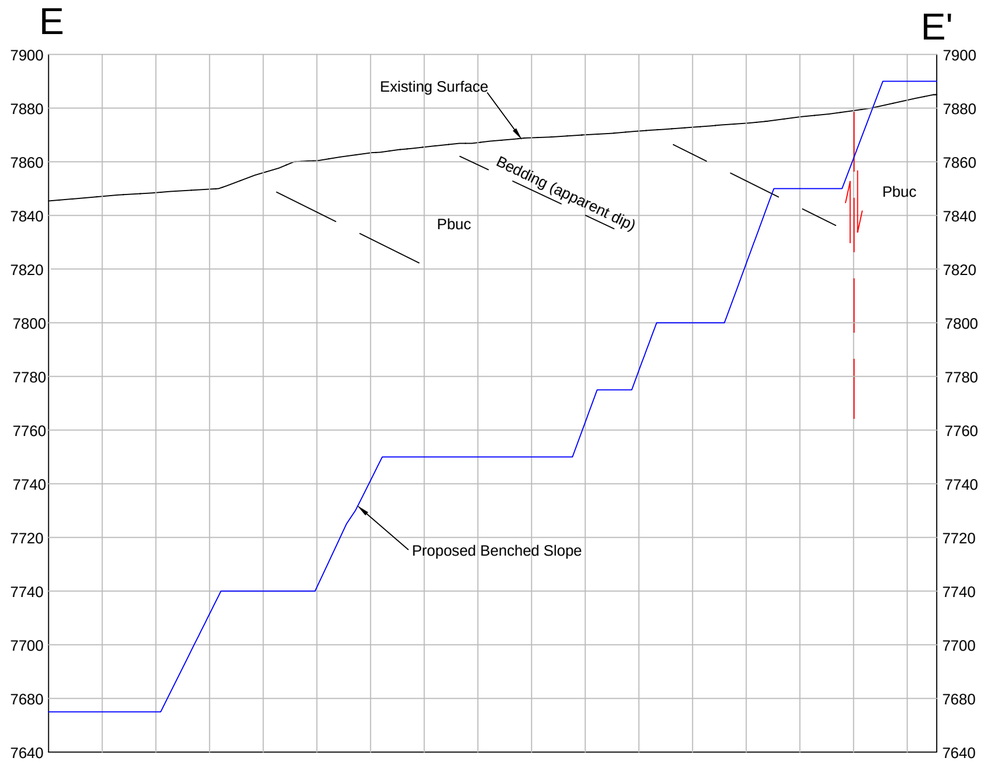
Terracon

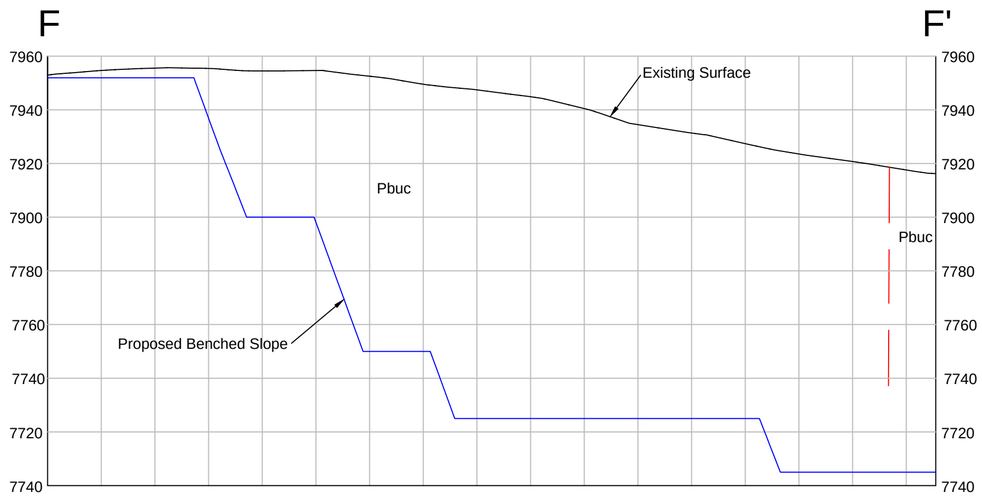
SCALE: 1" = 80'



GEOLOGIC CROSS SECTIONS		
FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "A-2.2c"
DATE: MARCH 2017		JOB NUMBER 17077-8
		Terracon

SCALE: 1" = 80'





PG. 4 OF 4

GEOLOGIC CROSS SECTIONS		
FOR: OMYA CALIFORNIA	SLOPE STABILITY INVESTIGATION PROPOSED AMENDED PLAN OF OPERATIONS FOR THE SENTINEL AND BUTTERFIELD 3 QUARRIES LUCERNE VALLEY, CALIFORNIA	ENCLOSURE "A-2.2d"
DATE: MARCH 2017		JOB NUMBER 17077-8
		Terracon

SCALE: 1" = 40'

Table B-1.1: Domain No. 1					
Includes Sentinel Location 1					
Discontinuity No.	**Continuity***	**Geologic Unit**	**Structure Type**	**Dip Direction**	**Dip Value**
1	slightly cont.	Bullion	joint	160	84
2	slightly cont.		joint	162	83
3	slightly cont.		joint	358	81
4	slightly cont.		joint	80	82
5	slightly cont.		joint	250	63
6	slightly cont.		joint	297	49
7	slightly cont.		joint	78	51
8	slightly cont.		joint	281	48
9	slightly cont.		joint	296	76
10	slightly cont.		joint	63	49
11	highly cont.		bedding	270	17

*based on Department of the Interior - Bureau of Reclamation, Engineering Geology Field Manual (2nd edition 1998)

Table B-1.2: Domain No. 2					
Includes Sentinel Locations 2,3, and 16 - 21					
Discontinuity No.	**Continuity**	**Geologic Unit**	**Structure Type**	**Dip Direction**	**Dip Value**
1	slightly cont.	Nopah Fm.	joint	110	60
2	slightly cont.		joint	288	51
3	slightly cont.		fault	308	63
4	moderately cont.		foliation	108	74
5	moderately cont.		foliation	90	63
6	slightly cont.		joint	226	37
7	slightly cont.		joint	165	62
8	slightly cont.		joint	130	49
9	very continuous		fault	270	38
10	slightly cont.		joint	111	51
11	slightly cont.		joint	111	64
12	moderately cont.		foliation	130	90

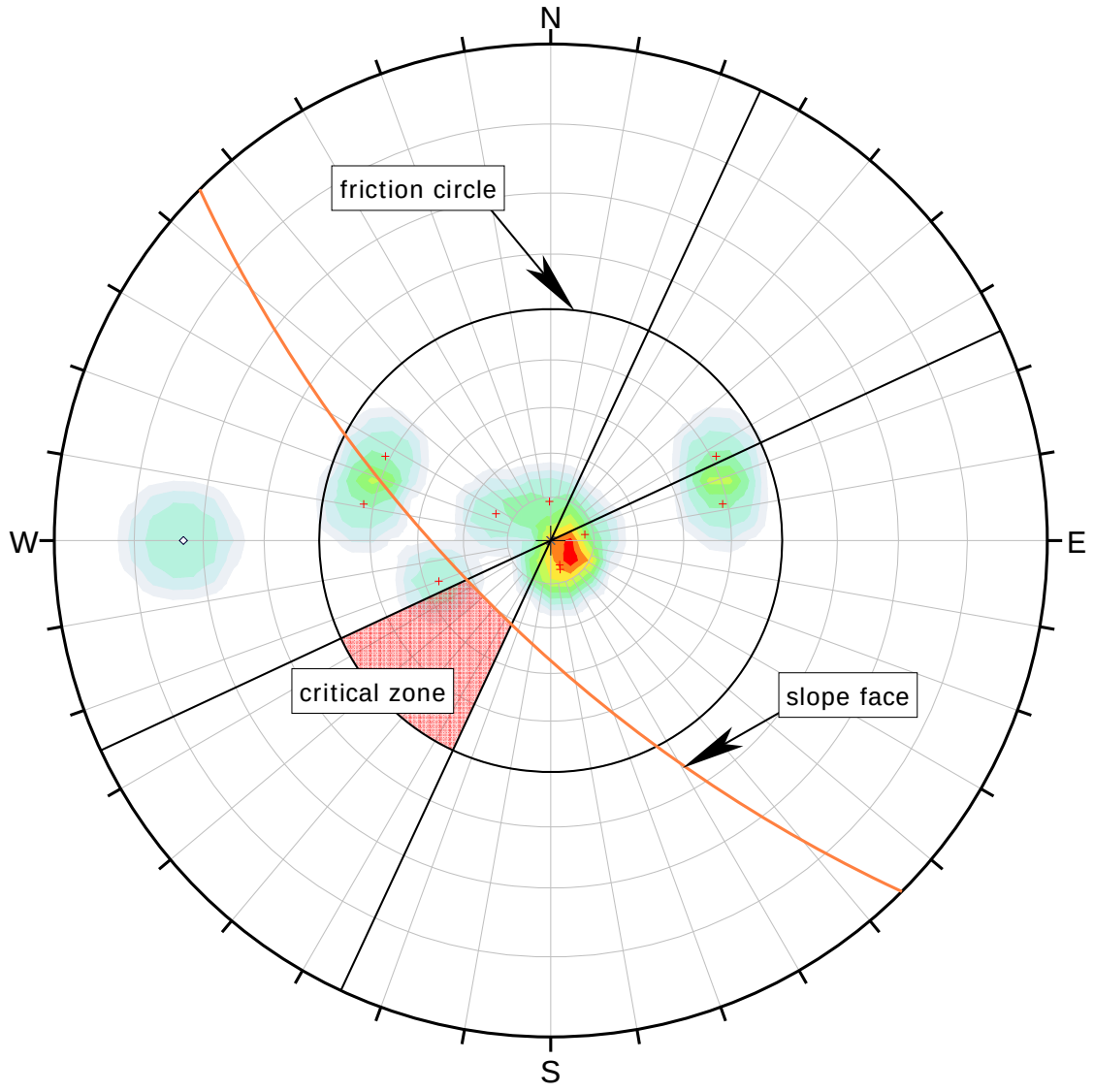
Table B-1.3: Domain No. 3					
Includes Sentinel Locations 8 - 11					
Discontinuity No.	**Continuity**	**Geologic Unit**	**Structure Type**	**Dip Direction**	**Dip Value**
1	highly cont.	Bullion	shear zone	197	27
2	slightly cont.		joint	74	87
3	slightly cont.		joint	259	85
4	slightly cont.		joint	203	86
5	slightly cont.		joint	284	35
6	slightly cont.		joint	284	52
7	slightly cont.		joint	334	43
8	slightly cont.		joint	334	49
9	moderately cont.		shear zone	40	10
10	slightly cont.		joint	95	51
11	slightly cont.		joint	220	73
12	slightly cont.		joint	10	89

Table B-1.4: Domain No. 4					
Includes Sentinel Locations 4 - 7					
Discontinuity No.	**Continuity**	**Geologic Unit**	**Structure Type**	**Dip Direction**	**Dip Value**
1	slightly cont.	Bullion	joint	86	72
2	slightly cont.		joint	30	56
3	slightly cont.		joint	342	36
4	slightly cont.		joint	342	65
5	slightly cont.		joint	288	84
6	slightly cont.		joint	37	57
7	slightly cont.		joint	240	76
8	slightly cont.		joint	259	81
9	slightly cont.		joint	170	73
10	slightly cont.		joint	170	85
11	slightly cont.		joint	357	50
12	slightly cont.		joint	155	68
13	slightly cont.		joint	155	87
14	slightly cont.		joint	168	89
15	slightly cont.		joint	273	74
16	moderately cont.	Bird Spring	foliation	235	25

Table B-1.5: Domain No. 5					
Includes Sentinel Locations 12, 13, 23 - 26					
Discontinuity No.	**Continuity**	**Geologic Unit**	**Structure Type**	**Dip Direction**	**Dip Value**
1	moderately cont.	Bird Spring	foliation	255	30
2	moderately cont.		shear zone	301	38
3	slightly cont.		joint	29	81
4	slightly cont.		joint	305	79
5	slightly cont.		joint	287	82
6	slightly cont.		joint	60	41
7	slightly cont.		joint	240	74
8	slightly cont.		joint	126	57
9	slightly cont.		joint	265	47
10	slightly cont.		joint	245	64
11	highly cont.	Yellowpine	bedding	300	50
12	moderately cont.		shear zone	340	11
13	moderately cont.		shear zone	343	14
14	very continuous	Bird Spring	fault	210	45
15	very continuous	Bird Spring	fault	240	45

Table B-2: Domain No. 6					
Butterfield 3 Quarry					
Discontinuity No.	**Continuity***	**Geologic Unit**	**Structure Type**	**Dip Direction**	**Dip Value**
1	slightly cont.	Bird Spring	joint	318	77
2	slightly cont.		joint	69	25
3	slightly cont.		joint	86	88
4	slightly cont.		joint	93	81
5	slightly cont.		shear zone	312	67
6	moderately cont.		shear zone	314	89
7	slightly cont.		joint	267	78
8	slightly cont.		joint	180	46
9	slightly cont.		joint	75	89
10	slightly cont.		joint	278	70
11	slightly cont.		joint	278	80
12	slightly cont.		joint	347	79
13	slightly cont.		joint	308	79
14	slightly cont.		joint	22	80
15	slightly cont.		joint	315	72
16	slightly cont.		joint	30	78
17	highly cont.		bedding	90	12
18	slightly cont.		joint	313	81
19	slightly cont.		joint	304	76
20	slightly cont.		joint	360	75
21	moderately cont.		shear zone	270	72
22	moderately cont.		shear zone	285	86
23	moderately cont.		shear zone	158	89
24	slightly cont.		joint	80	85
25	slightly cont.		joint	320	78
26	slightly cont.		shear	10	85
27	slightly cont.		joint	10	79
28	slightly cont.		joint	359	76
29	slightly cont.		joint	359	89

*based on Department of the Interior - Bureau of Reclamation, Engineering Geology Field Manual (2nd edition 1998)



Symbol	TYPE	Quantity
◇	bedding	1
+	joint	10

Color	Density Concentrations
	0.00 - 2.50
	2.50 - 5.00
	5.00 - 7.50
	7.50 - 10.00
	10.00 - 12.50
	12.50 - 15.00
	15.00 - 17.50
	17.50 - 20.00
	20.00 - 22.50
	22.50 - 25.00

Contour Data	Dip Vectors
Maximum Density	24.17%
Contour Distribution	Fisher
Counting Circle Size	1.0%

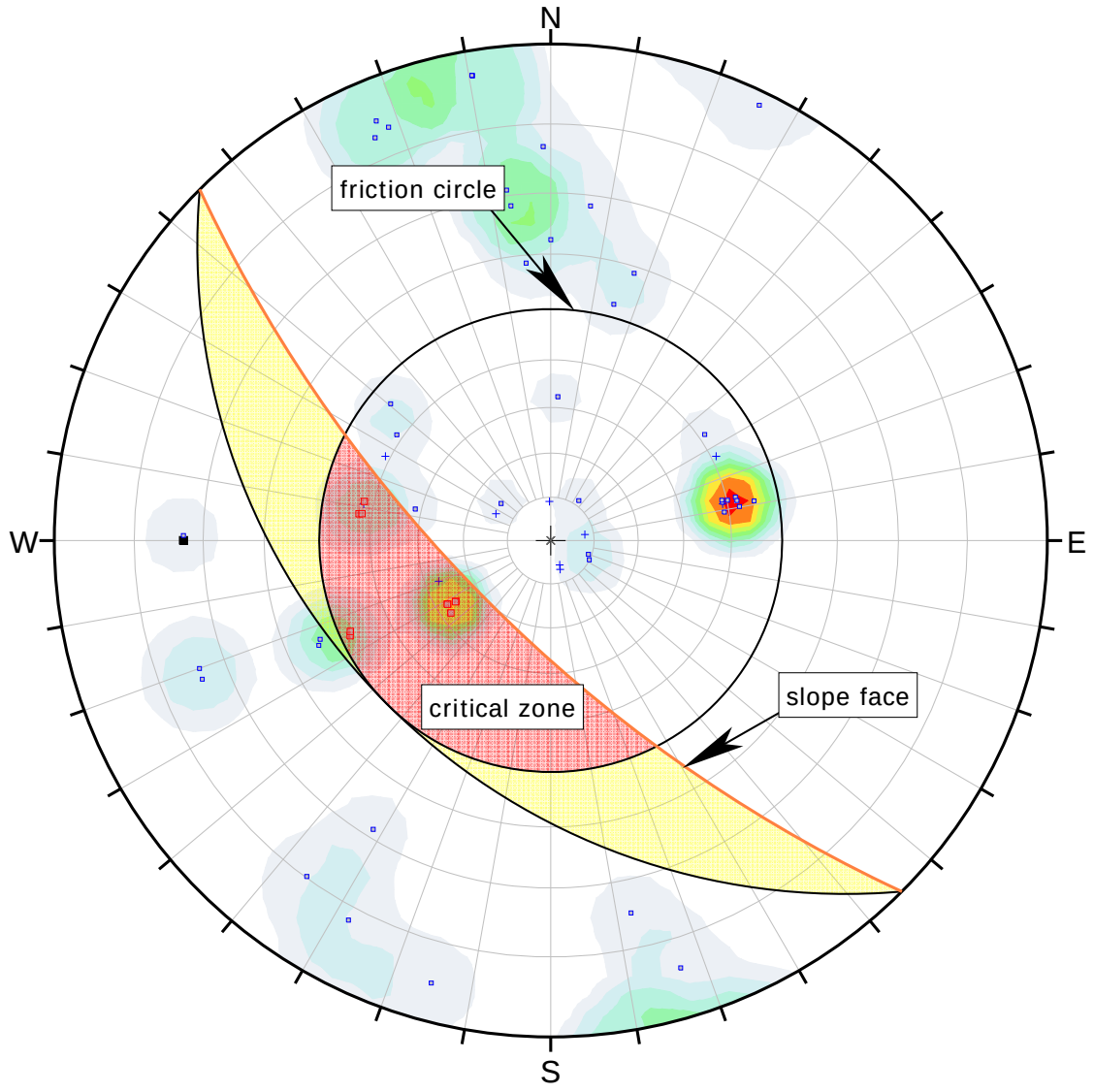
Kinematic Analysis	Planar Sliding
Slope Dip	70
Slope Dip Direction	225
Friction Angle	40°
Lateral Limits	20°

	Critical	Total	%
Planar Sliding (All)	0	11	0.00%

Plot Mode	Dip Vectors
Vector Count	11 (11 Entries)
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 1 - Planar Sliding Vector Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 1 Data_225 planar vector.dips7	*Date* 2/23/2017	*Enclosure* 1.1



Symbol	TYPE	Quantity
■	bedding	1
+	joint	10

Symbol	Feature
▫	Critical Intersection
▫	Intersection

Color	Density Concentrations
	0.00 - 1.50
	1.50 - 3.00
	3.00 - 4.50
	4.50 - 6.00
	6.00 - 7.50
	7.50 - 9.00
	9.00 - 10.50
	10.50 - 12.00
	12.00 - 13.50
	13.50 - 15.00

Contour Data	Intersections
Maximum Density	14.20%
Contour Distribution	Fisher
Counting Circle Size	1.0%

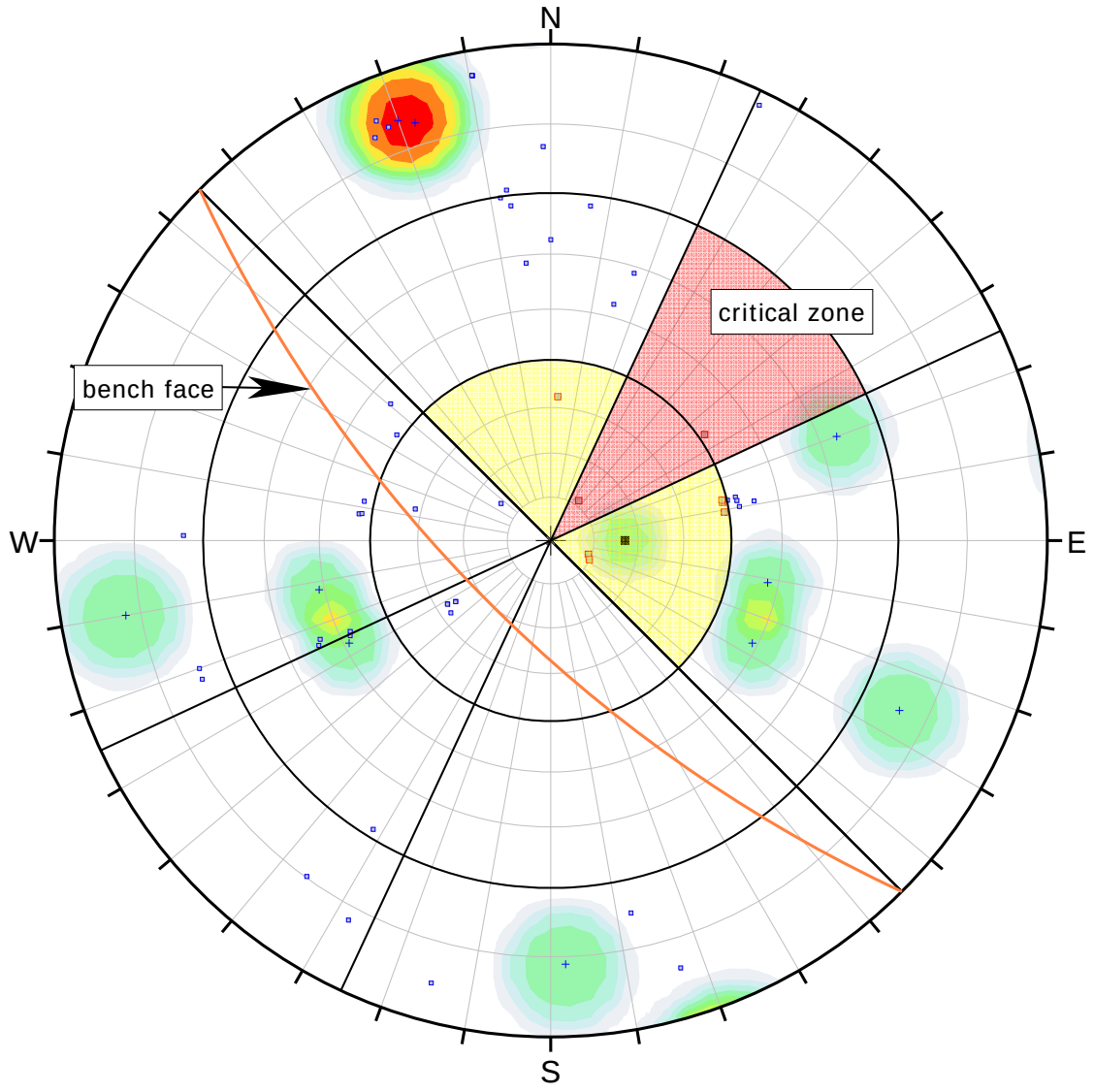
Kinematic Analysis	Wedge Sliding
Slope Dip	70
Slope Dip Direction	225
Friction Angle	40°

	Critical	Total	%
Wedge Sliding	11	55	20.00%

Plot Mode	Dip Vectors
Vector Count	11 (11 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	55
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 1 Wedge - Vector Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 1 Data_225 wedge vector.dips7	*Date* 2/24/2017	*Enclosure* 1.2



Symbol	TYPE	Quantity
■	bedding	1
+	joint	10
Symbol	**Feature**	
▫	Critical Intersection	
▫	Intersection	

Color	Density Concentrations
	0.00 - 1.90
	1.90 - 3.80
	3.80 - 5.70
	5.70 - 7.60
	7.60 - 9.50
	9.50 - 11.40
	11.40 - 13.30
	13.30 - 15.20
	15.20 - 17.10
	17.10 - 19.00

Contour Data	Pole Vectors
Maximum Density	18.04%
Contour Distribution	Fisher
Counting Circle Size	1.0%

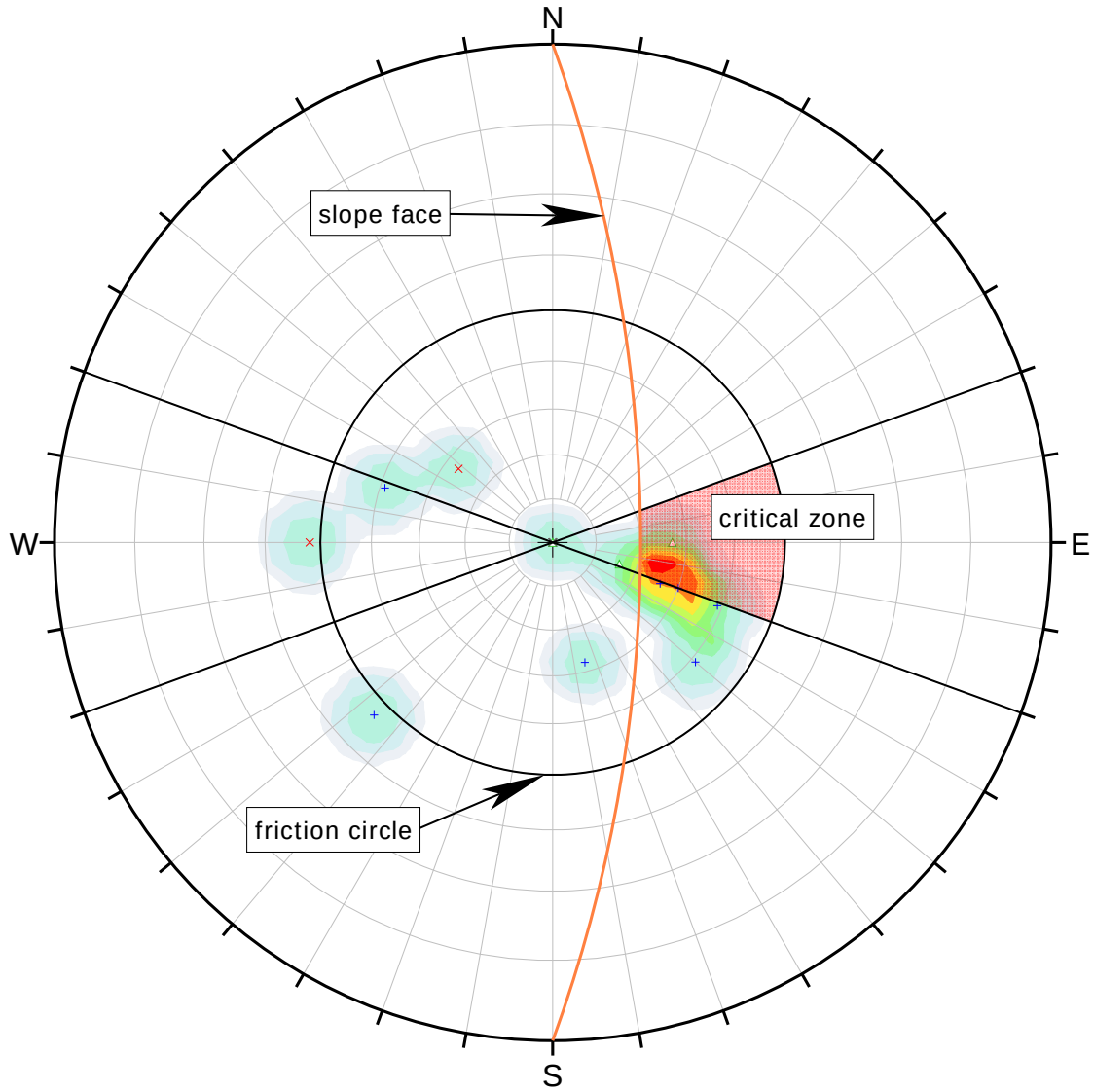
Kinematic Analysis	Direct Toppling
Slope Dip	70
Slope Dip Direction	225
Friction Angle	40°
Lateral Limits	20°

	Critical	Total	%
Direct Toppling (Intersection)	2	55	3.64%
Oblique Toppling (Intersection)	6	55	10.91%
Base Plane (All)	1	11	9.09%

Plot Mode	Pole Vectors
Vector Count	11 (11 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	55
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 1 topple - Pole Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 1_225 Topple.dips7	*Date* 2/24/2017	*Enclosure* 1.3



Symbol	TYPE	Quantity
×	fault	2
△	foliation	3
+	joint	7

Color	Density Concentrations
	0.00 - 2.40
	2.40 - 4.80
	4.80 - 7.20
	7.20 - 9.60
	9.60 - 12.00
	12.00 - 14.40
	14.40 - 16.80
	16.80 - 19.20
	19.20 - 21.60
	21.60 - 24.00

Contour Data	Dip Vectors
Maximum Density	23.43%
Contour Distribution	Fisher
Counting Circle Size	1.0%

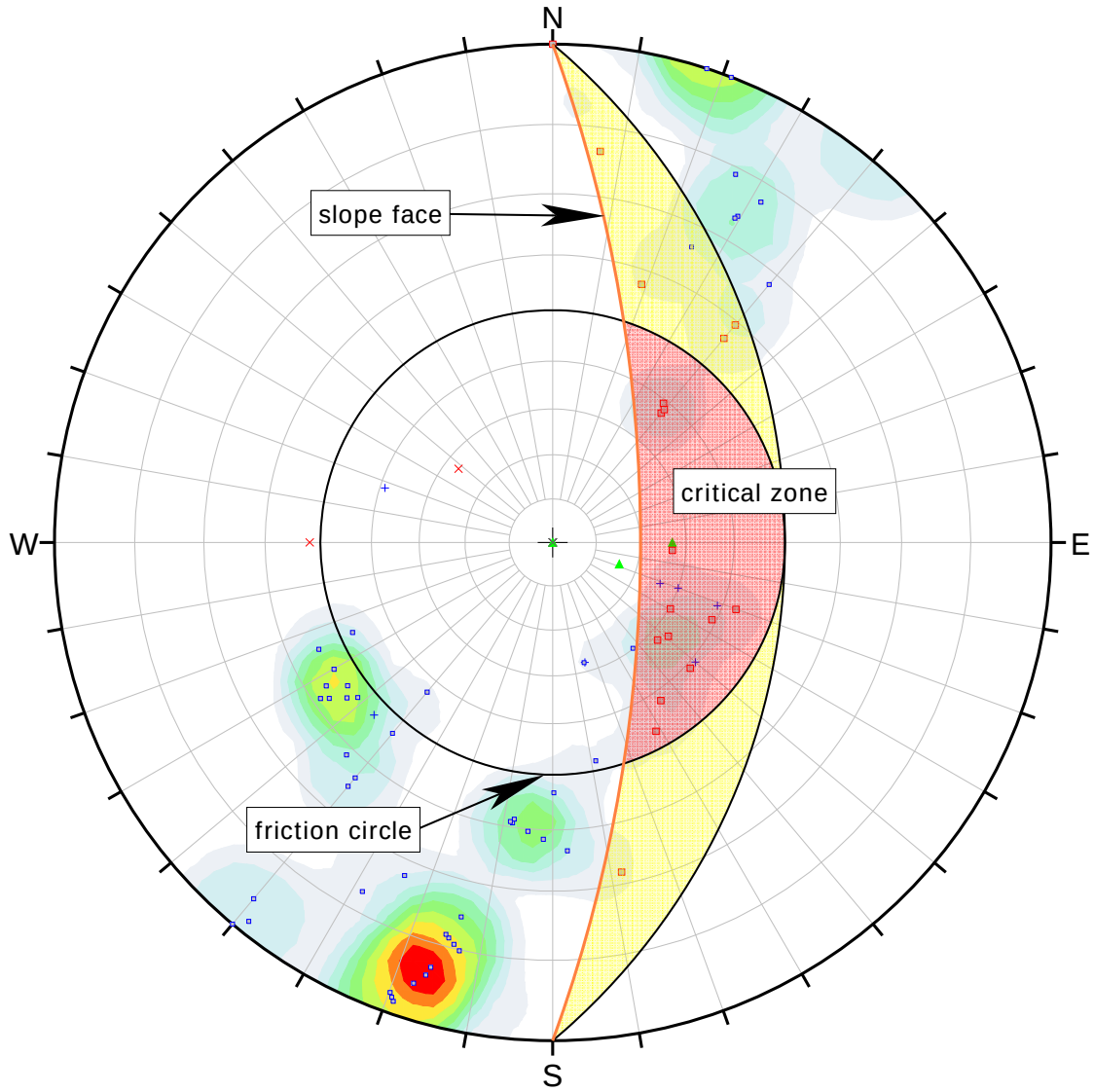
Kinematic Analysis	Planar Sliding
Slope Dip	70
Slope Dip Direction	90
Friction Angle	40°
Lateral Limits	20°

	Critical	Total	%
Planar Sliding (All)	2	12	16.67%

Plot Mode	Dip Vectors
Vector Count	12 (12 Entries)
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 2 - Planar Sliding Vector Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 2 90_planar vector.dips7	*Date* 2/23/2017	*Enclosure* 2.1



Symbol	TYPE	Quantity
×	fault	2
▲	foliation	3
+	joint	7
Symbol	**Feature**	
▫	Critical Intersection	
▫	Intersection	

Color	Density Concentrations
	0.00 - 1.60
	1.60 - 3.20
	3.20 - 4.80
	4.80 - 6.40
	6.40 - 8.00
	8.00 - 9.60
	9.60 - 11.20
	11.20 - 12.80
	12.80 - 14.40
	14.40 - 16.00

Contour Data	Intersections
Maximum Density	15.94%
Contour Distribution	Fisher
Counting Circle Size	1.0%

