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VA101-126/24-5

MONTANA RESOURCES
YANKEE DOODLE TAILINGS IMPOUNDMENT - STABILITY ASSESSMENT REPORT FOR 6,560 AMENDMENT DESIGN DOCUMENT

Rev	Description	Date
0	Issued in Final	September 23, 2024

EXECUTIVE SUMMARY

Montana Resources, LLC (MR) is in the process of preparing a permit amendment application (the 6,560 Amendment Application) for continued development of the Yankee Doodle Tailings Impoundment (YDTI) above the currently permitted maximum embankment crest elevation of 6,450 ft. The proposed amendment considers raising the crest elevation (El.) in two or more lifts to El. 6,560 ft to facilitate continued mining until the mid-2050s. The permit amendment application process requires the permit applicant (MR) to submit a design document related to the proposed facility expansion. Knight Piésold Ltd. (KP) prepared embankment designs for key construction stages to show progressive development of the facility throughout the remaining life of mine and the approximate embankment geometry at facility closure to support the 6,560 Amendment Design Document (the Design Document).

This stability assessment report presents the evaluation of the stability of the embankment configurations for the required loading conditions that include normal operating, earthquake, and post-earthquake. Steady-state seepage conditions were considered for this evaluation. This report summarizes the results of analyses completed to evaluate the static limit equilibrium, liquefaction potential, and dynamic earthquake response and displacements. In addition, this report summarizes the evaluations of the extensive historical database and monitoring data that informed the design of the assessment approach and were used to develop input parameters for the analyses.

The YDTI is a valley-fill impoundment, consisting of a large continuous rockfill embankment and an extensive tailings beach. The background and data review indicated the two material units that govern stability are the saturated overburden and rockfill. Although the tailings unit is the weakest, the stability results are not sensitive to the tailings due to the size of the rockfill embankment. The critical location that governs embankment stability is the central pedestal area, which includes the concave Horseshoe Bend (HsB) area, due to the exposure of unconfined overburden near the downstream toe that is saturated with a near-surface groundwater table.

Two hydrogeological regimes are evident in the review of monitoring data and site observations. An upper regime is present in the tailings and a lower regime subdivides the rockfill within the embankment near its base. The basal saturated zone is thickest at the upstream face and thins towards the ground surface at the downstream toe. The monitoring data supports connecting the two regimes with a vertical transition near the upstream face of the embankment to form a single continuous surface.

Screening-level assessments indicated the overburden and rockfill are potentially contractive, which focused the strength definition on the undrained condition. Review of historical site data indicated the presence of microstructure in the overburden and rockfill, which limited the use of empirical correlations for estimating the undrained shear strength. Laboratory data was evaluated and supplemented with additional testing. Notable in the laboratory data set is the lack of post-peak strength loss for the rockfill and limited strength loss for the overburden at lower confining pressures. Reduced overburden strengths were estimated to evaluate the sensitivity of the analysis results. Residual strengths were constrained from laboratory data for the saturated overburden and rockfill and seismic cone penetration testing data for the tailings. Dynamic properties of saturated tailings and overburden were estimated from cyclic laboratory testing. Cyclic testing of rockfill proved challenging and as a result, index testing and standard penetration testing data were used to estimate dynamic properties.

One-dimensional (1D) site response analyses indicated the tailings and overburden units are potentially susceptible to liquefaction under the Maximum Credible Earthquake (MCE). The MCE represents an 84th-percentile deterministic event, involving movement along the Continental-Elk Park fault. The rockfill was limited in data to complete the 1D site response but available data suggest susceptibility when saturated and in the absence of microstructure.

Static slope stability of the embankment design was assessed along five sections through the dam using the limit equilibrium (LE) method in two- and three-dimensions (2D and 3D, respectively) for normal operating and post-earthquake conditions. The target factors of safety (FS) were achieved for both loading conditions and at all analysis sections. The 3D analyses, which accounted for the lateral constraint of the HsB area, corroborated the 2D findings. The analyses also demonstrate the effectiveness of infilling the HsB area for continuous improvement of the dam stability and the consequential risk reduction for a variety of slip surface scales and associated potential failure modes. Dam stability is sensitive to the strength of the saturated overburden foundation, which controls the depth, dimension, and shape of the base of the critical slip surface. The LE analyses also identified the potential for surficial sloughing of the relocated pipeline ramp system and bench scale angle of repose slopes.

The dynamic analysis was completed on an interim construction stage and considered embankment response to five earthquake time histories. The results indicate earthquake-induced deformations are not expected to result in a loss of containment or uncontrolled release of impounded tailings or water. Excess pore pressure is generated in the unconfined overburden at the toe of the dam as a result of the seismic loading, suggesting possible liquefaction in response to earthquake loading and leading to an accumulation of shear strain. As a result, the dam is predicted to displace horizontally into the HsB area. The location of the relocated pipeline ramp likely contributes to this movement as the ramp fill is coincident with the largest downwards displacement and shear bands propagating from the overburden foundation form upstream of the ramp fill. Surficial sloughing of the steep ramp fill is also indicated in the results. Post-earthquake deformations are exacerbated in the absence of additional buttressing fill in the HsB area and in response to the strength loss of a continuous overburden foundation. These deformation results corroborate the key recommendation from the LE stability analyses of refining the configuration and fill sequencing during IFC design for mitigating deformations and thereby, increasing the FS of the dam at this stage.

The stability assessment identified two key areas of uncertainty that could improve the rigour and confidence of future evaluations. Uncertainty remains in the characterization of material response (contractive or dilative) and residual strengths of the soil units controlling stability and deformation. Related to improving material characterization is the uncertainty of the piezometric definition at the upstream face of the dam. Recommendations include ongoing incremental characterization of the material response and strength and verifying or refining the piezometric conditions. Both are included in the current five-year site characterization plan. Additionally, the use of stability analyses for assisting with design refinement and construction should continue.

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ABBREVIATIONS

1D	one dimensional
2D	two dimensions / two dimensional
3D	three dimensions / three dimensional
ACC	Anaconda Copper Company
atm	atmosphere
CDSS	cyclic direct simple shear
CIU	isotropically consolidated undrained
CPT	cone penetration test
CRR	cyclic resistance ratio
CSR	cyclic stress ratio
DSS	direct simple shear
El	elevation
FS	factor of safety
ft	feet
g	gravity (32.2 ft/s^2)
H:V	horizontal to vertical
HsB	Horseshoe Bend
IFC	Issued for Construction
IRP	Independent Review Panel
K_o	coefficient of lateral earth pressure at rest
KP	Knight Piésold Ltd.
kPa	kilopascals
LCI	Lettis Consultants International Inc.
LE	limit equilibrium
LiDAR	Light Detection and Ranging
LoM	life of mine
m	metre
M	moment magnitude
MCA	Montana Code Annotated
MCE	maximum credible earthquake
MR	Montana Resources, LLC
MSF	magnitude scaling factor
NO	normal operating
pcf	pounds per cubic feet
PEQ	post-earthquake
PGA	peak ground acceleration
PI	plasticity index
PPD	pore pressure dissipation
PSD	particle size distribution
psf	pounds per square feet
psi	pounds per square inch
RDS	rock disposal site

r_u .... excess pore water pressure ratio
SBTn .... normalized soil behaviour type
SC .... clayey sands soil classification (USCS)
SCPT .... seismic cone penetration test
SHA .... seismic hazard assessment
SM .... sand-silt soil classification (USCS)
SPT .... standard penetration test
SRA .... site response analysis
Sta .... station
Su .... undrained shear strength
TSF .... tailings storage facility
UBC .... University of British Columbia
UC Berkeley .... University of California, Berkeley
USCS .... Unified Soil Classification System
Vs .... shear wave velocity
Vs30 .... shear wave velocity to 30 m depth
VWP .... vibrating wire piezometer
WED .... West Embankment Drain
YDTI .... Yankee Doodle Tailings Impoundment

1.0 INTRODUCTION

1.1 GENERAL

Montana Resources, LLC (MR) operates the Montana Resources open pit copper and molybdenum mine located in Butte, Silver Bow County, Montana. The mine is bounded by Interstate 15 and the Continental Divide on the east, Moulton Reservoir Road on the west, and Farrell Street, Continental Drive and Shields Avenue to the south. MR has owned and operated the mine site since the 1980’s and is currently mining the Continental Pit. The property was acquired from Atlantic Richfield Company and the former Anaconda Copper Company (ACC) who had previously mined the Berkeley Pit between 1955 and the early 1980s.

The key components of the MR facilities, as shown on Figure 1.1, include the following:

- Yankee Doodle Tailings Impoundment (YDTI)
- Berkeley Pit
- Continental Pit
- Mill and processing facilities (the Concentrator)
- Horseshoe Bend (HsB) area and associated facilities
- Rock disposal sites (RDS) and inactive rockfill leaching areas

Mine tailings are stored in the YDTI. The YDTI was originally constructed in 1963, and the embankments have been progressively raised using rockfill from the Berkeley Pit (until 1982) and from the Continental Pit (beginning in 1986). The YDTI is a valley-fill impoundment with a continuous rockfill embankment that for descriptive purposes is divided into three segments, as shown on Figure 1.1 and described below.

- The North-South Embankment abuts the base of Rampart Mountain, which forms the eastern limit of the mine site.
- The East-West Embankment is situated immediately upstream of the HsB area and is coincident with the current maximum embankment height of approximately 800 feet (ft). The HsB area currently contains infrastructure related to YDTI seepage collection and miscellaneous mine buildings, including the truck maintenance workshop.
- The West Embankment abuts the West Ridge, which forms the western limit of the mine site, and incorporates several seepage control features, such as the West Embankment Drain (WED), to maintain hydrodynamic containment of YDTI seepage as the supernatant pond rises above the lowest groundwater elevations in the West Ridge.

The North RDS and associated mine haul ramp system is currently being progressively developed along the downstream side of the North-South Embankment during ongoing mining operations. Historical seepage collection ponds in the HsB area were decommissioned beginning in 2022, and construction of the Stage 1 HsB drainage system and Stage 1 HsB RDS up to approximately El. 5,900 ft is underway along the downstream side of the East-West Embankment at the maximum dam section. Construction of these features will be ongoing over the next several years.

NOTES:

1. AERIAL IMAGE PROVIDED BY MONTANA RESOURCES, LLC IN JULY 2023.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	19SEP'24	ISSUED WITH REPORT	JRG	RMM	DDF

MONTANA RESOURCES, LLC

MONTANA RESOURCES

YANKEE DOODLE TAILINGS IMPOUNDMENT PROJECT ARRANGEMENT

Knight Piésold CONSULTING

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FIGURE 1.1 REV 0

SAVED: M:\1\01\00126\24\A\Acad\FIGS\VA45, 7/10/2024 8:02:39 AM , RMCLELLAN PRINTED: 9/19/2024 10:43:49 AM, FIG 1.1, RMCLELLAN
XREF FILE(S): 5ft_01 2023-07-26; 2024-04-10 HsB Rock Disposal with Aug 2023 Image; Mapped Faults; Tailings Spigots and Reclaim Pipelines - June 2024 IMAGE FILE(S): 5ft_01 2023-07-26 04-10-2024 Aerial - Aug 2023 Survey Underlaid

1.2 PURPOSE AND SCOPE

The YDTI is currently permitted to a maximum crest elevation (El.) of 6,450 ft. The El. 6,450 ft embankment provides sufficient tailings storage capacity to support mining and ore processing until approximately 2034. MR is preparing a permit amendment application (6,560 Amendment Application) to facilitate continued operation of the mine thereafter by aligning approval for tailings storage at the YDTI with the remaining ore reserves. The permit amendment application process requires the permit applicant (MR) to submit a design document when expansion of an existing facility is proposed.

Knight Piésold Ltd. (KP) is developing the 6,560 Amendment Design Document (Design Document) to support the 6,560 Amendment Application. The Design Document presents the plan to progressively raise the crest elevation of the YDTI embankments to a maximum design crest of El. 6,560 ft in two or more lifts, to support continued mining and ore processing. The Design Document comprises a series of technical reports covering the subject areas and content to meet the requirements specified in Montana State law as well as evaluating opportunities for continued risk reduction to enhance safety as part of the fundamental objective for ongoing continuous improvement of the safety of the YDTI. The laws governing tailings storage facility design, operation and reclamation are contained within sections of Montana Code Annotated (MCA) Title 82 Chapter 4 Part 3 (MCA, 2023), as described in the following:

- Title 82: Minerals, Oil, and Gas
  - Chapter 4: Reclamation
    - Part 3: Metal Mine Reclamation

The governing regulations and design requirements for the Design Document are summarized in the Design Basis Report (KP, 2024a). The design criteria relevant to the stability assessment of the embankment are reproduced in this report for ease of reference. Legislation for the design of an expansion to a tailings storage facility (TSF) requires either an analysis showing that the design meets the minimum requirements for a new TSF or an analysis showing that the design does not reduce the factors of safety (FS) and seismic event design criteria for the original TSF. The design criteria selected for the Design Document consider the requirements for a new facility, and include the following:

- The response of the tailings, embankment, and foundation materials controlling slope stability under the anticipated static and/or dynamic loading conditions do not result in loss of containment.
- The minimum design FS against slope instability for the legislated loading conditions include the following:
  - 1.5 for normal operating, static loading conditions.
  - 1.2 for post-earthquake, static loading conditions.
  - If relevant, the analysis must consider appropriate use of undrained shear strength analysis for saturated, contractive materials.
  - Reduced FS or seismic design criteria are acceptable if the Independent Review Panel (IRP) agrees based on site-specific conditions.
- An analysis showing that the seismic response of the TSF does not result in the uncontrolled release of impounded materials or other undesirable consequences when subject to the ground motion associated with the 1-in-10,000-year event, or the maximum credible earthquake (MCE), whichever is larger. Any numerical analysis of the seismic response must be calculated for the normal maximum loading condition with steady-state seepage. The analysis must consider:
  - Anticipated ground motion frequency content, fundamental period, and dynamic response

- Potential liquefaction
- Loss of material strength
- Settlement, ground displacement, deformation
- Potential secondary failure modes

This stability assessment report presents the evaluation of the stability of the embankment geometries for the required loading conditions, including normal operating, earthquake, and post-earthquake conditions. Steady-state seepage conditions were considered for this evaluation. This report summarizes the results of analyses completed to evaluate the static limit equilibrium, liquefaction potential, and dynamic earthquake response and displacements.

1.3 ASSESSMENT OBJECTIVES

The objectives of the stability assessment for supporting the amendment application comprise the following:

- Material characterization of the mechanical response to the required loading conditions.
- Evaluation of the liquefaction potential of the YDTI material constituents.
- Static stability analyses for normal operating and post-earthquake loading conditions in two dimensions (2D) and three dimensions (3D).
- Dynamic analysis for evaluating the pore pressure and deformation response of the YDTI to a range of earthquake motions, completed in 2D and including a post-earthquake evaluation.
- Identification of data gaps and recommended follow-up work.

1.4 EMBANKMENT DESIGN AND CONSTRUCTION

The proposed life of mine (LoM) development sequence for the YDTI embankments up to El. 6,560 ft is presented separately (KP, 2024b). A summary of the embankment design and development sequence is provided below for context related to the analyses presented in this report. Refer to the design report for additional design details.

The LoM design for the YDTI is presented as a phased sequence to illustrate major development milestones during the proposed remaining LoM. The phased designs of the embankment and RDS were developed considering the layout and construction criteria presented in the design report (KP, 2024b). These criteria were based on historical construction practices and layout methodology with the objective to continuously enhance safety of the facility through slope flattening and progressive buttressing of the facility embankments where and when such enhancements were practicable.

The phases are summarized below with phases identified by bold text representing the future phases of development selected for evaluation in this stability assessment:

- **Phase 1: Ongoing construction activities to be completed prior to the permit amendment**
- **Phase 2: El. 6,500 ft Embankment Crest Raise**
- **Phase 3: El. 6,500 ft Lower Embankment Lifts**
- Phase 4: El. 6,500 ft Embankment Lifts and RDS Expansions
- Phase 5: El. 6,560 ft Embankment Crest Raise
- **Phase 6: Final Life of Mine**

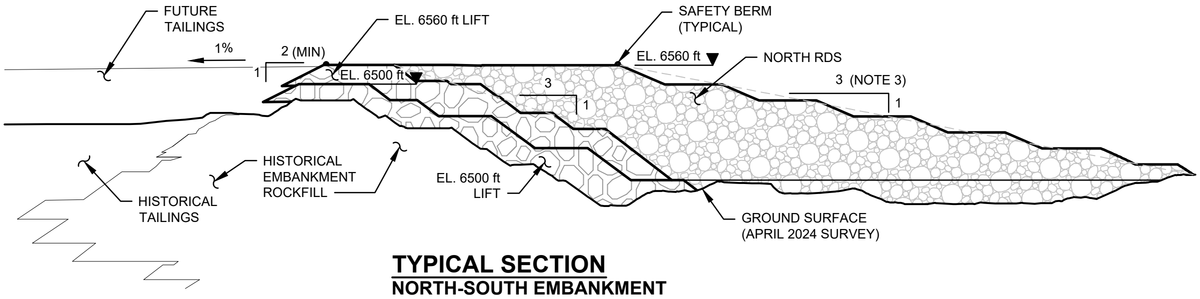
Construction of the embankments and RDS will be completed as a continuous activity as rockfill is available from mine operations. The delivery of embankment construction materials will be scheduled to coincide with availability of rockfill from the mine to meet the phased lift construction requirements. The timing required for the completion of each phase will depend on rockfill availability, tailings production rates, variability of the tailings density throughout the facility, final beach slopes, and the supernatant pond area and volume. The filling of the YDTI will be monitored throughout operations, and construction timing will be adjusted as required.

Issued for Construction (IFC) designs for the various development stages will be progressively completed during ongoing mine development. The YDTI development sequence presented in the Design Document will be updated as required for the IFC designs. Activities attributed to the phases described above and analyzed herein may be adjusted in the future as part of the ongoing facility development process. Final design geometries will take into consideration additions to the knowledge base resulting from ongoing site investigations, material testing, analysis, construction and operational monitoring processes. The methods of analysis and design criteria for the IFC design stages will evolve, if required, to remain consistent with applicable, appropriate, and current techniques practicable for the conditions at the mine.

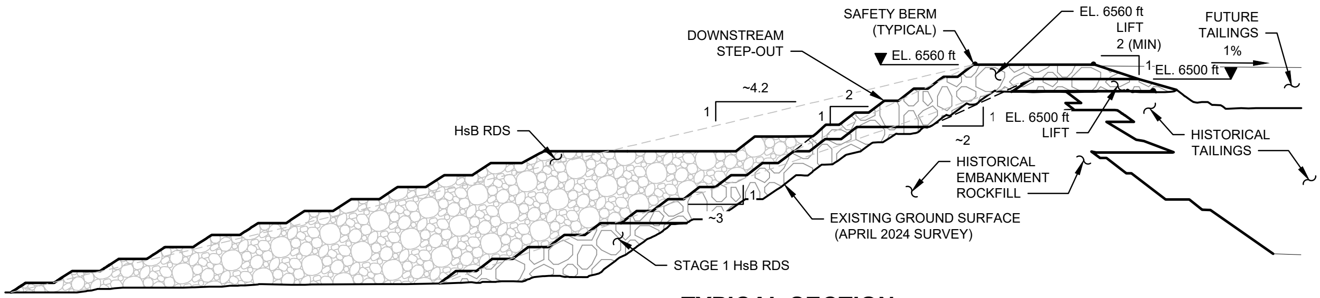
The LoM design for the YDTI embankment raises consists of placing additional rockfill atop the existing crest and along the downstream side of the embankment as shown on Figure 1.2 and Figure 1.3. Rockfill used for embankment and RDS construction will continue to be heterogeneous with variable geotechnical and hydraulic conductivity properties. The embankment designs incorporate a combination of raising by centerline and downstream methods. General layout and construction criteria that apply to all embankment limbs are summarized below and additional details related to the various phases are presented in the design report (KP, 2024b).

- Embankment rockfill upstream slopes are specified at angle of repose or flatter in select areas to facilitate placement of facing materials along the upstream face of each lift. The facing material will be placed as required with a slope of 2H:1V or flatter to maintain a separation zone between the tailings and embankment rockfill.
- Overall embankment downstream slopes are specified and will be achieved (except along the West Embankment) by incorporating benches between successive 50 to 100 ft high angle of repose slopes (consistent with historical practices). The width and frequency of the benches control the overall slope angle prior to reclamation. Target overall downstream slopes are generally 3H:1V or flatter with steeper slopes of up to approximately 2H:1V locally, where necessitated by embankment and ramp geometry.
- The overall embankment crest width may vary for each limb and crest elevation; however, a minimum width of 220 ft is generally specified.

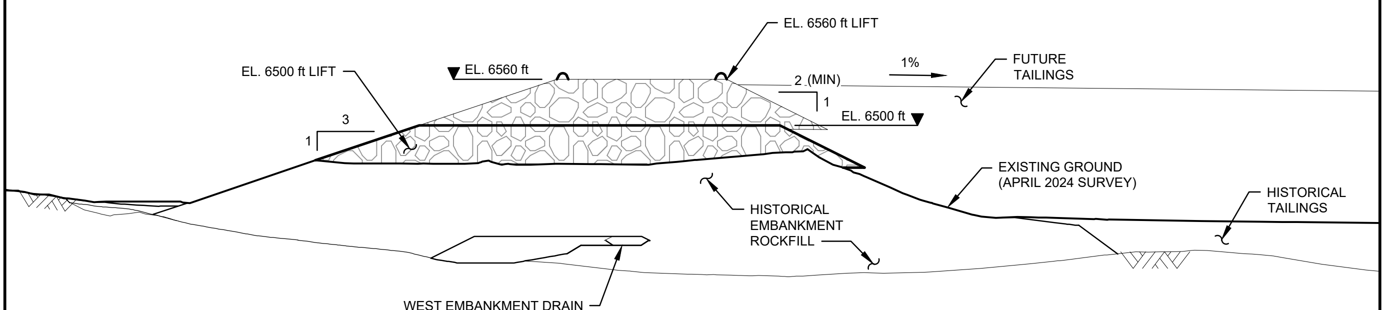
The construction method maintains the practice of previous raises, where rockfill was placed in lifts up to approximately 50 ft thick using the mine haul trucks and bulldozers (except along the downstream side of the West Embankment where thinner lifts are used). The lift surfaces are initially compacted from the mine haul fleet traffic and gradual settlement of the lift occurs thereafter. Ripping of the embankment surface is specified prior to subsequent fill placement to enhance vertical infiltration.



TYPICAL SECTION
NORTH-SOUTH EMBANKMENT
SCALE A



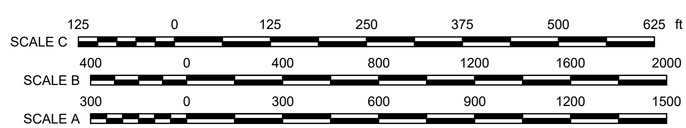
TYPICAL SECTION
EAST-WEST EMBANKMENT
SCALE B



TYPICAL SECTION
WEST EMBANKMENT
SCALE C

NOTES:

1. COORDINATE SYSTEM AND ELEVATIONS ARE BASED ON MINE GRID.



LEGEND:

EMBANKMENT ROCKFILL

ROCK DISPOSAL SITE / RAMPS / OTHER

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YANKEE DOODLE TAILINGS IMPOUNDMENT
TYPICAL EMBANKMENT SECTIONS

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FIGURE 1.2 REV 0

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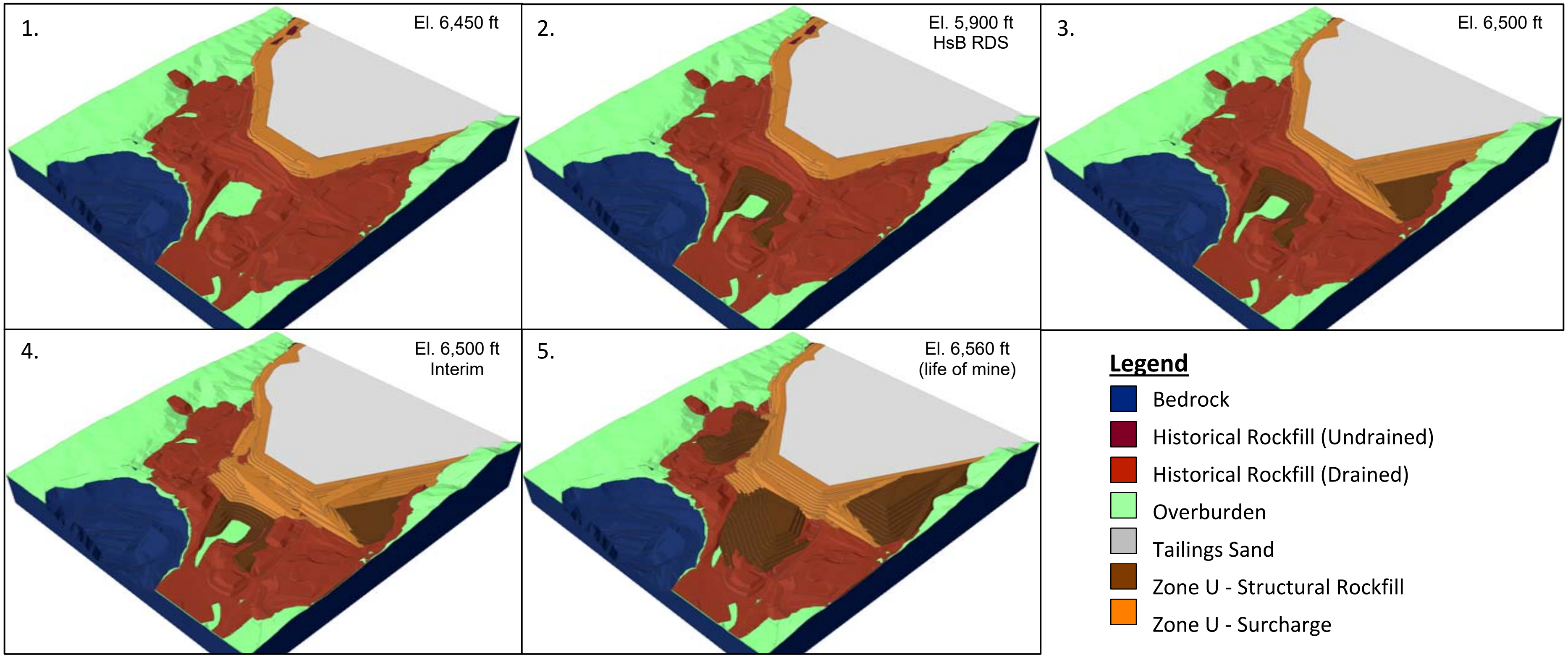

NOTES:

1. CURRENT EMBANKMENT CONFIGURATION (PRIOR TO PERMIT) AT THE COMPLETION OF THE EL. 6,450 ft CREST RAISE (~END OF 2023).
2. INTERIM EMBANKMENT CONFIGURATION (PRIOR TO PERMIT) AT THE COMPLETION OF THE HsB STAGE 1 RDS (EL. 5,900 ft) (~ 2027).
3. PHASE 2 INTERIM EMBANKMENT CONFIGURATION AT THE COMPLETION OF THE EL. 6,500 ft CREST RAISE WITH STAGE 1 HsB RDS AND NORTH RDS (~ 2031).
4. PHASE 3 INTERIM EMBANKMENT CONFIGURATION WITH LOWER EMBANKMENT LIFTS AND RAMP SYSTEM PRIOR TO EL. 6,560 ft CREST RAISE (~2036).
5. PHASE 6 FINAL EMBANKMENT CONFIGURATION WITH EL. 6,560 FT CREST AT END OF MINE LIFE (~2055).
6. MODEL DEVELOPED IN SLIDE3 (Rocscience, 2023) WITH HISTORICAL EMBANKMENT TOPOGRAPHIES.
7. REFER TO DESIGN REPORT (KP REF. # VA101-126/24-4) FOR PHASED CONSTRUCTION GEOMETRIES AND ADDITIONAL SPECIFICATIONS.

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MONTANA RESOURCES, LLC

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YANKEE DOODLE TAILINGS IMPOUNDMENT
KEY CONSTRUCTION STAGES

Knight Piésold CONSULTING

P/A NO. VA101-126/24

REF. NO. 5

FIGURE 1.3

REV 0

1.5 COORDINATE SYSTEM AND STATIONING

The mine site coordinate system is based on the Anaconda Mind Grid that was established by The Anaconda Company in 1957 and utilizes International Feet. The Anaconda Mind Grid is based on the ACC Vertical Datum that was established in 1915. The MR Site Coordinate System is based on the Anaconda Mine Grid and utilizes International Feet. All elevations are stated in Anaconda Mine Grid coordinates with respect to the ACC Vertical Datum unless specifically indicated otherwise.

The stability assessment references legacy cross section stationing that has been historically used. The stationing most likely aligns with a historical setting out line for the embankment that is no longer consistent with the recent raise designs. The legacy stationing is maintained for consistency. The convention begins with Station (Sta.) 0+00 at the interface between the North-South and East-West Embankments and increases in both directions. A directional suffix (e.g., N, NW or W) is included to clarify the locations: for example, Sta. 8+00N denotes 800 ft moving northward along the North-South Embankment and Sta. 8+00W denotes 800 ft moving westward along the East-West Embankment.

2.0 SITE SETTING

2.1 GENERAL

A comprehensive Site Characterization Report was prepared in 2017 (KP, 2017), which included relevant historical data available from other consultants prior to involvement in the project by KP as well as data collected by KP and MR during phased site investigation programs carried out in 2015 and 2016. This report provided a detailed description of the development of the YDTI and presented the geotechnical and hydrogeological characterization of the site conditions supporting the ongoing design of the YDTI. Additional site investigation programs were conducted annually between 2017 and 2023, which greatly increased the geological, geotechnical, and hydrogeological data available for the characterization and monitoring of the YDTI.

The findings of these more recent site investigation programs were generally consistent with and supportive of the existing geotechnical and hydrogeological model for the impoundment as presented in the Site Characterization Report (KP, 2017). The findings of each investigation are summarized in the individual site investigation reports along with details related to the site geological model and site investigation methodology. The investigations completed to date are commensurate in scope and scale with the complexity of the facility and site geology. The results of these site investigations are considered suitable to support the continued design and operation of the YDTI. Additional details and report references are provided in Appendix A. A summary of relevant site characteristics and assumptions made for the purposes of analysis are described in the following sections to provide context for the stability assessment.

2.2 GEOLOGICAL SETTING

The YDTI lies in the northern end of the upper Silver Bow Creek Basin at the historical confluence of Yankee Doodle Creek and Silver Bow Creek. The basin is 3.5 miles wide and 7 miles long. The YDTI is bordered by mountainous terrain on all sides except the south.

The basin and surrounding mountains lie entirely within the intrusive rock of the Boulder Batholith and have been subjected to intense faulting. Butte Quartz Monzonite is the dominant lithology and is subdivided into two units underlying the YDTI: an upper weathered rock zone and a lower competent and less weathered rock zone. Fault structures are found along the eastern boundary of the mine, as shown on Figure 1.1, and are associated with Rampart Mountain and the East Ridge.

The basin has a thin soil mantle and is underlain in places by alluvial overburden deposits of variable thickness. Two origins of overburden are generally recognized in the YDTI area: recent stream deposits (referred to as recent alluvium) and older outwash deposits (referred to as older alluvium). Recent alluvium deposits are mapped to exist along the historical Silver Bow Creek channel and minor tributaries existing within the embankment footprint. Older alluvium is located directly east of the historical Silver Bow Creek channel and forms a moderately sloping plain rising to the east, towards the East Ridge.

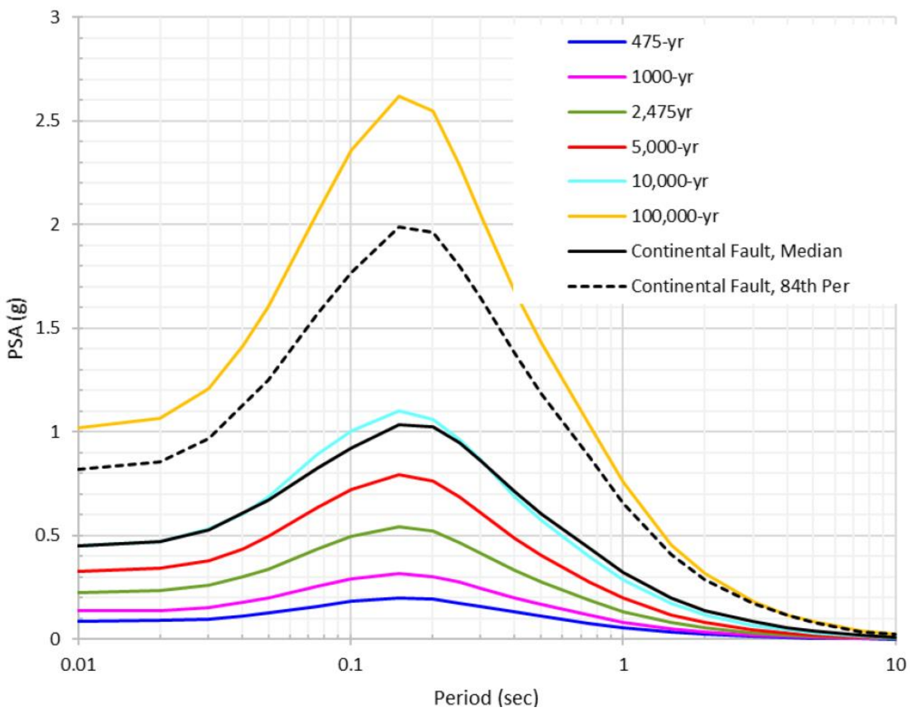
The valley slopes along the West Ridge are granitic bedrock covered with a layer of alluvium and/or residual soils up to approximately 10 ft thick. The topsoil, alluvium, and residual soils were generally stripped from the foundation of the West Embankment during construction and stockpiled locally for future reclamation purposes.

2.3 SEISMICITY

Regional and local faulting were evaluated by Lettis Consultants International Inc. (LCI), who identified faults in the immediate vicinity of the YDTI as shown on Figure 1.1 (LCI, 2021a; 2021b). LCI also evaluated faults located outside the figure boundary of Figure 1.1, including the Rocker fault (5 miles southwest of the YDTI) and the Elk Park fault (interpreted to be a northern continuation of the Klepper fault). Key findings from the assessment include the following:

- Strong evidence of late Pleistocene faulting on the Continental (0.75 miles from the YDTI) and Klepper-Elk Park (1.8 miles from the YDTI) faults
- Inferred evidence of late Pleistocene faulting along the East Ridge fault (1.9 miles from the YDTI)
- Limited evidence of faulting along the Rocker fault (5.3 miles from the YDTI)

The previous 2016 seismic hazard assessment (SHA) for the YDTI was updated (Al Atik and Gregor, 2022) with the fault evaluation findings (LCI, 2021b) to revise the uniform hazard and deterministic spectra for the MCE scenarios of the Continental-Elk Park and Rocker faults. The Continental and Klepper-Elk Park faults were combined as a single seismic source in this update. The updated spectra are shown on Figure 2.1. The 84th percentile deterministic spectrum of the Continental-Elk Park source was chosen to represent the design MCE based on guidance from the California Division of Safety of Dams, which recommends consideration of both the slip rate and damage potential in its consequence-hazard matrix (Al Atik and Gregor, 2022). The design earthquake is characterized as a Moment Magnitude (M) 7.0 event along the Continental fault, causing a peak ground acceleration (PGA) of 0.84 g at the YDTI.



Note(s):

1. Response spectra for time-averaged shear-wave velocity to a depth of 30 m (Vs30) of 760 m/sec site conditions.
2. Y-axis is pseudo-spectral acceleration.

Figure 2.1 Horizontal spectra at the YDTI site (Al Atik and Gregor, 2022)

Al Atik and Gregor (2022) developed five input earthquake time histories for defining the MCE design spectrum, as listed in Table 2.1. Due to the proximity of the YDTI to the Continental-Elk Park source, four of the five time histories were selected to include near-fault ground-motion pulse characteristics that can be more damaging than non-pulse motions. Each of the earthquake time histories was spectrally matched to the MCE design spectrum for the dynamic analysis.

Table 2.1 Input Time Series (Al Atik and Gregor, 2022)

ID	Earthquake	Station Name	Magnitude (M)	Fault Mechanism	Rupture Distance, Rrup (miles)	Pulse Period (seconds)
MCE 1	Loma Prieta	Saratoga, Aloha Ave	6.9	Reverse Oblique	5.3	4.57
MCE 2	Cape Mendocino	Petrolia	7.0	Reverse	5.1	3.00
MCE 3	Darfield, NZ	LINC	7.0	Strike Slip	4.4	7.39
MCE 4	Kobe, Japan	Nishi-Akashi	6.9	Strike Slip	4.4	-
MCE 5	Irpinia, Italy-01	Bagnoli Irpinio	6.9	Normal	5.9	1.74

3.0 ASSESSMENT APPROACH

3.1 GENERAL

The approach undertaken for the stability assessment began with an evaluation of the existing information, to determine the governing factors of the previous design and to understand the anticipated response of key materials to loading conditions. This review informed the definitions of base case conditions and sensitivity checks for the current stability analyses. The assessment also considered the evolving geometry of the embankment throughout the remaining LoM by analyzing key construction stages for calculating FS values and estimating earthquake-induced deformations.

3.2 KEY FINDINGS FROM THE PREVIOUS RAISE

Key findings from the design evaluation of the previous raise to El. 6,450 ft (KP, 2018a; 2018b) included the following:

- The definition of failure was a loss of containment, which was defined by the FS of a full-height slip through the upstream crest for the limit equilibrium (LE) analysis and crest settlement greater than 5 ft (freeboard) for the stress-strain (dynamic) analysis.
- Base case conditions comprised drained strengths for material properties and two hydrostatic phreatic lines. Material properties were developed from laboratory testing results. The phreatic lines were located based on monitoring data with an upper line through the tailings and a lower line through the embankment rockfill and top of overburden downstream of the dam.
- Slips in the downstream direction governed stability for the base case LE analysis. The FS for slips in the upstream direction was greater than five.
- Sensitivity checks for the LE analysis evaluated undrained strengths for the saturated rockfill and overburden. Two locations of saturated rockfill were evaluated with an upper location coincident with the Seep 10 Bench to represent a hypothetical perched condition and a lower location coincident with the lower phreatic line.
- The governing full-height downstream slip toed through the base of the saturated overburden for base case conditions and the sensitivity check. The sensitivity check for undrained strengths of the saturated rockfill and saturated overburden reduced the FS significantly.
- The 2018 dynamic analysis (KP, 2018b) was recently updated (KP, 2022a) and predicted high excess pore pressures in the saturated overburden downstream of the embankment toe and localized occurrences in the saturated basal rockfill. Crest settlements up to 4 ft were predicted and located at the upstream point. Settlements up to 5 ft were predicted in the rockfill surcharge overlying the tailings. The bulk of the embankment was predicted to displace downstream horizontally up to 6 ft with higher values occurring at the surface, indicating the likelihood of bench-scale sloughing.

3.3 DEFINITION OF BASE CASE CONDITIONS

Several site investigations were completed to further characterize the overburden and embankment rockfill (KP, 2018c; 2019a; 2019b; 2020a; 2020b; 2021; 2023a; 2023b) following the stability assessment of the previous raise to El. 6,450 ft (KP, 2018a). These investigations increased the monitoring and in-situ property databases significantly and collected additional materials for laboratory testing.

The monitoring data enabled an update of the piezometric representation, which forms an important analysis input. The data review indicated that three-dimensional (3D) considerations were required for defining steady-state conditions, in the form of a phreatic surface for use in the stability analyses.

The in-situ data enabled a more rigorous evaluation of the anticipated mechanical response of the critical materials, the saturated overburden and rockfill, in addition to development of analysis input parameters. Review of seismic cone penetration testing (SCPT) data indicated the potential presence of microstructure, which limited the use of in-situ data for developing strength parameters. Consequently, available laboratory data was reviewed, which suggested a potential for contractive behaviour. Although in-situ data suggests the dam is behaving in a drained manner, the analyses assumed triggering is possible and strength definition focused on an undrained response. A laboratory program was developed to augment the existing database for refining the undrained shear strength definition of the critical materials. The strengths were defined to represent the direct simple shear (DSS) mode of failure since the sub-horizontal geometry of the units suggests simple shear mode is likely to govern.

3.4 ANALYSIS GEOMETRIES

Ongoing construction of the embankment up to the El. 6,560 ft LoM design will be completed in stages that depend on the availability of embankment rockfill generated from mining. The final geometry of the raise represents the current concept for closure (KP, 2024b), which is focused on creating a landform with the large quantity of rockfill provided for mining the current estimate of reserves. As a result, the embankment will be significantly buttressed in the final geometry. However, the stability assessment for the static evaluation considers five key construction stages over the LoM as shown Figure 1.3 and described below:

- Completion of the El. 6,450 ft crest raise (currently permitted geometry), construction was substantially completed by the end of 2023.
- Completion of the HsB Stage 1 RDS to El. 5,900 ft and projected for approximately 2027.
- Completion of the crest raise to El. 6,500 ft and the new haul ramp to the top of the North-South Embankment, projected for approximately 2030.
- Completion of the pipeline relocation ramp with the crest at El. 6,500 ft and projected for approximately 2037.
- Completion of the El. 6,560 ft crest raise and the final embankment geometry, projected for 2055.

3.5 STABILITY ANALYSES

Analysis model geometry was developed by first constructing a site model in 3D, to account for the complex shape of the YDTI and the fill placement sequence. The geometrical complexity also necessitated a multi-dimensional evaluation that was discussed with the IRP, who concurred. Stability was evaluated in 2D to assess the regulatory requirements (target FS) and in 3D to refine the understanding of the slip scales and locations of concern. In addition, the 2D LE analysis included evaluation of a section through Sta. 0+00 due to the less restrictive toe geometry currently present in the HsB area.

The LE analysis also focused on downstream slips given the high FS results from the previous raise (KP, 2018a) for upstream slips. This is a result of in-situ data indicating that the upper 100 ft or more of tailings is unsaturated and consequently, has little flow potential.

The dynamic analysis was completed in 2D for a single geometry that represented a combination of the most aggressive slope angle and the least rockfill buttressing in the HsB area. The El. 6,500 ft interim construction stage, with the relocated pipeline ramp, was selected through discussion with the IRP.

4.0 SITE CONDITIONS

4.1 GENERAL

Site conditions were established by reviewing the results of site investigation programs completed by various engineering consultants over the last six decades to evaluate geotechnical and hydrogeological conditions. The investigations included in-situ and laboratory testing, instrumentation installations, and various monitoring activities. These databases and observations were reviewed to develop the stability assessment approach, plan for supplementary laboratory testing, and develop input parameters for the analyses. A discussion of the relevant data is presented below while a comprehensive overview of the site investigation programs is presented in Appendix A.

4.2 SOIL UNITS

Three primary soil units were considered in the stability assessment of the YDTI. The overburden unit is considered as a blanket of uniform thickness overlying the bedrock in the analyses. The rockfill unit forms the embankment dam and general fill downstream of the dam and is the construction material for future dam raises and the RDS fill. The tailings unit is impounded by the embankment dam.

The overburden unit consists predominantly of alluvial deposits that vary across the site. Two sources of overburden are generally recognized in the YDTI area: recent stream deposits (recent alluvium) and older outwash deposits (older alluvium). Recent alluvium deposits are mapped along the historical Silver Bow Creek channel, which approximately aligns with Sta. 8+00W, and minor tributaries existing within the embankment footprint. Recent alluvium material is typically dark brown, poorly graded, and compact to very dense sand with some silt, some gravel, and is generally non-plastic. Older alluvium is located directly east of the historical Silver Bow Creek channel and forms a moderately sloping plain rising to the east, towards the East Ridge. The older alluvium unit is generally poorly sorted, unconsolidated to moderately indurated, silt, sand, gravel and cobble detritus locally derived from granitic and volcanic rocks. Locally it may include talus deposits comprised of unsorted cobble and boulder rock fragments and debris flow deposits (KP, 2020a). Drillholes have encountered the overburden unit at thicknesses ranging up to approximately 40 ft. The unit is generally thin or absent on the western side of the YDTI.

The rockfill material generally consists of highly altered and weathered gravels, cobbles and boulders within a silty sand or sandy silt matrix. The weathering, alteration and gradation of the embankment rockfill is highly variable. Particle strength of clasts ranges from strong for unaltered rock to weak for highly-altered and friable rock. This variability is associated with differences in lithology and geological alteration in the parent rock (Berkeley and Continental Pits) as well as the spatial variability related to construction history of the dam. Material segregation occurs as the rockfill is end-dumped from the crest of each lift. Finer particles tend to accumulate near the top of the lift, while coarser material accumulates at the toe.

The tailings are deposited as a slurry around the perimeter of the embankment which results in segregation of the material along the beach. Coarser-grained tailings accumulate against the embankment, while finer-grained tailings settle towards the supernatant pond. Geological logs and particle size analyses for tailings show a mix of sand, silt sand, sandy silt and silt layers. The sand content ranges 9% to 85% and averages approximately 65%. The fines content ranges 14% to 90% and averages approximately 35%.

4.3 MECHANICAL RESPONSE OF CRITICAL SOIL UNITS

The units governing stability include the foundation overburden materials and the embankment rockfill. Although the tailings are the weakest unit, the analysis results are not sensitive to the tailings strength due to the size of the embankment. Hence, the evaluation of the mechanical response of the TSF soil units focused on the critical units of the overburden and rockfill. Data from the 2018 (KP, 2019a; 2019b) and 2019 (KP, 2020a; 2020b) site investigation programs form the primary database for the evaluation, particularly the SCPT data.

The in-situ state of the overburden soils was assessed using the Robertson (2016) normalized soil behaviour type (SBTn) classification, which was corroborated by normalized shear wave velocities (Vs), indicating that the overburden soils were predominantly dilative. However, data from the recent alluvium beneath the embankment toe suggested a potential for contractive behaviour (KP, 2020b).

Similarly, the in-situ state of the embankment rockfill was generally classified as dilative when evaluated using the state parameter and SBTn. However, pore pressure measurements taken from the SCPT indicated that dynamic pore pressures were generally higher than the equilibrium pore, suggesting a potential for contractive behaviour.

Further review of the SCPT data indicated a prevalence of microstructure in the overburden and embankment rockfill as shown on Figure 4.1 using the Robertson (2016) approach. Microstructure most commonly results from cementation and particle interlocking. The overburden data also suggested a potential difference between the two groups, with the older alluvium exhibiting more microstructure that is likely attributed to the relative age of the materials and the potential impact from nearby historical leaching operations. Likewise, the rockfill microstructure is attributed to its age and historical leaching activities in some areas.

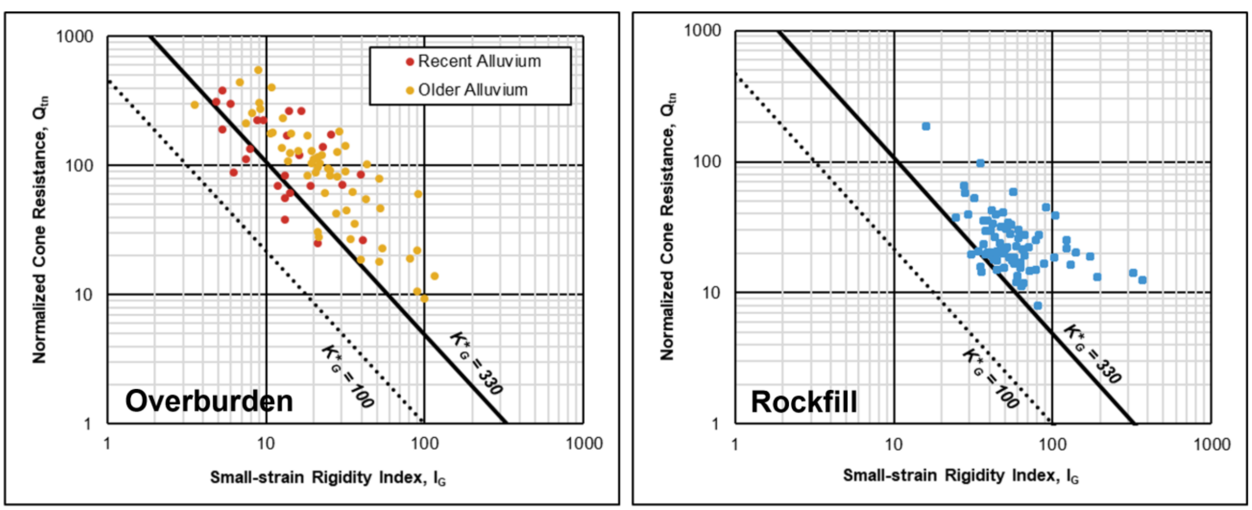
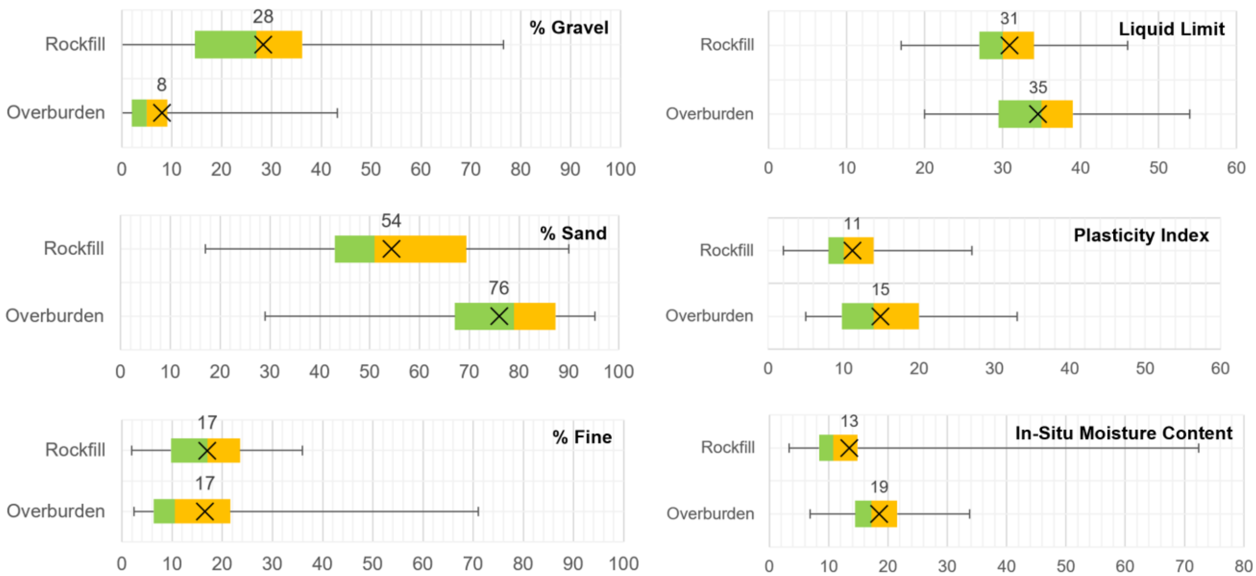


Figure 4.1 Microstructure Evidence from the 2018 and 2019 Investigations

The significance of microstructure is a tendency for dilation in shear, as suggested by an increase in cone tip resistance. At large strains, the same material could lose strength and become contractive once the microstructure is destroyed. Therefore, the overburden and rockfill may behave in a contractive manner at larger strains despite cone tip resistance suggesting a dilative response. Empirical strength correlations for the SCPT data interpretation are based on ideal soils, which are young and unstructured. The evidence of microstructure in the overburden and rockfill limit the reliability of these empirical correlations. As a result, the strength characterization of these materials returned to a laboratory derivation by testing remolded specimens to remove or minimize the influence of microstructure and targeted efforts on constraining the undrained shear strength.

4.4 MONOTONIC LABORATORY EVALUATION

A review of the laboratory database indicates variability in the materials, which can influence the strength testing. A statistical breakdown of particle size distribution (PSD) and plasticity results from the 2018 and 2019 site investigation programs is shown on Figure 4.2. The data shows a high degree of variability in each soil unit based on the relatively high standard deviations in relation to their mean. A compilation of the PSD results is provided in Appendix B1, along with a detailed discussion of the monotonic laboratory evaluation for estimating the undrained shear strength.



Note(s):

1. Black lines represent range, green boxes represent lower interquartile (25^{th} to 50^{th}), yellow boxes represent upper interquartile (50^{th} to 75^{th}), median values denoted by the green-yellow box transition, and mean values denoted by "x".
2. Larger particles were removed for testing, which is limited to 3-inch maximum particle size.
3. Drilling-related disturbance may have influenced the particle sizes of collected samples.
4. Database is compiled from results of samples collected during the 2018 and 2019 site investigation programs (KP, 2019a; 2019b; 2020a; 2020b).

Figure 4.2 Variability of Index Properties of Overburden and Rockfill

Strength testing was completed in phases with details provided in Appendix B1. Phase 1 was conducted between 2014 to 2016 on overburden (recent alluvium) and embankment rockfill (older and newer) specimens with isotropically consolidated undrained (CIU) triaxial loading conditions. Phase 2 was conducted in 2022 on older alluvium and older rockfill, under CIU triaxial and DSS loading conditions. The test specimens were remolded, ranged in density from as loose as possible to an estimated in-situ density, and ranged in diameter from 2 (nominally) to 24 inches.

Phase 1 testing required PSD modifications due to the smaller specimen sizes. The resulting stress paths for the recent alluvium indicated contractive behaviour but with less than 30% strength loss at 20% strain, implying shearing would induce excess pore pressure generation. In contrast, the rockfill stress paths transformed from initially contractive to dilative at large strains with no strength loss.

Phase 2 testing prioritized minimizing PSD modifications and evaluating the DSS failure mode. Testing of older alluvium overburden also included CIU triaxial to enable a comparison of the shearing modes. Except at the lowest confinement of 20 psi, the overburden specimens experienced limited contraction and hence, little strength loss was evident. This difference from the Phase 1 testing could be attributed to the mineralogical differences between the older and recent alluvium, as well as the size effect of an unmodified PSD. Testing of rockfill was remolded to a denser state than the Phase 1 specimens and only evaluated the DSS mode (24-inch specimens). The results were consistent with Phase 1 with the rockfill stress paths dilating at large strains after initially contracting and hence, did not exhibit strength loss.

A comparison of the triaxial and DSS modes demonstrated inconsistent findings with only the rockfill exhibiting the expected trend of the Ladd (1991) study, where the DSS mode produced lower undrained shear strength (Su) ratios than triaxial compression, as shown on Figure 4.3. The Su ratio is the undrained strength normalized by the initial overburden effective stress. The overburden DSS-derived strengths fell within the range of the triaxial-derived values from testing variable specimen sizes and both alluvial sources. The unexpected trend requires a more fulsome and systematic evaluation to understand the current results. Nevertheless, the Ladd (1991) findings were utilized to reduce the triaxial strengths to approximate equivalent DSS values to define base case values for peak strength and an appropriate sensitivity value for the stability analyses.

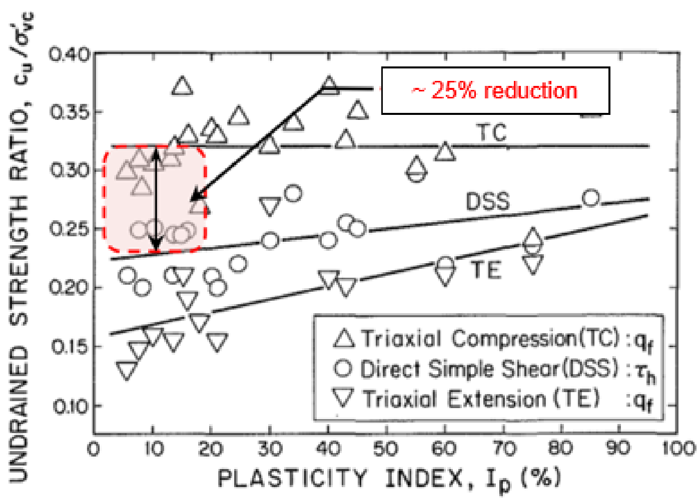


Figure 4.3 Undrained Shear Strength Anisotropy (modified from Ladd, 1991)

The plasticity index (PI) of the samples from the 2018 and 2019 site investigation programs indicate a range of 10 to 20 for the overburden and 8 to 14 for the embankment rockfill, which suggest medium to low plasticity. Using Ladd (1991), the estimated reduction factor was approximately 25%, as shown on Figure 4.3. The reduction of the CIU results is plotted with the DSS data on Figure 4.4 and show a reduced scatter in the data with a low standard of deviation. The consistency of the rockfill CIU and DSS data sets suggest a 30th-percentile value of 0.31 (mean and median are 0.35 and 0.33, respectively) can be conservatively used to define the base case Su ratio, which precludes the need for a sensitivity check. A more refined approach was required for defining the overburden strengths due to the larger spread in data. A mean value of 0.34 was selected for the base case peak strength since it is lower than the median value of 0.39. The

30th-percentile value of 0.26 was selected for a sensitivity check. Details of the statistical breakdown are provided in Appendix B1.

