Climax Molybdenum
A Freeport-McMoRan Company

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October 15, 2020

Mr. Dustin Czapla
Environmental Protection Specialist
Division of Reclamation, Mining and Safety
Department of Natural Resources
1313 Sherman St. Room 215
Denver, Colorado 80203

RE: Climax Mine, Permit No. M-1977-493, Technical Revision 32 – Minor Design Change to McNulty OSF, Modification to TR-25

Dear Mr. Scott,

Enclosed please find Technical Revision 32 to the Climax Mine Reclamation Permit (M-77-493) that consists of the following:

- Description of modification to TR-25, McNulty OSF Expansion Design and associated drawings

The TR materials (electronic files) are attached to this letter. The $1,006.00 fee applicable to a 112d operation has been paid via credit card on the online portal as part of this submittal. We appreciate your review of the TR and look forward to your approval. Please contact Diana Kelts at 719-486-7525 or me at 719-486-7717 if you need additional information.

Sincerely,

Alex Ungers

Alex Ungers
Senior Environmental Scientist

attachments

TECHNICAL MEMORANDUM

DATE October 8, 2020 **Reference No.** 19116177-6-TM-0

TO Diana Kelts
Climax Molybdenum

CC Christopher Schmitz

FROM Brent Bronson, PE, and Ryan Shedivy, PE **EMAIL** bbronson@Golder.com; rshedivy@golder.com

GEOTECHNICAL STABILITY OF UPDATED DESIGN OF THE MCNULTY OVERBURDEN STORAGE FACILITY AT THE CLIMAX MOLYBDENUM MINE NEAR CLIMAX, COLORADO

1.0 INTRODUCTION

Climax Molybdenum Company (Climax) is evaluating changes to the Colorado Division of Reclamation, Mining and Safety (DRMS) permitted life-of-mine (LoM) McNulty Overburden Storage Facility (OSF) design configurations due to optimizations to the LoM plan. This addendum presents the results of stability analyses completed by Golder to evaluate the global stability of mine plan changes to the ultimate OSF configuration at the Climax Mine in Climax, Colorado.

2.0 DESIGN CRITERIA AND GEOMETRY

The current permitted OSF design was permitted by DRMS in May 2017 as part of Technical Revision 25 (TR-25) to the Climax Mine permit No. M-1977-493. The proposed revised LoM configuration, which was developed to be compatible with the TR-25 closure design criteria, consists of extending the OSF toe limits by approximately 0 to 100 feet beyond the existing footprint for a limited extent, near the southwest corner of the McNulty OSF. Drawing 1 presents this proposed revised configuration (provided to Golder by Climax on October 1, 2020) and the 2017 OSF design grades and toe limits (Golder 2017a), with the area where the proposed revised LoM configuration extends beyond the 2017 design hatched in green. This revised LoM configuration is being proposed as the 2017 LoM plan was to stockpile low grade ore in this area of the OSF that would then be mined out and processed at the end of operations. Due to changes in the mine plan, it is no longer planned to place low grade ore at this location. As a result, Climax has developed this modified McNulty OSF design with a proposed toe buttress fill in the southwest sector of the OSF in order to meet the final closure TR-25 design criteria, given that the low-grade ore will not be mined out at the end of operations at this location (there are no other changes to the proposed LoM plan). Section C-C' as identified in TR-25 (Golder 2017a) is the only stability section impacted by this LoM modification. Section C-C' was identified in TR-25 as the critical section (lowest factor of safety [FoS]) for the McNulty OSF and runs east to west from the maximum build-out of the OSF toward Highway 91, as presented in Drawing 1. As documented in the TR-25 design report (Golder 2017a), the McNulty OSF stability analyses are supported by considerable field and laboratory characterization and were evaluated with conservative “worst case” stability parameters.

It is common for mines to update OSF plans throughout the life of the project for a variety of reasons. These routine changes occur within the framework established by the permitted project design criteria. For the OSF, those design criteria were developed in the permitted TR-25 (Golder 2017a). The minimum factors of safety established in the TR-25 design criteria were further addressed in a letter responding to DRMS comments on TR-25 (Golder 2017b). The relevant parameters from the TR-25 design criteria were used to evaluate the proposed revised LoM OSF configurations for purposes of the stability analysis presented in this technical memorandum. The relevant design criteria and geometry used for the OSF stability assessment presented in this addendum are listed below:

- Operational scenario (cross sections created using design surfaces provided by Climax):
  - Inter-bench angle of repose slopes are 1.4H:1V (or 36 degrees).
  - Operational benches are a minimum 200 feet wide, where the bench height is 200 feet.
  - The maximum height between benches is 200 feet.
  - Based on the above criteria, the composite operational slopes of the provided design surface were approximately 2.4H:1V.
- Closure design criteria:
  - Maximum regraded inter-bench slopes of 2H:1V.
  - Regraded closure benches are a nominal 22.4 feet wide.
  - A maximum height between regraded benches of 56 feet (i.e., an interbench slope length of 125 feet).
  - Overall regraded composite closure slopes are approximately 2.4H:1V

The global stability factors of safety and the design earthquake conditions from TR-25 (Golder 2017a) are summarized in the following bullets. DRMS provided a draft OSF guidance document with the TR-25 review comments, which Golder responded to (Golder 2017b) that supported the use and approval of the TR-25 design criteria (DRMS 2018):

- Operational criteria:
  - Minimum static FoS: ≥1.4
  - Minimum allowable seismic (pseudo-static) FoS: ≥1.0, or an acceptable level of displacement
  - Operational basis earthquake (OBE) peak ground acceleration (PGA): 0.06 g, representing the 1-in-475-years event
- Closure and post-closure criteria:
  - Minimum allowable static FoS: ≥1.5
  - Minimum allowable seismic (pseudo-static) FoS: ≥1.0
  - Maximum design earthquake (MDE) PGA: 0.14 g, representing the 1-in-2,475-years event

It is recognized that the design criteria factors of safety differ slightly from the Colorado Mine Reclamation Board Policy, which was finalized in 2018 (DRMS 2018). The TR-25 response letter (Golder 2017b) addresses many of these discrepancies. Specifically, DRMS (2018) identifies a pseudo-static FoS of ≥1.1 for non-critical structures and ≥1.15 for critical structures. It should be noted that the DRMS guidance does not define a minimum seismic reoccurrence interval nor an acceptable magnitude of movement. The magnitude of seismic events that could be considered in the analysis, and thus the range in computed factors of safety, can be expected to vary significantly depending upon the seismic reoccurrence interval selected. Also, as previously noted, Golder's stability analyses were supported by considerable field and laboratory characterization and were evaluated with conservative "worst case" stability parameters. Section 3.0 provides a summary of the justification for the TR-25 design criteria and the use of an FoS of unity for the pseudo-static conditions as summarized from Golder 2017b. Section 4.0 describes the stability methodology used, with Sections 5.0 and 6.0 presenting the material parameters and results of the stability analyses, respectively.

3.0 JUSTIFICATION FOR PSEUDO-STATIC CRITERIA

3.1 Mechanism of Movement

As noted in TR-25 (Golder 2017a), earthquake (seismic) loading conditions are typically simulated using a conservative and simplified pseudo-static approach, unless the results justify conducting a more rigorous displacement analysis to compute the actual predicted displacements. In an actual seismic event, a peak acceleration is be sustained for only a fraction of a second, before it reverses. Actual seismic time histories are characterized by multiple oscillating frequencies, which alternate between destabilizing and stabilizing forces. The accelerations produced by seismic events tend to build to a peak acceleration, which then quickly decays to lesser accelerations. Consequently, the duration during which a mass is actually subjected to a unidirectional, peak seismic acceleration is short and finite in time, rather than an infinite pulse as assumed by a simplistic pseudo-static simulation. As an example, a time history from the El Centro, California earthquake, as presented in Newmark (1965) is shown below as Figure 1.

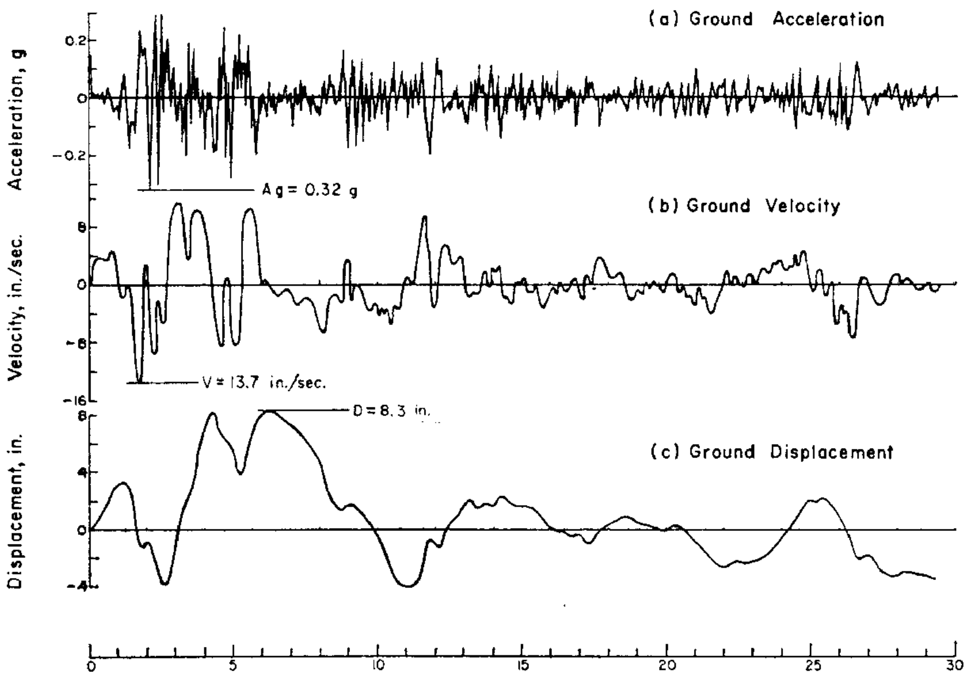

Figure 1: Example Earthquake Time History, El Centro Earthquake, From Newmark (1965)

A single integration of the measured acceleration history provides the velocity curve, with the displacement computed by double integrating the velocity. As can be seen in Figure 1, the ground moves in both a positive and negative direction during the earthquake. The maximum displacement, measured approximately 5 seconds after the start of shaking, was +8.3 inches. The final displacement at the cessation of shaking was approximately -3 inches.