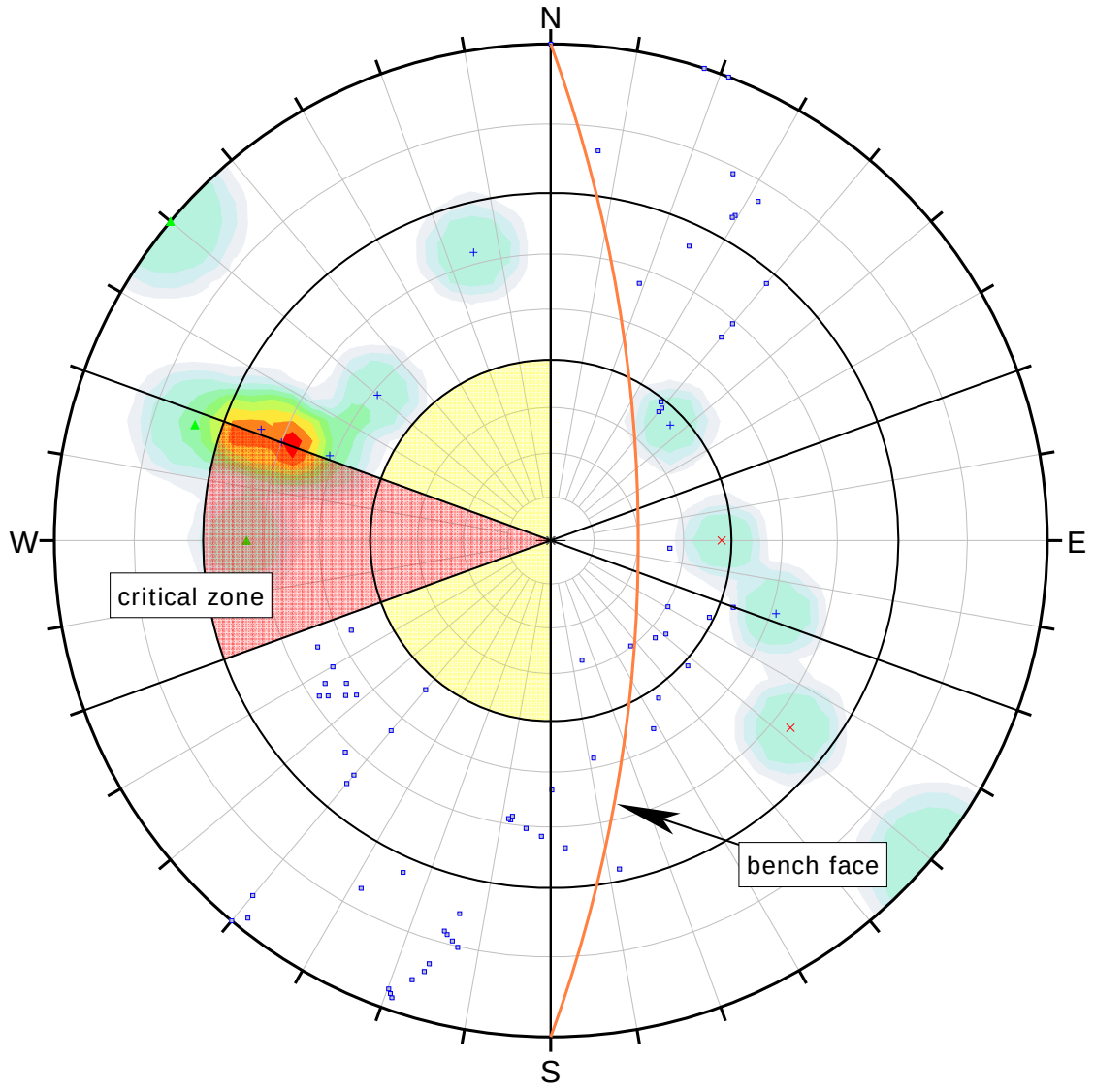
Kinematic Analysis	Wedge Sliding
Slope Dip	70
Slope Dip Direction	90
Friction Angle	40°

	Critical	Total	%
Wedge Sliding	18	66	27.27%

Plot Mode	Dip Vectors
Vector Count	12 (12 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	66
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 2 Wedge - Vector Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 2 90_wedge vector.dips7	*Date* 2/24/2017	*Enclosure* 2.2



Symbol	TYPE	Quantity
×	fault	2
▲	foliation	3
+	joint	7
Symbol	**Feature**	
▫	Critical Intersection	
▫	Intersection	

Color	Density Concentrations
	0.00 - 2.10
	2.10 - 4.20
	4.20 - 6.30
	6.30 - 8.40
	8.40 - 10.50
	10.50 - 12.60
	12.60 - 14.70
	14.70 - 16.80
	16.80 - 18.90
	18.90 - 21.00

Contour Data	Pole Vectors
Maximum Density	20.60%
Contour Distribution	Fisher
Counting Circle Size	1.0%

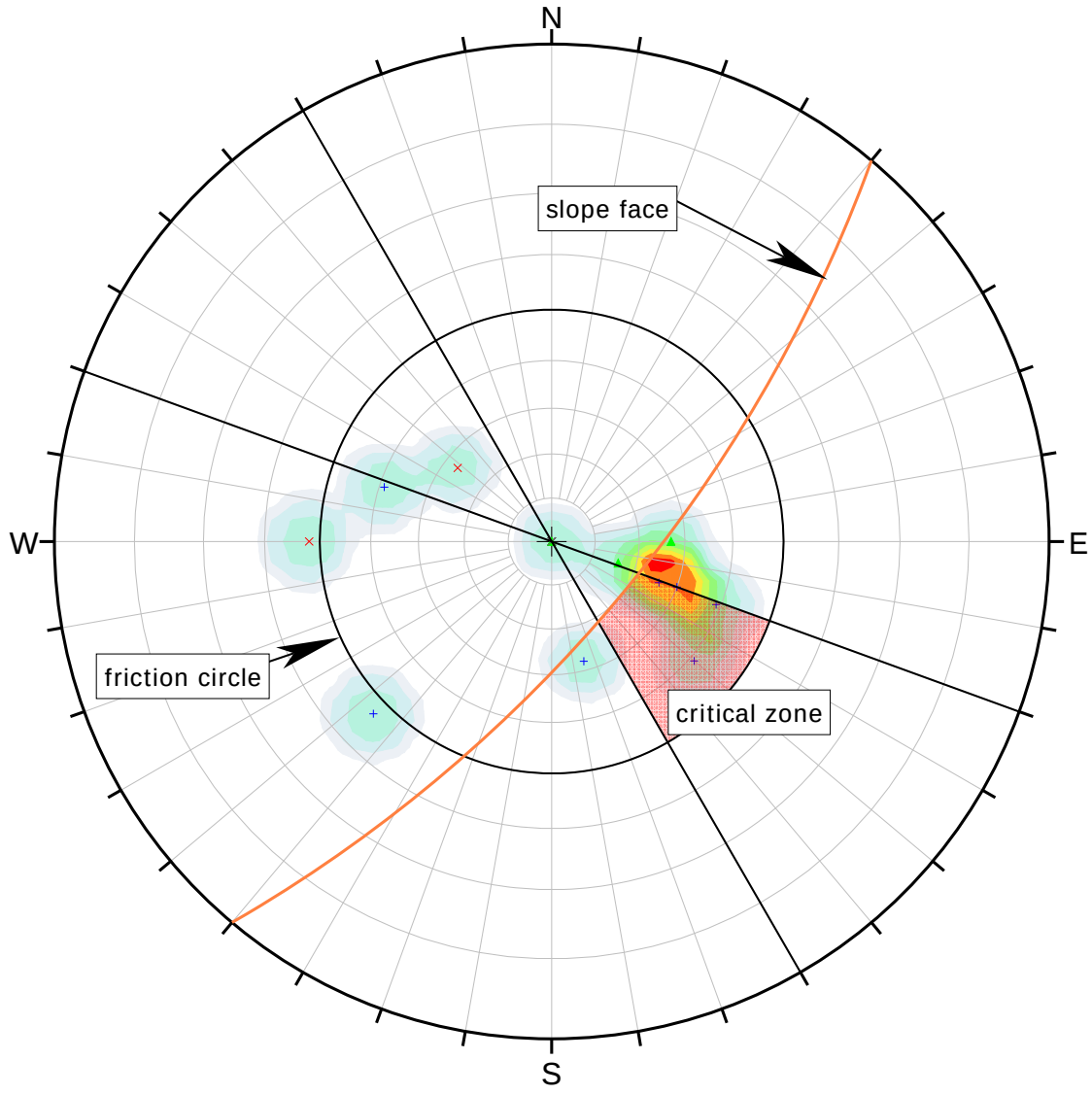
Kinematic Analysis	Direct Toppling
Slope Dip	70
Slope Dip Direction	90
Friction Angle	40°
Lateral Limits	20°

	Critical	Total	%
Direct Toppling (Intersection)	0	66	0.00%
Oblique Toppling (Intersection)	0	66	0.00%
Base Plane (All)	2	12	16.67%

Plot Mode	Pole Vectors
Vector Count	12 (12 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	66
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 2 topple - Pole Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 2_90 Topple.dips7	*Date* 2/24/2017	*Enclosure* 2.3



Symbol	TYPE	Quantity
×	fault	2
▲	foliation	3
+	joint	7

Color	Density Concentrations
	0.00 - 2.40
	2.40 - 4.80
	4.80 - 7.20
	7.20 - 9.60
	9.60 - 12.00
	12.00 - 14.40
	14.40 - 16.80
	16.80 - 19.20
	19.20 - 21.60
	21.60 - 24.00

Contour Data	Dip Vectors
Maximum Density	23.43%
Contour Distribution	Fisher
Counting Circle Size	1.0%

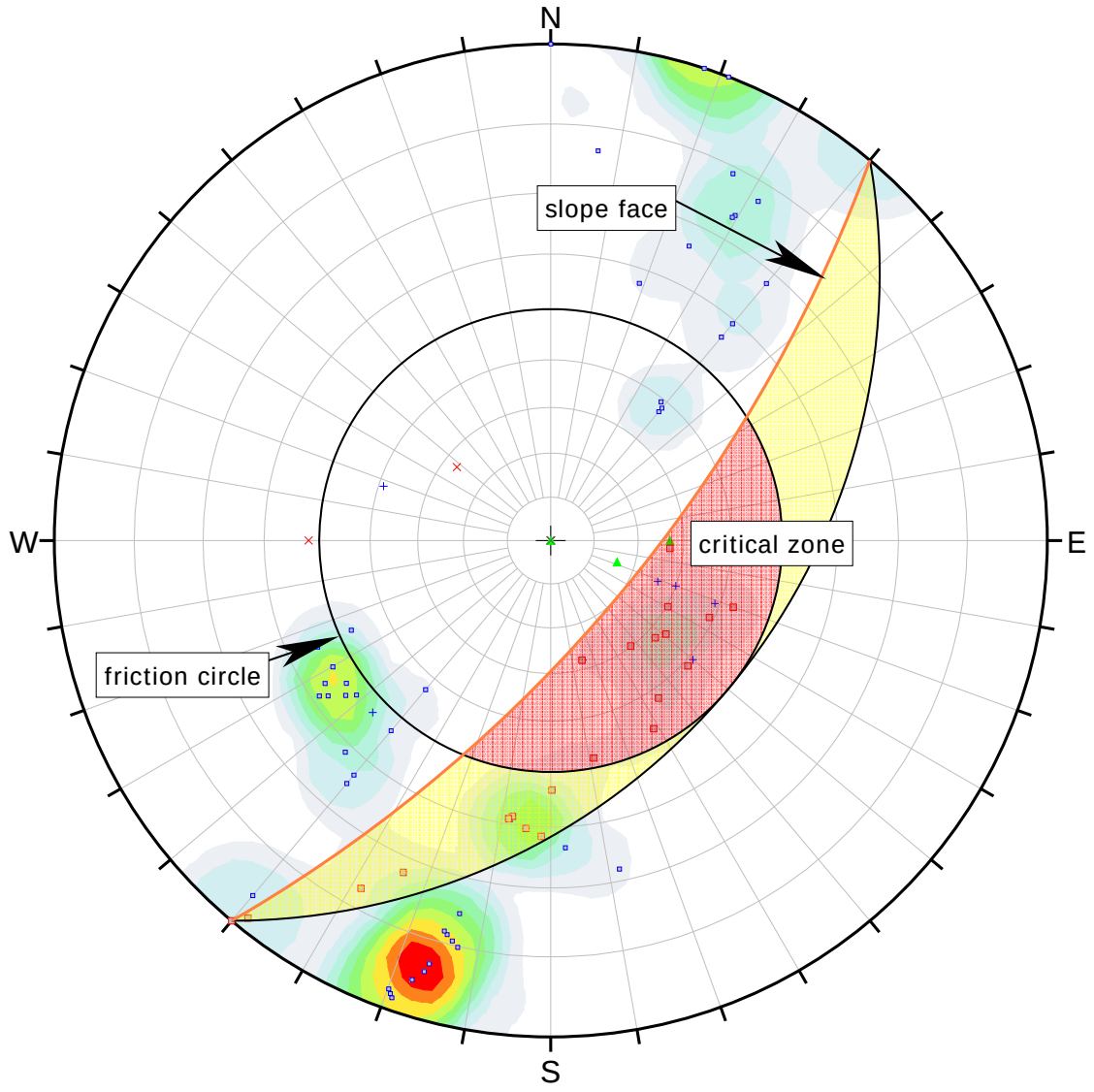
Kinematic Analysis	Planar Sliding
Slope Dip	70
Slope Dip Direction	130
Friction Angle	40°
Lateral Limits	20°

	Critical	Total	%
Planar Sliding (All)	4	12	33.33%

Plot Mode	Dip Vectors
Vector Count	12 (12 Entries)
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 2 - Planar Sliding Vector Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 2_130 planar vector.dips7	*Date* 2/23/2017	*Enclosure* 3.1



Symbol	TYPE	Quantity
×	fault	2
▲	foliation	3
+	joint	7
Symbol	**Feature**	
■	Critical Intersection	
▫	Intersection	

Color	Density Concentrations
	0.00 - 1.60
	1.60 - 3.20
	3.20 - 4.80
	4.80 - 6.40
	6.40 - 8.00
	8.00 - 9.60
	9.60 - 11.20
	11.20 - 12.80
	12.80 - 14.40
	14.40 - 16.00

Contour Data	Intersections
Maximum Density	15.94%
Contour Distribution	Fisher
Counting Circle Size	1.0%

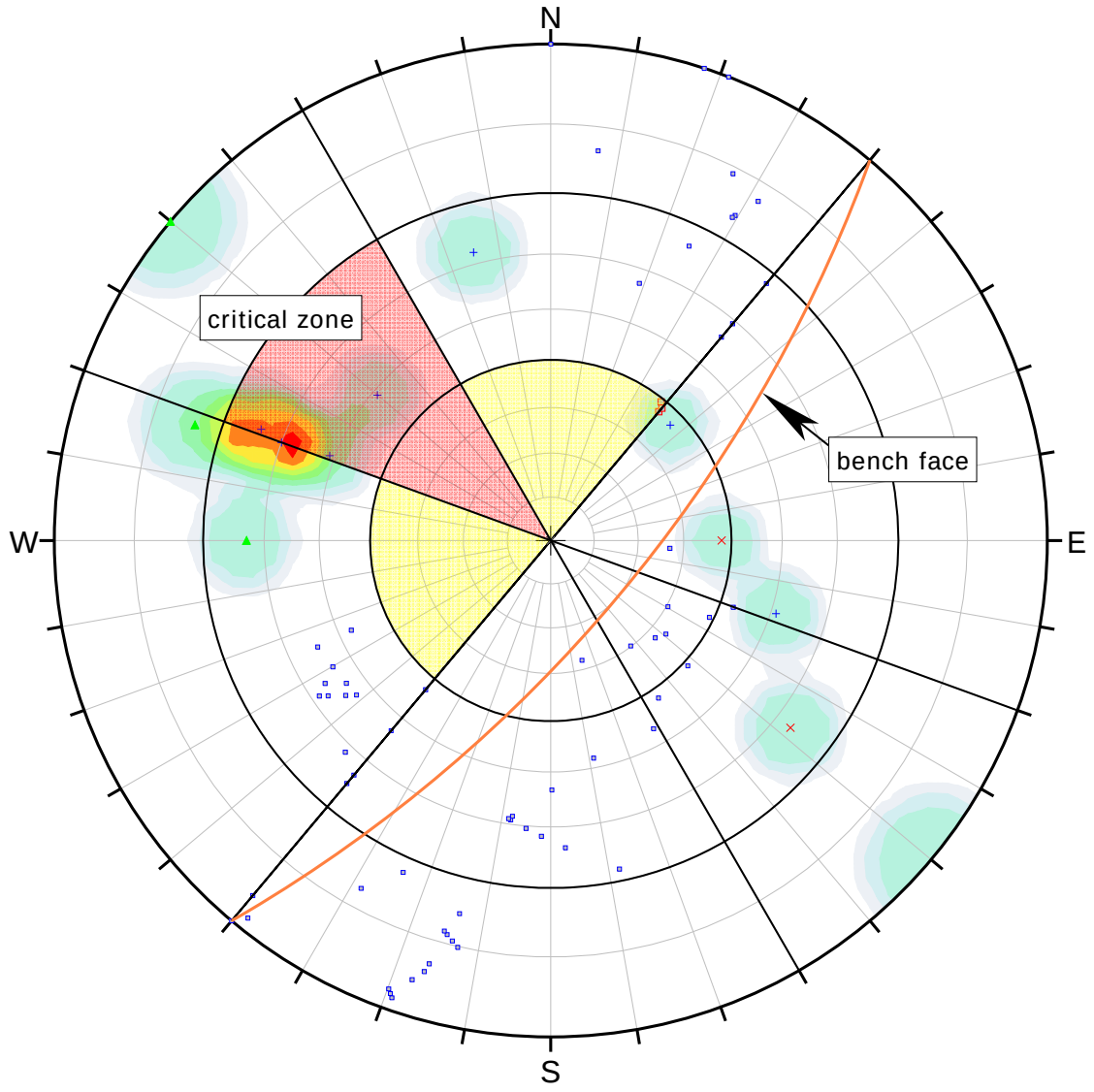
Kinematic Analysis	Wedge Sliding
Slope Dip	70
Slope Dip Direction	130
Friction Angle	40°

	Critical	Total	%
Wedge Sliding	21	66	31.82%

Plot Mode	Dip Vectors
Vector Count	12 (12 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	66
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 2 Wedge - Vector Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 2_130 wedge vector.dips7	*Date* 2/24/2017	*Enclosure* 3.2



Symbol	TYPE	Quantity
×	fault	2
▲	foliation	3
+	joint	7
Symbol	**Feature**	
▫	Critical Intersection	
▫	Intersection	

Color	Density Concentrations
	0.00 - 2.10
	2.10 - 4.20
	4.20 - 6.30
	6.30 - 8.40
	8.40 - 10.50
	10.50 - 12.60
	12.60 - 14.70
	14.70 - 16.80
	16.80 - 18.90
	18.90 - 21.00

Contour Data	Pole Vectors
Maximum Density	20.60%
Contour Distribution	Fisher
Counting Circle Size	1.0%

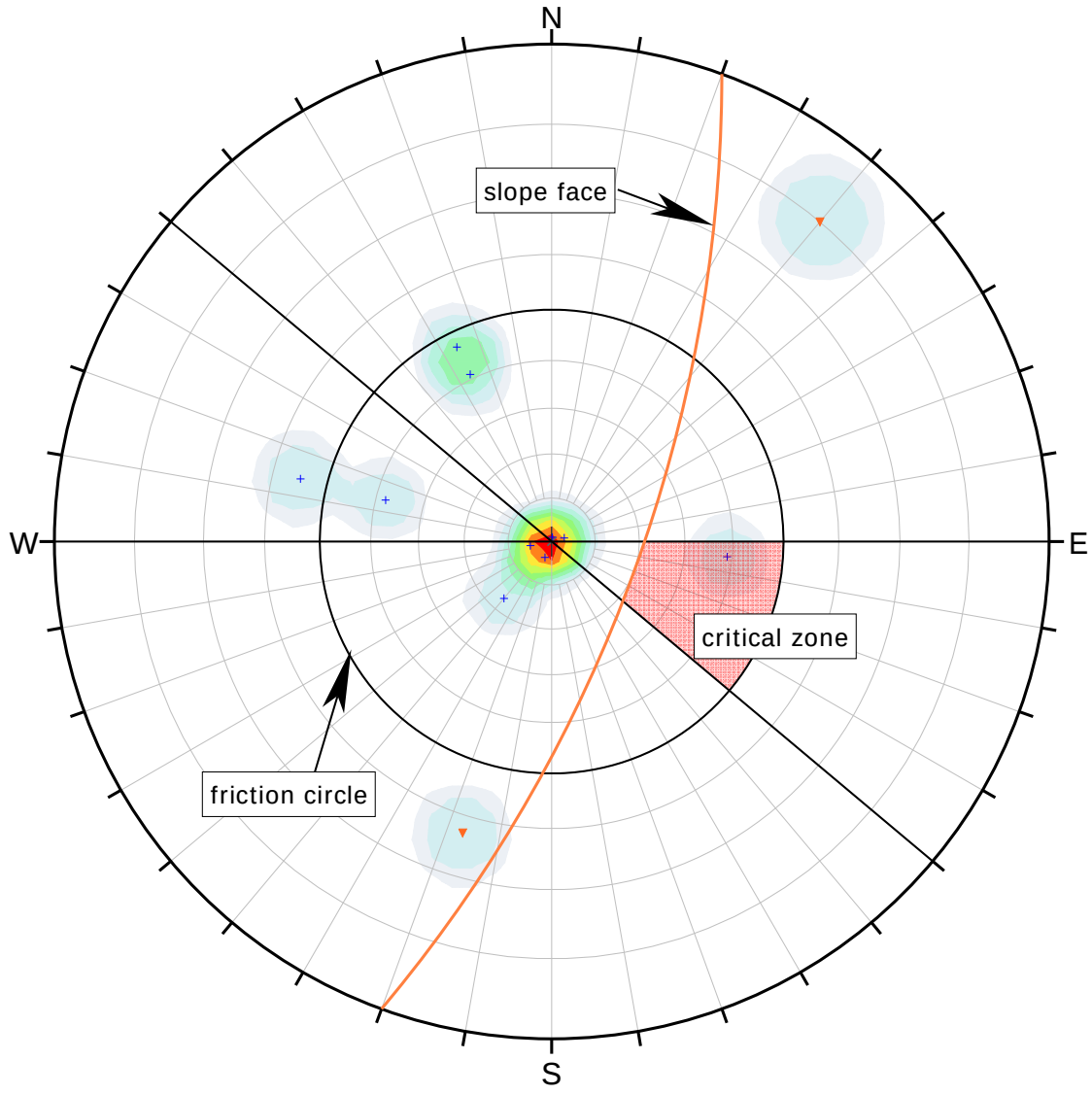
Kinematic Analysis	Direct Toppling
Slope Dip	70
Slope Dip Direction	130
Friction Angle	40°
Lateral Limits	20°

	Critical	Total	%
Direct Toppling (Intersection)	0	66	0.00%
Oblique Toppling (Intersection)	3	66	4.55%
Base Plane (All)	4	12	33.33%

Plot Mode	Pole Vectors
Vector Count	12 (12 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	66
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 2 topple - Pole Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 2_130 Topple.dips7	*Date* 2/24/2017	*Enclosure* 3.3



Symbol	TYPE	Quantity
+	joint	10
▼	shear	2

Color	Density Concentrations
	0.00 - 3.20
	3.20 - 6.40
	6.40 - 9.60
	9.60 - 12.80
	12.80 - 16.00
	16.00 - 19.20
	19.20 - 22.40
	22.40 - 25.60
	25.60 - 28.80
	28.80 - 32.00

Contour Data	Dip Vectors
Maximum Density	31.51%
Contour Distribution	Fisher
Counting Circle Size	1.0%

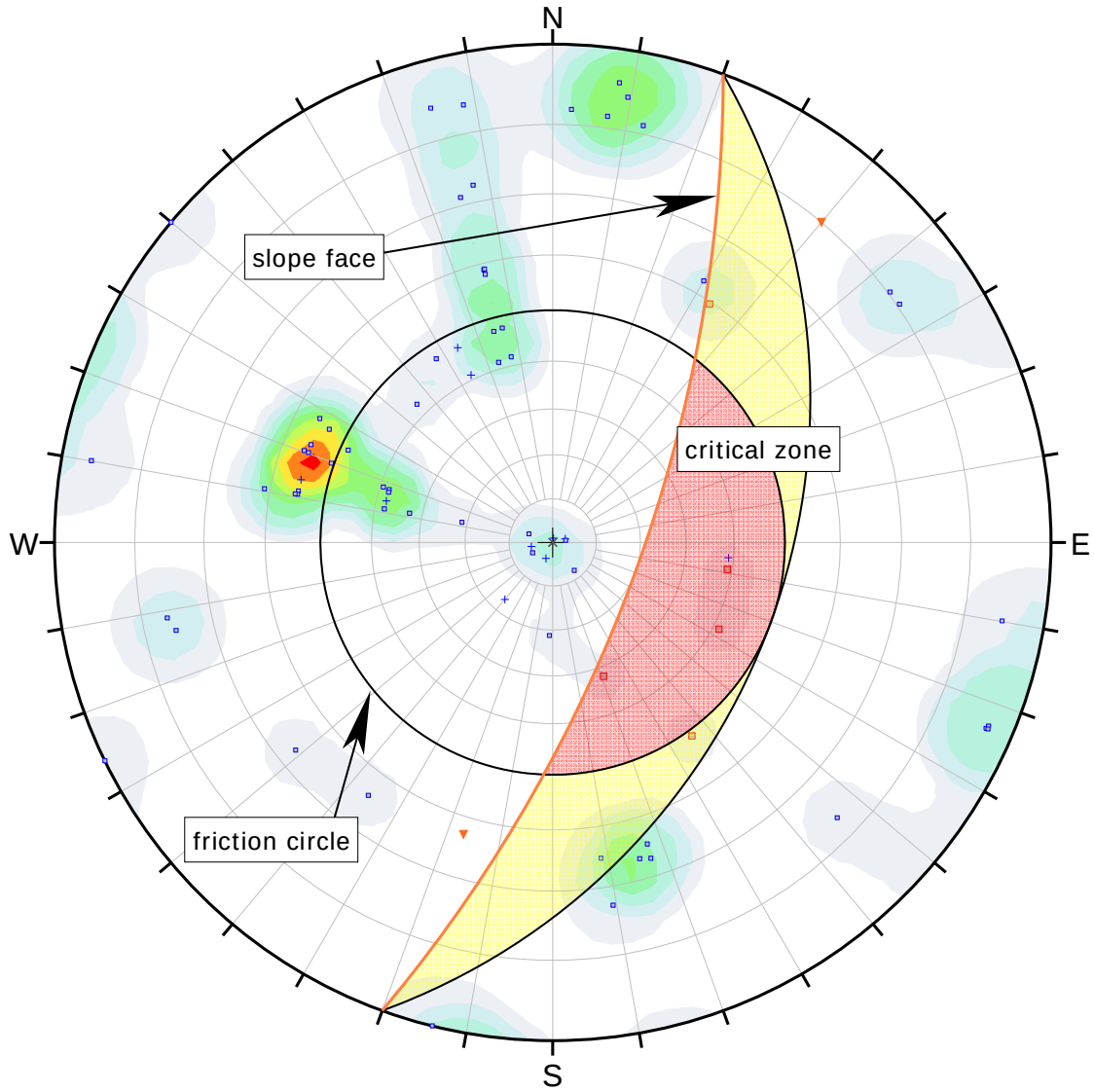
Kinematic Analysis	Planar Sliding
Slope Dip	70
Slope Dip Direction	110
Friction Angle	40°
Lateral Limits	20°

	Critical	Total	%
Planar Sliding (All)	1	12	8.33%

Plot Mode	Dip Vectors
Vector Count	12 (12 Entries)
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 3 - Planar Sliding Vector Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 3_110 planar vector.dips7	*Date* 2/23/2017	*Enclosure* 4.1



Symbol	TYPE	Quantity
+	joint	10
▼	shear	2
Symbol	**Feature**	
▫	Critical Intersection	
▫	Intersection	

Color	Density Concentrations
	0.00 - 1.30
	1.30 - 2.60
	2.60 - 3.90
	3.90 - 5.20
	5.20 - 6.50
	6.50 - 7.80
	7.80 - 9.10
	9.10 - 10.40
	10.40 - 11.70
	11.70 - 13.00

Contour Data	Intersections
Maximum Density	12.50%
Contour Distribution	Fisher
Counting Circle Size	1.0%

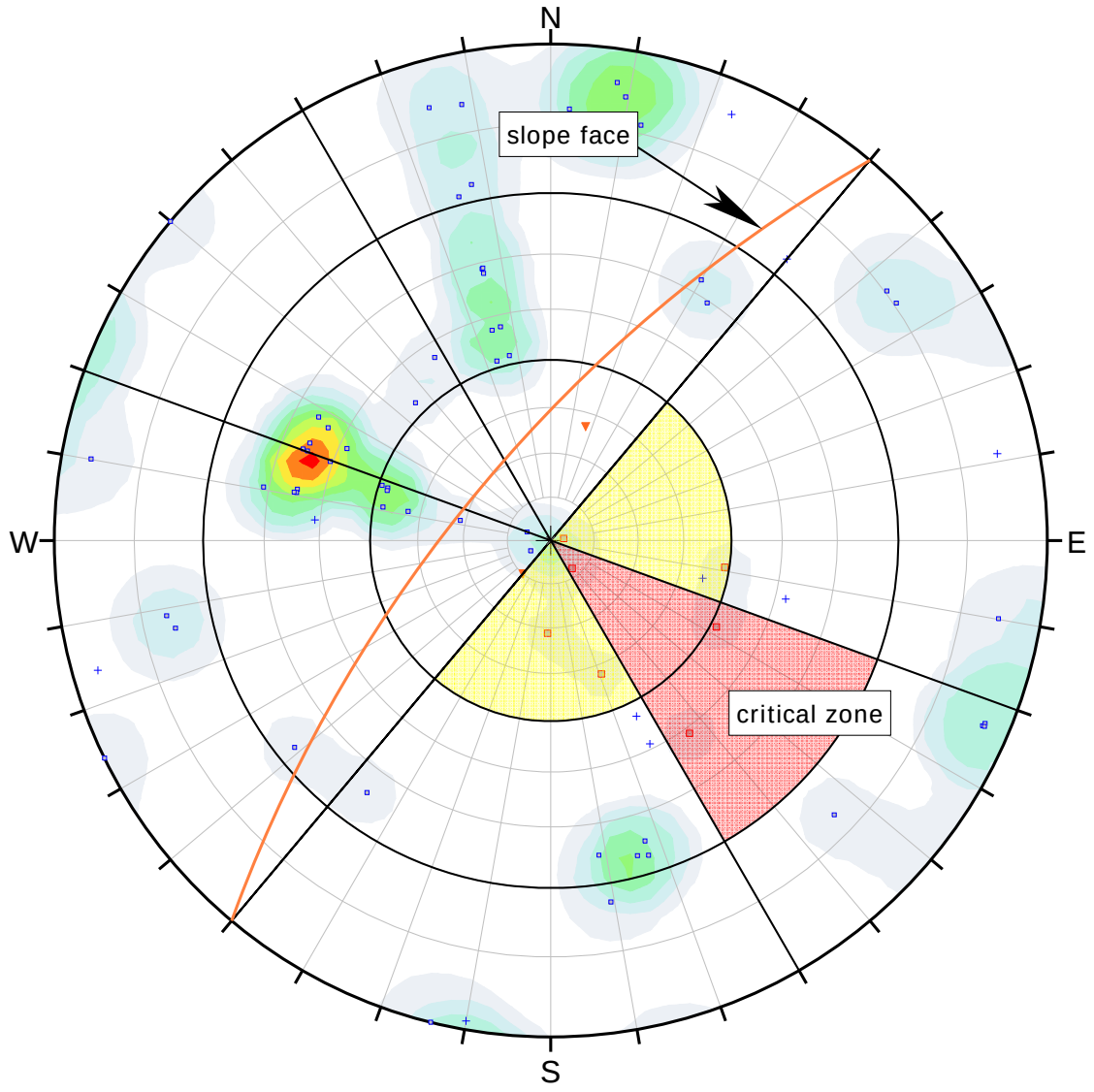
Kinematic Analysis	Wedge Sliding
Slope Dip	70
Slope Dip Direction	110
Friction Angle	40°

	Critical	Total	%
Wedge Sliding	5	66	7.58%

Plot Mode	Dip Vectors
Vector Count	12 (12 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	66
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 3 Wedge - Vector Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 3_110 wedge vector.dips7	*Date* 2/24/2017	*Enclosure* 4.2



Symbol	TYPE	Quantity
+	joint	10
▼	shear	2
Symbol	**Feature**	
▫	Critical Intersection	
▫	Intersection	

Color	Density Concentrations
	0.00 - 1.30
	1.30 - 2.60
	2.60 - 3.90
	3.90 - 5.20
	5.20 - 6.50
	6.50 - 7.80
	7.80 - 9.10
	9.10 - 10.40
	10.40 - 11.70
	11.70 - 13.00

Contour Data	Intersections
Maximum Density	12.50%
Contour Distribution	Fisher
Counting Circle Size	1.0%

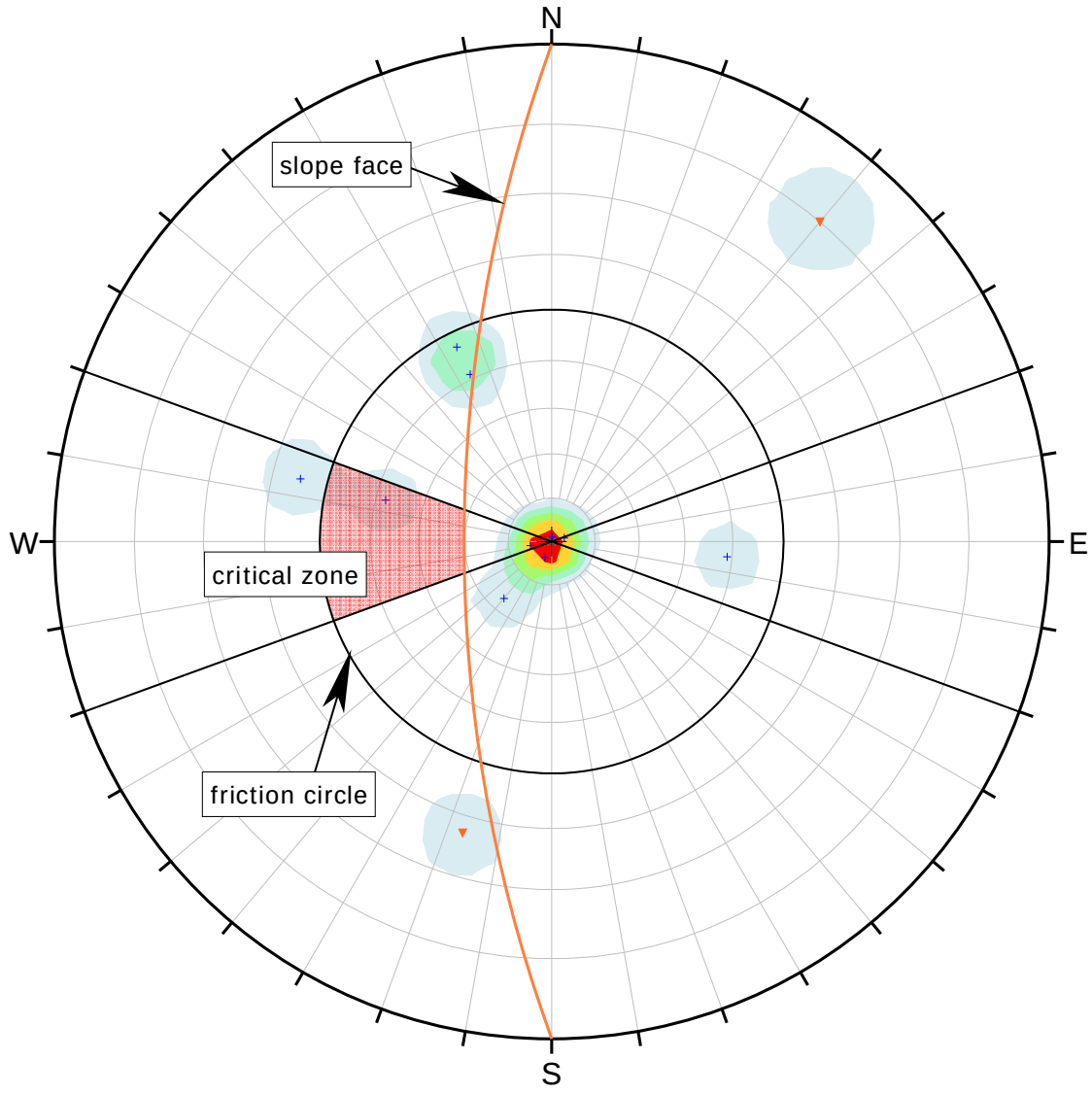
Kinematic Analysis	Direct Toppling
Slope Dip	70
Slope Dip Direction	310
Friction Angle	40°
Lateral Limits	20°