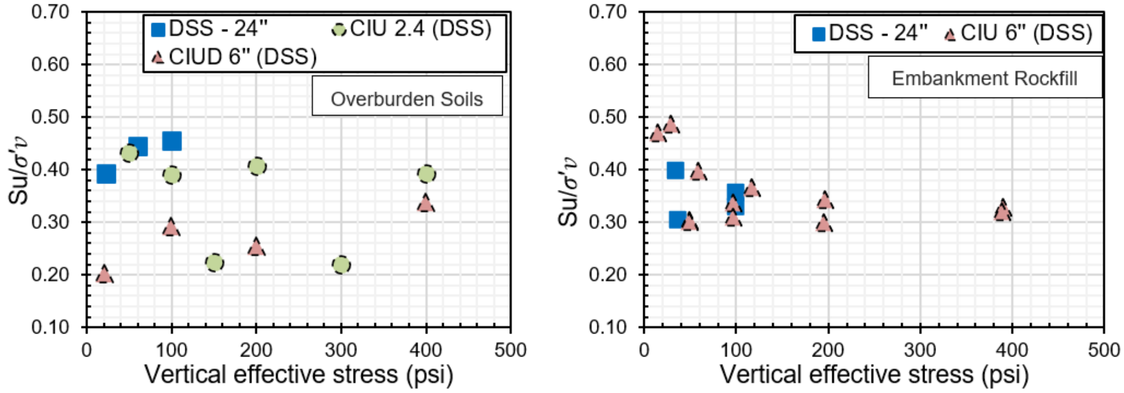
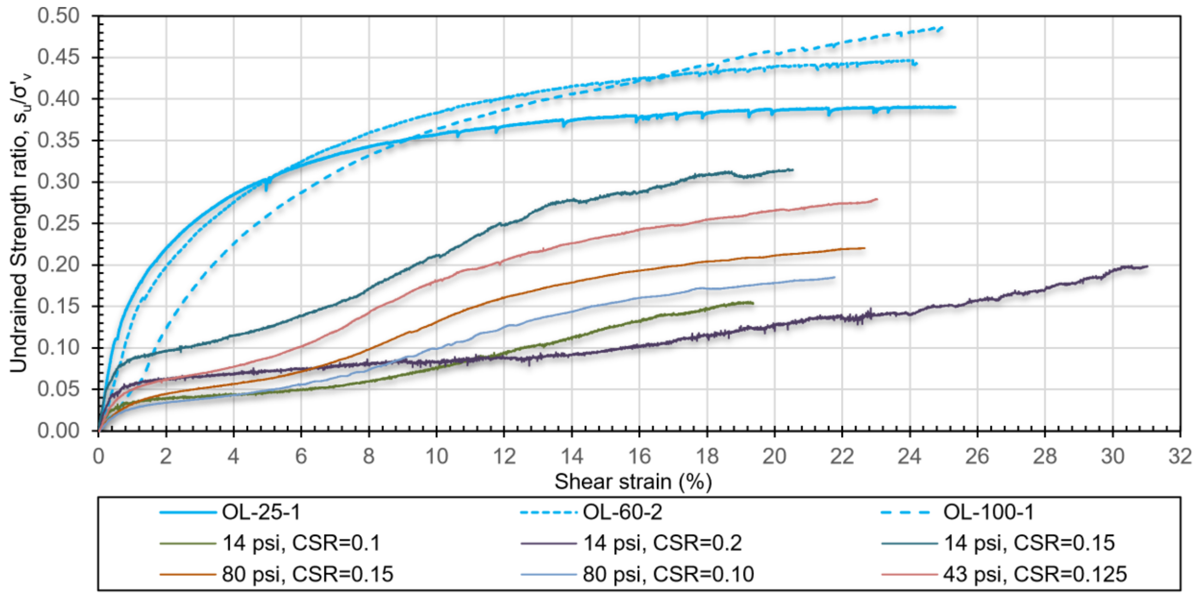


Figure 4.4 Undrained Peak Strength Ratios with CIU adjusted for DSS failure mode

The evidence of strength loss guided the definition of the residual Su ratio for both units. The lack of strength loss in the rockfill results suggested the residual value is equivalent to the peak value. For the overburden, the residual value was constrained from monotonic testing of liquefied specimens at the completion of cyclic direct simple shear (CDSS) tests or post-cyclic monotonic tests, as shown on Figure 4.5, along with the Phase 2 monotonic DSS results. A residual value of 0.22 was selected by averaging the post-cyclic monotonic values at a strain of approximately 19%. A sensitivity value of 0.2 was defined by reducing the peak sensitivity value (0.26) by 25% to align with the maximum strength loss indicated by the Phase 1 testing.



Note(s):

1. The “OL” samples are Phase 2 monotonic DSS results.
2. The post-cyclic monotonic tests (various Cyclic Stress Ratios, denoted by CSR) were conducted immediately after liquefaction, necessitating a reset of strain readings to zero at the start of monotonic loading.

Figure 4.5 Phase 2 Overburden DSS and Post-Cyclic Monotonic Results

4.5 CYCLIC LABORATORY EVALUATION

The cyclic response of the saturated tailings and overburden was evaluated by CDSS testing and estimated from empirical correlations for the saturated rockfill. Testing of rockfill samples by CDSS was attempted but the larger grain size in combination with the requirement for cyclic loading resulted in too many challenges to produce reliable results. As a result, dynamic properties for the rockfill were approximated from correlations with index properties and standard penetration test (SPT) results.

Testing of the tailings was conducted in 2014 (Wijewickreme, 2014) for evaluating the previous raise (KP, 2018b; 2022a). An update of the tailings properties was not required for evaluating the design since the tailings do not control embankment stability. The 2014 results were adopted for use in the dynamic analysis of the current design. The test results and report are provided in Appendix B2.

Initial testing of the overburden was conducted in 2023 (Zekkos and Sari, 2023) and focused on the older alluvium (from 2018 and 2019 HsB area drillholes) given its prevalence on site. The testing involved reconstituted specimens, confining pressures representing 15 to 90 ft of embankment height, and a target range of cyclic stress ratios (CSR) to represent the design earthquake. The criteria for triggering liquefaction was defined based on industry experience: 3.75% shear strain or an excess pore pressure ratio (r_u) of 0.9. The overburden results are plotted on Figure 4.6 and demonstrate the consistency between the triggering criteria since a similar number of cycles was required to reach the shear strain and r_u targets. As expected, less cycles were required to trigger liquefaction with increasing earthquake loading (i.e. increased CSR). The test results and a detailed discussion are provided in Appendix B2.

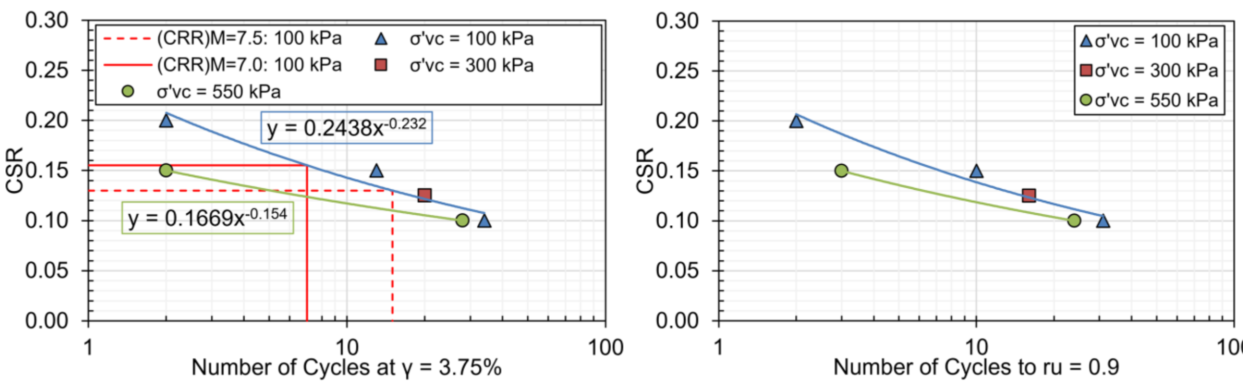


Figure 4.6 Number of Cycles Required to Trigger liquefaction

4.6 FOUNDATION STIFFNESS

The stiffness of the overburden foundation is required for the dynamic analysis and was estimated from Vs data collected in the HsB area (KP, 2019a; 2019b; 2020a; 2020b). The database includes two downhole acquisitions and twelve acquisitions with a SCPT probe. A time-averaged shear wave velocity to 30 m (100 ft) depth (Vs30) was estimated for the overburden and the underlying bedrock. The Vs30 of the overburden was estimated to be approximately 1380 ft/sec while the bedrock was approximately 1670 ft/sec.

4.7 PIEZOMETRIC CONDITIONS

The conceptual hydrogeological model for the YDTI embankments suggests that a basal saturated zone exists deep within the embankment rockfill and that isolated perched saturated zones exist within the overlying rockfill. Perched saturated zones are typically encountered within finer grained historical lift-top rockfill resulting from end-dumping and above historical haulage routes or pipeline alignment surfaces. Pore pressure monitoring data from embedded pore pressure monitoring instruments continue to corroborate this conceptual hydrogeological model, and piezometric trends are generally indicative of stable or slightly decreasing embankment piezometric conditions within the basal zone.

Hydrometrics (1997) initially characterized the piezometric conditions of the embankment dam through a seepage analysis that considered both isotropic and anisotropic permeability. Seepage through the facility was found to be dominated by the large difference (two orders of magnitude) between the permeability of the embankment and the tailings deposit, with the embankment acting as a drain. This interpretation is consistent with the monitoring data from the extensive network that is currently installed.

Tailings discharge will continue at multiple locations to maintain the large, drained tailings beaches that are integrated into the impoundment containment system. Tailings slurry water continually percolates into the tailings beach during operations and recharges the phreatic surface within the impoundment. The permeability contrast between the tailings and embankment materials and the permeability of the foundation materials are expected to continue to maintain future piezometric conditions consistent with conditions monitored over the past decade. Monitoring to confirm this piezometric design assumption will be carried out continuously throughout ongoing construction, operation, and following closure of the facility.

The piezometric monitoring data shows the presence of a saturated basal zone through the embankment with an overall downward gradient. The basal saturated zone is thickest at the upstream face and thins towards the ground surface at the downstream toe. The piezometric conditions in the HsB area are hydrostatic with a near-surface water level. Upstream of the dam, hydrostatic piezometric conditions are also evident but phreatic conditions range in depth from approximately 100 to 200 ft at the face to surface at the supernatant pond across the extensive beach of greater than 5,000 ft. The majority of seepage flow from the YDTI is generally directed towards the HsB area.

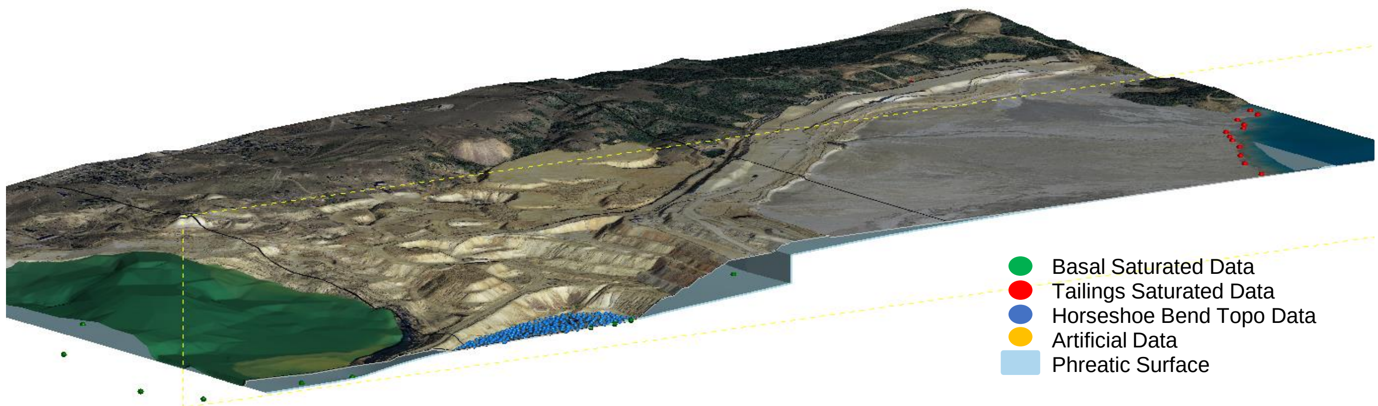
The piezometric conditions used in stability analyses of the YDTI were defined from a comprehensive evaluation of the various data sets, as discussed in Appendix C. The data review indicated that 3D considerations were required for defining steady-state conditions and identified the importance of two data sets, the piezometric sensors and surface observations. These data sets defined the shape (spatial distribution) and elevation (temporal trends) of the phreatic surface that was constructed from pressure values reported at the end of 2021 (KP, 2022b).

A phreatic surface was constructed by integrating the two prevailing hydrogeological regimes with a vertical transition near the upstream face of the embankment to form a single continuous surface, spanning from the supernatant pond to the Berkeley Pit, as shown on Figure 4.7. The highest resolution monitoring data located through the upstream face indicated that the selection of a vertical transition is a conservative representation at the maximum dam section of the central pedestal area. Construction of the phreatic surface for the stability and deformation models is described in greater detail in Appendix C.

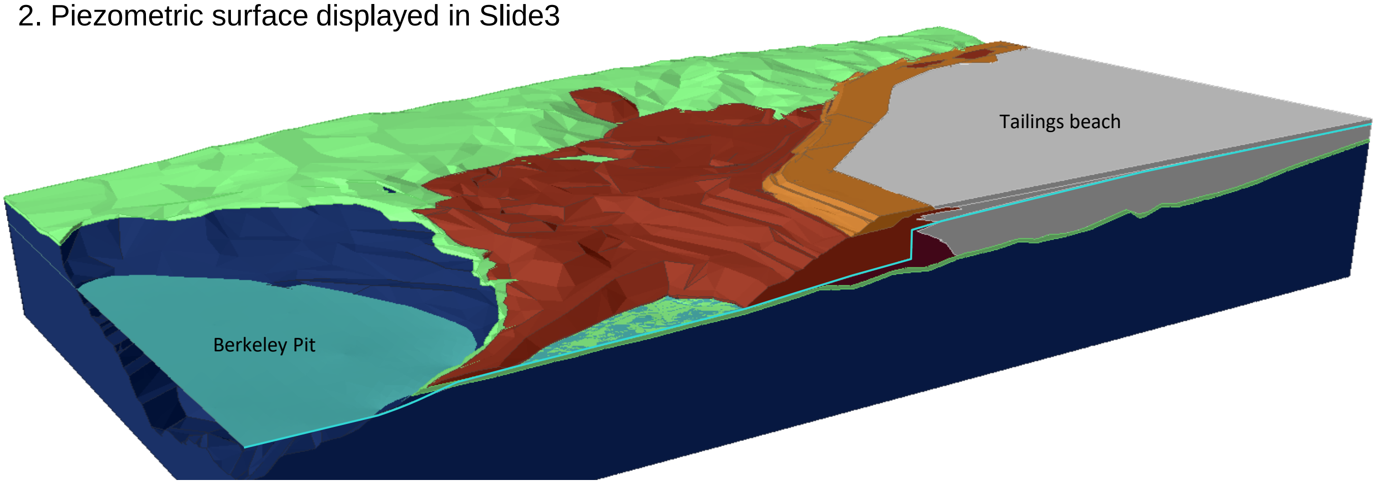
The monitoring data also indicates transient perched zones within the embankment. However, these transient conditions appear to be of limited extent and are not considered in the steady-state assessment for the overall stability of the proposed El. 6,560 embankment raise and interim conditions evaluated in the stability assessment.

The phreatic surface also forms an important internal unit boundary for the rockfill in the stability analyses, as the boundary delineates the assignment of drained and undrained shear strengths.

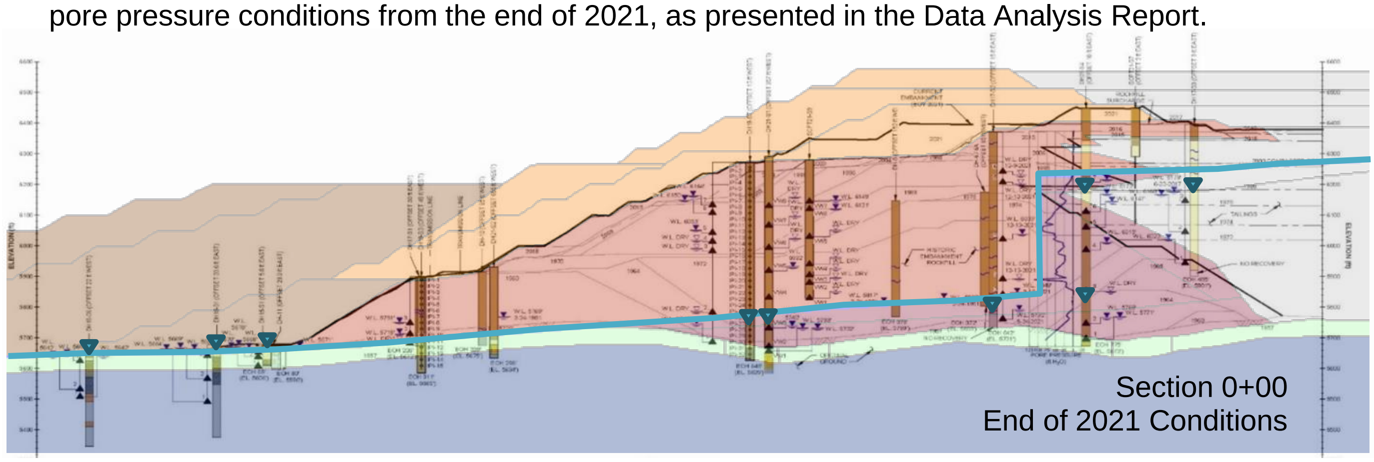
1. Piezometric surface construction in Leapfrog



2. Piezometric surface displayed in Slide3



3. Cross-section of the constructed phreatic surface at station 0+00, overlain on the monitored pore pressure conditions from the end of 2021, as presented in the Data Analysis Report.



Inferred piezometric surface

Piezometric elevation at monitoring instrumentation

NOTES:
1. TAILINGS BEACH ELEVATION IS SHOWN AT MAXIMUM OPERATING CONDITION WITH MINIMUM FREEBOARD OF 5 FT.
2. END OF 2021 PIEZOMETRIC LEVELS FROM DATA ANALYSIS REPORT (KP, 2022)

MONTANA RESOURCES, LLC

MONTANA RESOURCES

YANKEE DOODLE TAILINGS IMPOUNDMENT
PIEZOMETRIC DEFINITION

Knight Piésold CONSULTING

P/A NO. VA101-126/24

REF. NO. 5

FIGURE 4.7

REV 0

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SY3	SY

5.0 LIQUEFACTION POTENTIAL

5.1 GENERAL

An assessment of the liquefaction potential was carried out to evaluate if the key soil units are susceptible to cyclic liquefaction. Data availability for the assessment was not the same for all three soil units. Sufficient data was available for assessing the tailings and overburden units in isolation. However, a limited amount of data was available for the saturated rockfill due to the difficulty of advancing penetration equipment through the stiff and coarse-grained material to reach the saturated zone at the base of the 800 ft high embankment dam. As a result, the rockfill assessment was limited to a screening-level effort. The liquefaction potential of the tailings and overburden was evaluated, first with a screening-level effort and second with a one-dimensional total stress analysis to evaluate the site response to the MCE at multiple locations across the YDTI. A detailed summary of the assessments is provided in Appendix D.

5.2 MATERIAL SUSCEPTIBILITY

The screening-level assessment relied on PSD and SCPT data for evaluating the susceptibility of the rockfill and overburden. Empirical guidance from case studies indicates both units are potentially liquefiable based on their granular nature and fines content. Pore pressure dissipation (PPD) testing during SCPT soundings also indicated a potential in locations where dissipation was slow; hence, indicating possible contractive behavior. The SCPT data indicates microstructure is prevalent in both units, where cone advancement was possible. Although microstructure does not indicate liquefaction susceptibility directly, the saturated materials may contract if the microstructure is reduced or removed and thus, increase its susceptibility to liquefaction.

Plasticity characteristics and SCPT data were used to evaluate the liquefaction potential for the tailings. Laboratory results suggest the tailings are potentially liquefiable when evaluated with the Bray and Sancio (2006) framework. A similar conclusion was drawn from the SCPT state parameter and SBTn interpretations (Robertson, 2016), which indicate the tailings are contractive and therefore, potentially susceptible to liquefaction where saturated and distal to the influence of the surcharge loading at the dam crest.

5.3 SITE RESPONSE

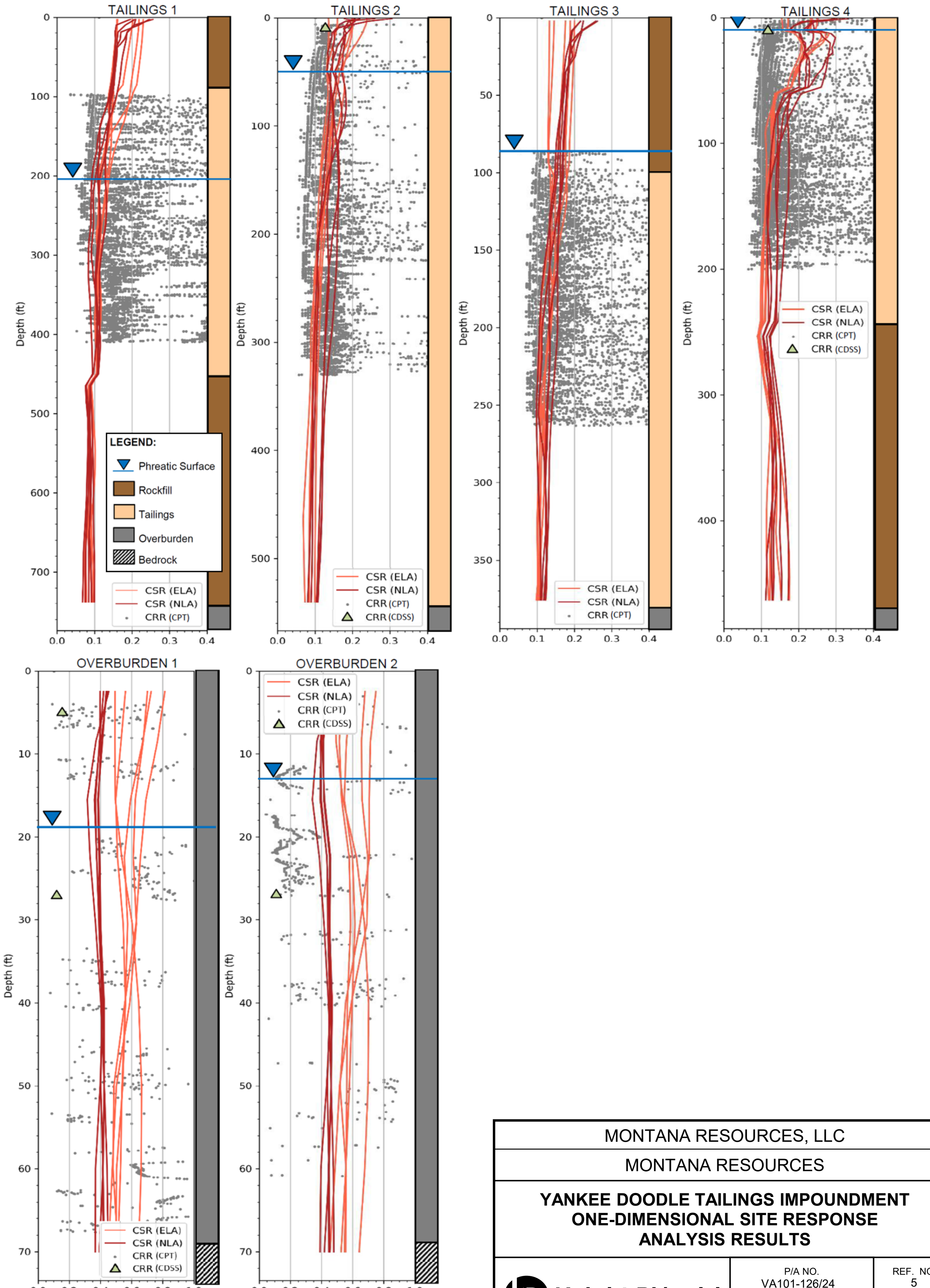
One-dimensional (1D) site response analyses (SRA) were completed to refine the evaluation of liquefaction potential of the tailings and overburden. Six locations across the YDTI were analyzed to evaluate spatial variability and variations in confinement and foundation conditions. The assessment estimated and compared the predicted CSR with the estimated Cyclic Resistance Ratio (CRR) for each location column. The CSR profiles were estimated from both equivalent linear and non-linear SRA for the five MCE time histories. The CRR profiles were estimated from SCPT data with correlations developed following Robertson (2009) and Boulanger and Idriss (2014). Where the CSR is greater than the CRR, liquefaction is predicted to occur.

A range of 0.1 to 0.2 was estimated for the tailings CSR, as shown on Figure 5.1. A relatively small difference between the equivalent linear and non-linear was observed and is attributed to the low stiffness of the tailings. The tailings CRR was exceeded below the phreatic surface and particularly at shallower depths, indicating the liquefaction susceptibility decreased with depth. The rockfill surcharge appeared to reduce the tailings susceptibility by increasing confinement and density through consolidation.

The overburden CSR estimates ranged from 0.3 to 0.7, as shown on Figure 5.1. A larger difference between the equivalent linear and non-linear analyses was observed and was attributed to the inability of the equivalent linear to capture the non-linear response at high strains. Continuous profiles of the overburden CRR were not available due to the drill outs required to push the cone to depth. As a result, CRR values were determined from the CDSS results and exhibited consistency with the SCPT-derived values. The available data suggests liquefaction susceptibility for the saturated overburden at shallow depths and a degree of uncertainty at greater depths. With shallow piezometric conditions observed in the HsB area, the saturated overburden may be susceptible to liquefaction.

5.4 SUMMARY

The screening-level assessment and 1D SRA results indicate the saturated tailings and overburden are potentially liquefiable. The screening-level results of the saturated rockfill likewise indicated potential susceptibility to liquefaction. A conservative approach was undertaken by completing a 2D dynamic analysis of the YDTI to assess the liquefaction potential and extent, as well as to estimate the earthquake-induced deformations by considering that the saturated materials of the three units (overburden, rockfill, tailings) are potentially susceptible to liquefaction.



REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	MJB2	SY

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MONTANA RESOURCES

YANKEE DOODLE TAILINGS IMPOUNDMENT ONE-DIMENSIONAL SITE RESPONSE ANALYSIS RESULTS

Knight Piésold CONSULTING

P/A NO. VA101-126/24

REF. NO. 5

FIGURE 5.1

REV 0

6.0 EMBANKMENT SLOPE STABILITY

6.1 GENERAL

The embankment slope stability analysis was completed with the LE method, which calculates the FS for each possible slip surface produced through a search algorithm. The LE analyses were completed with Rocscience (2022; 2024) software in 2D using Slide2 and 3D using Slide3. The FS was calculated with the General Limit Equilibrium or Morgenstern-Price method of slices (columns in 3D). The slip surface type was set to circular or ellipsoidal, which also generated composite surfaces if a weak or impenetrable layer was encountered. The evaluation of the LE results focused on slip surfaces on the downstream slope, given the significantly shorter height of the upstream slope available for a critical slip surface to develop a FS less than two.

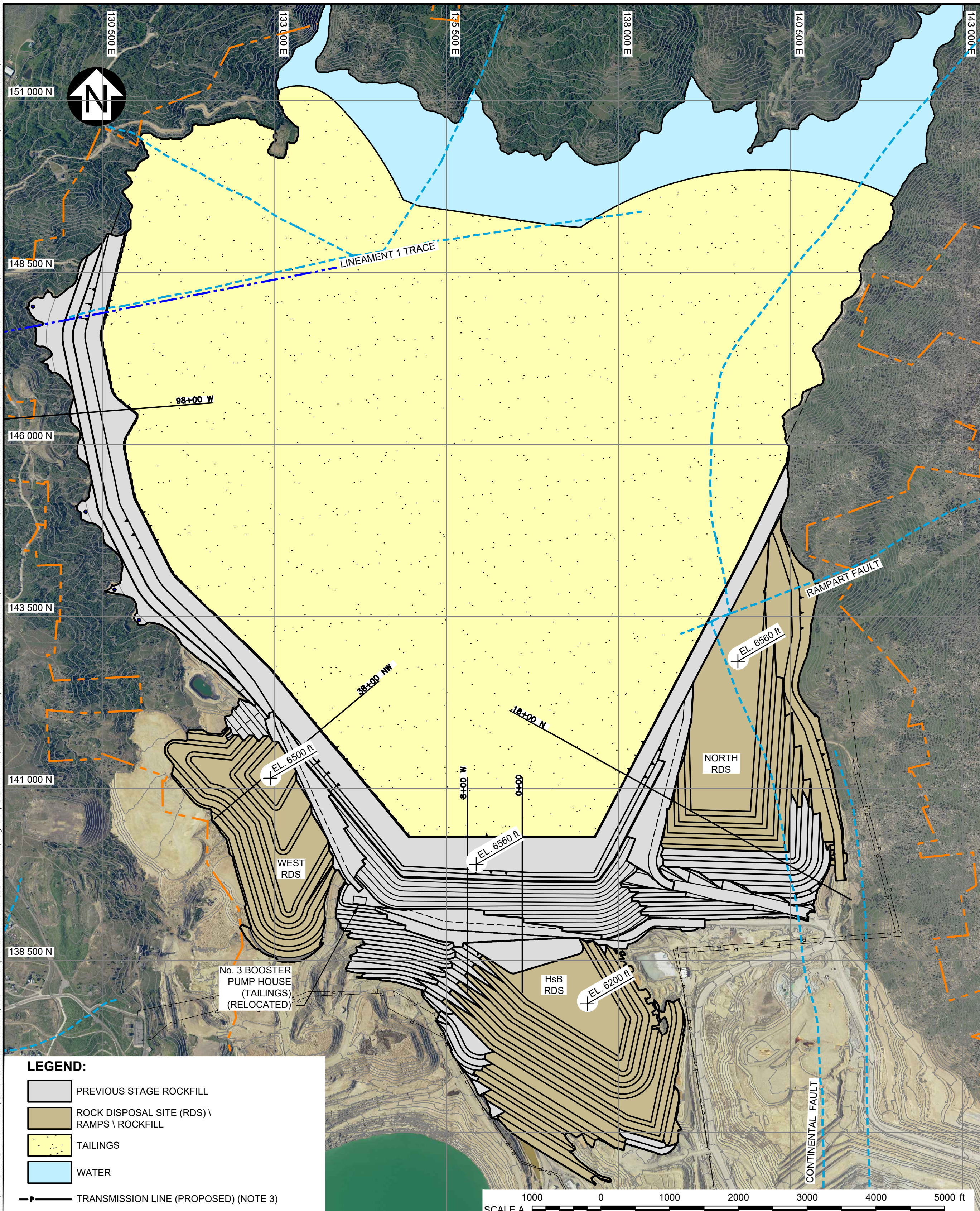
6.2 ANALYSIS GEOMETRIES

The analysis geometries were created from a 3D model of the site, which was constructed from topographical surveys and approximations where data was limited. Each component of the 3D model is described briefly in the following:

- The pre-dam topography was created from the available 1956 topography.
- The thickness of the overburden was estimated from drillholes completed during various site investigation programs (see Appendix A for references). A maximum thickness of approximately 40 ft was encountered during drilling. The drilling data indicates the overburden is thickest along the North-South Embankment and the central pedestal area of the East-West Embankment and thins significantly or is absent to the west. The overburden was striped under the West Embankment during construction. The overburden was conservatively simplified to a uniform thickness in the model that blankets the underlying bedrock surface across the facility by offsetting the pre-dam topography by 50 ft, except along the West Embankment where it was excluded from the model.
- The dam boundaries are based on the 2020 Light Detection and Ranging (LiDAR) survey, along with the geometries of the HsB area, the ponded Berkeley Pit, and the various fills abutting the downstream face of the dam. The base of the Berkeley Pit was created from the 2021 bathymetric survey. The upstream face of the dam was approximated by digitizing from available historical construction cross-sections and interpolating in between.
- The tailings surface was developed by considering the maximum allowable tailings discharge elevation of 5 ft below the embankment crest. This geometry provides the maximum driving force for assessing the stability of downstream slip surfaces.
- The geometries of the interim and final design phases were based on the YDTI LoM Design Report (KP, 2024b). The final LoM design geometry is shown on Figure 6.1.

The 2D LE analysis models were created by cutting cross-sections through the 3D model at five locations, as shown on Figure 6.1. The analysis locations are at Sta. 98+00W, Sta. 38+00NW, Sta. 8+00W, Sta. 0+00, Sta. 18+00N. The slope stability analysis in the central pedestal area for the previous raise to El. 6,450 ft was conducted at Sta. 8+00W as it is the maximum dam section. The cross-section along Sta. 0+00 was evaluated along with Sta. 8+00W in this analysis due to its more central location in the HsB area where toe support is less and the overall downstream slope angle is slightly steeper. The analysis models are shown on Figure 6.2.

The 3D LE analysis was completed on the site model to evaluate the 3D effects of the central pedestal area. These analysis models are shown on Figure 1.3.



NOTES:

1. COORDINATE SYSTEM AND ELEVATIONS BASED ON ANACONDA MINE GRID.
2. AERIAL IMAGE PROVIDED BY MONTANA RESOURCES, LLC IN JULY 2023.
3. HIGH VOLTAGE TRANSMISSION LINE IS APPROXIMATE AS PROVIDED BY MR IN SEPTEMBER 2023. LAYOUT BY NORTHWEST ENERGY.

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0	19SEP'24	ISSUED WITH REPORT	JRG	MJC	DDF

MONTANA RESOURCES, LLC

MONTANA RESOURCES

YANKEE DOODLE TAILINGS IMPOUNDMENT
LAYOUT OF SLOPE STABILITY SECTIONS
EMBANKMENT EL. 6560 ft (LIFE OF MINE)

Knight Piésold CONSULTING

P/A NO.	REF NO.
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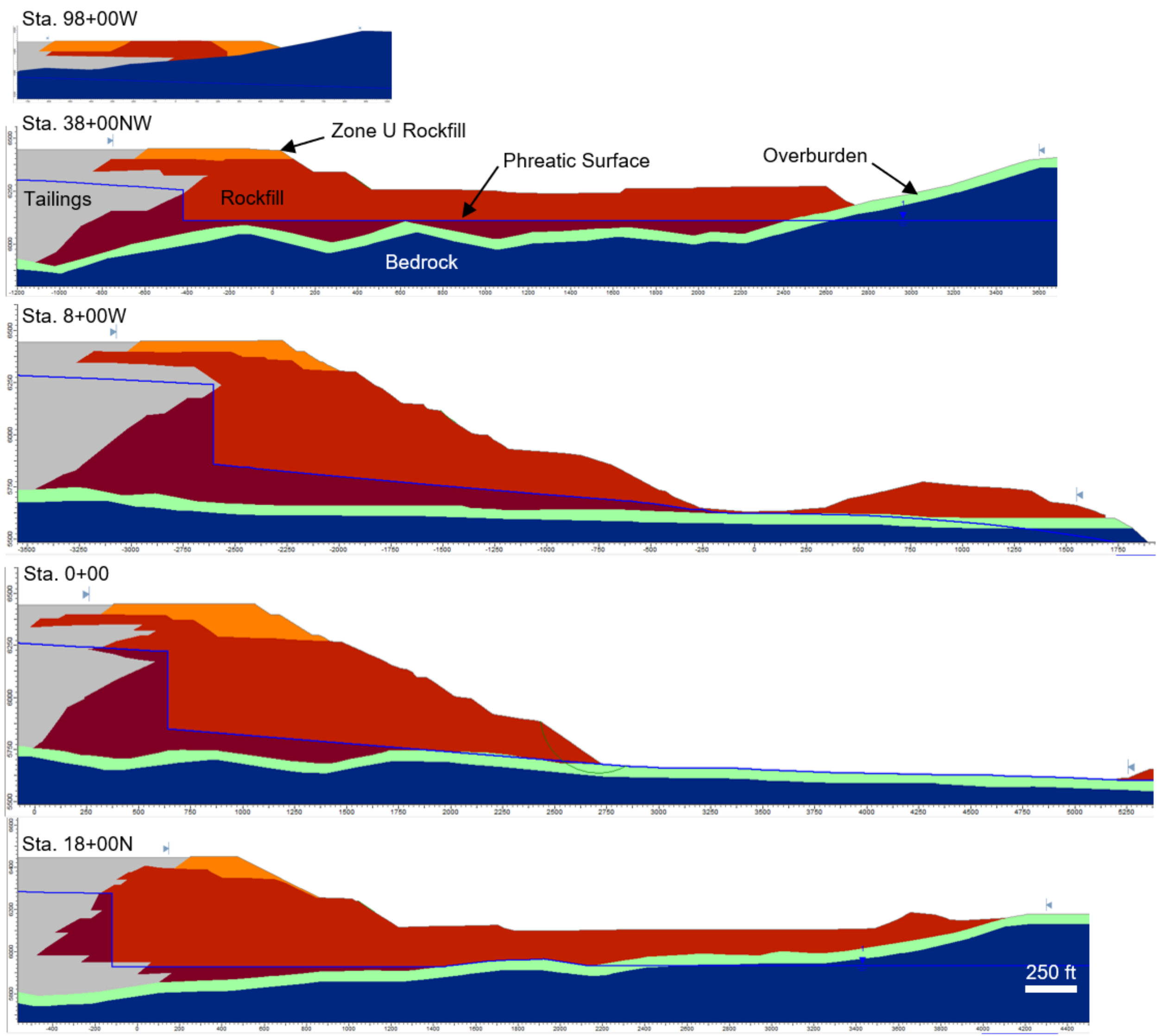
FIGURE 6.1 REV 0



Note(s):

1. Scale bar at bottom right is for horizontal and vertical dimensions of all images.

Figure 6.2 Two-Dimensional Limit Equilibrium Analysis Models of the EL. 6,450 ft Configuration

6.3 PIEZOMETRIC CONDITIONS

Piezometric conditions were represented by a phreatic surface for the 3D LE analyses and a phreatic line for the 2D LE analyses at the corresponding cross-section through the 3D phreatic surface. The 3D surface is shown on Figure 4.7 and the 2D lines are shown on Figure 6.2. As described previously and in Appendix C, the modeled piezometric conditions include adjustments at the upstream face of the dam (vertical step) and in the HsB area (elevated to the top of the ground surface). The 2D models of Sta. 38+00NW and Sta. 18+00N were further adjusted by projecting the lower phreatic line horizontally at the bottom of the vertical step, as shown on Figure 6.2. These modifications are conservative adjustments based on the piezometric elevations reported in the monitoring data (KP, 2022b; KP, 2023c). The modeled phreatic conditions subdivide the rockfill into saturated and unsaturated components and indicate the overburden is saturated in the vicinity of the dam and the HsB area.

6.4 MATERIAL PROPERTIES

The model comprises four material units: overburden, rockfill, tailings, and bedrock. The historical rockfill was divided into drained (unsaturated) and undrained (saturated) sub-units. New rockfill (Zone U rockfill) from the Continental Pit for future raises is assumed to be drained since it remains above the phreatic boundary. An undrained response was conservatively assumed for the overburden regardless of the location of the phreatic boundary. Likewise, the tailings unit was not subdivided but assumed to behave drained for normal operating and undrained for post-earthquake loading conditions. The bedrock was assumed infinitely strong relative to the soil units, which limits the maximum depth of slip surfaces to the base of the overburden unit, regardless of saturation.

Material property assignments are summarized in Table 6.1. The unit weights of the materials were adopted from the stability assessment of the previous raise to the current crest El. 6,450 ft (KP, 2018a).

Table 6.1 Limit Equilibrium Material Properties

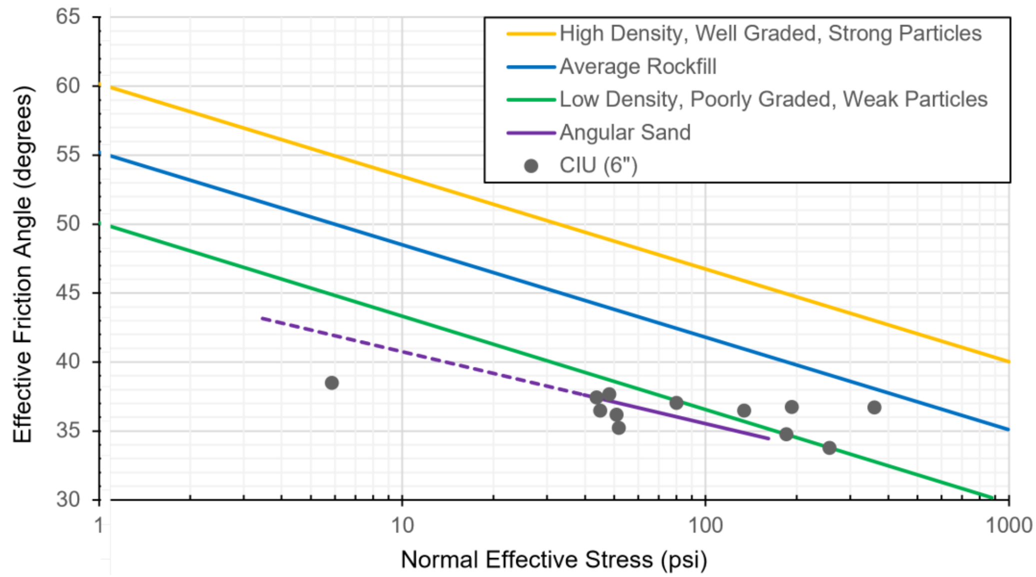
Material	Unit Weight (pcf)	Base Case Strength			Sensitivity Check	
		Drained	Undrained		Undrained Strength	
		f' (deg)	Peak S_u/σ'_v	Residual S_u/σ'_v	Peak S_u/σ'_v	Residual S_u/σ'_v
Overburden (Saturated)	135	-	0.34	0.22	0.26	0.20
Historical Rockfill (Saturated)	140	-	0.31	0.31	-	-
Historical Rockfill (Unsaturated)	140	Leps Angular Sand	-	-	-	-
Zone U Rockfill	140	Leps Lower Bound	-	-	-	-
Tailings	120	32	-	0.05	-	-
Bedrock	165	Infinite Strength			Infinite Strength	

Note(s):

1. Unit weight is in pounds per cubic feet (pcf) and representative of 100% saturation.
2. Strengths are denoted by ϕ' for effective friction and Su/σ'v for undrained strength ratio.
3. Zero cohesive strength assumed for drained conditions.
4. Leps (1970) strengths are shear-normal functions that are plotted on Figure 6.3.

The basis of the strengths of the undrained historical rockfill and undrained overburden units was described previously with additional details provided in Appendix B1.

The strength of the unsaturated (drained) historical and Zone U rockfill was estimated using the Leps (1970) depth-dependent (shear-normal) function, as shown on Figure 6.3. Leps compiled and analyzed data for large-scale triaxial tests on gravels and rockfill to develop a series of relations of friction angle as a function of normal pressure. The non-linear shear strength functions recognize that rockfill and sand have higher strengths at lower confinement (shallow depths) but exhibit a decreasing trend with depth (increasing stress) due to particle crushing. The weakest function of Angular Sand was adopted for the historical rockfill, which is consistent with laboratory data from triaxial testing of rockfill samples (Appendix B1) and considers the potential for site wide variability and long-term degradation of the rockfill material in closure. Use of this function may be somewhat conservative, particularly where historically the most durable rockfill materials have been placed. The Lower Bound function was assigned to the new rockfill material (Zone U rockfill from the Continental Pit).



Note(s):

1. Relations developed by Leps (1970) shown in solid color lines.
2. Extrapolation of angular sand relation shown in dashed line.
3. CIU triaxial data from YDTI rockfill testing (Appendix B1), values are taken at phase transformations.

Figure 6.3 Shear-Normal Strength Functions

The tailings strength was estimated with SCPT data collected from 2012 through 2015. The tailings are variable (laterally and vertically) in terms of grain-size distribution, water content, and densification (consolidation) due to the size of the facility and adjustments to the tailings discharge locations. Variability is evident in the SCPT data, indicating the behaviour can range from clean sand to clay at shallower depths and sand to silt at depth. Index testing indicates the tailings is non-plastic and therefore, the tailings is assumed to exhibit sand-like behavior. The selected peak frictional strength for the tailings was the 30th-percentile value estimated from the SCPT data. The liquefied strength was previously defined from an analysis of the SCPT data under MCE loading, which exhibited a lower bound Su ratio of 0.05. This value is reasonably consistent with the range (0.09 to 0.18 at 10% strain) indicated by the results of CDSS laboratory testing on tailings in 2014 (Wijewickreme, 2014). Estimated drained and undrained strength values from more recent SCPT soundings conducted in 2021 (KP, 2023b) are generally consistent with these selected strengths with slightly higher values estimated for tailings below the rockfill surcharge.

6.5 TWO-DIMENSIONAL LIMIT EQUILIBRIUM RESULTS

The 2D LE analyses assessed the stability of the YDTI at five sections, with locations shown on Figure 6.1, and for up to five construction stages. The assessment considers the possibility of failure by evaluating the FS distribution (safety map) over a range of scales and slip locations. The most critical scale is slip through the upstream crest over the full height of the dam. This slip surface corresponds to deformation that could result in a loss of containment. As a result, the stability of the dam is assessed using the FS of a slip through the upstream crest, which is required to meet the regulated target.

The FS results for the loss of containment slip surfaces described above are summarized in Table 6.2 for normal operating conditions and Table 6.3 for post-earthquake conditions. Visual results are provided in Appendix E1 for normal operating conditions, Appendix E2 for post-earthquake conditions, and Appendix E3 for evaluating the sensitivity to weaker overburden (i.e. lower undrained shear strength).

Table 6.2 2D Limit Equilibrium Normal Operating Results

Station	Stages of Construction Evaluated				
	El. 6,450 ft	El. 5,900 ft Stage 1 RDS	El. 6,500 ft	El. 6,500 ft Interim	El. 6,560 ft (LoM)
0+00	1.5	1.6	1.5	1.6	2.1
8+00W	1.5	1.9	1.6	2.0	2.0
38+00NW	>3.0	-	2.5	2.4	>3.0
98+00W	>5.0	-	>5.0	-	>3.0
18+00N	2.3	-	>3.0	>3.0	>3.0

Note(s):

1. Results correspond to slip through upstream crest and involves full height of dam.
2. El. 6,500 ft Interim corresponds to construction stage for relocated pipeline ramp (Figure 1.3).

Table 6.3 2D Limit Equilibrium Post-Earthquake Results

Station	Stages of Construction Evaluated				
	El. 6,450 ft	El. 5,900 ft Stage 1 RDS	El. 6,500 ft	El. 6,500 ft Interim	El. 6,560 ft (LoM)
0+00	1.2	1.3	1.2	1.3	1.6
8+00W	1.2	1.5	1.4	1.6	1.5
38+00NW	2.0	-	1.8	1.7	1.9
18+00N	1.9	-	2.6	2.6	>3.0

Note(s):

1. Results correspond to slip through upstream crest and involves full height of dam.
2. El. 6,500 ft Interim corresponds to construction stage for relocated pipeline ramp (Figure 1.3).
3. Results for Sta. 98+00W are not included due to the lack of overburden (removed during construction.

Full-height slips through the downstream edge of the crest were evaluated to enhance the resolution of the assessment. Safety maps were also produced to show smaller-scale slips that identify other areas of interest. This detailed evaluation provides for a more holistic approach that assesses dam stability (predicted FS compared to regulatory targets), identifies the area(s) of greatest concern, and demonstrates the possible impact of the proposed construction sequencing on the stability of the YDTI as it ages through the LoM and into closure.

The 2D results indicate all sections satisfy the FS requirement for a full-height slip through the upstream crest of the construction stages analyzed, for both normal operating (Appendix E1) and post-earthquake (Appendix E2) loading conditions. The safety maps identify bench-scale and shallow slips are possible but these are unlikely to lead to a loss of containment due to the relative size of the embankment.

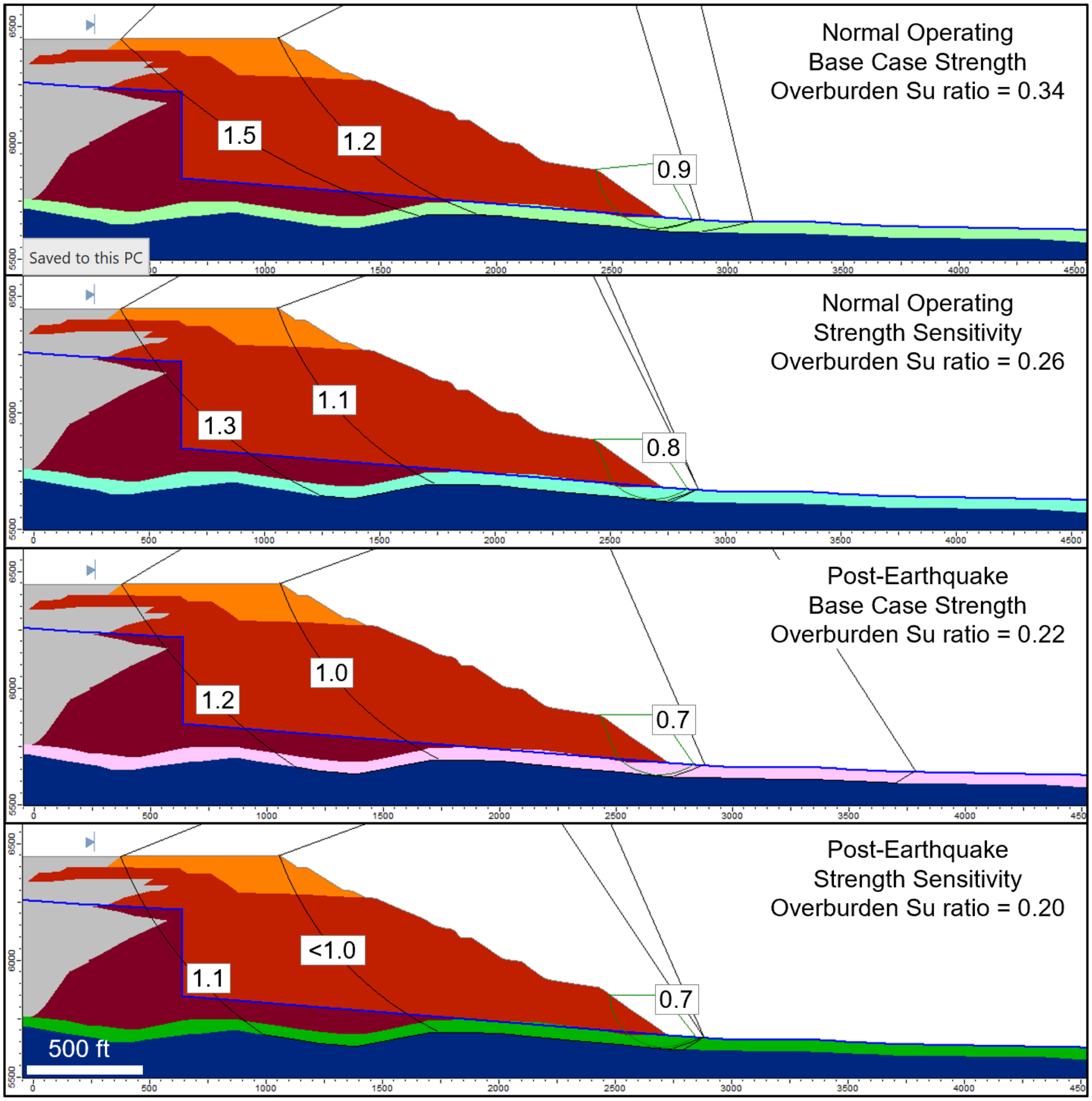
The greatest risk of instability lies in the central pedestal area, where the target FS is marginally achieved for the current geometry (crest at El. 6,450 ft) and multiple construction stages (Stage 1 RDS, crest raise to El. 6,500 ft, and relocated pipeline ramp with crest at El. 6,500 ft) for normal operating and post-earthquake conditions assuming undrained conditions are triggered. The central pedestal area is a known area of risk as it is coincident with the maximum height of the dam, in combination with the least toe confinement due to the proximity of the HsB facilities. The Stage 1 RDS is currently under construction to mitigate this risk by buttressing the toe, which is predicted to increase the FS by 5% to 25% for slips through the upstream crest. However, FS values for slips through the downstream crest increase by 25% to 50%, demonstrating the significant stabilizing effect of the Stage 1 RDS. Although this improvement is offset by the raise of the crest to El. 6,500 ft for slips through the upstream crest, continued fill placement in the HsB area for relocating the pipeline (El. 6,500 interim) produces a similar increase in the FS. Further buttressing with the final raise to the ultimate crest elevation of 6,560 ft provides greater stability by increasing the FS by 30% at Sta. 0+00. A similar improvement to the FS at Sta. 8+00W occurred once the relocated pipeline ramp (El. 6,500 interim) is constructed. The increasing trend of the FS results demonstrate the design strategy of continuous improvement, adopted during the previous raise to crest El. 6,450 ft and incorporated into the objectives for ongoing development of the YDTI (KP, 2024b).

The relocated pipeline ramp geometry (with crest El. 6,500 ft) shifts the area of interest from the dam toe to the steepened fill at mid-slope for both loading conditions in the central pedestal area. The results indicate a relatively shallow mechanism that is confined to the ramp fill at Sta. 8+00W and Sta. 0+00. However, a deep-seated mechanism is also apparent at Sta. 0+00 and extends from the top of the ramp fill to the underlying overburden foundation, toeing out into the open HsB area. These results suggest stability can be improved with adjustment to the design geometry and/or fill sequencing to provide additional buttressing in the HsB area concurrently with ramp system development. Additional buttressing in this area will require relocation of the truck maintenance workshop and other facilities located in the area.

A comparison of the post-earthquake results to the normal operating shows the greatest effect of a significant strength loss in the overburden is lengthening the slip extents through the unit. The slip toe is located farther downstream and entry into the overburden unit is located farther upstream. An exception is the ultimate LoM geometry (crest El. 6,560 ft) where differences in the location the slip toe and upstream entry into the overburden are not noticeable between the two loading conditions. This finding further demonstrates the important stabilizing effect of filling in the HsB area with the proposed RDS.

The lowest FS values consistently occur at Sta. 0+00 for both loading conditions. As a result, sensitivity analyses for the undrained shear strength estimates of the overburden focused on Sta. 0+00. The results are provided in Appendix E3 and a comparison to the base case strength is shown on Figure 6.4 for the El. 6,450 ft configuration. Although the strength sensitivity reduces the FS by 10% to 15%, the estimated FS is greater than 1.0 for post-earthquake loading conditions (indicating a stable arrangement) and stability gradually improves with FS greater than 1.5 at the LoM configuration.

A similar trend is seen with the governing slip entry into the overburden progressing upstream as the applied overburden strength is reduced. However, the trend of the slip toe progressing downstream is inconsistent. This comparison augments the previous finding of the greatest impact to strength loss by focusing the attention on the upstream propagation of the slip entry into the overburden unit. Although the toe trend is inconsistent, the significant stabilizing effect of infilling the HsB area is consistent with FS increases of 30% to 40% for the LoM configuration compared to the El. 6,450 ft configuration.



Note(s):

1. Scale bar at bottom left is for horizontal and vertical dimensions of all images.

Figure 6.4 Results of Strength Sensitivity at Sta. 0+00 for El. 6,450 ft Configuration

6.6 THREE-DIMENSIONAL LIMIT EQUILIBRIUM RESULTS

The 3D LE analyses entailed the same number of key construction stages except the LoM (crest El. 6,560 ft), which was excluded since the 2D results significantly exceed both normal operating and post-earthquake FS targets. Material properties matched the 2D analyses and the 3D phreatic surface defined the piezometric conditions. The 3D analyses focused on base case material properties to evaluate the sensitivity of the 2D results to the 3D effects of the HsB area (i.e. no sensitivity case is presented). The results are summarized in Table 6.4. Visual results are provided in Appendix E4 for normal operating conditions and Appendix E5 for post-earthquake conditions.