In general, the resistance to sliding for the OSF will be lower in the downslope direction, leading to a net downslope displacement in the event of a large seismic event. Due to the nature of the OSF foundation materials and the high strength mine overburden itself, a liquefaction-type failure or a high displacement mobilization of the OSF materials is considered implausible. A better analogue is to consider the OSF as a semi-rigid block, which has the potential to move over the foundation during strong ground motions caused by large earthquakes. There may also be some settlement of overburden within the dump, but this is not considered to be of consequence to any downgradient infrastructure (e.g., Highway 91). Under the semi-rigid block framework, the OSF may move incrementally in the downslope direction with each local peak in ground acceleration. However, the movement will stop (or even reverse direction) between local peaks, and the OSF will come to a complete stop at the end of the earthquake. The OSF will not "break loose" from the foundation and undergo rapid downslope movements in the manner of a debris flow in response to seismic shaking.

3.2 Pseudo-Static Approach

As previously noted, the pseudo-static analyses are conservative models that simplistically evaluate seismic events as a force with constant acceleration and direction (i.e., an infinitely long seismic pulse). As a result, the standard of practice for geotechnical engineers is to take only a fraction of the predicted PGA when modeling seismic events using a pseudo-static analyses. A pseudo-static FoS of 1.0 is considered appropriate for low to moderate risk water retention structures when the structures are evaluated using one-half the PGA generated from the design earthquake (Hynes-Griffin and Franklin 1984), with a strength reduction of 0.2 (i.e., use 80% of the static strength parameters) applied to materials that may generate excess pore pressure during shaking, and to account for any potential strain softening materials. The Climax OSF earthquake loading conditions were evaluated consistent with the Hynes-Griffin and Franklin methodology (1984), with the 20% strength reduction applied.

As defined by Hynes-Griffin and Franklin (1984), if the results of a pseudo-static analysis provide an FoS ≥ 1.0, any displacement occurring during a seismic event is expected to be within the displacement tolerance of the structure. In the event that the pseudo-static analysis results in an FoS of less than unity, one can estimate the magnitude of displacement using several techniques developed for seismic displacement analyses of embankments (e.g., Newmark [1965]; Marchson et al. [2007]; Makdisi and Seed [1979]; finite element analysis; etc.). For an OSF where the computed FoS is ≥ 1.0, the generally accepted seismic induced maximum displacements would be on the order of 1 meter (3.3 feet) or less. The inherent conservatism of pseudo-static analyses and the technical literature references (e.g., by Hynes-Griffin and Franklin) provide the technical basis for non-impounding and low to moderate risk water retention structures with a pseudo static FoS ≥1.0.

The fundamental goal of defining a minimum FoS is, essentially, to define the amount of risk or conservatism that is appropriate for a given facility under a specific potential failure mode. In static stability, a higher FoS corresponds with lower risk (higher conservatism). The same is generally true for pseudo-static evaluations, with the caveat that FoS is not the only factor that defines the risk. In addition to the FoS, it is possible to design for different risk levels by defining different design seismic events, different allowable displacements, or by varying the seismic coefficient. Several variations of the pseudo-static method, each with its own recommendations regarding the seismic coefficient, are acceptable FoS, applied strengths, etc. (see Bray 1995; Bray and Travasarou 2007; Bray and Travasarou 2009; Hynes-Griffin and Franklin 1984; Leps and Jansen 1984; Seed 1979). A FoS of 1.0 indicates acceptable levels of performance, depending on the nuances of the method used. For seismic stability evaluations of dams, the level of conservatism for seismic assessments is typically a function of the level of hazard (high, moderate, or low), seismic response, and reoccurrence interval selected.

One recent trend that Golder has observed for large mine waste structures is the standards of care being adopted for critical structures are similar to the requirements developed for impoundments. Specifically, the earthquake reoccurrence intervals are being selected based on the design life and risk level, with an operational base earthquake (OBE) developed to evaluate the conditions during the operational life of the facility, and a maximum design earthquake (MDE) developed to evaluate performance of the facility under long-term conditions (e.g., post closure). It should be recognized that for the long-term closure scenario, the corresponding MDE represents a conservative long-term reoccurrence interval, which varies depending on the risk level posed by the facility, but is commonly defined for moderate risk tailing dams as the 1-in-2,475-year event, or the event with 2% probability of exceedance over a 50-year period. The corresponding FoS calculated using the larger MDE will inherently result in a lower FoS relative to the more short-term OBE event. However, evaluating the MDE allows the consequence of a larger, low-probability event to be more realistically estimated. As a result, the actual risk to the facility is arguably less, provided an appropriate event is selected for the MDE and the consequences of the MDE (e.g., FoS or calculated displacement) are acceptable.

Although criteria for dams are generally considered to represent a more stringent condition than for a non-impounding OSF, the International Commission on Large Dams (ICOLD) guidelines are useful for comparison with the project design criteria. For reference, consider the ICOLD criteria from Bulletin 148, “Selecting Seismic Parameters for Large Dams” (ICOLD 2016), where ICOLD defines two different seismic events: the safety evaluation earthquake (SEE), which is analogous to the MDE as defined in the Climax OSF evaluations, and the OBE. Under ICOLD's terminology, the SEE and OBE are both evaluated, but with different criteria for acceptable performance. Specifically:

- SEE is defined as "the maximum level of ground motion for which the dam should be designed or analyzed. It will be required at least that there is no uncontrolled release of water when the dam is subjected to the seismic load imposed by the SEE" (ICOLD 2016). ICOLD notes that a higher level of performance should be expected under the OBE (e.g., a higher FoS).
- OBE is defined as "the level of ground motion at the dam site for which only minor damage is acceptable In many cases, it will be appropriate to choose a minimum return period of 145 years (i.e., a 50% probability of not being exceeded in 100 years)" (ICOLD 2016).

The seismic design criteria philosophy for the recently released Global Industry Standard on Tailings Management (GISTM 2020) is also consistent with this philosophy. The analysis presented in TR-25 (Golder 2017a) was developed to be generally consistent with this approach.

It is recognized that there are many documents that can be sited associated with regulatory oversight of the mining industry and that generally reflect the current standard of care for the industry. One commonly referenced document is the Best Available Demonstrated Control Technologies (BADCT) document by the Arizona Department of Environmental Quality (ADEQ 2016). As a comparison, the prescriptive stability criteria for a large dump leach, which is considered analogous to the Climax OSFs, consists of the following:

- Static FoS = 1.3
- Pseudo-static FoS = 1.0, or alternatively the predicted magnitude of displacements will not jeopardize the facility containment.
  - The earthquake to be considered in the pseudo-static evaluation is defined in different ways within the document, alternately as "the maximum earthquake likely to occur during a 100-year interval (80% probability of not being exceeded in 100 years)" and "largest earthquake with a 100-year return interval" (ADEQ 2016). The 1 in 100-year event specified is considered analogous to the OBE developed for the Climax OSFs (Golder selected a 1-in-475-year reoccurrence interval which is typically acceptable for water retention structures).
  - Where human life is potentially threatened, ADEQ includes a requirement for consideration of the maximum credible earthquake. While Golder does not consider the Climax OSFs to represent critical life-threatening facilities to the general public (e.g., a tailings dam), the 1-in-2,475-year event was selected as a conservative post-closure condition.

The Nevada Division of Environmental Protection, Bureau of Mining Regulation and Reclamation (NDEP BMRR) also publishes stability requirements for heap leach pads, which are similar to the Climax OSF. Requirements stated are:

- Static FoS = 1.3
- Pseudo-static FoS = 1.05, or deformation analysis demonstrating acceptable potential movements during the design seismic event.

- The recommended design event is the "seismic event with a maximum 10% probability of exceedance in 50 years" (NDEP BMRR 2017), which corresponds to the 1-in-475-year event.
- The recommended event is the same as the OBE event used to evaluate the Climax OSFs during operations. The MDE event used to evaluate the OSFs post-closure exceeds the recommended event significantly.