	Critical	Total	%
Direct Toppling (Intersection)	3	66	4.55%
Oblique Toppling (Intersection)	4	66	6.06%
Base Plane (All)	2	12	16.67%

Plot Mode	Pole Vectors
Vector Count	12 (12 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	66
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 3 topple - Pole Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 3_110 topple.dips7	*Date* 2/24/2017	*Enclosure* 4.3



Symbol	TYPE	Quantity
+	joint	10
▼	shear	2

Color	Density Concentrations
	0.00 - 5.40
	5.40 - 10.80
	10.80 - 16.20
	16.20 - 21.60
	21.60 - 27.00
	27.00 - 32.40

Contour Data	Dip Vectors
Maximum Density	31.51%
Contour Distribution	Fisher
Counting Circle Size	1.0%

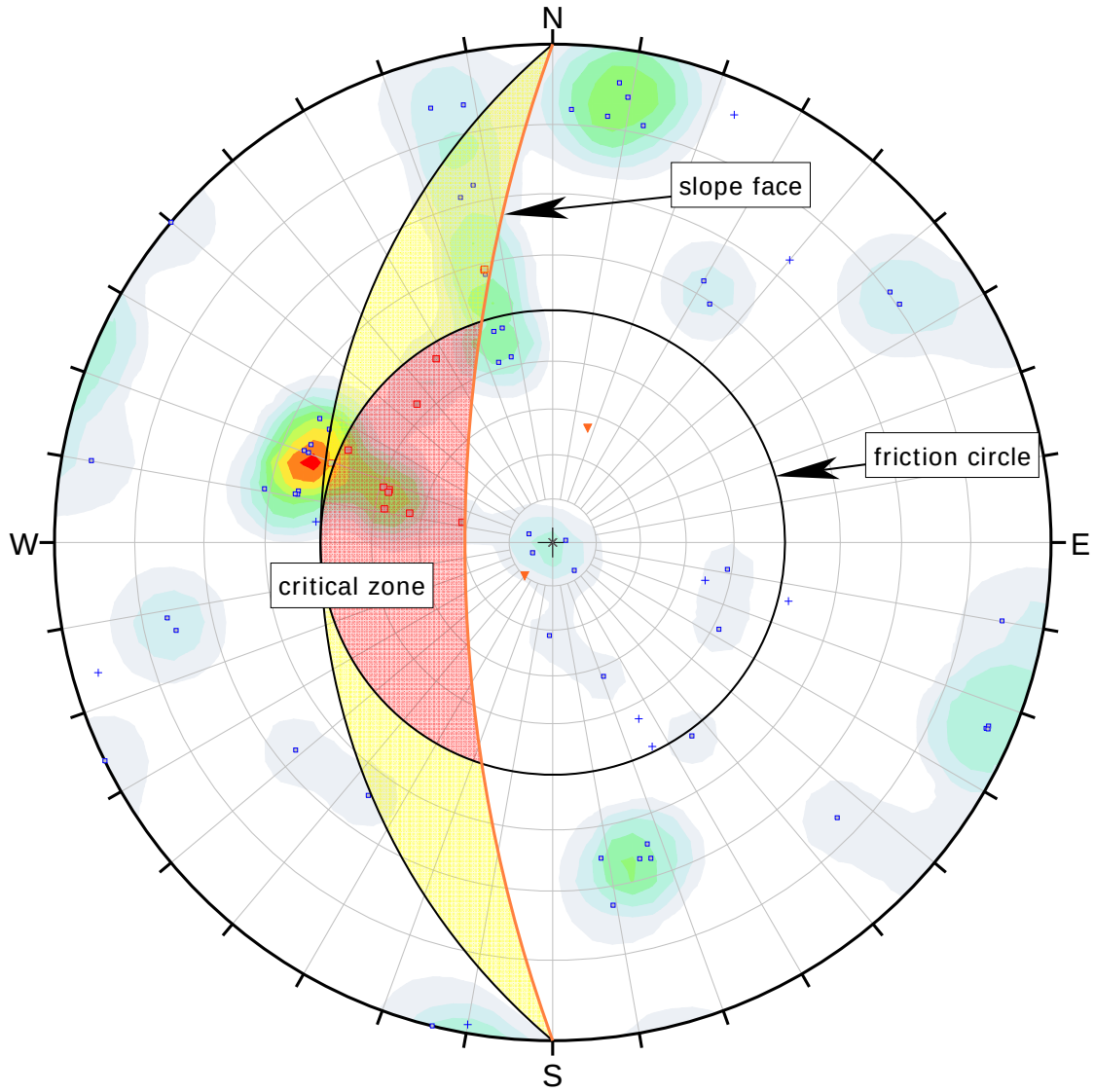
Kinematic Analysis	Planar Sliding
Slope Dip	70
Slope Dip Direction	270
Friction Angle	40°
Lateral Limits	20°

	Critical	Total	%
Planar Sliding (All)	1	12	8.33%

Plot Mode	Dip Vectors
Vector Count	12 (12 Entries)
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 3 - Planar Sliding Vector Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 3_110 planar vector.dips7	*Date* 2/23/2017	*Enclosure* 5.1



Symbol	TYPE	Quantity
+	joint	10
▼	shear	2
Symbol	**Feature**	
▫	Critical Intersection	
▫	Intersection	

Color	Density Concentrations
	0.00 - 1.30
	1.30 - 2.60
	2.60 - 3.90
	3.90 - 5.20
	5.20 - 6.50
	6.50 - 7.80
	7.80 - 9.10
	9.10 - 10.40
	10.40 - 11.70
	11.70 - 13.00

Contour Data	Intersections
Maximum Density	12.50%
Contour Distribution	Fisher
Counting Circle Size	1.0%

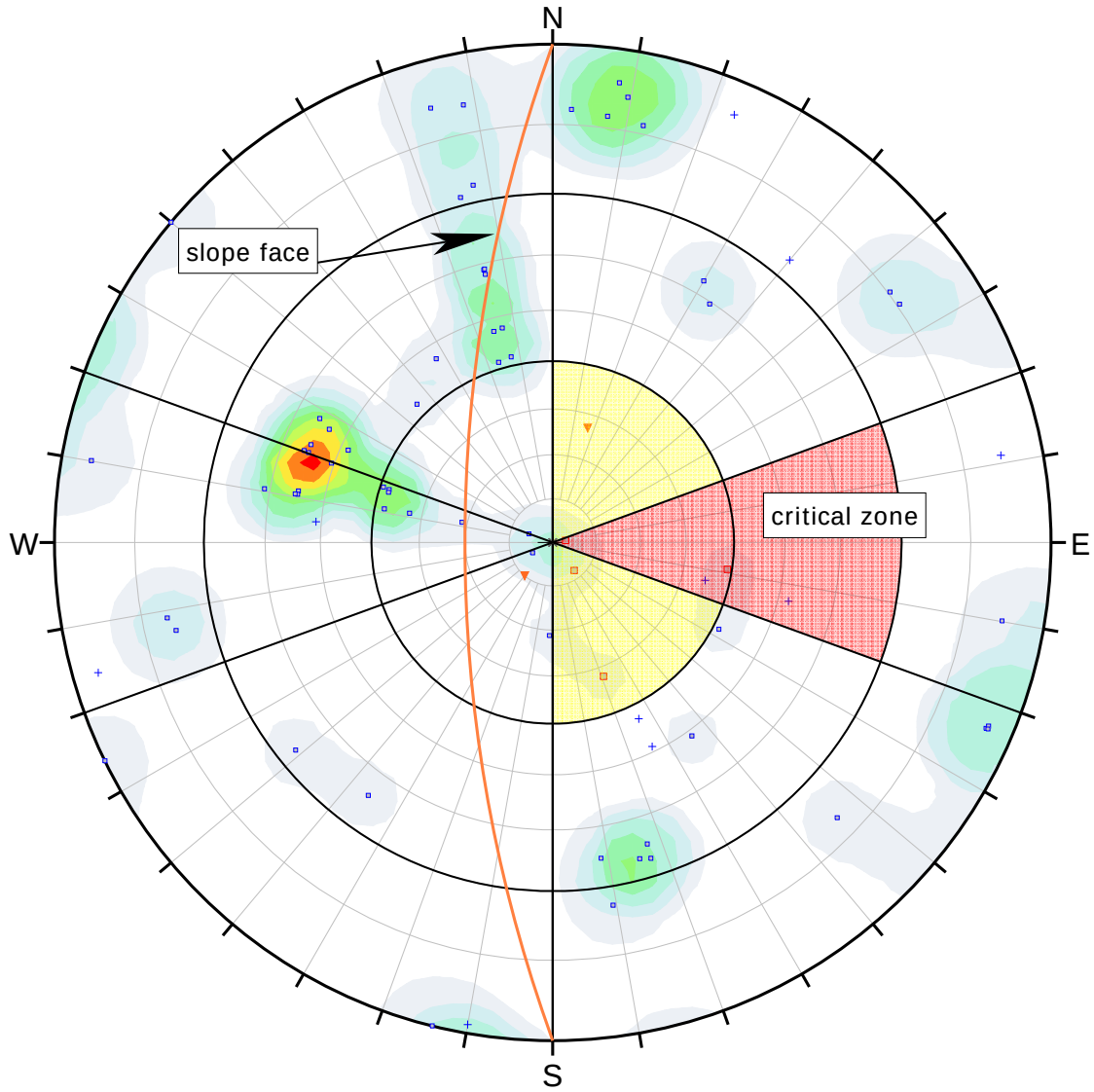
Kinematic Analysis	Wedge Sliding
Slope Dip	70
Slope Dip Direction	270
Friction Angle	40°

	Critical	Total	%
Wedge Sliding	12	66	18.18%

Plot Mode	Pole Vectors
Vector Count	12 (12 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	66
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 3 Wedge - Vector Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 3_270 wedge vector.dips7	*Date* 2/24/2017	*Enclosure* 5.2



Symbol	TYPE	Quantity
+	joint	10
▼	shear	2
Symbol	**Feature**	
▫	Critical Intersection	
▫	Intersection	

Color	Density Concentrations
	0.00 - 1.30
	1.30 - 2.60
	2.60 - 3.90
	3.90 - 5.20
	5.20 - 6.50
	6.50 - 7.80
	7.80 - 9.10
	9.10 - 10.40
	10.40 - 11.70
	11.70 - 13.00

Contour Data	Intersections
Maximum Density	12.50%
Contour Distribution	Fisher
Counting Circle Size	1.0%

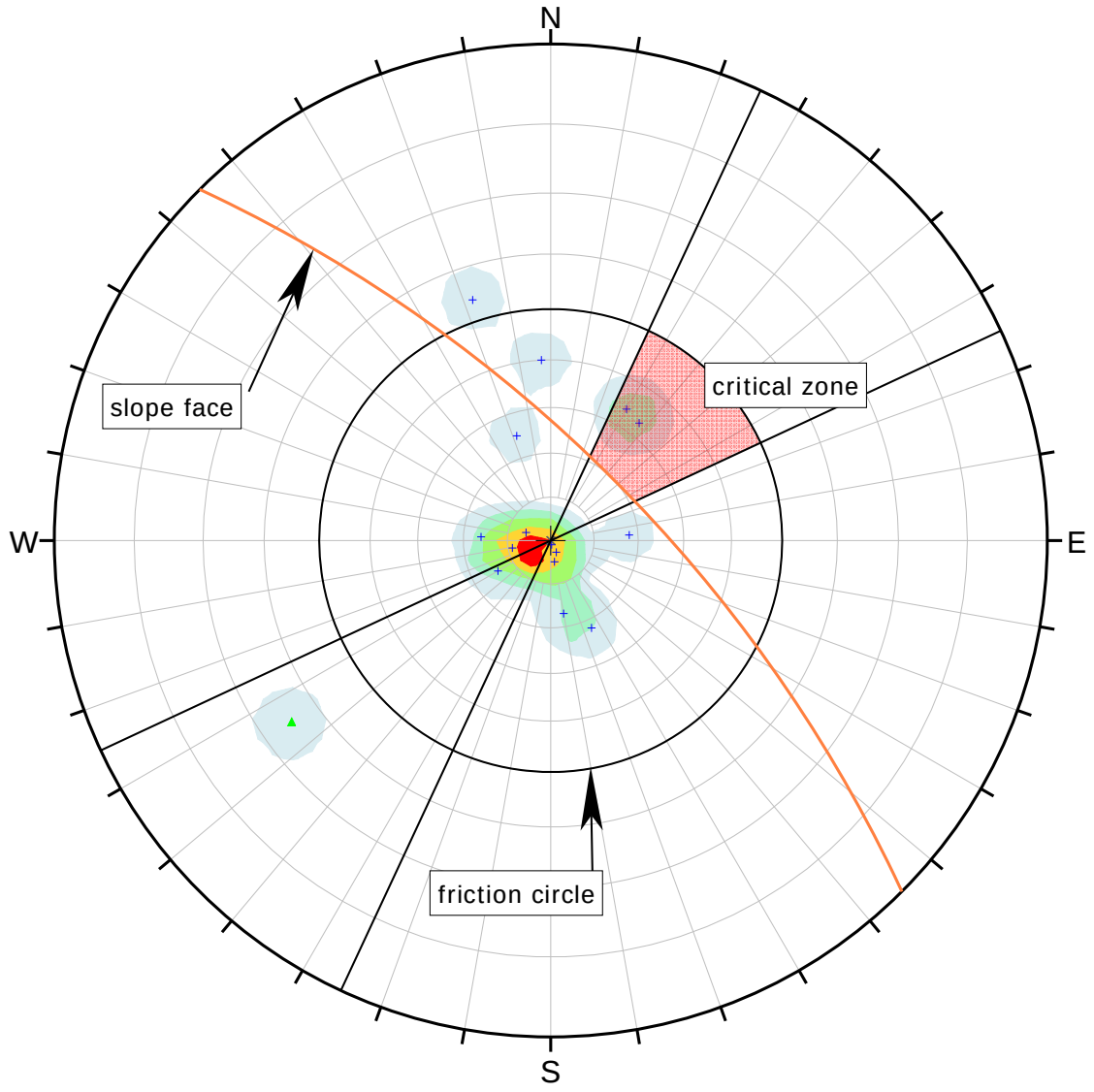
Kinematic Analysis	Direct Toppling
Slope Dip	70
Slope Dip Direction	270
Friction Angle	40°
Lateral Limits	20°

	Critical	Total	%
Direct Toppling (Intersection)	2	66	3.03%
Oblique Toppling (Intersection)	2	66	3.03%
Base Plane (All)	3	12	25.00%

Plot Mode	Pole Vectors
Vector Count	12 (12 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	66
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 3 topple - Pole Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 3_270 topple.dips7	*Date* 2/24/2017	*Enclosure* 5.3



Symbol	TYPE	Quantity
▲	foliation	1
+	joint	15

Color	Density Concentrations
	0.00 - 4.90
	4.90 - 9.80
	9.80 - 14.70
	14.70 - 19.60
	19.60 - 24.50
	24.50 - 29.40

Contour Data	Dip Vectors
Maximum Density	28.97%
Contour Distribution	Fisher
Counting Circle Size	1.0%

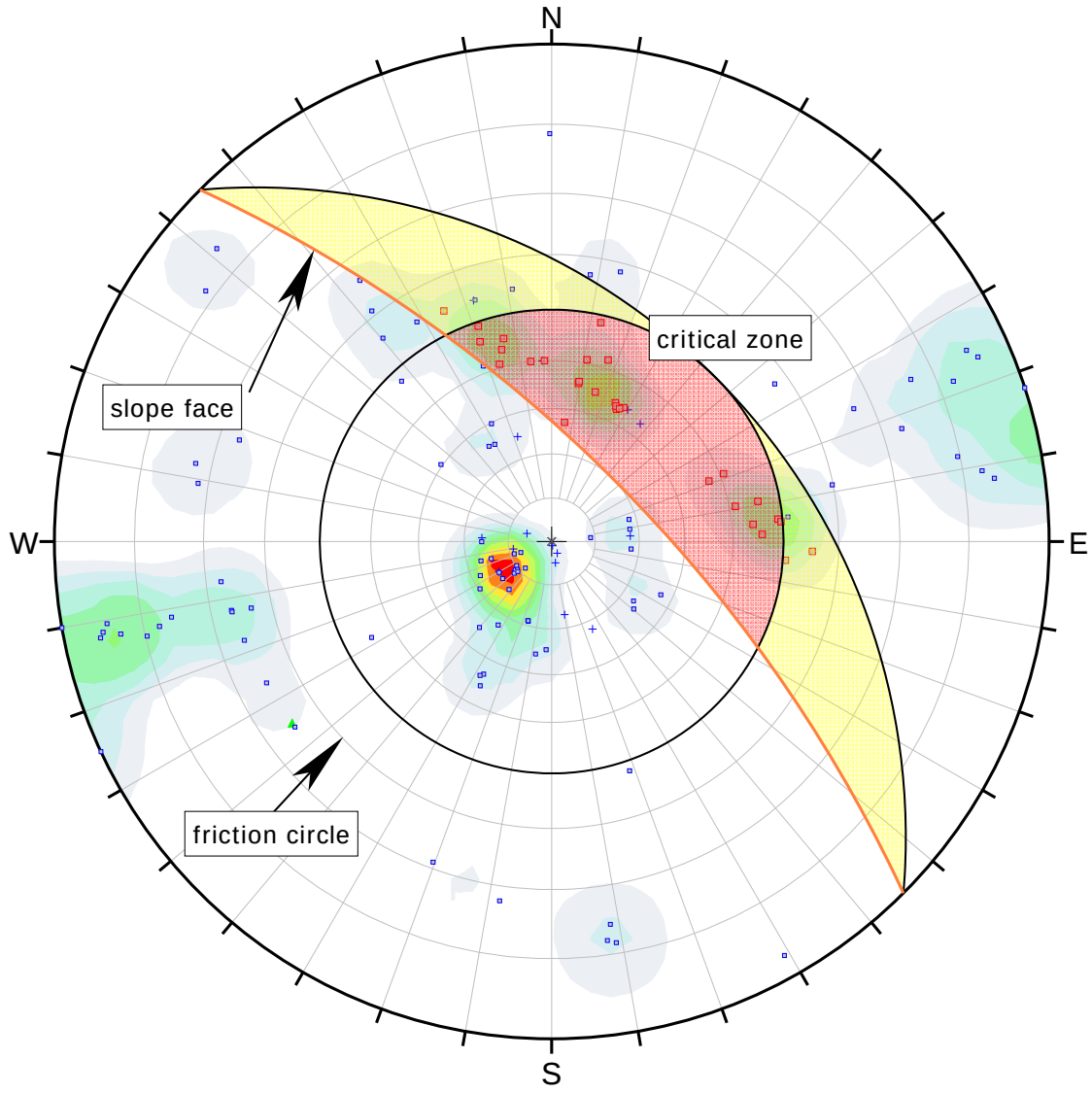
Kinematic Analysis	Planar Sliding
Slope Dip	70
Slope Dip Direction	45
Friction Angle	40°
Lateral Limits	20°

	Critical	Total	%
Planar Sliding (All)	2	16	12.50%

Plot Mode	Dip Vectors
Vector Count	16 (16 Entries)
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 4 planar - Vector Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 4_45 planar vector.dips7	*Date* 2/24/2017	*Enclosure* 6.1



Symbol	TYPE	Quantity
▲	foliation	1
+	joint	15
Symbol	**Feature**	
▫	Critical Intersection	
▫	Intersection	

Color	Density Concentrations
	0.00 - 1.20
	1.20 - 2.40
	2.40 - 3.60
	3.60 - 4.80
	4.80 - 6.00
	6.00 - 7.20
	7.20 - 8.40
	8.40 - 9.60
	9.60 - 10.80
	10.80 - 12.00

Contour Data	Intersections
Maximum Density	11.04%
Contour Distribution	Fisher
Counting Circle Size	1.0%

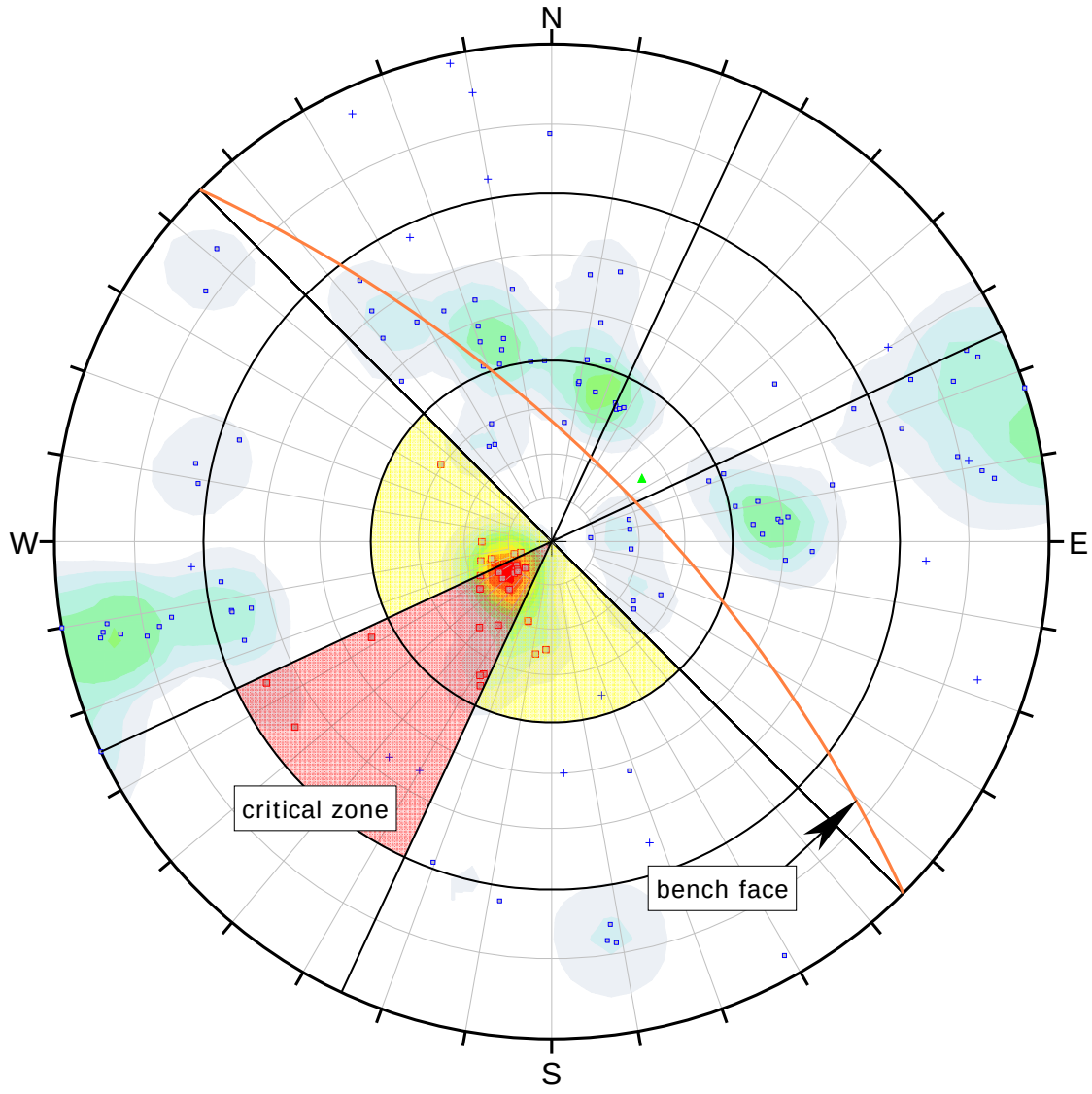
Kinematic Analysis	Wedge Sliding
Slope Dip	70
Slope Dip Direction	45
Friction Angle	40°

	Critical	Total	%
Wedge Sliding	30	120	25.00%

Plot Mode	Dip Vectors
Vector Count	16 (16 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	120
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 4 Wedge - Vector Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 4_45 wedge vector.dips7	*Date* 2/24/2017	*Enclosure* 6.2



Symbol	TYPE	Quantity
▲	foliation	1
+	joint	15
Symbol	**Feature**	
▫	Critical Intersection	
▫	Intersection	

Color	Density Concentrations
	0.00 - 1.20
	1.20 - 2.40
	2.40 - 3.60
	3.60 - 4.80
	4.80 - 6.00
	6.00 - 7.20
	7.20 - 8.40
	8.40 - 9.60
	9.60 - 10.80
	10.80 - 12.00

Contour Data	Intersections
Maximum Density	11.04%
Contour Distribution	Fisher
Counting Circle Size	1.0%

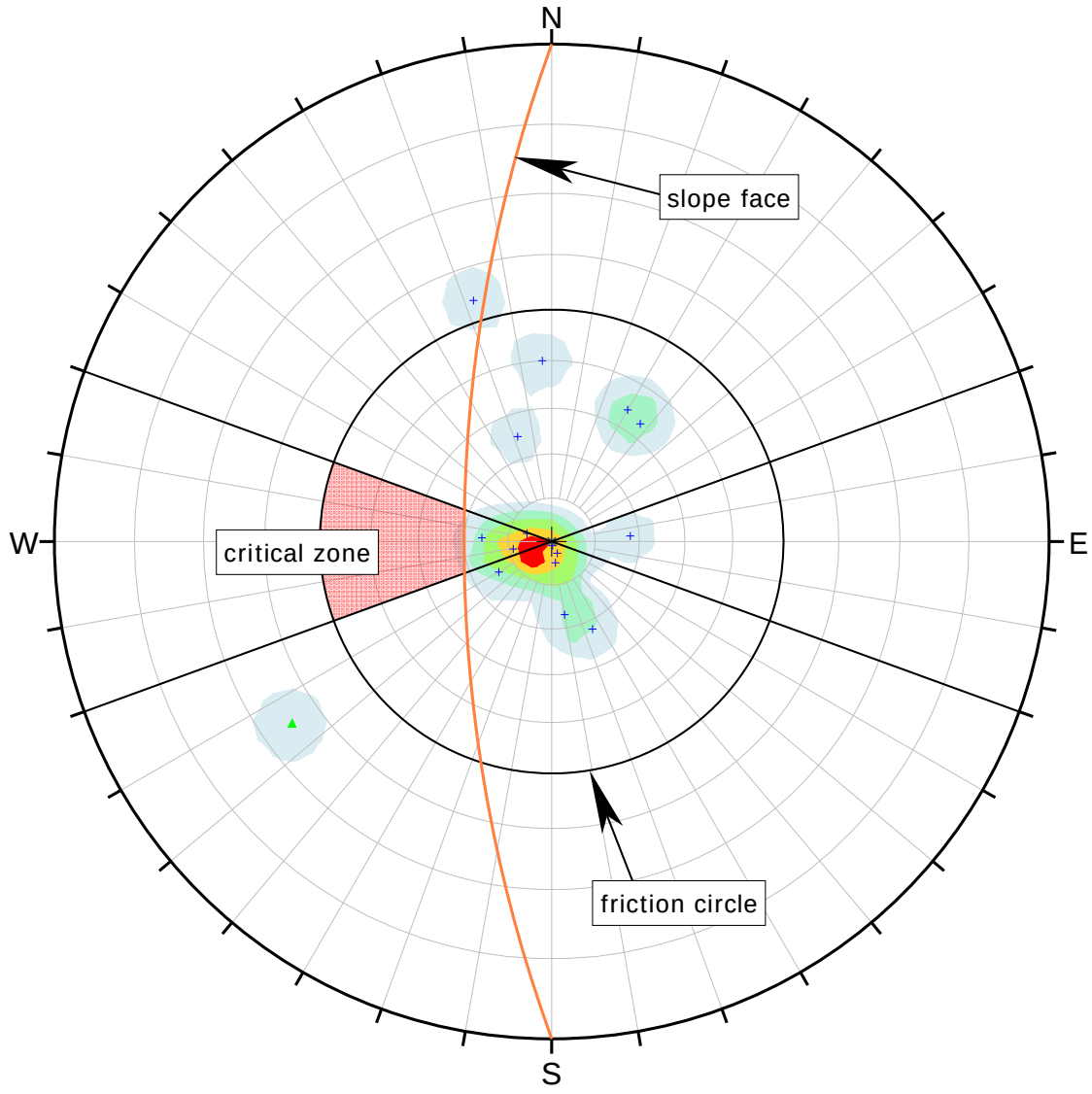
Kinematic Analysis	Direct Toppling
Slope Dip	70
Slope Dip Direction	45
Friction Angle	40°
Lateral Limits	20°

	Critical	Total	%
Direct Toppling (Intersection)	19	120	15.83%
Oblique Toppling (Intersection)	11	120	9.17%
Base Plane (All)	3	16	18.75%

Plot Mode	Pole Vectors
Vector Count	16 (16 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	120
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 4 topple - Pole Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 4 45 topple.dips7	*Date* 2/24/2017	*Enclosure* 6.3



Symbol	TYPE	Quantity
▲	foliation	1
+	joint	15

Color	Density Concentrations
	0.00 - 4.90
	4.90 - 9.80
	9.80 - 14.70
	14.70 - 19.60
	19.60 - 24.50
	24.50 - 29.40

Contour Data	Dip Vectors
Maximum Density	28.97%
Contour Distribution	Fisher
Counting Circle Size	1.0%

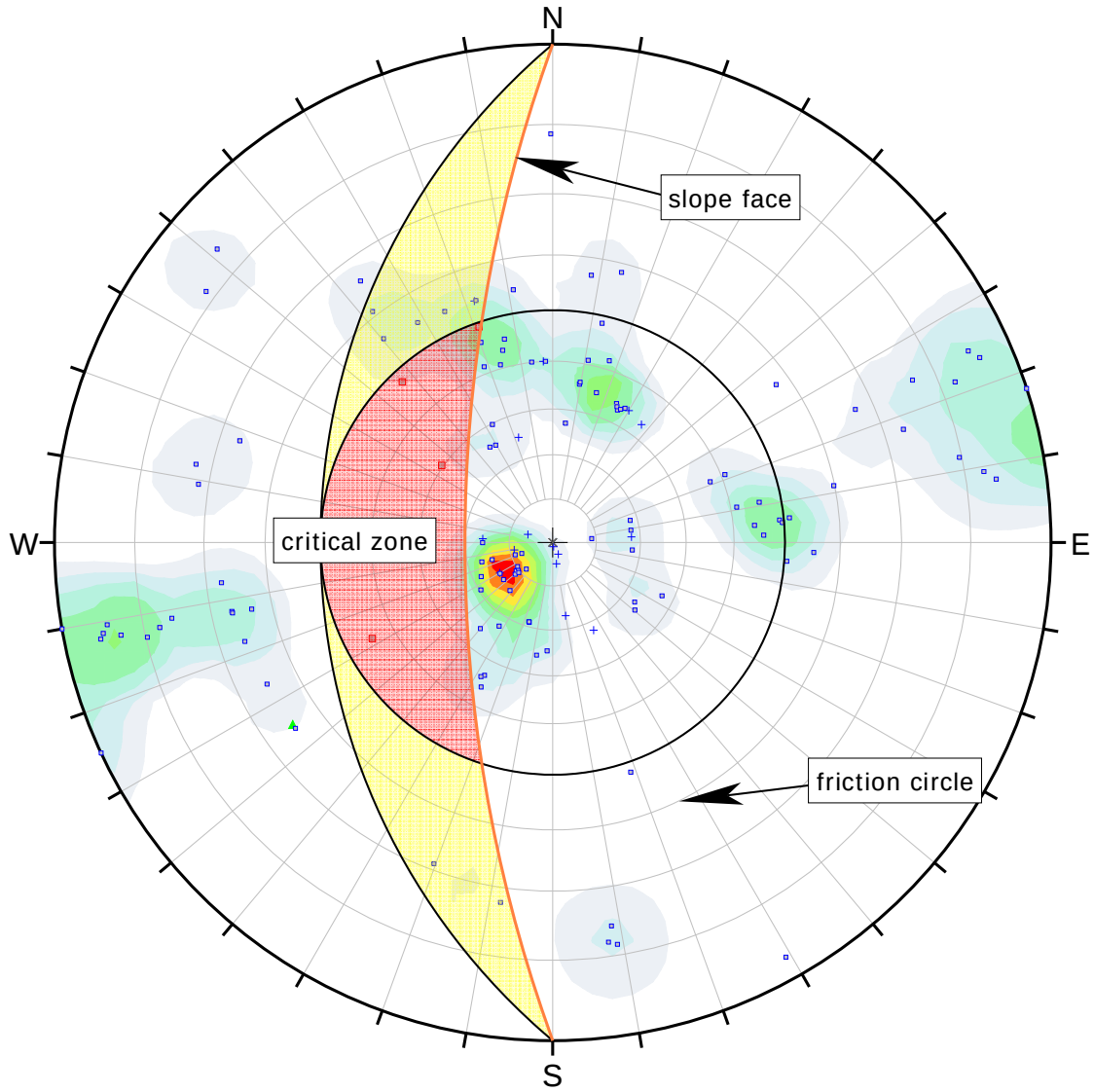
Kinematic Analysis	Planar Sliding
Slope Dip	70
Slope Dip Direction	270
Friction Angle	40°
Lateral Limits	20°

	Critical	Total	%
Planar Sliding (All)	0	16	0.00%

Plot Mode	Dip Vectors
Vector Count	16 (16 Entries)
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 4 planar - Vector Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 4_270 planar vector.dips7	*Date* 2/24/2017	*Enclosure* 7.1



Symbol	TYPE	Quantity
▲	foliation	1
+	joint	15
Symbol	**Feature**	
▫	Critical Intersection	
▫	Intersection	

Color	Density Concentrations
	0.00 - 1.20
	1.20 - 2.40
	2.40 - 3.60
	3.60 - 4.80
	4.80 - 6.00
	6.00 - 7.20
	7.20 - 8.40
	8.40 - 9.60
	9.60 - 10.80
	10.80 - 12.00

Contour Data	Intersections
Maximum Density	11.04%
Contour Distribution	Fisher
Counting Circle Size	1.0%