Table 6.4 3D Limit Equilibrium Results

Crest Location Slip (Loading Condition)	Stages of Construction Evaluated			
	El. 6,450 ft	El. 5,900 ft Stage 1 RDS	El. 6,500 ft	El. 6,500 ft Interim
Upstream (NO)	1.9	1.9	1.8	2.0
Downstream (NO)	1.5	2.2	1.9	1.9
Upstream (PEQ)	1.4	1.6	1.5	1.8
Downstream (PEQ)	1.3	1.8	1.6	1.7

Note(s):

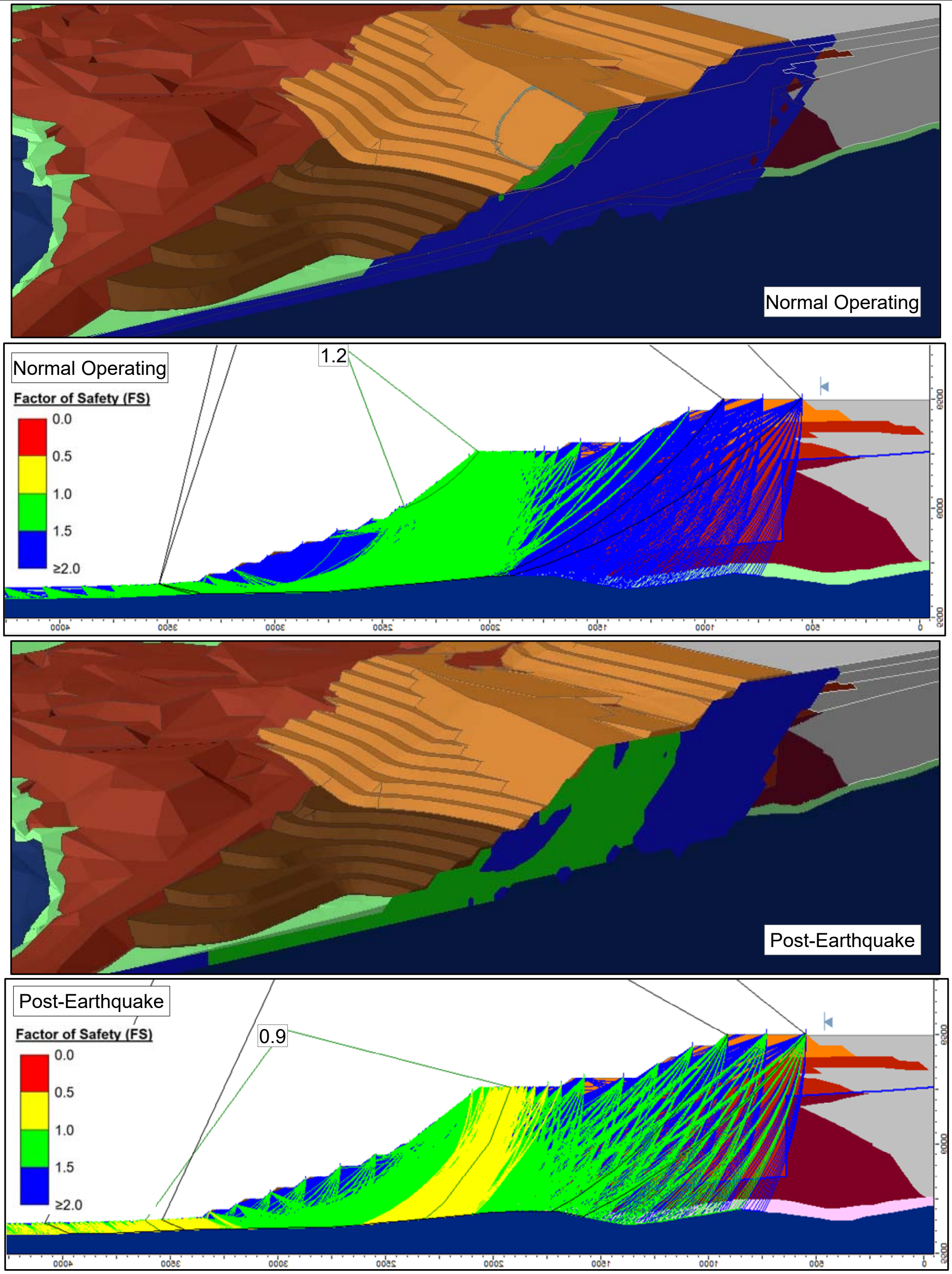
1. NO denotes normal operating loading conditions. PEQ denotes post-earthquake loading condition.
2. El. 6,500 ft Interim corresponds to construction stage for the relocated pipeline ramp (Figure 1.3).

The 3D results demonstrate the significant control of the concave shape of the HsB area over the size of the predicted slips, notably restricting the lateral extents. Interestingly, the 3D and 2D results predict similar scales of slip that govern the stability of the dam, as shown on the safety map of a section at Sta. 0+00 in Appendix E4 for normal operating and Appendix E5 for post-earthquake conditions. The lowest FS slips are predicted in the bottom (Seep 10) bench for the El. 6,450 ft configuration, due to the unbuttressed toe in the HsB area, with values indicating marginal stability (FS of 0.9) locally at the toe if an undrained response is triggered. The FS progressively increases upstream, exceeding 1.5 beyond the downstream crest for normal operating conditions and 1.3 for post-earthquake conditions. Despite the significant lateral restraint of the rockfill forming the HsB area, the predicted full-height slips with the lowest FS are substantial in size with lateral extents spanning the overall width of downstream face of the dam.

The buttressing effect of the Stage 1 HsB RDS is consistent with the 2D results in showing significant improvement for slip surfaces from the Seep 10 bench, mid-embankment slope, and downstream crest, which demonstrates the importance of the RDS to risk reduction. Increases in FS are greater than 35% over the range of loading conditions.

The crest raise to El. 6,500 ft coincides with a slight reduction in FS, approximately 5%, for slips through the upstream crest and 15% for slips through the downstream crest, for both loading conditions. The full-height FS indicates stability is achieved for both loading conditions, with values exceeding the regulated minimum. Like the 2D results, the 3D results show a reversal of the FS reduction with the construction of the pipeline relocation ramp (El. 6,500 ft interim). The 3D results suggest the ramp fill has a greater stabilizing effect on the slip through the upstream crest than the slip through the downstream crest and corroborate the 2D results as shown on Figure 6.5 in identifying areas of interest for IFC design refinement of the fill geometry and/or RDS construction sequencing.

The 3D LE analyses demonstrate that the concave shape of the HsB area controls the size and location of the predicted slip surfaces. FS results less than 1.5 for normal operating conditions and less than 1.2 for post-earthquake conditions are constrained to the Seep 10 bench and side slopes of the HsB area, toeing out into the unconfined and saturated overburden at the El. 6,450 ft configuration. Fill placement in the HsB area stabilizes the dam and reduces the slip scale of interest. These findings provide further support of the effectiveness of continual improvement by fill placement in the HsB area to buttress the dam.



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YANKEE DOODLE TAILINGS IMPOUNDMENT AREAS OF INTEREST FOR IFC DESIGN REFINEMENT OF THE RELOCATED PIPELINE RAMP

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FIGURE 6.5

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6.7 SUMMARY

The LE results indicate the stability of the dam design meets the regulatory requirements for both normal operating and post-earthquake loading conditions. The results from the 3D analyses corroborate the findings of the 2D analysis but better capture the important lateral constraint of the fill surrounding the HsB area. The analyses demonstrate the effectiveness of fill placement in the HsB area for continuous improvement of the dam stability and the consequential risk reduction for a variety of slip surface scales and associated potential failure modes.

The stability assessment indicates refinements of the design fill configuration for relocating the pipeline ramp and/or incorporating additional buttressing in the HsB area concurrently with ramp construction at the IFC design stage could minimize the likelihood of shallow sloughing and reduce the risk of smaller scale instabilities if significant strength loss is triggered in the overburden foundation.

Sensitivity analyses show that the dam remains stable at lower overburden strength. However, uncertainty remains due to the variability of the site materials and complex piezometric conditions in the dam. Additional laboratory testing is recommended to improve the strength definition. Sensitivity analysis is also recommended in future assessments for evaluating variability in piezometric conditions, as informed by the monitoring data.

7.0 EARTHQUAKE-INDUCED DEFORMATIONS

7.1 GENERAL

Dynamic deformation analyses were conducted using FLAC2D (Itasca, 2022), an explicit Langragian finite-volume program, to evaluate the seismic response of the YDTI. The FLAC2D model builds on the 1D liquefaction assessment by generating 2D predictions of the deformation and pore pressure responses of the dam to the MCE.

7.2 GEOMETRY

The model was constructed using the geometry of the El. 6,500 ft interim configuration at Sta. 0+00, following construction of the pipeline relocation ramp. This configuration was selected based on discussion with the IRP during the June 2023 Annual Meeting. Details of this configuration can be found on Drawing MR-C4330 (KP, 2024b), which is reproduced in Appendix F. The dam crest is at El. 6,500 ft and the tailings is filled to the maximum level prior to completion of the raise to El. 6,500 ft (i.e. the completion of filling of the El. 6,450 ft lift). This modified configuration evaluates an unconfined upstream face for a height of 55 ft below the crest. The geometry underlying the embankment and tailings is based on the pre-dam topography. The overburden was modeled as a continuous layer with a uniform thickness of 50 ft, which corresponds to the LE analysis. The FLAC model geometry is shown on Figure 7.1.

The model boundaries were located to minimize boundary effects. The bottom boundary is approximately 1,600 ft below the base of the embankment or twice the height of the embankment and the side boundaries are approximately one embankment width from the upstream and downstream toes.

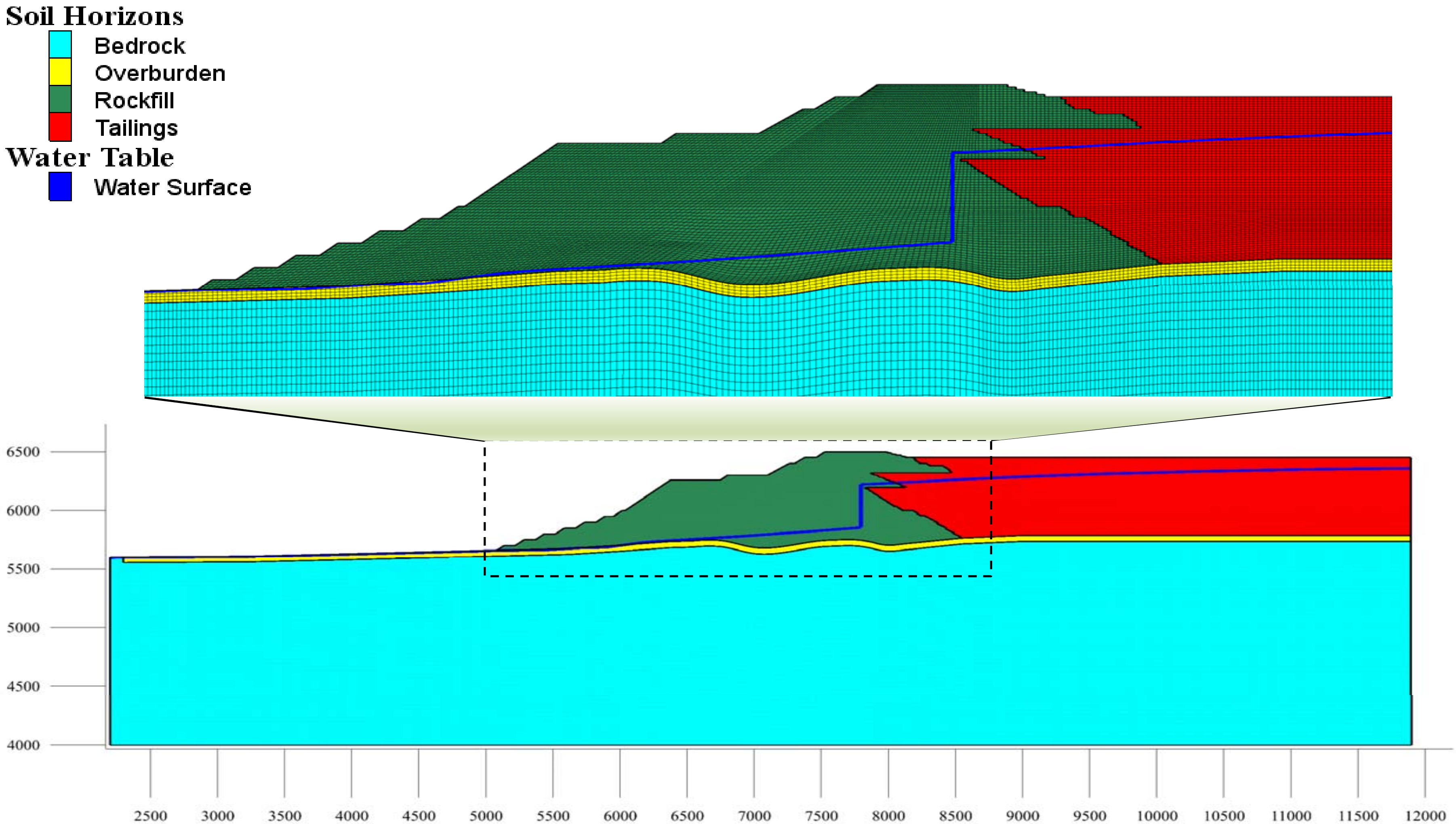
The model was discretized into a mesh of approximately 58,000 zones for accurate wave propagation of the input motions. As a result, the zone width is 15 ft across the model but varies in height with 20 ft for bedrock zones, 15 ft for overburden, and 10 ft for the rockfill and tailings.

7.3 ANALYSIS INPUTS

The model comprises four material units: bedrock, overburden, rockfill, and tailings. The piezometric conditions subdivide the rockfill and tailings into saturated and unsaturated components, while the overburden and bedrock are saturated. The sensitivity of the analysis to the inherent variability of earthquake loading was assessed by applying the five time histories developed Al Atik and Gregor (2022).

7.3.1 MATERIAL PROPERTIES

The analysis comprises three computational stages involving static (gravitational) loading before and after dynamic (earthquake) loading. As a result, three sets of material constitutive models were required. One set was developed for the static analysis to establish pre-dynamic conditions, a second set was developed for the dynamic analysis, and a third set for the post-earthquake static analysis. The material parameters for each constitutive model are summarized in Appendix G1. The pre-dynamic parameters are summarized in Table G1.1 and were developed from in-situ data and laboratory testing results. The dynamic parameters are summarized in Tables G1.2 and G1.3. The post-earthquake parameters are summarized in Table G1.4.



NOTES:

1. AXIS LABEL UNITS ARE FEET.

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YANKEE DOODLE TAILINGS IMPOUNDMENT
DYNAMIC DEFORMATION ANALYSIS
MODEL GEOMETRY (SECTION 0+00)

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FIGURE 7.1

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The unsaturated tailings and rockfill were modeled using the UBCHYST constitutive model (Naesgaard et al., 2015), which was calibrated using modulus reduction and damping curves. The unsaturated rockfill was calibrated against the Darendeli (2001) modulus reduction and damping curves for a plasticity index of 15, while the unsaturated tailings were calibrated to the Rojas-González et al. (1985) modulus reduction and damping curves for copper tailings. Results from the single element calibration are included in Appendix G2. The calibrated modulus reduction and damping curves have a good match to the literature curves at target strain rates less than 0.1%.

The saturated tailings, rockfill, and overburden were modeled using the PM4Sand constitutive model (Boulanger and Ziotopoulou, 2023). The saturated tailings and overburden were calibrated to match the response of the CDSS tests, while the saturated rockfill was calibrated from 30th percentile SPT data using the correlations described by Boulanger and Ziotopoulou (2023). The calibrated overburden and tailings responses are conservative compared to the laboratory CDSS test results and generally reach the liquefaction criteria sooner than the laboratory test results at a low to moderate CSRs. At higher CSRs, the laboratory results reach liquefaction one to three cycles sooner than the calibrated results.

The post-earthquake analysis was simplified through a static analysis, using the Mohr-Coulomb constitutive model. The residual strengths defined in Appendix B1 were assigned to zones that surpassed liquefaction triggering criteria under MCE loading during the dynamic analysis.

7.3.2 PORE PRESSURE CONDITIONS

Pore pressure conditions were defined using a phreatic line that corresponds with the LE analysis. The initial pore pressure conditions are presented in Appendix H.

7.3.3 EARTHQUAKE TIME HISTORIES

The earthquake loading utilized in the analysis are five MCE time histories deconvoluted for stiffer bedrock by performing a linear SRA in ProSHAKE (EduPro, 2023), following the procedures outlined by Mejia and Dawson (2006). Al Atik and Gregor (2022) developed time histories for ground conditions coinciding with a Vs30 of 2,490 ft/sec (760 m/sec). The input acceleration time histories were applied to the base of a 66 ft (20 m) one-dimensional bedrock column with a Vs of 2,100 ft/sec (640 m/sec) and the acceleration time histories at the top of the column were recorded. The FLAC2D model uses a stiffer base with a bedrock Vs of 4,921 ft/sec (1,500 m/sec), therefore the recorded acceleration time histories at the top of the column were deconvoluted to the base of a one-dimensional bedrock column with a Vs of 4,921 ft/sec (1,500 m/sec).

The FLAC2D mesh cannot pass high frequency contents (Kuhlemeyer and Lysmer, 1973), so the velocity Fourier amplitude spectra of the deconvoluted acceleration time histories was inspected and it was determined that frequency contents greater than 5 Hz have a minimal contribution to the input energy of the seismic loading. Therefore, frequency content greater than 5 Hz was removed with a Butterworth filter, after which the processed time histories underwent a baseline correction to correct for drift. Comparisons of the processed time histories to the original time histories are shown in Appendix I.

7.4 INITIAL STATIC STRESS CONDITIONS

The initial static conditions were established in stages using fixed bottom and roller side boundaries. Stresses were initialized in the overburden and bedrock by modeling the two units elastically and applying gravitational loading. The rockfill and tailings were then added as elastic materials with stresses initialized using an assumed coefficient of lateral earth pressure at rest (K_o) and the model was brought to equilibrium under gravitational loading. Lastly, pore water pressures were initialized using the phreatic line. Overburden, rockfill, and tailings were assigned the Mohr-Coulomb constitutive model before static equilibrium was established. Profiles of the initial static stress state, coefficient of lateral earth pressure, and static shear stress bias are presented in Appendix J1.

7.5 DYNAMIC RESPONSE

The constitutive models were changed to the dynamic set after the pre-dynamic stress state was established. Displacements and velocities were set to zero, a compliant or quiet boundary condition was assigned to the base of the model, and free-field boundaries were applied to the sides of the model. The velocity time histories were converted to shear stress time histories and applied to the base of the model. A minimal amount of Rayleigh damping (0.5% at a center frequency of 2.0 Hz) was applied for numerical stability. The dynamic analysis was completed in two stages. The first stage modeled dynamic loading until the end of the input time history. The second stage modeled reconsolidation settlements by utilizing the PM4Sand PostShake feature and running the model for an additional 10 seconds by which time additional displacements had stabilized.

The analysis results are similar across the five input motions and are provided in Appendix J2. The results predict high r_u values (close to 1.0), suggesting a likelihood for liquefaction, in the unconfined overburden downstream of the dam toe. Underneath the embankment, r_u values are predicted to be between 0.3 and 0.7, with the highest values reached where there is less confinement. This is seen to affect the predicted deformations discussed in the following paragraphs. In the tailings, r_u is predicted to be less than 0.2. Excess pore pressure generation in the saturated rockfill is negligible. A typical distribution of the excess pore pressure ratio is shown on Figure 7.2.

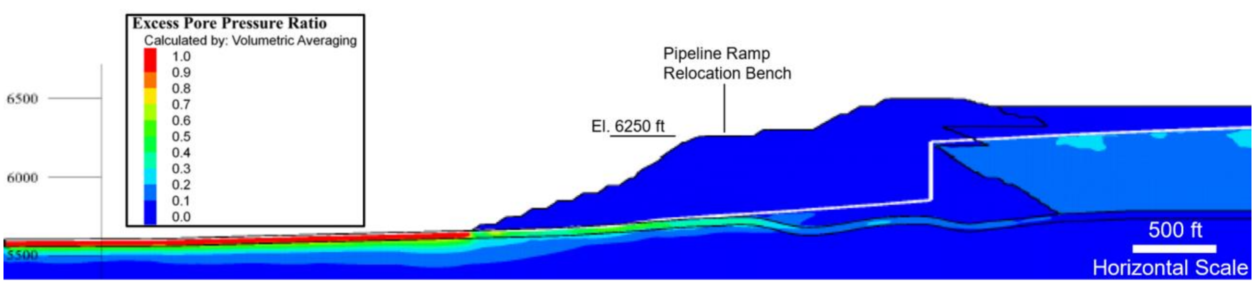

Figure 7.2 Excess Pore Pressure Ratio for MCE 4

The displacement patterns are consistent across the five earthquake time history records, with typical results shown on Figure 7.3 and Figure 7.4. The MCE 4 (M6.9 Kobe, Japan) time history produced the greatest horizontal displacements at the dam toe while the MCE 1 (M6.9 Loma Prieta) time history produced the greatest vertical displacements at the dam crest. These are shown on the displacement contours and the displacement histories of select locations along the surface of the dam that are provided in Appendix J2. Displacement of the dam crest is dominated by settlement (up to 2 ft locally) with the upstream point displacing more than the downstream point across all earthquake loading. This finding is consistent with the expectation that the softer tailings foundation underlying the surcharge rockfill is more compliant to deformation than the denser and more rigid foundation of historical rockfill underlying the downstream crest. Horizontal displacement (up to 7 ft) is dominated by downstream movement into the HsB area, with displacement contours indicating the embankment will likely deform as a block where earthquake shaking has generated excess pore pressure in the saturated overburden and basal rockfill, as shown on Figure 7.3.

The dynamic results also indicate vertical displacements are drawn to the relocated pipeline ramp, where settlement predictions are at a maximum value. Up to 2 ft of settlement is expected over the bulk of the ramp fill. However, the downstream face of the ramp fill is expected to slough at greater magnitudes (up to 8 ft horizontally and up to 5 ft vertically) but to a shallow depth, as shown on Figure 7.4. This finding is consistent with the LE analyses in suggesting further consideration at the IFC design stage to mitigate the likelihood and reduce the risk of shallow instabilities along the ramp system.

The possibility of smaller scale instabilities is also evident. Sloughing of the downstream face above the pipeline ramp and adjacent step-out and localized deformation at the dam toe are predicted.

Similar conclusions regarding the deformation response of the dam are drawn from the shear strain contours, provided in Appendix J2, which also provide additional insights. High strains are concentrated in the downstream half of the relocated pipeline ramp, the dam toe, and the downstream face above the pipeline ramp and adjacent step-out. Shear bands are evident at the interface with the step-out and extends to the overburden foundation, suggesting straining in the overburden is propagating into the overlying rockfill embankment. In a similar fashion, deformation of the compliant tailings leads to shear bands in the rigid rockfill that forms the overlying surcharge loading at the dam crest. The shear bands in the shear strain contours suggest a possibility for retrogressive failure as a result of the relatively weak overburden that concentrates strain under earthquake shaking. Additionally, the influence of the phreatic line is notable with higher strains predicted below the phreatic surface.

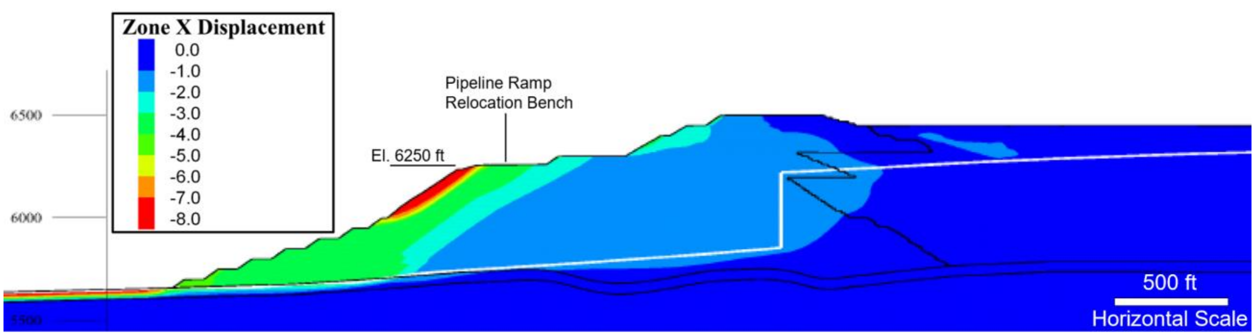

Figure 7.3 Horizontal Displacement for MCE 5

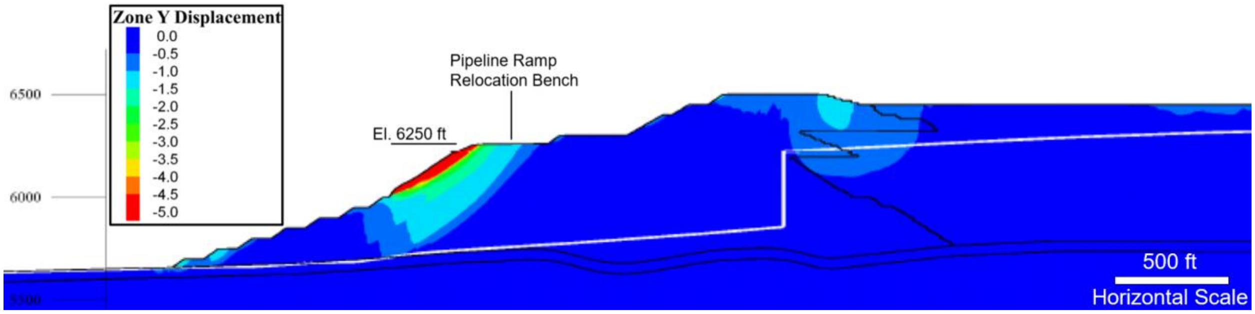

Figure 7.4 Vertical Displacement for MCE 4

7.6 POST-EARTHQUAKE STABILITY

The effect of strength loss in the liquefied material was evaluated through a post-earthquake analysis. At the end of the dynamic analysis, zones were conservatively defined as liquefied if the r_u was greater than 0.7 or if shear strains were greater than 3%. These zones were assigned the Mohr-Coulomb constitutive model with residual strength. The dynamic boundary conditions were removed in preparation for a static analysis with fixed base and roller side boundaries. The model was run under gravitational loading.

Shear band formation in the results, illustrated on Figure 7.5, suggest the potential for multiple scales of failure if liquefaction degrades the strength of the overburden near the toe of the dam. The potential for retrogression is suggested once toe support is reduced.

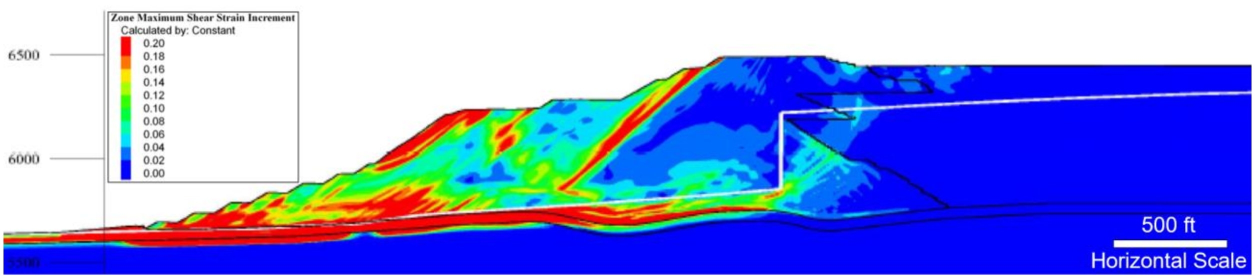

Figure 7.5 Post-Earthquake Stability Strain Contours (MCE 5)

The predicted deformation pattern is generally consistent with expectations for the conditions modeled. The lower part of the embankment (Stage 1 HsB RDS) and pipeline ramp system are predicted to deform horizontally towards the HsB area and settle. The deformations along the embankment toe and mid-slope reduce support of the upper embankment areas and increase shear strains in those regions, suggesting retrogressive and additional post-earthquake crest settlement.

The predicted displacements are an order of magnitude greater than the dynamic results over the range of earthquake motions evaluated. The post-earthquake displacement and estimated shear strain results are provided in Appendix J3. The lower part of the dam is predicted to displace up to 30 ft horizontally into the remaining open and unbuttressed HsB area. Crest settlements up to 8 ft are estimated if earthquake shaking triggers significant strength loss in the overburden. The predicted crest settlement is accompanied by limited horizontal displacement of the crest.

The deformations predicted by the post-earthquake stability analysis are not expected to result in a loss of containment or uncontrolled release of impounded materials. Field data suggests that the tailings adjacent to the embankment in the central pedestal area have little flow potential since the upper 100 to 200 ft of tailings are not saturated. The supernatant pond is also located over 5,000 ft to the north and maintained at least 20 ft (or substantially more during most of the operating period) below the crest due to storm storage freeboard requirements. Tailings slurry water infiltrating into the tailings beach during operations provides the primary source of recharge to the phreatic surface within the impoundment. During closure, the level of saturation within the tailings will be further reduced without active tailings discharge and the supernatant pond volume and elevation will also be drawn down, further limiting the flow potential of the tailings and proximity of the supernatant pond.

The post-earthquake stability results further highlight the potential importance of expanding buttressing at dam toe as soon as practicable and at least concurrently with development of the relocated ramp system. The results also highlight the importance of continued evaluation of the potential range of residual strength of the overburden. The findings suggest additional strength testing should prioritize increasing the confidence of the residual strength definition and further evaluating the impact of material variability on the strength definition.

7.7 SUMMARY

The dynamic analysis results indicate earthquake-induced deformations are not expected to result in an uncontrolled release of tailings. The crest is predicted to settle to 2 ft, which can be accommodated by the design freeboard. The bulk of the dam is predicted to displace horizontally into the HsB area up to 4 ft, as a result of excess pore pressures generated in the underlying saturated overburden. Shear bands are expected to propagate into the overlying rockfill as a result of high strain accumulation in the overburden. These deformations will be mitigated as the HsB area is infilled, following relocation of the pipeline.

The post-earthquake stability modeling results indicate that although seismic loading from the MCE and potential liquefaction of zones within the overburden foundation could cause significant horizontal displacement and bulging on the downstream side of the embankment and up to 10 ft of combined vertical deformation of the embankment crest, the deformations would not be expected to result in a loss of containment or uncontrolled release of impounded materials. Priority should be given to further evaluation of the residual strength of the overburden materials and the potential variability of the material at the site. Additionally, the shear strain results indicate sensitivity to piezometric variability should be evaluated in future assessments.

The results also support previous conclusions that refinements of the design fill configuration for relocating the pipeline ramp and/or incorporating additional buttressing in the HsB area concurrently with ramp construction at the IFC design stage could minimize the likelihood of shallow sloughing and reduce the risk of smaller scale instabilities if significant strength loss is triggered in the overburden foundation.

8.0 FINDINGS AND RECOMMENDATIONS

8.1 GENERAL

The stability assessment for the Design Document comprised the following:

- Review of previous work that included stability analyses, site investigation data and observations, monitoring data.
- Material characterization for the mechanical response and undrained shear strength of the saturated overburden and basal embankment rockfill.
- Evaluation of piezometric conditions and definition of a phreatic surface for the analyses.
- Evaluation of the liquefaction potential of the overburden, rockfill, and tailings.
- 2D and 3D limit equilibrium analyses for normal operating and post-earthquake conditions.
- 2D dynamic analysis for normal operating conditions that evaluated the sensitivity of five earthquake time histories.

The findings of the analyses and material characterization are summarized below, along with recommendations for ongoing refinement of site characterization to refine future stability assessments.

8.2 CONCLUSIONS

The material constituents of the YDTI comprise three soil units that overlie bedrock. Of the three soil units, the overburden and rockfill govern stability results when saturated. Although the tailings unit is the weakest, the stability results are not sensitive to the tailings due to the size of the rockfill embankment. Microstructure evident in the SCPT data reduces reliability of empirically-derived undrained strength correlations. Existing laboratory data was supplemented and used to constrain the peak undrained strength of saturated overburden and rockfill. Notable in the laboratory data set is the lack of strength loss post-peak for the rockfill and a small strength loss for the overburden at low confining pressures. Reduced strengths were estimated to evaluate the sensitivity of the analysis results. Residual strengths were constrained from laboratory data for the saturated overburden and rockfill and SCPT data for the tailings. Dynamic properties of saturated tailings and overburden were estimated from cyclic laboratory testing. Cyclic testing of rockfill proved challenging and as a result, index testing and SPT data were used to estimate dynamic properties.

Monitoring data and site observations were used to evaluate the piezometric conditions of the facility. Two hydrogeological regimes are evident, with an upper phreatic surface defined in the tailings and a lower that subdivided the rockfill embankment at its base. Monitoring data indicated a vertical transition between the two regimes where the tailings phreatic surface intersects the upstream face of the dam is an appropriately conservative representation of the piezometric conditions within the embankment.

The liquefaction potential of the soil units to the MCE was evaluated first with a screening-level effort (index properties and SCPT data) and followed with a 1D site response analysis that considered linear and non-linear methods. The MCE represents an 84th percentile deterministic event, involving the Continental-Elk Park fault. The rockfill was limited in data to complete the 1D site response but available data suggested susceptibility when saturated and in the absence of microstructure. Saturated overburden and tailings exhibited liquefaction susceptibility in the screening-level evaluation and the 1D site response. The results of the liquefaction assessment support the consideration of post-earthquake conditions in the stability assessment and completion of a dynamic analysis to evaluate the deformation response of the dam.

Static stability was analyzed with the LE method in 2D for the final LoM configuration and four key construction stages that included the currently constructed geometry (crest El. 6,450 ft). The stability of the embankment geometry along five sections was evaluated. The central pedestal area (Sta. 0+00 and Sta. 8+00W) governs stability of the YDTI with critical slips predicted to toe out into the unconfined saturated overburden north of the HsB area mine facilities (e.g. truck maintenance workshop). The analyses demonstrated the sensitivity of dam stability to the strength of the saturated overburden foundation, which controls the depth, dimension, and shape of the base of the critical slip surface. The analysis results show that the design of the embankment dam raise presented in the Design Document is sufficiently dimensioned to satisfy the regulated targets for both normal operating and post-earthquake loading conditions. The 3D results, which considers the important lateral constraint of the HsB area, corroborates the 2D LE findings in demonstrating the effectiveness of infilling the HsB area to buttress the dam toe and the continuous improvement provided by the proposed construction sequencing. In addition, both analyses predict potential for shallow sloughing of the steep downstream face of the relocated pipeline ramp with the crest at El. 6,500 ft indicating that refinements of the design fill configuration for relocating the pipeline ramp and/or incorporating additional buttressing in the HsB area concurrently with ramp construction at the IFC design stage would be beneficial.

The dynamic analysis considers an interim construction stage required for relocating the tailings pipeline prior to the El. 6,560 ft embankment raise. Excess pore pressure generation in the unconfined overburden at the toe of the dam resulted from seismic loading is predicted, which suggests the possibility of liquefaction due to earthquake loading and the consequential accumulation of shear strain. As a result, the dam is estimated to displace horizontally up to 4 ft into the HsB area in this configuration. The location of the relocated pipeline ramp likely contributes to the dominant downstream movement of the dam as the ramp fill is coincident with the largest downwards displacement and shear bands propagating from the overburden foundation form upstream of the ramp fill. In addition, surficial sloughing of the steep ramp fill is indicated in the results. The crest is predicted to settle to 2 ft during the MCE, which is lower than the available freeboard requirements and indicates earthquake-induced deformation will not result in loss of containment or uncontrolled release of impounded tailings or water. Post-earthquake deformations estimating following the dynamic analysis are exacerbated in the absence of additional buttressing fill in the HsB area and in response to the potential strength loss of a continuous overburden foundation. These deformation results corroborate the key recommendation from the stability analysis of refining the configuration and fill sequencing during IFC design for mitigating deformations and thereby, increasing the FS of the dam.

8.3 RECOMMENDATIONS

The stability assessment identified two key areas of uncertainty that could improve the rigour and confidence of future evaluations. Uncertainty remains in the characterization of material response (contractive or dilative) and residual strengths of the soil units controlling stability and deformation. Related to improving material characterization is the uncertainty of the piezometric definition at the upstream face of the dam. The following are recommended for ongoing augmentation of the site characterization:

- Continue the incremental addition of laboratory data to capture the site variability (mineralogical influences, construction history, depositional source/age) for:
  - Constraining the peak and post-peak undrained shear strengths of the overburden and rockfill with a greater focus on the DSS mode of shear.

  - Refining the understanding of mechanical response (contractive or dilative) of the saturated overburden and rockfill.
  - Defining cyclic material properties for saturated rockfill and expanding the overburden definition to include higher confining pressures.
  - Drawing conclusions on the effect of specimen size and sub-unit differences (older and recent alluvium, older and newer rockfill).
- Install additional high-resolution piezometric instrumentation (e.g., Geo4Sight or multi-point VWPs) through the upstream face of the embankment into the overburden, if possible.
- Continue to evaluate piezometer data for verifying and refining, where required, the piezometric conditions utilized in the stability analyses.
- Consider sensitivity analyses for variable piezometric conditions.
- Additional improvements related to piezometric conditions that may improve the stability assessment include further ongoing piezometric characterization, calibrated seepage analysis, and evaluating the influence of transient conditions.
- Continue to utilize stability analyses to assist with design refinement in the IFC stage for determining optimal fill geometry and construction sequencing for fill placement to achieve the LoM configuration.

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10.0 CERTIFICATION

This report was prepared and reviewed by the undersigned.

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APPENDIX A

Site Characterization Overview

(Pages A-1 to A-8)

APPENDIX A
SITE CHARACTERIZATION OVERVIEW

1.0 INTRODUCTION

This appendix summarizes the relevant historical and recent geotechnical and hydrogeological site investigation programs that support the design of the Yankee Doodle Tailings Impoundment (YDTI). Site investigation programs were conducted by several different engineering consultants in coordination with the mine operator of the time using a variety of methods. The work spans over six decades from 1962 to present, and typically coincided with certain periods of project development.

A comprehensive Site Characterization Report was prepared in 2017 for the Amendment 10 Design Document (KP, 2017). Relevant historical data available from other consultants prior to involvement in the project by Knight Piésold Ltd. (KP) as well as data collected by KP and Montana Resources, LLC (MR) during phased site investigation programs carried out in 2015 and 2016 were compiled and summarized. The Site Characterization Report provided a detailed description of the development of the YDTI and presented the geotechnical and hydrogeological characterization of the site conditions supporting the ongoing design of the YDTI.

Geotechnical and hydrogeological site investigation programs have been carried out annually at the YDTI since 2016 to further refine the geotechnical and hydrogeological characterization of the embankments, tailings mass, and foundation materials, and to expand the operational instrumentation monitoring network. These investigation programs also included a variety of in-situ testing and laboratory testing programs. The findings of these more recent programs were generally consistent with and supportive of the existing geotechnical and hydrogeological model for the impoundment as presented in the Site Characterization Report (KP, 2017).

2.0 SUMMARY OF SITE INVESTIGATIONS

2.1 PREVIOUS INVESTIGATIONS

Site investigation programs conducted between 1962 and 2016 were summarized in the Site Characterization Report (KP, 2017). The work spanned over five decades from 1962 to present, and typically coincided with certain periods of project development. It is also possible that other site investigation work was carried out by Anaconda Copper Company (ACC) before MR took ownership of the property in 1986; however, only the known, available, and useful investigative studies were described in this preceding report. Some programs included a number of drillholes and laboratory test work while others were literature reviews of previous investigations. These previous site investigation programs are summarized in Table 2.1. Report references for the previous investigation programs and the available logs for these historical drillholes, standpipe piezometers, monitoring wells, and test pits were compiled in the Site Characterization Report (KP, 2017).

Table 2.1 Historical Site Investigation Summary (1962 to 2016)

Report Objectives	Site Investigations
Dames and Moore (1962) Characterized the North Embankment and Horseshoe Bend, described site surficial geology and foundation conditions prior to substantial YDTI development, evaluated the stability of embankments.	• 5 drillholes (62-T1 to 62-T5) • Index and shear testing • Permeability testing • 1 test pit
Dames and Moore (1963) Summarized subsurface conditions of YDTI based on 1962 site investigation results, developed design and construction criteria for YDTI, and developed tailings deposition plan.	• 1 drillhole (62-T6) • Index testing
Botz (1969a, 1969b and 1970) Summarized physiography and geology of the region. Analyzed movement of groundwater in the regional alluvial aquifer. Drilling investigation of asphalt pad and alluvium beneath leach pads downstream of the YDTI.	• 9 drillholes (SD-1 to SD-3, MD-1 to MD-5, and MD-5A) • Laboratory test work reportedly included shear strength and permeability testing of alluvium but results unavailable.
Golder Associates (1980) Characterized the alluvium strength for East Berkeley Pit Expansion	• 3 drillholes (311-398, 297-390, and 297-390B) • Laboratory test work including consolidated drained triaxial tests on alluvium samples
IECO (1981) Evaluated site geology and seismicity, described foundation conditions and characteristics of existing embankment, and evaluated the stability of existing embankment for an expansion.	• 14 drillholes (DH-1 to DH-13 and DH-6A) • Various sampling devices • Index, direct shear and triaxial shear testing • Standpipe piezometer installations
Goldberg (1990) Engineering literature review for the embankment	None
Harding Lawson Associates (1993) Investigated in-place density of tailings along North-South Embankment and updated seismic design criteria	• 2 drillholes (92-1 and 92-2B)
MR Engineering Department (1993 to 1994) Investigated pore pressure conditions in the YDTI and East-West Embankment.	• 22 standpipe piezometers (93-1 to 93-5, 94-1 to 94-12, 94-B1 to 94-B5) • Water level monitoring
MR Engineering Dept. (1999) Evaluation of YDTI embankment stability throughout design life, review of the foundation, embankment, and tailings engineering properties and seismic hazard analysis.	• Summarize existing information • Stability analysis modeling for static and pseudo-static conditions • Tailings auger boring sampling
Hydrometrics (2012) Characterize West Ridge area hydrogeology, establish baseline hydrogeology and groundwater chemistry data and review of existing residential wells.	• 8 monitoring wells (MW12-11 to MW12-18) • Groundwater sampling of monitoring wells
Knight Piésold (2012) Investigated tailings material and hydrogeological conditions within YDTI.	• 4 drillholes with SPTs (DH12-01B, DH12-03, DH12-04, DH12-05A) • 5 CPTs (CPT12-01A, CPT12-03A, CPT12-04, CPT12-04A, CPT12-05) • Index tests on tailings sand • 3 VWP installations (CPT12-03A, 04 and 04A)
Knight Piésold (2013) Investigated tailings material and hydrogeological conditions within YDTI.	• 2 drillholes with SPTs (DH13-07 and DH13-09) • 6 CPTs (CPT13-01 to 06) • 3 settlement monitoring points on test pads • 6 VWP installations (CPT13-01 to 06) • Index tests on tailings sand

Report Objectives	Site Investigations
Knight Piésold (2014) Investigated deep tailings material of YDTI, tailings material north of 'Rocky Knob', collected tailings samples for shear testing, investigated the strength of embankment fill near Horseshoe Bend, and assessed hydrogeological conditions within YDTI.	• 5 CPTs (CPT14-01, CPT14-01A, CPT14-02, CPT14-04, CPT14-05) • 11 test pits at Horseshoe Bend (TP14-01 to TP14-11) • 3 VWP installations (CPT14-01A, 02, 04) • 5 index tests on tailings sand, 8 on rockfill, proctor and triaxial test on rockfill
Hydrometrics (2015) Investigated West Ridge area hydrogeology, established baseline hydrogeology and groundwater chemistry data and established inventory and quality of nearby residential wells.	• 13 monitoring wells (MW15-01 to MW15-13)
Knight Piésold (2015) Investigated West Ridge geotechnical and hydrogeological conditions, East-West Embankment and foundation conditions, tailings impoundment materials and installed VWP monitoring network. Identified presence of low piezometric conditions in a deep isolated fracture system.	• 14 drillholes (DH15-01 to DH15-14) • 6 sonic drillholes (DH15-S1 to DH15-S6) • 8 CPTs (CPT15-01 to CPT15-08) • 33 test pits (TP15-01 to 14, 18 to 31, 33, 34, and 38 to 40) • 11 trenches (T-1 to T-11) • 76 VWP installations • Laboratory test work
Knight Piésold (2016) Investigated West Ridge area hydrogeology targeting deep isolated fracture system identified by KP investigation in 2015.	• 5 drillholes (DH16-01 and DH16-05) • 25 VWP installations
Hydrometrics (2016) Investigated West Ridge area hydrogeology targeting deep isolated fracture system identified by KP investigation in 2015.	• 15 trenches T-12 to T-26 • 3 monitoring wells (MW16-01, MW16-02D and MW16-02S)

Note(s):

1. Table above adapted from Table 2.1 of the Site Characterization Report (KP, 2017); references available therein.
2. SPT is Standard Penetration Test; CPT is Cone Penetration Test; VWP is Vibrating Wire Piezometer.
3. Report references available in the Site Characterization Report (KP, 2017).

2.2 RECENT INVESTIGATIONS

An initial 5-year phased site investigation and instrumentation plan was developed as part of the Amendment 10 permit application for continued use of the YDTI facilitated by continued construction of the embankment to a crest elevation of 6,450 ft. The majority of the initial 5-year plan was implemented through a series of site investigation programs completed from 2017 through 2021. Modifications were made based on findings of preceding investigations, in response to feedback from the Independent Review Panel (IRP), and/or to achieve updated project objectives.

An updated 5-year site investigation, instrumentation, and monitoring plan for the YDTI covering the period of 2022 through 2026 was developed in late 2021 (KP, 2021b). The drilling investigations and instrumentation program over this period relies on techniques proven to be of highest value during completion of the initial 5-year plan. The objectives of the updated 5-year site investigation, instrumentation and monitoring plan include expanding spatial coverage of subsurface investigations from 2022 through 2026 to:

- Advance characterization of the nature and distribution of rockfill and foundation materials within the East-West and North-South Embankments.
- Further investigate rockfill saturation within the embankments including the influence of rockfill material properties and distribution on drainage within the embankment.

- Install additional pore water pressure and surface/subsurface deformation monitoring instrumentation to progressively supplement the operational instrumentation network within the East-West and North-South Embankments.

A summary of these more recent programs through 2023 and relevant references are provided below in Table 2.2. The findings of each investigation are summarized in the individual site investigation reports along with details related to the site geological model and site investigation methodology. The specialized laboratory testing programs conducted to inform selection of material strength properties for the geotechnical analyses presented in this report are summarized in subsequent appendices.

Table 2.2 Recent Site Investigation Summary (2017 to 2023)

Program Objectives	Site Investigations
Knight Piésold (2017) Investigated the geotechnical and hydrogeological characteristics within the East-West Embankment rockfill, foundation units, and tailings mass adjacent to the central pedestal area along Sections 0+00 and 12+00W. Attempted downhole geophysical testing in the embankment. (KP, 2018a)	• 4 sonic drillholes (DH17-S1 to DH17-S4) • Field moisture content testing completed on the majority of grab samples • Suspension velocity profiling in the rockfill and foundation materials at DH17-S1, DH17-S2, and DH17-S4 to measure shear (S) and compressional (P) wave velocities • 15 VWP installations at 4 locations • Laboratory index testing on soil samples
Knight Piésold (2018) Investigated the geotechnical and hydrogeological characteristics within rockfill and foundation materials at the East-West Embankment (along Sections 28+00NW & 43+00NW) and North-South Embankment (along Sections 28+00N & 43+00N). Evaluated alternative downhole geophysical testing methodologies and compared them with previously attempted methods. (KP, 2019a)	• 5 sonic drillholes (DH18-S1 to DH18-S5) • FWS and DST completed within geophysical casing at DH17-S2 for comparison with 2017 suspension profiling and within cased drillhole at DH18-S3 to test alternative methodology • 23 VWP installations at 5 locations • Laboratory index testing on soil samples
Knight Piésold (2018) Investigated the spatial distribution and hydrogeological regime of fill materials, natural soils, and bedrock within the Horseshoe (HsB) area. Developed conceptual geological model of the HsB area, including further differentiation of spatial extents of alluvial material units (i.e. recent and older alluvium) relevant to the characterization of the foundation conditions of the YDTI embankments and future HsB area rock disposal site. (KP, 2019b)	• 12 sonic drillholes with rotary-coring to recover competent bedrock (DH18-01 to DH18-12) • Packer and open-hole hydraulic conductivity testing in competent and weathered bedrock, respectively • SPT conducted within fill and natural foundation materials • DST completed within 2 drillholes • Seismic refraction and surface resistivity geophysical surveys along six transects • 30 VWP installations at 10 locations • Laboratory index testing on soil samples and UCS testing on rock core samples
Knight Piésold (2019) Investigated the geospatial extents of the saturated rockfill material within at the Seep 10 Bench, the Historical Western Leach Area, and the Historical Reclaim Pipeline Alignment with a multi-faceted approach comparing multiple investigation techniques. Investigated the changes in tailings characteristics due to single-point and multi-point tailings discharge. Installation of automated surface and subsurface deformation monitoring instrumentation within the central pedestal area. (KP, 2020a)	• 7 sonic drillholes (DH19-S1 to DH19-S7) • 4 SCPTu soundings (SCPT19-13, SCPT19-14, SCPT19-15, SCPT19-16) with drillouts using sonic methods. • Downhole volumetric moisture content assessment using borehole NMR geophysical testing at 3 drillholes • 31 VWP installations at 5 locations • 4 IPIs co-located with GNSS surface deformation instrumentation • Laboratory index testing on soil samples

Program Objectives	Site Investigations
Knight Piésold (2019) Investigated physical and behavioral characteristics of soil and historical fill materials encountered in the HsB area using seismic cone penetration testing, low-disturbance soil sampling, and laboratory testing methods. Further developed geotechnical and hydrogeological characterization of the HsB area through collection of significant additional data and identification of layering and varying degrees of microstructure in HsB area soils. (KP, 2020b)	• 12 drillholes completed with SCPTu soundings (SCPT19-01 to SCPT19-12) • Shelby tube sampling • Laboratory index testing and tube sample density measurement
Knight Piésold (2020) Continued investigation of the hydrogeological and geotechnical conditions within rockfill and tailings along Section 8+00W of the East-West Embankment, including multifaceted assessment of geospatial distribution of basal saturated zone and perched saturated zones within the embankment rockfill. Extended downhole volumetric moisture content measurement using NMR methods. Installed first Geo4Sight instrumentation to develop detailed embankment pore pressure profile with sensors at 6 to 18 ft spacing and provide supplemental sub-surface deformation data. (KP, 2021a)	• 2 sonic drillholes (DH20-S1 & DH20-S2) and 1 dual-rotary drillhole (DH20-01) • Nested FOP installed at 1 drillhole (DH20-S1) and nested VWPs installed at 1 drillhole (DH20-S2); however, these instruments were damaged during installation. • Downhole volumetric moisture content assessment using borehole NMR geophysical testing at 2 drillholes • Elexon Geo4Sight installation at 1 drillhole (DH20-S2) along Section 8+00W • Laboratory index testing
Knight Piésold (2021) Investigated the hydrogeological and geotechnical conditions within embankment rockfill, tailings, and foundation materials within the central pedestal area of the East-West Embankment and along the North-South Embankment with focus on identifying and establishing monitoring points within historical lift-top features. Expanded subsurface deformation monitoring instrumentation network and installed a second Geo4Sight monitoring site to further refine hydrogeological characterization in the central pedestal area. Attempted SCPTu testing within embankment rockfill with varied and inconsistent levels of successful implementation due to the inhibitive nature of dense rockfill to cone advancement. (KP, 2023a)	• 4 sonic drillholes (DH21-S1 to DH21-S4) • 2 drillholes completed with SCPTu soundings and sonic drillouts in embankment rockfill (SCPT21-S8 & SCPT21-S9) • Elexon Geo4Sight installation at 1 drillhole (DH21-S4) along Section 0+00 • 23 VWP installations at 4 locations • Geophysical casing and inclinometer installations with Sondex settlement protection systems at 2 drillholes • 1 geophysical casing and inclinometer installed within historically leached rockfill at the North-South Embankment • Laboratory index testing
Knight Piésold (2021) Investigated the geotechnical and hydrogeological conditions within the YDTI tailings (surcharged and beach tailings) and expanded operational instrumentation monitoring network. Evaluated differences between in-situ tailings properties (strength and moisture content) resulting from tailings densification occurring through natural consolidation and from surcharge loading. Comparison of estimated tailings properties from 2015 and 2021 to evaluate if higher effective stresses following rockfill surcharge placement have resulted in higher density and increases to estimated peak/residual undrained shear strengths for the surcharged tailings. (KP, 2023b)	• 7 drillholes completed with SCPTu soundings and sonic drillouts (SCPT21-S1 to SCPT21-S7) • 22 VWP installations at 6 locations • Laboratory index testing

Program Objectives	Site Investigations
Knight Piésold (2022) Investigated the hydrogeological and geotechnical conditions within embankment rockfill and foundation materials along Section 8+00W of the East-West Embankment. Expanded subsurface deformation monitoring instrumentation network. Challenging installation conditions resulted in failure and loss of communication with most of the pore pressure monitoring instruments installed within the drillholes. (KP, 2024a)	• 2 sonic drillholes (DH22-S1 & DH22-S2) • Geophysical casing and inclinometer installations with Sondex settlement protection system at 1 drillhole • 2 VWP installations at 1 location (failure during installation of 22 of 24 VWP sensors and lost communication with Geo4Sight sensors installed in DH22-S1) • Laboratory index testing
Knight Piésold (2023) Investigated the hydrogeological and geotechnical conditions within embankment rockfill and foundation materials along Sections 8+00W and 0+00 of the East-West Embankment. Expanded subsurface deformation monitoring instrumentation network. (KP, 2024b)	• 4 sonic drillholes (DH23-S1 to DH23-S4) • Geophysical casing and inclinometer installation with Sondex settlement protection system at 1 drillhole. • 36 VWP installations at 4 locations • Laboratory index testing

Note(s):

1. Abbreviations: VWP is Vibrating wire piezometer; FWS is Full-Waveform Sonic; DST is Downhole Seismic Test; SPT is Standard Penetration Test; UCS is Unconfined Compressive Strength; SCPTu is Seismic Cone Penetration Test with Pore Pressure Dissipation Testing; NMR is Nuclear Magnetic Resonance; IPI is In-Place Inclinometer; GNSS is Global Navigation Satellite System; FOP is Fibre Optic Piezometer.
2. Report references available in references section below.

3.0 DATA ANALYSIS REPORTS

An annual Data Analysis Report (DAR) is prepared by KP that provides supplemental information related to the monitoring and performance of the YDTI for each calendar year. The DAR has been prepared each year since 2017 (KP, 2018b, 2019c, 2020c, 2021c, 2022, 2023c). The DAR generally includes the following items:

- A description of the annual construction activities, providing context for interpretation of the monitoring and performance data.
- A description of the annual tailings and water management monitoring activities and data.
- A description and interpretation of the annual piezometric and embankment deformation instrumentation and monitoring data.

Piezometric conditions at the YDTI are monitored with multiple lines of instrumentation installed along several dam cross-sections. The instrumentation network is also actively augmented, annually and as needed. The conceptual hydrogeological model for the YDTI embankments presented in the Site Characterization Report (KP, 2017) suggests that a basal saturated zone exists deep within the embankment rockfill and that isolated perched saturated zones exist within the overlying rockfill. Perched saturated zones are typically encountered within finer grained historical lift-top rockfill resulting from end-dumping and above historical haulage routes or pipeline alignment surfaces. Pore pressure monitoring data from embedded VWPs and standpipe piezometers continue to corroborate this conceptual hydrogeological model, and piezometric trends are generally indicative of stable or slightly decreasing embankment piezometric conditions within the basal zone. Additional details of the instrumentation and performance monitoring programs currently operational at the YDTI are available in the most recent DARs (KP, 2022, 2023c).

4.0 CONCLUSIONS AND RECOMMENDATIONS

The site investigation programs conducted between 2017 and 2023 greatly increased the geological, geotechnical, and hydrogeological data available for the characterization and monitoring of the YDTI. The findings of these more recent programs were generally consistent with and supportive of the existing geotechnical and hydrogeological model for the impoundment as presented in the Site Characterization Report (KP, 2017). The findings of each investigation are summarized in the individual site investigation reports along with details related to the site geological model and site investigation methodology. The investigations completed to date are commensurate in scope and scale with the complexity of the facility and site geology. The results of these site investigations are considered suitable to support the continued design and operation of the YDTI.

Continued geotechnical and hydrogeological data collection and instrumentation installation programs are recommended for ongoing operations. Investigation, instrumentation, and monitoring plans for the YDTI through 2026 should continue to follow the five-year plan that was developed in late 2021 (KP, 2021b). Investigation, maintenance and expansion of the instrumentation and monitoring network around the YDTI and within the adjacent rock disposal sites will continue throughout the development of the facility. The site investigations and expansion of the network will initially use similar methods to those described above. It is anticipated that the available technology and state of practice will continue to evolve over the long design life presented in this report, and the methods used for investigation and monitoring will evolve to remain consistent with applicable, appropriate and current technologies and techniques practicable for the conditions at the mine. Specific locations for site investigation and ongoing monitoring, including pore pressures and deformation behavior (surface and subsurface), will be developed and updated as construction progresses. The practice of developing and following site investigation, instrumentation, and monitoring plans for the YDTI at regular intervals will continue during the development phases described in this report.