4.0 METHODS AND ASSUMPTIONS

The only design section impacted by the modified LoM design toe fill is Section C-C', which was also the most critical stability section identified in TR-25. Section C-C' was revised to reflect the new LoM design surface, with the material properties, bedrock geometry, phreatic surface, and seismic parameters unaltered from Section C-C' as presented in TR-25 (Golder 2017a). As shown in Drawing 1, the proposed revised LoM design toe limits are generally consistent with the previous TR-25 limits except in the location shown in green, where the proposed revised LoM toe limits extend approximately 15 feet beyond the TR-25 design at the Section C-C' location. Global stability analyses were performed with RocScience's 2-D limit equilibrium program, Slide 2 (Rocscience 2020). Additional assumptions and methodology included were consistent with those from the TR-25 analyses. For example:

- Factors of safety were computed based on Spencer's Method of Slices (Spencer 1967).
- Both circular and non-circular (block) failure surfaces were evaluated.
- All foundation materials were evaluated using conservative residual (not peak) shear strengths to ensure conservatism in the analysis.
- Seismic stability was evaluated using a pseudo-static analysis procedure generally following the Hynes-Griffin and Franklin method (1984). For this pseudo-static analysis, 80% of the effective stress shear strength was used for all materials except the overburden material, as straining and strength degradation due to shaking are expected to be minimal for the high-permeability overburden. Seismic load coefficients of 0.03 for the OBE and 0.07 for the MDE (half the PGA for each case) were used for the pseudo-static analyses.

5.0 MATERIAL PARAMETERS

The material properties presented in Table 1 and Table 2 were used for the static and pseudo-static analyses, respectively. These parameters are consistent with those previously used in TR-25 (Golder 2017). The design criteria parameters were selected based on a review of the available laboratory test data, historical reports, and engineering judgment. A more in-depth discussion of material strength selection is presented in TR-25 (Golder 2017) with a brief highlight of the selected material parameters discussed in this section.

Table 1 presents the material properties used for the static stability analyses. A combination of Mohr-Coulomb and bi-linear Mohr-Coulomb failure envelopes were used for the native materials. A traditional Mohr-Coulomb failure envelope was used for the Minturn Formation. The Minturn Formation shear strength envelope was obtained from a staged consolidated, undrained triaxial test performed on a relatively undisturbed sample of clayey residual soil weathered from the Minturn Formation. Bi-linear Mohr-Coulomb failure envelopes were constructed for both the Lincoln Porphyry and Glacial Till. For these materials, bi-linear envelopes were found to provide the best fit to the data provided by large-scale direct shear tests on reconstituted samples of these materials.

Table 1: Strength Parameters Used for Static Stability Analysis

Soil Type	Total Unit Weight (pcf)	Failure Envelope Type	Failure Envelope Definition (psf)	Notes
Native Materials				
Minturn Formation	119	Mohr-Coulomb	$\tau' = \sigma'\tan(31°)$	This failure envelope was determined from the strength results of a staged undrained triaxial test with pore pressure measurements. No cohesion was included for conservatism.
Lincoln Porphyry	117	Bi-Linear Mohr Coulomb	$\tau' = \sigma'\tan(50°)$ for $\sigma'<7200$ $\tau' = \sigma'\tan(33°)+4200$ for $\sigma'>7200$	This failure envelope was determined from the residual strength results of a series of large-scale direct shear tests.
Glacial Till	123	Bi-Linear Mohr Coulomb	$\tau' =$ 'tan(44°) for $\sigma'<7200$ $\tau' =$ 'tan(30°)+2688 for $\sigma'>7200$	This failure envelope was determined from the residual strength results of a series of large-scale direct shear tests.
Overburden Materials				
Best Approximation Overburden	120	Power Function	$\tau' = 3.18\ \sigma'^{0.86}$	This failure envelope was determined from the residual strength results of a series of large-scale direct shear tests. This envelope lies between the average and low envelopes developed by Leps (1971).
Lower Bound Overburden	120	Power Function	$\tau' = 2.02\ \sigma'^{0.90}$	This failure envelope was used to account for a higher proportion of weaker materials with in the OSF. This envelope is analogous to the low strength envelopes developed by Leps (1971).

Two large-scale direct shear tests were performed on samples of mine overburden collected from the site in 2011. The shear box was 12 inches by 12 inches, and as a result only the sampled material finer than 2 inches was used in the test. Assuming zero cohesion, the results indicate residual strengths of 35 to 36 degrees (linear Mohr-Coulomb). A power curve that best fit the laboratory data lies approximately midway between the Leps (1971) curves for low and average strength rockfill.

For the Climax mine overburden, a curvilinear power curve fit to the large-scale direct shear test data was selected for use in stability modeling. This curve was selected to be conservative for the expected OSF material properties prior to mining for where overburden is primarily derived from igneous and/or metamorphic rock, which makes up the majority of the OSF fill. For the majority of the OSF, this strength envelope is considered conservative, as the tests were performed only on the finer grained matrix material and was not corrected to account for the large amount of oversize material present in the OSFs. Further, inspection of the OSFs by the EoR during the annual inspections confirm that the majority of the mine overburden is coarse, blocky, and competent, with very high shear strengths. Approximately 30% of the overburden is expected to consist of sedimentary rock. The power curve described above is also considered representative for areas of the OSF containing average quantities of sedimentary rock-derived overburden based on the visual inspections. Golder used the low strength Leps (1971) curve as a conservative “lower bound” strength envelope in the event that a significant contiguous portion of the facility is constructed primarily from sedimentary overburden. However, it should be noted that for the majority of the OSF, the Leps (1971) high-strength shear strength curves are considered more representative.

Table 2 presents the material properties used for the pseudo-static stability analyses. For this case, all native soil shear strengths were reduced by 20% in accordance with Makdisi and Seed (1977) to simulate the elastic reduction in strength (i.e., strain softening) that may be imparted by seismic shaking. This practice was also adopted by Hynes-Griffin and Franklin (1984) for pseudo-static stability analyses. This reduction factor was not applied to the overburden material as seismic shaking is not expected to produce strain softening conditions resulting from the development of excess pore pressure for the overburden materials.

Table 2: Strength Parameters Used for Pseudo-Static Stability Analysis

Soil Type	Total Unit Weight (pcf)	Failure Envelope Type	Failure Envelope Definition (psf)	Notes
Native Materials				
Minturn Formation	119	Mohr-Coulomb	$\tau' = \sigma'\tan(25.7°)$	This failure envelope was determined from the strength results of a staged consolidated undrained triaxial test with pore pressure measurements. No cohesion was included for conservatism. Values were reduced by 20% for the seismic condition.
Lincoln Porphyry	117	Bi-Linear Mohr Coulomb	$\tau' = \sigma'\tan(44°)$ for $\sigma'<7200$ $\tau' = \sigma'\tan(28°)+3360$ for $\sigma'>7200$	This failure envelope was determined from the residual strength results of a series of large-scale direct shear tests with the values reduced by 20%.
Glacial Till	123	Bi-Linear Mohr Coulomb	$\tau' = \sigma'\tan(38°)$ for $\sigma'<7200$ $\tau' = \sigma'\tan(25°)+2150$ for $\sigma'>7200$	This failure envelope was determined from the residual strength results of a series of large-scale direct shear tests with the values reduced by 20%.
Waste Rock Materials				
Best Approximation Overburden	120	Power Function	$\tau' = 3.18\ \sigma'^{0.86}$	This failure envelope was determined from the residual strength results of a series of large-scale direct shear tests. This envelope lies between the average and low envelopes developed by Leps (1971).
Lower Bound Overburden	120	Power Function	$\tau' = 2.02\ \sigma'^{0.90}$	This failure envelope was used to account for a higher proportion of weaker materials with in the OSF. This envelope is analogous to the low strength envelopes developed by Leps (1971).

The residual shear strengths that were used for the Lincoln, Maroon, and Minturn formations are considered conservative as they are based upon laboratory testing of the “worst case” residual soil encountered during the OSF foundation investigations (i.e., the most weathered, finest grained, and highest clay content material). Additional inherent conservatism for Section C-C' is a result of the residual shear strengths used and does not consider an increase in average formation strength with depth as weathering decreases (e.g., the Minturn formation at a depth of 100 feet was modeled using the same strength parameters as the residual soils).

6.0 RESULTS

The stability analysis results for the overburden “best approximation” and “lower bound” conditions (as defined in TR-25), for both the operations and closure scenarios, are presented in the attached Figures 2 through 9 with the results of the “lower bound” conditions summarized in Table 3. For reference, the results for the proposed modified LoM are compared with the results of the same cross section (Section C-C') from TR-25 (Golder 2017a) with the minimum criteria established by DRMS (2018), as discussed in Section 3.0. Golder notes that the project criteria for static FoS exceed the DRMS (2018) requirements and we consider that the project seismic FoS criteria represent a similar or higher level of conservatism to the previous approved TR-25 design and to DRMS (2018), given that a more conservative 1-in-2,475-year seismic return interval was used to evaluate the post closure seismic condition.

The stability analyses performed indicate that the computed FoSs for both scenarios meet or exceed those established by the Project Design Criteria, with the revised LoM operation scenario being more favorable than the previous permitted LoM configuration. Pseudo-static stability results are presented for both the 1-in-475-year and the 1-in-2,475-year return interval seismic criteria. Even when using the conservative 1-in-2,475-year event, the pseudo-static analysis yielded a FoS of ≥1.0 for the Climax OSF.