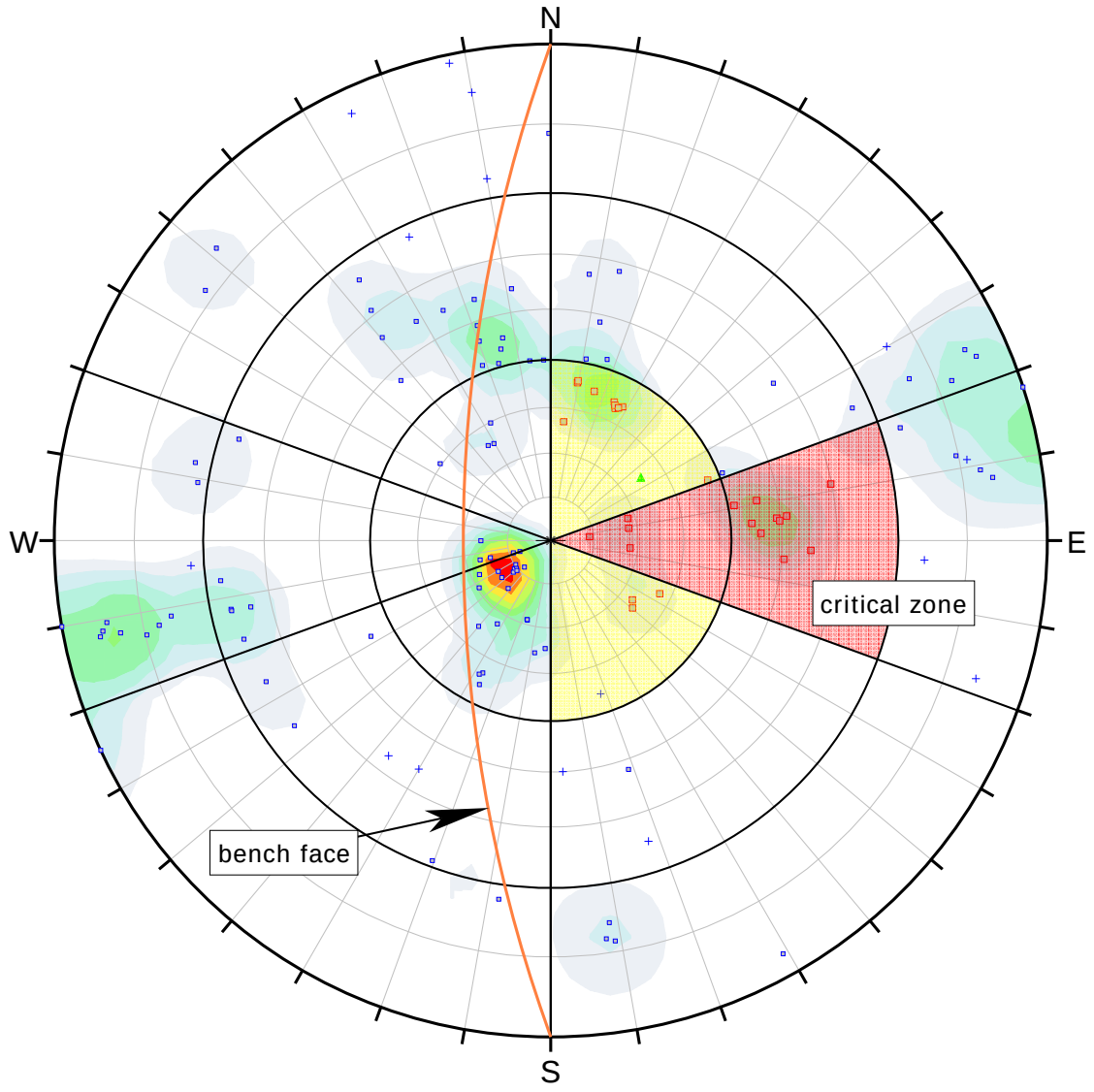
Kinematic Analysis	Wedge Sliding
Slope Dip	70
Slope Dip Direction	270
Friction Angle	40°

	Critical	Total	%
Wedge Sliding	4	120	3.33%

Plot Mode	Dip Vectors
Vector Count	16 (16 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	120
Hemisphere	Lower
Projection	Equal Angle

Project	Sentinel & B3		
Analysis Description	Dom 4 Wedge - Vector Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 4_270 wedge vector.dips7	*Date* 2/24/2017	*Enclosure* 7.2

DIPS 7.007



Symbol	TYPE	Quantity
▲	foliation	1
+	joint	15

Symbol	Feature
▫	Critical Intersection
▫	Intersection

Color	Density Concentrations
	0.00 - 1.20
	1.20 - 2.40
	2.40 - 3.60
	3.60 - 4.80
	4.80 - 6.00
	6.00 - 7.20
	7.20 - 8.40
	8.40 - 9.60
	9.60 - 10.80
	10.80 - 12.00

Contour Data	Intersections
Maximum Density	11.04%
Contour Distribution	Fisher
Counting Circle Size	1.0%

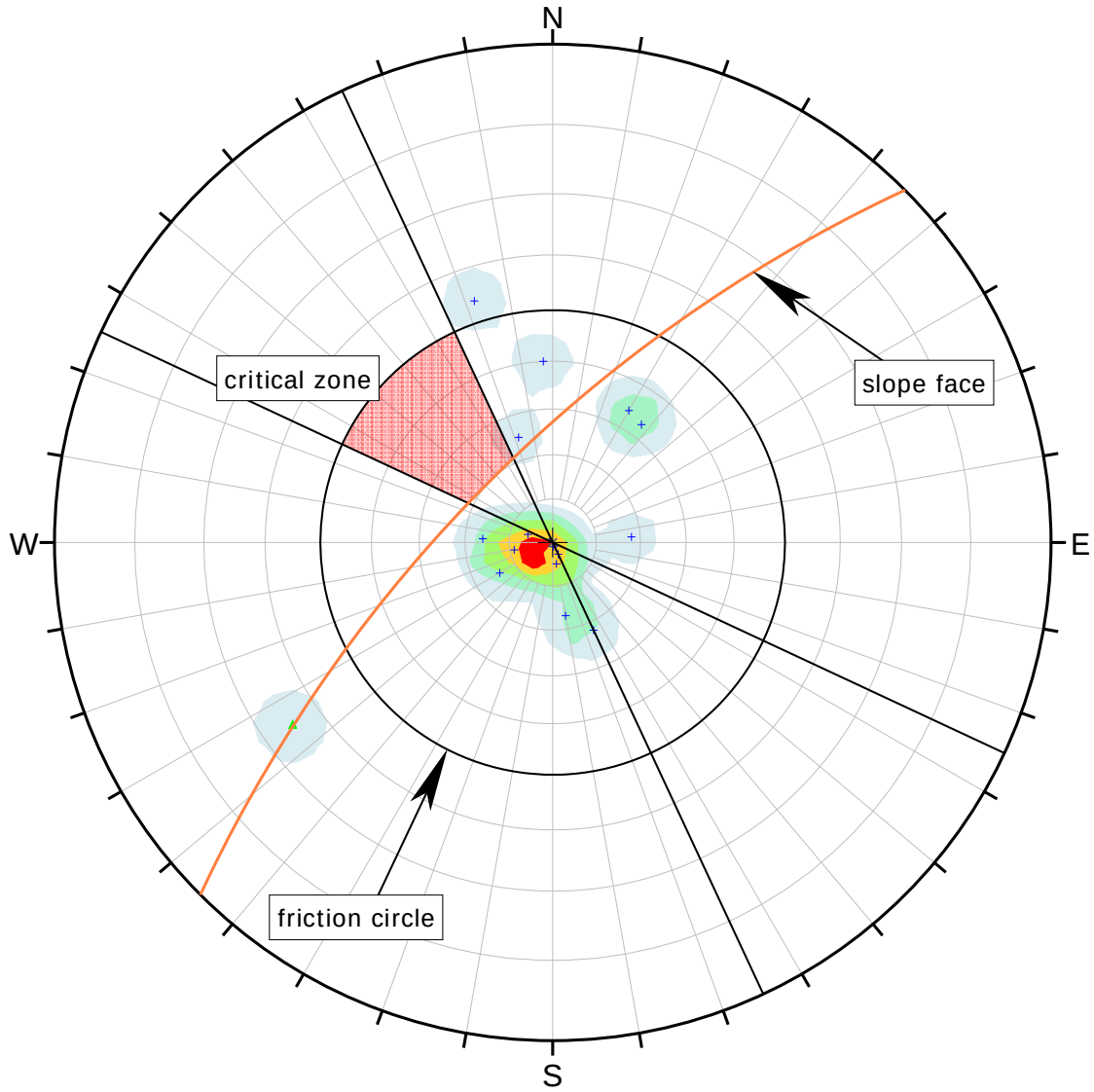
Kinematic Analysis	Direct Toppling
Slope Dip	70
Slope Dip Direction	270
Friction Angle	40°
Lateral Limits	20°

	Critical	Total	%
Direct Toppling (Intersection)	14	120	11.67%
Oblique Toppling (Intersection)	13	120	10.83%
Base Plane (All)	2	16	12.50%

Plot Mode	Pole Vectors
Vector Count	16 (16 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	120
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 4 topple - Pole Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 4 270 topple.dips7	*Date* 2/24/2017	*Enclosure* 7.3



Symbol	TYPE	Quantity
▲	foliation	1
+	joint	15

Color	Density Concentrations
	0.00 - 4.90
	4.90 - 9.80
	9.80 - 14.70
	14.70 - 19.60
	19.60 - 24.50
	24.50 - 29.40

Contour Data	Dip Vectors
Maximum Density	28.97%
Contour Distribution	Fisher
Counting Circle Size	1.0%

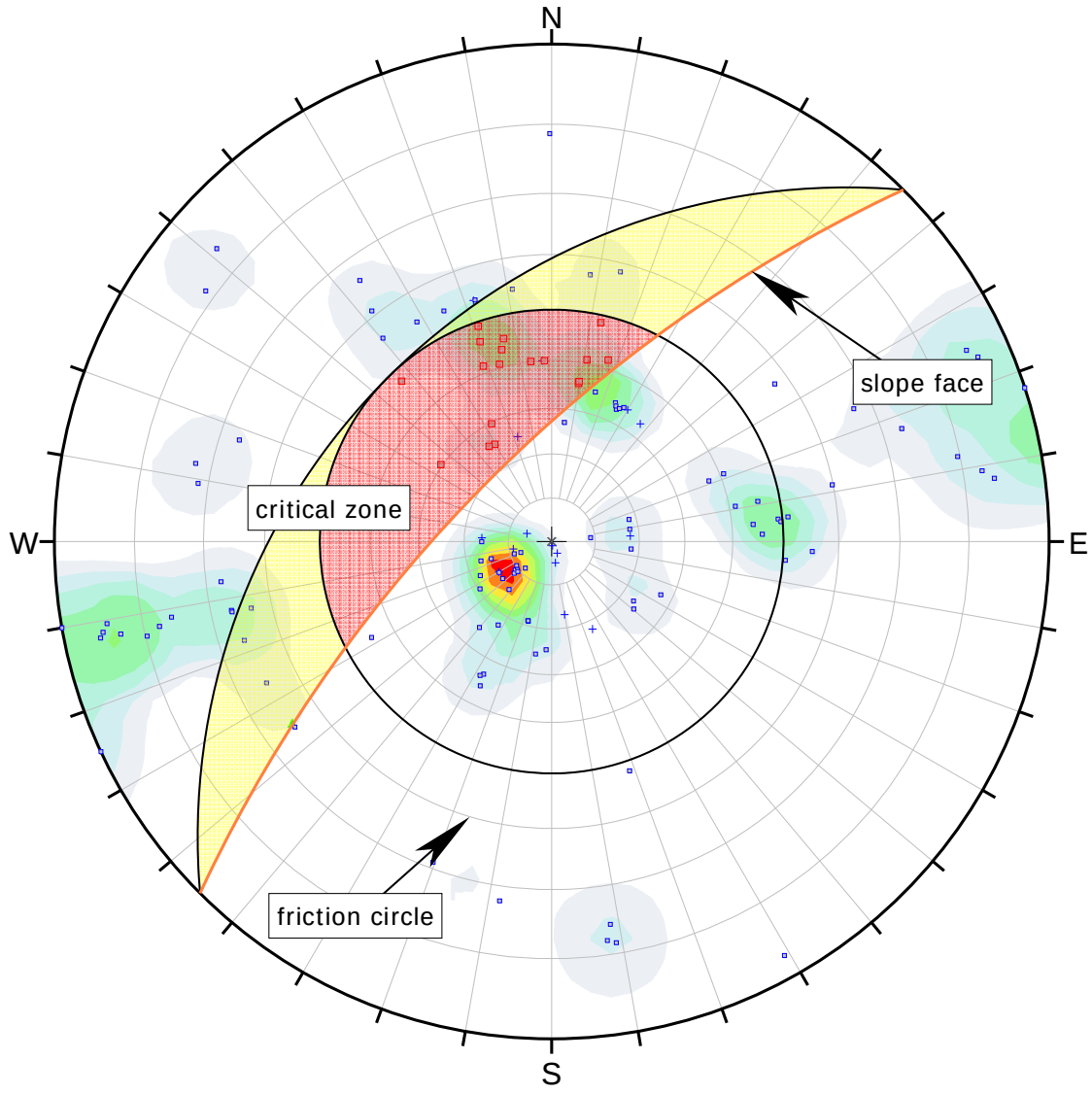
Kinematic Analysis	Planar Sliding
Slope Dip	70
Slope Dip Direction	315
Friction Angle	40°
Lateral Limits	20°

	Critical	Total	%
Planar Sliding (All)	0	16	0.00%

Plot Mode	Dip Vectors
Vector Count	16 (16 Entries)
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 4 planar - Vector Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 4_315 planar vector.dips7	*Date* 2/24/2017	*Enclosure* 8.1



Symbol	TYPE	Quantity
▲	foliation	1
+	joint	15
Symbol	**Feature**	
▫	Critical Intersection	
▫	Intersection	

Color	Density Concentrations
	0.00 - 1.20
	1.20 - 2.40
	2.40 - 3.60
	3.60 - 4.80
	4.80 - 6.00
	6.00 - 7.20
	7.20 - 8.40
	8.40 - 9.60
	9.60 - 10.80
	10.80 - 12.00

Contour Data	Intersections
Maximum Density	11.04%
Contour Distribution	Fisher
Counting Circle Size	1.0%

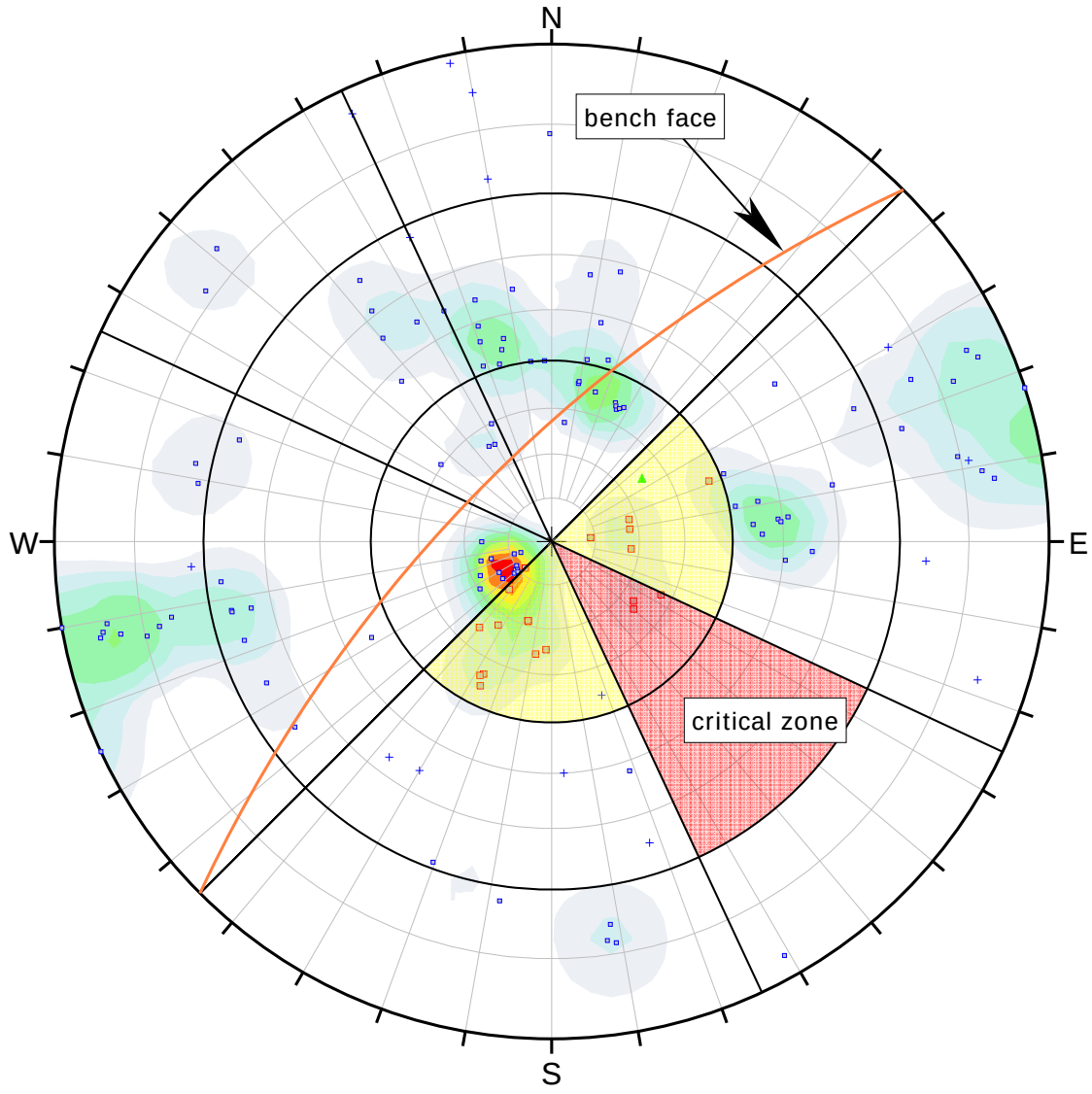
Kinematic Analysis	Wedge Sliding
Slope Dip	70
Slope Dip Direction	315
Friction Angle	40°

	Critical	Total	%
Wedge Sliding	18	120	15.00%

Plot Mode	Dip Vectors
Vector Count	16 (16 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	120
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 4 Wedge - Vector Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 4_315 wedge vector.dips7	*Date* 2/24/2017	*Enclosure* 8.2



Symbol	TYPE	Quantity
▲	foliation	1
+	joint	15

Symbol	Feature
▫	Critical Intersection
▫	Intersection

Color	Density Concentrations
	0.00 - 1.20
	1.20 - 2.40
	2.40 - 3.60
	3.60 - 4.80
	4.80 - 6.00
	6.00 - 7.20
	7.20 - 8.40
	8.40 - 9.60
	9.60 - 10.80
	10.80 - 12.00

Contour Data	Intersections
Maximum Density	11.04%
Contour Distribution	Fisher
Counting Circle Size	1.0%

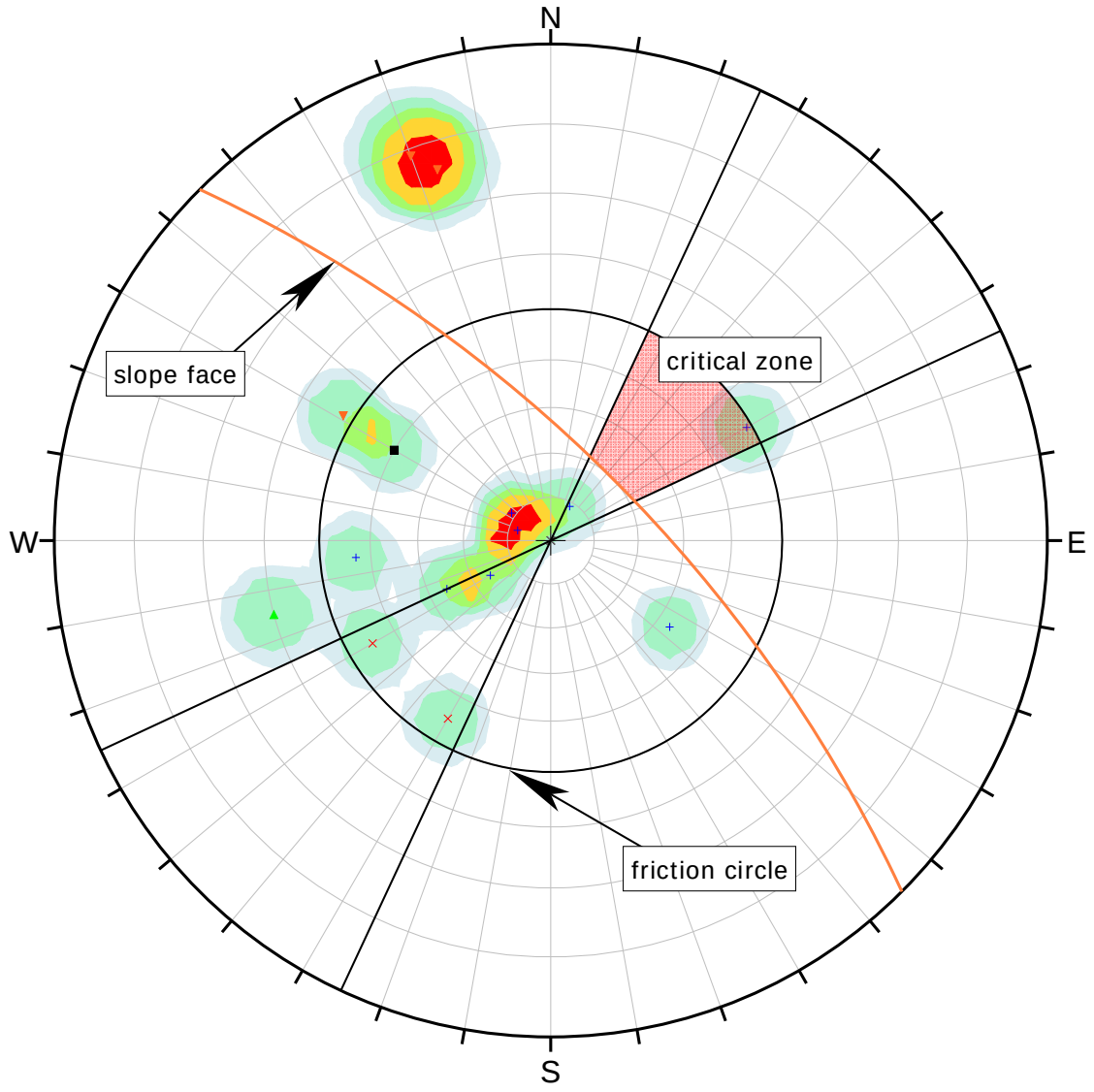
Kinematic Analysis	Direct Toppling
Slope Dip	70
Slope Dip Direction	315
Friction Angle	40°
Lateral Limits	20°

	Critical	Total	%
Direct Toppling (Intersection)	3	120	2.50%
Oblique Toppling (Intersection)	17	120	14.17%
Base Plane (All)	2	16	12.50%

Plot Mode	Pole Vectors
Vector Count	16 (16 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	120
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 4 topple - Pole Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 4 315 topple.dips7	*Date* 2/24/2017	*Enclosure* 8.3



Symbol	TYPE	Quantity
■	bedding	1
×	fault	2
▲	foliation	1
+	joint	8
▼	shear	3

Color	Density Concentrations
	0.00 - 2.40
	2.40 - 4.80
	4.80 - 7.20
	7.20 - 9.60
	9.60 - 12.00
	12.00 - 14.40

Contour Data	Dip Vectors
Maximum Density	13.52%
Contour Distribution	Fisher
Counting Circle Size	1.0%

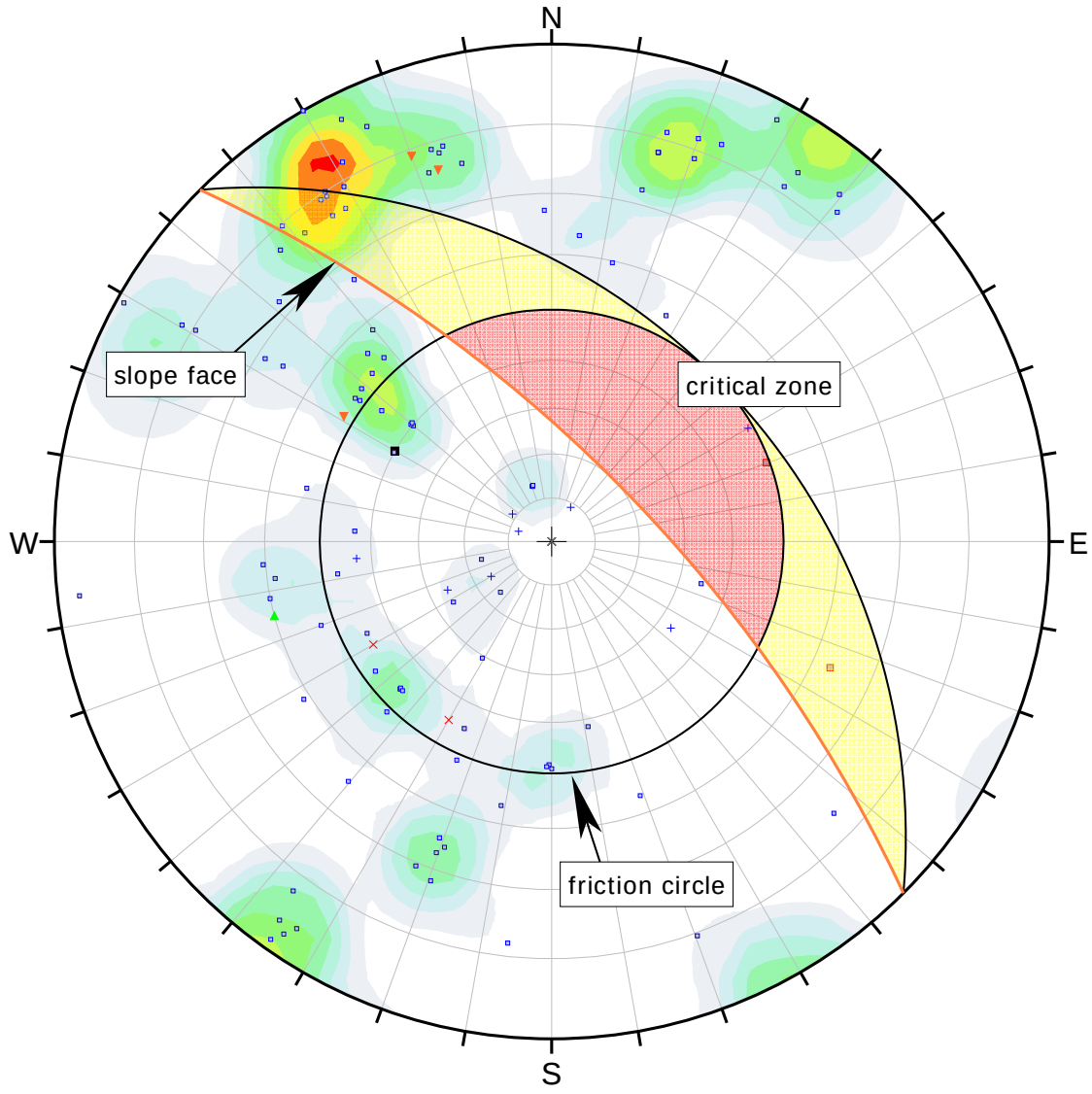
Kinematic Analysis	Planar Sliding
Slope Dip	70
Slope Dip Direction	45
Friction Angle	40°
Lateral Limits	20°

	Critical	Total	%
Planar Sliding (All)	1	15	6.67%

Plot Mode	Dip Vectors
Vector Count	15 (15 Entries)
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 5 - Planar Sliding Vector Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 5_45 planar vector.dips7	*Date* 2/23/2017	*Enclosure* 9.1



Symbol	TYPE	Quantity
■	bedding	1
×	fault	2
▲	foliation	1
+	joint	8
▼	shear	3

Symbol	Feature
▫	Critical Intersection
▫	Intersection

Color	Density Concentrations
	0.00 - 1.00
	1.00 - 2.00
	2.00 - 3.00
	3.00 - 4.00
	4.00 - 5.00
	5.00 - 6.00
	6.00 - 7.00
	7.00 - 8.00
	8.00 - 9.00
	9.00 - 10.00

Contour Data	Intersections
Maximum Density	9.41%
Contour Distribution	Fisher
Counting Circle Size	1.0%

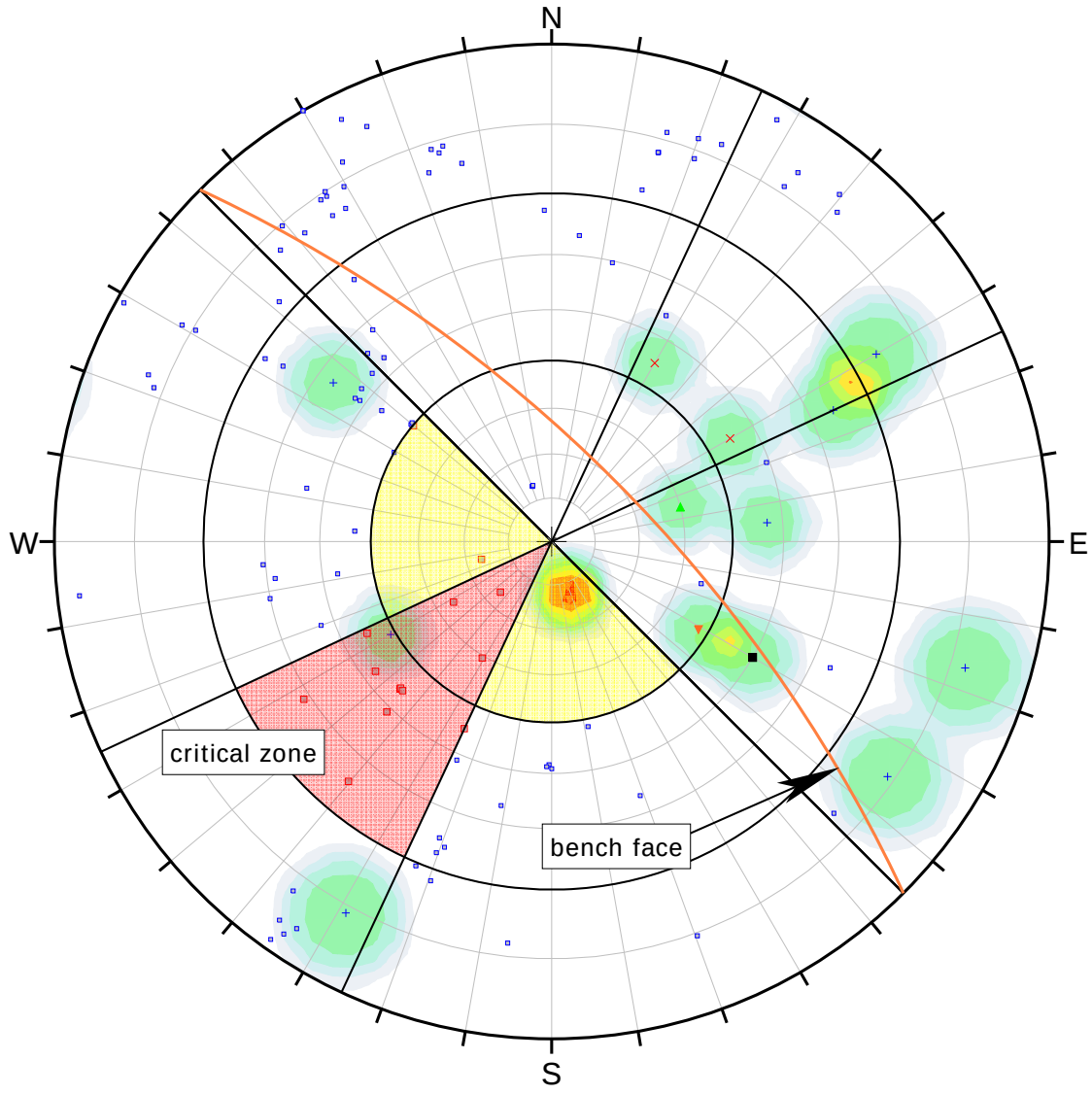
Kinematic Analysis	Wedge Sliding
Slope Dip	70
Slope Dip Direction	45
Friction Angle	40°

	Critical	Total	%
Wedge Sliding	2	105	1.90%

Plot Mode	Dip Vectors
Vector Count	15 (15 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	105
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 5 wedge - Vector Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 5_45 wedge vector.dips7	*Date* 2/24/2017	*Enclosure* 9.2



Symbol	TYPE	Quantity
■	bedding	1
×	fault	2
▲	foliation	1
+	joint	8
▼	shear	3
Symbol	**Feature**	
▫	Critical Intersection	
▫	Intersection	

Color	Density Concentrations
	0.00 - 1.40
	1.40 - 2.80
	2.80 - 4.20
	4.20 - 5.60
	5.60 - 7.00
	7.00 - 8.40
	8.40 - 9.80
	9.80 - 11.20
	11.20 - 12.60
	12.60 - 14.00

Contour Data	Pole Vectors
Maximum Density	13.01%
Contour Distribution	Fisher
Counting Circle Size	1.0%

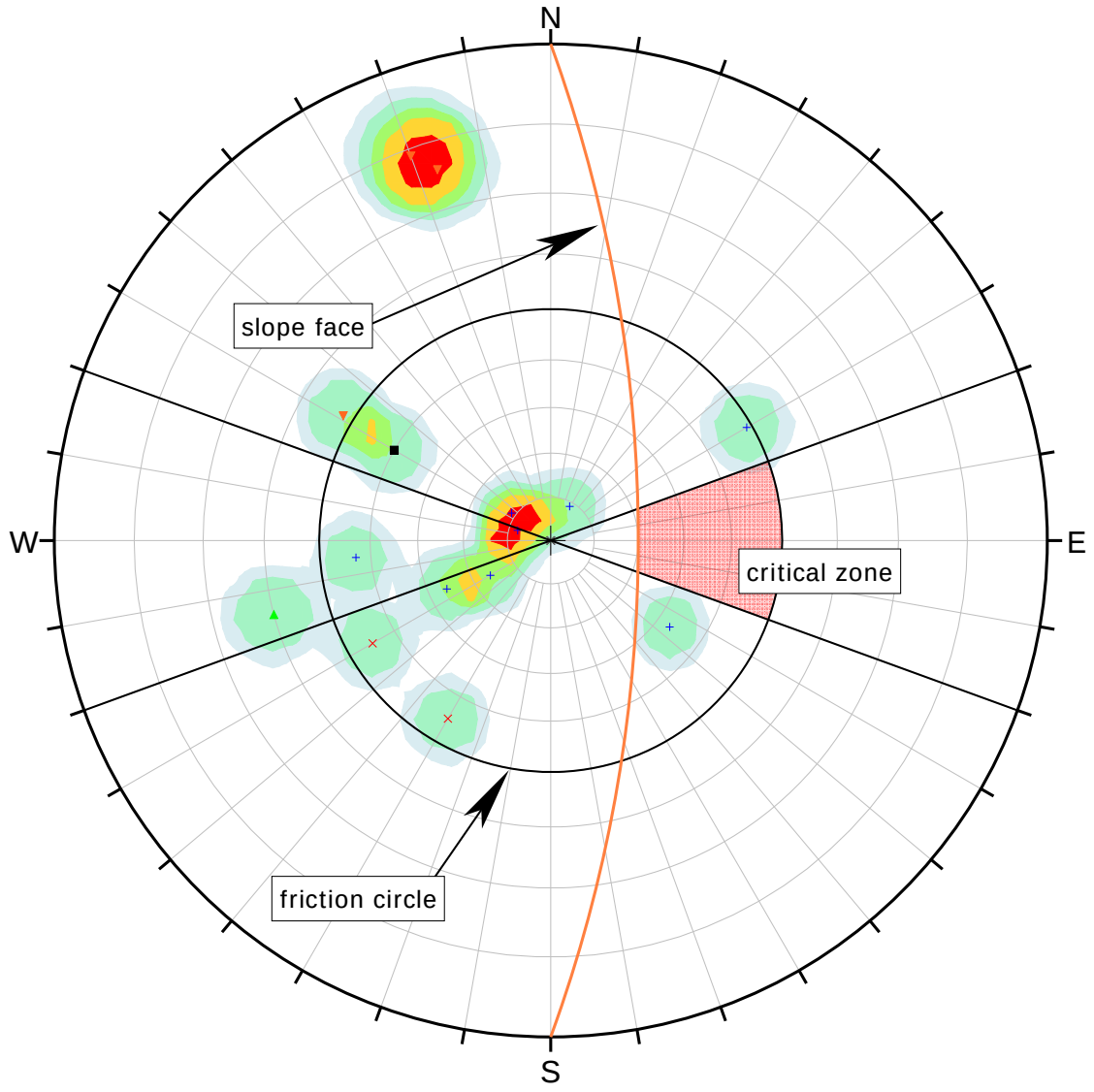
Kinematic Analysis	Direct Toppling
Slope Dip	70
Slope Dip Direction	45
Friction Angle	40°
Lateral Limits	20°