5.0 REFERENCES

Knight Piésold Ltd. (KP), 2017. Yankee Doodle Tailings Impoundment – Site Characterization Report. August 11. Vancouver, BC. Ref. No. VA101-126/14-2, Rev 2.

Knight Piésold Ltd. (KP), 2018a. Yankee Doodle Tailings Impoundment – 2017 Geotechnical Site Investigation Report. May 2. Vancouver, BC. KP Reference No. VA101-126/16-2, Rev 0.

Knight Piésold Ltd. (KP), 2018b. Yankee Doodle Tailings Impoundment – 2017 Data Analysis Report. July 20. Vancouver, BC. Ref. No. VA101-126/16-5, Rev 0.

Knight Piésold Ltd. (KP), 2019a. Yankee Doodle Tailings Impoundment – 2018 Embankment Geotechnical Site Investigation Report. May 22. Vancouver, BC. Ref. No. VA101-126/19-1, Rev 0.

Knight Piésold Ltd. (KP), 2019b. Yankee Doodle Tailings Impoundment – 2018 Horseshoe Bend Geotechnical Site Investigation. May 27. Vancouver, BC. Ref. No. VA101-126/20-1, Rev 0.

Knight Piésold Ltd. (KP), 2019c. Yankee Doodle Tailings Impoundment – 2018 Data Analysis Report. August 15. Vancouver, BC. Ref. No. VA101-126/19-4, Rev 0.

Knight Piésold Ltd. (KP), 2020a. Yankee Doodle Tailings Impoundment – 2019 Embankment Geotechnical Site Investigation Report. July 16. Vancouver, BC. Ref. No. VA101-126/21-1, Rev 0.

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Knight Piésold (KP), 2021b. 5-Year Site Investigation, Instrumentation and Monitoring Plan for Yankee Doodle Tailings Impoundment. December 22. Vancouver, BC. File No. VA101-00126/25-A.01, KP Cont. No. VA21-02063.

Knight Piésold Ltd. (KP), 2021c. Yankee Doodle Tailings Impoundment – 2020 Data Analysis Report. June 30. Vancouver, BC. Ref. No. VA101-126/23-5, Rev 0.

Knight Piésold Ltd. (KP), 2022. Yankee Doodle Tailings Impoundment – 2021 Data Analysis Report. May 20. Vancouver, BC. Ref. No. VA101-126/25-6, Rev 0.

Knight Piésold Ltd. (KP), 2023a. Yankee Doodle Tailings Impoundment – 2021 Embankment Geotechnical Site Investigation Report. December 19. Vancouver, BC. Ref. No. VA101-126/25-4, Rev 0.

Knight Piésold Ltd. (KP), 2023b. Yankee Doodle Tailings Impoundment – 2021 Tailings SCPT Site Investigation. December 22. Vancouver, BC. Ref. No. VA101-126/25-7, Rev 0.

Knight Piésold Ltd. (KP), 2023c. Yankee Doodle Tailings Impoundment – 2022 Data Analysis Report. June 8. Vancouver, BC. Ref. No. VA101-126/27-4, Rev 0.

Knight Piésold Ltd. (KP), 2024a. Yankee Doodle Tailings Impoundment – 2022 Embankment Geotechnical Site Investigation Report. Date TBD. Ref. No. VA101-126/27-5, Rev 0.

Knight Piésold Ltd. (KP), 2024b. Yankee Doodle Tailings Impoundment – 2023 Embankment Geotechnical Site Investigation Report. Date TBD. Ref. No. VA101-126/29-6, Rev 0.

APPENDIX B

Laboratory Strength Characterization

Appendix B1
Static Undrained Strength Characterization

Appendix B2
Overburden Dynamic Strength Characterization

APPENDIX B1

Static Undrained Strength Characterization

(Pages B1-1 to B1-166)

APPENDIX B1
STATIC UNDRAINED STRENGTH CHARACTERIZATION

1.0 INTRODUCTION

The stability assessment of the Yankee Doodle Tailings Impoundment (YDTI) considers three primary soil units: overburden, embankment rockfill, and tailings. The overburden unit overlies the bedrock beneath the YDTI. The rockfill unit forms the embankment dam and the tailings unit is impounded by the rockfill embankment.

Monitoring data and surface observations indicate that the base of the rockfill embankment and the overburden are saturated. The average fines contents of the three units are greater than 10%, which suggest the fine fraction could be influential on the mechanical and hydraulic responses of the materials. The combination of saturated conditions and a fines content greater than 10% indicate that undrained loading conditions could be relevant and should be considered in stability analyses.

Stability analyses show the results are not sensitive to the strength of the tailings unit due to the size of the embankment. Therefore, the strength characterization for undrained loading discussed herein is focused on the critical units for the stability assessment, which are the saturated overburden and embankment rockfill materials. This appendix summarizes the evaluation of the undrained strength of these units based on results from monotonic laboratory testing carried out through May 2023.

2.0 MONOTONIC TESTING FRAMEWORK AND OBJECTIVES

The response of a soil to any loading (stress change due to construction, earthquakes, etc.) depends on its in-situ state, dilatancy (contractive or dilative behavior), and degree of saturation. Undrained loading can occur in a relatively short period of time and can lead to liquefaction (rapid failure) if the loss of strength results in slope instabilities. Soil liquefaction is a phenomenon whereby the loss of strength and stiffness (brittle or contractive behavior) can be triggered by dynamic (e.g., earthquakes) or static (e.g., construction, tailings deposition, etc.) loading. Saturated and contractive materials can mobilize undrained shear strengths that can range from approximately 10% to 50% of the drained shear strength.

Screening-level assessments conducted using seismic cone penetration tests (SCPT) in past investigations at the YDTI (KP, 2020a, 2020b) suggest potential for contractive behavior in the saturated overburden and embankment rockfill materials. However, microstructure was also evident in the SCPT data resulting in low confidence in established SCPT correlations to estimate appropriate undrained shear strengths. Consequently, focus shifted towards a laboratory program for estimating strength of these critical materials.

The goals of the monotonic laboratory program were to determine which soils are potentially susceptible to liquefaction (i.e., exhibit contractive behaviour) and what undrained strength, or range of strengths, should be considered in the stability analyses. The underlying premise for the stability assessment supporting the design of the YDTI expansion is that contractive materials have the potential to mobilize undrained shear strength, regardless of the triggering mechanism.

3.0 PHASE 1 STRENGTH TESTS (2014 TO 2016)

3.1 GENERAL

Strength testing conducted between 2014 to 2016 comprised isotropically consolidated undrained (CIU) triaxial tests on the overburden and embankment rockfill. Testing on the overburden soils included a total of two three-point tests on specimens remolded to a density of 100 pounds per cubic foot (pcf), to replicate estimated site conditions. The rockfill testing included a total of three four-point tests on remolded specimens from composite samples of older and newer rockfill. The 2014 rockfill specimens were prepared to an estimated in-situ density, while the composite rockfill specimens were prepared as loose as possible. A summary of the samples tested is presented in Table 3.1.

Table 3.1 Phase 1 Strength Tests

Sample Source	Soil Sub-Unit	Test Type	Sample Preparation	Sample Depth (ft)
Overburden Material[1]				
DH15-S5-25	Recent Alluvium	CIU with pore pressure measurements	Remolded to 100 pcf density	718 to 719
DH15-S5-27	Recent Alluvium	CIU with pore pressure measurements	Remolded to 100 pcf density	720 to 721
Embankment Rockfill[2]				
2014 Older Rockfill (TP14-01) (TP14-02) (TP14-03) (TP14-04)	Older Rockfill	CIU with pore pressure measurements	Remolded to 90% proctor density	6 to 11
Composite 1 through 4 (Older Rockfill)	Older Rockfill	CIU with pore pressure measurements	Remolded, loose as possible	~0 (surface)
Composite 5 through 8 (Newer Rockfill)	Newer Rockfill	CIU with pore pressure measurements	Remolded, loose as possible	~0 (surface)

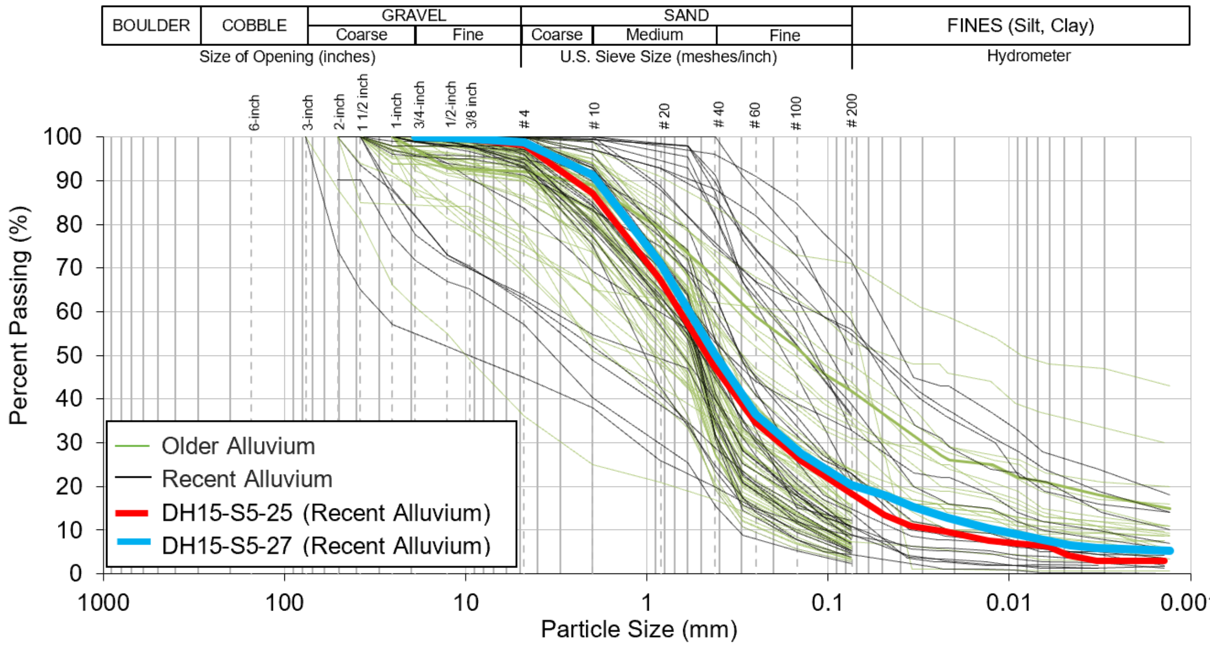
Note(s):

1. Three-point tests on nominal 2-inch diameter specimens.
2. Four-point tests on 6-inch diameter specimens.

3.2 PARTICLE SIZE DISTRIBUTION

The particle size distribution (PSD) of the overburden samples utilized for strength testing (DH15-S5-25 and DH15-S5-27) are presented on Figure 3.1, which also includes the PSD results of index testing from the 2018 and 2019 Horseshoe Bend (HsB) (KP, 2019, 2020b) and 2019 Embankment Site Investigations (KP, 2020a). The laboratory testing sheets for the recent overburden samples are attached. These samples are categorized based on their origin: older alluvium and recent alluvium. The samples from the 2018 and 2019 investigations produced varying curves that ranged from well-graded to gap graded. The two strength samples were well-graded (largely comprised sand and silt), classified as sand-silt mixtures (SM) in accordance with the Unified Soil Classification System (USCS), and are non-plastic.

The PSDs of the embankment rockfill samples are presented on Figure 3.2, which also includes the PSD results of index testing from the 2018 and 2019 site investigations (KP, 2019, 2020a, 2020b). All three strength samples were relatively well-graded. All samples were classified as clayey sands with gravel (SC), according to the USCS.



Note(s):

1. Green (Older Alluvium) and grey (Recent Alluvium) lines are results from the 2018 and 2019 HsB Site Investigations.

Figure 3.1 Phase 1 Overburden Particle Size Distributions

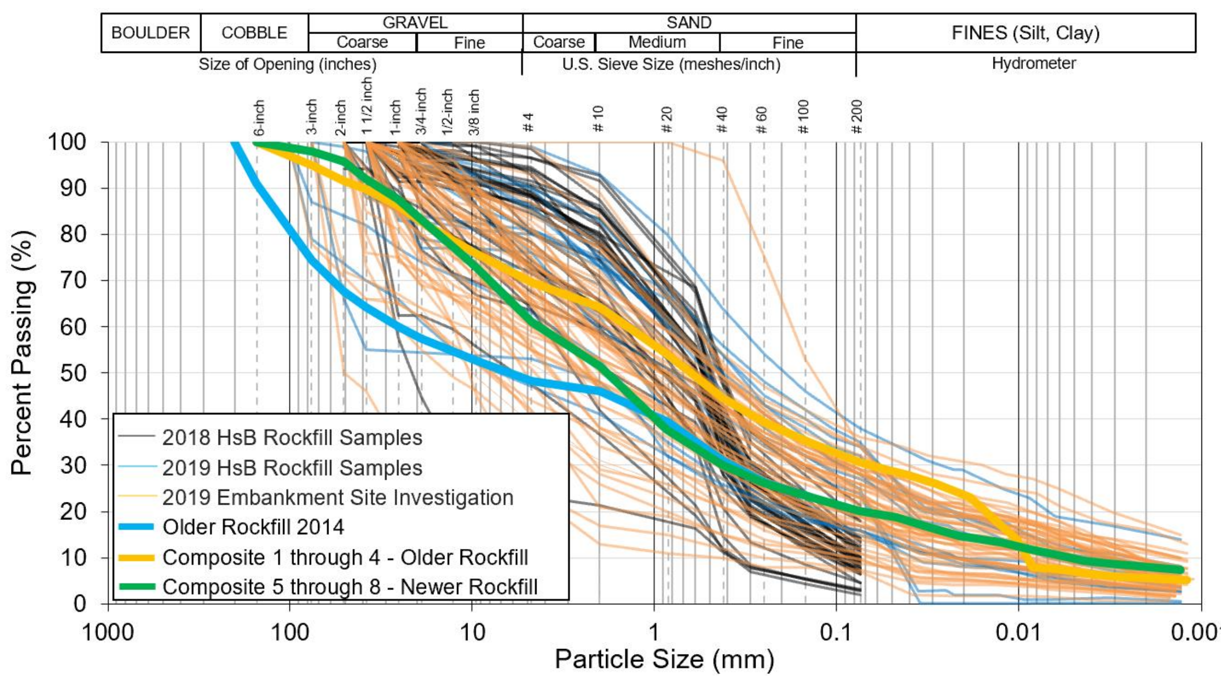
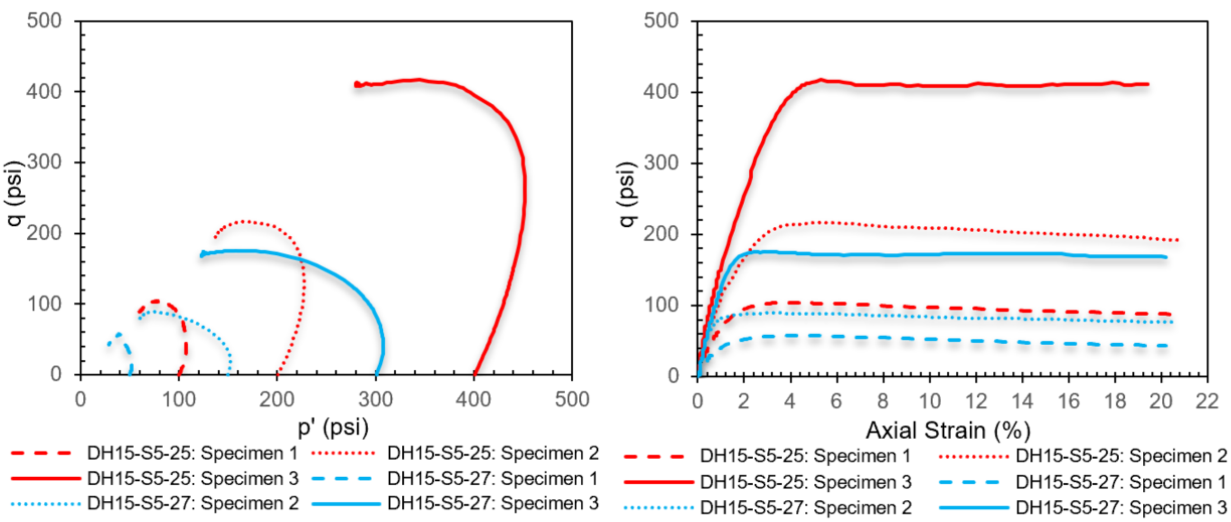


Figure 3.2 Phase 1 Embankment Rockfill Particle Size Distributions

3.3 OVERBURDEN TRIAXIAL STRENGTH TEST RESULTS

The stress paths of the CIU tests completed on the overburden samples are presented on Figure 3.3, in deviatoric stress (q) and mean effective stress (p') space. All six specimens exhibited contractive behaviour, as indicated by the generation of positive pore pressures during shearing. However, the associated strength loss was less than 30% at axial strains up to 20%. A minimum peak undrained strength ratio, Su/σ'_{vo}, of 0.29 was estimated, where Su represents the peak undrained shear strength and σ'_{vo} represents the effective overburden stress. A minimum residual strength ratio, Sr/σ'_{vo}, of 0.25 was estimated, where Sr represents the residual undrained shear strength. Additional plots of the test data are summarized in Table B1.1 and on Figure B1.1.

The stress-strain trends of the overburden CIU tests are also presented on Figure 3.3, showing the response of the deviatoric stress as the axial strain increases. Most of the specimens reach a peak shear strength within 4% axial strain. The maximum strength loss observed was 25% on sample, "DH15-S5-27: Specimen 1", which was consolidated to the lowest confining pressure of 50 psi.



Note(s):

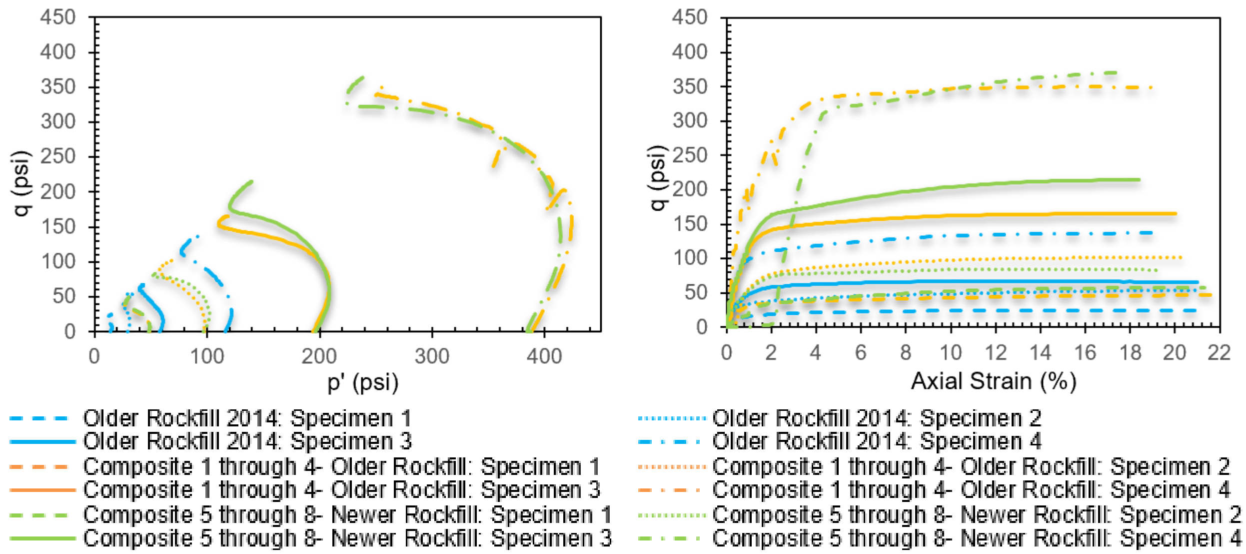
1. Samples were reconstituted to 100 pcf to replicate site conditions.

Figure 3.3 Phase 1 Overburden Triaxial Results

3.4 ROCKFILL TRIAXIAL STRENGTH TEST RESULTS

A total of 12 embankment rockfill specimens were subjected to CIU tests. The stress paths and stress-strain trends are presented on Figure 3.4. The plots demonstrate that each specimen initially contracted but transitioned through a phase transformation to a final dilative stage (increasing effective stress). This suggests that the soil experienced limited contraction as dilation occurred with increasing stress.

The undrained peak strength ratios were selected at the phase transformation (quasi steady state) as a conservative approach. The minimum peak undrained strength ratio was estimated as 0.40. As all the rockfill samples exhibited dilation at large strains without strength loss, the recommended residual strength is equivalent to the peak strength. Additional data plots of the test data are summarized in Table B1.1 and on Figure B1.2.



Note(s):

1. Older Rockfill 2014 remolded to 90% proctor density.
2. Composite 1 through 4 remolded loose as possible.
3. Composite 5 through 8 remolded loose as possible.

Figure 3.4 Phase 1 Embankment Rockfill Triaxial Results

The results showed little difference between the newer and older rockfill samples. Additionally, there was no significant difference between the samples compacted to 90% Proctor density and those reconstituted as loose as possible. Using the point of phase transformation, peak strength was reached between 1% and 8% strain and subsequent strength loss was not evident through 17% strain.

3.5 SUMMARY OF PHASE 1 STRENGTH TESTS

The testing completed in Phase 1 was preliminary and provided the first results indicating potential strength and state behaviour for these critical materials. Findings from the evaluation of the Phase 1 testing included material variability, laboratory limitations in testing coarse-grained materials, and a limited data set for a confident and comprehensive determination of strength and the expected mechanical behaviour of the critical soil units.

Site investigation data shows a high degree of variability in the PSD of the overburden and embankment rockfill, as illustrated on Figures B1.3 through B1.5 for the samples collected during the 2018 and 2019 site investigations (KP, 2019, 2020a, 2020b). Test specimens were formed from sampling five locations, which likely does not fully capture the material variability on site.

Strength testing was completed on specimen sizes of 2 (nominally) and 6 inches in diameter, which required modifications to the PSD that could influence the results. Furthermore, Phase 1 testing focused on the triaxial mode of shearing, which may not capture the dominate mode of shear resistance. The sub-horizontal geometry of the critical units suggests the direct simple shear (DSS) mode is likely to govern.

Phase 2 testing was scoped based on these findings and prioritized minimizing PSD modifications and evaluating the DSS failure mode.

4.0 PHASE 2 STRENGTH TESTS (2022)

4.1 GENERAL

A summary of Phase 2 testing is shown in Table 4.1. Testing specimens were formed from soil samples recovered from sonic drilling conducted during past site investigation programs. Overburden testing focused on the older alluvium since it is more prevalent on site. Testing comprised one four-point CIU triaxial test on 6-inch specimens and one three-point DSS test on 24-inch specimens that were reconstituted as loose as possible. Testing on the embankment rockfill comprised two two-point DSS tests on 24-inch specimens with one reconstituted as loose as possible and the other compacted to 90% standard Proctor density, which approximated the in-situ density. The CIU triaxial laboratory testing sheets are attached and the DSS results are discussed in the attached report by the University of Arkansas (Barry, 2023).

Table 4.1 Phase 2 Strength Tests

Sample Source	Soil Sub-Unit	Test Type	Specimen Preparation	Sample Depth (ft)
Overburden Material				
DH18-01 (1)	Older Alluvium	CIU with pore pressure measurements	Remolded loose as possible	18 to 37
Overburden Loose (2) (KP-22-1)	Older Alluvium	DSS	Remolded loose as possible	17 to 50
Embankment Rockfill				
Rockfill Loose (3)	Older Rockfill	DSS	Remolded loose as possible	67 to 462
Rockfill Dense (3)	Older Rockfill	DSS	Remolded to 90% proctor	67 to 462

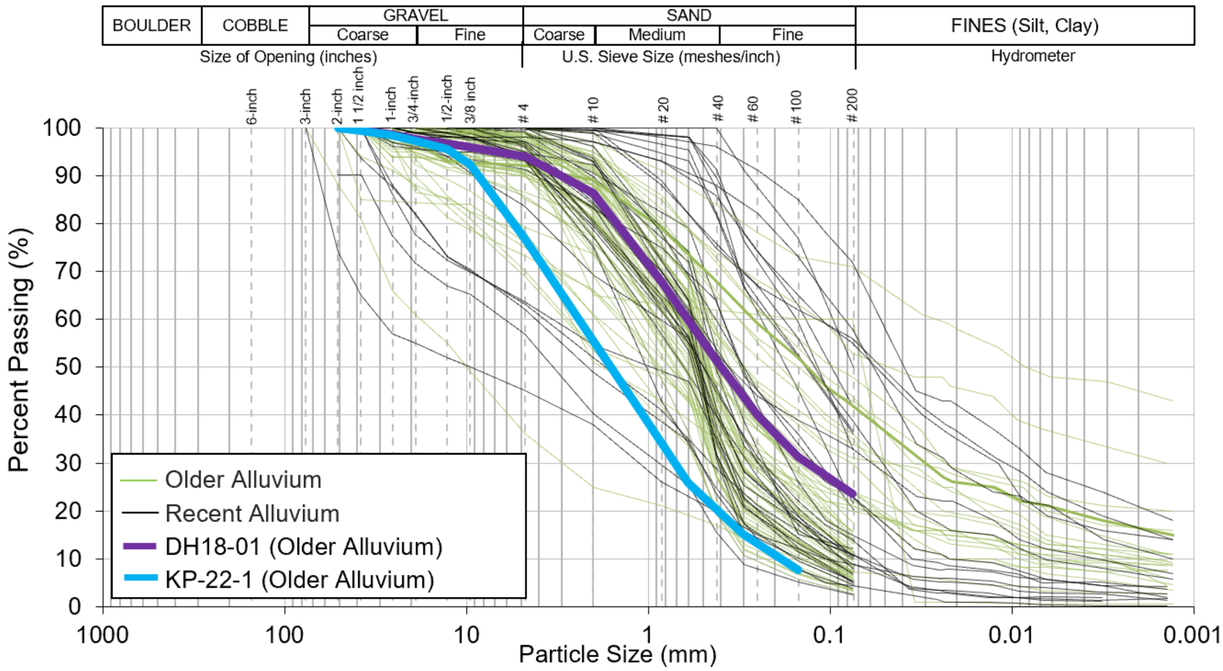
Note(s):

1. Four-point tests on 6-inch diameter specimens.
2. Three-point tests on 24-inch diameter specimens.
3. Two-point tests on 24-inch diameter specimens.

4.2 PARTICLE SIZE DISTRIBUTION

The Phase 2 PSD of the overburden samples are summarized on Figure 4.1, in comparison with the 2018 and 2019 test results. The overburden samples were well-graded with a significantly coarser fraction for the DSS test on KP-22-1 compared to the triaxial test on DH18-01. This difference is attributed to the methodology employed in sieve analysis; a wet sieve analysis was carried out to produce sample DH18-01, whereas a dry sieve analysis was conducted on sample KP-22-1. It is expected that sample KP-22-1 would produce a distribution with finer fraction if a wet sieve analysis were conducted.

A single rockfill sample was created for Phase 2 testing by creating a composite of samples from several drillholes. The Phase 2 PSD of the rockfill sample is summarized on Figure 4.2 in comparison with 2018 and 2019 test results and shows a well-graded curve. A dry sieve analysis was also conducted on the Phase 2 sample; therefore, it is expected that a wet sieve analysis would produce a distribution with finer fraction (i.e., higher sands content).



Note(s):

1. Green (Older Alluvium) and grey (Recent Alluvium) lines are results from the 2018 and 2019 HsB Site Investigations.

Figure 4.1 Phase 2 Overburden Particle Size Distributions

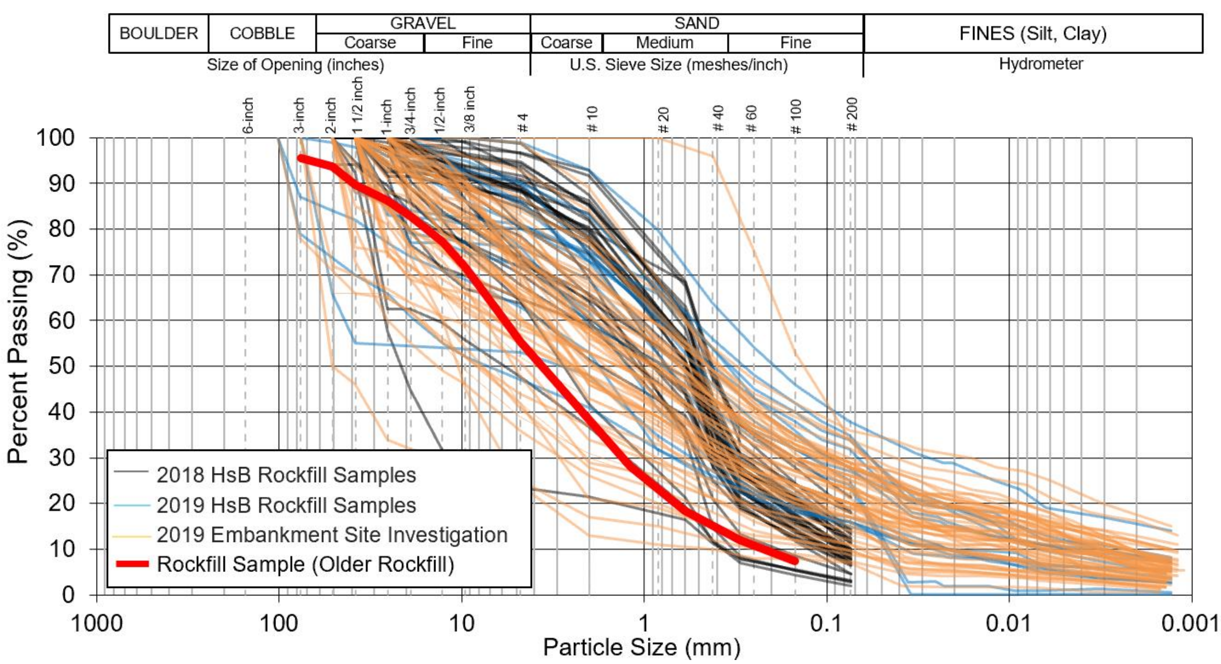


Figure 4.2 Phase 2 Embankment Rockfill Particle Size Distribution

4.3 OVERBURDEN STRENGTH TEST RESULTS

The results for the CIU tests (6-inch specimens) are summarized on Figure 4.3 and the DSS results (24-inch specimens) are summarized on Figure 4.4. The CIU tests on the older alluvium indicated that the specimens experienced limited contraction except at the lowest confinement of 20 psi. Little strength loss was evident, even up to 15% axial strain. Similarly, the DSS results did not exhibit strength loss up to 24% shear strain.

Minimum peak undrained strength ratios of 0.27 and 0.39 were estimated for the CIU and DSS tests, respectively. The maximum reduction in shear strength observed was 5% for the CIU test. No strain softening was observed in the DSS tests. Therefore, a minimum residual strength ratio of 0.26 was estimated.

These results differ from the Phase 1 CIU tests, which were on smaller specimens of recent alluvium that showed a contractive response even at the highest mean effective stress of 400 psi. These differences could be attributed to the mineralogical differences between the older and recent alluvium. Utilization of the larger 6-inch specimen size minimized modifications to the PSD, which could have led to a larger influence of the coarse fraction and added to the difference in the CIU test results between the two phases. Additional test results are summarized in Table B1.2 and on Figure B1.6 and Figure B1.7.

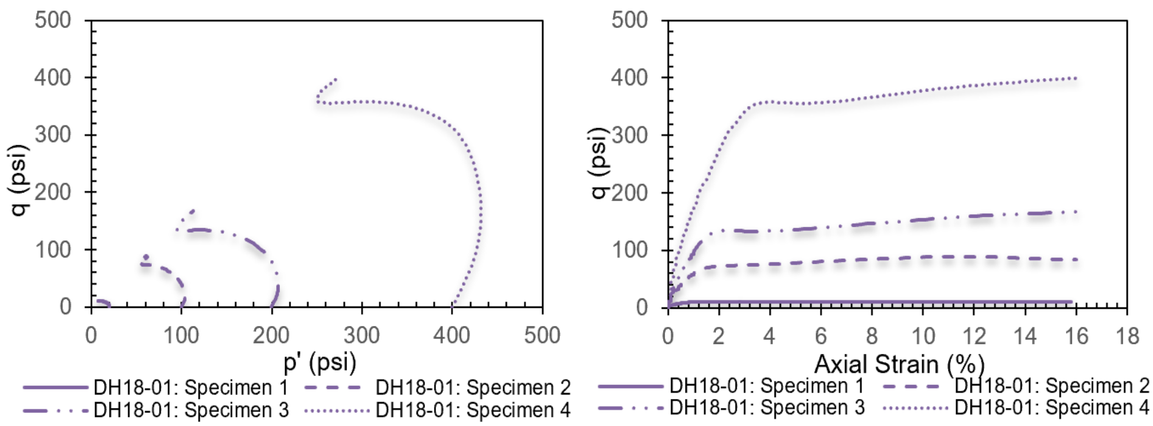


Figure 4.3 Phase 2 Overburden Triaxial Strength Tests

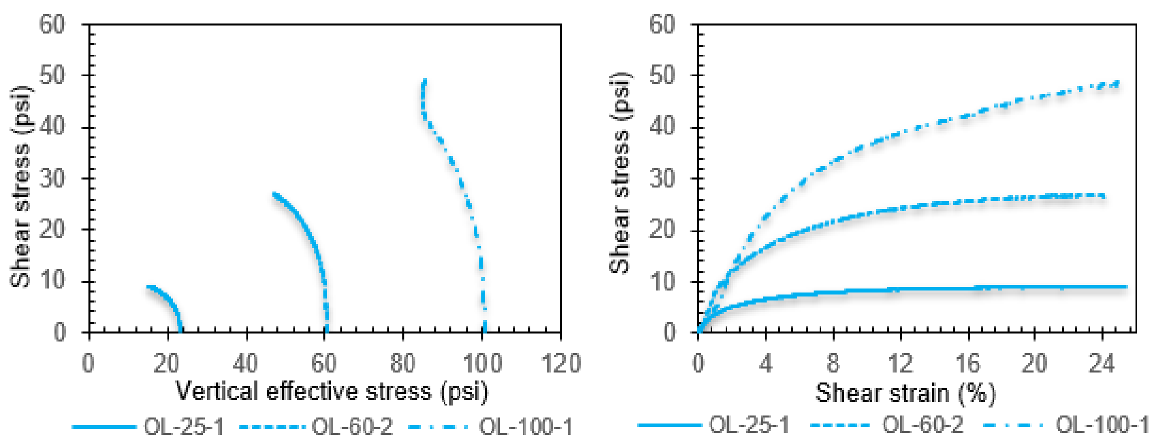


Figure 4.4 Phase 2 Overburden Direct Simple Shear Results

4.4 ROCKFILL STRENGTH TEST RESULTS

The DSS test results on the rockfill specimens are shown on Figure 4.5. The specimens that were remolded to a dense state tended to dilate earlier than the specimens reconstituted to a loose state. However, significant differences in the stress-strain behaviour are not evident. Additionally, the stress paths of the 6-inch CIU tests and the 24-inch DSS tests indicate a consistent behaviour: contraction is followed by dilation across a range of confining stresses (14 to 360 psi). Strength loss during shear was not evident in the test data. Additional data results and plots are summarized in Table B1.2 and on Figure B1.8.

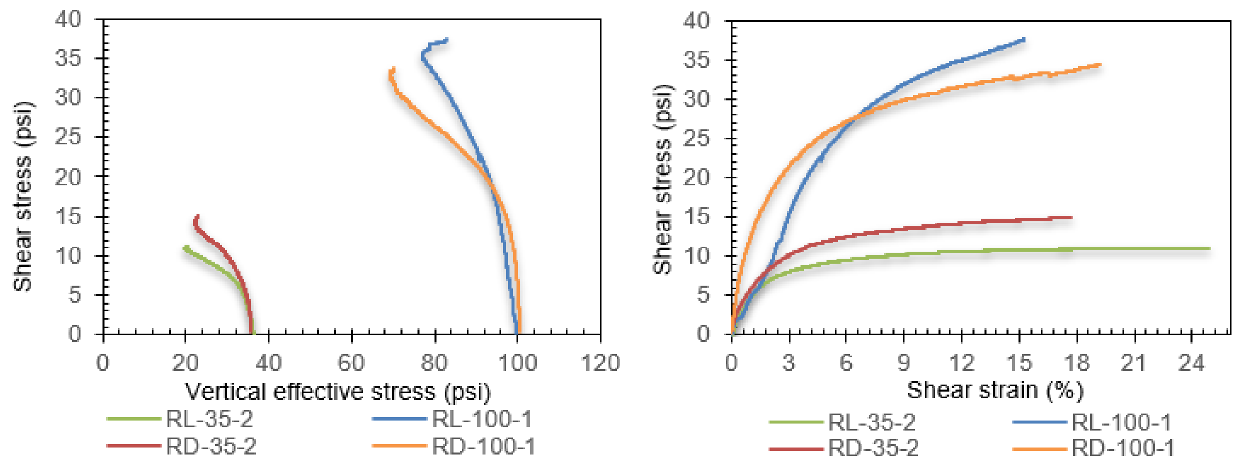


Figure 4.5 Phase 2 Rockfill DSS Test Results

5.0 UNDRAINED SHEAR STRENGTH ESTIMATES

Results from the CIU and DSS strength tests are summarized on Figure 5.1, which compares the peak undrained shear strength (Su) ratio to the vertical effective stress imposed on the overburden and rockfill specimens for the Phase 1 and Phase 2 tests. The results show a larger scatter for the overburden samples than the rockfill.

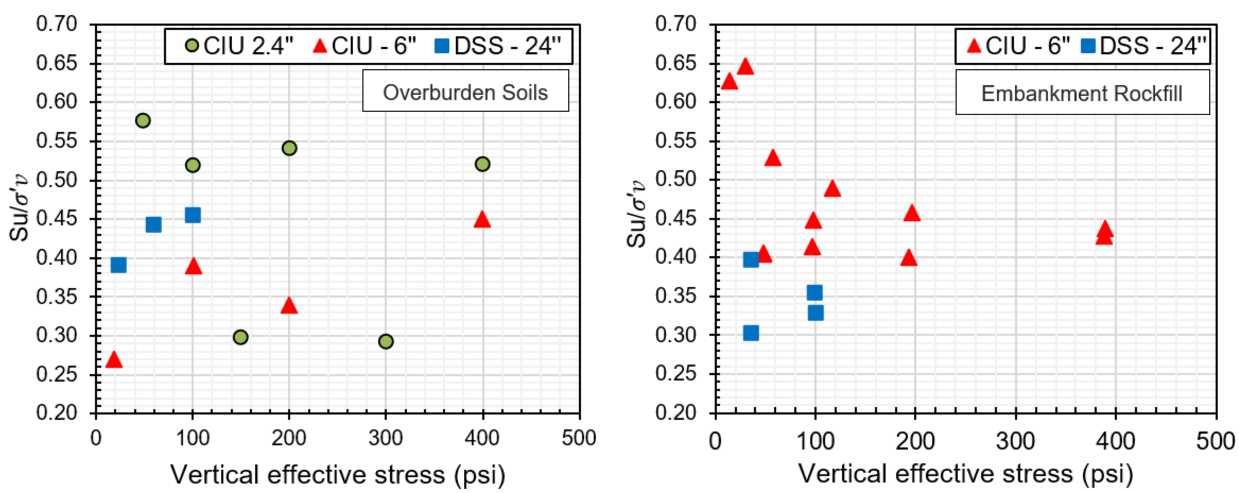


Figure 5.1 Undrained Peak Strength Ratios

The test results on the rockfill specimens confirm the findings by Ladd (1991), which illustrate that the triaxial compression test tends to provide higher strengths compared to the DSS test. However, tests on the overburden material showed that the DSS results fell within the range of the CIU results.

The current database for constraining the undrained shear strength for stability analysis is small and consists of two modes of shear. The sub-horizontal geometry of the overburden and basal saturation of the embankment rockfill indicate the governing mode is DSS. As a result, a reduction of the CIU results to approximate equivalent DSS values is required. A simple method was utilized, based on Ladd (1991) and the plasticity index (PI).

The PI from over 150 grab samples (60 overburden and 90 rockfill), which were obtained from the 2018 and 2019 site investigations (KP, 2019, 2020a, 2020b), indicate a range of 10 to 20 for the overburden and 8 to 14 for the embankment rockfill. These values suggest that both materials are medium to low plasticity. Using Ladd (1991) and the PI range of both materials, the estimated reduction factor was approximately 25% for the CIU values to produce equivalent DSS values, as shown on Figure 5.2.

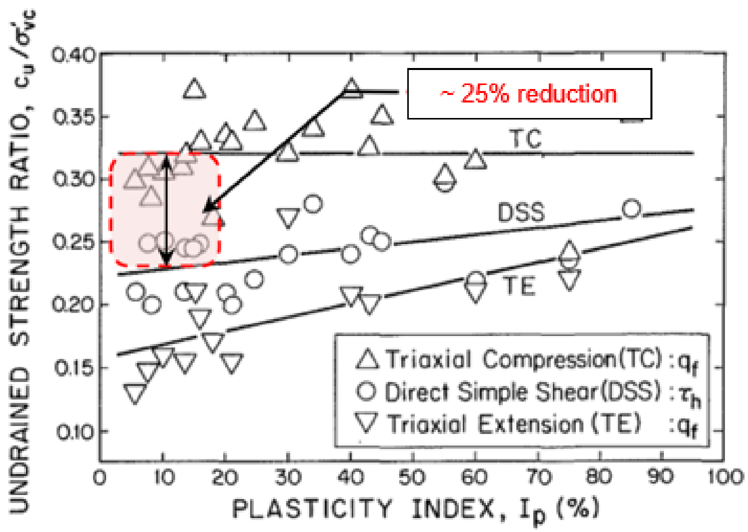


Figure 5.2 Undrained Shear Strength Anisotropy (modified from Ladd, 1991)

The reduction of the CIU results by 25% to develop equivalent DSS values is plotted on Figure 5.3. Although there are only a small number of tests, a preliminary statistical breakdown was utilized to constrain the undrained peak strength ratios, and the results are presented in Table 5.1. The low standard deviation suggests consistency (a small spread) in the data set.

A conservative and efficient approach was taken for defining the rockfill strength due to the consistency of the CIU and DSS results. The 30th-percentile value of 0.31 was used to define the base case peak strength of the rockfill, which precluded the need for a sensitivity check. In addition, the CIU and DSS results indicate no strength loss, which suggest the residual strength value is equivalent to the peak value.

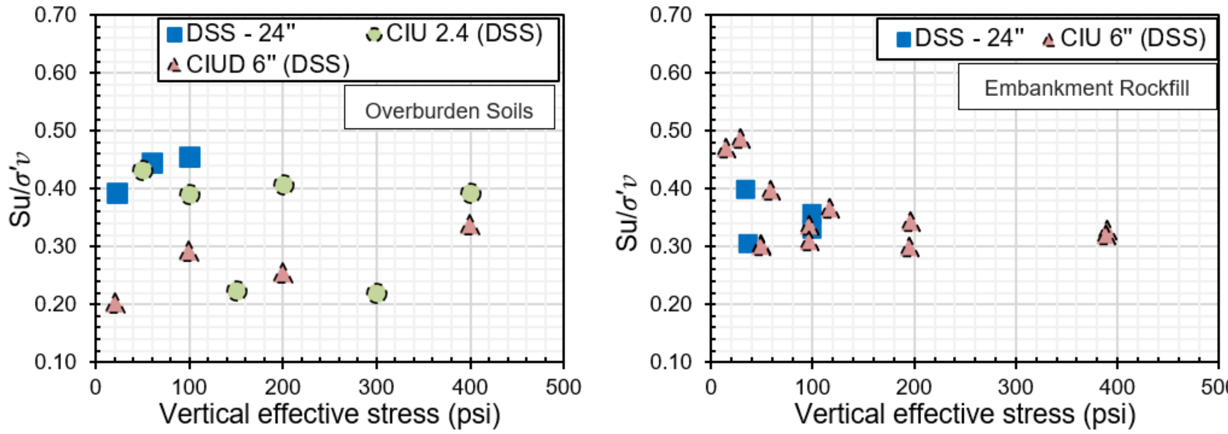


Figure 5.3 Undrained Peak Strength Ratios with CIU adjusted for DSS failure mode

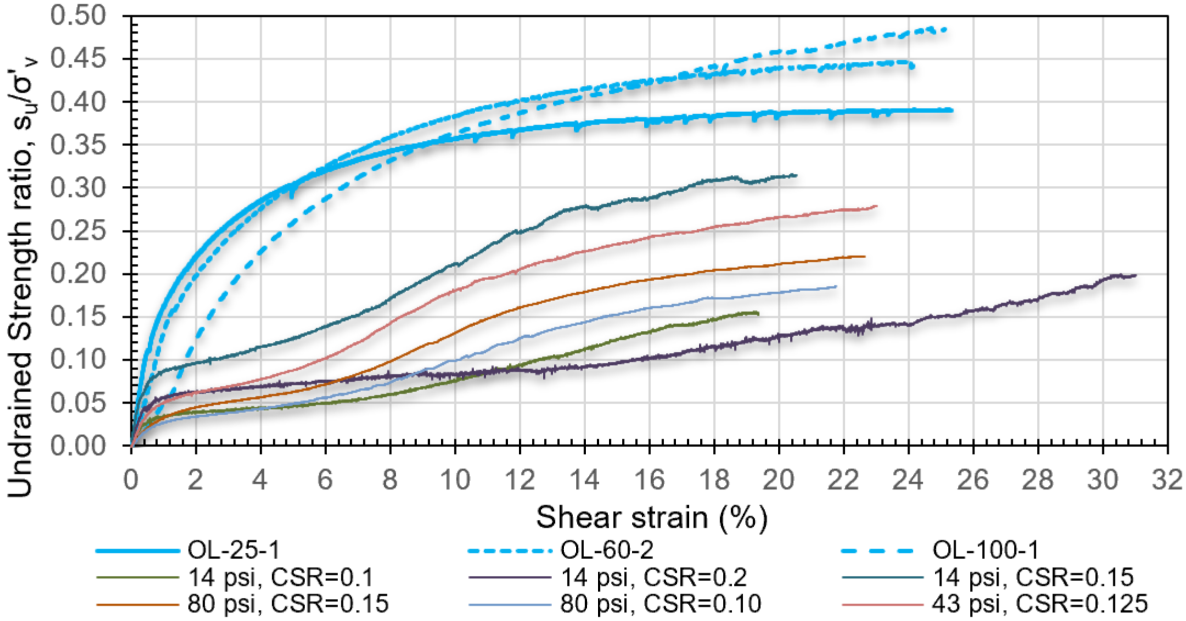
Table 5.1 Statistical Breakdown of Peak Undrained Strengths

Parameter	Overburden Soils	Embankment Rockfill
Count	13	16
Mean	0.34	0.35
Standard Deviation	0.09	0.06
Min	0.21	0.3
Median	0.39	0.33
Max	0.45	0.49
30th percentile	0.26	0.31

A more refined approach was required for defining the overburden strengths. The mean value of 0.34 was selected for the base case peak strength as it is lower than the median value. Due to the spread of the CIU and DSS data, the 30th-percentile value of 0.26 was selected for a sensitivity check. The residual value was constrained from monotonic testing of liquefied specimens at the completion of cyclic direct simple shear (CDSS) tests or post-cyclic monotonic tests.

The results of six specimens of older alluvium (2018 and 2019 site investigations) are shown on Figure 5.4, along with the three results from the Phase 2 testing of 24-inch specimens (also older alluvium). A residual value of 0.22 was selected by averaging the post-cyclic monotonic values at a strain of approximately 19%. This value represents a 35% reduction in strength from the peak strength mean value (0.34) and a 15% reduction in strength from the 30th-percentile value (0.26) used as a sensitivity check of the peak value. A sensitivity check of the residual strength of 0.2 was defined by reducing the peak sensitivity value (0.26) by 25% to align with the strength loss indicated by the Phase 1 testing.

The maximum strength loss observed in the monotonic strength testing results was 25% at a confining pressure of 50 psi. Limited strength loss was observed in tests conducted at higher confining pressures. It is inferred that the higher confining pressures prevalent along the slip surfaces evaluated in the stability assessment will result in more ductile behavior; however, the selected residual strength value is in close alignment with the maximum strength loss observed in testing and represents a reasonably conservative value for the purposes of design given the limited data set, variability in the material, and uncertainty in bulk behavior at full scale.



Note(s):

1. The “OL” samples are Phase 2 monotonic DSS results.
2. The post-cyclic monotonic tests (various Cyclic Stress Ratios, denoted by CSR) were conducted immediately after liquefaction, necessitating adjustments to reset the strain readings to zero at the start of monotonic loading.

Figure 5.4 Phase 2 Overburden DSS and Post Cyclic Monotonic Results

6.0 CONCLUSIONS AND RECOMMENDATIONS

The monotonic testing program conducted on the overburden soils and embankment rockfill has provided further insight into the mechanical behaviour of these critical soil units under undrained conditions. The preliminary values were constrained by focusing on the governing DSS mode and provide a sound basis for updating the strength definition for the stability analyses. The peak undrained strength ratios range from 0.27 to 0.58 for the overburden and 0.30 to 0.65 for the rockfill, across two modes of shearing. The residual strength ratios from the monotonic and post-cyclic DSS tests range from 0.15 to 0.5. The testing exhibits significant variability due to the size of the data set, which limits the confidence level of the strength estimates for capturing the bulk behaviour of both soil units across the project site.

Additional strength testing is recommended to increase the size of the database, for the ability to discern the influence of the mineralogical variability of both soil units on the strength response and potential for contraction. A greater focus should be placed on DSS testing and constraining the strength loss in future programs. Conclusion of the effect of the specimen size should be drawn as quickly as possible to develop more efficient and focused programs. Where possible, a more systematic evaluation of the differences between the older and recent alluvium should be completed.

7.0 REFERENCES

Barry M., 2023. *Summary Report for Laboratory Testing of Overburden and Rockfill Soils*. May 12. GMRL Project No. KP-22-1.

Knight Piésold Ltd. (KP), 2019. *Yankee Doodle Tailings Impoundment – 2018 Horseshoe Bend Geotechnical Site Investigation*. May 27. Vancouver, BC. Ref. No. VA101-126/20-1, Rev 0.

Knight Piésold Ltd. (KP), 2020a. *Yankee Doodle Tailings Impoundment – 2019 Embankment Geotechnical Site Investigation Report*. July 16. Vancouver, BC. Ref. No. VA101-126/21-1, Rev 0.

Knight Piésold Ltd. (KP), 2020b. *Yankee Doodle Tailings Impoundment – 2019 Horseshoe Bend Geotechnical Site Investigation*. December 1. Vancouver, BC. Ref. No. VA101-126/22-1, Rev 0.

Ladd, C.C., 1991. *Stability evaluation during staged construction (22nd Terzaghi Lecture)*. Journal of Geotechnical Engineering, ASCE. Vol. 117. 537-615.

Attachments:
Phase 1 Laboratory Testing Sheets
Phase 2 Laboratory Testing Sheets
University of Arkansas Report – Summary Report for Laboratory Testing of Overburden and Rockfill Soils

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TABLE B1.1

MONTANA RESOURCES, LLC
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PHASE 1 OVERBURDEN AND ROCKFILL MATERIAL TEST WORK
SUMMARY OF TRIAXIAL RESULTS

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Sample Source	Soil Sub-Unit	Test Type	Specimen No.	Sample Type	Initial specimen size, diameter (in)	Sample Depth (ft)	Consolidated Void Ratio, e	Atterberg Limtits			Effective Confining Cell Pressure, P_0' (psi)	Critical State Void Ratio, e_{cs}	State (1) Parameter, ψ	Su/σ'_{vo} (2)
								LL	PL	PI				
DH15-S5-25	Recent Alluvium	CU with Pore Pressures	1	Remolded	2.25	718-719'	0.51	NP	NP	NP	100	0.56	-0.05	0.52
			2		2.29		0.49				201	0.53	-0.04	0.54
			3		2.28		0.52				401	0.50	0.02	0.52
DH15-S5-27	Recent Alluvium	CU with Pore Pressures	1	Remolded	2.40	720-721'	0.65	NP	NP	NP	50	0.59	0.06	0.58
			2		2.40		0.58				150	0.55	0.03	0.30
			3		2.40		0.56				301	0.52	0.04	0.29
2014 Older Rockfill (TP14-01) (TP14-02) (TP14-03) (TP14-04)	Older Rockfill	CU with Pore Pressures	1	Remolded	6.00	6-11'	0.36	NP	NP	NP	14	0.36	0.00	0.63
			2		6.01		0.29				29	0.33	-0.05	0.65
			3		6.00		0.34				58	0.31	0.03	0.53
			4		6.00		0.28				116	0.27	0.01	0.49
Composite 1 through 4-Older Rockfill	Older Rockfill	CU with Pore Pressures	1	Remolded	6.00	N/A	0.47	38	21	17	49	0.44	0.02	0.41
			2		6.00		0.43				98	0.40	0.03	0.45
			3		6.00		0.40				194	0.35	0.04	0.40
			4		6.00		0.33				389	0.30	0.03	0.44
Composite 5 through 8-Newer Rockfill	Newer Rockfill	CU with Pore Pressures	1	Remolded	6.00	N/A	0.32	45	16	29	48	0.31	0.01	0.40
			2		6.00		0.34				97	0.28	0.06	0.41
			3		6.00		0.27				196	0.24	0.03	0.46
			4		6.00		0.22				387	0.19	0.03	0.43

M:\1\01\00126\24\A\Report\5 - YDTI Stability Assessment Report\Rev 0\Appx B1 - Monotonic Test Results\[Strength Testing Summary_B1 Pt1.xlsm]Table B1.1

NOTES:

1. STATE PARAMETER ESTIMATED FROM BEST FIT POWER LINE.
2. PEAK STRENGTH RATIOS ESTIMATED AT PHASE TRANSFORMATION FOR SPECIMENS WHICH EXHIBIT CONTRACTION AND DILATION.
3. DH15-S5-25 & DH15-S5-27 SPECIMENS RECONSTITUTED TO REPRESENT IN-SITU CONDITIONS (~100 pcf).
4. 2014 OLDER ROCKFILL SPECIMENS PREPARED TO 90% PROCTOR DENSITY.
5. COMPOSITE 1 THROUGH 4 AND 5 THROUGH 8 RECONSTITUTED LOOSE AS POSSIBLE.

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TABLE B1.2

MONTANA RESOURCES, LLC
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PHASE 2 OVERBURDEN AND ROCKFILL MATERIAL TEST WORK
SUMMARY OF TRIAXIAL RESULTS

Print Sep-23-24 9:20:32

Sample Source	Soil Sub-Unit	Test Type	Specimen No.	Sample Type	Initial specimen size, diameter (in)	Sample Depth (ft)	Consolidated Void Ratio, e	Atterberg Limtits			Vertical Effective Confining Stress, (kPa)	Effective Confining Cell Pressure, kPa	Critical State Void Ratio, e_{cs}	State [1] Parameter, ψ	Su/σ'_{vo} [2]
								LL	PL	PI					
Rockfill Loose [6]	Older Rockfill	Large-scale Direct Simple Shear	RL-35-2	Remolded	24"	67-462'	0.43	-	-	-	251	-	-	-	0.30
			RL-100-1		24"		0.38				688	-	-	-	0.35
Rockfill Dense [6]	Older Rockfill	Large-scale Direct Simple Shear	RD-35-2	Remolded	24"	67-462'	0.35	-	-	-	245	-	-	-	0.40
			RD-100-1		24"		0.31				693	-	-	-	0.33
Overburden Loose DH18-07 DH18-08	Older Alluvium	Large-scale Direct Simple Shear	OL-25-1	Remolded	24"	17-50'	0.58	NP	NP	NP	160	-	-	-	0.39
			OL-60-2		24"		0.53				417	-	-	-	0.44
			OL-100-1		24"		0.47				694	-	-	-	0.45
DH18-01	Older Alluvium	CU with Pore Pressures	1	Remolded	6"	18-37'	0.45	NP	NP	NP	-	136	0.42	0.03	0.27
			2		6"		0.39				-	689	0.36	0.03	0.39
			3		6"		0.34				-	1378	0.32	0.02	0.34
			4		6"		0.30				-	2756	0.28	0.02	0.45

M:\1\01\00126\24\A\Report\5 - YDTI Stability Assessment Report\Rev 0\Appx B1 - Monotonic Test Results\[Strength Testing Summary_B1_Pt2.xlsm]Table B1.2

NOTES:

1. STATE PARAMETER ESTIMATED FROM BEST FIT POWER LINE.
2. PEAK STRENGTH RATIO ESTIMATED AT PHASE TRANSFORMATION FOR SPECIMENS WHICH EXHIBIT CONTRACTION AND DILATION.
3. SAMPLE RL-35-2 AND RL-100-1 WERE RECONSTITUTED LOOSE AS POSSIBLE.
4. SAMPLE RD-35-2 AND RD-100-1 WERE RECONSTITUTED TO 90% PROCTOR COMPACTION.
5. OLDER ALLUVIUM SAMPLES RECONSTITUTED LOOSE AS POSSIBLE.
6. ROCKFILL SAMPLES SOURCED FROM DRILLHOLES; DH19-S7, DH17-2, DH20-S1, DH15-S5.