Table 3: Comparison of Stability Results and Various Criteria

Design Section	Seismicity	DRMS 2018 (Non-Critical Structures)[3]	DRMS 2018 (Critical Structures)	TR-25 Project Design Criteria	Cross Section C-C' (2017 TR-25 Submittal)[1] FoS	Cross Section C-C' (Proposed Revised LoM OSF Design)[1] FoS
Operations	Static	1.25	1.3	1.4	1.5	1.7
	Pseudo-static[2]	1.1	1.15	1.0 or acceptable displacement	1.1	1.4
Closure	Static	1.25	1.3	1.5	1.5	1.5
	Pseudo-static[2]	1.1	1.15	1.0 or acceptable displacement	1.0	1.0

Notes:

1. Reported FoS uses the lower bound overburden shear strength and non-circular failure envelopes, which coincide with the lowest FoS generated from this analysis. Minimum FoSs are for failures that span at least an entire operational lift. Partial lift minor “veneer” failures were excluded.
2. The design earthquake for DRMS 2018 is not defined. The design earthquake as defined in the TR-25 design criteria and used in the updated stability analyses presented in this technical memorandum are the following:
    a. Operating basis earthquake (OBE): 1-in-475-year event
    b. Maximum designated earthquake (MDE): 1-in-2,475-year event
3. Given that the OSFs are composed of coarse blocky competent mine waste and are unsaturated due to the inherent high hydraulic conductivities, which result in a low potential for runout and there are no critical downgradient structures, Golder interprets that the Climax OSFs would classify as a non-critical structure.

7.0 CONCLUSIONS

The current LoM OSF design was permitted by DRMS in May 2017 as part of TR-25 for the Climax Mine permit No. M-1977-493. The proposed revised McNulty OSF LoM configuration, which was developed by Climax to be compatible with the TR-25 closure design criteria, is generally consistent with the previous TR-25 toe limits except at the locations shown in green in Drawing 1. For the Section C-C' location, the proposed revised LoM toe limit extends approximately 15 feet beyond the TR-25 design. Revisions to the McNulty OSF LoM configuration are being proposed by Climax as the 2017 LoM plan was developed to stockpile low-grade ore in this area of the OSF that would then be mined out and processed at closure. Due to changes in the mine plan, it is no longer planned to place low-grade ore at this location. As a result, Climax has developed the proposed revised OSF design provided in Drawing 1 with a toe buttress fill to meet the final closure TR-25 design criteria.

At the request of Climax, Golder has evaluated the stability of the potential modified McNulty OSF LoM configuration. The only design section impacted by the modified LoM design is Section C-C', which was also the most critical stability section identified in TR-25. Section C-C' was revised to reflect the new LoM design surface which extends approximately 15 feet beyond the TR-25 design surface at the section location, with the material properties, bedrock geometry, phreatic surface, and seismic parameters unaltered from Section C-C' as presented in TR-25 (Golder 2017a).

The results of the stability analyses show that extending the proposed revised OSF configuration has a favorable result to the OSF stability when compared to the currently permitted TR-25 OSF configuration (Golder 2017a). Operational static and pseudo-static factors of safety improve, and closure static and pseudo-static factors of safety remain at or above the design criteria and the previous TR-25 results. These results conclude that the proposed revised McNulty OSF LoM configuration presented in Drawing 1 meets the stability design criteria established in TR-25 (Golder 2017a).

8.0 REFERENCES

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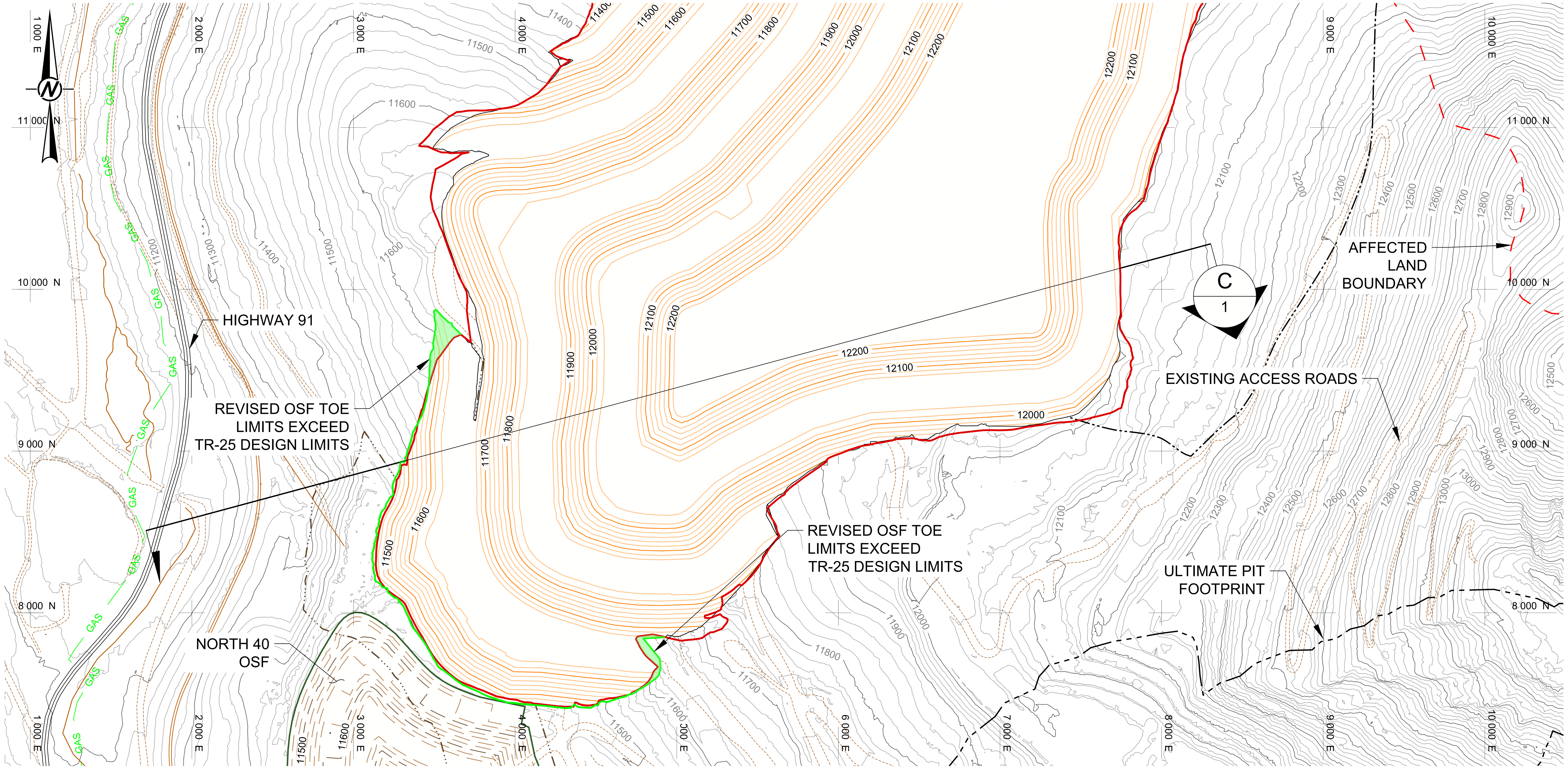
Drawings



LEGEND

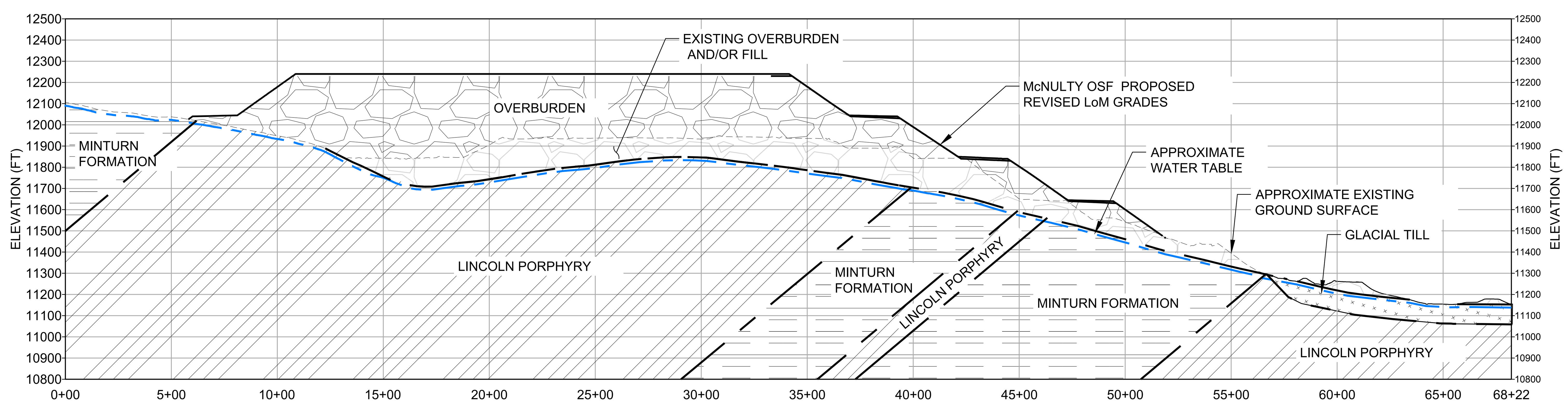
- 11000 EXISTING GROUND (REFERENCE 1)
- 11000 NORTH 40 OSF DESIGN GRADES
- 11000 McNULTY OSF PROPOSED REVISED LoM GRADES (REFERENCE 2)
- 2017 TR-25 OSF TOE LIMITS
- McNULTY OSF PROPOSED REVISED LoM TOE LIMITS
- REVISED OSF TOE LIMITS EXCEED TR-25 DESIGN LIMITS
- LINCOLN PORPHYRY
- OVERBURDEN FILL
- GLACIAL TILL
- EXISTING OVERBURDEN AND/OR FILL
- **MINTURN FORMATION**

NOTE(S)

1. MCNULTY OSF GRADES SHOWN DO NOT INCLUDE ALL HAUL ROADS, LOCATIONS OF WHICH WILL CHANGE OVER TIME. AS A RESULT, CONSTRUCTED GRADES MAY VARY LOCALLY FROM THOSE SHOWN, DEPENDING ON HAUL ROAD LOCATION.