	Critical	Total	%
Direct Toppling (Intersection)	12	105	11.43%
Oblique Toppling (Intersection)	2	105	1.90%
Base Plane (All)	3	15	20.00%

Plot Mode	Pole Vectors
Vector Count	15 (15 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	105
Hemisphere	Lower

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 5 topple - Pole Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 5 45 topple.dips7	*Date* 2/24/2017	*Enclosure* 9.3



Symbol	TYPE	Quantity
■	bedding	1
×	fault	2
▲	foliation	1
+	joint	8
▼	shear	3

Color	Density Concentrations
	0.00 - 2.40
	2.40 - 4.80
	4.80 - 7.20
	7.20 - 9.60
	9.60 - 12.00
	12.00 - 14.40

Contour Data	Dip Vectors
Maximum Density	13.52%
Contour Distribution	Fisher
Counting Circle Size	1.0%

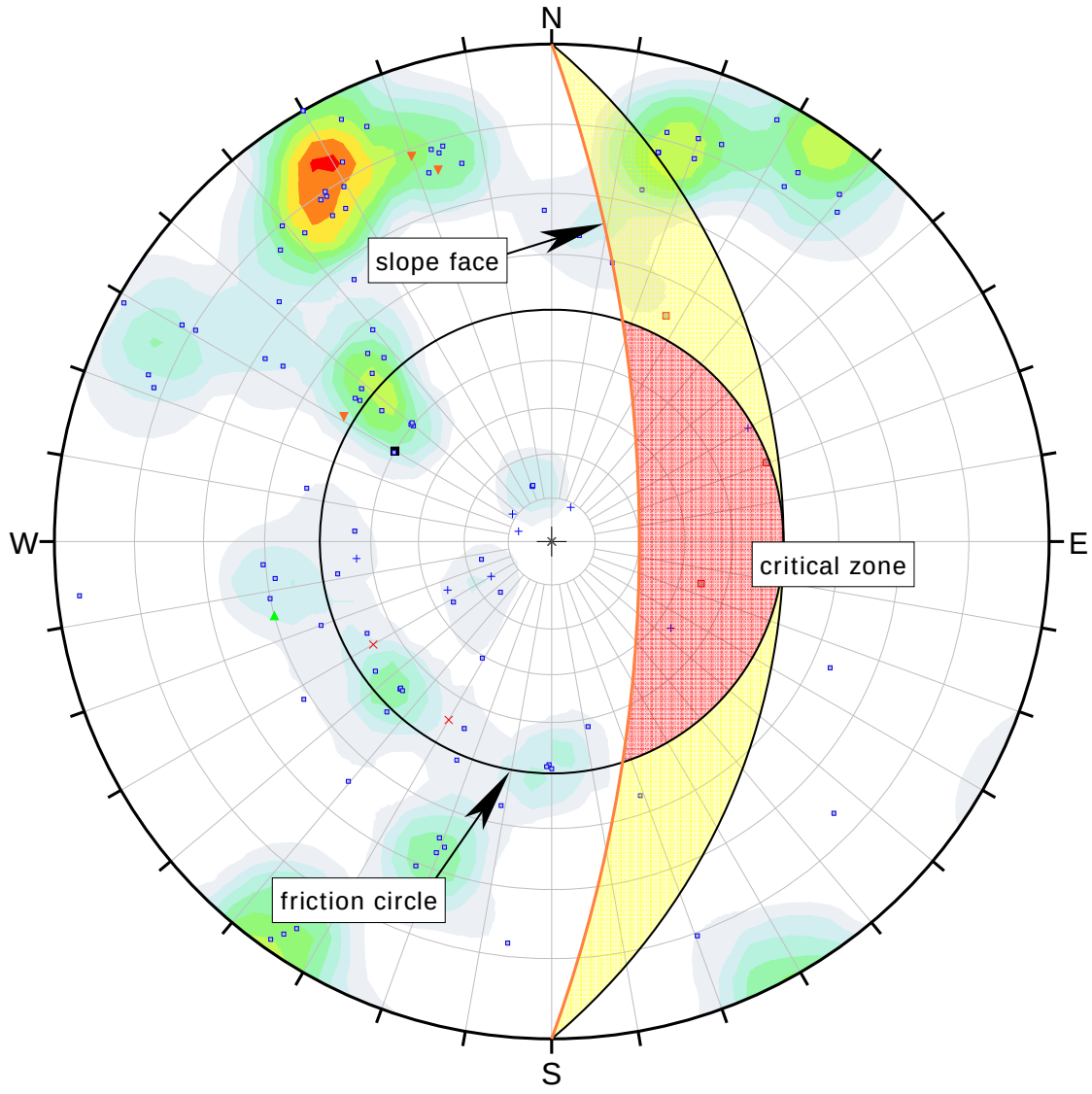
Kinematic Analysis	Planar Sliding
Slope Dip	70
Slope Dip Direction	90
Friction Angle	40°
Lateral Limits	20°

	Critical	Total	%
Planar Sliding (All)	0	15	0.00%

Plot Mode	Dip Vectors
Vector Count	15 (15 Entries)
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 5 - Planar Sliding Vector Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 5_90 planar vector.dips7	*Date* 2/23/2017	*Enclosure* 10.1



Symbol	TYPE	Quantity
■	bedding	1
×	fault	2
▲	foliation	1
+	joint	8
▼	shear	3

Symbol	Feature
▫	Critical Intersection
▫	Intersection

Color	Density Concentrations
	0.00 - 1.00
	1.00 - 2.00
	2.00 - 3.00
	3.00 - 4.00
	4.00 - 5.00
	5.00 - 6.00
	6.00 - 7.00
	7.00 - 8.00
	8.00 - 9.00
	9.00 - 10.00

Contour Data	Intersections
Maximum Density	9.41%
Contour Distribution	Fisher
Counting Circle Size	1.0%

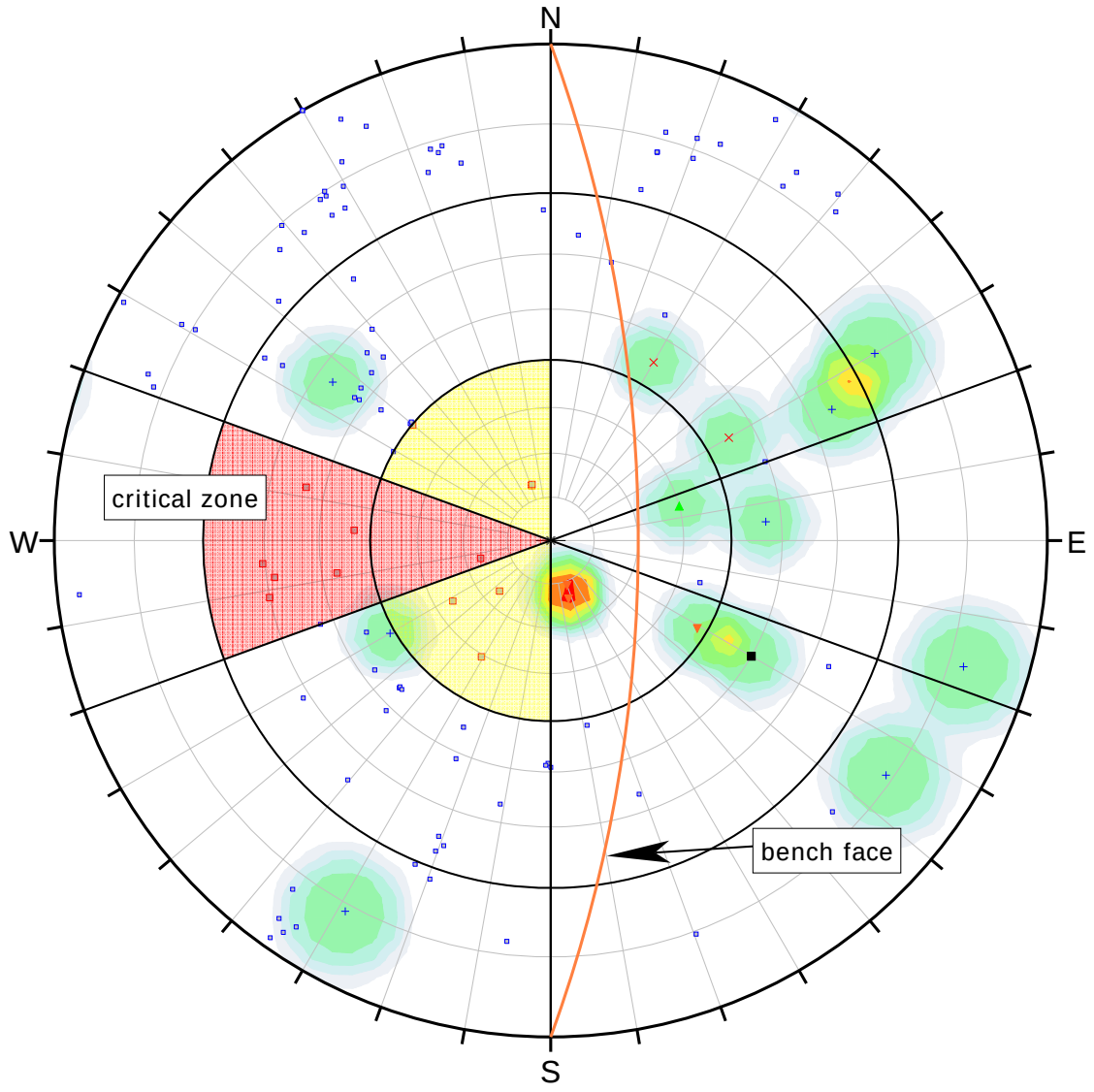
Kinematic Analysis	Wedge Sliding
Slope Dip	70
Slope Dip Direction	90
Friction Angle	40°

	Critical	Total	%
Wedge Sliding	3	105	2.86%

Plot Mode	Dip Vectors
Vector Count	15 (15 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	105
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 5 wedge - Vector Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 5_90 wedge vector.dips7	*Date* 2/24/2017	*Enclosure* 10.2



Symbol	TYPE	Quantity
■	bedding	1
×	fault	2
▲	foliation	1
+	joint	8
▼	shear	3

Symbol	Feature
▫	Critical Intersection
▫	Intersection

Color	Density Concentrations
	0.00 - 1.40
	1.40 - 2.80
	2.80 - 4.20
	4.20 - 5.60
	5.60 - 7.00
	7.00 - 8.40
	8.40 - 9.80
	9.80 - 11.20
	11.20 - 12.60
	12.60 - 14.00

Contour Data	Pole Vectors
Maximum Density	13.01%
Contour Distribution	Fisher
Counting Circle Size	1.0%

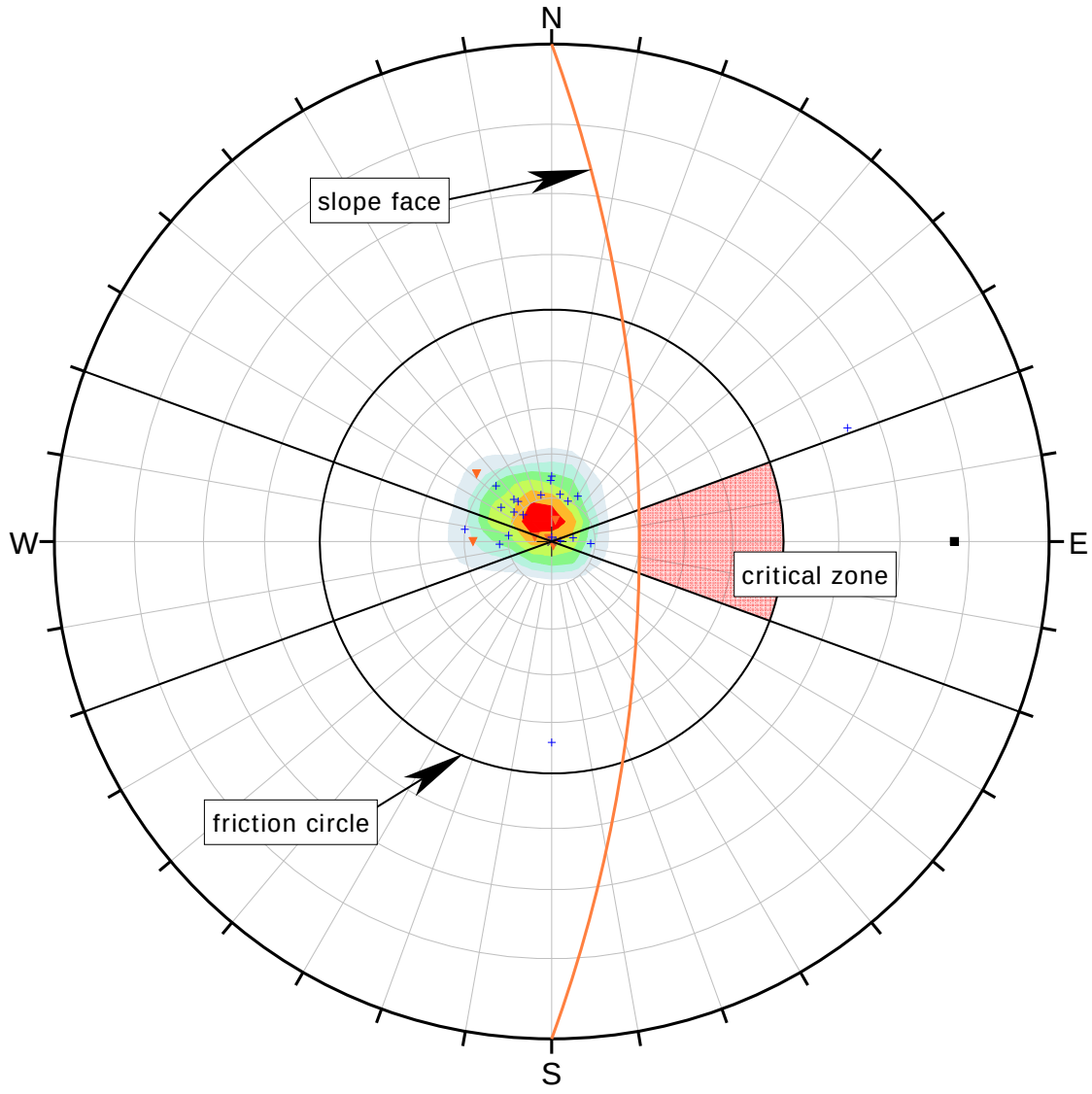
Kinematic Analysis	Direct Toppling
Slope Dip	70
Slope Dip Direction	90
Friction Angle	40°
Lateral Limits	20°

	Critical	Total	%
Direct Toppling (Intersection)	7	105	6.67%
Oblique Toppling (Intersection)	7	105	6.67%
Base Plane (All)	0	15	0.00%

Plot Mode	Pole Vectors
Vector Count	15 (15 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	105
Hemisphere	Lower

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 5 topple - Pole Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 5 90 topple.dips7	*Date* 2/24/2017	*Enclosure* 10.3



Symbol	TYPE	Quantity
■	bedding	1
+	joint	22
▼	shear	6

Color	Density Concentrations
	0.00 - 6.00
	6.00 - 12.00
	12.00 - 18.00
	18.00 - 24.00
	24.00 - 30.00
	30.00 - 36.00
	36.00 - 42.00

Contour Data	Dip Vectors
Maximum Density	41.26%
Contour Distribution	Fisher
Counting Circle Size	1.0%

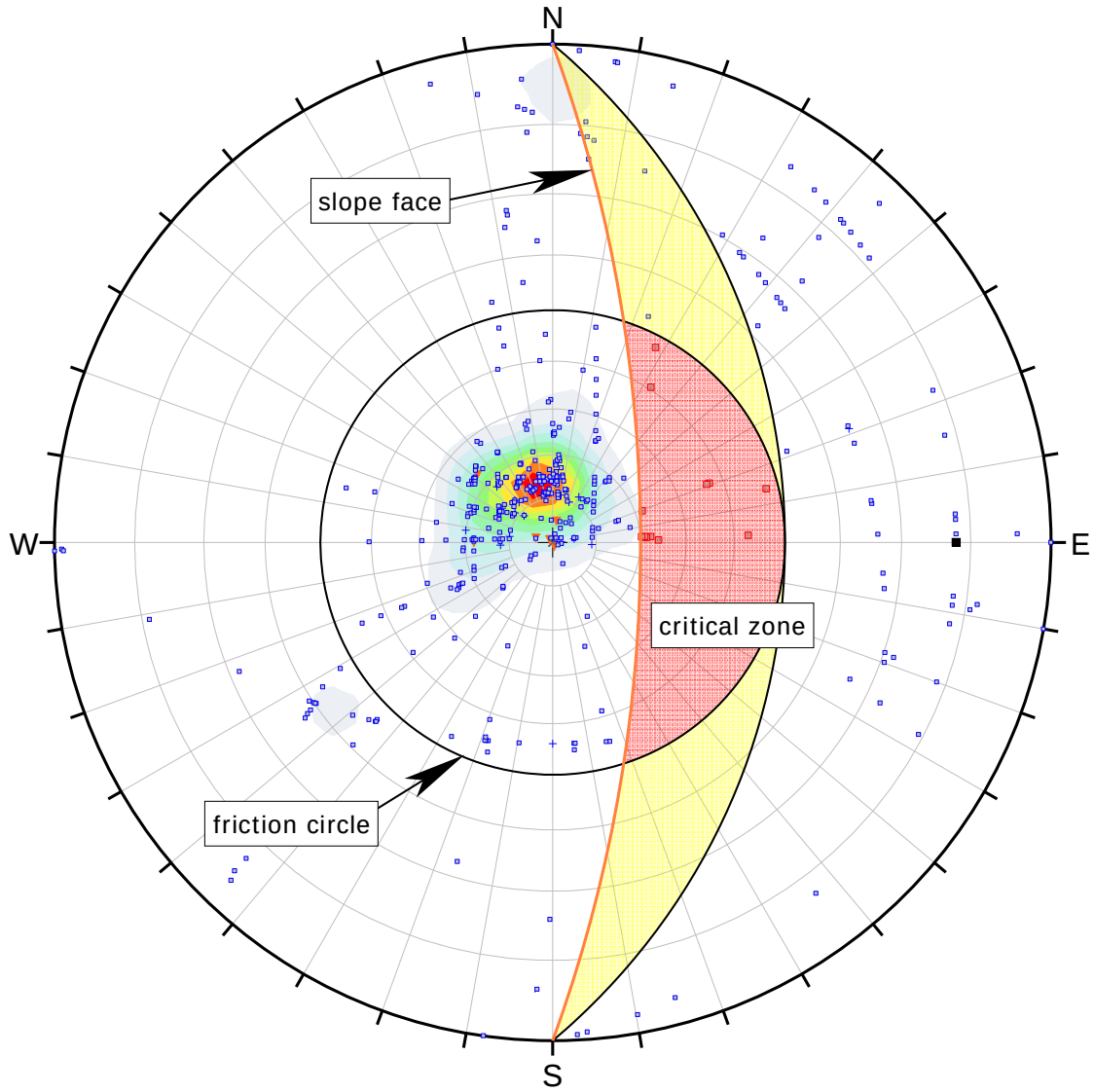
Kinematic Analysis	Planar Sliding
Slope Dip	70
Slope Dip Direction	90
Friction Angle	40°
Lateral Limits	20°

	Critical	Total	%
Planar Sliding (All)	0	29	0.00%

Plot Mode	Dip Vectors
Vector Count	29 (29 Entries)
Hemisphere	Lower
Projection	Equal Angle

Project	Sentinel & B3		
Analysis Description	Dom 6 - Planar Sliding Vector Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 6_90 planar vector.dips7	*Date* 2/23/2017	*Enclosure* 11.1

DIPS 7.007



Symbol	TYPE	Quantity
■	bedding	1
+	joint	22
▼	shear	6
Symbol	**Feature**	
▫	Critical Intersection	
▫	Intersection	

Color	Density Concentrations
	0.00 - 2.30
	2.30 - 4.60
	4.60 - 6.90
	6.90 - 9.20
	9.20 - 11.50
	11.50 - 13.80
	13.80 - 16.10
	16.10 - 18.40
	18.40 - 20.70
	20.70 - 23.00

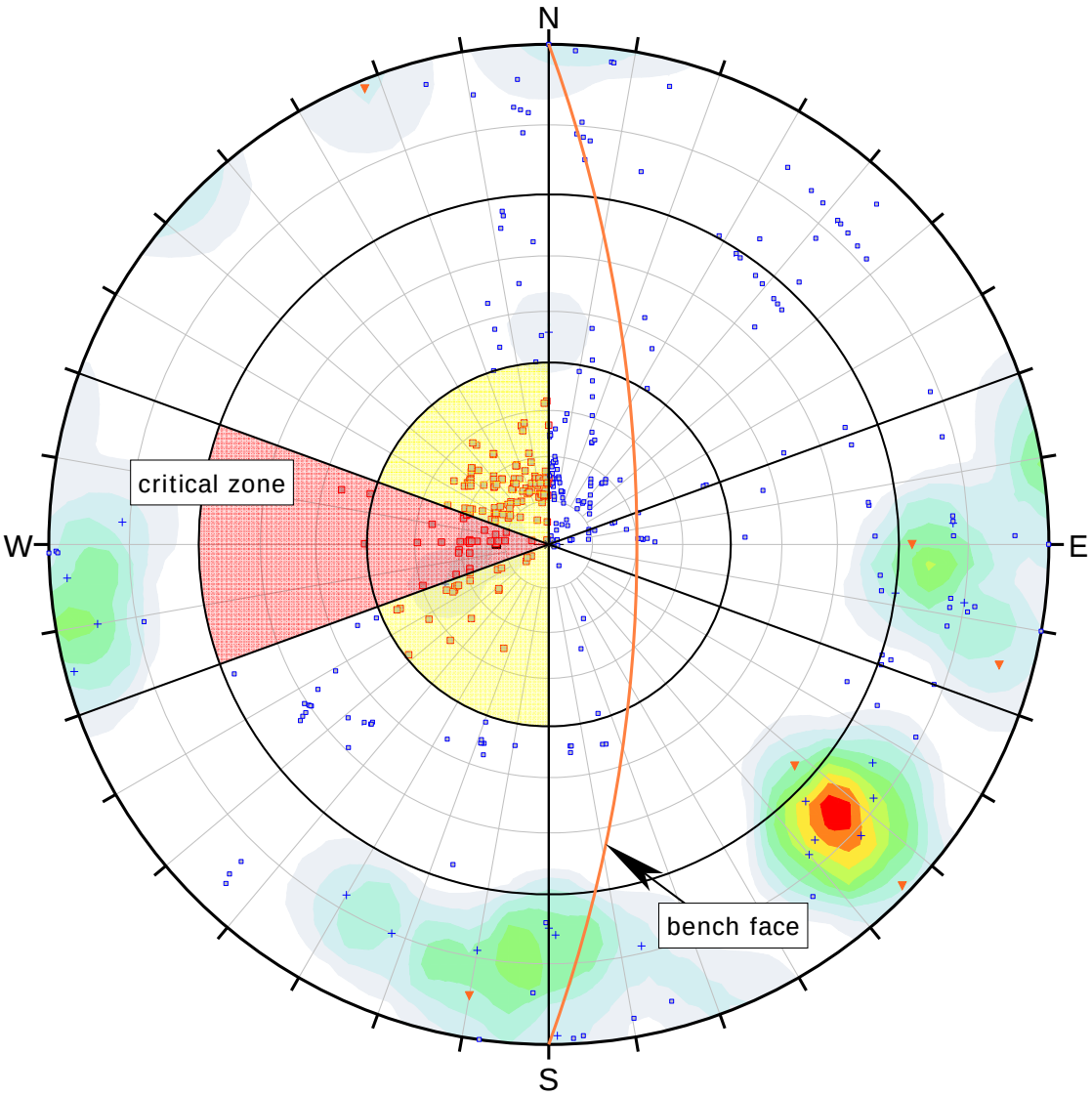
Contour Data	Intersections
Maximum Density	22.70%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Wedge Sliding
Slope Dip	70
Slope Dip Direction	90
Friction Angle	40°

	Critical	Total	%
Wedge Sliding	12	406	2.96%

Plot Mode	Dip Vectors
Vector Count	29 (29 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	406
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007	*Project* Sentinel & B3		
	Analysis Description Dom 6 wedge - Vector Plot		
	Drawn By CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
	File Name Dom 6_90 wedge vector.dips7	*Date* 2/24/2017	*Enclosure* 11.2



Symbol	TYPE	Quantity
■	bedding	1
+	joint	22
▼	shear	6

Symbol	Feature
▫	Critical Intersection
▫	Intersection

Color	Density Concentrations
	0.00 - 1.70
	1.70 - 3.40
	3.40 - 5.10
	5.10 - 6.80
	6.80 - 8.50
	8.50 - 10.20
	10.20 - 11.90
	11.90 - 13.60
	13.60 - 15.30
	15.30 - 17.00

Contour Data	Pole Vectors
Maximum Density	16.55%
Contour Distribution	Fisher
Counting Circle Size	1.0%

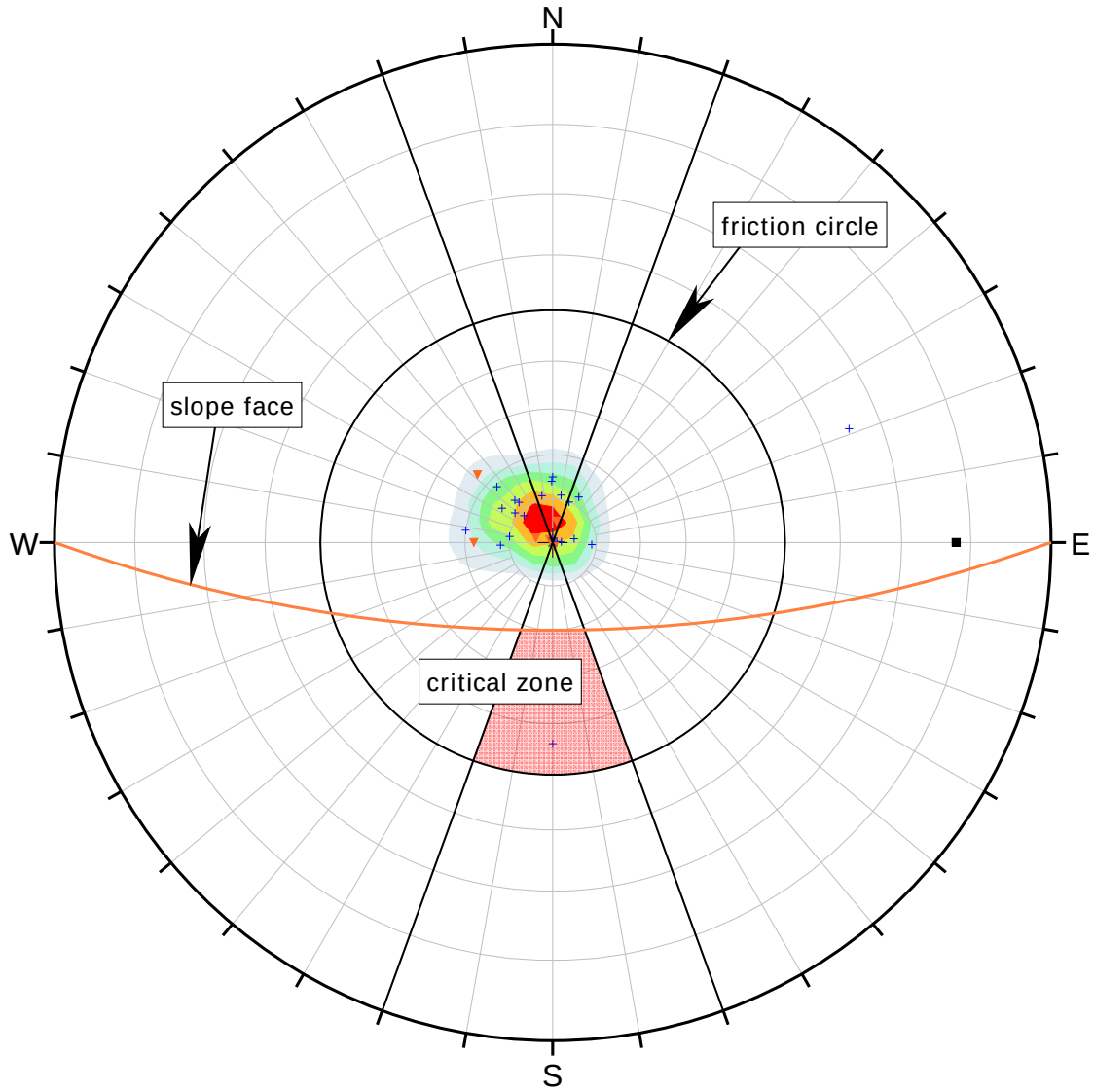
Kinematic Analysis	Direct Toppling
Slope Dip	70
Slope Dip Direction	90
Friction Angle	40°
Lateral Limits	20°

	Critical	Total	%
Direct Toppling (Intersection)	32	406	7.88%
Oblique Toppling (Intersection)	150	406	36.95%
Base Plane (All)	2	29	6.90%

Plot Mode	Pole Vectors
Vector Count	29 (29 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	406
Hemisphere	Lower
Projection	Equal Angle

Project	Sentinel & B3		
Analysis Description	Dom 6 topple - Pole Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 6 90 topple.dips7	*Date* 2/24/2017	*Enclosure* 11.3

DIPS 7.007



Symbol	TYPE	Quantity
■	bedding	1
+	joint	22
▼	shear	6

Color	Density Concentrations
	0.00 - 6.00
	6.00 - 12.00
	12.00 - 18.00
	18.00 - 24.00
	24.00 - 30.00
	30.00 - 36.00
	36.00 - 42.00

Contour Data	Dip Vectors
Maximum Density	41.26%
Contour Distribution	Fisher
Counting Circle Size	1.0%

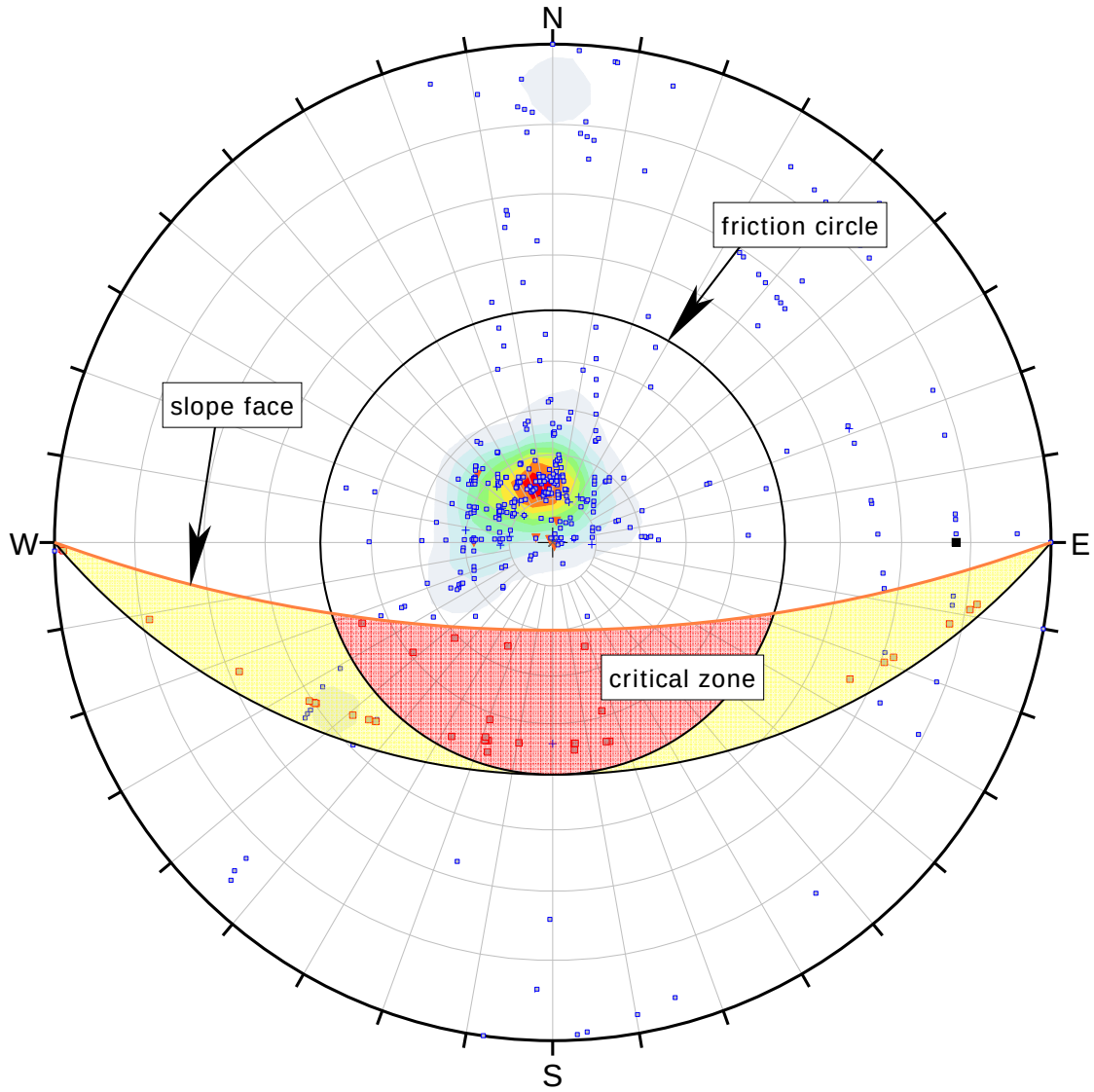
Kinematic Analysis	Planar Sliding
Slope Dip	70
Slope Dip Direction	180
Friction Angle	40°
Lateral Limits	20°

	Critical	Total	%
Planar Sliding (All)	1	29	3.45%

Plot Mode	Dip Vectors
Vector Count	29 (29 Entries)
Hemisphere	Lower
Projection	Equal Angle

Project	Sentinel & B3		
Analysis Description	Dom 6 - Planar Sliding Vector Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 6_180 planar vector.dips7	*Date* 2/23/2017	*Enclosure* 12.1

DIPS 7.007



Symbol	TYPE	Quantity
■	bedding	1
+	joint	22
▼	shear	6
Symbol	**Feature**	
▫	Critical Intersection	
▫	Intersection	

Color	Density Concentrations
	0.00 - 2.30
	2.30 - 4.60
	4.60 - 6.90
	6.90 - 9.20
	9.20 - 11.50
	11.50 - 13.80
	13.80 - 16.10
	16.10 - 18.40
	18.40 - 20.70
	20.70 - 23.00

Contour Data	Intersections
Maximum Density	22.70%
Contour Distribution	Fisher
Counting Circle Size	1.0%