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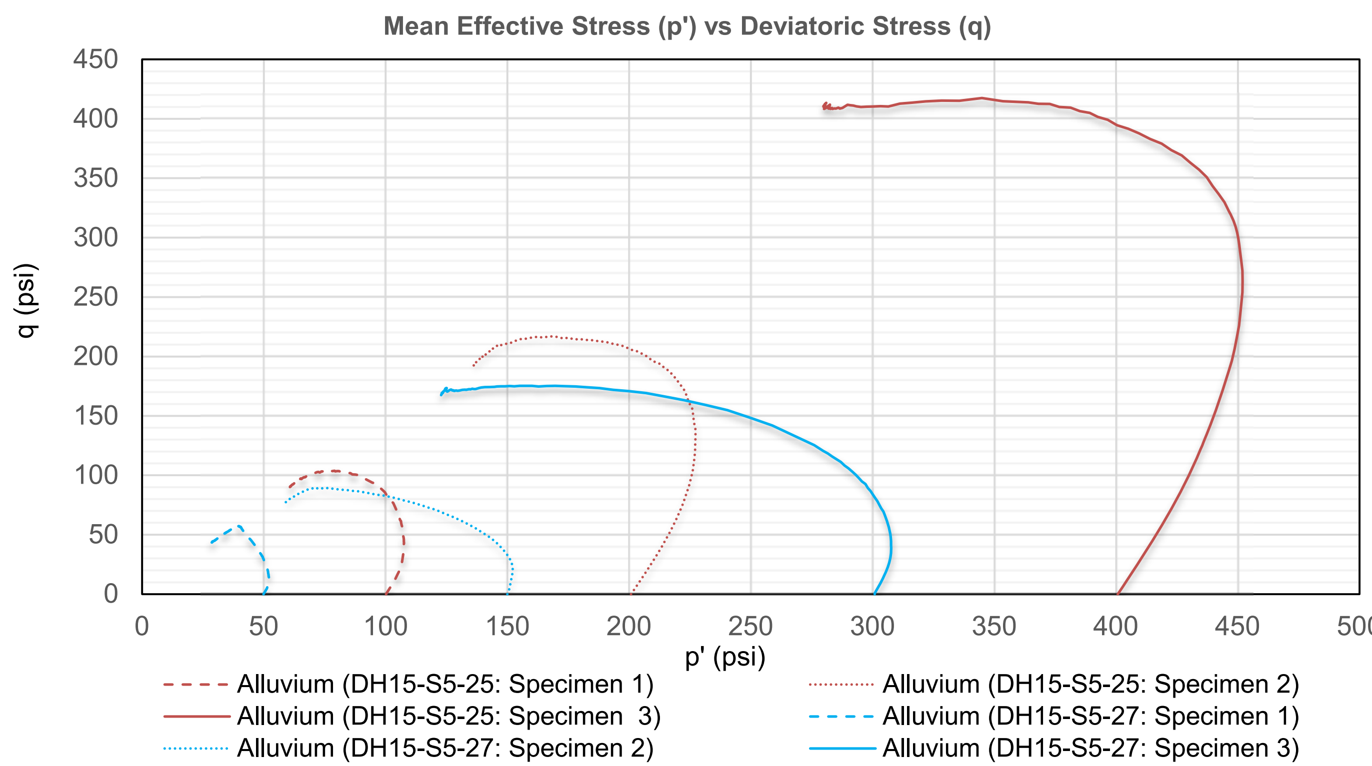

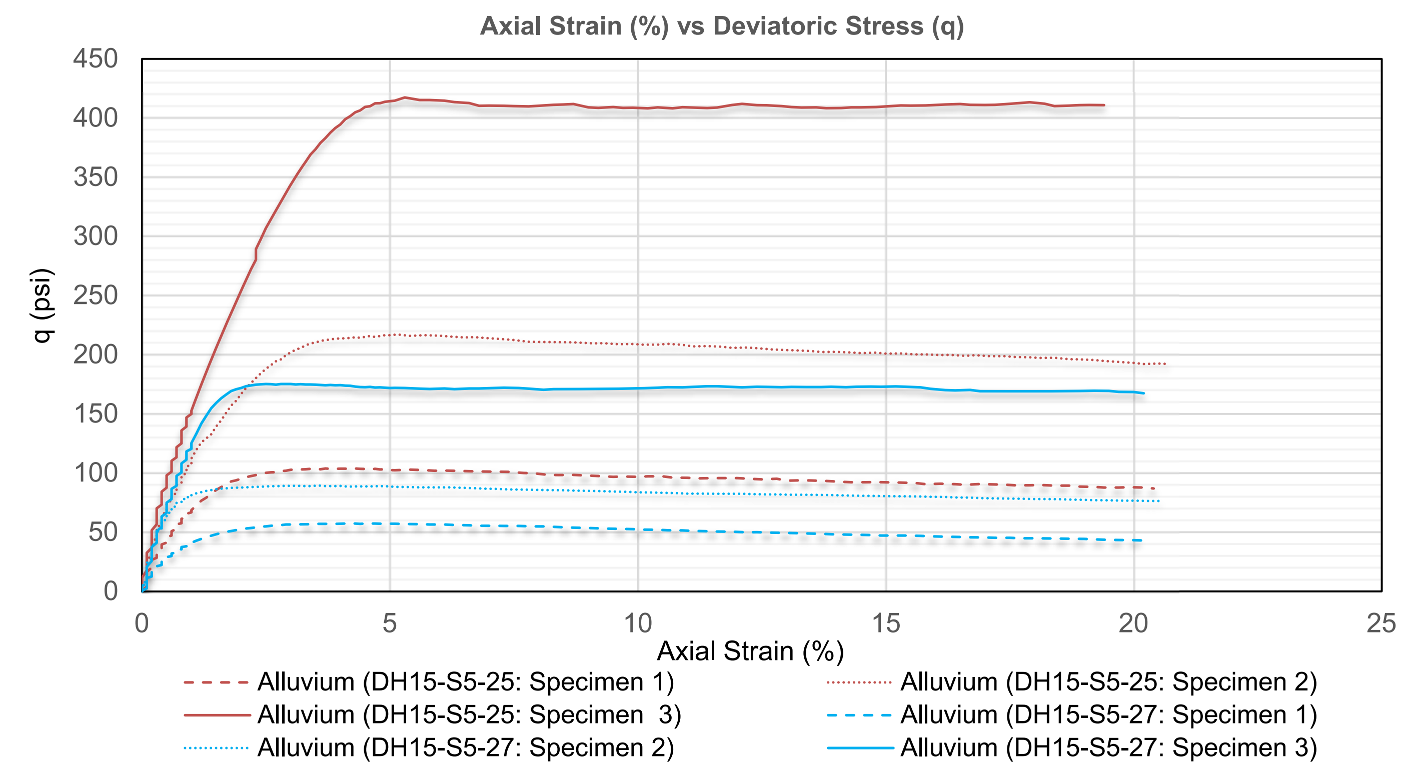

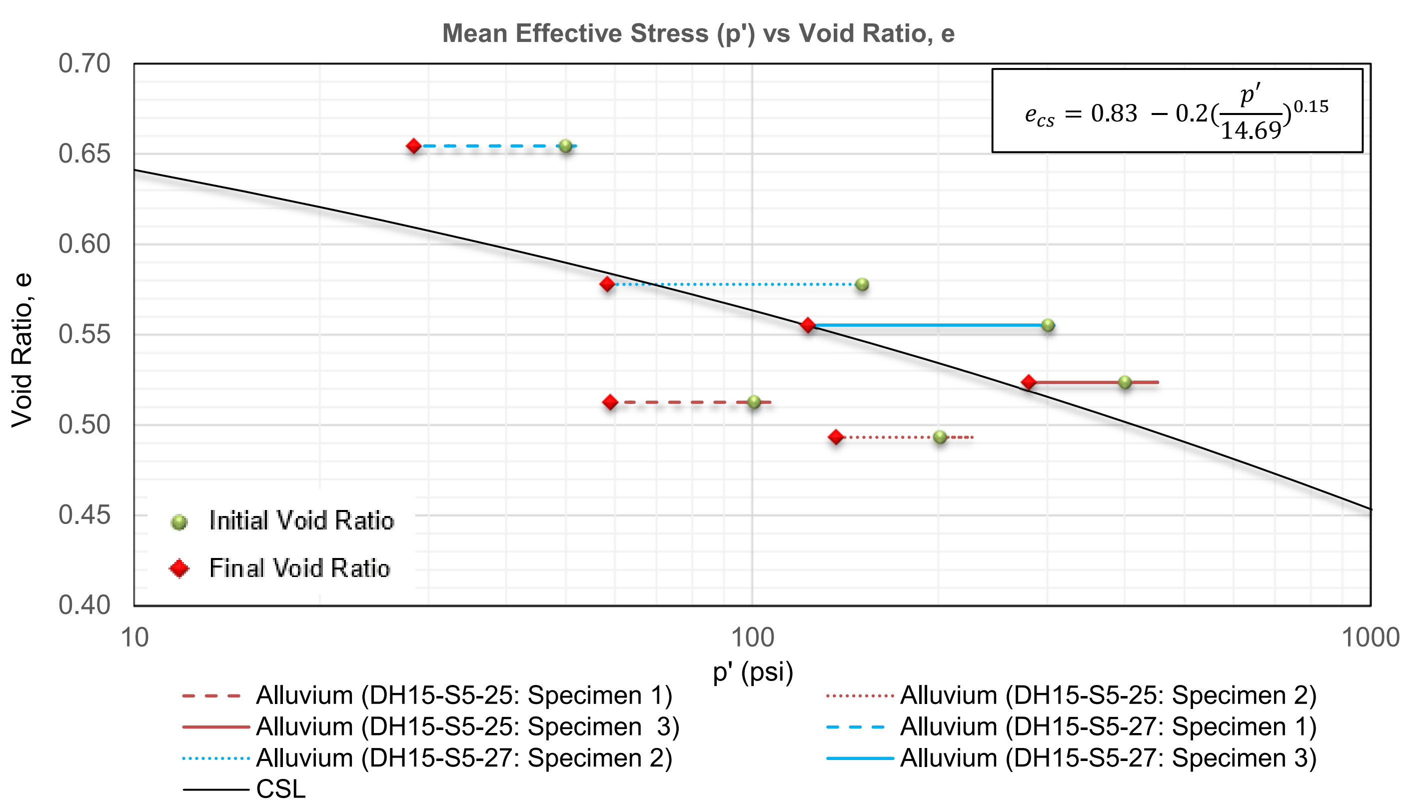

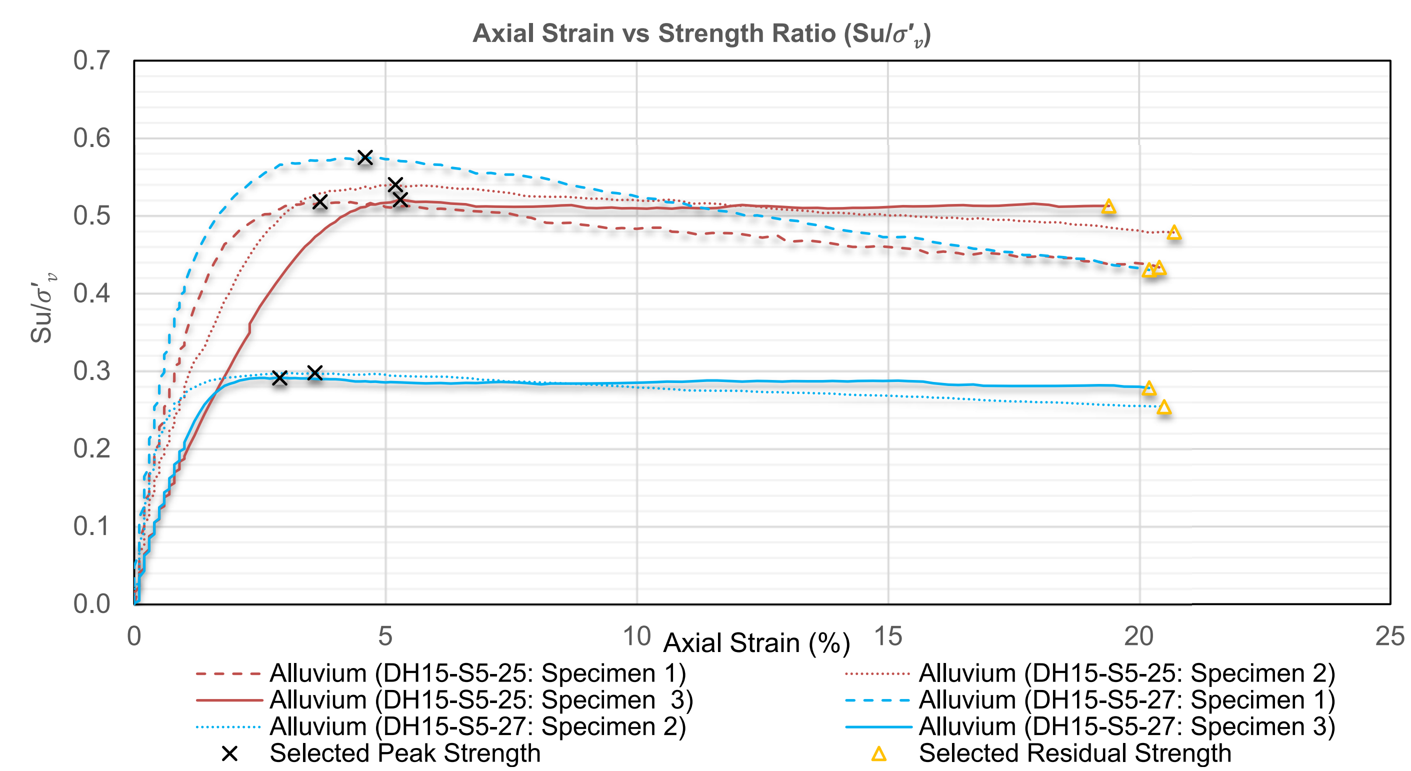

NOTES:

1. SAMPLES WERE RECONSTITUTED TO REPRESENT IN-SITU CONDITIONS (~100 pcf).
2. CRITICAL STATE LINE ESTIMATED USING A POWER FUNCTION (Li & Wang, 1998).

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CONSOLIDATED UNDRAINED TRIAXIAL OVERBURDEN SOILS

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P/A NO. VA101-00126/24

REF. NO. 5

FIGURE B1.1

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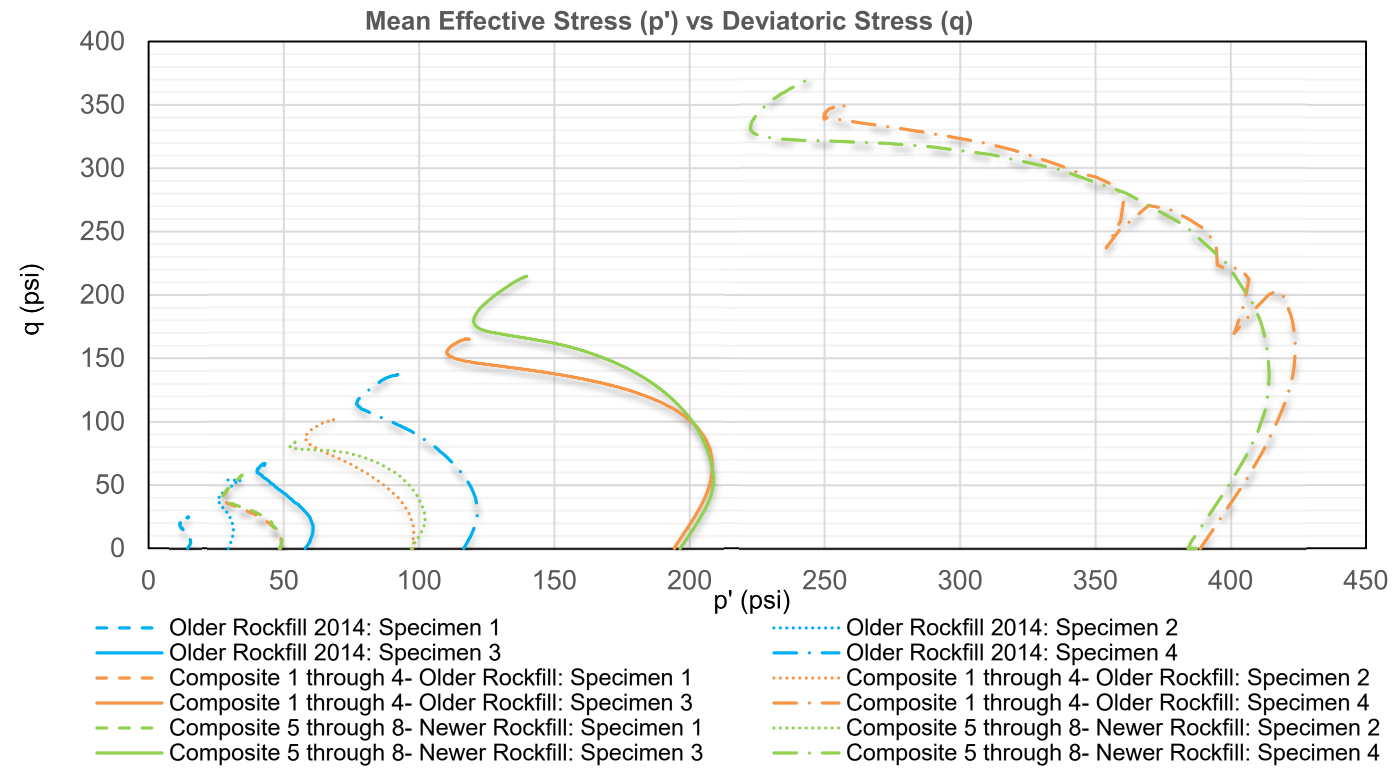

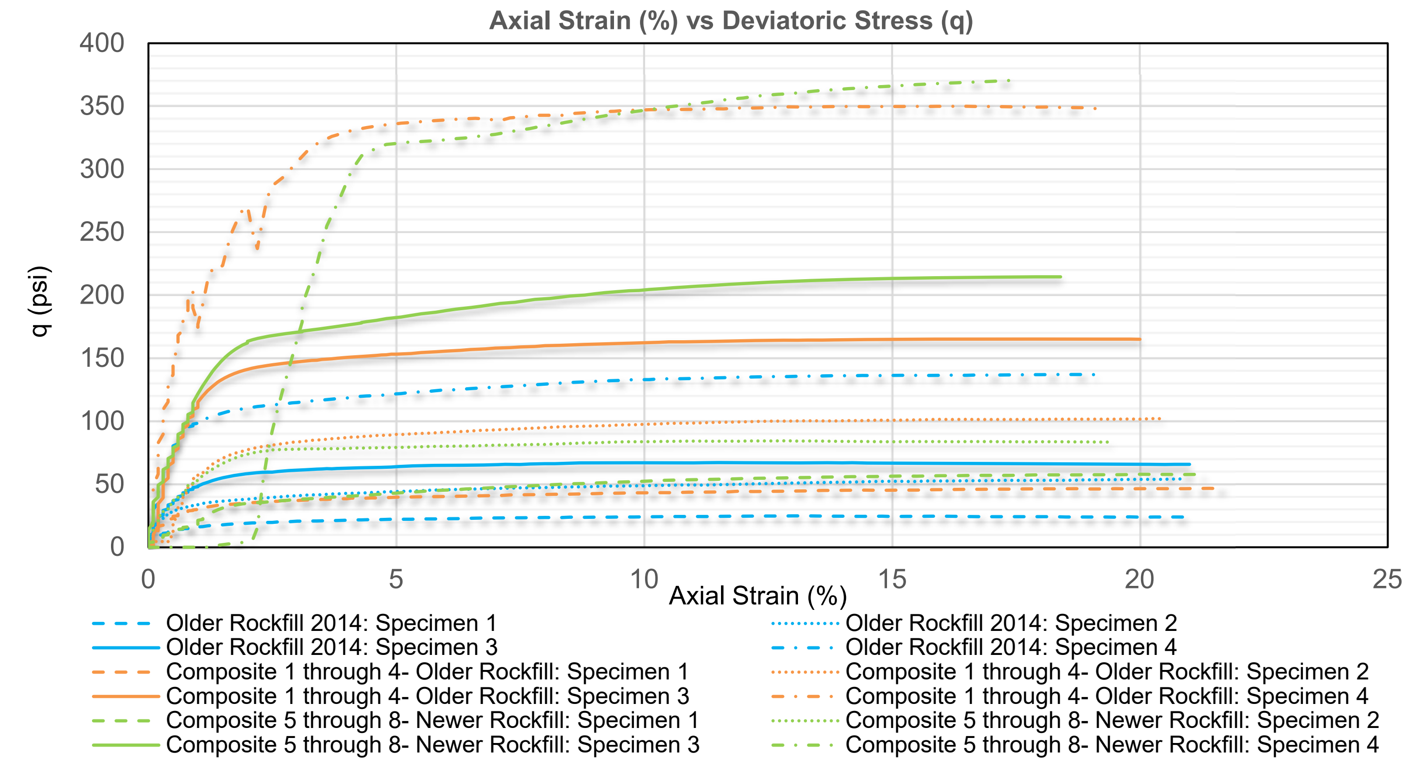

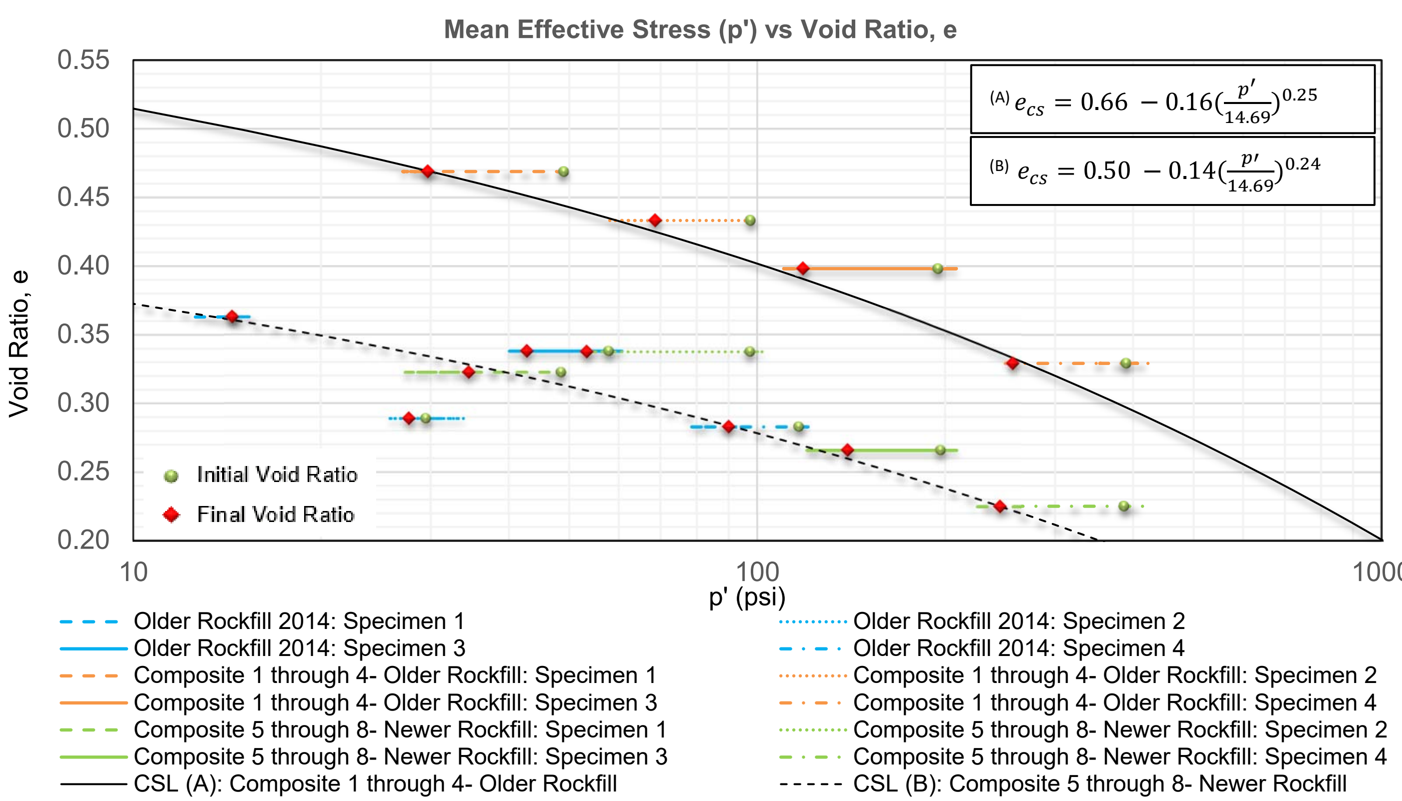

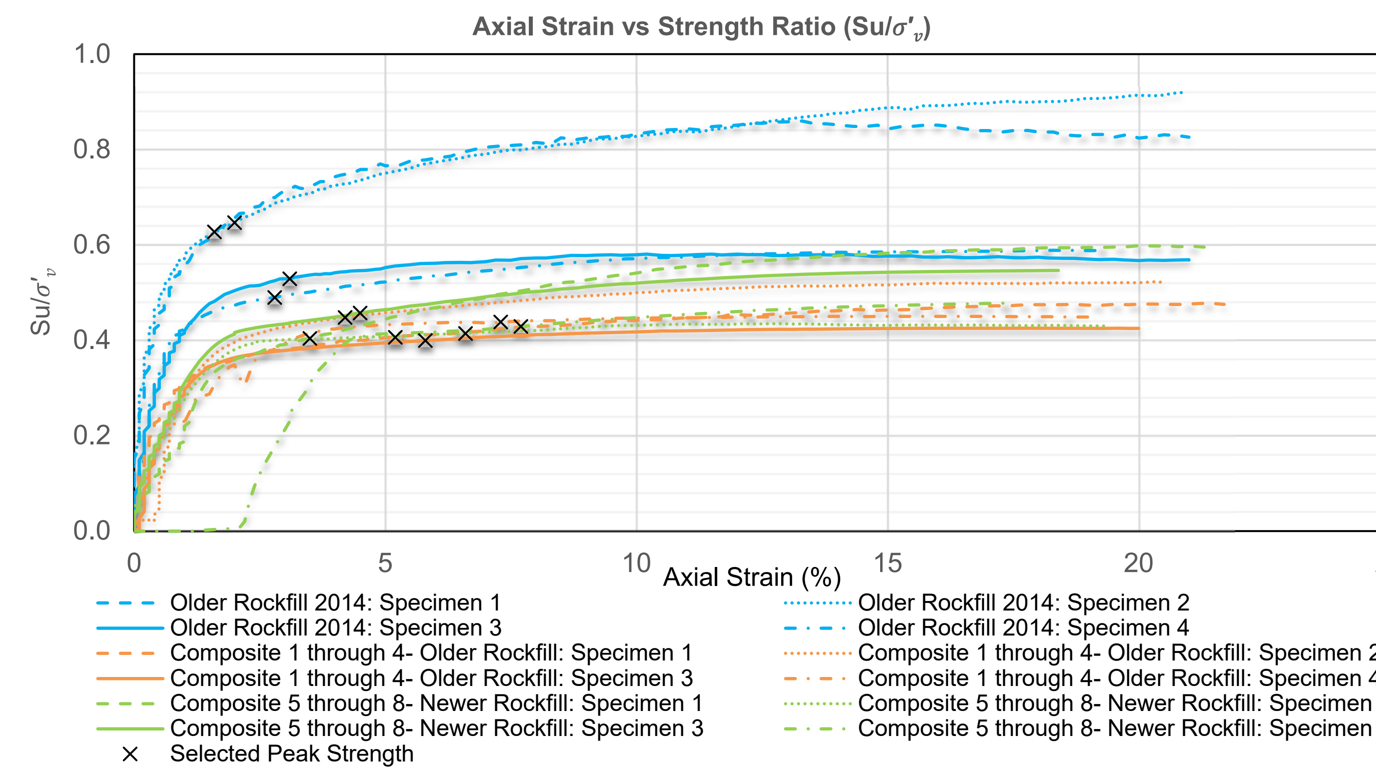

NOTES:

1. OLDER ROCKFILL 2014 SAMPLES WERE COMPACTED TO 90% PROCTOR.
2. COMPOSITE 1 THROUGH 4 AND 5 THROUGH 8 RECONSTITUTED LOOSE AS POSSIBLE.
3. CRITICAL STATE LINE ESTIMATED USING A POWER FUNCTION (Li & Wang, 1998).

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CONSOLIDATED UNDRAINED TRIAXIAL EMBANKMENT ROCKFILL

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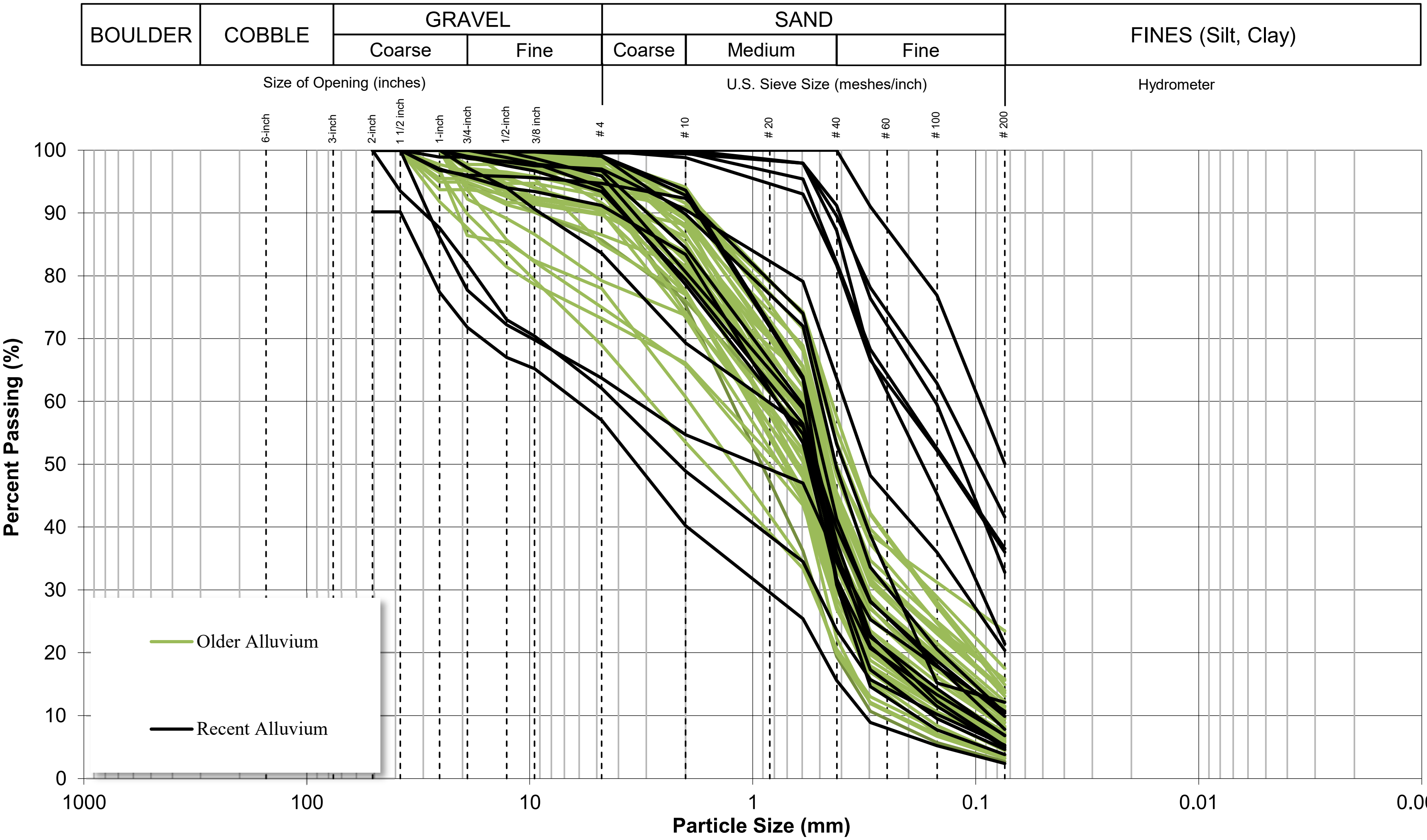
FIGURE B1.2 | REV 0



NOTES:
1. GRAIN-SIZE DATA SHOWN ARE FROM SAMPLES COLLECTED FROM THE 2018 HsB SITE INVESTIGATION PROGRAM.

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2018 HsB SI OVERBURDEN SAMPLES
GRAIN-SIZE DISTRIBUTION (OVERBURDEN MATERIAL)

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P/A NO. VA101-00126/24 | REF. NO. 5

FIGURE B1.3 REV 0

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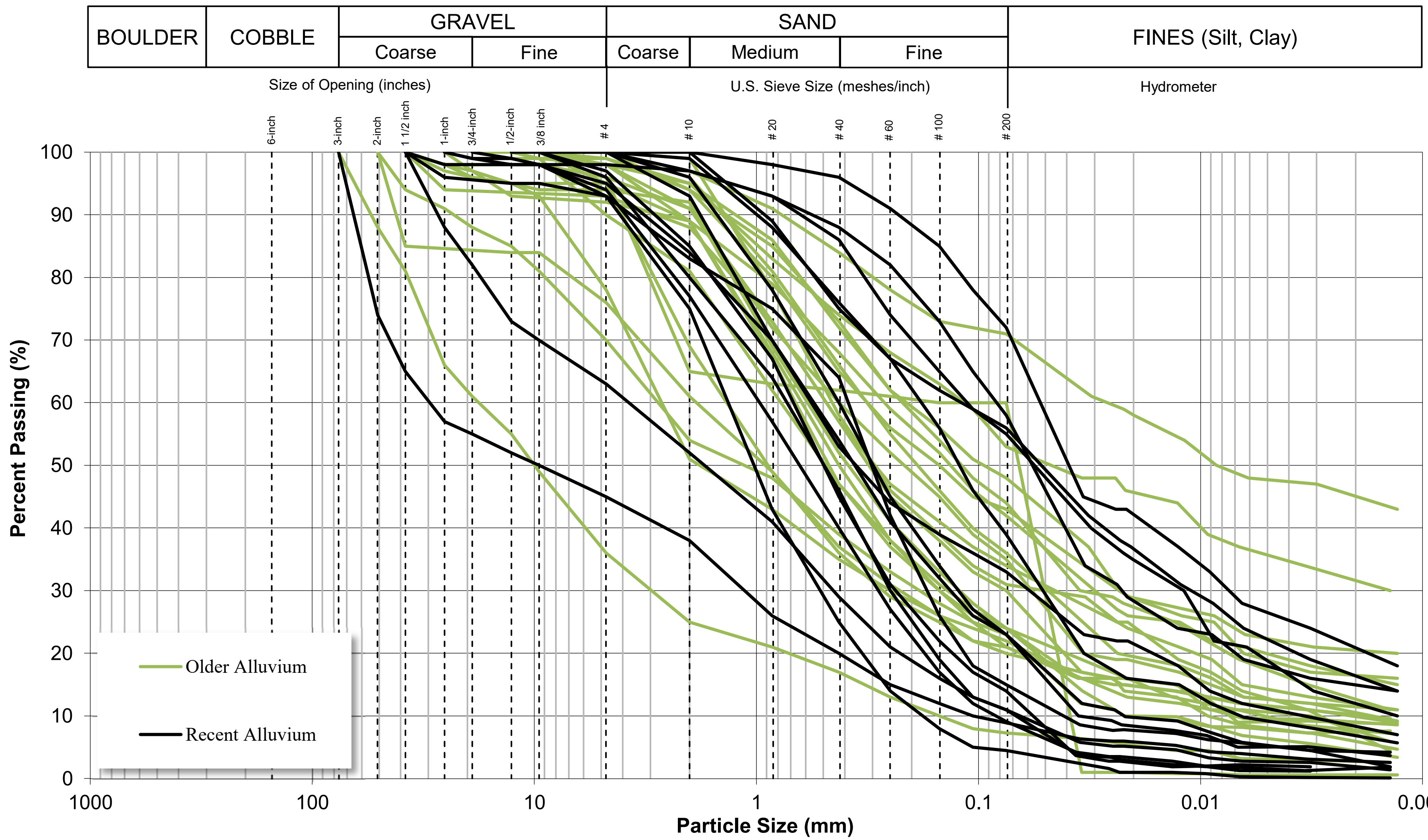

NOTES:
1. GRAIN-SIZE DATA SHOWN ARE FROM SAMPLES COLLECTED FROM THE 2019 HsB SITE INVESTIGATION PROGRAM.

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2019 HsB SI OVERBURDEN SAMPLES
GRAIN-SIZE DISTRIBUTION (OVERBURDEN MATERIAL)

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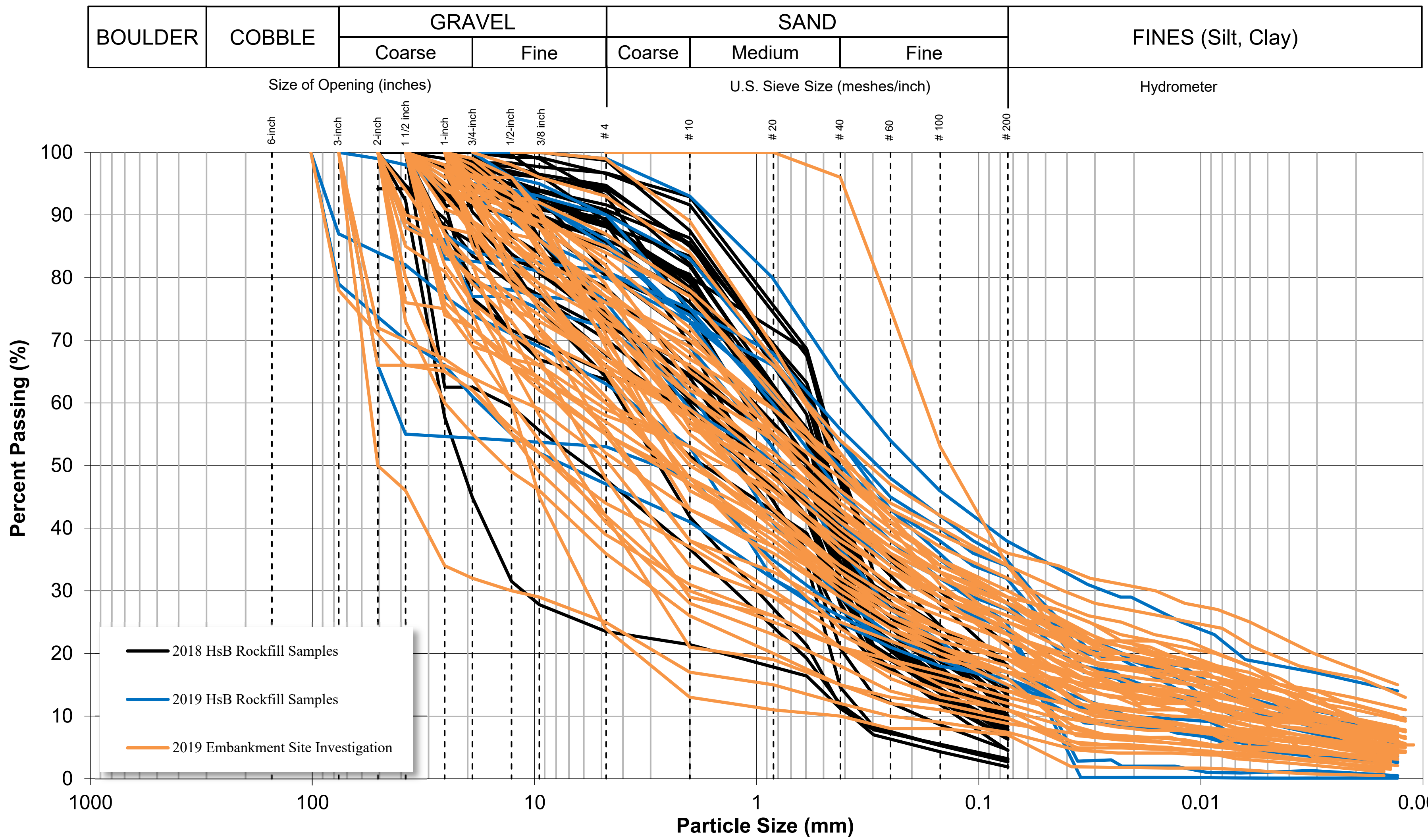
P/A NO.	REF. NO.
VA101-00126/24	5

FIGURE B1.4 REV 0

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY



NOTES:

1.GRAIN-SIZE DATA SHOWN ARE FROM SAMPLES COLLECTED FROM THE 2018 and 2019 HsB SITE INVESTIGATION PROGRAM, AND THE 2019 EMBANKMENT SITE INVESTIGATION.

0	19SEP'24	ISSUED WITH REPORT	SVW	SY
REV	DATE	DESCRIPTION	PREP'D	RVW'D

MONTANA RESOURCES, LLC

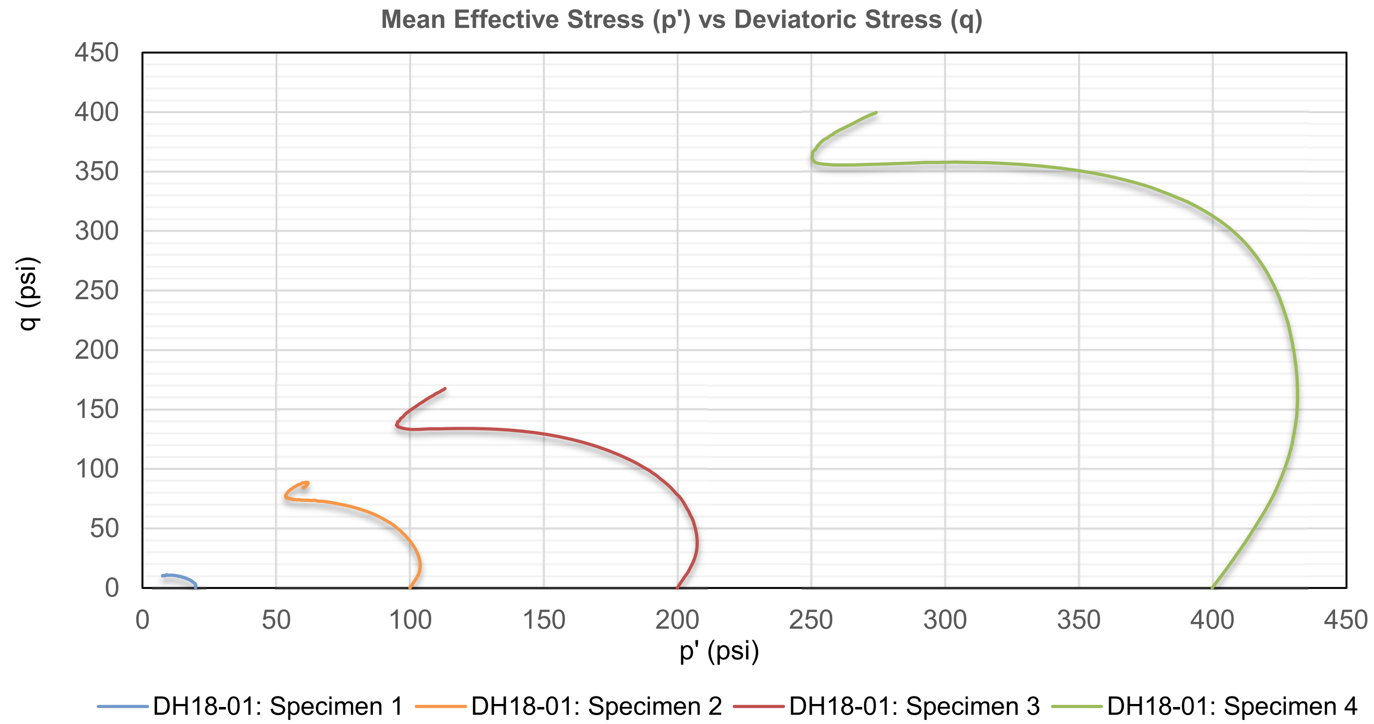
MONTANA RESOURCES

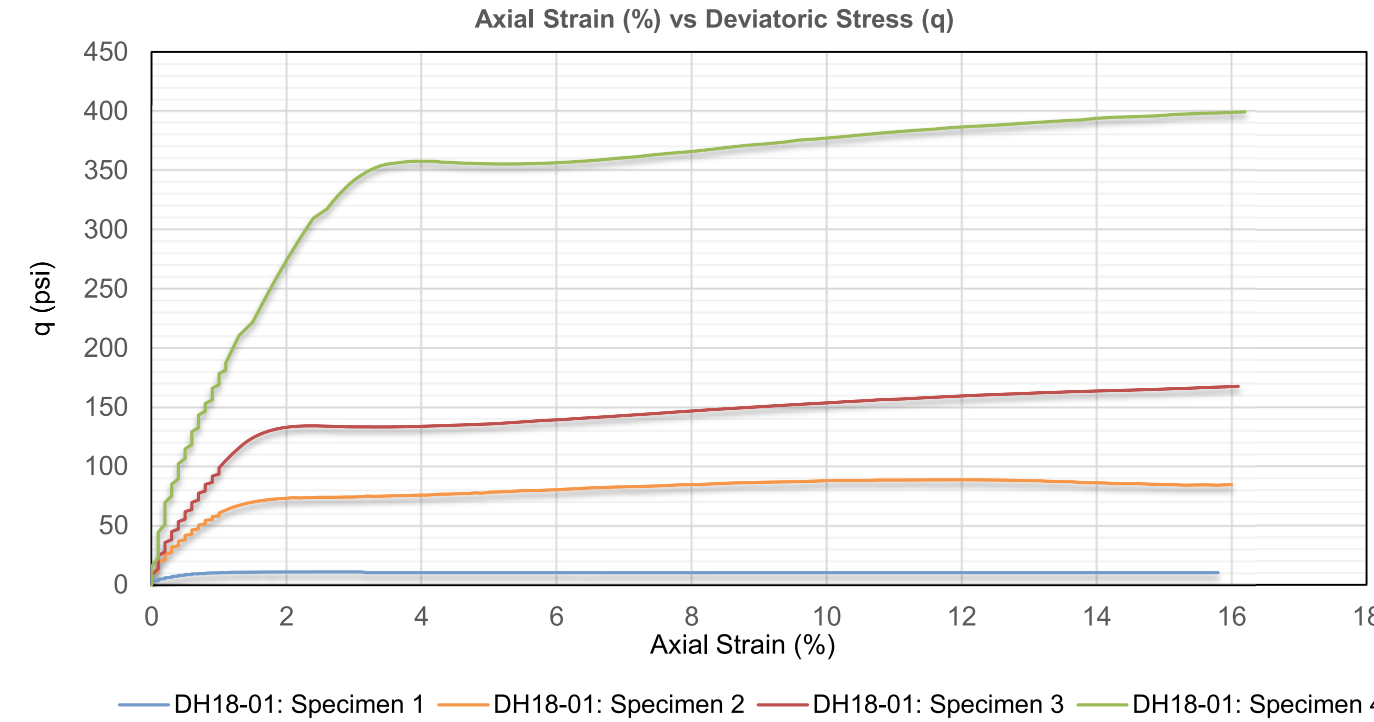
2018 & 2019 ROCKFILL SAMPLES
GRAIN-SIZE DISTRIBUTION (ROCKFILL MATERIAL)

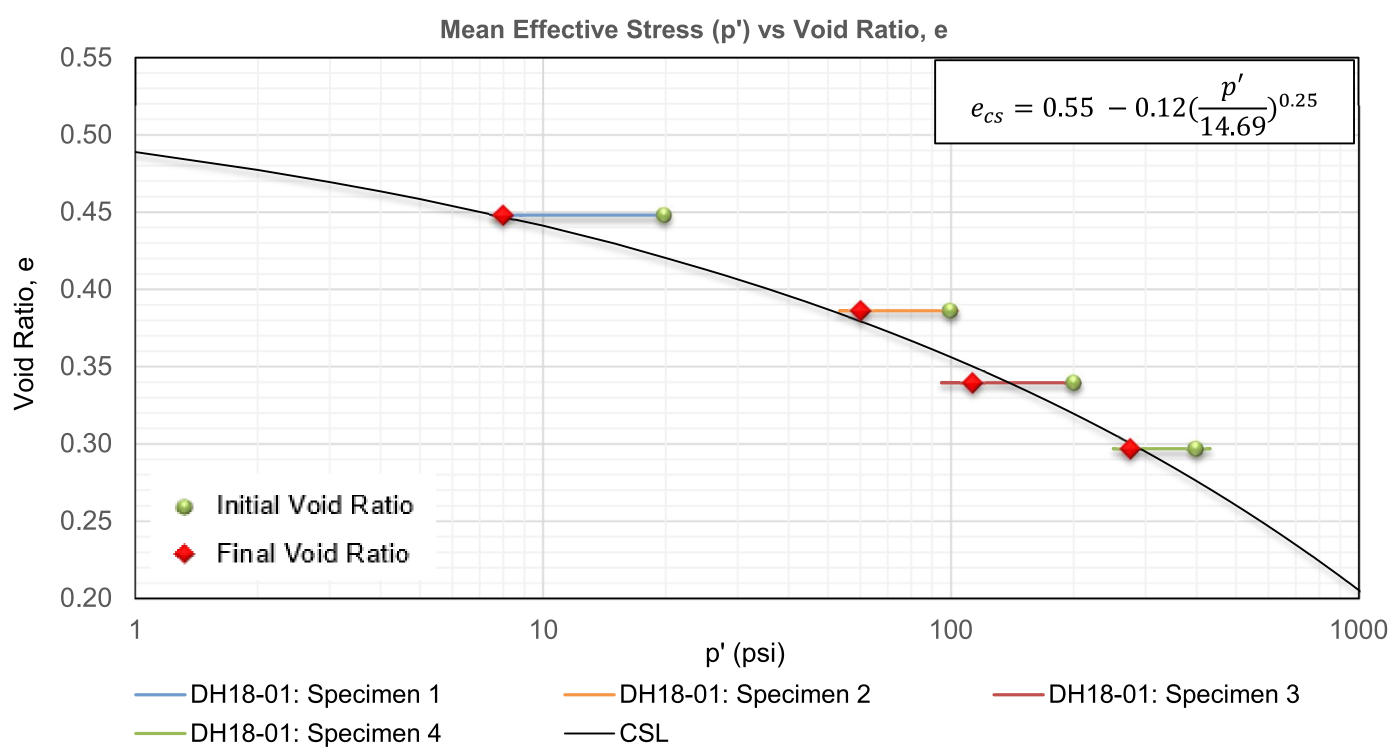
Knight Piésold CONSULTING

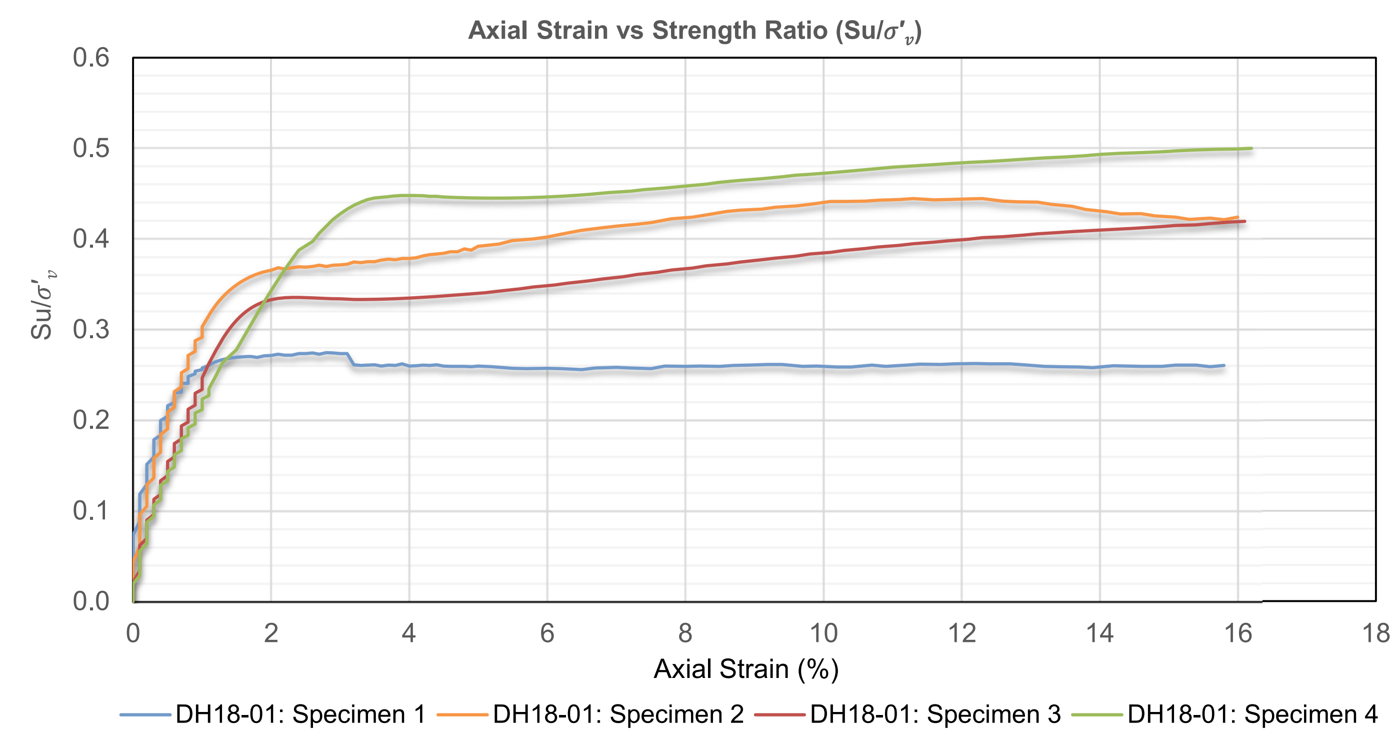
P/A NO. VA101-00126/24 | REF. NO. 5

FIGURE B1.5 | REV 0









NOTES:

1. GRAB SAMPLES WERE COLLECTED FROM AVAILABLE SONIC DRILL CORES FROM 2015 THROUGH 2020 DRILLING PROGRAMS.
2. SAMPLES WERE RECONSTITUTED LOOSE AS POSSIBLE.
3. CRITICAL STATE LINE ESTIMATED USING A POWER FUNCTION (Li & Wang, 1998).