REFERENCE(S)

1. 2020 EXISTING GROUND TOPOGRAPHY PROVIDED BY CLIMAX JULY 30, 2020 AND SHOWN AT 25-FOOT CONTOUR INTERVAL.
2. UPDATED OSF DESIGN GRADES PROVIDED BY CLIMAX OCTOBER 1, 2020 AND SHOWN AT 25-FOOT CONTOUR INTERVAL.



SCALE 1":600' C 1 Section C-C'

0 600 1200
1" = 600' FEET

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2020-10-08	ISSUED FOR TR-25 PERMIT ADDENDUM	CLIMAX	KS	RFS	BRB
A	2020-09-28	ISSUED FOR CLIENT REVIEW	CLIMAX	KS	RFS	BRB

SEAL

COLORADO REGISTERED PROFESSIONAL ENGINEER BRENT R. BRONSON 34969 8 Oct 2020

CLIENT
CLIMAX MOLYBDENUM COMPANY
CLIMAX MINE

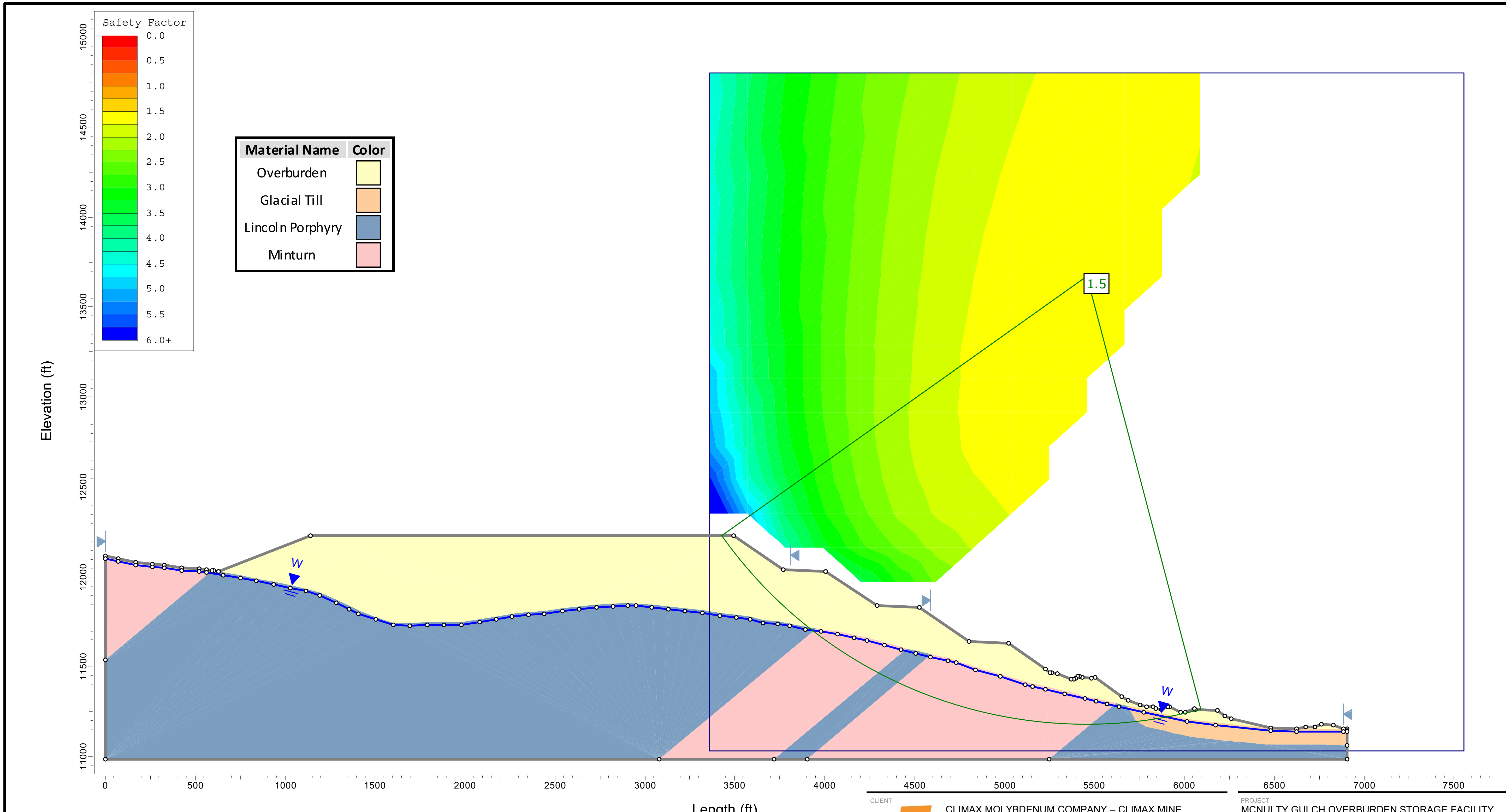
CONSULTANT
GOLDER
DENVER OFFICE
7245 W ALASKA DR, STE 200
LAKEWOOD, COLORADO
USA
[+1] (303) 980-0540
www.golder.com

PROJECT
CLIMAX OVERBURDEN STORAGE FACILITY
TR-25 PERMIT ADDENDUM

TITLE
CLIMAX UPDATED DESIGN AND SECTION C-C'