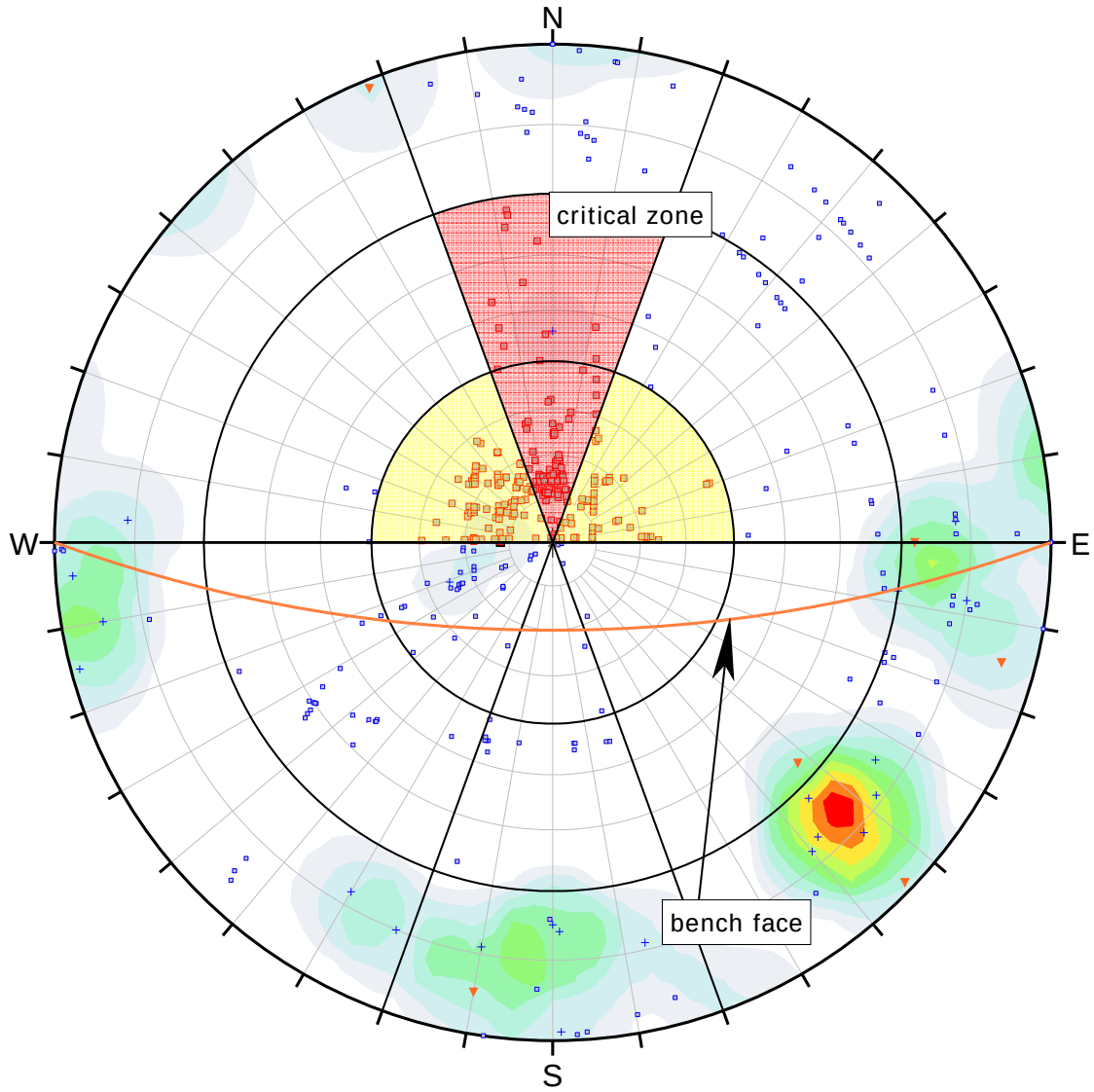
Kinematic Analysis	Wedge Sliding
Slope Dip	70
Slope Dip Direction	180
Friction Angle	40°

	Critical	Total	%
Wedge Sliding	37	406	9.11%

Plot Mode	Dip Vectors
Vector Count	29 (29 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	406
Hemisphere	Lower
Projection	Equal Angle

Project	Sentinel & B3		
Analysis Description	Dom 6 wedge - Vector Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 6_180 wedge vector.dips7	*Date* 2/24/2017	*Enclosure* 12.2

DIPS 7.007



Symbol	TYPE	Quantity
■	bedding	1
+	joint	22
▼	shear	6
Symbol	**Feature**	
▫	Critical Intersection	
▫	Intersection	

Color	Density Concentrations
	0.00 - 1.70
	1.70 - 3.40
	3.40 - 5.10
	5.10 - 6.80
	6.80 - 8.50
	8.50 - 10.20
	10.20 - 11.90
	11.90 - 13.60
	13.60 - 15.30
	15.30 - 17.00

Contour Data	Pole Vectors
Maximum Density	16.55%
Contour Distribution	Fisher
Counting Circle Size	1.0%

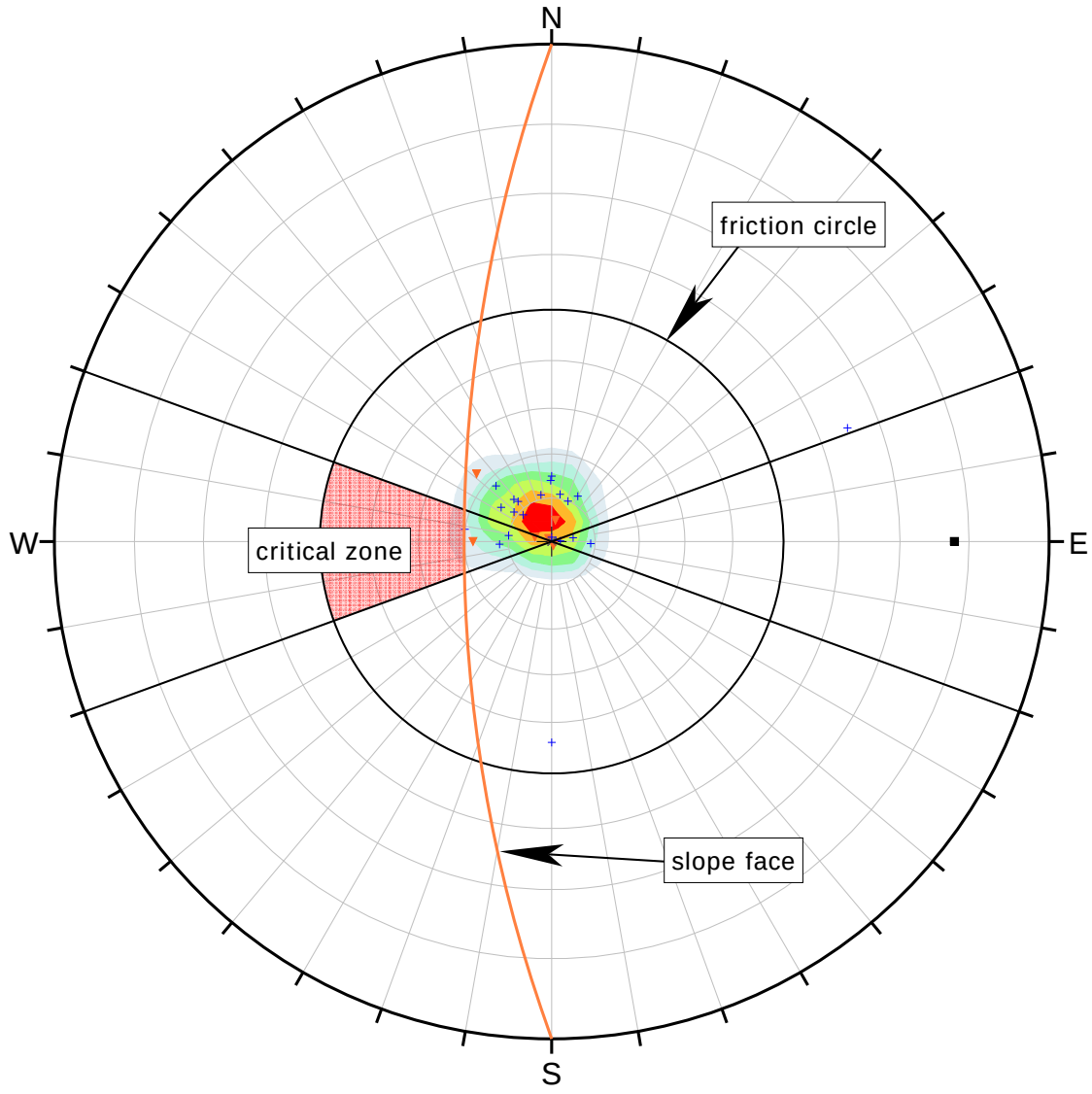
Kinematic Analysis	Direct Toppling
Slope Dip	70
Slope Dip Direction	180
Friction Angle	40°
Lateral Limits	20°

	Critical	Total	%
Direct Toppling (Intersection)	103	406	25.37%
Oblique Toppling (Intersection)	145	406	35.71%
Base Plane (All)	2	29	6.90%

Plot Mode	Pole Vectors
Vector Count	29 (29 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	406
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 6 topple - Pole Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 6 180 topple.dips7	*Date* 2/24/2017	*Enclosure* 12.3



Symbol	TYPE	Quantity
■	bedding	1
+	joint	22
▼	shear	6

Color	Density Concentrations
	0.00 - 6.00
	6.00 - 12.00
	12.00 - 18.00
	18.00 - 24.00
	24.00 - 30.00
	30.00 - 36.00
	36.00 - 42.00

Contour Data	Dip Vectors
Maximum Density	41.26%
Contour Distribution	Fisher
Counting Circle Size	1.0%

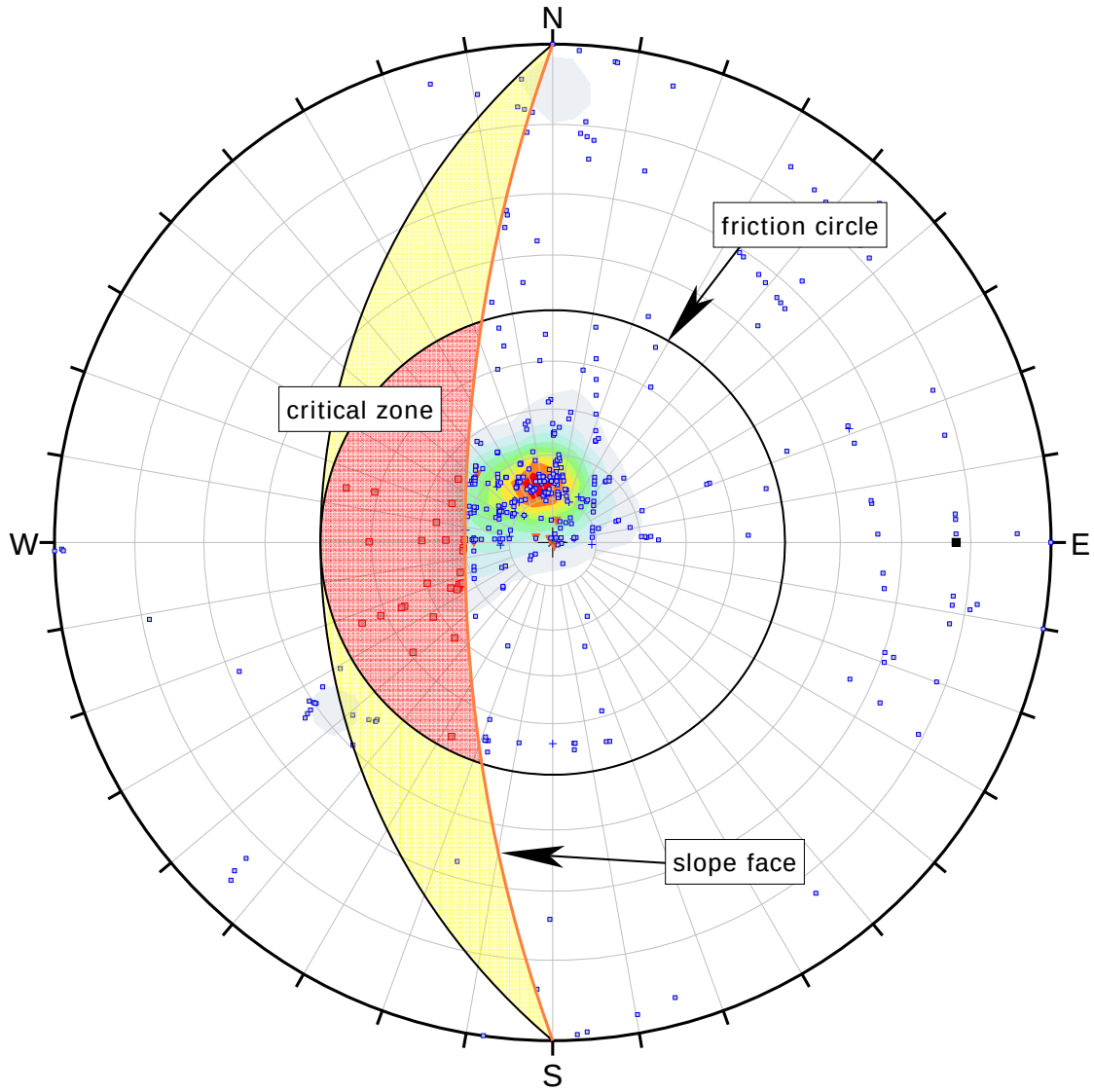
Kinematic Analysis	Planar Sliding
Slope Dip	70
Slope Dip Direction	270
Friction Angle	40°
Lateral Limits	20°

	Critical	Total	%
Planar Sliding (All)	0	29	0.00%

Plot Mode	Dip Vectors
Vector Count	29 (29 Entries)
Hemisphere	Lower
Projection	Equal Angle

Project	Sentinel & B3		
Analysis Description	Dom 6 - Planar Sliding Vector Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 6_270 planar vector.dips7	*Date* 2/23/2017	*Enclosure* 13.1

DIPS 7.007



Symbol	TYPE	Quantity
■	bedding	1
+	joint	22
▼	shear	6
Symbol	**Feature**	
▫	Critical Intersection	
▫	Intersection	

Color	Density Concentrations
	0.00 - 2.30
	2.30 - 4.60
	4.60 - 6.90
	6.90 - 9.20
	9.20 - 11.50
	11.50 - 13.80
	13.80 - 16.10
	16.10 - 18.40
	18.40 - 20.70
	20.70 - 23.00

Contour Data	Intersections
Maximum Density	22.70%
Contour Distribution	Fisher
Counting Circle Size	1.0%

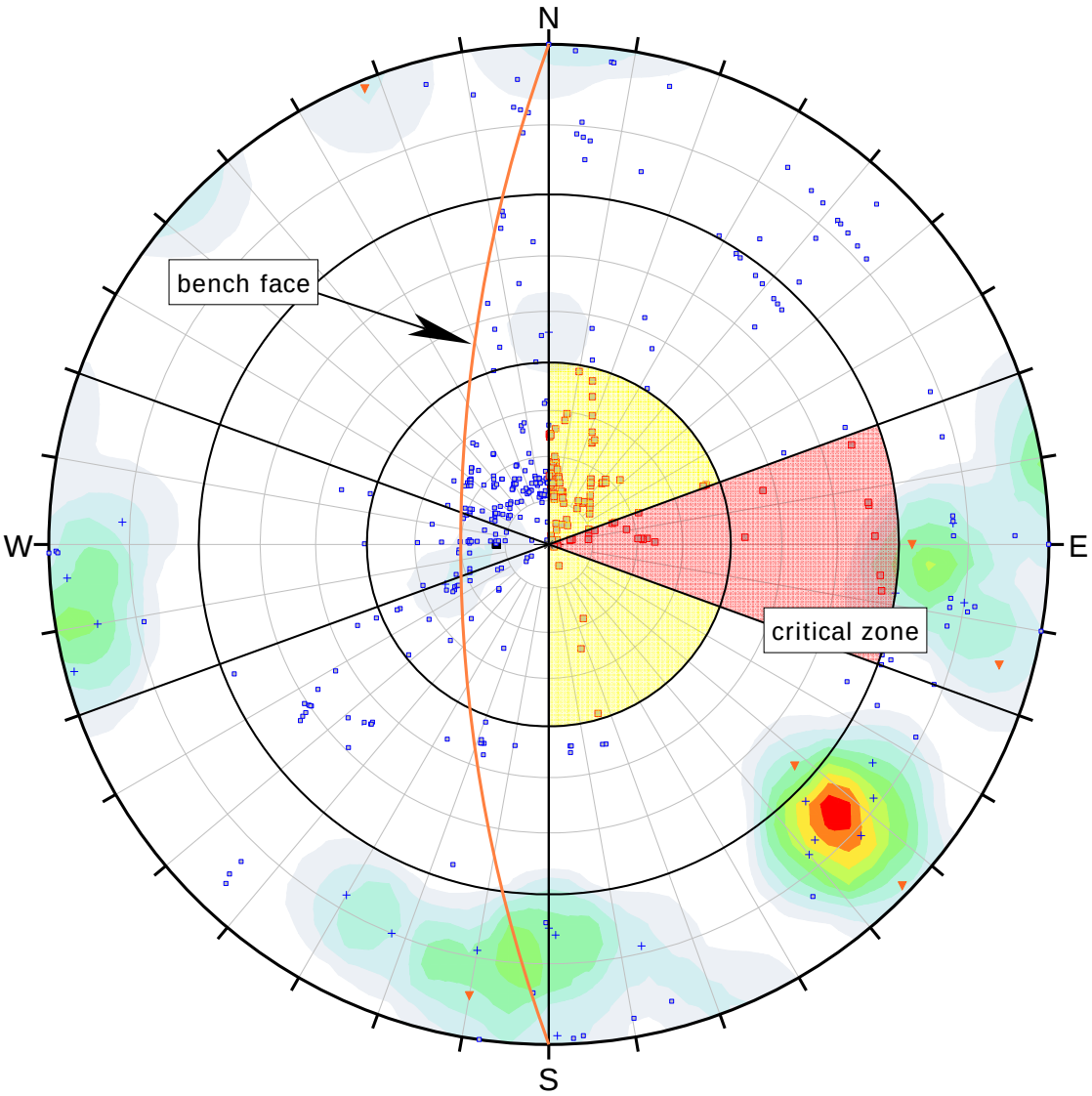
Kinematic Analysis	Wedge Sliding
Slope Dip	70
Slope Dip Direction	270
Friction Angle	40°

	Critical	Total	%
Wedge Sliding	28	406	6.90%

Plot Mode	Dip Vectors
Vector Count	29 (29 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	406
Hemisphere	Lower
Projection	Equal Angle

Project	Sentinel & B3		
Analysis Description	Dom 6 wedge - Vector Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 6_270 wedge vector.dips7	*Date* 2/24/2017	*Enclosure* 13.2

DIPS 7.007



Symbol	TYPE	Quantity
■	bedding	1
+	joint	22
▼	shear	6
Symbol	**Feature**	
▫	Critical Intersection	
▫	Intersection	

Color	Density Concentrations
	0.00 - 1.70
	1.70 - 3.40
	3.40 - 5.10
	5.10 - 6.80
	6.80 - 8.50
	8.50 - 10.20
	10.20 - 11.90
	11.90 - 13.60
	13.60 - 15.30
	15.30 - 17.00

Contour Data	Pole Vectors
Maximum Density	16.55%
Contour Distribution	Fisher
Counting Circle Size	1.0%

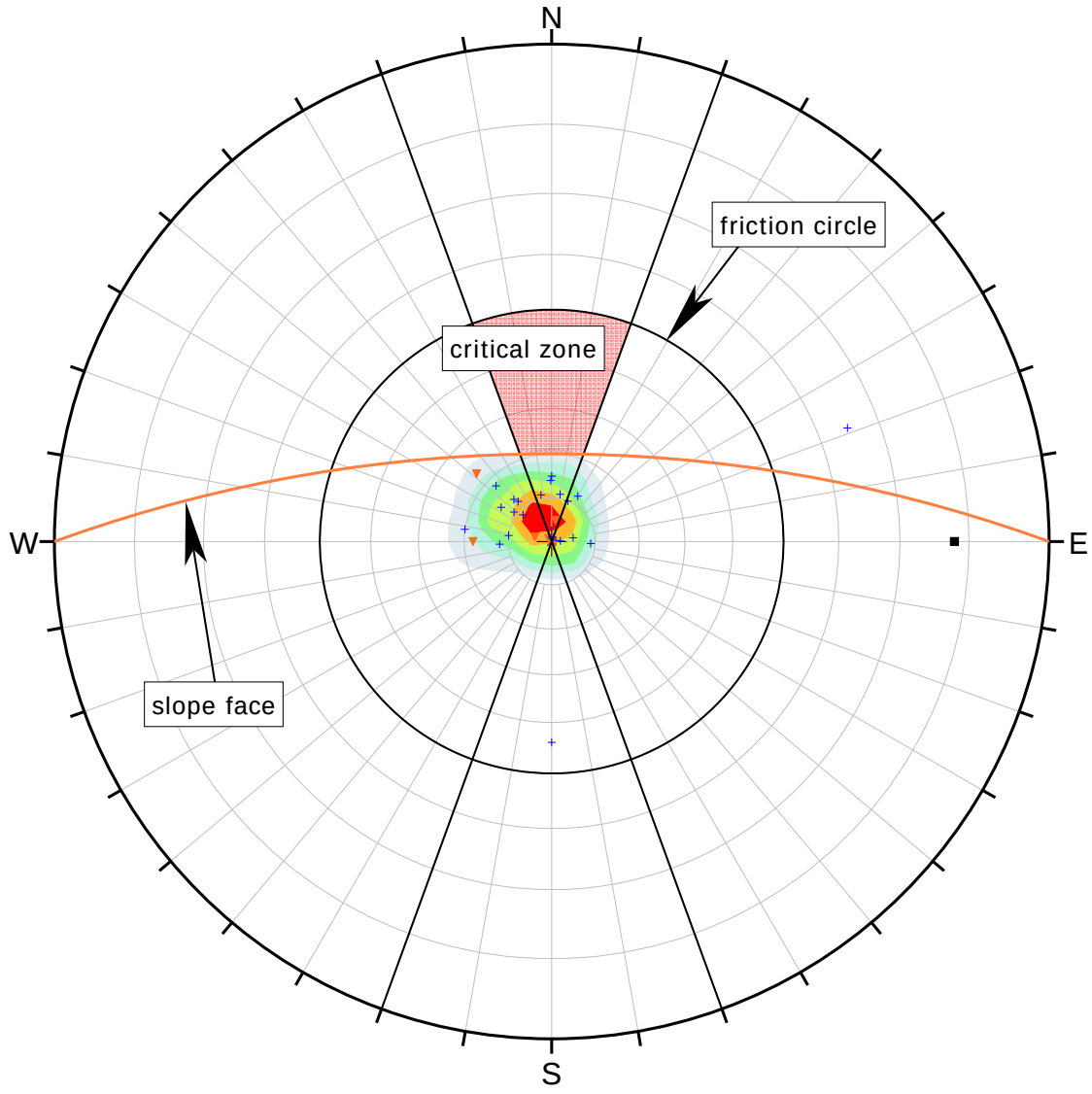
Kinematic Analysis	Direct Toppling
Slope Dip	70
Slope Dip Direction	270
Friction Angle	40°
Lateral Limits	20°

	Critical	Total	%
Direct Toppling (Intersection)	24	406	5.91%
Oblique Toppling (Intersection)	76	406	18.72%
Base Plane (All)	1	29	3.45%

Plot Mode	Pole Vectors
Vector Count	29 (29 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	406
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 6 topple - Pole Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 6 270 topple.dips7	*Date* 2/24/2017	*Enclosure* 13.3



Symbol	TYPE	Quantity
■	bedding	1
+	joint	22
▼	shear	6

Color	Density Concentrations
	0.00 - 6.00
	6.00 - 12.00
	12.00 - 18.00
	18.00 - 24.00
	24.00 - 30.00
	30.00 - 36.00
	36.00 - 42.00

Contour Data	Dip Vectors
Maximum Density	41.26%
Contour Distribution	Fisher
Counting Circle Size	1.0%

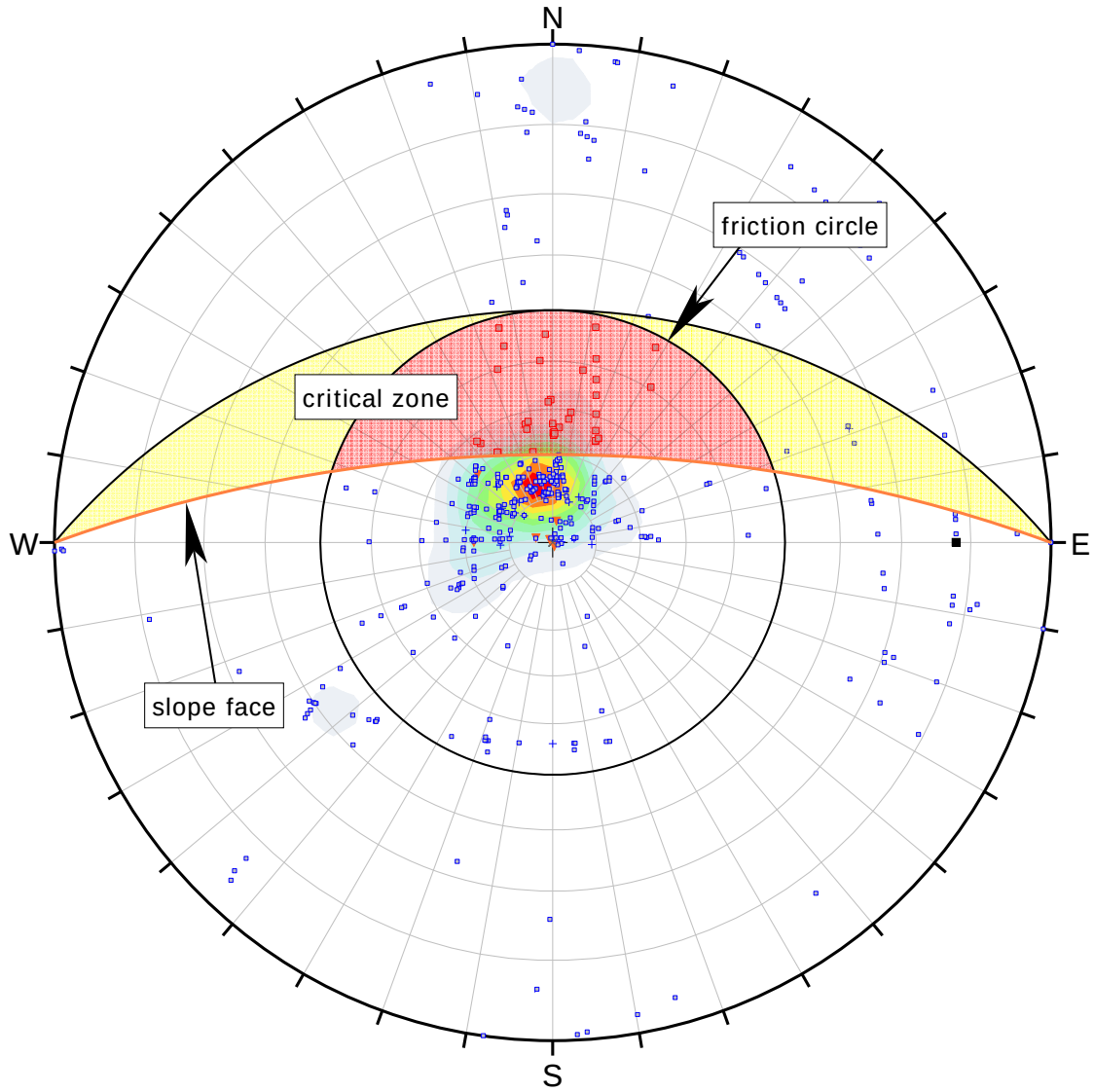
Kinematic Analysis	Planar Sliding
Slope Dip	70
Slope Dip Direction	0
Friction Angle	40°
Lateral Limits	20°

	Critical	Total	%
Planar Sliding (All)	0	29	0.00%

Plot Mode	Dip Vectors
Vector Count	29 (29 Entries)
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 6 - Planar Sliding Vector Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 6_360 planar vector.dips7	*Date* 2/23/2017	*Enclosure* 14.1



Symbol	TYPE	Quantity
■	bedding	1
+	joint	22
▼	shear	6
Symbol	**Feature**	
▫	Critical Intersection	
▫	Intersection	

Color	Density Concentrations
	0.00 - 2.30
	2.30 - 4.60
	4.60 - 6.90
	6.90 - 9.20
	9.20 - 11.50
	11.50 - 13.80
	13.80 - 16.10
	16.10 - 18.40
	18.40 - 20.70
	20.70 - 23.00

Contour Data	Intersections
Maximum Density	22.70%
Contour Distribution	Fisher
Counting Circle Size	1.0%

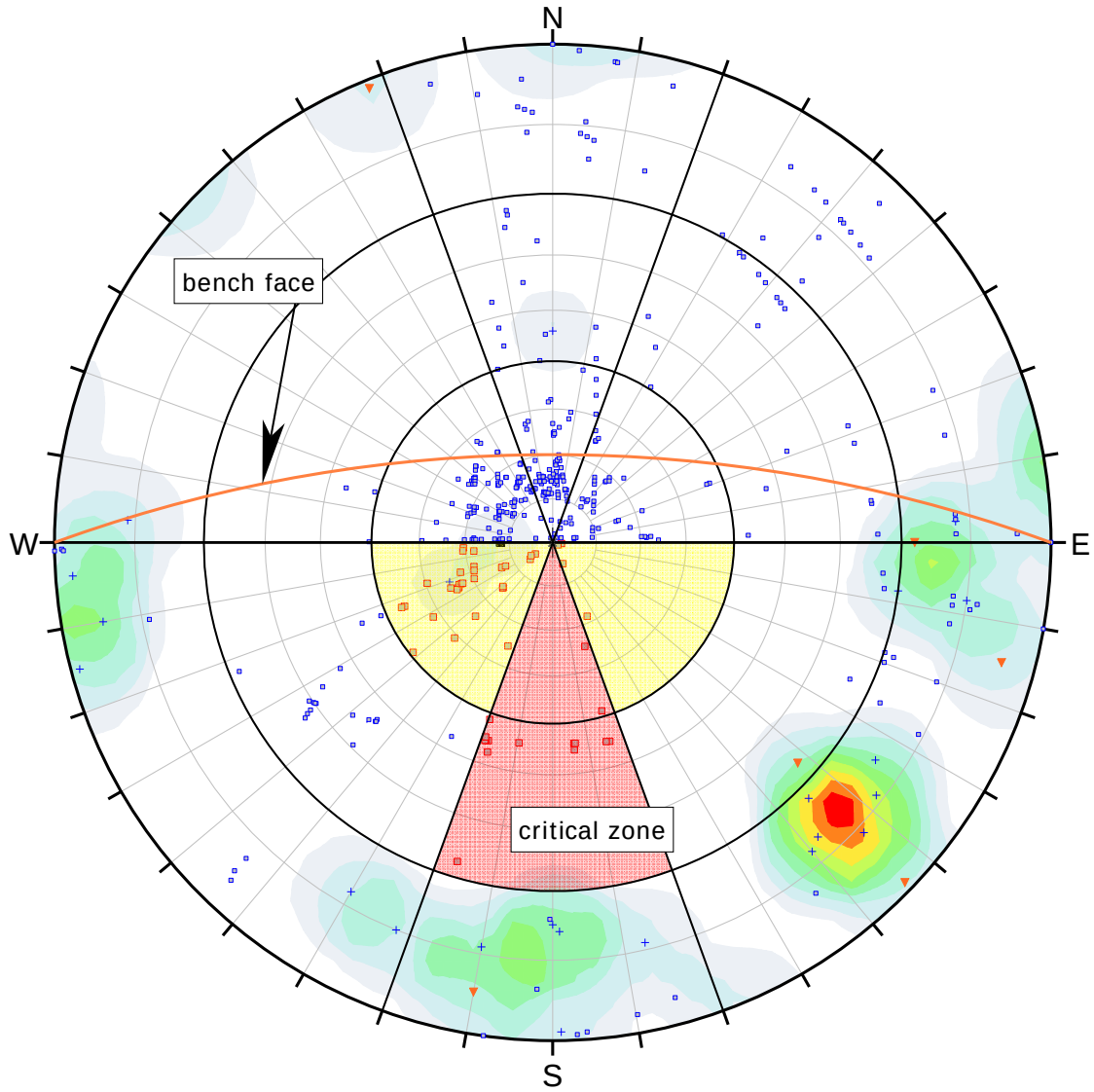
Kinematic Analysis	Wedge Sliding
Slope Dip	70
Slope Dip Direction	0
Friction Angle	40°

	Critical	Total	%
Wedge Sliding	36	406	8.87%

Plot Mode	Dip Vectors
Vector Count	29 (29 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	406
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Dom 6 wedge - Vector Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 6_360 wedge vector.dips7	*Date* 2/24/2017	*Enclosure* 14.2



Symbol	TYPE	Quantity
■	bedding	1
+	joint	22
▼	shear	6
Symbol	**Feature**	
▫	Critical Intersection	
▫	Intersection	

Color	Density Concentrations
	0.00 - 1.70
	1.70 - 3.40
	3.40 - 5.10
	5.10 - 6.80
	6.80 - 8.50
	8.50 - 10.20
	10.20 - 11.90
	11.90 - 13.60
	13.60 - 15.30
	15.30 - 17.00

Contour Data	Pole Vectors
Maximum Density	16.55%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Kinematic Analysis	Direct Toppling
Slope Dip	70
Slope Dip Direction	0
Friction Angle	40°
Lateral Limits	20°