MONTANA RESOURCES, LLC

MONTANA RESOURCES

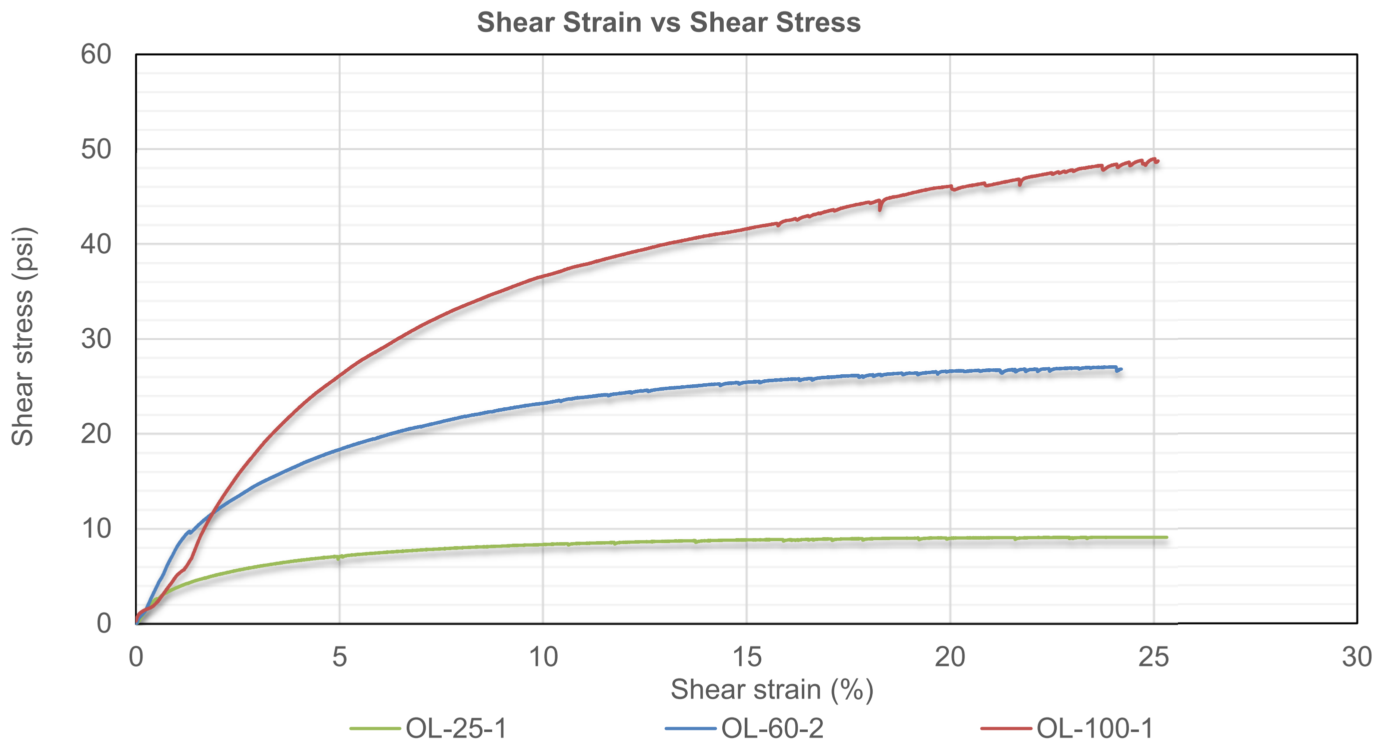
CONSOLIDATED UNDRAINED TRIAXIAL OVERBURDEN SOILS

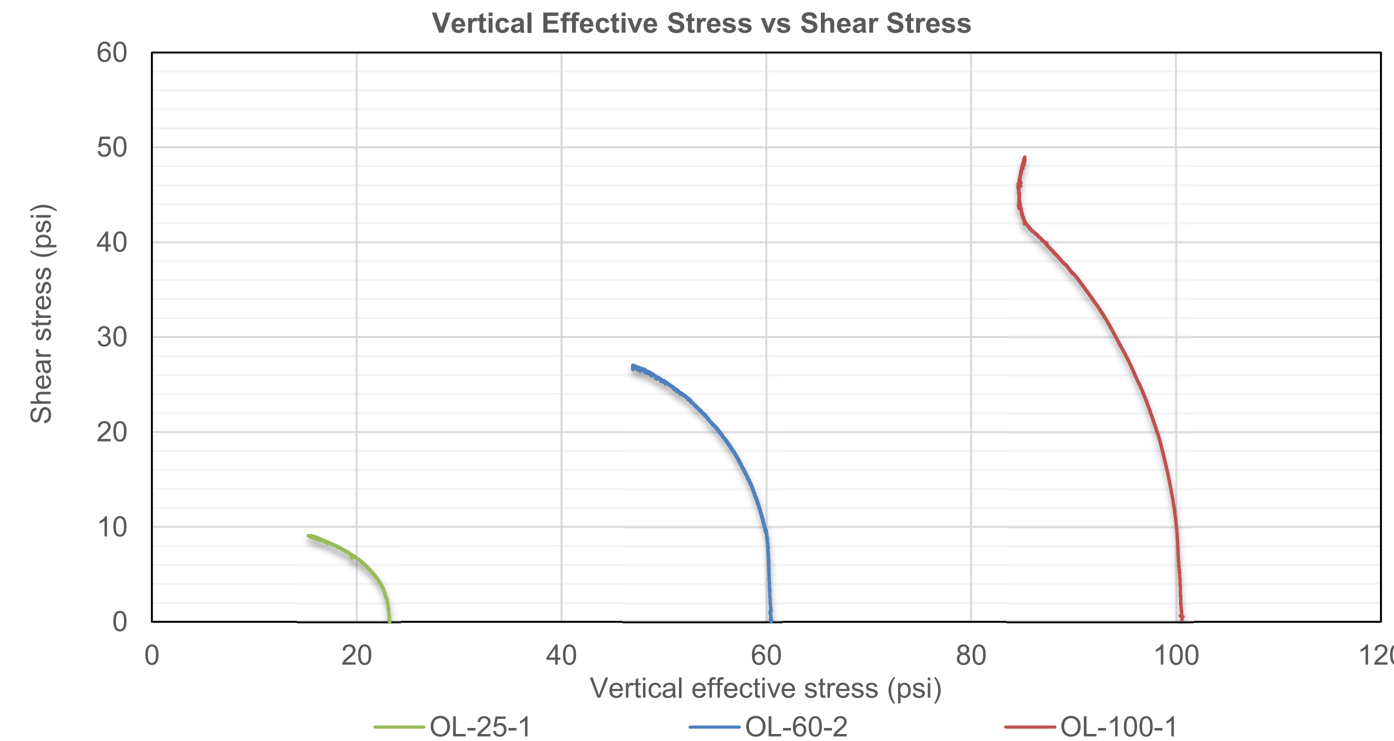
Knight Piésold CONSULTING

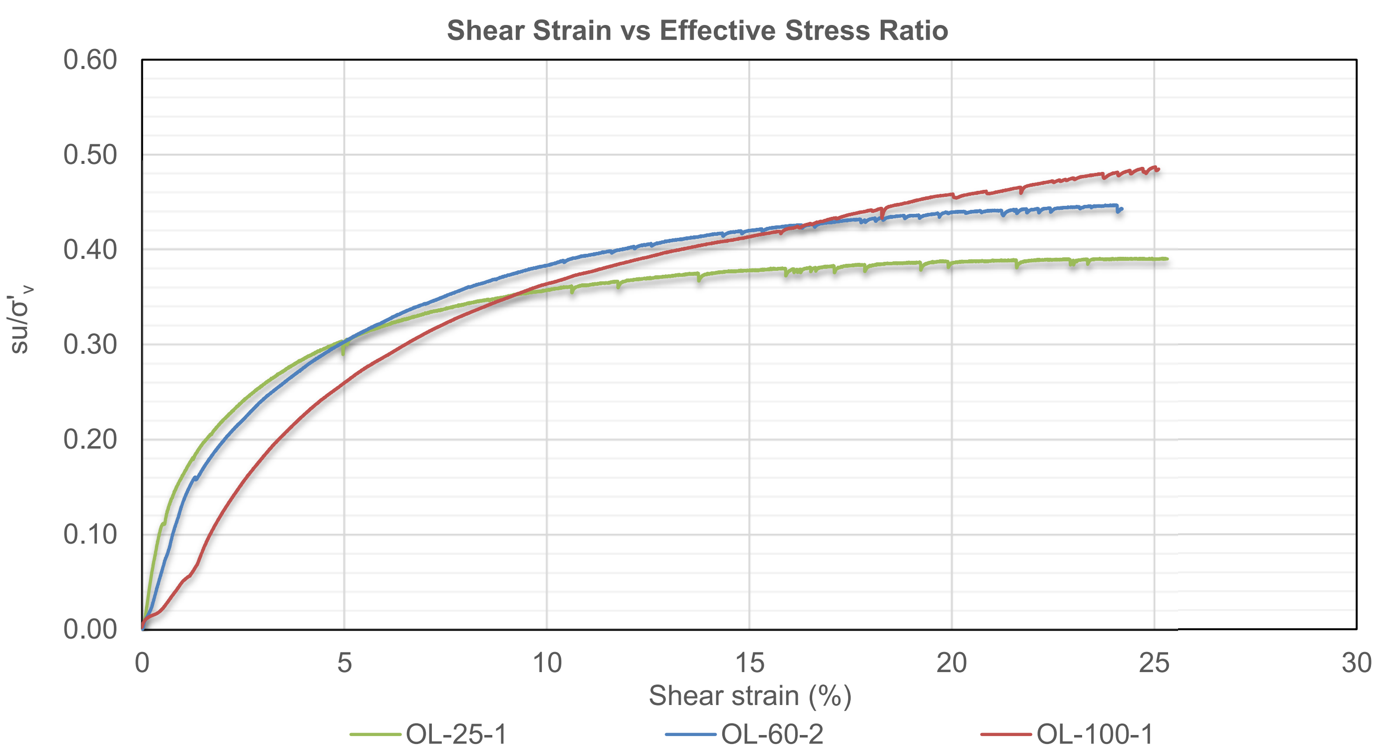
P/A NO. VA101-00126/24 | REF. NO. 5

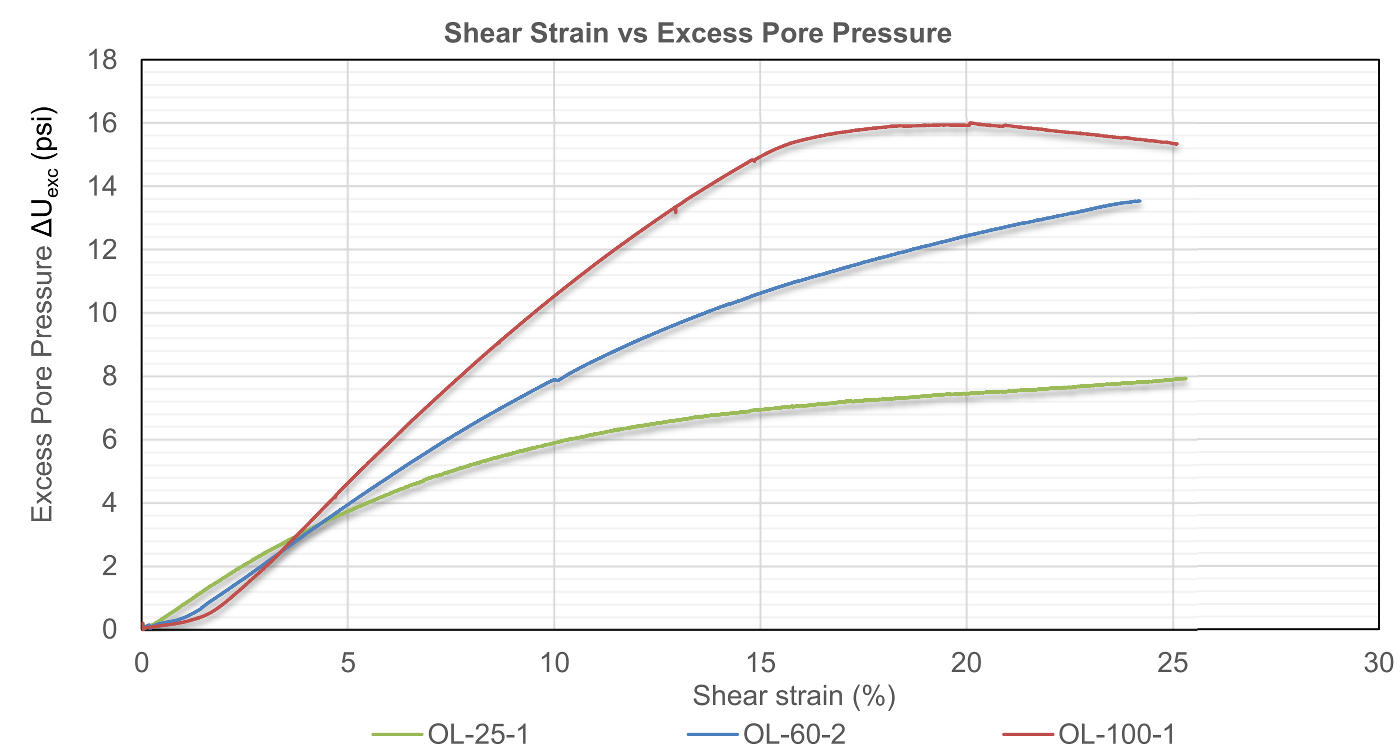
FIGURE B1.6 | REV 0

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY









NOTES:

1. GRAB SAMPLES WERE COLLECTED FROM AVAILABLE SONIC DRILL CORES FROM 2015 THROUGH 2020 DRILLING PROGRAMS.
2. SAMPLES WERE RECONSTITUTED LOOSE AS POSSIBLE.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

MONTANA RESOURCES, LLC

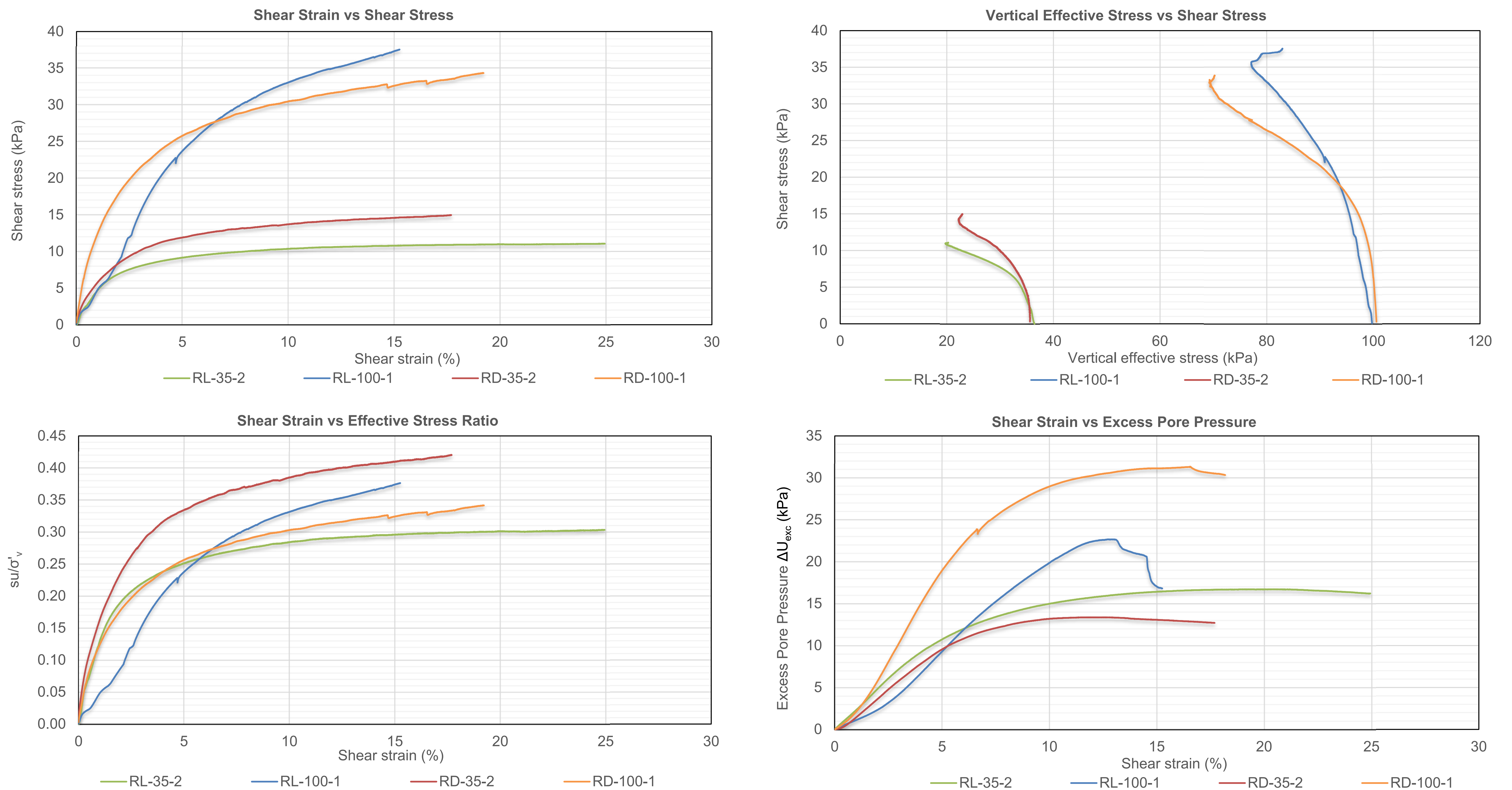
MONTANA RESOURCES

DIRECT SIMPLE SHEAR TEST OVERBURDEN SOILS

Knight Piésold CONSULTING

P/A NO. VA101-00126/24 | REF. NO. 5

FIGURE B1.7 REV 0



NOTES:

1. GRAB SAMPLES WERE COLLECTED FROM AVAILABLE SONIC DRILL CORES FROM 2015 THROUGH 2020 DRILLING PROGRAMS.
2. SAMPLE RL-35-2 AND RL-100-1 WERE RECONSTITUTED LOOSE AS POSSIBLE.
3. SAMPLE RD-35-2 AND RD-100-1 WERE RECONSTITUTED TO 90% PROCTOR COMPACTION.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

DIRECT SIMPLE SHEAR TEST
ROCKFILL MATERIAL

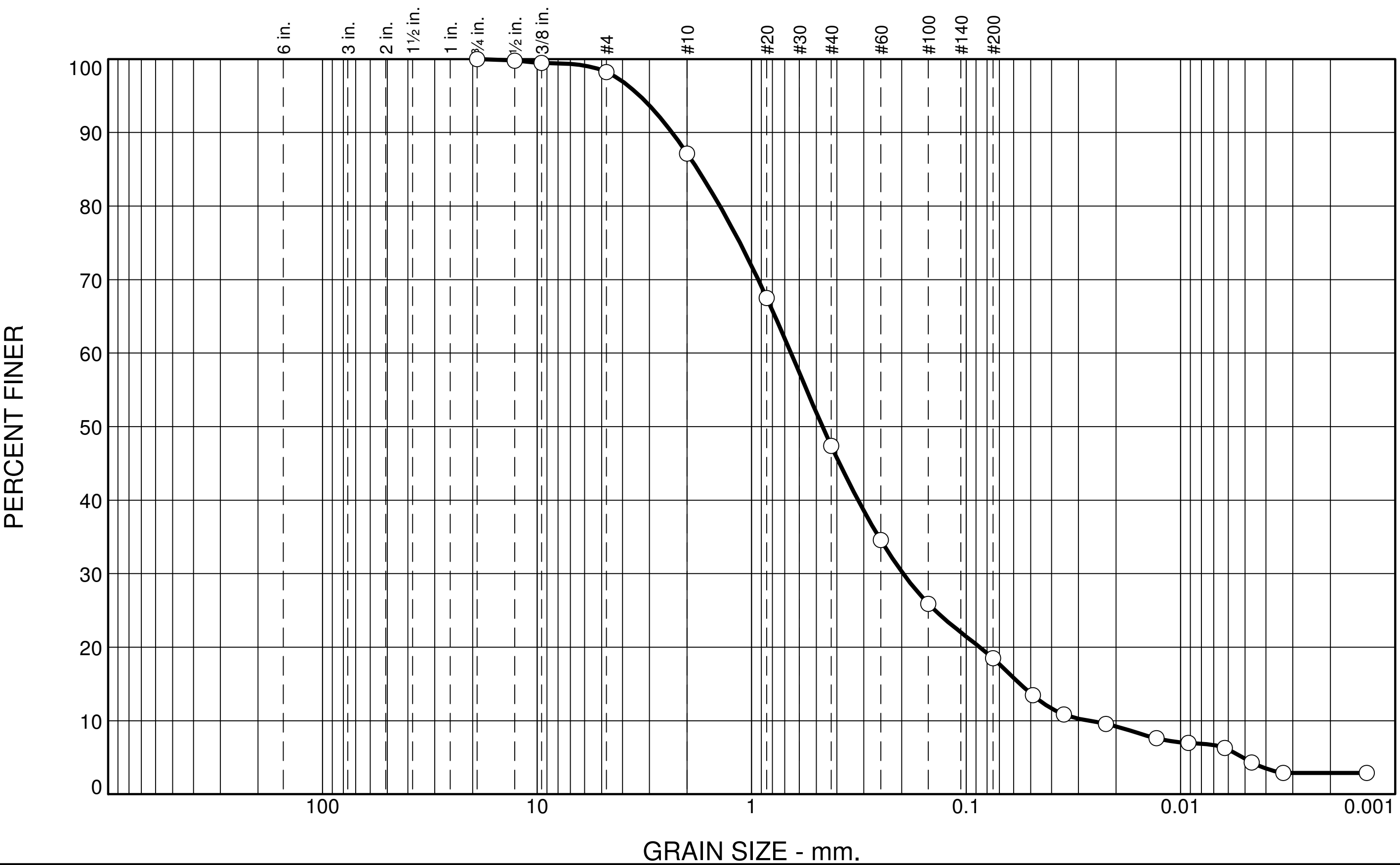
Knight Piésold CONSULTING

P/A NO. VA101-00126/24 | REF. NO. 5

FIGURE B1.8 | REV 0

PHASE 1 LABORATORY TESTING SHEETS

Particle Size Distribution Report ASTM D422



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	1.8	11.1	39.7	28.9	15.6	2.9

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75	100.0		
.5	99.8		
.375	99.5		
#4	98.2		
#10	87.1		
#20	67.5		
#40	47.4		
#60	34.6		
#100	25.9		
#200	18.5		
0.0489 mm.	13.5		
0.0350 mm.	10.9		
0.0223 mm.	9.6		
0.0130 mm.	7.6		
0.0092 mm.	7.0		
0.0062 mm.	6.3		
0.0047 mm.	4.3		
0.0033 mm.	2.9		
0.0014 mm.	2.9		

* (no specification provided)

Soil Description

silty sand

Atterberg Limits

PL= NP LL= NP PI= NP

Coefficients

D_{90}= 2.3513 D_{85}= 1.7866 D_{60}= 0.6556
D_{50}= 0.4663 D_{30}= 0.1963 D_{15}= 0.0561
D_{10}= 0.0268 C_u= 24.47 C_c= 2.19

Classification

USCS= SM AASHTO= A-1-b

Remarks

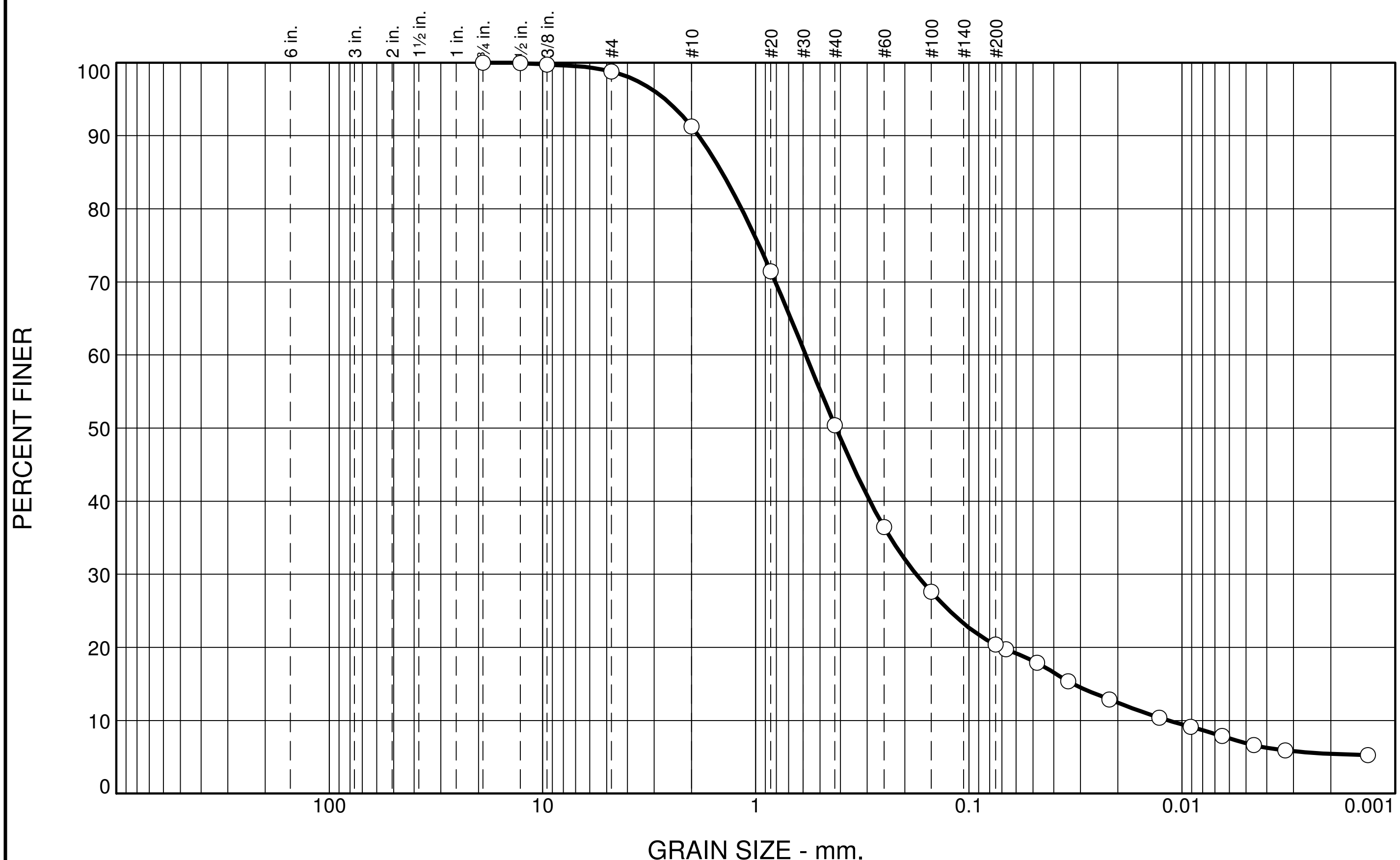
Sample No.: 25 **Source of Sample:** **Date:** 2/12/16
Location: DH15-S5 **Elev./Depth:** 718-719'

Knight Piésold CONSULTING

Client:
Project: Yankee Doodle Impoundment Dam Site Investigation
Project No: 10100126.14 **Figure**

Tested By: JDH **Checked By:** JDB

Particle Size Distribution Report ASTM D422



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	1.2	7.6	40.8	30.0	15.0	5.4

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75	100.0		
.5	99.9		
.375	99.7		
#4	98.8		
#10	91.2		
#20	71.4		
#40	50.4		
#60	36.5		
#100	27.6		
#200	20.4		
0.0670 mm.	19.7		
0.0478 mm.	17.9		
0.0342 mm.	15.4		
0.0219 mm.	12.9		
0.0128 mm.	10.4		
0.0091 mm.	9.1		
0.0065 mm.	7.9		
0.0046 mm.	6.6		
0.0033 mm.	5.9		
0.0013 mm.	5.3		

* (no specification provided)

Soil Description

silty sand

Atterberg Limits

PL= NP LL= NP PI= NP

Coefficients

D_{90}= 1.8558 D_{85}= 1.4401 D_{60}= 0.5825
D_{50}= 0.4193 D_{30}= 0.1763 D_{15}= 0.0323
D_{10}= 0.0115 C_u= 50.46 C_c= 4.63

Classification

USCS= SM AASHTO= A-1-b

Remarks

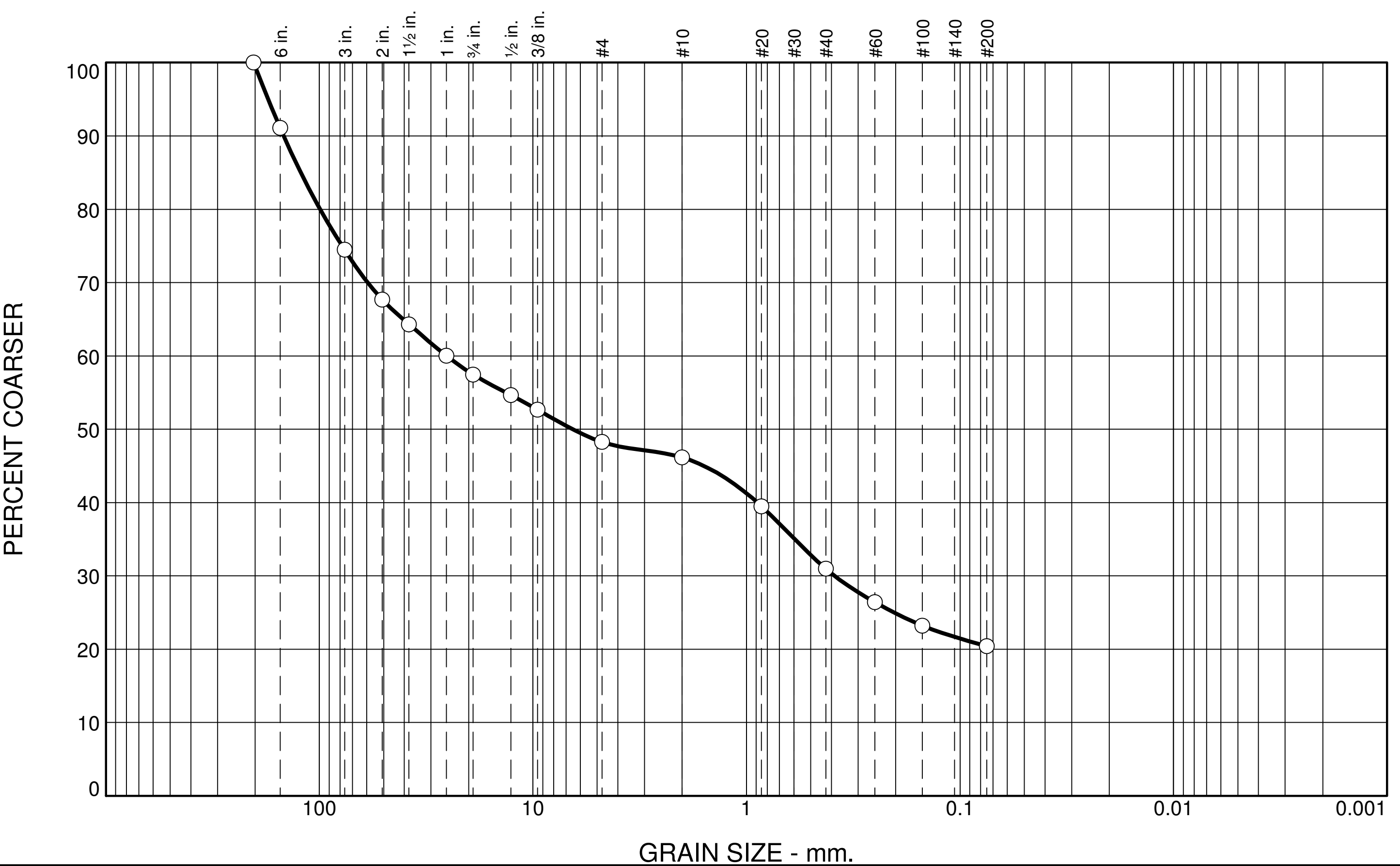
Sample No.: 27 **Source of Sample:** **Date:** 1/27/16
Location: DH15-S5 **Elev./Depth:** 720-721

Knight Piésold CONSULTING

Client:
Project: Yankee Doodle Impoundment Dam Site Investigation
Project No: 10100126.14 **Figure**

Tested By: JDH **Checked By:** JDB

Particle Size Distribution Report



The USCS classification pertains only to the portion of sample that passes the 3" sieve as per ASTM D2487.

% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
25.5	17.0	9.2	2.2	15.1	10.6	20.4	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
8	100.0		
6	91.1		
3	74.5		
2	67.7		
1.5	64.3		
1	60.0		
.75	57.5		
.5	54.6		
.375	52.7		
#4	48.3		
#10	46.1		
#20	39.5		
#40	31.0		
#60	26.4		
#100	23.2		
#200	20.4		

* (no specification provided)

Soil Description

clayey SAND with gravel

Atterberg Limits

PL= 19 LL= 30 PI= 11

Coefficients

D_{90}= 146.8094 D_{85}= 122.0767 D_{60}= 25.3450
D_{50}= 6.5164 D_{30}= 0.3867 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SC AASHTO= A-2-6(0)

Remarks

As Received

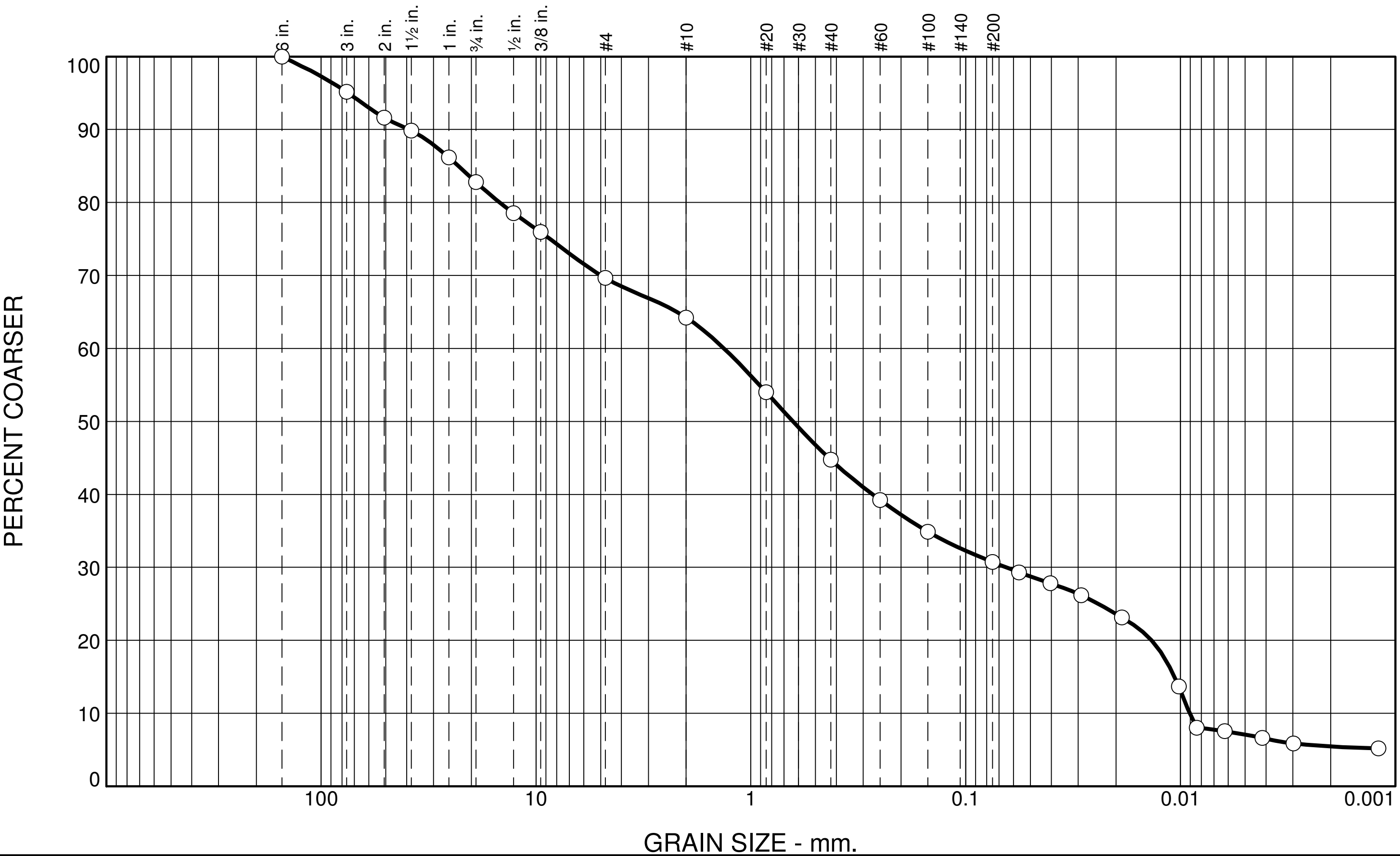
Sample No.: TP14-01-04 Comp. **Source of Sample:** TP14 **Date:** 7/16/2014
Location: TP14-01, TP14-02, TP14-03, TP14-04 **Elev./Depth:** 6'-11'

Knight Piésold CONSULTING

Client: KP Vancouver
Project: Yankee Doodle Dam
Project No: VA101-126/08 **Figure**

Tested By: DAB **Checked By:** DAB

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
4.9	12.3	13.2	5.4	19.5	14.0	25.2	5.5

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
6	100.0		
3	95.1		
2	91.6		
1.5	89.8		
1	86.2		
.75	82.8		
.5	78.6		
.375	75.9		
#4	69.6		
#10	64.2		
#20	54.0		
#40	44.7		
#60	39.2		
#100	34.9		
#200	30.7		
0.0565 mm.	29.3		
0.0404 mm.	27.8		
0.0290 mm.	26.2		
0.0187 mm.	23.1		
0.0102 mm.	13.7		
0.0084 mm.	8.0		
0.0062 mm.	7.5		
0.0042 mm.	6.6		
0.0030 mm.	5.9		
0.0012 mm.	5.2		

* (no specification provided)

Soil Description

clayey SAND with gravel

Atterberg Limits

PL= 21 LL= 38 PI= 17

Coefficients

D_{90}= 39.0195 D_{85}= 22.9616 D_{60}= 1.3336
D_{50}= 0.6372 D_{30}= 0.0650 D_{15}= 0.0107
D_{10}= 0.0091 C_u= 146.70 C_c= 0.35

Classification

USCS= SC AASHTO= A-2-6(1)

Remarks

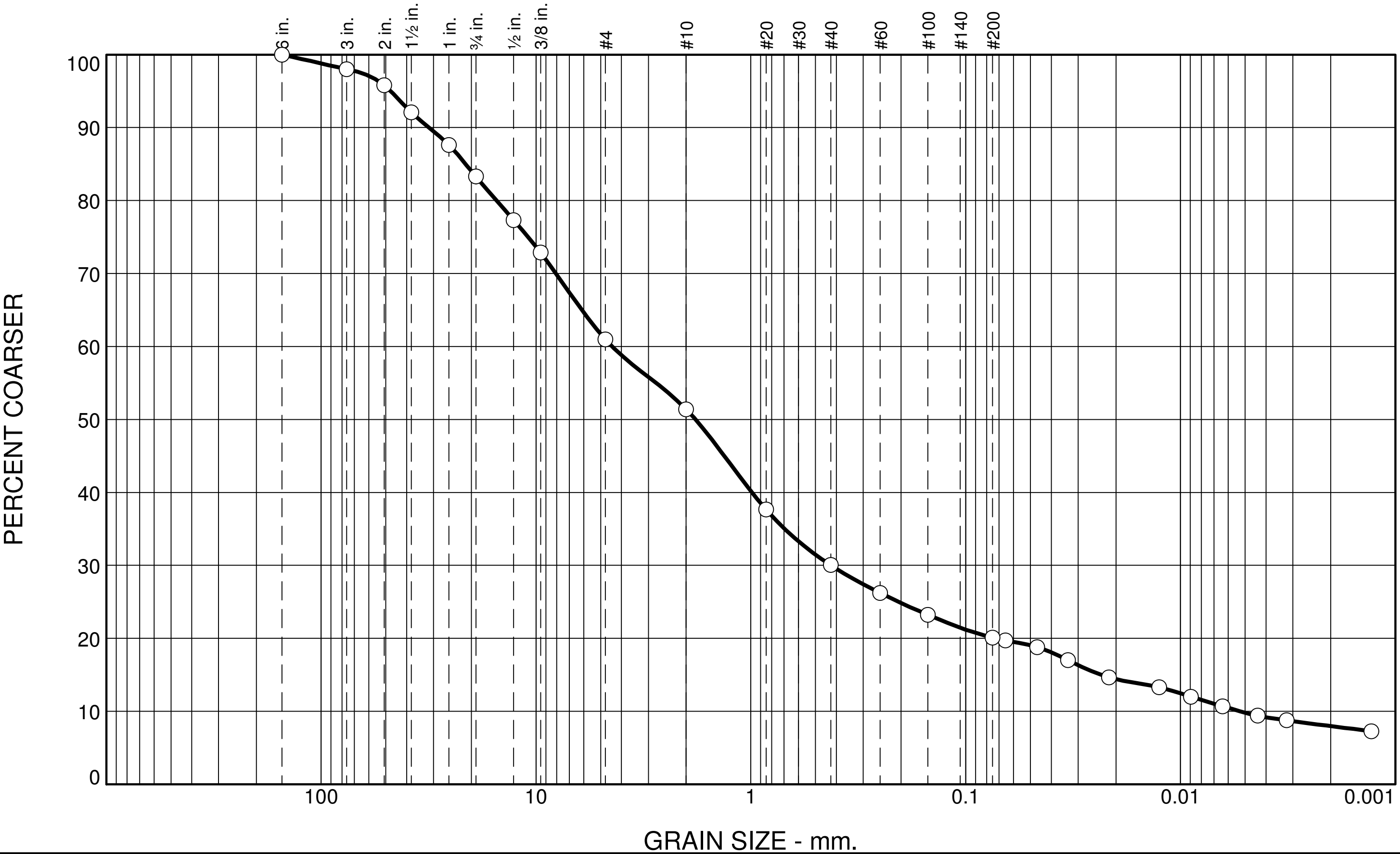
Sample No.: **Source of Sample:** **Date:** 7/18/17
Location: Composite 1 through 4- Older Rockfill **Elev./Depth:**

Knight Piésold CONSULTING

Client: Montana Resources
Project: Yankee Doodle Tailings Impoundment
Project No: VA101-00126/17 **Figure**

Tested By: JDH **Checked By:** JDB

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
2.0	14.7	22.3	9.6	21.4	9.9	12.1	8.0

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
6	100.0		
3	98.0		
2	95.8		
1.5	92.1		
1	87.6		
.75	83.3		
.5	77.3		
.375	72.9		
#4	61.0		
#10	51.4		
#20	37.7		
#40	30.0		
#60	26.2		
#100	23.2		
#200	20.1		
0.0653 mm.	19.7		
0.0465 mm.	18.8		
0.0334 mm.	17.0		
0.0215 mm.	14.7		
0.0126 mm.	13.3		
0.0090 mm.	12.0		
0.0064 mm.	10.7		
0.0044 mm.	9.4		
0.0032 mm.	8.8		
0.0013 mm.	7.3		

* (no specification provided)

Soil Description

clayey SAND with gravel

Atterberg Limits

PL= 16 LL= 45 PI= 29

Coefficients

D_{90}= 31.5037 D_{85}= 21.2460 D_{60}= 4.4187
D_{50}= 1.8112 D_{30}= 0.4227 D_{15}= 0.0233
D_{10}= 0.0053 C_u= 836.14 C_c= 7.65

Classification

USCS= SC AASHTO= A-2-7(1)

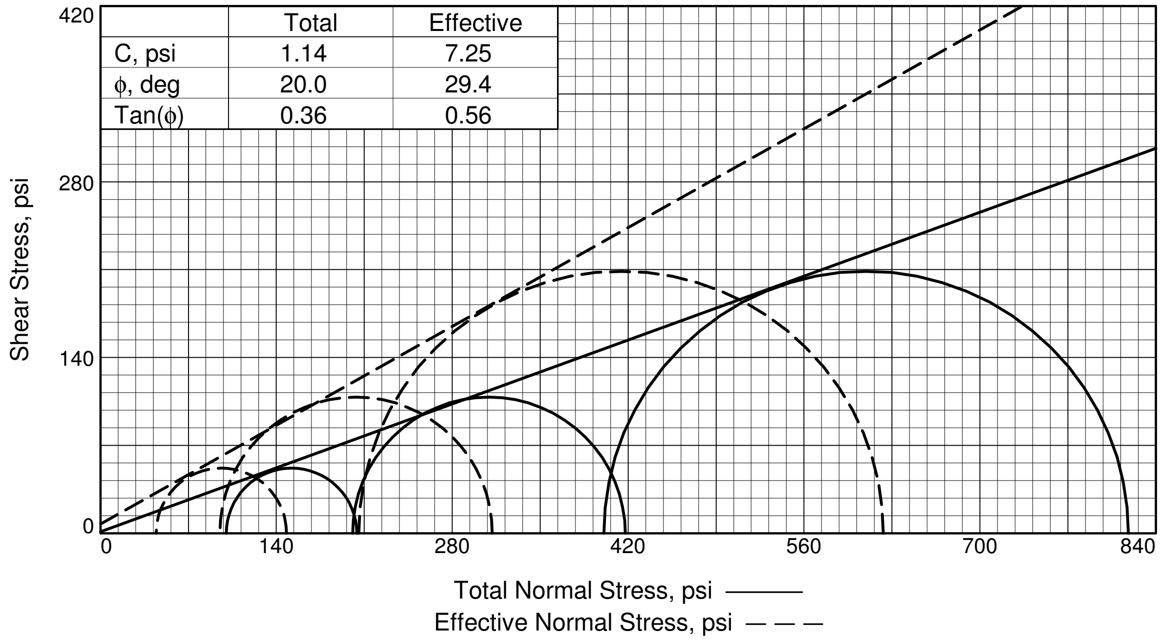
Remarks

Sample No.: **Source of Sample:** **Date:** 7/18/17
Location: Composite 5 through 8- Newer Rockfill **Elev./Depth:**

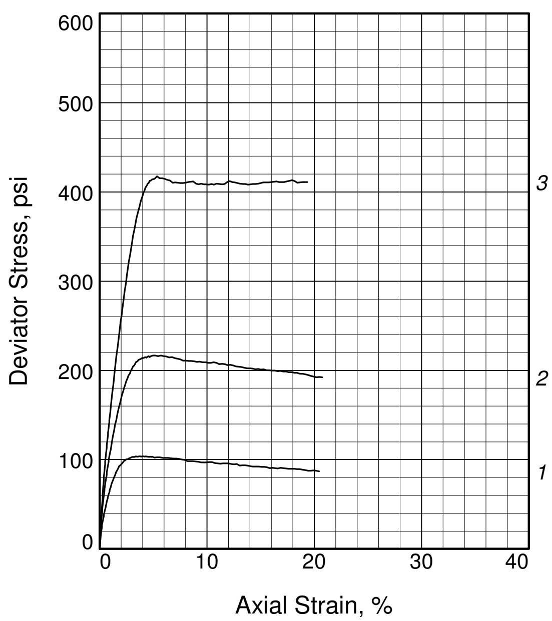
Knight Piésold CONSULTING

Client: Montana Resources
Project: Yankee Doodle Tailings Impoundment
Project No: VA101-00126/17 **Figure**

Tested By: JDH **Checked By:** JDB



	Total	Effective
C, psi	1.14	7.25
φ, deg	20.0	29.4
Tan(φ)	0.36	0.56



	Specimen No.	1	2	3
Initial	Water Content, %	11.9	11.9	11.9
	Dry Density, pcf	104.4	101.3	101.5
	Saturation, %	52.2	48.3	48.5
	Void Ratio	0.6144	0.6646	0.6611
	Diameter, in.	2.25	2.29	2.28
	Height, in.	4.80	4.80	4.81
At Test	Water Content, %	19.0	18.3	19.4
	Dry Density, pcf	111.4	112.9	110.6
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.5125	0.4931	0.5235
	Diameter, in.	2.20	2.21	2.22
	Height, in.	4.70	4.63	4.68
	Strain rate, %/min.	0.03	0.03	0.03
	Eff. Cell Pressure, psi	100	201	401
	Fail. Stress, psi	104	217	417
	Excess Pore Pr., psi	56	106	195
	Strain, %	3.7	5.2	5.3
	Ult. Stress, psi			
	Excess Pore Pr., psi			
	Strain, %			
	$\bar{\sigma}_1$ Failure, psi	148	312	623
	$\bar{\sigma}_3$ Failure, psi	44	95	206

Type of Test:
CU with Pore Pressures

Sample Type: Remolded

Description: silty sand

LL= NP **PI=** NP

Assumed Specific Gravity= 2.7

Remarks: Failure tangents drawn at peak deviator stress.

Figure _______

Client:

Project: Yankee Doodle Impoundment Dam Site Investigation

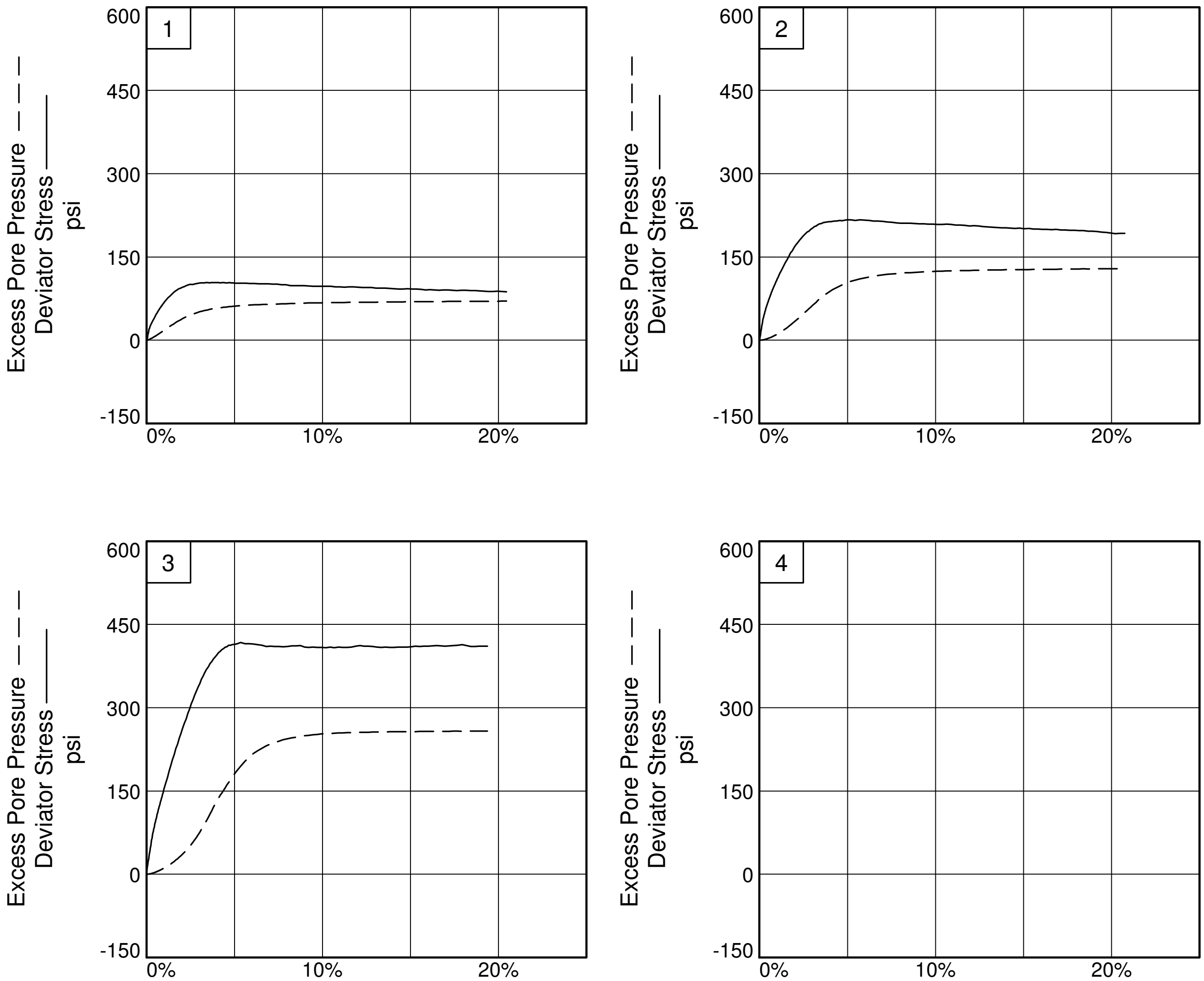
Location: DH15-S5

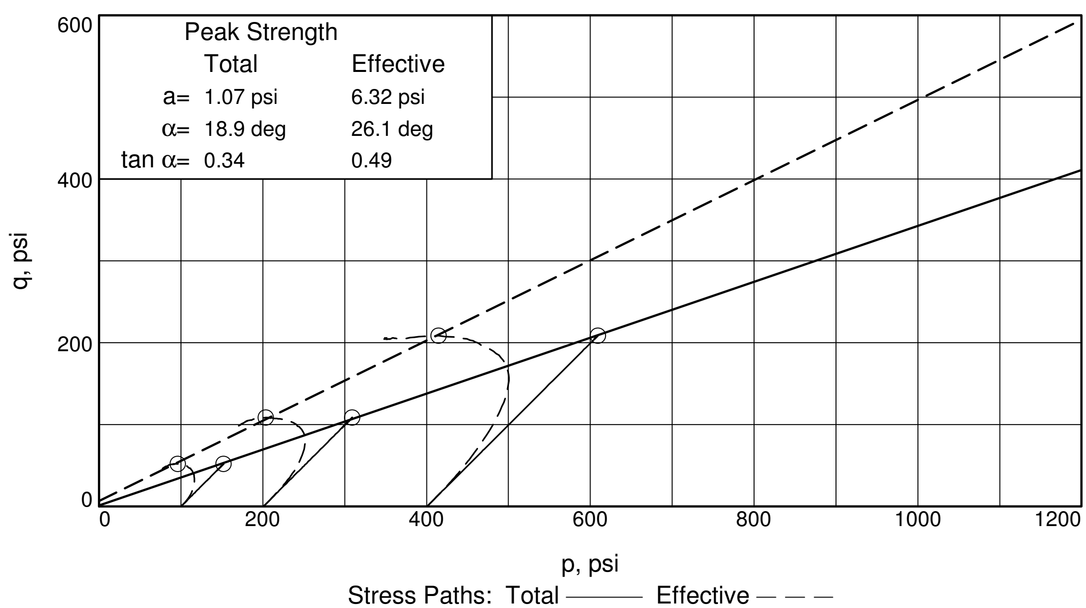
Sample Number: 25 **Depth:** 718-719'

Proj. No.: 10100126.14 **Date Sampled:** 2/12/16

Knight Piésold
CONSULTING

Tested By: JHK **Checked By:** JDB





Client:

Project: Yankee Doodle Impoundment Dam Site Investigation

Location: DH15-S5 **Depth:** 718-719' **Sample Number:** 25

Project No.: 10100126.14 **Figure** _______

Knight Piesold Geotechnical Lab.