PROJECT NO. 19116177 | REV. 0 | 1 of 1 | DRAWING 1

Figures



CLIENT
CLIMAX MOLYBDENUM COMPANY – CLIMAX MINE
HIGHWAY 91 – FREEMONT PASS
CLIMAX, CO 80429

CONSULTANT
GOLDER

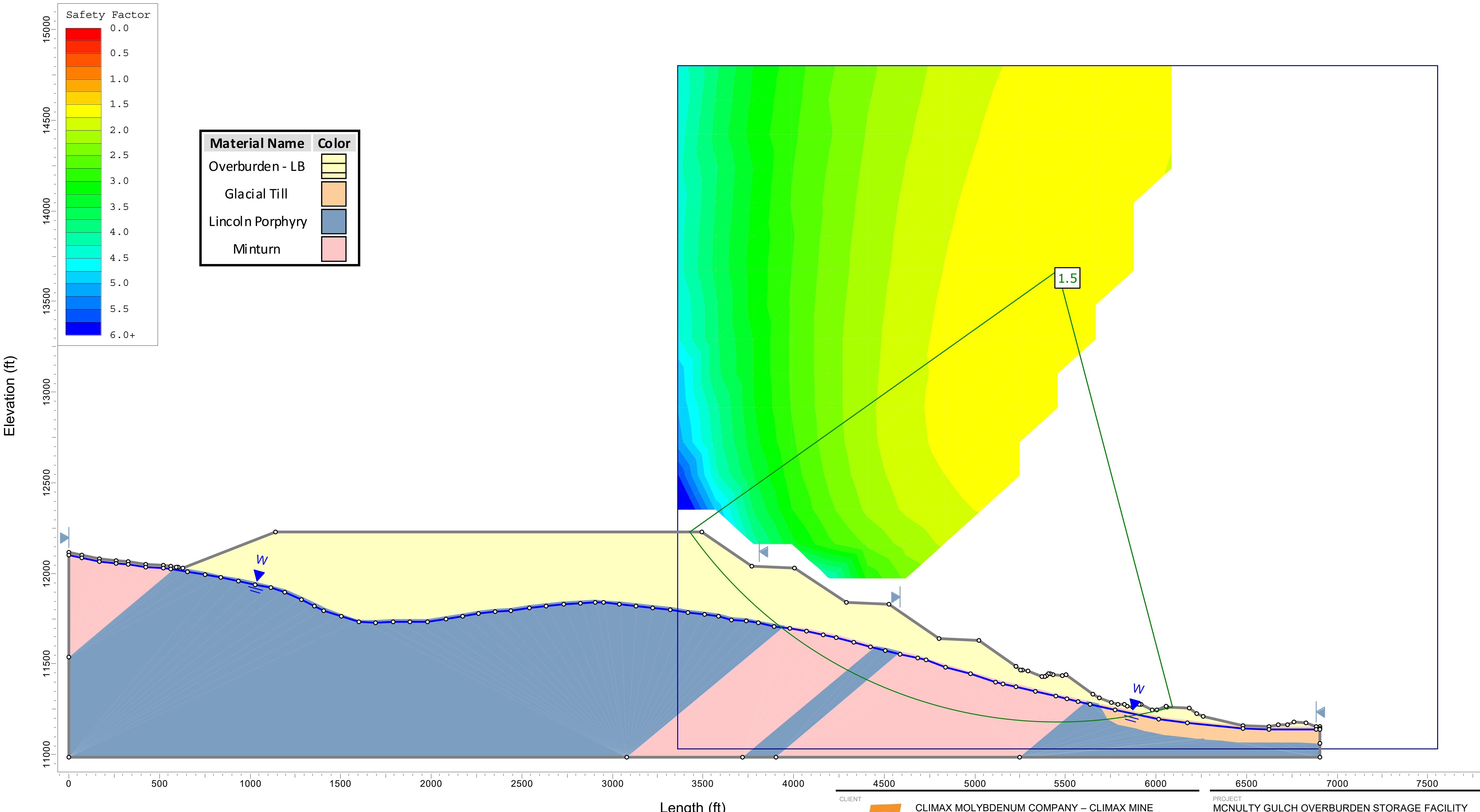
DATE	2020-08-24
PREPARED	KAS
DESIGN	CLIMAX
REVIEW	RFS
APPROVED	BRB

PROJECT
MCNULTY GULCH OVERBURDEN STORAGE FACILITY
OSF STABILITY ANALYSIS
CLIMAX, CO

TITLE
CROSS SECTION C-C' – STATIC ANALYSIS DURING OPERATIONS

PROJECT No.	Rev.	FIGURE
19116177	A	2

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



CLIENT

CLIMAX MOLYBDENUM COMPANY – CLIMAX MINE
HIGHWAY 91 – FREEMONT PASS
CLIMAX, CO 80429

CONSULTANT

GOLDER

DATE	2020-08-24
PREPARED	KAS
DESIGN	CLIMAX
REVIEW	RFS
APPROVED	BRB

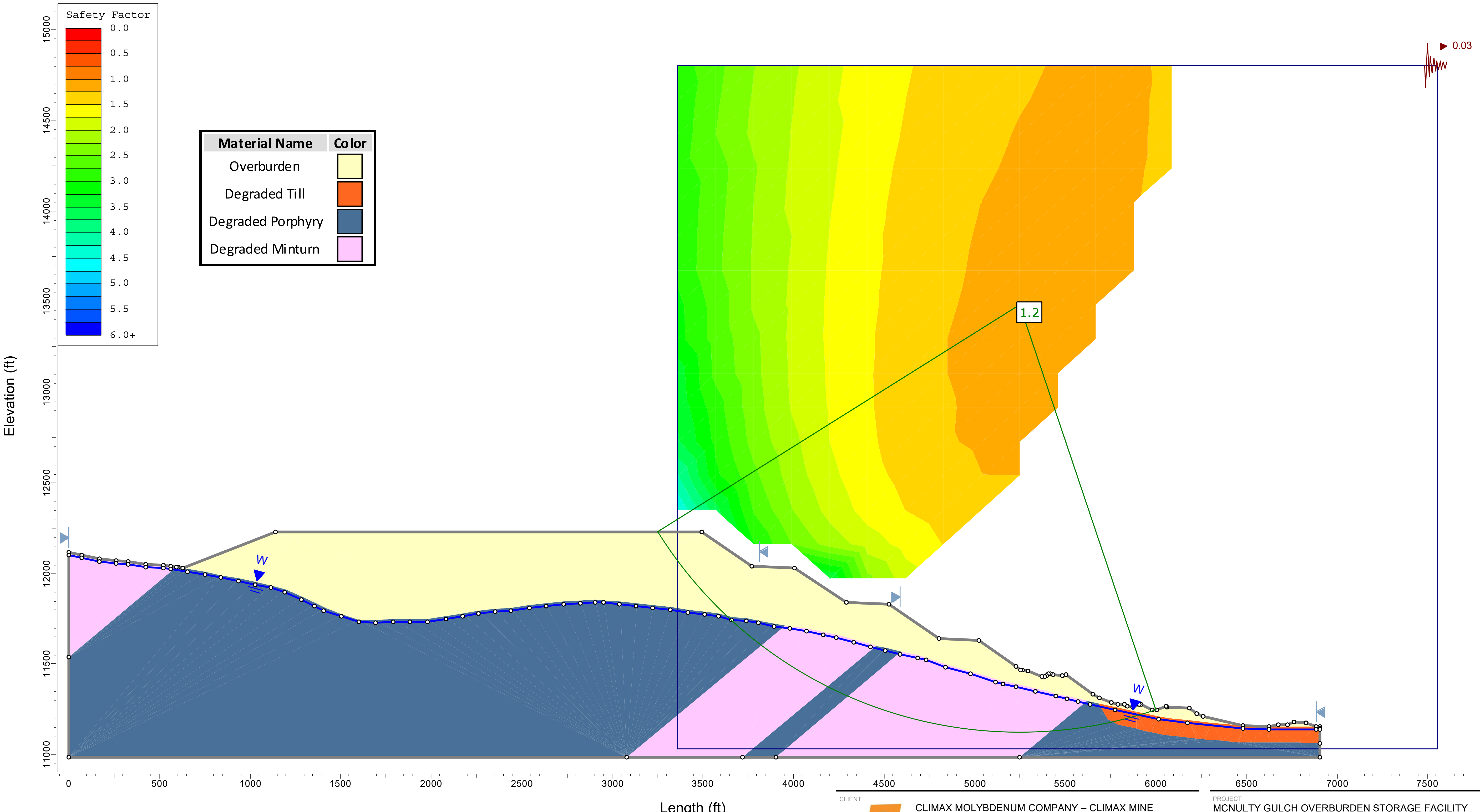
PROJECT

MCNULTY GULCH OVERBURDEN STORAGE FACILITY
OSF STABILITY ANALYSIS
CLIMAX, CO

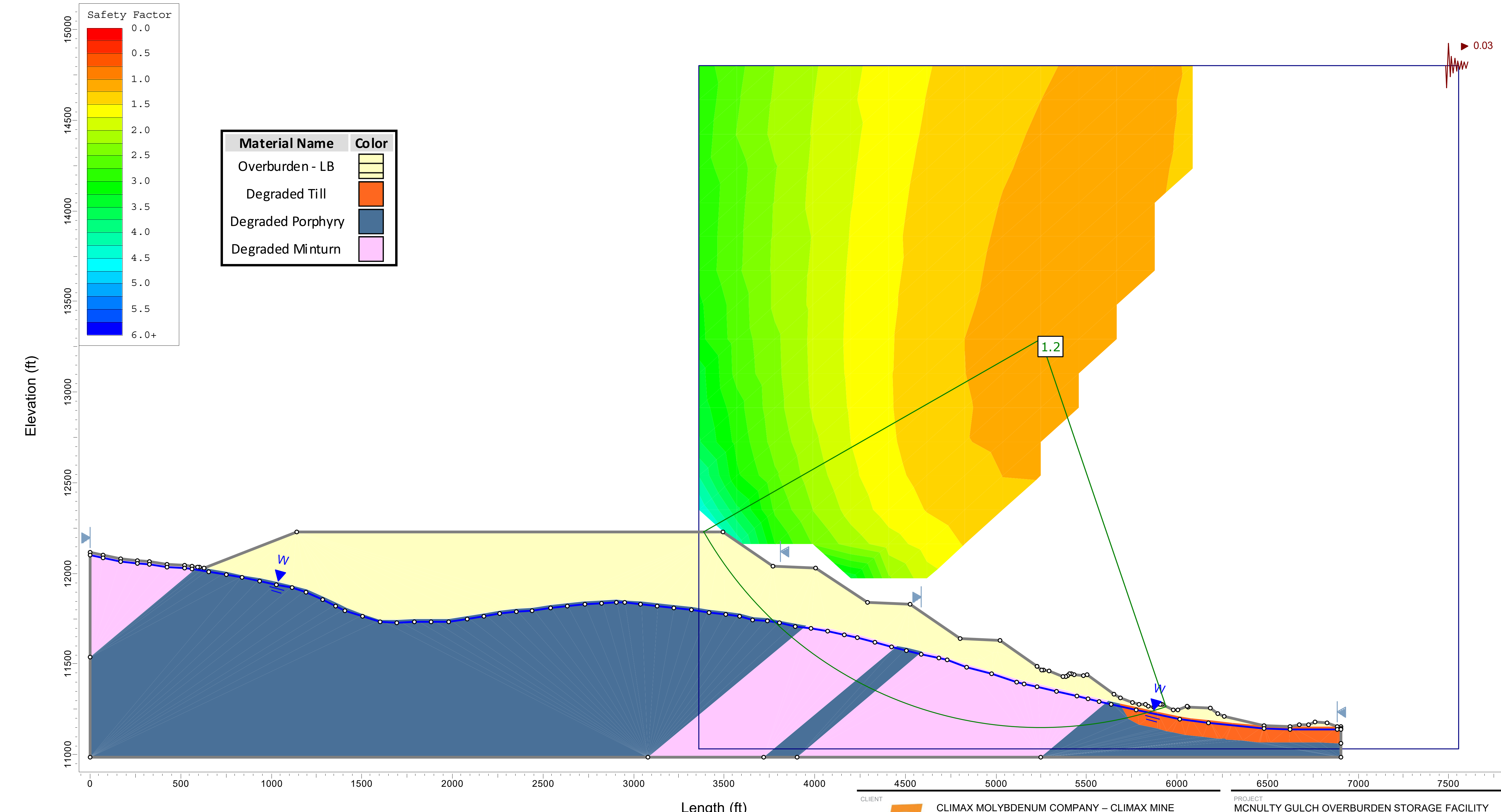
TITLE

CROSS SECTION C-C' – STATIC LOWER BOUND ANALYSIS DURING OPERATIONS

PROJECT No.	Rev.	FIGURE
19116177	A	3



CLIENT CLIMAX MOLYBDENUM COMPANY – CLIMAX MINE HIGHWAY 91 – FREEMONT PASS CLIMAX, CO 80429	PROJECT MCNULTY GULCH OVERBURDEN STORAGE FACILITY OSF STABILITY ANALYSIS CLIMAX, CO
CONSULTANT GOLDER DATE 2020-08-24 PREPARED KAS DESIGN CLIMAX REVIEW RFS APPROVED BRB	TITLE CROSS SECTION C-C' – PSEUDO-STATIC ANALYSIS DURING OPERATIONS (1 in 475-YEAR EVENT) PROJECT No. 19116177 Rev. A FIGURE 4