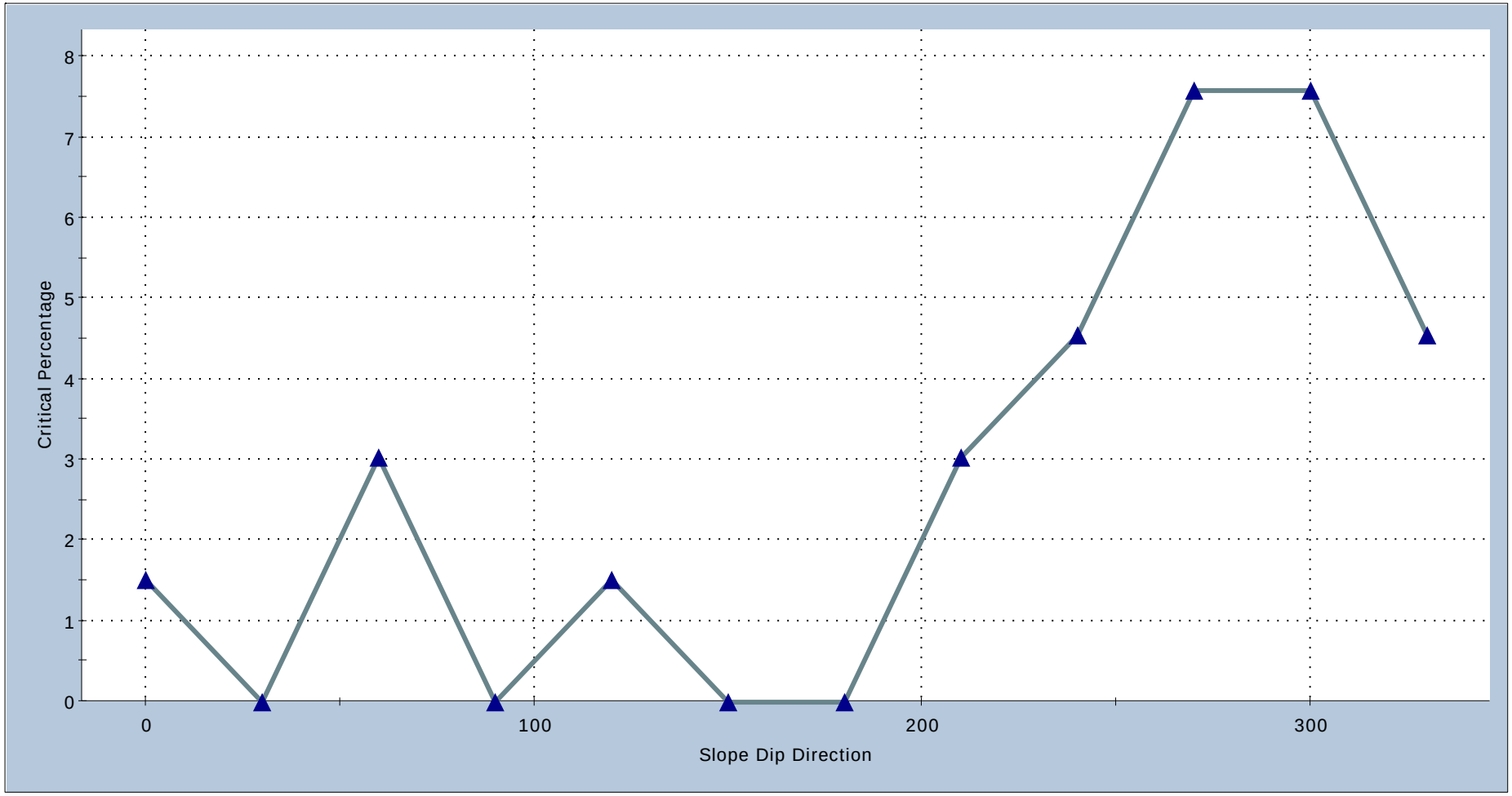
	Critical	Total	%
Direct Toppling (Intersection)	15	406	3.69%
Oblique Toppling (Intersection)	34	406	8.37%
Base Plane (All)	2	29	6.90%

Plot Mode	Pole Vectors
Vector Count	29 (29 Entries)
Intersection Mode	Grid Data Planes
Intersections Count	406
Hemisphere	Lower
Projection	Equal Angle

Project	Sentinel & B3		
Analysis Description	Dom 6 topple - Pole Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Dom 6 360 topple.dips7	*Date* 2/24/2017	*Enclosure* 14.3

DIPS 7.007

Planar Sliding: Critical Percentage vs. Slope Dip Direction

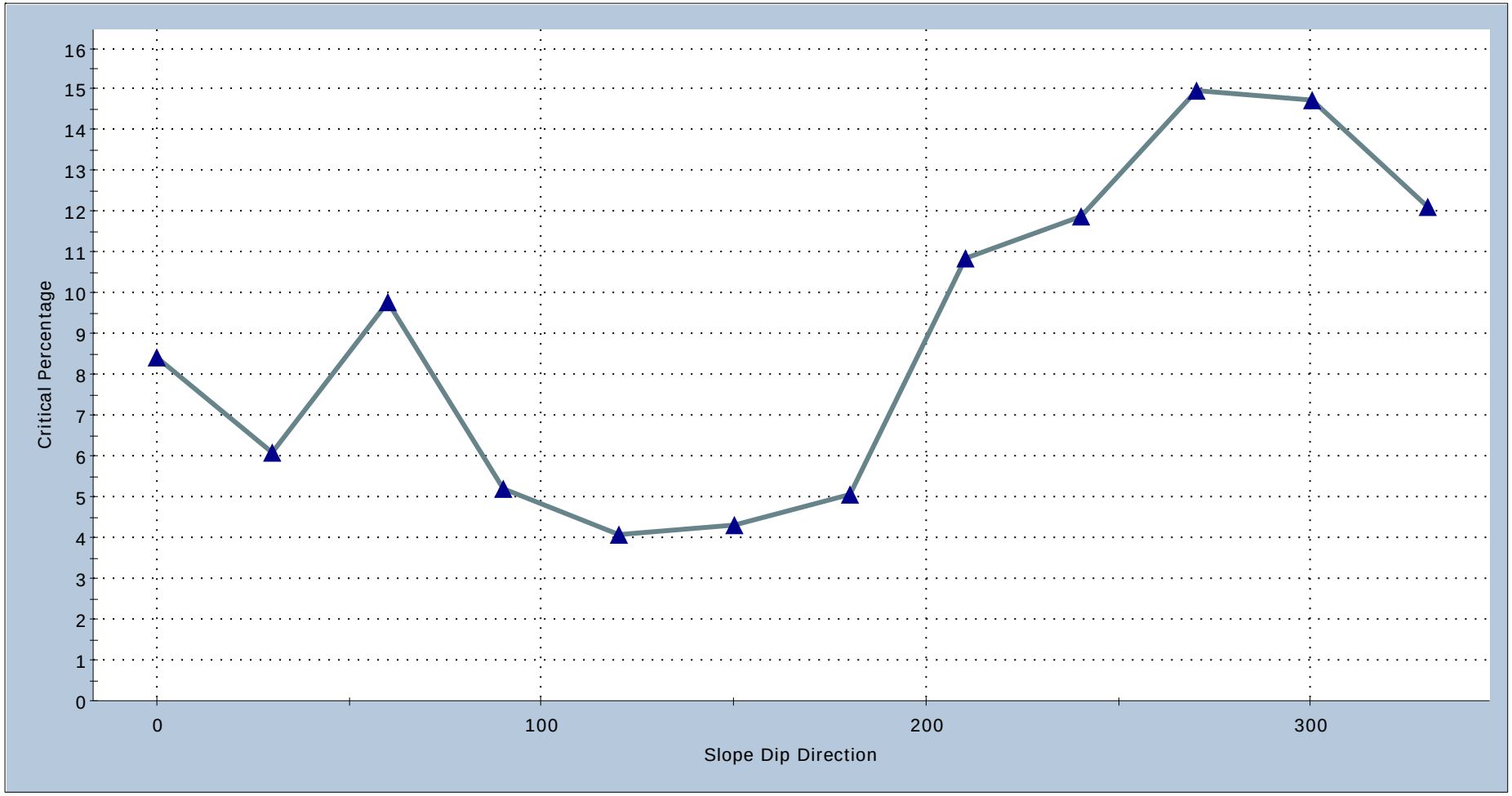


Mean Values

Slope Dip = 50 **Slope Dip Direction = 0** **Friction Angle = 30** **Lateral Limit = 20**

DIPS 7.007	*Project* Sentinel & B3		
	Analysis Description Sensitivity Plot - Sentinel Data: Planar Sliding		
	Drawn By CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
	File Name Sentinel Only Data sens planar.dips7	*Date* 3/1/2017	*Enclosure* 15.1

Wedge Sliding: Critical Percentage vs. Slope Dip Direction

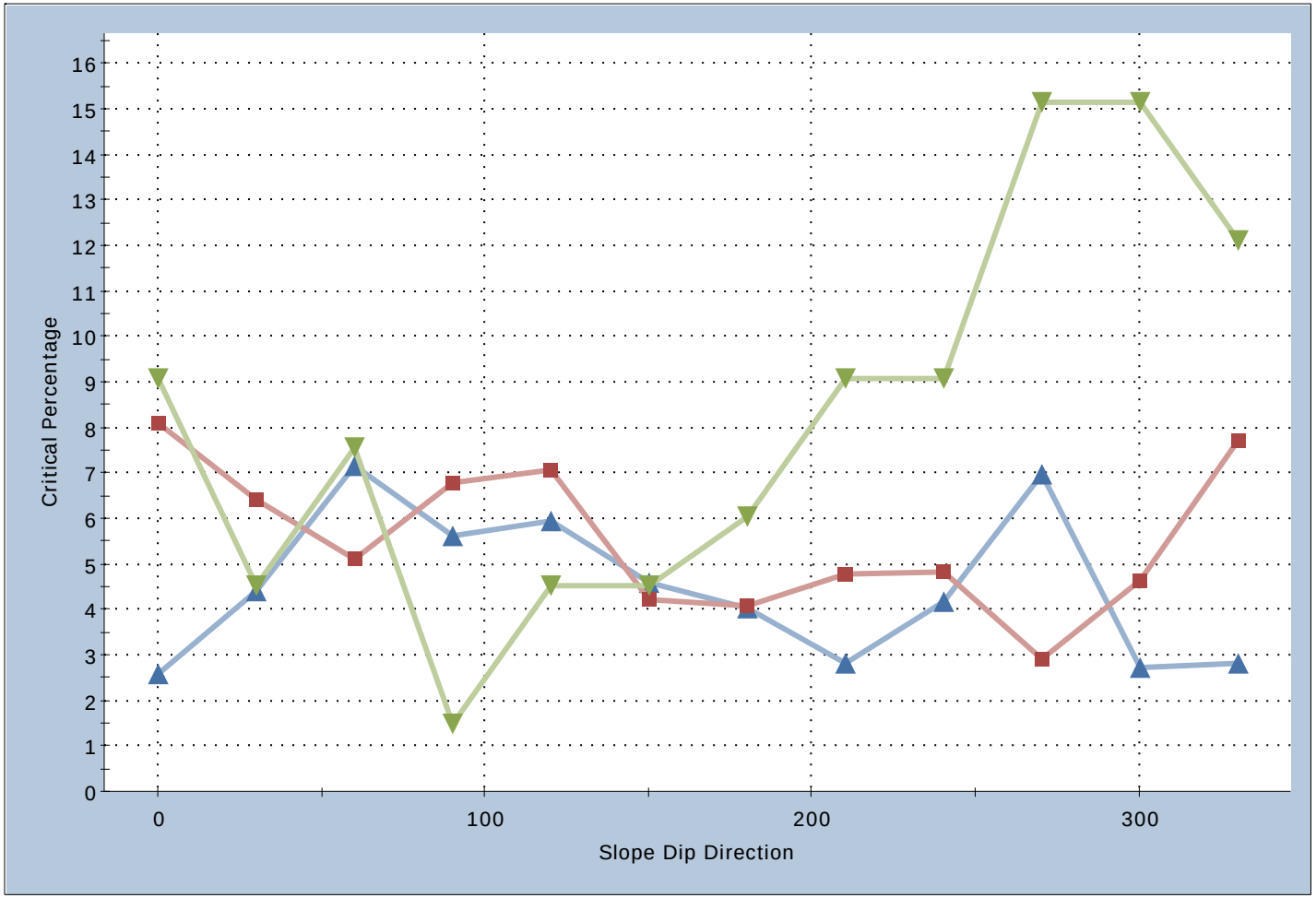


Mean Values

Slope Dip = 50 **Slope Dip Direction = 0** **Friction Angle = 30** **Lateral Limit = 20**

DIPS 7.007	*Project* Sentinel & B3		
	Analysis Description Sensitivity Plot - Sentinel Data: Wedge Sliding		
	Drawn By CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
	File Name Sentinel Only Data sens wedge.dips7	*Date* 3/1/2017	*Enclosure* 15.2

Direct Toppling: Critical Percentage vs. Slope Dip Direction

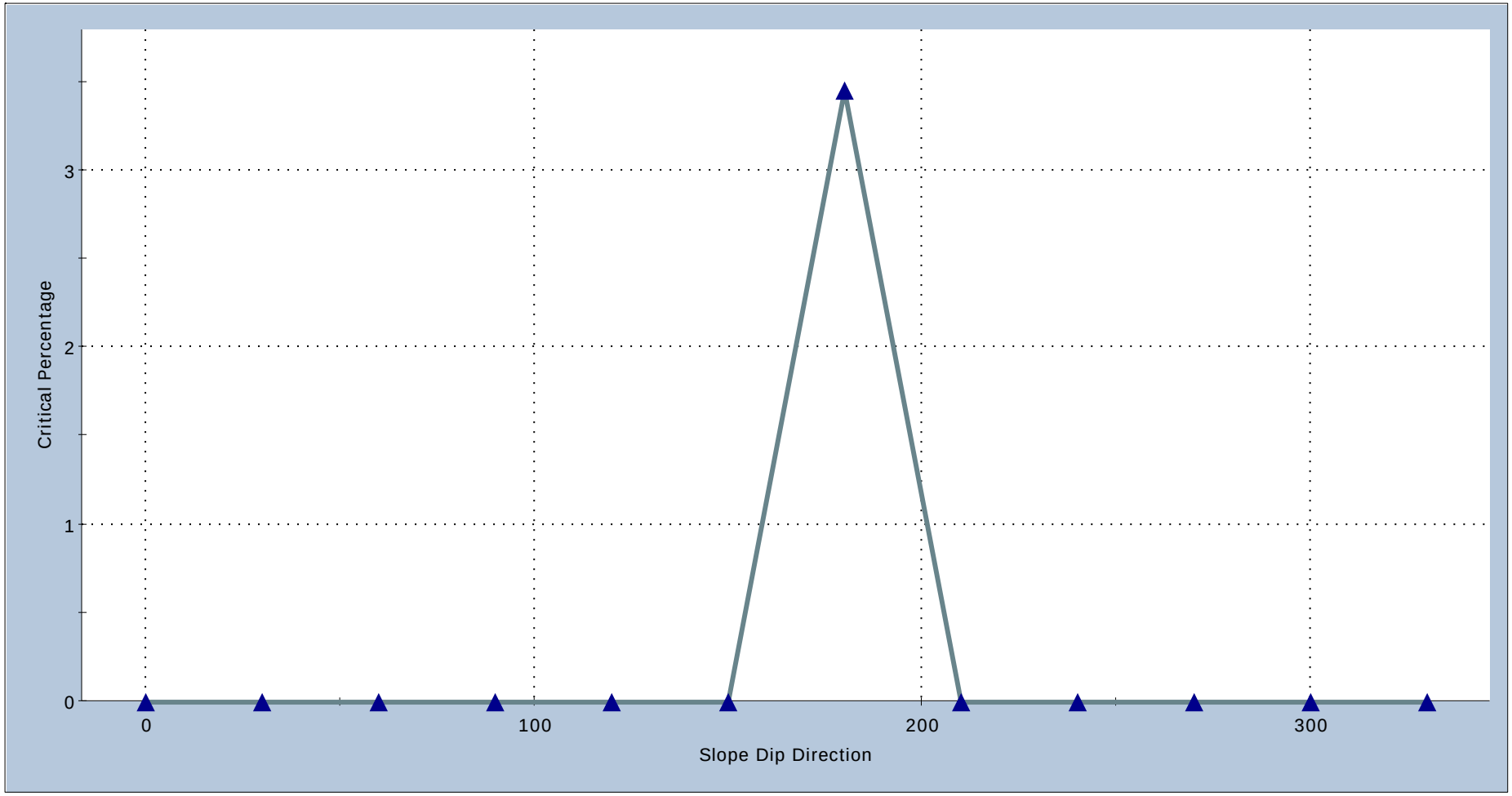


Mean Values

Slope Dip = 50 **Slope Dip Direction = 0** **Friction Angle = 30** **Lateral Limit = 20**

DIPS 7.007	*Project* Sentinel & B3		
	Analysis Description Sensitivity Plot - Sentinel Data: Topple		
	Drawn By CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
	File Name Sentinel Only Data sens topple.dips7	*Date* 3/1/2017	*Enclosure* 15.3

Planar Sliding: Critical Percentage vs. Slope Dip Direction

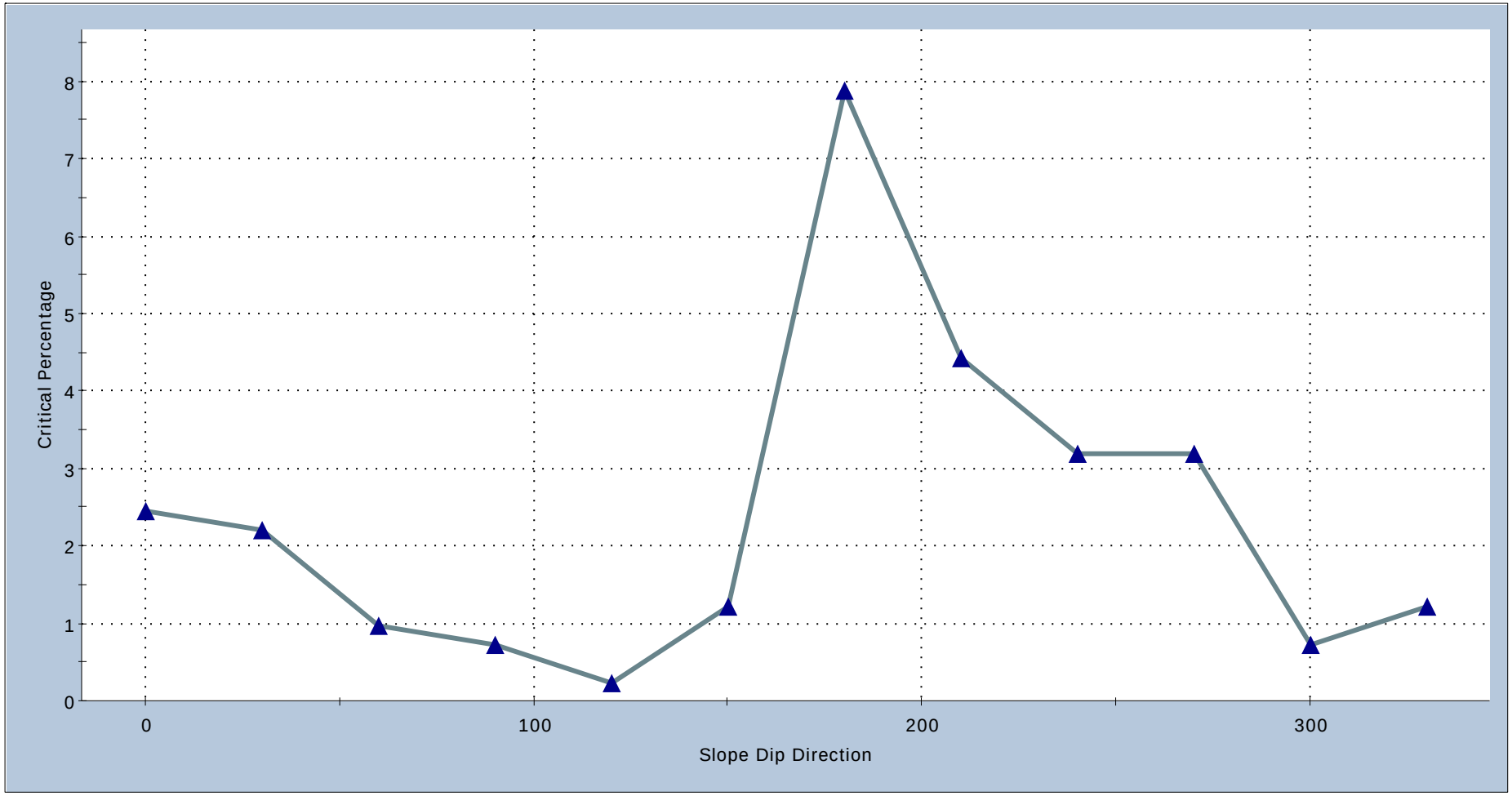


Mean Values

Slope Dip = 50 **Slope Dip Direction = 0** **Friction Angle = 30** **Lateral Limit = 20**

DIPS 7.007	*Project* Sentinel & B3		
	Analysis Description Sensitivity Plot - Butterfield Data: Planar Sliding		
	Drawn By CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
	File Name B3 Data sens planar.dips7	*Date* 3/1/2017	*Enclosure* 16.1

Wedge Sliding: Critical Percentage vs. Slope Dip Direction

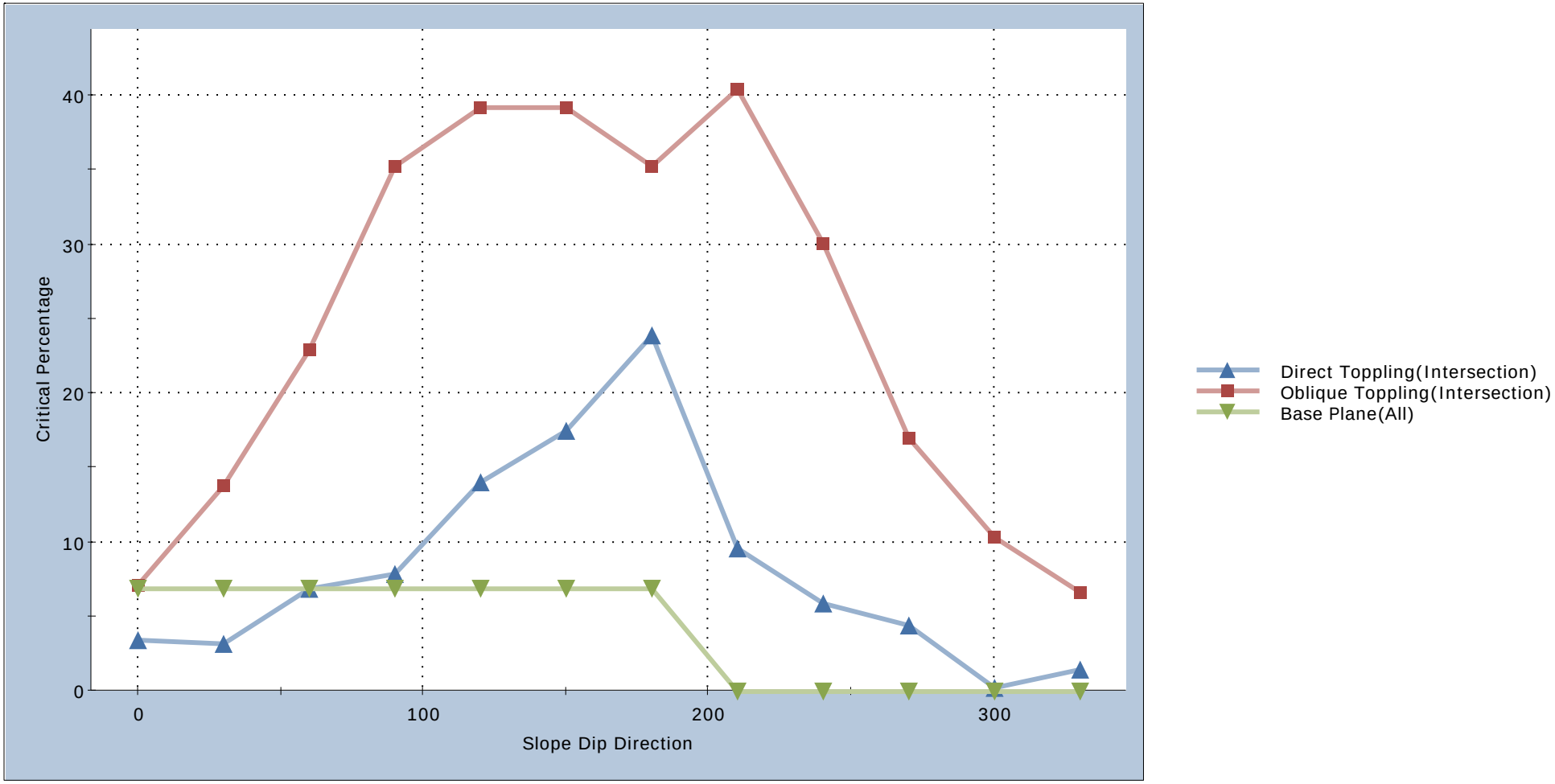


Mean Values

Slope Dip = 50 **Slope Dip Direction = 0** **Friction Angle = 30** **Lateral Limit = 20**

DIPS 7.007	*Project* Sentinel & B3		
	Analysis Description Sensitivity Plot - Butterfield Data: Wedge Sliding		
	Drawn By CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
	File Name B3 Data sens wedge.dips7	*Date* 3/1/2017	*Enclosure* 16.2

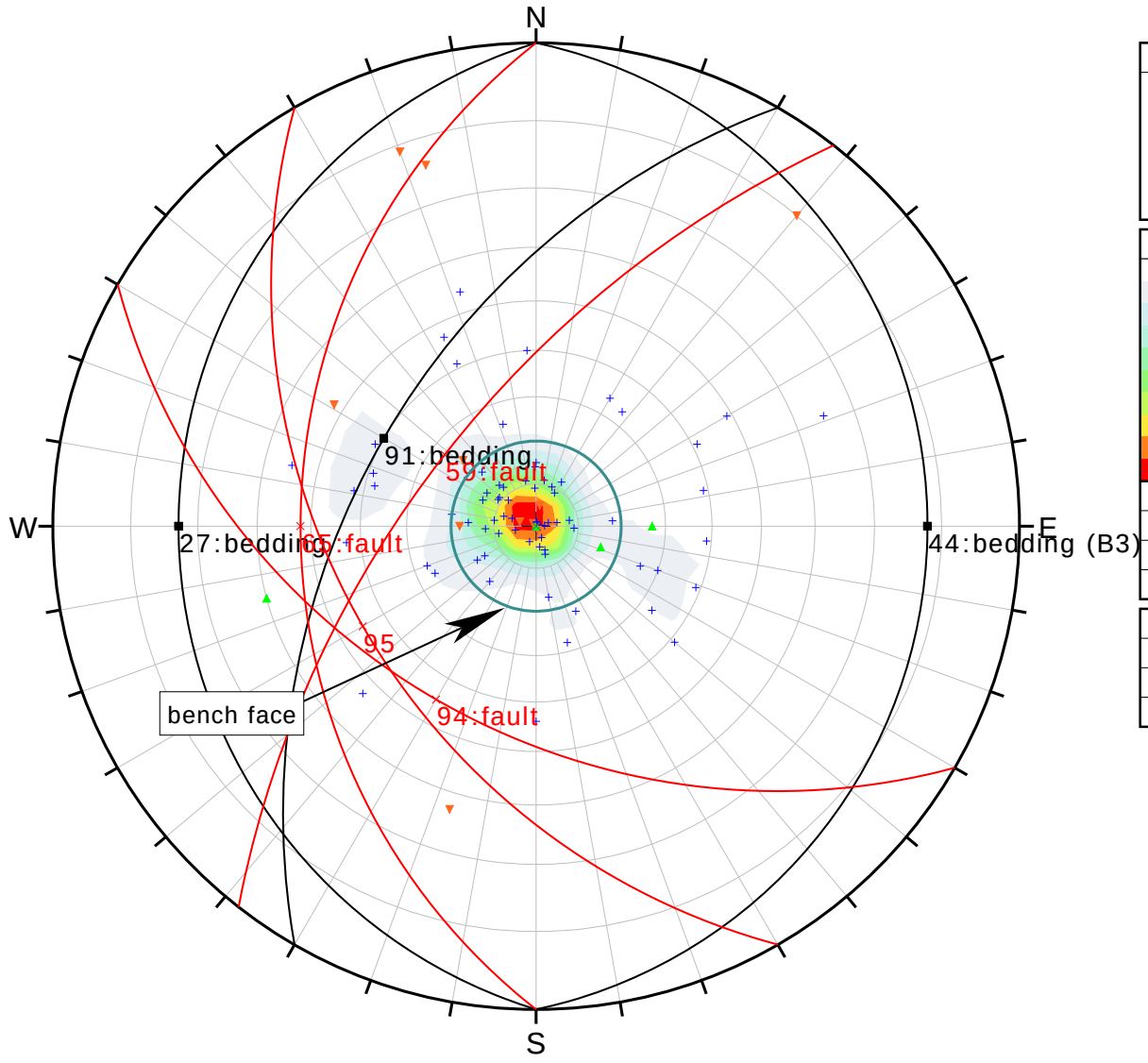
Direct Toppling: Critical Percentage vs. Slope Dip Direction



Mean Values

Slope Dip = 50 **Slope Dip Direction = 0** **Friction Angle = 30** **Lateral Limit = 20**

DIPS 7.007	*Project* Sentinel & B3		
	Analysis Description Sensitivity Plot - Butterfield Data: Topple		
	Drawn By CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
	File Name B3 Data sens topple.dips7	*Date* 3/1/2017	*Enclosure* 16.3



Symbol	TYPE	Quantity
■	bedding	3
×	fault	4
▲	foliation	5
+	joint	72
▼	shear	11

Color	Density Concentrations
	0.00 - 2.30
	2.30 - 4.60
	4.60 - 6.90
	6.90 - 9.20
	9.20 - 11.50
	11.50 - 13.80
	13.80 - 16.10
	16.10 - 18.40
	18.40 - 20.70
	20.70 - 23.00

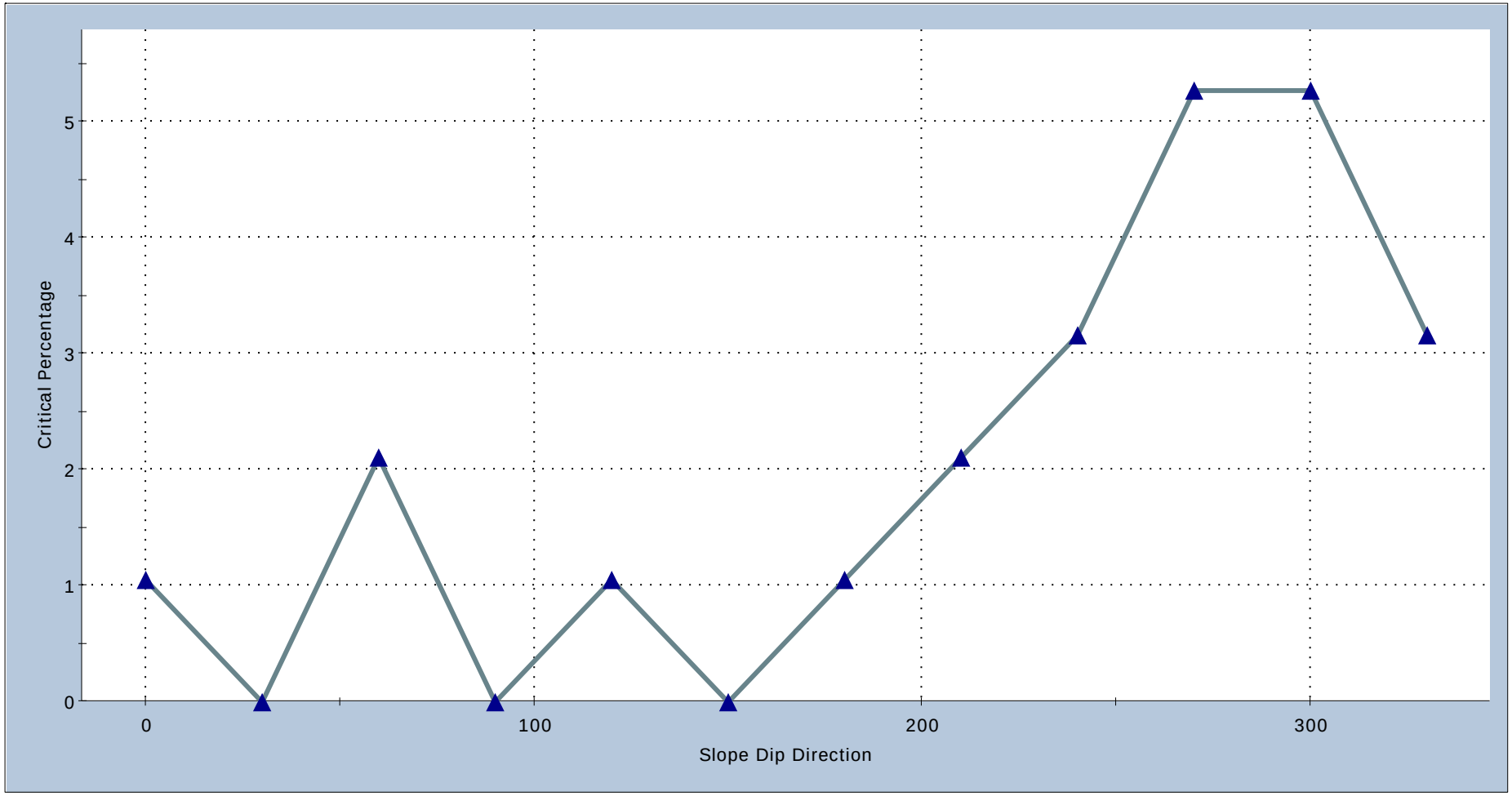
Contour Data	Dip Vectors
Maximum Density	22.22%
Contour Distribution	Fisher
Counting Circle Size	1.0%

Plot Mode	Dip Vectors
Vector Count	95 (95 Entries)
Hemisphere	Lower
Projection	Equal Angle

DIPS 7.007

Project	Sentinel & B3		
Analysis Description	Sentinel Global Data: Bedding & Faults - Vector Plot		
Drawn By	CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
File Name	Sentinel Data 2012 Bedding_flts Eval.dips7	*Date* 2/24/2017	*Enclosure* 17.1

Planar Sliding: Critical Percentage vs. Slope Dip Direction

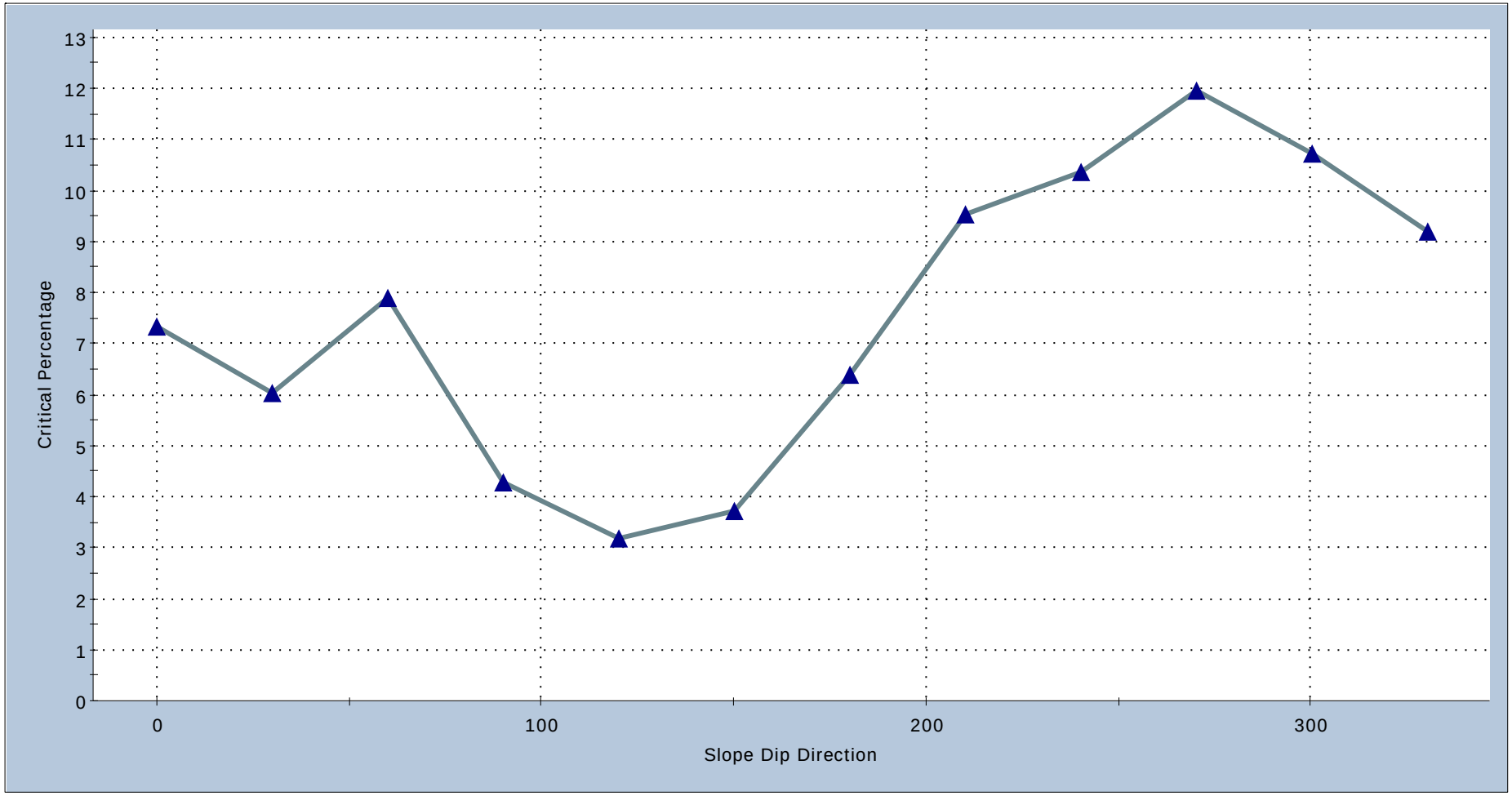


Mean Values

Slope Dip = 50 **Slope Dip Direction = 0** **Friction Angle = 30** **Lateral Limit = 20**