Tested By: JHK **Checked By:** JDB

TRIAXIAL COMPRESSION TEST

CU with Pore Pressures

2/20/2016
1:19 PM

Date: 2/12/16
Client:
Project: Yankee Doodle Impoundment Dam Site Investigation
Project No.: 10100126.14
Location: DH15-S5
Depth: 718-719' **Sample Number:** 25
Description: silty sand
Remarks: Failure tangents drawn at peak deviator stress.
Type of Sample: Remolded
Assumed Specific Gravity=2.7 **LL=**NP **PL=** **PI=**NP
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	618.800			999.600
Moisture content: Dry soil+tare, gms.	568.600			917.900
Moisture content: Tare, gms.	146.020			394.430
Moisture, %	11.9	22.8	19.0	15.6
Moist specimen weight, gms.	586.2			
Diameter, in.	2.25	2.25	2.20	
Area, in.²	3.98	3.98	3.81	
Height, in.	4.80	4.80	4.70	
Net decrease in height, in.		0.00	0.10	
Wet density, pcf	116.8	128.2	132.6	
Dry density, pcf	104.4	104.4	111.4	
Void ratio	0.6144	0.6144	0.5125	
Saturation, %	52.2	100.0	100.0	

Test Readings for Specimen No. 1

Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.0635 cm
Consolidation cell pressure = 140.28 psi
Consolidation back pressure = 40.06 psi
Consolidation effective confining stress = 100.22 psi
Strain rate, %/min. = 0.03
Fail. Stress = 103.84 psi **at reading no.** 66

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
0	0.0552	16.000	0.0	0.0	0.00	100.22	100.22	1.00	40.06	100.22	0.00
1	0.0564	16.371	0.4	0.0	0.10	100.14	100.24	1.00	40.14	100.19	0.05
2	0.0576	32.963	17.0	0.1	4.45	100.04	104.49	1.04	40.24	102.27	2.22
3	0.0588	51.521	35.5	0.1	9.31	99.89	109.20	1.09	40.39	104.54	4.65
4	0.0600	66.548	50.5	0.1	13.24	99.67	112.91	1.13	40.61	106.29	6.62
5	0.0612	78.871	62.9	0.1	16.47	99.38	115.85	1.17	40.90	107.62	8.23
6	0.0624	92.113	76.1	0.2	19.93	99.04	118.97	1.20	41.24	109.00	9.97
7	0.0636	100.099	84.1	0.2	22.02	98.66	120.68	1.22	41.62	109.67	11.01
8	0.0648	109.843	93.8	0.2	24.56	98.24	122.80	1.25	42.04	110.52	12.28
9	0.0660	117.573	101.6	0.2	26.58	97.83	124.41	1.27	42.45	111.12	13.29
10	0.0672	124.319	108.3	0.3	28.33	97.38	125.72	1.29	42.90	111.55	14.17
11	0.0684	131.022	115.0	0.3	30.08	96.94	127.02	1.31	43.34	111.98	15.04
12	0.0696	137.758	121.8	0.3	31.83	96.49	128.32	1.33	43.79	112.40	15.92
13	0.0708	144.619	128.6	0.3	33.62	96.04	129.66	1.35	44.24	112.85	16.81
14	0.0720	150.800	134.8	0.4	35.23	95.59	130.82	1.37	44.69	113.21	17.61
15	0.0732	156.985	141.0	0.4	36.83	95.12	131.95	1.39	45.16	113.53	18.42
16	0.0744	161.565	145.6	0.4	38.02	94.65	132.67	1.40	45.63	113.66	19.01
17	0.0756	167.484	151.5	0.4	39.55	94.16	133.72	1.42	46.12	113.94	19.78
18	0.0768	174.124	158.1	0.5	41.28	93.69	134.97	1.44	46.59	114.33	20.64
19	0.0780	180.726	164.7	0.5	42.99	93.20	136.19	1.46	47.08	114.70	21.50
20	0.0792	185.943	169.9	0.5	44.34	92.70	137.04	1.48	47.58	114.87	22.17
21	0.0805	191.461	175.5	0.5	45.77	92.20	137.97	1.50	48.08	115.08	22.88
22	0.0817	196.773	180.8	0.6	47.14	91.70	138.84	1.51	48.58	115.27	23.57
23	0.0829	201.406	185.4	0.6	48.34	91.19	139.53	1.53	49.09	115.36	24.17
24	0.0841	205.356	189.4	0.6	49.36	90.68	140.03	1.54	49.60	115.36	24.68
25	0.0853	211.200	195.2	0.6	50.86	90.14	141.01	1.56	50.14	115.57	25.43
26	0.0865	219.126	203.1	0.7	52.92	89.60	142.52	1.59	50.68	116.06	26.46
27	0.0877	223.730	207.7	0.7	54.10	89.07	143.18	1.61	51.21	116.12	27.05
28	0.0889	228.218	212.2	0.7	55.26	88.52	143.77	1.62	51.76	116.15	27.63
29	0.0901	233.392	217.4	0.7	56.59	87.97	144.56	1.64	52.31	116.27	28.29
30	0.0913	237.313	221.3	0.8	57.60	87.44	145.03	1.66	52.84	116.23	28.80
31	0.0925	241.696	225.7	0.8	58.72	86.90	145.62	1.68	53.38	116.26	29.36
32	0.0937	246.805	230.8	0.8	60.03	86.37	146.40	1.70	53.91	116.38	30.02
33	0.0949	252.107	236.1	0.8	61.40	85.82	147.22	1.72	54.46	116.52	30.70
34	0.0961	255.230	239.2	0.9	62.19	85.27	147.46	1.73	55.01	116.37	31.10
35	0.0973	259.335	243.3	0.9	63.24	84.72	147.97	1.75	55.56	116.34	31.62
36	0.0985	264.558	248.6	0.9	64.59	84.16	148.75	1.77	56.12	116.46	32.29
37	0.0997	268.614	252.6	0.9	65.62	83.60	149.22	1.78	56.68	116.41	32.81
38	0.1009	273.027	257.0	1.0	66.75	83.06	149.81	1.80	57.22	116.44	33.38
39	0.1021	277.656	261.7	1.0	67.94	82.50	150.44	1.82	57.78	116.47	33.97
40	0.1033	280.766	264.8	1.0	68.73	81.97	150.69	1.84	58.31	116.33	34.36
41	0.1081	296.577	280.6	1.1	72.75	79.76	152.52	1.91	60.52	116.14	36.38
42	0.1129	311.936	295.9	1.2	76.66	77.58	154.24	1.99	62.70	115.91	38.33
43	0.1177	322.445	306.4	1.3	79.30	75.34	154.64	2.05	64.94	114.99	39.65
44	0.1225	335.050	319.1	1.4	82.47	73.19	155.66	2.13	67.09	114.42	41.24
45	0.1273	348.171	332.2	1.5	85.78	71.06	156.84	2.21	69.22	113.95	42.89
46	0.1321	358.017	342.0	1.6	88.23	69.01	157.24	2.28	71.27	113.12	44.11

Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
47	0.1369	366.751	350.8	1.7	90.39	67.03	157.42	2.35	73.25	112.23	45.19
48	0.1417	376.968	361.0	1.8	92.92	65.09	158.01	2.43	75.19	111.55	46.46
49	0.1465	380.735	364.7	1.9	93.79	63.23	157.03	2.48	77.05	110.13	46.90
50	0.1513	386.572	370.6	2.0	95.20	61.47	156.66	2.55	78.81	109.06	47.60
51	0.1561	392.166	376.2	2.1	96.53	59.79	156.32	2.61	80.49	108.06	48.27
52	0.1609	399.607	383.6	2.3	98.34	58.20	156.54	2.69	82.08	107.37	49.17
53	0.1657	403.295	387.3	2.4	99.18	56.73	155.91	2.75	83.55	106.32	49.59
54	0.1705	407.639	391.6	2.5	100.19	55.30	155.48	2.81	84.98	105.39	50.09
55	0.1753	409.863	393.9	2.6	100.65	53.99	154.64	2.86	86.29	104.31	50.33
56	0.1801	410.434	394.4	2.7	100.69	52.74	153.43	2.91	87.54	103.08	50.35
57	0.1849	415.051	399.1	2.8	101.76	51.62	153.38	2.97	88.66	102.50	50.88
58	0.1897	416.307	400.3	2.9	101.98	50.53	152.51	3.02	89.75	101.52	50.99
59	0.1946	419.831	403.8	3.0	102.77	49.52	152.29	3.08	90.76	100.91	51.38
60	0.1994	421.271	405.3	3.1	103.02	48.59	151.61	3.12	91.69	100.10	51.51
61	0.2042	422.059	406.1	3.2	103.12	47.73	150.85	3.16	92.55	99.29	51.56
62	0.2090	422.715	406.7	3.3	103.17	46.92	150.09	3.20	93.36	98.50	51.59
63	0.2138	424.788	408.8	3.4	103.59	46.20	149.79	3.24	94.08	98.00	51.79
64	0.2186	424.910	408.9	3.5	103.51	45.55	149.06	3.27	94.73	97.30	51.76
65	0.2234	424.224	408.2	3.6	103.23	44.90	148.13	3.30	95.38	96.51	51.61
66	0.2282	427.102	411.1	3.7	103.84	44.31	148.16	3.34	95.97	96.23	51.92
67	0.2330	426.629	410.6	3.8	103.62	43.76	147.37	3.37	96.52	95.56	51.81
68	0.2378	426.731	410.7	3.9	103.53	43.24	146.77	3.39	97.04	95.00	51.77
69	0.2426	427.741	411.7	4.0	103.68	42.75	146.42	3.43	97.53	94.59	51.84
70	0.2474	428.138	412.1	4.1	103.66	42.27	145.94	3.45	98.01	94.10	51.83
71	0.2522	427.571	411.6	4.2	103.41	41.81	145.22	3.47	98.47	93.51	51.71
72	0.2570	429.579	413.6	4.3	103.81	41.40	145.21	3.51	98.88	93.31	51.90
73	0.2618	429.018	413.0	4.4	103.55	40.98	144.53	3.53	99.30	92.75	51.78
74	0.2666	428.991	413.0	4.5	103.44	40.60	144.03	3.55	99.68	92.32	51.72
75	0.2714	427.807	411.8	4.6	103.03	40.24	143.27	3.56	100.04	91.75	51.51
76	0.2762	430.301	414.3	4.7	103.54	39.90	143.44	3.59	100.38	91.67	51.77
77	0.2810	428.962	413.0	4.8	103.10	39.56	142.65	3.61	100.72	91.10	51.55
78	0.2858	430.002	414.0	4.9	103.25	39.24	142.48	3.63	101.04	90.86	51.62
79	0.2906	427.597	411.6	5.0	102.53	38.94	141.47	3.63	101.34	90.20	51.27
80	0.2954	427.492	411.5	5.1	102.40	38.68	141.08	3.65	101.60	89.88	51.20
81	0.3074	430.435	414.4	5.4	102.85	38.08	140.93	3.70	102.20	89.51	51.43
82	0.3194	430.501	414.5	5.6	102.59	37.51	140.10	3.74	102.77	88.81	51.30
83	0.3314	429.110	413.1	5.9	101.97	37.01	138.98	3.76	103.27	88.00	50.99
84	0.3434	430.822	414.8	6.1	102.12	36.57	138.69	3.79	103.71	87.63	51.06
85	0.3554	430.773	414.8	6.4	101.82	36.19	138.02	3.81	104.09	87.11	50.91
86	0.3674	430.816	414.8	6.6	101.56	35.91	137.47	3.83	104.37	86.69	50.78
87	0.3795	431.170	415.2	6.9	101.37	35.63	136.99	3.85	104.65	86.31	50.68
88	0.3915	431.275	415.3	7.2	101.11	35.30	136.42	3.86	104.98	85.86	50.56
89	0.4035	432.023	416.0	7.4	101.02	35.00	136.02	3.89	105.28	85.51	50.51
90	0.4155	429.500	413.5	7.7	100.13	34.76	134.88	3.88	105.52	84.82	50.06
91	0.4275	429.057	413.1	7.9	99.74	34.48	134.22	3.89	105.80	84.35	49.87
92	0.4395	424.962	409.0	8.2	98.48	34.19	132.67	3.88	106.09	83.43	49.24
93	0.4515	425.576	409.6	8.4	98.35	33.91	132.27	3.90	106.37	83.09	49.18

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
94	0.4635	427.269	411.3	8.7	98.48	33.70	132.18	3.92	106.58	82.94	49.24
95	0.4755	426.311	410.3	8.9	97.98	33.48	131.46	3.93	106.80	82.47	48.99
96	0.4875	425.628	409.6	9.2	97.54	33.25	130.79	3.93	107.03	82.02	48.77
97	0.4995	424.011	408.0	9.5	96.88	33.11	129.99	3.93	107.17	81.55	48.44
98	0.5115	426.104	410.1	9.7	97.11	32.94	130.05	3.95	107.34	81.50	48.55
99	0.5235	426.353	410.4	10.0	96.89	32.88	129.77	3.95	107.40	81.33	48.44
100	0.5355	428.821	412.8	10.2	97.20	32.79	129.99	3.96	107.49	81.39	48.60
101	0.5475	429.949	413.9	10.5	97.18	32.64	129.83	3.98	107.64	81.23	48.59
102	0.5595	426.665	410.7	10.7	96.14	32.56	128.70	3.95	107.72	80.63	48.07
103	0.5715	427.177	411.2	11.0	95.98	32.45	128.43	3.96	107.83	80.44	47.99
104	0.5835	426.061	410.1	11.2	95.45	32.31	127.76	3.95	107.97	80.03	47.72
105	0.5955	428.804	412.8	11.5	95.81	32.18	127.99	3.98	108.10	80.08	47.90
106	0.6075	429.917	413.9	11.8	95.79	32.07	127.86	3.99	108.21	79.96	47.89
107	0.6195	430.760	414.8	12.0	95.71	32.01	127.72	3.99	108.27	79.87	47.85
108	0.6315	429.188	413.2	12.3	95.07	31.88	126.95	3.98	108.40	79.41	47.53
109	0.6435	428.542	412.5	12.5	94.64	31.81	126.45	3.98	108.47	79.13	47.32
110	0.6555	432.076	416.1	12.8	95.17	31.76	126.94	4.00	108.52	79.35	47.59
111	0.6676	426.091	410.1	13.0	93.53	31.64	125.17	3.96	108.64	78.40	46.76
112	0.6796	428.503	412.5	13.3	93.80	31.56	125.37	3.97	108.72	78.47	46.90
113	0.6916	429.569	413.6	13.5	93.77	31.45	125.22	3.98	108.83	78.34	46.88
114	0.7036	428.673	412.7	13.8	93.29	31.36	124.65	3.97	108.92	78.01	46.64
115	0.7156	426.970	411.0	14.1	92.63	31.23	123.86	3.97	109.05	77.54	46.31
116	0.7276	426.367	410.4	14.3	92.22	31.12	123.34	3.96	109.16	77.23	46.11
117	0.7396	427.702	411.7	14.6	92.24	31.09	123.33	3.97	109.19	77.21	46.12
118	0.7516	429.766	413.8	14.8	92.43	31.04	123.47	3.98	109.24	77.25	46.21
119	0.7636	429.529	413.5	15.1	92.10	30.92	123.02	3.98	109.36	76.97	46.05
120	0.7756	429.871	413.9	15.3	91.90	30.85	122.75	3.98	109.43	76.80	45.95
121	0.7876	429.487	413.5	15.6	91.53	30.82	122.35	3.97	109.46	76.59	45.77
122	0.7996	426.458	410.5	15.8	90.59	30.75	121.34	3.95	109.53	76.05	45.29
123	0.8116	429.621	413.6	16.1	91.01	30.72	121.73	3.96	109.56	76.22	45.50
124	0.8236	429.070	413.1	16.4	90.61	30.67	121.28	3.95	109.61	75.97	45.31
125	0.8356	427.951	412.0	16.6	90.09	30.65	120.74	3.94	109.63	75.69	45.04
126	0.8476	432.046	416.0	16.9	90.71	30.56	121.27	3.97	109.72	75.91	45.35
127	0.8596	432.522	416.5	17.1	90.53	30.51	121.04	3.97	109.77	75.77	45.26
128	0.8716	432.203	416.2	17.4	90.18	30.47	120.66	3.96	109.81	75.57	45.09
129	0.8836	430.960	415.0	17.6	89.63	30.45	120.08	3.94	109.83	75.26	44.82
130	0.8956	432.561	416.6	17.9	89.70	30.37	120.07	3.95	109.91	75.22	44.85
131	0.9076	434.923	418.9	18.1	89.93	30.34	120.27	3.96	109.94	75.30	44.96
132	0.9196	433.696	417.7	18.4	89.39	30.32	119.71	3.95	109.96	75.02	44.69
133	0.9317	434.845	418.8	18.7	89.35	30.27	119.62	3.95	110.01	74.95	44.68
134	0.9437	432.509	416.5	18.9	88.57	30.24	118.81	3.93	110.04	74.52	44.29
135	0.9557	432.755	416.8	19.2	88.35	30.17	118.52	3.93	110.11	74.34	44.17
136	0.9677	431.127	415.1	19.4	87.72	30.11	117.83	3.91	110.17	73.97	43.86
137	0.9797	432.404	416.4	19.7	87.71	30.05	117.76	3.92	110.23	73.90	43.86
138	0.9917	435.488	419.5	19.9	88.08	30.01	118.09	3.94	110.27	74.05	44.04
139	1.0037	435.209	419.2	20.2	87.74	29.95	117.69	3.93	110.33	73.82	43.87
140	1.0156	432.587	416.6	20.4	86.92	29.86	116.78	3.91	110.42	73.32	43.46

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	618.800			993.100
Moisture content: Dry soil+tare, gms.	568.600			915.800
Moisture content: Tare, gms.	146.020			393.440
Moisture, %	11.9	24.6	18.3	14.8
Moist specimen weight, gms.	586.4			
Diameter, in.	2.29	2.29	2.21	
Area, in.²	4.11	4.11	3.82	
Height, in.	4.80	4.80	4.63	
Net decrease in height, in.		0.00	0.17	
Wet density, pcf	113.3	126.2	133.5	
Dry density, pcf	101.3	101.3	112.9	
Void ratio	0.6646	0.6646	0.4931	
Saturation, %	48.3	100.0	100.0	

Test Readings for Specimen No. 2

Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.0635 cm
Consolidation cell pressure = 239.97 psi
Consolidation back pressure = 39.19 psi
Consolidation effective confining stress = 200.78 psi
Strain rate, %/min. = 0.03
Fail. Stress = 216.89 psi **at reading no.** 82

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
0	0.0000	56.394	0.0	0.0	0.00	200.78	200.78	1.00	39.19	200.78	0.00
1	0.0002	57.267	0.9	0.0	0.23	200.80	201.03	1.00	39.17	200.91	0.11
2	0.0002	57.310	0.9	0.0	0.24	200.81	201.05	1.00	39.16	200.93	0.12
3	0.0014	74.027	17.6	0.0	4.62	200.79	205.40	1.02	39.18	203.10	2.31
4	0.0026	94.961	38.6	0.1	10.09	200.76	210.86	1.05	39.21	205.81	5.05
5	0.0038	116.082	59.7	0.1	15.62	200.74	216.36	1.08	39.23	208.55	7.81
6	0.0050	136.840	80.4	0.1	21.04	200.64	221.68	1.10	39.33	211.16	10.52
7	0.0062	156.886	100.5	0.1	26.28	200.55	226.83	1.13	39.42	213.69	13.14
8	0.0074	174.085	117.7	0.2	30.77	200.48	231.24	1.15	39.49	215.86	15.38
9	0.0086	190.917	134.5	0.2	35.16	200.31	235.47	1.18	39.66	217.89	17.58
10	0.0098	203.482	147.1	0.2	38.43	200.18	238.61	1.19	39.79	219.40	19.22
11	0.0110	216.382	160.0	0.2	41.79	200.01	241.80	1.21	39.96	220.91	20.90
12	0.0122	228.425	172.0	0.3	44.93	199.83	244.75	1.22	40.14	222.29	22.46
13	0.0134	240.530	184.1	0.3	48.08	199.60	247.68	1.24	40.37	223.64	24.04
14	0.0146	252.667	196.3	0.3	51.23	199.44	250.67	1.26	40.53	225.05	25.62
15	0.0158	261.974	205.6	0.3	53.65	199.20	252.85	1.27	40.77	226.02	26.82
16	0.0170	274.956	218.6	0.4	57.02	198.92	255.94	1.29	41.05	227.43	28.51
17	0.0182	285.552	229.2	0.4	59.77	198.69	258.46	1.30	41.28	228.58	29.88
18	0.0194	293.981	237.6	0.4	61.95	198.44	260.40	1.31	41.53	229.42	30.98
19	0.0206	305.515	249.1	0.4	64.94	198.15	263.09	1.33	41.82	230.62	32.47
20	0.0218	313.473	257.1	0.5	67.00	197.89	264.89	1.34	42.08	231.39	33.50
21	0.0230	323.416	267.0	0.5	69.57	197.59	267.16	1.35	42.38	232.37	34.79
22	0.0242	334.413	278.0	0.5	72.42	197.27	269.69	1.37	42.70	233.48	36.21
23	0.0254	342.634	286.2	0.5	74.54	196.97	271.51	1.38	43.00	234.24	37.27
24	0.0266	351.436	295.0	0.6	76.81	196.67	273.49	1.39	43.30	235.08	38.41

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
25	0.0278	359.926	303.5	0.6	79.00	196.30	275.30	1.40	43.67	235.80	39.50
26	0.0290	366.946	310.6	0.6	80.81	195.95	276.76	1.41	44.02	236.36	40.40
27	0.0302	375.612	319.2	0.7	83.04	195.59	278.64	1.42	44.38	237.12	41.52
28	0.0314	386.466	330.1	0.7	85.84	195.24	281.08	1.44	44.73	238.16	42.92
29	0.0326	392.701	336.3	0.7	87.44	194.84	282.28	1.45	45.13	238.56	43.72
30	0.0338	402.370	346.0	0.7	89.93	194.47	284.40	1.46	45.50	239.44	44.97
31	0.0350	410.312	353.9	0.8	91.97	194.06	286.03	1.47	45.91	240.05	45.99
32	0.0362	417.003	360.6	0.8	93.69	193.65	287.34	1.48	46.32	240.50	46.84
33	0.0374	425.169	368.8	0.8	95.78	193.23	289.01	1.50	46.74	241.12	47.89
34	0.0386	432.716	376.3	0.8	97.72	192.81	290.53	1.51	47.16	241.67	48.86
35	0.0398	441.464	385.1	0.9	99.96	192.39	292.35	1.52	47.58	242.37	49.98
36	0.0410	446.493	390.1	0.9	101.24	191.95	293.19	1.53	48.02	242.57	50.62
37	0.0422	456.184	399.8	0.9	103.73	191.53	295.26	1.54	48.44	243.40	51.86
38	0.0434	463.001	406.6	0.9	105.47	191.11	296.58	1.55	48.86	243.84	52.74
39	0.0446	468.908	412.5	1.0	106.98	190.61	297.58	1.56	49.36	244.10	53.49
40	0.0458	476.827	420.4	1.0	109.00	190.17	299.17	1.57	49.80	244.67	54.50
41	0.0470	482.071	425.7	1.0	110.33	189.71	300.04	1.58	50.26	244.88	55.17
42	0.0482	489.880	433.5	1.0	112.33	189.22	301.54	1.59	50.75	245.38	56.16
43	0.0530	518.690	462.3	1.1	119.67	187.22	306.88	1.64	52.75	247.05	59.83
44	0.0578	543.124	486.7	1.2	125.86	185.17	311.03	1.68	54.80	248.10	62.93
45	0.0626	570.721	514.3	1.4	132.85	182.98	315.83	1.73	56.99	249.41	66.43
46	0.0674	596.564	540.2	1.5	139.38	180.77	320.15	1.77	59.20	250.46	69.69
47	0.0722	617.411	561.0	1.6	144.61	178.44	323.05	1.81	61.53	250.74	72.31
48	0.0770	642.420	586.0	1.7	150.90	175.97	326.87	1.86	64.00	251.42	75.45
49	0.0818	666.990	610.6	1.8	157.06	173.47	330.53	1.91	66.50	252.00	78.53
50	0.0866	683.509	627.1	1.9	161.14	170.83	331.96	1.94	69.14	251.40	80.57
51	0.0914	706.100	649.7	2.0	166.77	168.10	334.86	1.99	71.87	251.48	83.38
52	0.0962	726.661	670.3	2.1	171.86	165.31	337.17	2.04	74.66	251.24	85.93
53	0.1010	743.794	687.4	2.2	176.07	162.43	338.49	2.08	77.54	250.46	88.03
54	0.1058	761.103	704.7	2.3	180.31	159.47	339.78	2.13	80.50	249.63	90.16
55	0.1106	777.617	721.2	2.4	184.34	156.53	340.87	2.18	83.44	248.70	92.17
56	0.1154	793.039	736.6	2.5	188.08	153.46	341.54	2.23	86.51	247.50	94.04
57	0.1202	806.054	749.7	2.6	191.20	150.36	341.56	2.27	89.61	245.96	95.60
58	0.1250	819.606	763.2	2.7	194.45	147.34	341.79	2.32	92.63	244.57	97.23
59	0.1298	827.136	770.7	2.8	196.16	144.21	340.37	2.36	95.76	242.29	98.08
60	0.1346	841.813	785.4	2.9	199.68	141.12	340.80	2.41	98.85	240.96	99.84
61	0.1394	852.315	795.9	3.0	202.14	138.11	340.25	2.46	101.86	239.18	101.07
62	0.1442	861.973	805.6	3.1	204.37	135.13	339.50	2.51	104.84	237.31	102.18
63	0.1490	868.281	811.9	3.2	205.75	132.19	337.94	2.56	107.78	235.07	102.87
64	0.1538	877.407	821.0	3.3	207.84	129.31	337.15	2.61	110.66	233.23	103.92
65	0.1586	885.441	829.0	3.4	209.65	126.51	336.16	2.66	113.46	231.34	104.82
66	0.1634	888.935	832.5	3.5	210.31	123.80	334.11	2.70	116.17	228.96	105.15
67	0.1683	895.253	838.9	3.6	211.67	121.19	332.86	2.75	118.78	227.03	105.84
68	0.1731	899.388	843.0	3.7	212.49	118.75	331.24	2.79	121.22	224.99	106.24
69	0.1779	901.697	845.3	3.8	212.84	116.41	329.25	2.83	123.56	222.83	106.42
70	0.1827	906.134	849.7	3.9	213.73	114.08	327.81	2.87	125.89	220.95	106.86
71	0.1875	907.143	850.7	4.0	213.75	111.98	325.73	2.91	127.99	218.86	106.88

Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
72	0.1923	910.083	853.7	4.2	214.26	109.89	324.15	2.95	130.08	217.02	107.13
73	0.1971	913.089	856.7	4.3	214.78	107.96	322.74	2.99	132.01	215.35	107.39
74	0.2019	912.452	856.1	4.4	214.39	106.24	320.63	3.02	133.73	213.44	107.19
75	0.2067	916.379	860.0	4.5	215.14	104.49	319.63	3.06	135.48	212.06	107.57
76	0.2115	920.218	863.8	4.6	215.86	102.89	318.75	3.10	137.08	210.82	107.93
77	0.2163	917.915	861.5	4.7	215.05	101.39	316.44	3.12	138.58	208.92	107.53
78	0.2211	922.160	865.8	4.8	215.88	99.95	315.83	3.16	140.02	207.89	107.94
79	0.2259	925.719	869.3	4.9	216.53	98.55	315.08	3.20	141.42	206.82	108.27
80	0.2307	926.882	870.5	5.0	216.58	97.31	313.89	3.23	142.66	205.60	108.29
81	0.2355	929.054	872.7	5.1	216.89	96.13	313.02	3.26	143.84	204.58	108.44
82	0.2403	930.025	873.6	5.2	216.89	95.02	311.91	3.28	144.95	203.47	108.45
83	0.2523	928.840	872.4	5.4	216.00	92.50	308.50	3.34	147.47	200.50	108.00
84	0.2643	933.557	877.2	5.7	216.58	90.32	306.90	3.40	149.65	198.61	108.29
85	0.2763	934.209	877.8	6.0	216.14	88.49	304.63	3.44	151.48	196.56	108.07
86	0.2883	933.973	877.6	6.2	215.49	86.98	302.47	3.48	152.99	194.73	107.74
87	0.3003	933.288	876.9	6.5	214.73	85.47	300.19	3.51	154.50	192.83	107.36
88	0.3123	936.408	880.0	6.7	214.89	84.23	299.12	3.55	155.74	191.68	107.45
89	0.3243	935.087	878.7	7.0	213.97	83.07	297.04	3.58	156.90	190.06	106.99
90	0.3363	934.127	877.7	7.3	213.14	82.21	295.36	3.59	157.76	188.78	106.57
91	0.3483	934.187	877.8	7.5	212.56	81.42	293.98	3.61	158.55	187.70	106.28
92	0.3603	930.348	874.0	7.8	211.04	80.70	291.74	3.62	159.27	186.22	105.52
93	0.3723	932.131	875.7	8.0	210.88	80.10	290.98	3.63	159.87	185.54	105.44
94	0.3843	933.968	877.6	8.3	210.72	79.53	290.25	3.65	160.44	184.89	105.36
95	0.3963	936.140	879.7	8.6	210.65	79.05	289.70	3.66	160.92	184.38	105.32
96	0.4083	937.089	880.7	8.8	210.28	78.53	288.81	3.68	161.44	183.67	105.14
97	0.4203	937.259	880.9	9.1	209.72	78.03	287.75	3.69	161.94	182.89	104.86
98	0.4323	940.154	883.8	9.3	209.81	77.67	287.48	3.70	162.30	182.58	104.91
99	0.4443	939.304	882.9	9.6	209.01	77.33	286.34	3.70	162.64	181.83	104.50
100	0.4563	942.376	886.0	9.9	209.14	76.93	286.06	3.72	163.04	181.49	104.57
101	0.4683	942.770	886.4	10.1	208.63	76.62	285.24	3.72	163.35	180.93	104.31
102	0.4803	945.293	888.9	10.4	208.62	76.39	285.01	3.73	163.58	180.70	104.31
103	0.4923	950.668	894.3	10.6	209.27	76.16	285.43	3.75	163.81	180.79	104.64
104	0.5043	949.791	893.4	10.9	208.46	75.93	284.39	3.75	164.04	180.16	104.23
105	0.5163	946.719	890.3	11.1	207.14	75.70	282.84	3.74	164.27	179.27	103.57
106	0.5283	950.306	893.9	11.4	207.37	75.48	282.85	3.75	164.49	179.17	103.68
107	0.5403	950.789	894.4	11.7	206.87	75.24	282.11	3.75	164.73	178.68	103.44
108	0.5523	949.237	892.8	11.9	205.91	75.15	281.06	3.74	164.82	178.11	102.95
109	0.5643	953.169	896.8	12.2	206.21	75.01	281.21	3.75	164.96	178.11	103.10
110	0.5763	953.273	896.9	12.4	205.62	74.85	280.47	3.75	165.12	177.66	102.81
111	0.5883	951.238	894.8	12.7	204.55	74.64	279.19	3.74	165.33	176.92	102.27
112	0.6003	951.474	895.1	13.0	203.99	74.46	278.45	3.74	165.51	176.45	102.00
113	0.6123	952.944	896.5	13.2	203.72	74.40	278.12	3.74	165.57	176.26	101.86
114	0.6243	953.076	896.7	13.5	203.14	74.20	277.34	3.74	165.77	175.77	101.57
115	0.6363	952.072	895.7	13.7	202.31	74.15	276.46	3.73	165.82	175.31	101.15
116	0.6483	955.429	899.0	14.0	202.46	73.99	276.44	3.74	165.98	175.21	101.23
117	0.6603	955.889	899.5	14.3	201.95	73.93	275.88	3.73	166.04	174.90	100.97
118	0.6723	955.955	899.6	14.5	201.35	73.90	275.25	3.72	166.07	174.58	100.68

Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
119	0.6843	960.710	904.3	14.8	201.80	73.77	275.57	3.74	166.20	174.67	100.90
120	0.6963	959.920	903.5	15.0	201.02	73.49	274.50	3.74	166.48	174.00	100.51
121	0.7083	963.255	906.9	15.3	201.14	73.46	274.61	3.74	166.51	174.03	100.57
122	0.7203	962.273	905.9	15.6	200.31	73.38	273.69	3.73	166.59	173.53	100.15
123	0.7323	965.235	908.8	15.8	200.35	73.20	273.54	3.74	166.77	173.37	100.17
124	0.7443	965.476	909.1	16.1	199.78	73.24	273.03	3.73	166.73	173.14	99.89
125	0.7563	968.811	912.4	16.3	199.90	73.14	273.04	3.73	166.83	173.09	99.95
126	0.7683	967.780	911.4	16.6	199.05	73.12	272.18	3.72	166.85	172.65	99.53
127	0.7803	973.132	916.7	16.8	199.60	73.02	272.62	3.73	166.95	172.82	99.80
128	0.7923	972.233	915.8	17.1	198.78	72.87	271.65	3.73	167.10	172.26	99.39
129	0.8043	975.057	918.7	17.4	198.77	72.77	271.55	3.73	167.20	172.16	99.39
130	0.8163	975.189	918.8	17.6	198.18	72.73	270.91	3.72	167.24	171.82	99.09
131	0.8283	976.906	920.5	17.9	197.92	72.59	270.51	3.73	167.38	171.55	98.96
132	0.8403	977.399	921.0	18.1	197.40	72.40	269.80	3.73	167.57	171.10	98.70
133	0.8523	980.657	924.3	18.4	197.48	72.24	269.72	3.73	167.73	170.98	98.74
134	0.8643	977.937	921.5	18.7	196.27	72.35	268.61	3.71	167.62	170.48	98.13
135	0.8763	980.498	924.1	18.9	196.19	72.33	268.51	3.71	167.64	170.42	98.09
136	0.8883	980.833	924.4	19.2	195.63	72.21	267.85	3.71	167.76	170.03	97.82
137	0.9003	979.796	923.4	19.4	194.79	72.11	266.89	3.70	167.86	169.50	97.39
138	0.9123	978.524	922.1	19.7	193.89	72.04	265.94	3.69	167.93	168.99	96.95
139	0.9243	978.090	921.7	20.0	193.17	72.04	265.22	3.68	167.93	168.63	96.59
140	0.9363	976.264	919.9	20.2	192.17	72.06	264.23	3.67	167.91	168.14	96.08
141	0.9483	981.134	924.7	20.5	192.56	72.04	264.60	3.67	167.93	168.32	96.28
142	0.9603	982.522	926.1	20.7	192.22	72.04	264.26	3.67	167.93	168.15	96.11
143	0.9608	983.613	927.2	20.7	192.42	71.96	264.38	3.67	168.01	168.17	96.21

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	618.800			1006.400
Moisture content: Dry soil+tare, gms.	568.600			928.100
Moisture content: Tare, gms.	146.020			403.340
Moisture, %	11.9	24.5	19.4	14.9
Moist specimen weight, gms.	586.1			
Diameter, in.	2.28	2.28	2.22	
Area, in.²	4.09	4.09	3.86	
Height, in.	4.81	4.81	4.68	
Net decrease in height, in.		0.00	0.14	
Wet density, pcf	113.5	126.3	132.1	
Dry density, pcf	101.5	101.5	110.6	
Void ratio	0.6611	0.6611	0.5235	
Saturation, %	48.5	100.0	100.0	

Test Readings for Specimen No. 3

Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.0635 cm
Consolidation cell pressure = 439.15 psi
Consolidation back pressure = 38.44 psi
Consolidation effective confining stress = 400.71 psi
Strain rate, %/min. = 0.03
Fail. Stress = 417.40 psi **at reading no.** 83

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
0	0.0000	101.252	0.0	0.0	0.00	400.71	400.71	1.00	38.44	400.71	0.00
1	0.0011	125.318	24.1	0.0	6.24	400.68	406.92	1.02	38.47	403.80	3.12
2	0.0023	146.043	44.8	0.0	11.61	400.60	412.21	1.03	38.55	406.40	5.80
3	0.0034	169.352	68.1	0.1	17.65	400.56	418.21	1.04	38.59	409.39	8.82
4	0.0045	189.661	88.4	0.1	22.90	400.49	423.40	1.06	38.66	411.94	11.45
5	0.0057	207.453	106.2	0.1	27.51	400.38	427.89	1.07	38.77	414.14	13.75
6	0.0068	226.912	125.7	0.1	32.54	400.30	432.84	1.08	38.85	416.57	16.27
7	0.0079	243.365	142.1	0.2	36.79	400.16	436.95	1.09	38.99	418.56	18.39
8	0.0091	262.303	161.1	0.2	41.68	400.06	441.74	1.10	39.09	420.90	20.84
9	0.0102	282.837	181.6	0.2	46.99	399.90	446.89	1.12	39.25	423.40	23.49
10	0.0113	300.738	199.5	0.2	51.60	399.71	451.31	1.13	39.44	425.51	25.80
11	0.0125	320.147	218.9	0.3	56.61	399.55	456.16	1.14	39.60	427.85	28.31
12	0.0136	339.930	238.7	0.3	61.71	399.34	461.05	1.15	39.81	430.20	30.86
13	0.0147	351.782	250.5	0.3	64.76	399.11	463.87	1.16	40.04	431.49	32.38
14	0.0158	372.716	271.5	0.3	70.16	398.92	469.08	1.18	40.23	434.00	35.08
15	0.0170	384.711	283.5	0.4	73.24	398.66	471.90	1.18	40.49	435.28	36.62
16	0.0181	399.579	298.3	0.4	77.06	398.42	475.48	1.19	40.73	436.95	38.53
17	0.0192	415.977	314.7	0.4	81.28	398.19	479.47	1.20	40.96	438.83	40.64
18	0.0204	427.511	326.3	0.4	84.24	397.89	482.13	1.21	41.26	440.01	42.12
19	0.0215	440.849	339.6	0.5	87.66	397.62	485.27	1.22	41.53	441.44	43.83
20	0.0226	456.793	355.5	0.5	91.75	397.33	489.09	1.23	41.82	443.21	45.88
21	0.0238	467.438	366.2	0.5	94.48	397.04	491.51	1.24	42.11	444.27	47.24
22	0.0249	481.374	380.1	0.5	98.05	396.73	494.78	1.25	42.42	445.76	49.02
23	0.0260	493.582	392.3	0.6	101.17	396.41	497.58	1.26	42.74	446.99	50.59
24	0.0272	503.921	402.7	0.6	103.81	396.09	499.90	1.26	43.06	447.99	51.91

Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
25	0.0283	518.745	417.5	0.6	107.61	395.77	503.38	1.27	43.38	449.58	53.80
26	0.0294	529.308	428.1	0.6	110.30	395.42	505.72	1.28	43.73	450.57	55.15
27	0.0306	540.935	439.7	0.7	113.27	395.05	508.32	1.29	44.10	451.69	56.64
28	0.0317	551.959	450.7	0.7	116.08	394.73	510.81	1.29	44.42	452.77	58.04
29	0.0328	564.124	462.9	0.7	119.19	394.33	513.51	1.30	44.82	453.92	59.59
30	0.0340	574.741	473.5	0.7	121.89	394.01	515.90	1.31	45.14	454.96	60.95
31	0.0351	587.235	486.0	0.8	125.08	393.65	518.73	1.32	45.50	456.19	62.54
32	0.0362	597.535	496.3	0.8	127.70	393.24	520.94	1.32	45.91	457.09	63.85
33	0.0374	607.730	506.5	0.8	130.29	392.89	523.18	1.33	46.26	458.04	65.14
34	0.0385	619.517	518.3	0.8	133.29	392.50	525.79	1.34	46.65	459.14	66.64
35	0.0396	630.480	529.2	0.8	136.07	392.13	528.20	1.35	47.02	460.17	68.04
36	0.0408	643.231	542.0	0.9	139.32	391.73	531.05	1.36	47.42	461.39	69.66
37	0.0419	652.944	551.7	0.9	141.78	391.34	533.12	1.36	47.81	462.23	70.89
38	0.0430	662.734	561.5	0.9	144.26	390.93	535.19	1.37	48.22	463.06	72.13
39	0.0442	673.851	572.6	0.9	147.08	390.53	537.61	1.38	48.62	464.07	73.54
40	0.0453	685.303	584.1	1.0	149.99	390.08	540.07	1.38	49.07	465.07	74.99
41	0.0464	696.140	594.9	1.0	152.73	389.67	542.40	1.39	49.48	466.03	76.37
42	0.0510	740.109	638.9	1.1	163.86	387.92	551.78	1.42	51.23	469.85	81.93
43	0.0555	781.039	679.8	1.2	174.19	386.02	560.20	1.45	53.13	473.11	87.09
44	0.0600	825.074	723.8	1.3	185.29	384.09	569.38	1.48	55.06	476.74	92.65
45	0.0645	869.361	768.1	1.4	196.43	382.03	578.46	1.51	57.12	480.25	98.22
46	0.0691	908.701	807.4	1.5	206.29	379.85	586.15	1.54	59.30	483.00	103.15
47	0.0736	947.487	846.2	1.6	215.99	377.56	593.55	1.57	61.59	485.56	107.99
48	0.0781	987.875	886.6	1.7	226.07	375.15	601.23	1.60	64.00	488.19	113.04
49	0.0827	1023.370	922.1	1.8	234.89	372.65	607.54	1.63	66.50	490.10	117.45
50	0.0872	1061.344	960.1	1.9	244.33	369.96	614.28	1.66	69.19	492.12	122.16
51	0.0917	1100.547	999.3	2.0	254.05	367.19	621.24	1.69	71.96	494.21	127.03
52	0.0962	1137.178	1035.9	2.1	263.10	364.24	627.35	1.72	74.91	495.79	131.55
53	0.1008	1173.792	1072.5	2.2	272.13	361.14	633.28	1.75	78.01	497.21	136.07
54	0.1053	1206.809	1105.6	2.3	280.23	357.98	638.21	1.78	81.17	498.09	140.12
55	0.1098	1243.423	1142.2	2.3	289.23	354.50	643.73	1.82	84.65	499.12	144.61
56	0.1143	1278.748	1177.5	2.4	297.88	350.90	648.78	1.85	88.25	499.84	148.94
57	0.1189	1315.670	1214.4	2.5	306.91	347.10	654.01	1.88	92.05	500.56	153.46
58	0.1234	1347.452	1246.2	2.6	314.63	343.15	657.79	1.92	96.00	500.47	157.32
59	0.1279	1377.874	1276.6	2.7	321.99	339.03	661.02	1.95	100.12	500.02	161.00
60	0.1325	1409.624	1308.4	2.8	329.67	334.58	664.25	1.99	104.57	499.41	164.84
61	0.1370	1438.209	1337.0	2.9	336.54	329.95	666.49	2.02	109.20	498.22	168.27
62	0.1415	1466.399	1365.1	3.0	343.29	325.17	668.47	2.06	113.98	496.82	171.65
63	0.1460	1497.968	1396.7	3.1	350.88	320.22	671.10	2.10	118.93	495.66	175.44
64	0.1506	1524.496	1423.2	3.2	357.19	314.97	672.15	2.13	124.18	493.56	178.59
65	0.1551	1548.885	1447.6	3.3	362.95	309.54	672.49	2.17	129.61	491.01	181.47
66	0.1596	1575.128	1473.9	3.4	369.16	303.87	673.03	2.21	135.28	488.45	184.58
67	0.1642	1594.499	1493.2	3.5	373.63	298.14	671.77	2.25	141.01	484.95	186.82
68	0.1687	1617.858	1516.6	3.6	379.10	292.29	671.39	2.30	146.86	481.84	189.55
69	0.1732	1635.342	1534.1	3.7	383.08	286.27	669.35	2.34	152.88	477.81	191.54
70	0.1777	1655.421	1554.2	3.8	387.71	280.25	667.96	2.38	158.90	474.11	193.85
71	0.1823	1672.642	1571.4	3.9	391.61	274.43	666.03	2.43	164.72	470.23	195.80

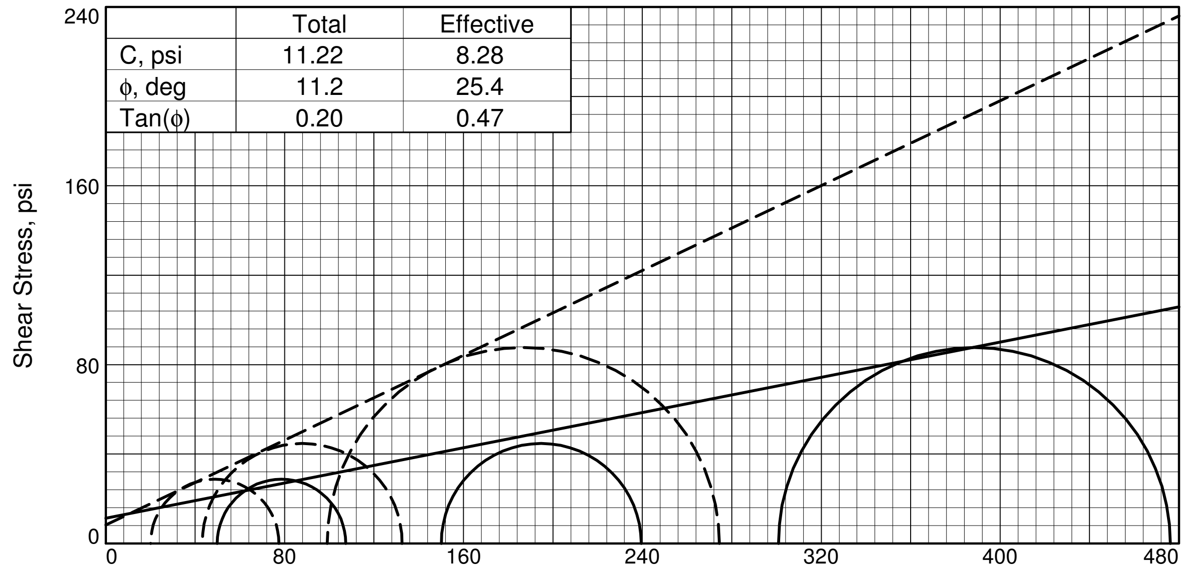
Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 3

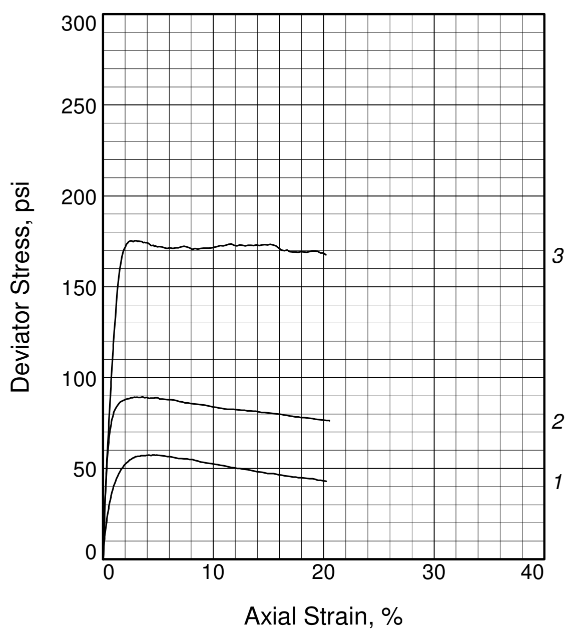
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
72	0.1868	1686.128	1584.9	4.0	394.57	268.83	663.40	2.47	170.32	466.11	197.29
73	0.1913	1706.031	1604.8	4.1	399.12	263.52	662.64	2.51	175.63	463.08	199.56
74	0.1959	1717.593	1616.3	4.2	401.59	258.62	660.21	2.55	180.53	459.41	200.80
75	0.2004	1732.593	1631.3	4.3	404.91	254.26	659.17	2.59	184.89	456.71	202.45
76	0.2049	1740.726	1639.5	4.4	406.52	249.61	656.12	2.63	189.54	452.86	203.26
77	0.2094	1754.097	1652.8	4.5	409.42	244.82	654.24	2.67	194.33	449.53	204.71
78	0.2140	1758.112	1656.9	4.6	410.00	240.07	650.07	2.71	199.08	445.07	205.00
79	0.2185	1769.931	1668.7	4.7	412.50	235.27	647.77	2.75	203.88	441.52	206.25
80	0.2230	1771.949	1670.7	4.8	412.58	230.57	643.15	2.79	208.58	436.86	206.29
81	0.2276	1778.536	1677.3	4.9	413.79	226.01	639.80	2.83	213.14	432.90	206.89
82	0.2389	1786.779	1685.5	5.1	414.76	215.26	630.02	2.93	223.89	422.64	207.38
83	0.2502	1801.850	1700.6	5.3	417.40	205.74	623.14	3.03	233.41	414.44	208.70
84	0.2615	1797.293	1696.0	5.6	415.22	197.22	612.45	3.11	241.93	404.83	207.61
85	0.2728	1801.987	1700.7	5.8	415.30	189.88	605.18	3.19	249.27	397.53	207.65
86	0.2841	1803.847	1702.6	6.1	414.69	183.47	598.16	3.26	255.68	390.82	207.34
87	0.2955	1803.583	1702.3	6.3	413.56	178.16	591.72	3.32	260.99	384.94	206.78
88	0.3068	1804.702	1703.5	6.6	412.76	173.59	586.35	3.38	265.56	379.97	206.38
89	0.3181	1799.174	1697.9	6.8	410.35	169.62	579.98	3.42	269.53	374.80	205.18
90	0.3294	1804.554	1703.3	7.0	410.59	166.33	576.91	3.47	272.82	371.62	205.29
91	0.3407	1808.190	1706.9	7.3	410.39	163.40	573.79	3.51	275.75	368.60	205.20
92	0.3521	1811.810	1710.6	7.5	410.19	160.86	571.05	3.55	278.29	365.95	205.09
93	0.3634	1815.123	1713.9	7.8	409.91	158.60	568.50	3.58	280.55	363.55	204.95
94	0.3747	1821.989	1720.7	8.0	410.47	156.50	566.97	3.62	282.65	361.74	205.23
95	0.3860	1829.607	1728.4	8.3	411.20	155.01	566.21	3.65	284.14	360.61	205.60
96	0.3973	1835.311	1734.1	8.5	411.47	153.69	565.16	3.68	285.46	359.42	205.74
97	0.4087	1841.497	1740.2	8.7	411.85	152.47	564.32	3.70	286.68	358.40	205.92
98	0.4200	1834.582	1733.3	9.0	409.12	151.27	560.39	3.70	287.88	355.83	204.56
99	0.4313	1837.220	1736.0	9.2	408.66	150.38	559.04	3.72	288.77	354.71	204.33
100	0.4426	1844.936	1743.7	9.5	409.38	149.50	558.87	3.74	289.65	354.18	204.69
101	0.4539	1846.390	1745.1	9.7	408.62	148.71	557.34	3.75	290.44	353.03	204.31
102	0.4652	1851.633	1750.4	9.9	408.75	148.01	556.77	3.76	291.14	352.39	204.38
103	0.4766	1854.331	1753.1	10.2	408.28	147.43	555.72	3.77	291.72	351.57	204.14
104	0.4879	1862.514	1761.3	10.4	409.08	147.01	556.10	3.78	292.14	351.56	204.54
105	0.4992	1863.830	1762.6	10.7	408.28	146.60	554.88	3.79	292.55	350.74	204.14
106	0.5105	1872.468	1771.2	10.9	409.17	146.16	555.33	3.80	292.99	350.75	204.59
107	0.5219	1875.539	1774.3	11.2	408.77	145.88	554.65	3.80	293.27	350.27	204.38
108	0.5332	1879.582	1778.3	11.4	408.58	145.72	554.30	3.80	293.43	350.01	204.29
109	0.5445	1885.943	1784.7	11.6	408.92	145.55	554.48	3.81	293.60	350.01	204.46
110	0.5558	1900.263	1799.0	11.9	411.08	145.38	556.46	3.83	293.77	350.92	205.54
111	0.5671	1909.241	1808.0	12.1	411.99	145.18	557.17	3.84	293.97	351.17	206.00
112	0.5785	1909.614	1808.4	12.4	410.94	145.01	555.95	3.83	294.14	350.48	205.47
113	0.5898	1914.216	1813.0	12.6	410.85	144.81	555.66	3.84	294.34	350.24	205.43
114	0.6011	1915.927	1814.7	12.9	410.10	144.68	554.78	3.83	294.47	349.73	205.05
115	0.6124	1917.836	1816.6	13.1	409.39	144.57	553.97	3.83	294.58	349.27	204.70
116	0.6237	1920.753	1819.5	13.3	408.91	144.38	553.29	3.83	294.77	348.83	204.45
117	0.6351	1926.660	1825.4	13.6	409.09	144.24	553.33	3.84	294.91	348.79	204.55
118	0.6464	1928.629	1827.4	13.8	408.38	143.97	552.35	3.84	295.18	348.16	204.19

Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
119	0.6577	1934.377	1833.1	14.1	408.52	144.04	552.56	3.84	295.11	348.30	204.26
120	0.6690	1941.731	1840.5	14.3	409.00	143.99	553.00	3.84	295.16	348.50	204.50
121	0.6803	1947.369	1846.1	14.5	409.10	143.92	553.02	3.84	295.23	348.47	204.55
122	0.6916	1953.742	1852.5	14.8	409.35	143.89	553.24	3.84	295.26	348.57	204.67
123	0.7030	1961.410	1860.2	15.0	409.87	143.77	553.64	3.85	295.38	348.71	204.94
124	0.7143	1970.684	1869.4	15.3	410.74	143.68	554.42	3.86	295.47	349.05	205.37
125	0.7256	1975.230	1874.0	15.5	410.57	143.53	554.10	3.86	295.62	348.82	205.28
126	0.7369	1981.351	1880.1	15.8	410.73	143.48	554.21	3.86	295.67	348.84	205.36
127	0.7482	1988.234	1887.0	16.0	411.05	143.34	554.38	3.87	295.81	348.86	205.52
128	0.7596	1995.781	1894.5	16.2	411.50	143.26	554.77	3.87	295.89	349.01	205.75
129	0.7709	2002.872	1901.6	16.5	411.85	143.26	555.11	3.87	295.89	349.18	205.93
130	0.7822	2005.417	1904.2	16.7	411.21	143.28	554.49	3.87	295.87	348.89	205.60
131	0.7935	2010.463	1909.2	17.0	411.10	143.16	554.25	3.87	295.99	348.71	205.55
132	0.8048	2016.819	1915.6	17.2	411.27	143.17	554.44	3.87	295.98	348.80	205.63
133	0.8161	2025.068	1923.8	17.4	411.83	142.96	554.79	3.88	296.19	348.88	205.91
134	0.8275	2034.720	1933.5	17.7	412.68	143.09	555.77	3.88	296.06	349.43	206.34
135	0.8388	2043.868	1942.6	17.9	413.42	143.16	556.58	3.89	295.99	349.87	206.71
136	0.8501	2044.066	1942.8	18.2	412.24	143.04	555.28	3.88	296.11	349.16	206.12
137	0.8614	2040.271	1939.0	18.4	410.22	143.03	553.24	3.87	296.12	348.14	205.11
138	0.8727	2047.691	1946.4	18.7	410.57	142.99	553.55	3.87	296.16	348.27	205.28
139	0.8841	2055.386	1954.1	18.9	410.96	143.03	553.99	3.87	296.12	348.51	205.48
140	0.8954	2061.753	1960.5	19.1	411.07	143.02	554.09	3.87	296.13	348.56	205.54
141	0.9061	2066.969	1965.7	19.4	411.00	143.00	554.00	3.87	296.15	348.50	205.50



	Total	Effective
C, psi	11.22	8.28
ϕ, deg	11.2	25.4
Tan(ϕ)	0.20	0.47



Specimen No.		1	2	3
Initial	Water Content, %	11.5	11.5	11.5
	Dry Density, pcf	98.7	98.9	95.9
	Saturation, %	43.9	44.1	41.0
	Void Ratio	0.7073	0.7046	0.7575
	Diameter, in.	2.40	2.40	2.40
	Height, in.	4.81	4.80	4.95
At Test	Water Content, %	24.2	21.4	20.6
	Dry Density, pcf	101.9	106.8	108.4
	Saturation, %	100.0	100.0	100.0
	Void Ratio	0.6544	0.5778	0.5552
	Diameter, in.	2.37	2.34	2.30
	Height, in.	4.76	4.68	4.75
Strain rate, %/min.		0.03	0.03	0.03
Eff. Cell Pressure, psi		50	150	301
Fail. Stress, psi		57	89	175
Excess Pore Pr., psi		30	107	202
Strain, %		4.6	3.6	2.9
Ult. Stress, psi				
Excess Pore Pr., psi				
Strain, %				
$\bar{\sigma}_1$ Failure, psi		77	133	274
$\bar{\sigma}_3$ Failure, psi		20	43	99

Type of Test:
CU with Pore Pressures

Sample Type: Remolded

Description: silty sand

LL= NP **PI=** NP

Assumed Specific Gravity= 2.7

Remarks: Failure tangents drawn at peak deviator stress.