CLIENT

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HIGHWAY 91 – FREEMONT PASS
CLIMAX, CO 80429

CONSULTANT

GOLDER

DATE	2020-08-24
PREPARED	KAS
DESIGN	CLIMAX
REVIEW	RFS
APPROVED	BRB

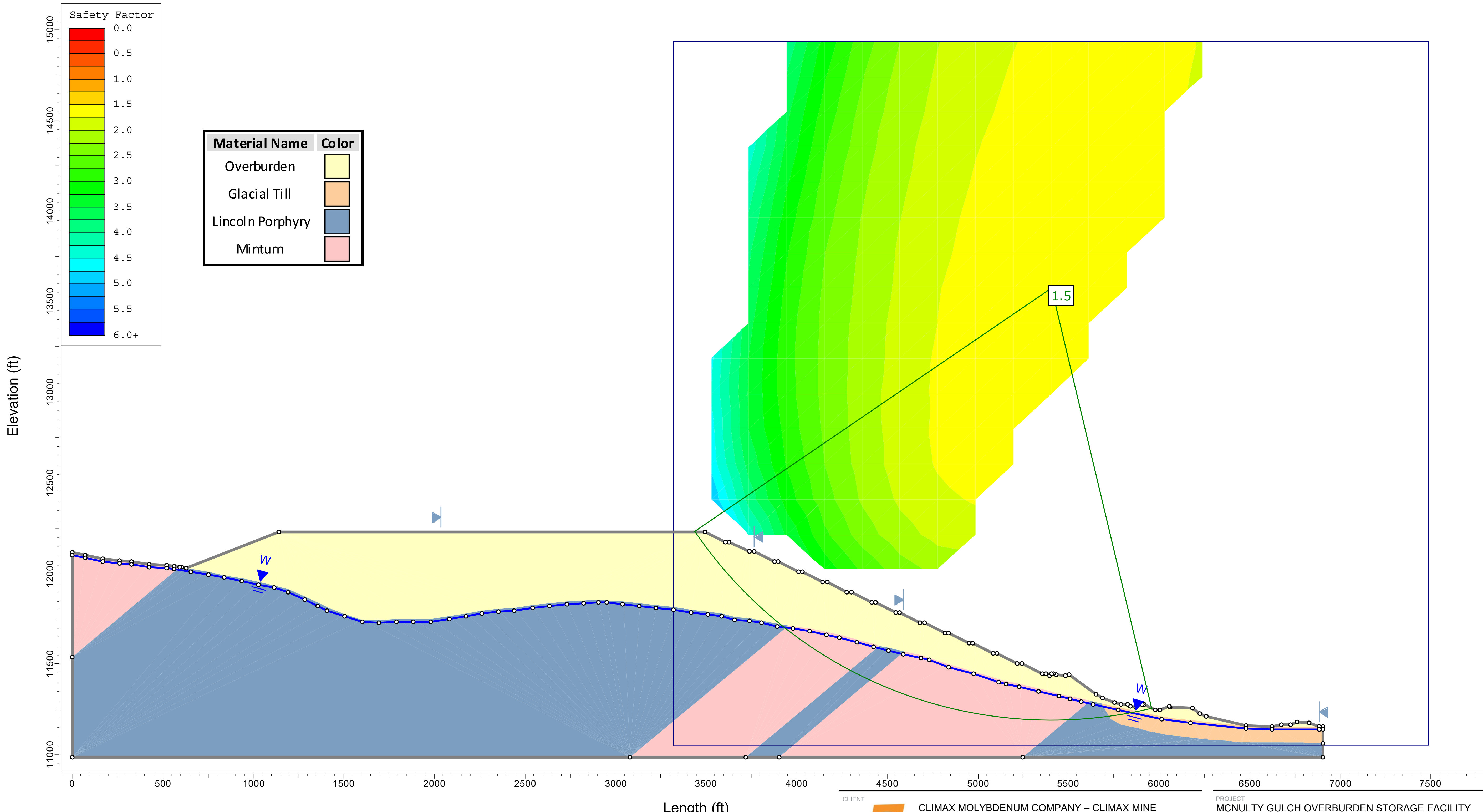
PROJECT

MCNULTY GULCH OVERBURDEN STORAGE FACILITY
OSF STABILITY ANALYSIS
CLIMAX, CO

TITLE

CROSS SECTION C-C' – PSEUDO-STATIC LOWER BOUND ANALYSIS DURING OPERATIONS (1 in 475-YEAR EVENT)