DIPS 7.007	*Project* Sentinel & B3		
	Analysis Description Sensitivity Plot - Planar Sliding on Continuous Structures		
	Drawn By CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
	File Name Sentinel Data 2012 Bedding_flts planar.dips7	*Date* 3/1/2017	*Enclosure* 17.2

Wedge Sliding: Critical Percentage vs. Slope Dip Direction

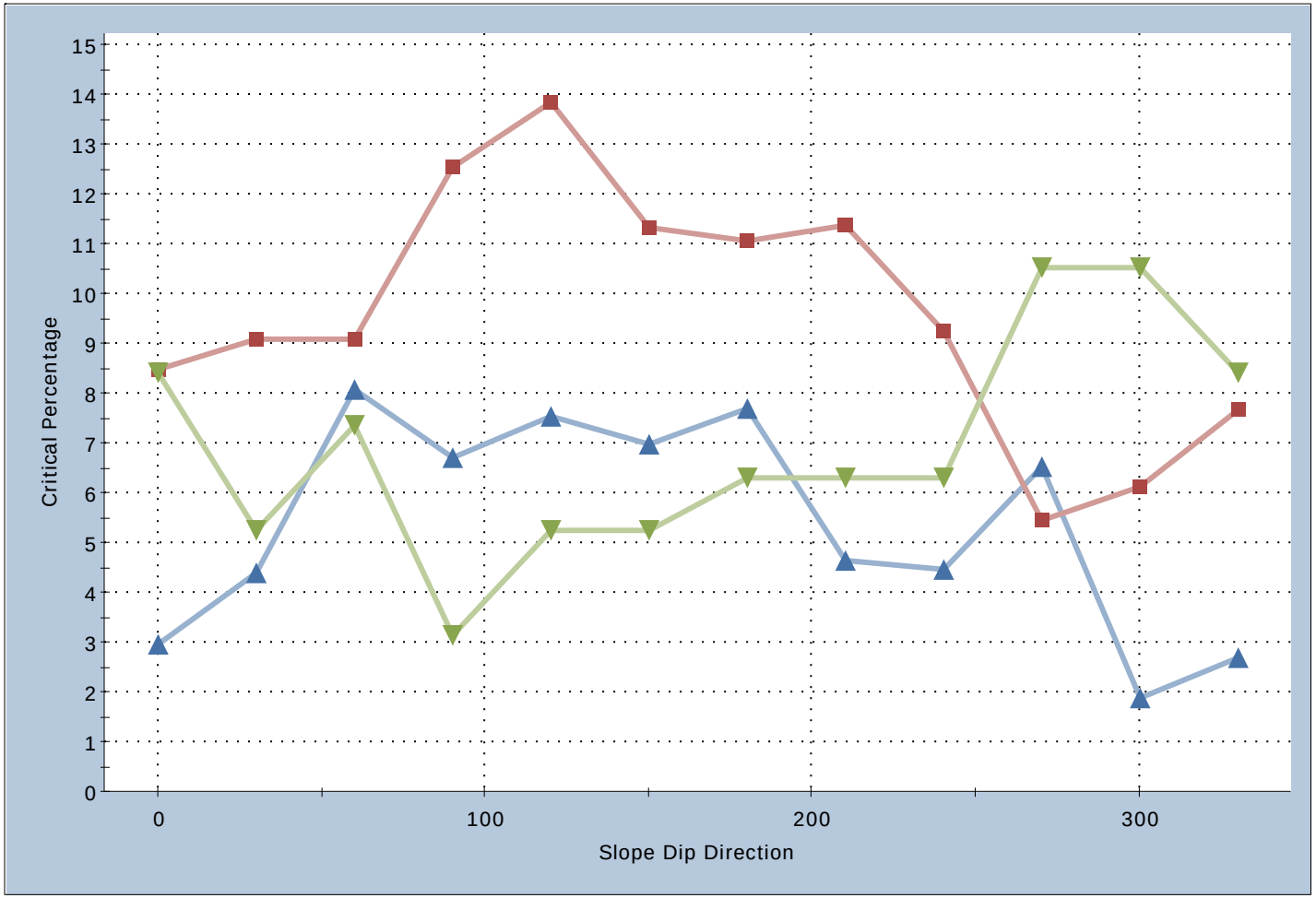


Mean Values

Slope Dip = 50 **Slope Dip Direction = 0** **Friction Angle = 30** **Lateral Limit = 20**

DIPS 7.007	*Project* Sentinel & B3		
	Analysis Description Sensitivity Plot - Wedge Formation on Continuous Structures		
	Drawn By CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
	File Name Sentinel Data 2012 Bedding_flts wedge.dips7	*Date* 3/1/2017	*Enclosure* 17.3

Direct Toppling: Critical Percentage vs. Slope Dip Direction



Mean Values

Slope Dip = 50 **Slope Dip Direction = 0** **Friction Angle = 30** **Lateral Limit = 20**

DIPS 7.007	*Project* Sentinel & B3		
	Analysis Description Sensitivity Plot - Topple Formation on Continuous Structures		
	Drawn By CHJ - Terracon	*Author* JMc	*Scale* $ModelScale
	File Name Sentinel Data 2012 Bedding_flts topple sens.dips7	*Date* 3/1/2017	*Enclosure* 17.4

Appendix H-2: Geology and Soil Report

(SLR, 2013)

Memorandum

To: Maya Rohr, Sespe Consulting

From: John Bennett, P.G., SLR Consulting

Date: June 5, 2013

Subject: Geology and Soils, EIR/EIS, Proposed Amended Plan of Operations, Omya Inc., Lucerne Valley, CA

1. INTRODUCTION

This section describes the local and regional geologic, soils, and seismic conditions that occur in the vicinity of the Project site. These conditions are described and evaluated to ensure that the Project facilities or personnel would not be significantly affected by seismic hazards such as ground rupture or ground shaking due to seismic activity; and that quarry slopes would not present physical hazards as a result of slope failures. Much of the information in this section is derived from, Slope Stability Investigation, Proposed Amended Mine Plan of Operations for the Sentinel and Butterfield Quarries (CHJ, 2012). CHJ (2012) is on file with the County of San Bernardino and the U.S Forest Service, and is included as Appendix XX of this Environmental Impact Report (EIR).

2. GEOLOGY

2.1 Regional

The Sentinel and Butterfield quarries are located in the northern portion of the San Bernardino Mountains, an east-west-trending range within the Transverse Ranges of southern California. The north slope of the range rises abruptly from the desert floor in Lucerne Valley, with elevations along the north range crest reaching 8,400 feet.

Rocks exposed in the San Bernardino Mountains range from Precambrian to Quaternary in age and include igneous, sedimentary and metamorphic rocks (Figure 1). Extensive exposures of pre-Mesozoic metasedimentary rocks unconformably overlie Precambrian basement in the San Bernardino Mountains. The lower part of the section is clastic dominated, the middle part is dolomite-dominated, and the upper part is limestone dominated.

Most of the northern San Bernardino Mountains are underlain at a shallow depth by crystalline bedrock of plutonic composition. However, remnants of Paleozoic metamorphic rocks are present in the northern San Bernardino Mountains. These remnants consist of moderate- to high-grade metamorphosed sandstones, shales, limestones, and dolomites originally deposited in broad marine basins. The sequence of correlatable marine rocks has been identified throughout the western United States, extending to Utah through Nevada and eastern California.

2.2 Site Geology

The Sentinel and Butterfield quarries are located on a large roof pendant of Paleozoic marine rocks (Figure 2). The oldest unit in the Paleozoic sequence present in the Sentinel quarry is the Cambrian Nopah Formation. The Nopah Formation consists of moderately to thickly bedded, fine- to coarse-grained dolomite and dolomitic marble. The Nopah Formation was observed in the west Sentinel quarry area. Bedding is variable, but generally dips moderately toward the east. The Nopah Formation is not considered ore material.

The Mississippian Monte Cristo Limestone is the primary ore body of the Sentinel quarry and is separated from the Nopah Formation by a well-exposed north-northeast trending west-dipping high-angle reverse fault. The Monte Cristo Limestone includes several members, with the 350-feet thick Bullion Member forming the majority of rock exposed in the Sentinel quarry. The Bullion Member consists of a limestone that was metamorphosed into a light gray to white fine-grained calcite marble of very high purity. The Yellowpine Member comprises a small exposure in the southwest portion of Sentinel quarry. The Monte Cristo Limestone consists of white to yellowish marble in thin to thick beds. Bedding is variable and exhibits little structural control relative to joints in the Monte Cristo units. Generally, bedding in the Monte Cristo Formation dips westward at moderate angles.

The Pennsylvanian Bird Spring Formation is exposed at the ground surface across most of the south Sentinel quarry area and is shown to be in thrust fault contact with the Monte Cristo Limestone members to the north. Bird Spring Formation exposed at the Sentinel quarry area is the lower part of the formation and generally consists of gray marble with chert nodules. Based on surface exposures, this unit is folded on a small and large scale. Variability in bedding orientation can be observed within individual outcrops. The Upper Bird Spring Formation comprises the white calcite marble ore of the Butterfield quarry (CHJ, 2012).

2.3 Soils

Generally, soil or growth medium is rarely more than 6 to 12 inches thick but may reach 2 feet in thickness near or within ravines. This thin soil cover is due to the rugged mountainous nature of the Project Area and arid climate.

Forest Service studies (USFS, 1988) have determined that much of the soil found in the limestone mining area is classified as low to very low in productivity. The soils are predominantly shallow, moderate to excessively drained, coarse textured, with low moisture holding capacity. Bedrock outcroppings and substantial rock fragments are present throughout the soil in the areas of Sentinel and Butterfield quarries.

2.4 Groundwater Conditions

Groundwater has not been encountered in the Project Area. The depth of groundwater in the Project Area has not been measured because no wells exist in the vicinity. As reported in Pluess-Stauffer (1994) in over 100 exploration core holes drilled to depth 100 ft below ground surface did not encounter groundwater. Therefore, the current depth to groundwater in the Project Area is expected to be greater than 550 ft bgs (CHJ, 2012).

3. SEISMICITY AND SEISMIC HAZARDS

3.1 Regional Seismicity and Faulting

The tectonics of the Southern California area are dominated by the interaction of the North American and Pacific tectonic plates, which are sliding past each other in a transform motion. Although some of the motion may be accommodated by rotation of crustal blocks such as the western Transverse Ranges (Dickinson, 1996), the San Andreas Fault zone is thought to represent the major surface expression of the tectonic boundary and to be accommodating most of the transform motion between the Pacific Plate and the North American Plate. However, some of the plate motion is apparently also accommodated by other northwest-trending strike-slip faults that are related to the San Andreas system, such as the San Jacinto fault and the Elsinore fault. Local compressional or extensional strain resulting from the transform motion along this boundary is accommodated by left-lateral, reverse, and normal faults such as the Cucamonga fault and the nearby North Frontal fault zone.

The fault having the most significance to the site from a ground shaking standpoint is the North Frontal Fault Zone, which is exposed approximately 2 miles north of the site along the range front of the San Bernardino Mountains. This fault actually consists of a complex zone of left-lateral, thrust, and reverse faults and forms the boundary between the Mojave Desert Geomorphic Province and the Transverse Ranges Geomorphic Province to the south. Since this fault dips at a moderate angle to the south, the fault plane is probably less than 2 miles beneath the site.

The Eastern California Shear Zone (ECSZ) is a zone of regional deformation traversing the Mojave Desert that includes a system of predominantly northwest-trending strike-slip faults. The ECSZ accommodates strain along the Pacific/North American Plate boundary across a zone approximately 65 miles wide and is thought to transfer as much as 15 percent of the total plate boundary shear into the Great Basin area (Shermer and others, 1996). A number of faults of this system ruptured in combination during the 1992

Landers earthquake east of the site. Rupture of that event extended within approximately 25 miles of the mine area and included several faults (Hauksson, 1992). An earthquake of M 6.4, known as the Big Bear earthquake, occurred a few hours later. The Big Bear quake and its aftershocks occurred along a northeast-trending alignment located approximately 12 miles southeast of the site. The Hector Mine earthquake of 1999 occurred on the Lavic Lake and Bullion faults of the ECSZ. The Helendale fault, Lenwood-Lockhart fault, and Johnson Valley fault of this system are located approximately 4.9 miles northeast, 15.5 miles northeast, and 19 miles east-northeast of the site, respectively. These faults are major components of the ECSZ and are considered Holocene active.

The northwest-trending San Andreas Fault is located approximately 18 miles southwest of the site. The toe of the mountain front in the San Bernardino area roughly demarcates the presently active trace of the San Bernardino Mountains segment (CHJ, 2012).

3.2 Local Seismicity and Faulting

According to the latest Alquist-Priolo Earthquake Fault Zone Maps, no known active or potentially active faults are located within the Project Area. Based on their review of published and unpublished literature and maps, stereoscopic aerial photographs, or during the field mapping, CHJ (2012) describes finding only inactive faults traversing the Project Area. Therefore, ground rupture due to primary fault slip in the Project Area is not anticipated.

CHJ (2012) reports observations of various faults in the quarry walls. In the mapped areas, both high-angle and low-angle faults were observed. Such faulting is typical of the northern San Bernardino Mountains, and most or all of these are likely to predate or be associated with uplift of the San Bernardino Mountains. Quaternary activity along these faults is unlikely.

In the western portion of the Sentinel quarry, the Cambrian Nopah Formation is in reverse fault contact with the ore (Mississippian Monte Cristo Limestone). This fault strikes about N30E and dips steeply (70 degrees) toward the northwest.

A thrust fault is exposed in the southern portion of the existing Sentinel quarry. The thrust dips toward the south-southwest at a moderate angle (45 degrees) and places the Pennsylvanian Bird Spring Formation over the older Monte Cristo Limestone. In the south Sentinel quarry, the dark gray limestone of the Bird Spring Formation represents a significant overburden on the ore body.

Various high-angle faults of limited continuity are exposed in the existing Butterfield quarry walls. These faults include intruded fault zones that exhibit thick gouge zones and limited exposure (CHJ, 2012).

3.3 Ground motion parameters

The 2010 California Building Code (CBC) Design Acceleration Parameters for structures were determined from latitude/longitude coordinates N34.3303, W116.9413 using the web-based U.S. Geological Survey Ground Motion Parameter Calculator and are summarized in Table 1.

The corresponding value of peak ground acceleration (PGA) from the design acceleration spectrum according to the 2010 CBC is 0.52g (CHJ, 2012). This PGA estimation means that the Project Area could experience heavy ground shaking in the event of an earthquake.

4. SLOPE STABILITY

The Project involves lateral expansion of the existing Sentinel and Butterfield quarries (Figure 3). Rock (limestone) slopes in the quarries will be up to a maximum of approximately 625 feet high and inclined with an overall slope of approximately 48 degrees to 50 degrees. Mining will be conducted with approximately 60-foot high inter-bench slope faces inclined at 70 degrees in the Sentinel quarry and approximately 50-foot high inter-bench slope faces inclined at 70 degrees in the Butterfield quarry. An intervening bench approximately 30 feet wide and 25 feet wide for the Sentinel and Butterfield quarries, respectively, will be created. The placement of haul roads across some slopes and the proposed benching plan will result in the approximate 48- to 50-degree overall slope angle of quarry walls.

The B5 Pad, which is used to store overburden and waste materials, will be expanded to accommodate the additional materials that will be generated by excavation of the expanded quarries. The B5 Pad will have maximum elevations that will be 150 to 200 feet above adjacent grade. Slopes of the expanded B5 Pad were also evaluated with regard to slope stability for several heights and bench configurations, yielding overall reclaimed slope gradients of 2(h) to 1(v).

CHJ's evaluation of slopes proposed for the quarries and the B5 Pad is described in this section.

4.1 Strength parameters

Kinematic and global slope stability of the proposed reclaimed slopes for Sentinel and Butterfield quarries were performed by Pluess-Staufer (1992a, and 1992b) and by CHJ (2012) to ascertain the long term stability of the rock slopes. In addition, CHJ (2012) evaluated the stability of the slopes of the proposed overburden that will be stockpiled in the B5 Pad.

Rock strength properties for global stability calculations were modeled using Hoek Brown criteria and the ultimate mining depths (highest slopes) anticipated in each

quarry. The shear strength properties of the overburden stockpile were modeled using the Mohr-Coulomb (i.e. cohesion and friction angle) criterion. Final quarry bottom elevations in the Sentinel quarry and eastern portion of the Butterfield quarry include backfill that will result in shorter overall slope heights. A discussion and summary of these analyses is presented below. Slope stability analyses performed are discussed in following sections and the calculations are presented in CHJ (2012). Strength parameters used in the stability analyses are reported in Tables 2 through 5.

4.2 Kinematic Analysis

Kinematic analysis involves the evaluation of bedrock stability based on the presence of structural discontinuities including joints, faults, shear zones, bedding and foliations. Kinematic analysis addresses only the potential failure mode(s) and does not consider mass or force in a limit-equilibrium analysis. Structurally-controlled kinematic failure modes include planar, wedge, and topple failures. Circular failure of highly fractured rock masses is also feasible and is considered in a global stability analysis (as presented previously).

CHJ Consultants performed stereonet analyses for selected representative rock slopes utilizing the data from mapped geologic structures within the site. Rock slopes in the Sentinel quarry were evaluated for slopes with dip azimuths oriented at 45°, 90°, 110°, 130°, 225°, 270° and 315° and for Butterfield quarry at 90°, 180°, 270°, and 360° representing the suite of proposed slope aspects. The stereonet data are included in the CHJ (2012).

The proposed 70-degree intra-bench rock slopes were analyzed for wedge and plane failure modes where kinematic evaluation using Markland's Test indicated a potential failure mode. The results of the planar and wedge failure mode analysis for individual structures indicate overall suitable intra-bench stability (factors of safety) for the proposed mining and reclamation slopes in all domains and aspects (CHJ, 2012).

4.3 Global Stability Analysis

The mining rock slopes for the Sentinel and Butterfield quarries for native-over-cut and overburden-over-cut rock slopes were evaluated for several configurations of proposed overburden stockpile (fill) slopes, including heights of 250 feet, 400 feet and 560 feet.

The global (rotational) stability of proposed mining slopes as depicted in the Amended Mining Plan (AMP) and proposed reclaimed B5 Pad as depicted in the Reclamation Plan was analyzed using Spencer's method under both static and seismic conditions for rotational failures utilizing the SLIDE computer program, version 6.0 (Rocscience, Inc., 2011). Selection of the AMP slope configurations for the analysis of excavated slopes, which depicts the tallest anticipated excavated/native slopes proposed for mining at the Sentinel and Butterfield quarries, is based on a most-conservative analysis approach.

Reclamation is planned to fill portions of the quarry bottoms so that ultimate reclaimed slope heights will be shorter and the fill will be confined within the enclosed quarry pit.

Representative slope sections of the excavated rock slopes and overburden stockpiles derived from the AMP were modeled. The seismic stability calculations were performed using a lateral pseudostatic coefficient "k" of 0.20 due to the proximity of the North Frontal fault zone. Groundwater was not considered in the global stability evaluation due to the lack of seepage or groundwater anticipated in the generally arid site environment.

The calculated static and pseudo-static factors of safety are in excess of 1.5 and 1.1 respectively for the modeled proposed rock and overburden slope configurations. These results satisfy Surface Mining and Reclamation Act (SMARA) guidelines and standard of practice for slope stability, based on the intended open space and habitat end uses of the reclaimed Project Area.

5. EVALUATION OF OTHER GEOLOGIC HAZARDS

In addition to ground shaking due to earthquakes, effects of seismic activity could include surface fault rupture, soil liquefaction, seismically-induced differential settlement, ground lurching, seismically induced landsliding, lateral spreading, earthquake-induced flooding, seiches, and tsunamis. How these secondary effects may apply to the project site is discussed below.

5.1 Liquefaction Potential and Groundwater Conditions

Liquefaction occurs when saturated sediments temporarily lose strength during an earthquake and act like a liquid rather than a solid. Liquefaction potential is a function of three factors: soil type, depth to groundwater, and seismic induced ground shaking potential. The potential for liquefaction within the Sentinel and Butterfield quarries property boundaries is low due to the lack near-surface groundwater.

5.2 Surface Fault Rupture

According to the Alquist Priolo Fault Zone Map depicting the Project Area, no mapped surface fault crosses through or extends towards the Project site. Therefore, the Project Area is not located within a designated active fault zone. Based on available data reviewed by CHJ (2012), including site specific geologic mapping, the potential for surface rupture resulting from the movement of a previously unrecognized fault is not known with certainty but is considered low.

5.3 Seismically-Induced Settlement

Earthquake induced settlement is compression of the underlying loose soils due to liquefaction or densification that occur during strong ground shaking and causes uneven

settlement of the ground surface. The potential for soil liquefaction is considered low and accordingly the potential for liquefaction-induced settlement is low. This would not be a concern for the predominantly hard rock conditions at this site.

5.4 Ground Lurching and Seismically-Induced Landsliding

Ground lurching is the horizontal movement of ground located adjacent to slope faces caused by seismic forces exerted during an earthquake. It can occur in areas underlain by soft or weak deposits and often results in permanent displacement and longitudinal cracking parallel to the slope face at some distance setback from the top of the slope. In steep slope areas, significant ground shaking may cause landslides or rock slope failures.

The Project Area could experience heavy ground shaking in the event of an earthquake, but bedrock is generally competent. Ground acceleration was integrated into the slope stability evaluation described above in Section 4, which concluded that factors of safety for the proposed slopes in the expanded quarries and the B5 Pad are acceptable.

5.5 Lateral Spreading

Seismically induced lateral spreading involves lateral movement of earth materials due to ground shaking. Lateral spreading is characterized by near-vertical cracks with predominantly horizontal movement of the soil mass involved along potentially liquefiable layers. Because the site liquefaction potential is low, the potential for lateral spreading is considered low.

5.6 Earthquake-Induced Flooding

Flooding may be caused by failure of dams or other water retaining structures due to an earthquake. There are no major water storage facilities or dams in the immediate vicinity of the site.

5.7 Tsunamis and Seiches

Tsunamis are generated in large bodies of water by fault displacement or major ground movement. A seiche is an earthquake-induced wave in a confined body of water such as a lake, reservoir, or bay. Based on the location and the elevation of the site, there is no risk of tsunamis or seiches affecting the Project Area.

6. REGULATORY SETTING

6.1 Federal Regulations

The 1997 Uniform Building Code (UBC) was developed by the International Conference of Building Officials (ICBO) and is used by most states, including California, as well as local jurisdictions to set basic standards for acceptable design of structures and facilities.

The UBC provides information on criteria for seismic design, construction, and load-bearing capacity associated with various buildings and other structures and features. Additionally, the UBC identifies design and construction requirements for addressing and mitigating potential geologic hazards. New construction generally must meet the requirements of the most recent version of the UBC.

6.2 State Regulations

Alquist-Priolo Earthquake Fault Zone Act

The State Alquist-Priolo Earthquake Fault Zoning Act (A-P Act) of 1972 was passed to mitigate the hazards associated with surface faulting in California. Administered by the California Department of Conservation (DOC), the A-P Act prevents construction of buildings used for human occupancy on the surface traces of active faults. Before a project can be permitted, cities and counties must require a geologic investigation to demonstrate that proposed buildings will not be constructed across active faults.

Seismic Hazards Mapping Act

The 1990 Seismic Hazards Mapping Act and related regulations establish a statewide minimum public safety standard for mitigation of earthquake hazards. The purpose of this Act is to protect the public from the effects of strong ground shaking, liquefaction, landslides, or other ground failure as well as other hazards caused by earthquakes. The Act provides the minimum level of mitigation needed to reduce the risk of a building collapse. Under this Act, the lead agency can withhold permits until geologic investigations are conducted and mitigation measures are incorporated into building plans. In addition, the Act addresses not only seismically induced hazards but also expansive soils, settlement, and slope stability. The program and actions mandated by this Act closely resemble those of the A-P Act by requiring the State Geologist to delineate various “seismic hazard zones”; and Cities, counties, and/or other local permitting authority to regulate certain development “projects” within these zones by withholding the development permits for a site until the geologic and soil conditions are investigated and appropriate mitigation measures (if required) are incorporated into development plans.

California Building Code

The California Building Code (CBC), known as Title 24, CCR, Part 2, specifies the acceptable design and construction requirements associated with various facilities or structures. These codes are administered and updated by the California Building Standards Commission. This Code specifies criteria for open excavation, seismic design, and load-bearing capacity directly related to construction in the State. The CBC augments the UBC and provides information for specific changes to various sections in it. The seismic building requirements under the CBC are more stringent than the federal UBC.

Surface Mining and Reclamation Act

With respect to addressing geotechnical slope stability for final reclamation slopes, SMARA does not specify a minimum factor of safety for slope stability. However, §3502(b)(3) indicates that final reclaimed slopes shall be flatter than the critical gradient, which implies that static factors of safety should be greater than 1.0. The section further states:

> *"Wherever final slopes approach the critical gradient for the type of material involved, regulatory agencies shall require an engineering analysis of slope stability. Special emphasis on slope stability and design shall be taken when public safety or adjacent property are affected."*
> Section 3704(f) states that,
>
> *"Cut slopes, including final highwalls and quarry faces, shall have a minimum slope stability factor of safety that is suitable for the proposed end use and conform with the surrounding topography and/or approved end use."*

7. PROJECT IMPACTS AND MITIGATION MEASURES

7.1 Analysis Methodology and Significance Criteria

Appendix G of the California Environmental Quality Act (CEQA) Guidelines contains the following criteria in evaluating impacts a project may have relative to Geology and Soils.

a) Expose people or structures to potential substantial adverse effects, involving the risk of loss, injury, or death involving:
   - Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zone Map issued by the State Geologist for the area or based on other substantial evidence of known fault;
   - Strong seismic ground shaking;
   - Seismic-related ground failure, including liquefaction; or
   - Landslides;

b) Result in substantial soil erosion or the loss of topsoil.

c) Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse.

d) Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to the life or property.

e) Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water.

Criteria (a), (b), and (c) are discussed below. The Project Area does not contain expansive soils, and no septic systems are planned for the Project Area. Therefore, no impacts would occur under criteria (d) and (e) above, and those criteria are not considered further.

7.2 Impact GS-1: The Project Could Expose People or Structures to Strong Ground Shaking During a Seismic Event

The Project Area is not located within a currently designated State of California Earthquake Fault Zone (Alquist Priolo Zone, known as Special Studies Zones prior to January 1, 1994). However, there are active faults in the region, from which ground shaking can be anticipated to occur over the life of the Project. In most of California, ground-shaking caused by earthquakes associated with rupturing faults is likely to occur. Earthquake intensities vary throughout the region, depending upon the magnitude of the earthquake, the distance from the causative fault, and the type of geologic material underlying a given location.

Peak ground acceleration of 0.52 g was calculated for the Project Area in CHJ (2012). This means that the Project Area could experience a relatively high degree of ground acceleration (shaking) during an earthquake. The potential hazard to humans associated with such shaking would be failure of structures and resulting falling objects. However, no inhabited structures are anticipated in the project area. Therefore, the Project will not expose people or structures to potential substantial adverse effects, involving the risk of loss, injury, or death involving the risk of loss, injury, or death. As a result, this impact is considered less than significant under criterion (a) above and no mitigation is required.

7.3 Impact GS-2: Potential to Expose Structures and Workers to Geologic Hazards

The Project Area may experience heavy ground shaking if an earthquake occurs. In addition to ground shaking, effects of seismic activity may include surface fault rupture, soil liquefaction, seismically induced differential settlement, ground lurching, lateral spreading, earthquake-induced flooding, seiches, and tsunamis. As described in Section 4, none of these geologic hazards is expected to occur at the Project Area.

In steep slope areas, such as the quarry walls that would be extended by the Project, heavy ground shaking can cause slope failures. Ground shaking at the Project Area could be heavy in the event of an earthquake. Based on factors of safety calculated for the proposed slopes, CHJ (2012) concluded that the proposed slopes will be suitably stable against gross failure for the anticipated long term conditions, including the effects of seismic shaking. However a future earthquake could change the existing slope conditions and cause localized weak zones, possibly causing unanticipated slope failures. Implementation of Mitigation Measure GS-1 will bring this potential impact to less than significant.

Level of Significance Prior to Mitigation: Potentially Significant

Mitigation Measure GS-1: Inspect Slope Conditions After Seismic Events and Remove Precarious Rocks From Slopes

This mitigation measure requires that slope conditions in the Project Area be inspected after a seismic event exceeding 5.5 magnitude on the Richter Scale originating from an epicenter located within 100 miles of the Project Area. Quarry operations will be halted until a qualified geotechnical engineer is retained to inspect slope conditions for potential loose blocks or other unsafe or unstable conditions. Any required slope stabilization measures must lead to achievement of a minimum factor of safety of 1.5 before quarry operations continue.

Under this Mitigation Measure, the Project Area also must be inspected for precarious rocks. Natural weathering processes will result in accumulation of talus on excavated benches. The talus can be left on the slopes to facilitate revegetation and to give reclaimed slopes a relatively natural appearance. It is anticipated that any boulders resulting from weathering processes will be angular and will therefore be less likely to roll downhill. Any large unstable rounded boulders on slopes steeper than 2:1 must be removed or stabilized where accessible. Areas below loose rocks must be restricted from entry and identified with proper signage.

Level of Significance After Mitigation: Less than significant.

Impact GS-3: Ground Disturbance and Vegetation Removal Could Increase Soil Erosion

Expanding the existing quarries and B5 Pad will involve grubbing and removal of topsoil and overburden removal. Such activities will result in surface disturbance and removal of vegetation, leading to increased soil exposure and the potential for increased soil erosion. However, according to the proposed Amended Plan of Operations, topsoils removed during the Project will be stored onsite in designated areas for later use in reclamation.

The Project has been designed to convey storm water runoff to on-site drainage basins. Temporary diversion ditches, berms, catchment basins, and use of erosion control materials would be employed for sediment control. Soil erosion would represent a potentially significant impact under criterion (c) above. Implementation of Mitigation Measure 3.6-5 would reduce impacts associated with erosion to a less than significant level.

Level of Significance Before Mitigation: Potentially Significant

Mitigation Measure GS-2: Implement Soil Stabilization and Erosion Control Measures

The following preventative measures shall be implemented to minimize wind and water erosion of onsite soils:

- Surface disturbance shall be kept to the minimum that is required to construct and operate the Project.
- The Project shall be designed and constructed with erosion control features (e.g., berms, retention ponds, and vegetation cover) to minimize runoff and to protect on-site areas susceptible to erosion from surface flow or wind and to protect off-site receiving waters from being affected by pollutants.
- Areas of exposed soils resulting from excavation and grading work shall be weatherized by covering with materials such as rocks, vegetation, asphalt, or concrete, or through use of soil stabilization chemicals, watering, or other means to withstand and avoid erosion.
- Drainage control structures shall be used where necessary to direct surface drainage away from disturbed areas and to minimize runoff and sediment disposition down-slope from all disturbed areas. These structures shall include culverts, ditches, water bars (berms and cross ditches), and/or sediment traps. Polluted discharge from disturbed on-site areas shall be inhibited through implementation of appropriate storm water best management practices.
- Reclamation of disturbed areas shall occur concurrently with mining when and where practical.

In addition, the Project Proponent shall prepare and implement a Storm Water Pollution Prevention Plans (SWPPP) for construction activities and subsequently for operations. The SWPPPs shall be prepared as required by and consistent with the State Water Resources Control Board requirements. In addition, all mine personnel shall be trained before they enter the worksite regarding environmental concerns, pertinent laws and regulations, and elements of the SWPPP.

Level of Significance After Mitigation: Less than Significant

Table 1: 2010 CBC - Seismic Parameters

PARAMETER	VALUE
Mapped Spectral Acceleration Parameters	Ss = 1.94 and S1 = 0.75
Site Coefficients	Fa = 1.0 and Fv = 1.0
Adjusted Maximum Considered Earthquake (MCE) Spectral Response Parameters	SMS = 1.94 and SM1 = 0.75
Design Spectral Acceleration Parameters	SDS = 1.29 and SD1 = 0.50

Table 2: Sentinel Quarry - Monte Cristo and Bird Spring Bedrock Units - Slope Stability Parameters

PARAMETER	VALUE	DESCRIPTION
Unit Weight (pcf*)	150	--
Intact UCS1 (psf**)	1,500,000	Specimen requires more than one blow of a geological hammer to fracture it
Geological Strength Index	65	Very blocky with good surface conditions
Intact Rock Constant (mi***)	9	Marble
Disturbance Factor	1	Production blasting

1 Uniaxial Compressive Strength test result
* pcf = pounds per cubic foot
** psf = pounds per square foot
*** mi = unitless constant

Table 3: Butterfield Quarry - Bird Spring Bedrock Units - Slope Stability Parameters

PARAMETER	VALUE	DESCRIPTION
Unit Weight (pcf*)	150	--
Intact UCS1 (psf**)	1,500,000	Specimen requires more than one blow of a geological hammer to fracture it
Geological Strength Index	65	Blocky with good surface conditions
Intact Rock Constant (mi***)	9	Marble
Disturbance Factor	1	Production blasting

1 Uniaxial Compressive Strength test result
* pcf = pounds per cubic foot
** psf = pounds per square foot
*** mi = unitless constant

Table 4: Planar Analyses - Slope Stability Parameters

PARAMETER	VALUE	DESCRIPTION
Unit Weight (pcf*)	150	--
Cohesion (psf)	800	Specimen requires more than one blow of a geological hammer to fracture it
Friction Angle (degrees)	50	Blocky with good surface conditions

Table 5: Shear Strength Parameters of Stockpile Stability Analyses

PARAMETER	VALUE	COMMENT
Overburden stockpiles material		
Unit Weight (pcf)	125	Results from tests on comparable material at White Knob quarry
Cohesion (psf)	100	Results from tests on comparable material at White Knob quarry
Friction Angle (degrees)	35	Results from tests on comparable material at White Knob quarry
Native subgrade beneath overburden stockpiles.		
Unit Weight (pcf)	130	Results from tests on comparable material at White Knob quarry
Cohesion (psf)	200	Results from tests on comparable material at White Knob quarry
Friction Angle (degrees)	38	Results from tests on comparable material at White Knob quarry

8. REFERENCES

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