PROJECT No.	Rev.	FIGURE
19116177	A	5



CLIENT

CLIMAX MOLYBDENUM COMPANY – CLIMAX MINE
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CLIMAX, CO 80429

CONSULTANT

GOLDER

DATE	2020-08-24
PREPARED	KAS
DESIGN	CLIMAX
REVIEW	RFS
APPROVED	BRB

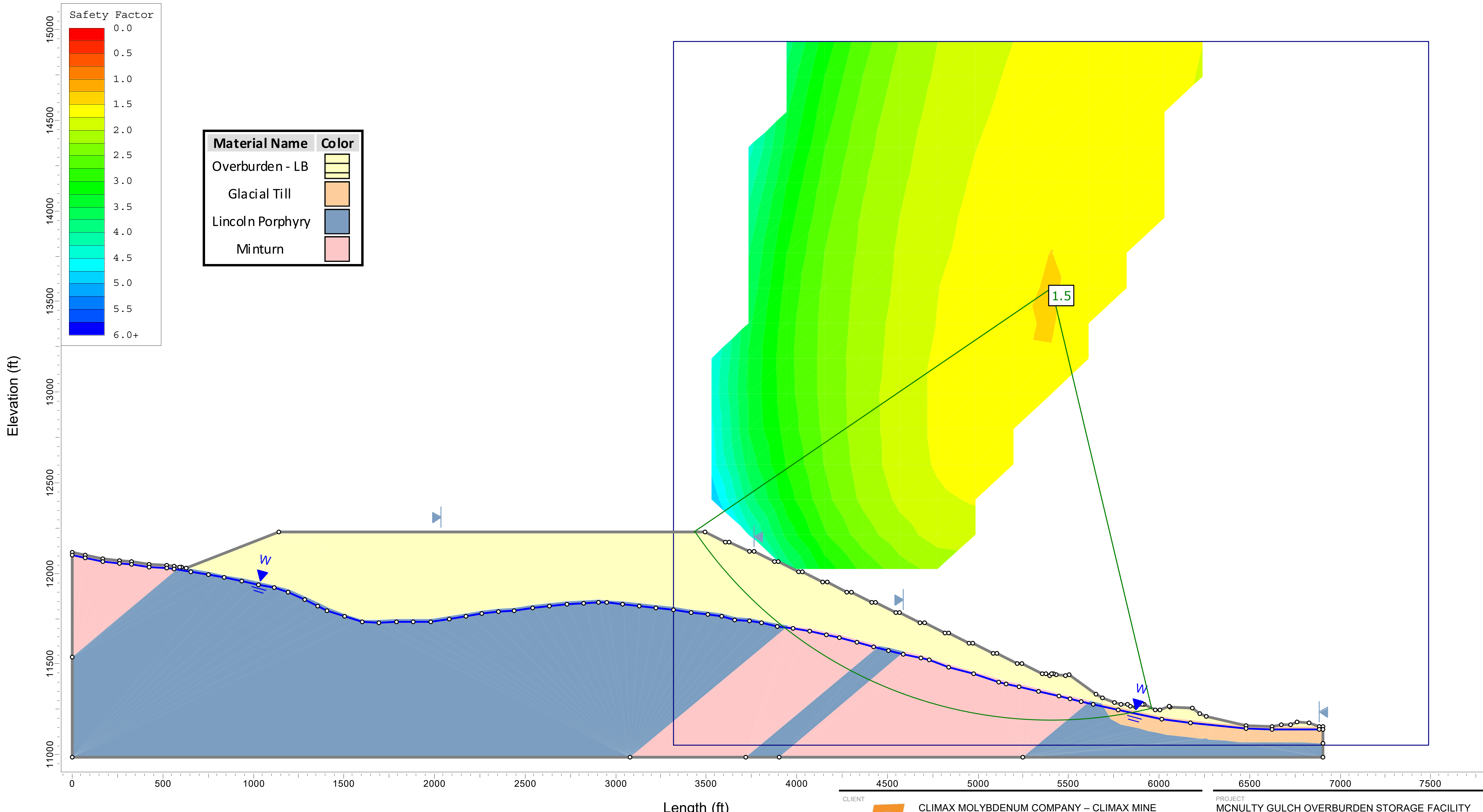
PROJECT

MCNULTY GULCH OVERBURDEN STORAGE FACILITY
OSF STABILITY ANALYSIS
CLIMAX, CO

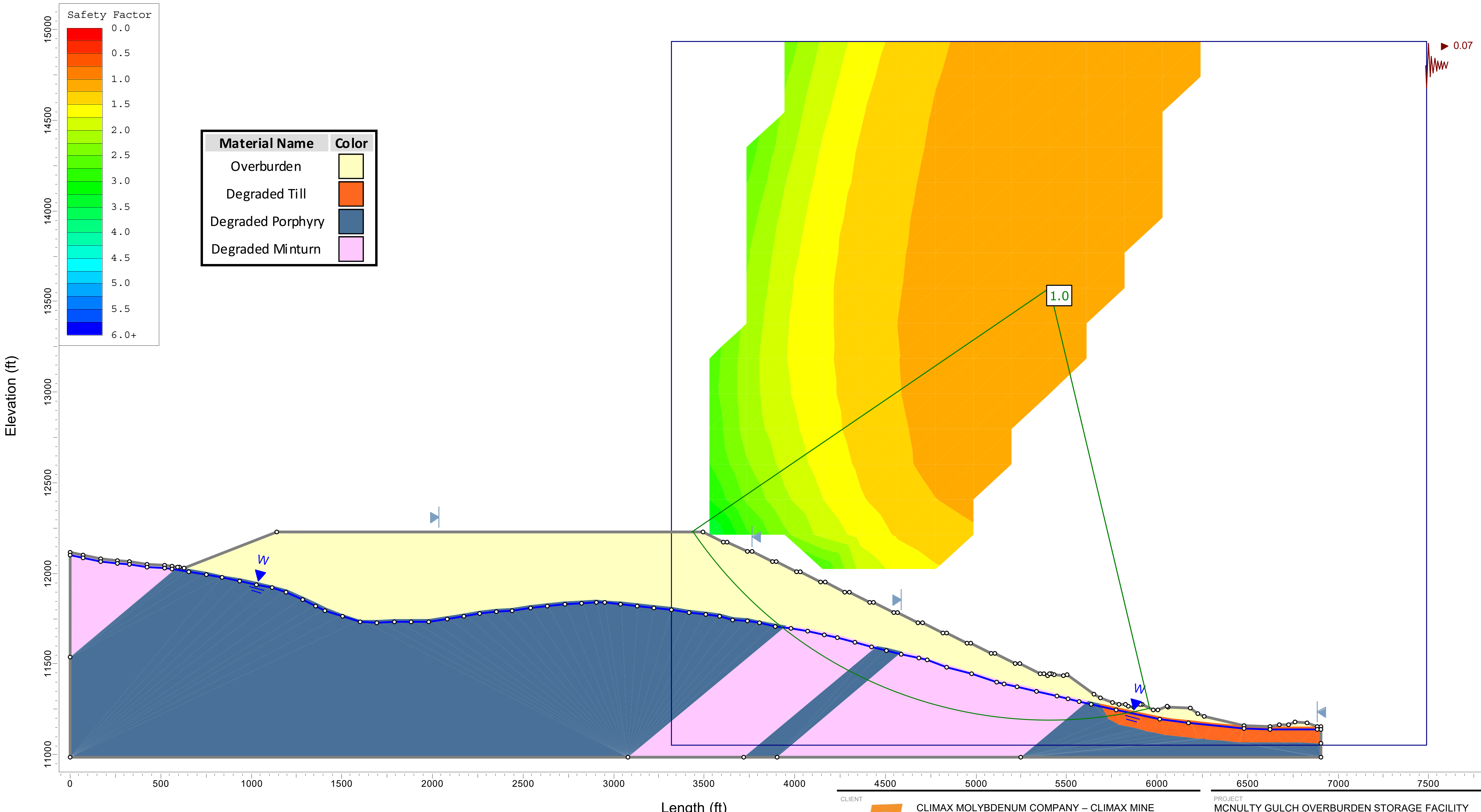
TITLE

CROSS SECTION C-C' – STATIC ANALYSIS DURING CLOSURE

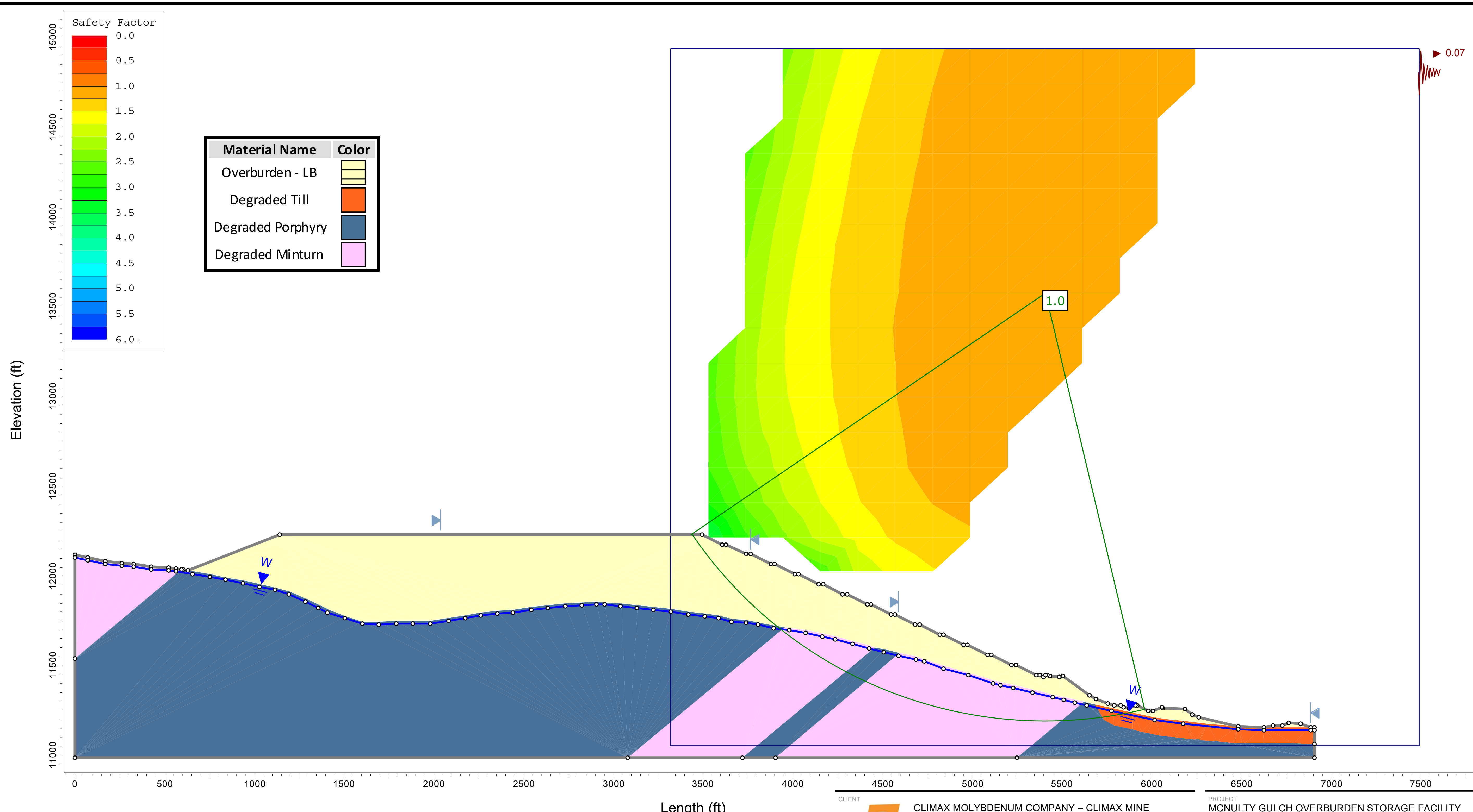
PROJECT No.	Rev.	FIGURE
19116177	A	6



CLIENT	CLIMAX MOLYBDENUM COMPANY – CLIMAX MINE HIGHWAY 91 – FREEMONT PASS CLIMAX, CO 80429
CONSULTANT	GOLDER
DATE	2020-08-24
PREPARED	KAS
DESIGN	CLIMAX
REVIEW	RFS
APPROVED	BRB
PROJECT	MCNULTY GULCH OVERBURDEN STORAGE FACILITY OSF STABILITY ANALYSIS CLIMAX, CO
TITLE	CROSS SECTION C-C' – STATIC LOWER BOUND ANALYSIS DURING CLOSURE
PROJECT No.	19116177
Rev.	A
FIGURE	7



CLIENT CLIMAX MOLYBDENUM COMPANY – CLIMAX MINE HIGHWAY 91 – FREEMONT PASS CLIMAX, CO 80429	PROJECT MCNULTY GULCH OVERBURDEN STORAGE FACILITY OSF STABILITY ANALYSIS CLIMAX, CO
CONSULTANT GOLDER DATE 2020-08-24 PREPARED KAS DESIGN CLIMAX REVIEW RFS APPROVED BRB	TITLE CROSS SECTION C-C' – PSEUDO-STATIC ANALYSIS DURING CLOSURE (1 in 2,475-YEAR EVENT) PROJECT No. 19116177 Rev. A FIGURE 8



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HIGHWAY 91 – FREEMONT PASS
CLIMAX, CO 80429

CONSULTANT

GOLDER

DATE	2020-08-24
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DESIGN	CLIMAX
REVIEW	RFS
APPROVED	BRB

PROJECT

MCNULTY GULCH OVERBURDEN STORAGE FACILITY
OSF STABILITY ANALYSIS
CLIMAX, CO

TITLE

CROSS SECTION C-C' – PSEUDO-STATIC LOWER BOUND ANALYSIS DURING CLOSURE (1 in 2,475-YEAR EVENT)

PROJECT No.	Rev.	FIGURE
19116177	A	9

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