Figure ________

Client:

Project: Yankee Doodle Impoundment Dam Site Investigation

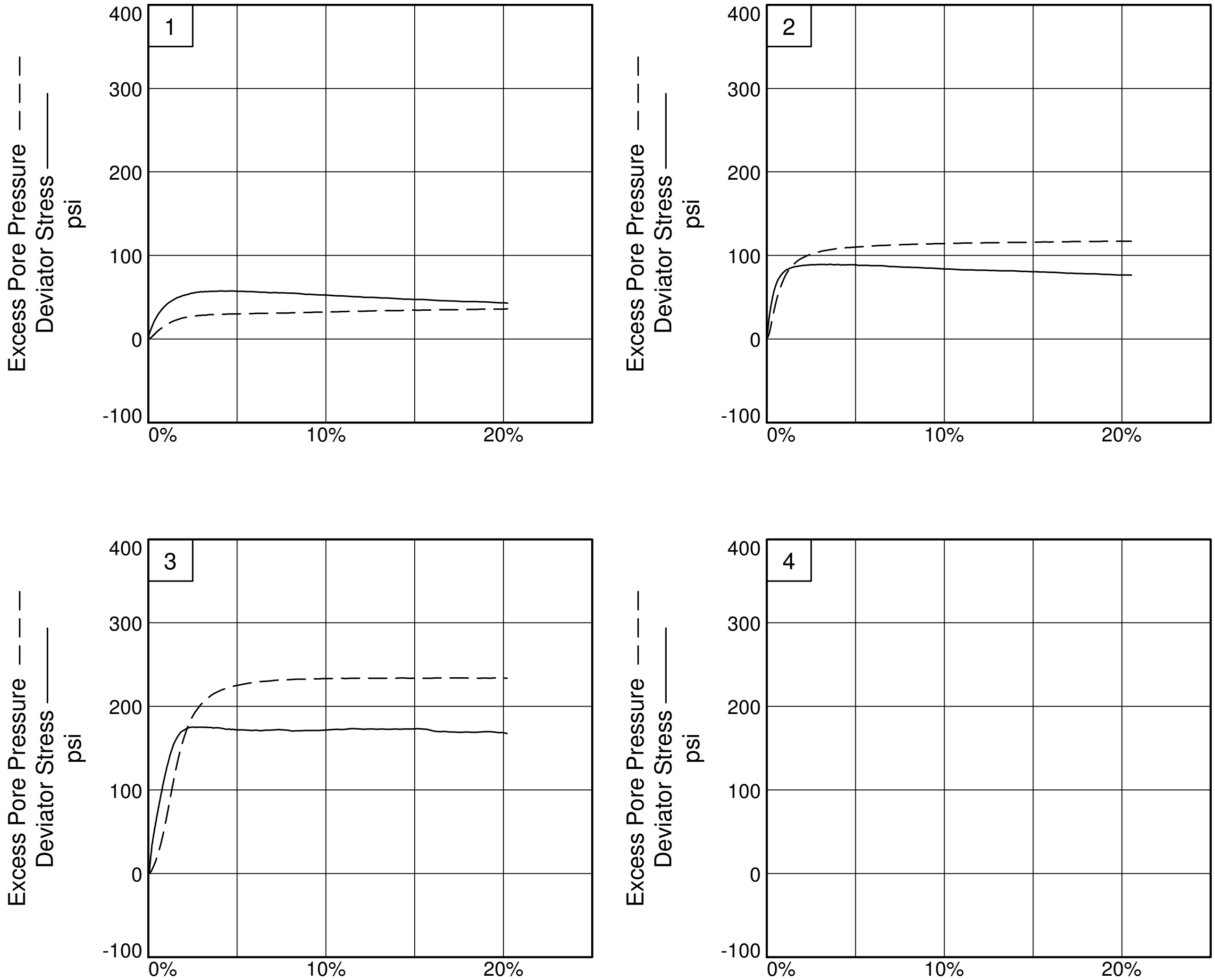
Location: DH15-S5

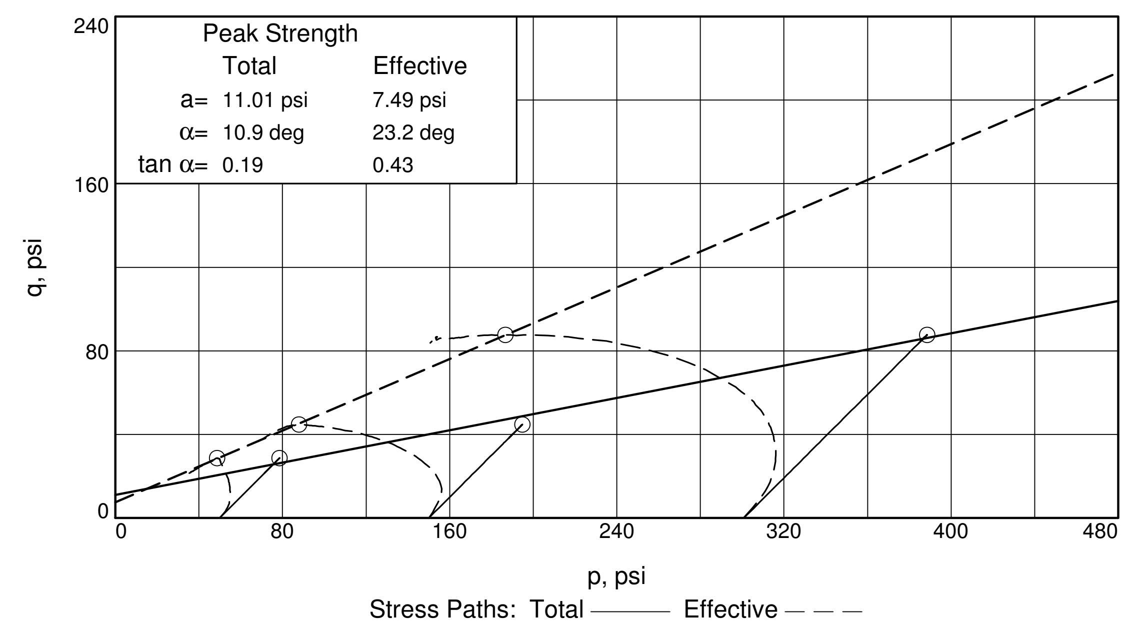
Sample Number: 27 **Depth:** 720-721

Proj. No.: 10100126.14 **Date Sampled:** 1/27/16

Knight Piésold
CONSULTING

Tested By: JHK **Checked By:** JDB





Client:

Project: Yankee Doodle Impoundment Dam Site Investigation

Location: DH15-S5 **Depth:** 720-721 **Sample Number:** 27

Project No.: 10100126.14 **Figure** ________

Knight Piesold Geotechnical Lab.

Tested By: JHK **Checked By:** JDB

Cursory interpretations provided require review by a professional engineer. Knight Piesold accepts no responsibility in subsequent analyses.

TRIAXIAL COMPRESSION TEST

CU with Pore Pressures

3/22/2017
1:33 PM

Date: 1/27/16
Client:
Project: Yankee Doodle Impoundment Dam Site Investigation
Project No.: 10100126.14
Location: DH15-S5
Depth: 720-721 **Sample Number:** 27
Description: silty sand
Remarks: Failure tangents drawn at peak deviator stress.
Type of Sample: Remolded
Assumed Specific Gravity=2.7 **LL=**NP **PL=** **PI=**NP
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	674.600			801.200
Moisture content: Dry soil+tare, gms.	620.300			706.600
Moisture content: Tare, gms.	148.400			144.230
Moisture, %	11.5	26.2	24.2	16.8
Moist specimen weight, gms.	628.4			
Diameter, in.	2.40	2.40	2.37	
Area, in.²	4.52	4.52	4.43	
Height, in.	4.81	4.81	4.76	
Net decrease in height, in.		0.00	0.05	
Wet density, pcf	110.1	124.6	126.6	
Dry density, pcf	98.7	98.7	101.9	
Void ratio	0.7073	0.7073	0.6544	
Saturation, %	43.9	100.0	100.0	

Test Readings for Specimen No. 1

Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.0635 cm
Consolidation cell pressure = 90.15 psi
Consolidation back pressure = 40.24 psi
Consolidation effective confining stress = 49.91 psi
Strain rate, %/min. = 0.03
Fail. Stress = 57.41 psi **at reading no.** 75

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
0	0.0529	2.800	0.0	0.0	0.00	49.91	49.91	1.00	40.24	49.91	0.00
1	0.0545	24.383	21.6	0.0	4.87	49.64	54.51	1.10	40.51	52.08	2.44
2	0.0557	31.973	29.2	0.1	6.58	49.37	55.96	1.13	40.78	52.67	3.29
3	0.0569	39.312	36.5	0.1	8.24	49.06	57.30	1.17	41.09	53.18	4.12
4	0.0581	46.225	43.4	0.1	9.79	48.72	58.51	1.20	41.43	53.62	4.90
5	0.0593	52.209	49.4	0.1	11.14	48.35	59.49	1.23	41.80	53.92	5.57
6	0.0606	58.509	55.7	0.2	12.56	47.93	60.48	1.26	42.22	54.21	6.28
7	0.0618	64.513	61.7	0.2	13.91	47.49	61.40	1.29	42.66	54.44	6.95
8	0.0630	69.393	66.6	0.2	15.00	46.99	61.99	1.32	43.16	54.49	7.50
9	0.0642	75.680	72.9	0.2	16.41	46.46	62.87	1.35	43.69	54.67	8.21
10	0.0654	80.791	78.0	0.3	17.56	45.97	63.53	1.38	44.18	54.75	8.78
11	0.0666	86.519	83.7	0.3	18.84	45.45	64.30	1.41	44.70	54.87	9.42
12	0.0678	91.719	88.9	0.3	20.01	44.93	64.94	1.45	45.22	54.94	10.01
13	0.0690	97.254	94.5	0.3	21.25	44.41	65.66	1.48	45.74	55.04	10.63
14	0.0702	101.800	99.0	0.4	22.27	43.85	66.12	1.51	46.30	54.99	11.13
15	0.0714	106.721	103.9	0.4	23.37	43.31	66.68	1.54	46.84	55.00	11.68
16	0.0726	111.482	108.7	0.4	24.43	42.80	67.24	1.57	47.35	55.02	12.22
17	0.0738	115.775	113.0	0.4	25.39	42.29	67.68	1.60	47.86	54.99	12.70
18	0.0750	119.434	116.6	0.5	26.21	41.80	68.00	1.63	48.35	54.90	13.10
19	0.0762	123.206	120.4	0.5	27.05	41.31	68.36	1.65	48.84	54.83	13.52
20	0.0774	127.726	124.9	0.5	28.06	40.81	68.87	1.69	49.34	54.84	14.03
21	0.0786	131.636	128.8	0.5	28.93	40.35	69.28	1.72	49.80	54.81	14.46
22	0.0798	135.570	132.8	0.6	29.80	39.89	69.69	1.75	50.26	54.79	14.90
23	0.0810	138.978	136.2	0.6	30.56	39.44	70.00	1.77	50.71	54.72	15.28
24	0.0822	143.081	140.3	0.6	31.47	38.99	70.46	1.81	51.16	54.73	15.74
25	0.0834	145.787	143.0	0.6	32.07	38.54	70.61	1.83	51.61	54.58	16.04
26	0.0846	149.164	146.4	0.7	32.82	38.09	70.91	1.86	52.06	54.50	16.41
27	0.0859	152.634	149.8	0.7	33.59	37.66	71.25	1.89	52.49	54.45	16.79
28	0.0871	155.204	152.4	0.7	34.16	37.22	71.37	1.92	52.93	54.30	17.08
29	0.0883	158.370	155.6	0.7	34.86	36.81	71.67	1.95	53.34	54.24	17.43
30	0.0895	161.700	158.9	0.8	35.59	36.41	72.00	1.98	53.74	54.21	17.80
31	0.0907	164.675	161.9	0.8	36.25	36.01	72.26	2.01	54.14	54.14	18.13
32	0.0919	167.648	164.8	0.8	36.91	35.64	72.55	2.04	54.51	54.09	18.45
33	0.0931	170.351	167.6	0.8	37.50	35.24	72.74	2.06	54.91	53.99	18.75
34	0.0943	172.972	170.2	0.9	38.08	34.85	72.93	2.09	55.30	53.89	19.04
35	0.0955	175.647	172.8	0.9	38.67	34.39	73.06	2.12	55.76	53.72	19.33
36	0.0967	177.655	174.9	0.9	39.11	34.00	73.11	2.15	56.15	53.55	19.55
37	0.0979	180.026	177.2	0.9	39.63	33.62	73.24	2.18	56.53	53.43	19.81
38	0.0991	182.520	179.7	1.0	40.18	33.28	73.46	2.21	56.87	53.37	20.09
39	0.1003	184.936	182.1	1.0	40.71	32.93	73.63	2.24	57.22	53.28	20.35
40	0.1015	186.776	184.0	1.0	41.11	32.61	73.72	2.26	57.54	53.16	20.55
41	0.1063	194.695	191.9	1.1	42.83	31.42	74.25	2.36	58.73	52.84	21.42
42	0.1111	201.859	199.1	1.2	44.39	30.30	74.69	2.46	59.85	52.49	22.19
43	0.1160	208.584	205.8	1.3	45.84	29.29	75.13	2.56	60.86	52.21	22.92
44	0.1208	214.409	211.6	1.4	47.09	28.20	75.29	2.67	61.95	51.75	23.54
45	0.1256	219.963	217.2	1.5	48.27	27.44	75.72	2.76	62.71	51.58	24.14
46	0.1304	224.762	222.0	1.6	49.29	26.69	75.98	2.85	63.46	51.33	24.64

Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
47	0.1352	229.240	226.4	1.7	50.23	26.06	76.29	2.93	64.09	51.18	25.12
48	0.1400	232.627	229.8	1.8	50.93	25.49	76.42	3.00	64.66	50.95	25.47
49	0.1449	236.879	234.1	1.9	51.82	24.79	76.61	3.09	65.36	50.70	25.91
50	0.1497	240.188	237.4	2.0	52.50	24.34	76.84	3.16	65.81	50.59	26.25
51	0.1545	243.058	240.3	2.1	53.08	23.92	77.00	3.22	66.23	50.46	26.54
52	0.1593	245.232	242.4	2.2	53.50	23.60	77.10	3.27	66.55	50.35	26.75
53	0.1641	248.076	245.3	2.3	54.07	23.28	77.35	3.32	66.87	50.32	27.04
54	0.1689	251.191	248.4	2.4	54.70	22.78	77.49	3.40	67.37	50.13	27.35
55	0.1737	252.566	249.8	2.5	54.95	22.58	77.53	3.43	67.57	50.05	27.48
56	0.1785	255.030	252.2	2.6	55.44	22.35	77.78	3.48	67.80	50.06	27.72
57	0.1833	257.079	254.3	2.7	55.83	22.16	77.99	3.52	67.99	50.07	27.91
58	0.1882	258.308	255.5	2.8	56.04	21.95	77.99	3.55	68.20	49.97	28.02
59	0.1930	260.721	257.9	2.9	56.51	21.63	78.14	3.61	68.52	49.88	28.25
60	0.1978	260.878	258.1	3.0	56.48	21.50	77.98	3.63	68.65	49.74	28.24
61	0.2026	262.271	259.5	3.1	56.73	21.37	78.10	3.66	68.78	49.73	28.37
62	0.2074	262.256	259.5	3.2	56.67	21.27	77.93	3.66	68.88	49.60	28.33
63	0.2122	262.762	260.0	3.4	56.72	21.15	77.87	3.68	69.00	49.51	28.36
64	0.2171	264.593	261.8	3.5	57.06	20.86	77.92	3.74	69.29	49.39	28.53
65	0.2219	264.706	261.9	3.6	57.02	20.81	77.84	3.74	69.34	49.32	28.51
66	0.2267	265.170	262.4	3.7	57.06	20.76	77.82	3.75	69.39	49.29	28.53
67	0.2315	265.431	262.6	3.8	57.06	20.68	77.74	3.76	69.47	49.21	28.53
68	0.2363	265.750	263.0	3.9	57.07	20.61	77.68	3.77	69.54	49.15	28.53
69	0.2411	266.780	264.0	4.0	57.23	20.40	77.63	3.81	69.75	49.02	28.62
70	0.2460	267.357	264.6	4.1	57.30	20.34	77.64	3.82	69.81	48.99	28.65
71	0.2508	267.691	264.9	4.2	57.31	20.33	77.64	3.82	69.82	48.98	28.65
72	0.2556	267.794	265.0	4.3	57.27	20.27	77.54	3.83	69.88	48.90	28.64
73	0.2604	267.108	264.3	4.4	57.06	20.28	77.34	3.81	69.87	48.81	28.53
74	0.2652	268.780	266.0	4.5	57.36	20.07	77.44	3.86	70.08	48.75	28.68
75	0.2700	269.279	266.5	4.6	57.41	20.06	77.47	3.86	70.09	48.77	28.70
76	0.2748	269.304	266.5	4.7	57.35	20.08	77.43	3.86	70.07	48.75	28.68
77	0.2796	269.058	266.3	4.8	57.24	20.03	77.28	3.86	70.12	48.66	28.62
78	0.2845	269.899	267.1	4.9	57.36	20.04	77.40	3.86	70.11	48.72	28.68
79	0.2893	269.453	266.7	5.0	57.20	19.81	77.02	3.89	70.34	48.41	28.60
80	0.2941	269.791	267.0	5.1	57.22	19.83	77.04	3.89	70.32	48.43	28.61
81	0.3061	269.345	266.5	5.3	56.97	19.77	76.74	3.88	70.38	48.26	28.48
82	0.3181	269.534	266.7	5.6	56.86	19.59	76.44	3.90	70.56	48.02	28.43
83	0.3302	268.910	266.1	5.8	56.57	19.57	76.14	3.89	70.58	47.85	28.29
84	0.3422	269.279	266.5	6.1	56.50	19.37	75.86	3.92	70.78	47.61	28.25
85	0.3542	268.188	265.4	6.3	56.11	19.34	75.45	3.90	70.81	47.40	28.06
86	0.3662	267.776	265.0	6.6	55.88	19.15	75.03	3.92	71.00	47.09	27.94
87	0.3783	266.108	263.3	6.8	55.37	19.10	74.48	3.90	71.05	46.79	27.69
88	0.3903	267.113	264.3	7.1	55.43	18.91	74.34	3.93	71.24	46.63	27.72
89	0.4023	266.887	264.1	7.3	55.24	18.91	74.14	3.92	71.24	46.52	27.62
90	0.4144	267.669	264.9	7.6	55.25	18.75	73.99	3.95	71.40	46.37	27.62
91	0.4264	266.632	263.8	7.9	54.88	18.71	73.59	3.93	71.44	46.15	27.44
92	0.4384	267.163	264.4	8.1	54.84	18.48	73.32	3.97	71.67	45.90	27.42
93	0.4505	265.691	262.9	8.4	54.39	18.47	72.86	3.94	71.68	45.66	27.19

Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
94	0.4625	264.578	261.8	8.6	54.01	18.23	72.23	3.96	71.92	45.23	27.00
95	0.4745	263.349	260.5	8.9	53.60	18.18	71.79	3.95	71.97	44.99	26.80
96	0.4865	263.215	260.4	9.1	53.43	17.98	71.41	3.97	72.17	44.70	26.71
97	0.4986	261.655	258.9	9.4	52.96	17.93	70.89	3.95	72.22	44.41	26.48
98	0.5106	261.807	259.0	9.6	52.84	17.74	70.58	3.98	72.41	44.16	26.42
99	0.5226	261.224	258.4	9.9	52.58	17.65	70.22	3.98	72.50	43.94	26.29
100	0.5347	260.197	257.4	10.1	52.22	17.53	69.75	3.98	72.62	43.64	26.11
101	0.5467	260.264	257.5	10.4	52.09	17.35	69.44	4.00	72.80	43.40	26.04
102	0.5587	259.079	256.3	10.6	51.70	17.27	68.97	3.99	72.88	43.12	25.85
103	0.5707	259.097	256.3	10.9	51.56	17.06	68.62	4.02	73.09	42.84	25.78
104	0.5828	257.860	255.1	11.1	51.16	17.10	68.26	3.99	73.05	42.68	25.58
105	0.5948	257.030	254.2	11.4	50.85	16.85	67.70	4.02	73.30	42.27	25.43
106	0.6068	256.469	253.7	11.6	50.60	16.89	67.49	3.99	73.26	42.19	25.30
107	0.6189	256.224	253.4	11.9	50.40	16.70	67.11	4.02	73.45	41.90	25.20
108	0.6309	254.480	251.7	12.2	49.91	16.68	66.59	3.99	73.47	41.64	24.96
109	0.6429	255.521	252.7	12.4	49.97	16.40	66.38	4.05	73.75	41.39	24.99
110	0.6550	254.721	251.9	12.7	49.67	16.40	66.07	4.03	73.75	41.23	24.84
111	0.6670	254.279	251.5	12.9	49.44	16.13	65.57	4.07	74.02	40.85	24.72
112	0.6790	254.130	251.3	13.2	49.27	16.16	65.42	4.05	73.99	40.79	24.63
113	0.6910	253.067	250.3	13.4	48.92	15.91	64.83	4.07	74.24	40.37	24.46
114	0.7031	252.279	249.5	13.7	48.62	16.03	64.65	4.03	74.12	40.34	24.31
115	0.7151	251.242	248.4	13.9	48.28	15.86	64.13	4.04	74.29	39.99	24.14
116	0.7271	250.462	247.7	14.2	47.98	15.85	63.83	4.03	74.30	39.84	23.99
117	0.7392	250.284	247.5	14.4	47.81	15.61	63.42	4.06	74.54	39.52	23.90
118	0.7512	249.812	247.0	14.7	47.58	15.62	63.20	4.05	74.53	39.41	23.79
119	0.7632	248.544	245.7	14.9	47.19	15.38	62.57	4.07	74.77	38.98	23.60
120	0.7753	249.253	246.5	15.2	47.19	15.49	62.68	4.05	74.66	39.09	23.59
121	0.7873	250.132	247.3	15.4	47.21	15.35	62.57	4.08	74.80	38.96	23.61
122	0.7993	249.266	246.5	15.7	46.91	15.43	62.34	4.04	74.72	38.88	23.45
123	0.8114	248.113	245.3	15.9	46.55	15.26	61.80	4.05	74.89	38.53	23.27
124	0.8234	247.188	244.4	16.2	46.23	15.23	61.46	4.04	74.92	38.34	23.12
125	0.8354	246.652	243.9	16.5	45.99	15.03	61.02	4.06	75.12	38.03	23.00
126	0.8475	245.833	243.0	16.7	45.70	15.01	60.71	4.04	75.14	37.86	22.85
127	0.8595	245.793	243.0	17.0	45.55	14.84	60.39	4.07	75.31	37.62	22.78
128	0.8715	245.355	242.6	17.2	45.33	14.91	60.24	4.04	75.24	37.57	22.67
129	0.8835	245.582	242.8	17.5	45.24	14.80	60.03	4.06	75.35	37.42	22.62
130	0.8956	244.470	241.7	17.7	44.89	14.83	59.72	4.03	75.32	37.27	22.45
131	0.9076	245.116	242.3	18.0	44.87	14.69	59.56	4.06	75.46	37.12	22.44
132	0.9196	245.221	242.4	18.2	44.75	14.51	59.26	4.08	75.64	36.89	22.38
133	0.9317	245.091	242.3	18.5	44.59	14.45	59.04	4.09	75.70	36.75	22.30
134	0.9437	244.975	242.2	18.7	44.43	14.22	58.65	4.12	75.93	36.44	22.22
135	0.9557	245.385	242.6	19.0	44.37	14.30	58.67	4.10	75.85	36.49	22.18
136	0.9678	244.128	241.3	19.2	44.00	14.14	58.14	4.11	76.01	36.14	22.00
137	0.9798	242.522	239.7	19.5	43.57	14.29	57.86	4.05	75.86	36.07	21.79
138	0.9918	242.538	239.7	19.7	43.44	14.12	57.55	4.08	76.03	35.84	21.72
139	1.0038	241.994	239.2	20.0	43.20	14.15	57.35	4.05	76.00	35.75	21.60
140	1.0151	241.440	238.6	20.2	42.97	13.92	56.89	4.09	76.23	35.41	21.49

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	674.600			779.800
Moisture content: Dry soil+tare, gms.	620.300			692.900
Moisture content: Tare, gms.	148.400			160.800
Moisture, %	11.5	26.1	21.4	16.3
Moist specimen weight, gms.	628.5			
Diameter, in.	2.40	2.40	2.34	
Area, in.²	4.52	4.52	4.30	
Height, in.	4.80	4.80	4.68	
Net decrease in height, in.		0.00	0.12	
Wet density, pcf	110.3	124.7	129.7	
Dry density, pcf	98.9	98.9	106.8	
Void ratio	0.7046	0.7046	0.5778	
Saturation, %	44.1	100.0	100.0	

Test Readings for Specimen No. 2

Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.0635 cm
Consolidation cell pressure = 190.31 psi
Consolidation back pressure = 40.26 psi
Consolidation effective confining stress = 150.05 psi
Strain rate, %/min. = 0.03
Fail. Stress = 89.40 psi **at reading no.** 65

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
0	0.0439	1.400	0.0	0.0	0.00	150.05	150.05	1.00	40.26	150.05	0.00
1	0.0451	24.750	23.3	0.0	5.43	149.23	154.66	1.04	41.08	151.94	2.72
2	0.0463	41.140	39.7	0.1	9.25	148.21	157.45	1.06	42.10	152.83	4.62
3	0.0475	62.492	61.1	0.1	14.21	147.07	161.28	1.10	43.24	154.18	7.11
4	0.0487	84.464	83.1	0.1	19.32	145.82	165.14	1.13	44.49	155.48	9.66
5	0.0499	104.067	102.7	0.1	23.87	144.18	168.05	1.17	46.13	156.11	11.93
6	0.0511	121.825	120.4	0.2	27.99	142.14	170.13	1.20	48.17	156.14	13.99
7	0.0523	137.605	136.2	0.2	31.65	139.89	171.53	1.23	50.42	155.71	15.82
8	0.0535	152.516	151.1	0.2	35.11	137.55	172.65	1.26	52.76	155.10	17.55
9	0.0547	166.381	165.0	0.2	38.32	135.10	173.42	1.28	55.21	154.26	19.16
10	0.0559	180.416	179.0	0.3	41.57	132.56	174.12	1.31	57.75	153.34	20.78
11	0.0571	193.215	191.8	0.3	44.53	129.93	174.46	1.34	60.38	152.19	22.26
12	0.0583	205.805	204.4	0.3	47.44	127.22	174.66	1.37	63.09	150.94	23.72
13	0.0595	217.058	215.7	0.3	50.03	124.49	174.52	1.40	65.82	149.50	25.02
14	0.0607	227.306	225.9	0.4	52.40	121.81	174.21	1.43	68.50	148.01	26.20
15	0.0619	237.505	236.1	0.4	54.75	119.19	173.94	1.46	71.12	146.57	27.37
16	0.0631	246.806	245.4	0.4	56.89	116.60	173.50	1.49	73.71	145.05	28.45
17	0.0643	256.007	254.6	0.4	59.01	114.07	173.08	1.52	76.24	143.58	29.50
18	0.0655	264.134	262.7	0.5	60.88	111.62	172.50	1.55	78.69	142.06	30.44
19	0.0667	271.610	270.2	0.5	62.59	109.27	171.86	1.57	81.04	140.56	31.30
20	0.0679	278.585	277.2	0.5	64.19	107.05	171.24	1.60	83.26	139.14	32.10
21	0.0691	285.192	283.8	0.5	65.71	104.82	170.52	1.63	85.49	137.67	32.85
22	0.0703	291.337	289.9	0.6	67.11	102.69	169.80	1.65	87.62	136.24	33.56
23	0.0715	297.275	295.9	0.6	68.47	100.63	169.10	1.68	89.68	134.87	34.23
24	0.0727	302.946	301.5	0.6	69.76	98.68	168.44	1.71	91.63	133.56	34.88

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
25	0.0740	308.565	307.2	0.6	71.04	96.76	167.80	1.73	93.55	132.28	35.52
26	0.0752	312.261	310.9	0.7	71.88	94.93	166.81	1.76	95.38	130.87	35.94
27	0.0764	316.606	315.2	0.7	72.87	93.22	166.08	1.78	97.09	129.65	36.43
28	0.0776	320.714	319.3	0.7	73.80	91.53	165.33	1.81	98.78	128.43	36.90
29	0.0788	324.794	323.4	0.7	74.72	89.87	164.59	1.83	100.44	127.23	37.36
30	0.0800	328.390	327.0	0.8	75.53	88.26	163.79	1.86	102.05	126.03	37.77
31	0.0812	332.031	330.6	0.8	76.35	86.75	163.10	1.88	103.56	124.92	38.18
32	0.0824	335.171	333.8	0.8	77.06	85.30	162.35	1.90	105.01	123.82	38.53
33	0.0836	338.015	336.6	0.8	77.69	83.90	161.59	1.93	106.41	122.75	38.85
34	0.0848	340.470	339.1	0.9	78.24	82.56	160.80	1.95	107.75	121.68	39.12
35	0.0860	342.787	341.4	0.9	78.75	81.30	160.06	1.97	109.01	120.68	39.38
36	0.0872	346.075	344.7	0.9	79.49	80.04	159.53	1.99	110.27	119.78	39.75
37	0.0884	348.159	346.8	1.0	79.95	78.82	158.77	2.01	111.49	118.79	39.98
38	0.0896	350.942	349.5	1.0	80.57	77.59	158.16	2.04	112.72	117.87	40.29
39	0.0908	353.301	351.9	1.0	81.10	76.47	157.57	2.06	113.84	117.02	40.55
40	0.0920	354.816	353.4	1.0	81.42	75.40	156.82	2.08	114.91	116.11	40.71
41	0.0968	361.854	360.5	1.1	82.96	71.48	154.44	2.16	118.83	112.96	41.48
42	0.1016	365.890	364.5	1.2	83.80	68.03	151.83	2.23	122.28	109.93	41.90
43	0.1064	370.899	369.5	1.3	84.86	65.15	150.01	2.30	125.16	107.58	42.43
44	0.1112	374.534	373.1	1.4	85.61	62.67	148.28	2.37	127.64	105.47	42.81
45	0.1160	378.367	377.0	1.5	86.40	60.33	146.73	2.43	129.98	103.53	43.20
46	0.1208	380.371	379.0	1.6	86.77	58.39	145.16	2.49	131.92	101.77	43.38
47	0.1256	381.983	380.6	1.7	87.05	56.63	143.68	2.54	133.68	100.16	43.52
48	0.1304	384.360	383.0	1.8	87.50	55.09	142.59	2.59	135.22	98.84	43.75
49	0.1352	385.660	384.3	2.0	87.70	53.68	141.39	2.63	136.63	97.53	43.85
50	0.1400	387.148	385.7	2.1	87.95	52.48	140.43	2.68	137.83	96.46	43.98
51	0.1448	388.342	386.9	2.2	88.13	51.45	139.58	2.71	138.86	95.51	44.07
52	0.1496	389.677	388.3	2.3	88.34	50.37	138.71	2.75	139.94	94.54	44.17
53	0.1544	390.515	389.1	2.4	88.44	49.49	137.93	2.79	140.82	93.71	44.22
54	0.1593	392.052	390.7	2.5	88.70	48.69	137.38	2.82	141.62	93.03	44.35
55	0.1641	393.155	391.8	2.6	88.85	47.96	136.81	2.85	142.35	92.39	44.43
56	0.1689	394.051	392.7	2.7	88.96	47.27	136.23	2.88	143.04	91.75	44.48
57	0.1737	394.630	393.2	2.8	89.00	46.62	135.62	2.91	143.69	91.12	44.50
58	0.1785	396.154	394.8	2.9	89.25	46.17	135.42	2.93	144.14	90.79	44.62
59	0.1833	395.751	394.4	3.0	89.06	45.55	134.61	2.96	144.76	90.08	44.53
60	0.1881	397.197	395.8	3.1	89.30	45.04	134.34	2.98	145.27	89.69	44.65
61	0.1929	396.876	395.5	3.2	89.13	44.64	133.77	3.00	145.67	89.21	44.56
62	0.1977	396.880	395.5	3.3	89.04	44.21	133.24	3.01	146.10	88.73	44.52
63	0.2025	397.121	395.7	3.4	89.00	43.79	132.79	3.03	146.52	88.29	44.50
64	0.2073	398.776	397.4	3.5	89.27	43.45	132.72	3.05	146.86	88.09	44.64
65	0.2121	399.788	398.4	3.6	89.40	43.18	132.59	3.07	147.13	87.89	44.70
66	0.2169	398.382	397.0	3.7	88.99	42.78	131.77	3.08	147.53	87.27	44.50
67	0.2217	398.665	397.3	3.8	88.96	42.50	131.47	3.09	147.81	86.99	44.48
68	0.2265	399.220	397.8	3.9	88.99	42.23	131.22	3.11	148.08	86.72	44.50
69	0.2313	400.158	398.8	4.0	89.11	41.99	131.10	3.12	148.32	86.55	44.55
70	0.2361	399.144	397.7	4.1	88.78	41.67	130.45	3.13	148.64	86.06	44.39
71	0.2409	398.703	397.3	4.2	88.59	41.44	130.03	3.14	148.87	85.73	44.30

Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
72	0.2457	399.529	398.1	4.3	88.68	41.27	129.95	3.15	149.04	85.61	44.34
73	0.2505	399.780	398.4	4.4	88.64	40.98	129.63	3.16	149.33	85.31	44.32
74	0.2553	400.538	399.1	4.5	88.71	40.80	129.52	3.17	149.51	85.16	44.36
75	0.2601	401.041	399.6	4.6	88.73	40.59	129.32	3.19	149.72	84.96	44.37
76	0.2649	402.111	400.7	4.7	88.87	40.50	129.37	3.19	149.81	84.94	44.44
77	0.2697	402.865	401.5	4.8	88.94	40.35	129.29	3.20	149.96	84.82	44.47
78	0.2745	402.916	401.5	4.9	88.86	40.10	128.96	3.22	150.21	84.53	44.43
79	0.2793	402.486	401.1	5.0	88.67	39.97	128.64	3.22	150.34	84.31	44.33
80	0.2842	401.026	399.6	5.1	88.25	39.78	128.03	3.22	150.53	83.90	44.12
81	0.2962	401.471	400.1	5.4	88.11	39.41	127.52	3.24	150.90	83.46	44.05
82	0.3082	401.789	400.4	5.6	87.94	39.07	127.01	3.25	151.24	83.04	43.97
83	0.3202	402.794	401.4	5.9	87.92	38.77	126.69	3.27	151.54	82.73	43.96
84	0.3322	403.846	402.4	6.2	87.91	38.53	126.44	3.28	151.78	82.48	43.96
85	0.3442	403.524	402.1	6.4	87.60	38.20	125.80	3.29	152.11	82.00	43.80
86	0.3562	403.173	401.8	6.7	87.28	37.92	125.21	3.30	152.39	81.57	43.64
87	0.3682	401.917	400.5	6.9	86.77	37.69	124.46	3.30	152.62	81.07	43.39
88	0.3802	402.197	400.8	7.2	86.59	37.52	124.12	3.31	152.79	80.82	43.30
89	0.3922	401.206	399.8	7.4	86.14	37.30	123.44	3.31	153.01	80.37	43.07
90	0.4042	401.894	400.5	7.7	86.05	37.13	123.18	3.32	153.18	80.15	43.02
91	0.4162	401.879	400.5	8.0	85.81	36.95	122.75	3.32	153.36	79.85	42.90
92	0.4282	402.069	400.7	8.2	85.61	36.79	122.40	3.33	153.52	79.59	42.80
93	0.4402	402.451	401.1	8.5	85.45	36.63	122.08	3.33	153.68	79.36	42.73
94	0.4522	402.589	401.2	8.7	85.24	36.50	121.74	3.34	153.81	79.12	42.62
95	0.4642	402.290	400.9	9.0	84.94	36.35	121.29	3.34	153.96	78.82	42.47
96	0.4763	402.949	401.5	9.2	84.84	36.21	121.05	3.34	154.10	78.63	42.42
97	0.4883	402.101	400.7	9.5	84.42	36.05	120.46	3.34	154.26	78.26	42.21
98	0.5003	401.936	400.5	9.8	84.14	35.95	120.10	3.34	154.36	78.03	42.07
99	0.5123	401.150	399.7	10.0	83.74	35.80	119.54	3.34	154.51	77.67	41.87
100	0.5243	401.718	400.3	10.3	83.62	35.70	119.32	3.34	154.61	77.51	41.81
101	0.5363	401.542	400.1	10.5	83.34	35.61	118.95	3.34	154.70	77.28	41.67
102	0.5483	401.164	399.8	10.8	83.03	35.53	118.56	3.34	154.78	77.05	41.51
103	0.5603	400.461	399.1	11.0	82.64	35.36	118.01	3.34	154.95	76.68	41.32
104	0.5723	401.244	399.8	11.3	82.57	35.26	117.83	3.34	155.05	76.55	41.28
105	0.5843	402.192	400.8	11.6	82.52	35.17	117.69	3.35	155.14	76.43	41.26
106	0.5963	403.225	401.8	11.8	82.49	35.07	117.57	3.35	155.24	76.32	41.25
107	0.6083	404.195	402.8	12.1	82.45	35.10	117.55	3.35	155.21	76.33	41.23
108	0.6203	404.096	402.7	12.3	82.19	35.01	117.20	3.35	155.30	76.10	41.10
109	0.6323	404.176	402.8	12.6	81.97	34.86	116.83	3.35	155.45	75.84	40.98
110	0.6443	405.238	403.8	12.8	81.94	34.81	116.76	3.35	155.50	75.79	40.97
111	0.6564	405.291	403.9	13.1	81.71	34.67	116.38	3.36	155.64	75.53	40.86
112	0.6684	406.641	405.2	13.3	81.74	34.50	116.24	3.37	155.81	75.37	40.87
113	0.6804	406.683	405.3	13.6	81.51	34.39	115.90	3.37	155.92	75.15	40.76
114	0.6924	407.493	406.1	13.9	81.43	34.41	115.84	3.37	155.90	75.12	40.72
115	0.7044	407.090	405.7	14.1	81.11	34.42	115.53	3.36	155.89	74.97	40.55
116	0.7164	407.090	405.7	14.4	80.87	34.39	115.26	3.35	155.92	74.82	40.43
117	0.7284	407.859	406.5	14.6	80.78	34.35	115.13	3.35	155.96	74.74	40.39
118	0.7404	408.485	407.1	14.9	80.66	34.25	114.90	3.36	156.06	74.57	40.33

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
119	0.7524	409.034	407.6	15.1	80.52	34.07	114.59	3.36	156.24	74.33	40.26
120	0.7644	408.963	407.6	15.4	80.27	33.99	114.25	3.36	156.32	74.12	40.13
121	0.7764	409.650	408.3	15.7	80.16	33.92	114.07	3.36	156.39	73.99	40.08
122	0.7884	409.409	408.0	15.9	79.87	33.95	113.81	3.35	156.36	73.88	39.93
123	0.8004	410.119	408.7	16.2	79.76	33.87	113.63	3.36	156.44	73.75	39.88
124	0.8124	409.579	408.2	16.4	79.41	33.83	113.24	3.35	156.48	73.54	39.71
125	0.8244	409.797	408.4	16.7	79.21	33.74	112.95	3.35	156.57	73.34	39.60
126	0.8364	409.147	407.7	16.9	78.84	33.67	112.51	3.34	156.64	73.09	39.42
127	0.8484	409.176	407.8	17.2	78.60	33.54	112.14	3.34	156.77	72.84	39.30
128	0.8604	409.275	407.9	17.5	78.38	33.44	111.82	3.34	156.87	72.63	39.19
129	0.8724	410.394	409.0	17.7	78.35	33.36	111.71	3.35	156.95	72.54	39.17
130	0.8844	410.157	408.8	18.0	78.06	33.42	111.47	3.34	156.89	72.44	39.03
131	0.8964	411.402	410.0	18.2	78.05	33.41	111.46	3.34	156.90	72.44	39.03
132	0.9085	411.701	410.3	18.5	77.86	33.33	111.20	3.34	156.98	72.26	38.93
133	0.9205	411.710	410.3	18.7	77.62	33.29	110.91	3.33	157.02	72.10	38.81
134	0.9325	411.748	410.3	19.0	77.38	33.21	110.60	3.33	157.10	71.91	38.69
135	0.9445	411.672	410.3	19.2	77.12	33.07	110.19	3.33	157.24	71.63	38.56
136	0.9565	412.200	410.8	19.5	76.98	33.01	109.99	3.33	157.30	71.50	38.49
137	0.9685	411.852	410.5	19.8	76.67	32.88	109.55	3.33	157.43	71.21	38.33
138	0.9805	412.943	411.5	20.0	76.62	32.93	109.56	3.33	157.38	71.25	38.31
139	0.9925	413.184	411.8	20.3	76.42	32.89	109.32	3.32	157.42	71.10	38.21
140	1.0045	414.629	413.2	20.5	76.44	32.88	109.33	3.32	157.43	71.10	38.22
141	1.0046	413.847	412.4	20.5	76.30	32.87	109.17	3.32	157.44	71.02	38.15

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	674.600			781.000
Moisture content: Dry soil+tare, gms.	620.300			702.700
Moisture content: Tare, gms.	148.400			143.570
Moisture, %	11.5	28.1	20.6	14.0
Moist specimen weight, gms.	628.5			
Diameter, in.	2.40	2.40	2.30	
Area, in.²	4.52	4.52	4.17	
Height, in.	4.95	4.95	4.75	
Net decrease in height, in.		0.00	0.20	
Wet density, pcf	106.9	122.8	130.7	
Dry density, pcf	95.9	95.9	108.4	
Void ratio	0.7575	0.7575	0.5552	
Saturation, %	41.0	100.0	100.0	

Test Readings for Specimen No. 3

Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.0635 cm
Consolidation cell pressure = 340.82 psi
Consolidation back pressure = 39.98 psi
Consolidation effective confining stress = 300.84 psi
Strain rate, %/min. = 0.03
Fail. Stress = 175.29 psi **at reading no.** 59

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
0	0.1868	9.700	0.0	0.0	0.00	300.84	300.84	1.00	39.98	300.84	0.00
1	0.1885	12.299	2.6	0.0	0.62	300.65	301.28	1.00	40.17	300.97	0.31
2	0.1897	20.807	11.1	0.1	2.66	300.49	303.15	1.01	40.33	301.82	1.33
3	0.1909	48.442	38.7	0.1	9.29	300.15	309.43	1.03	40.67	304.79	4.64
4	0.1921	73.615	63.9	0.1	15.32	299.64	314.96	1.05	41.18	307.30	7.66
5	0.1933	96.716	87.0	0.1	20.85	298.91	319.76	1.07	41.91	309.33	10.43
6	0.1945	117.036	107.3	0.2	25.71	298.14	323.85	1.09	42.68	311.00	12.86
7	0.1957	135.125	125.4	0.2	30.04	297.19	327.23	1.10	43.63	312.21	15.02
8	0.1969	152.691	143.0	0.2	34.24	296.16	330.39	1.12	44.66	313.28	17.12
9	0.1981	166.349	156.6	0.2	37.50	295.06	332.56	1.13	45.76	313.81	18.75
10	0.1993	181.409	171.7	0.3	41.09	293.91	335.01	1.14	46.91	314.46	20.55
11	0.2005	195.700	186.0	0.3	44.50	292.74	337.25	1.15	48.08	315.00	22.25
12	0.2017	209.369	199.7	0.3	47.76	291.50	339.26	1.16	49.32	315.38	23.88
13	0.2029	222.742	213.0	0.3	50.95	290.21	341.15	1.18	50.61	315.68	25.47
14	0.2041	236.944	227.2	0.4	54.33	288.85	343.18	1.19	51.97	316.01	27.17
15	0.2053	248.244	238.5	0.4	57.02	287.42	344.44	1.20	53.40	315.93	28.51
16	0.2065	262.529	252.8	0.4	60.42	285.97	346.39	1.21	54.85	316.18	30.21
17	0.2077	274.649	264.9	0.4	63.30	284.44	347.74	1.22	56.38	316.09	31.65
18	0.2089	287.576	277.9	0.5	66.37	282.85	349.22	1.23	57.97	316.04	33.18
19	0.2101	300.762	291.1	0.5	69.50	281.21	350.72	1.25	59.61	315.96	34.75
20	0.2113	311.776	302.1	0.5	72.11	279.53	351.64	1.26	61.29	315.58	36.06
21	0.2125	323.846	314.1	0.5	74.97	277.77	352.74	1.27	63.05	315.25	37.49
22	0.2137	336.752	327.1	0.6	78.03	275.97	354.01	1.28	64.85	314.99	39.02
23	0.2149	348.338	338.6	0.6	80.78	274.12	354.90	1.29	66.70	314.51	40.39
24	0.2161	360.523	350.8	0.6	83.66	272.23	355.89	1.31	68.59	314.06	41.83

Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
25	0.2173	373.253	363.6	0.6	86.68	270.27	356.95	1.32	70.55	313.61	43.34
26	0.2185	384.289	374.6	0.7	89.29	268.24	357.52	1.33	72.58	312.88	44.64
27	0.2198	398.244	388.5	0.7	92.59	266.14	358.73	1.35	74.68	312.44	46.29
28	0.2210	407.874	398.2	0.7	94.86	264.01	358.87	1.36	76.81	311.44	47.43
29	0.2222	419.636	409.9	0.7	97.64	261.85	359.49	1.37	78.97	310.67	48.82
30	0.2234	431.448	421.7	0.8	100.42	259.60	360.02	1.39	81.22	309.81	50.21
31	0.2246	443.072	433.4	0.8	103.17	257.28	360.45	1.40	83.54	308.86	51.58
32	0.2258	454.136	444.4	0.8	105.77	254.87	360.64	1.42	85.95	307.75	52.89
33	0.2270	464.464	454.8	0.8	108.20	252.42	360.63	1.43	88.40	306.52	54.10
34	0.2282	477.391	467.7	0.9	111.25	249.92	361.17	1.45	90.90	305.54	55.63
35	0.2294	487.197	477.5	0.9	113.55	247.36	360.91	1.46	93.46	304.14	56.78
36	0.2306	497.002	487.3	0.9	115.86	244.82	360.67	1.47	96.00	302.74	57.93
37	0.2318	507.665	498.0	0.9	118.36	242.22	360.59	1.49	98.60	301.40	59.18
38	0.2330	516.970	507.3	1.0	120.54	239.57	360.12	1.50	101.25	299.85	60.27
39	0.2342	526.974	517.3	1.0	122.89	236.95	359.83	1.52	103.87	298.39	61.44
40	0.2354	537.746	528.0	1.0	125.41	234.28	359.69	1.54	106.54	296.98	62.71
41	0.2402	571.912	562.2	1.1	133.39	223.20	356.59	1.60	117.62	289.89	66.70
42	0.2450	608.473	598.8	1.2	141.92	211.55	353.48	1.67	129.27	282.52	70.96
43	0.2498	636.724	627.0	1.3	148.47	200.15	348.61	1.74	140.67	274.38	74.23
44	0.2546	664.288	654.6	1.4	154.83	188.77	343.61	1.82	152.05	266.19	77.42
45	0.2594	683.838	674.1	1.5	159.29	178.12	337.41	1.89	162.70	257.76	79.65
46	0.2642	701.251	691.6	1.6	163.24	168.27	331.51	1.97	172.55	249.89	81.62
47	0.2690	715.404	705.7	1.7	166.41	158.87	325.28	2.05	181.95	242.07	83.21
48	0.2738	728.315	718.6	1.8	169.28	150.50	319.78	2.12	190.32	235.14	84.64
49	0.2787	735.482	725.8	1.9	170.79	142.85	313.65	2.20	197.97	228.25	85.40
50	0.2835	741.176	731.5	2.0	171.96	136.07	308.03	2.26	204.75	222.05	85.98
51	0.2883	748.123	738.4	2.1	173.41	129.99	303.40	2.33	210.83	216.69	86.70
52	0.2931	751.680	742.0	2.2	174.06	124.63	298.69	2.40	216.19	211.66	87.03
53	0.2979	755.417	745.7	2.3	174.76	119.74	294.50	2.46	221.08	207.12	87.38
54	0.3027	757.352	747.7	2.4	175.03	115.25	290.28	2.52	225.57	202.76	87.52
55	0.3075	759.045	749.3	2.5	175.25	111.28	286.53	2.57	229.54	198.91	87.62
56	0.3123	759.616	749.9	2.6	175.20	107.76	282.95	2.63	233.06	195.35	87.60
57	0.3171	758.588	748.9	2.7	174.78	104.56	279.34	2.67	236.26	191.95	87.39
58	0.3219	761.381	751.7	2.8	175.25	101.74	276.98	2.72	239.08	189.36	87.62
59	0.3267	762.370	752.7	2.9	175.29	99.11	274.40	2.77	241.71	186.75	87.65
60	0.3315	763.002	753.3	3.0	175.26	96.68	271.94	2.81	244.14	184.31	87.63
61	0.3363	762.452	752.8	3.1	174.95	94.52	269.47	2.85	246.30	182.00	87.47
62	0.3411	763.881	754.2	3.2	175.10	92.55	267.65	2.89	248.27	180.10	87.55
63	0.3460	763.947	754.2	3.3	174.93	90.71	265.64	2.93	250.11	178.17	87.46
64	0.3507	764.739	755.0	3.4	174.93	89.04	263.97	2.96	251.78	176.51	87.47
65	0.3556	764.700	755.0	3.5	174.74	87.45	262.19	3.00	253.37	174.82	87.37
66	0.3604	763.293	753.6	3.7	174.23	86.09	260.32	3.02	254.73	173.20	87.11
67	0.3652	764.981	755.3	3.8	174.44	84.81	259.24	3.06	256.01	172.03	87.22
68	0.3700	765.008	755.3	3.9	174.26	83.73	257.99	3.08	257.09	170.86	87.13
69	0.3748	765.866	756.2	4.0	174.27	82.78	257.06	3.11	258.04	169.92	87.14
70	0.3796	765.448	755.7	4.1	173.99	81.83	255.82	3.13	258.99	168.82	87.00
71	0.3844	765.294	755.6	4.2	173.78	80.97	254.75	3.15	259.85	167.86	86.89

Knight Piesold Geotechnical Lab.

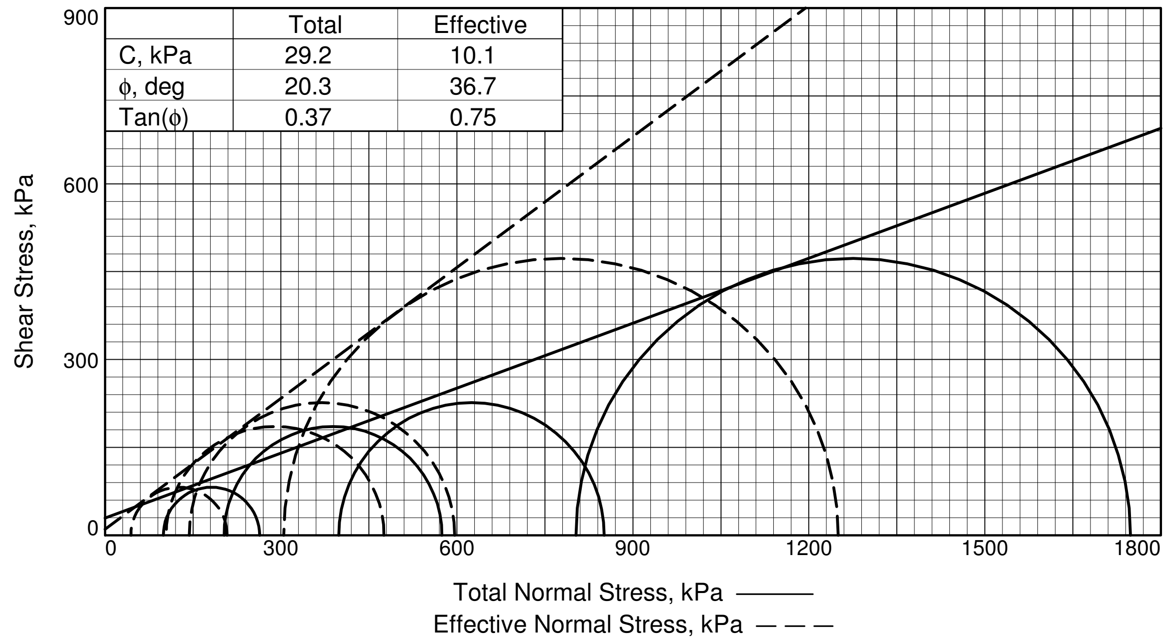
Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
72	0.3892	763.486	753.8	4.3	173.18	80.16	253.34	3.16	260.66	166.75	86.59
73	0.3940	762.084	752.4	4.4	172.67	79.38	252.05	3.18	261.44	165.72	86.34
74	0.3988	762.568	752.9	4.5	172.60	78.69	251.30	3.19	262.13	165.00	86.30
75	0.4036	764.299	754.6	4.6	172.82	78.04	250.86	3.21	262.78	164.45	86.41
76	0.4084	763.112	753.4	4.7	172.36	77.38	249.75	3.23	263.44	163.57	86.18
77	0.4132	764.349	754.6	4.8	172.46	76.81	249.27	3.25	264.01	163.04	86.23
78	0.4180	763.991	754.3	4.9	172.20	76.26	248.45	3.26	264.56	162.35	86.10
79	0.4228	763.661	754.0	5.0	171.94	75.75	247.69	3.27	265.07	161.72	85.97
80	0.4276	765.118	755.4	5.1	172.09	75.28	247.37	3.29	265.54	161.33	86.04
81	0.4396	766.283	756.6	5.3	171.89	74.24	246.14	3.32	266.58	160.19	85.95
82	0.4516	766.102	756.4	5.6	171.39	73.31	244.70	3.34	267.51	159.00	85.70
83	0.4636	767.003	757.3	5.8	171.14	72.51	243.65	3.36	268.31	158.08	85.57
84	0.4756	770.433	760.7	6.1	171.45	71.76	243.21	3.39	269.06	157.49	85.73
85	0.4877	770.477	760.8	6.3	171.00	71.16	242.16	3.40	269.66	156.66	85.50
86	0.4997	774.682	765.0	6.6	171.48	70.69	242.18	3.43	270.13	156.44	85.74
87	0.5117	776.528	766.8	6.8	171.43	70.24	241.68	3.44	270.58	155.96	85.72
88	0.5237	781.057	771.4	7.1	171.98	69.84	241.82	3.46	270.98	155.83	85.99
89	0.5357	784.372	774.7	7.3	172.25	69.49	241.74	3.48	271.33	155.62	86.12
90	0.5477	784.927	775.2	7.6	171.90	69.19	241.09	3.48	271.63	155.14	85.95
91	0.5597	784.745	775.0	7.8	171.39	68.88	240.27	3.49	271.94	154.57	85.70
92	0.5717	782.728	773.0	8.1	170.48	68.57	239.04	3.49	272.25	153.81	85.24
93	0.5837	787.213	777.5	8.3	171.00	68.28	239.28	3.50	272.54	153.78	85.50
94	0.5957	788.356	778.7	8.6	170.78	68.15	238.93	3.51	272.67	153.54	85.39
95	0.6077	792.110	782.4	8.9	171.12	68.08	239.21	3.51	272.74	153.64	85.56
96	0.6197	794.573	784.9	9.1	171.19	68.03	239.22	3.52	272.79	153.62	85.59
97	0.6317	796.843	787.1	9.4	171.21	67.90	239.11	3.52	272.92	153.51	85.60
98	0.6437	799.283	789.6	9.6	171.26	67.81	239.07	3.53	273.01	153.44	85.63
99	0.6557	802.487	792.8	9.9	171.47	67.68	239.15	3.53	273.14	153.41	85.74
100	0.6677	806.159	796.5	10.1	171.78	67.57	239.35	3.54	273.25	153.46	85.89
101	0.6797	810.270	800.6	10.4	172.19	67.47	239.65	3.55	273.35	153.56	86.09
102	0.6917	814.338	804.6	10.6	172.57	67.36	239.93	3.56	273.46	153.64	86.29
103	0.7038	815.838	806.1	10.9	172.41	67.30	239.70	3.56	273.52	153.50	86.20
104	0.7158	820.010	810.3	11.1	172.81	67.36	240.17	3.57	273.46	153.76	86.40
105	0.7278	825.044	815.3	11.4	173.39	67.31	240.70	3.58	273.51	154.01	86.69
106	0.7398	827.705	818.0	11.6	173.46	67.30	240.75	3.58	273.52	154.03	86.73
107	0.7518	827.221	817.5	11.9	172.86	67.23	240.09	3.57	273.59	153.66	86.43
108	0.7638	827.858	818.2	12.1	172.50	67.23	239.73	3.57	273.59	153.48	86.25
109	0.7758	832.871	823.2	12.4	173.06	67.24	240.29	3.57	273.58	153.76	86.53
110	0.7878	834.394	824.7	12.6	172.88	67.20	240.08	3.57	273.62	153.64	86.44
111	0.7998	835.251	825.6	12.9	172.56	67.20	239.76	3.57	273.62	153.48	86.28
112	0.8118	839.181	829.5	13.1	172.87	67.21	240.08	3.57	273.61	153.65	86.44
113	0.8238	841.121	831.4	13.4	172.77	67.18	239.96	3.57	273.64	153.57	86.39
114	0.8358	843.226	833.5	13.7	172.71	67.17	239.88	3.57	273.65	153.53	86.35
115	0.8478	847.403	837.7	13.9	173.07	67.16	240.22	3.58	273.66	153.69	86.53
116	0.8598	847.871	838.2	14.2	172.65	66.93	239.58	3.58	273.89	153.26	86.33
117	0.8718	852.262	842.6	14.4	173.05	66.89	239.93	3.59	273.93	153.41	86.52
118	0.8838	855.280	845.6	14.7	173.16	66.97	240.13	3.59	273.85	153.55	86.58

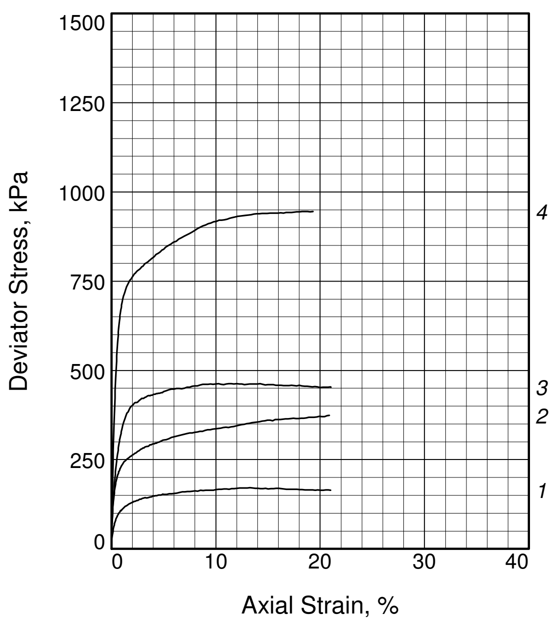
Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
119	0.8958	857.082	847.4	14.9	173.01	67.02	240.03	3.58	273.80	153.53	86.51
120	0.9078	860.996	851.3	15.2	173.29	67.06	240.36	3.58	273.76	153.71	86.65
121	0.9198	861.760	852.1	15.4	172.93	66.99	239.93	3.58	273.83	153.46	86.47
122	0.9318	861.958	852.3	15.7	172.46	67.01	239.47	3.57	273.81	153.24	86.23
123	0.9438	858.440	848.7	15.9	171.23	67.02	238.25	3.55	273.80	152.64	85.62
124	0.9558	855.472	845.8	16.2	170.12	66.93	237.05	3.54	273.89	151.99	85.06
125	0.9678	856.863	847.2	16.4	169.89	66.95	236.84	3.54	273.87	151.90	84.94
126	0.9799	861.298	851.6	16.7	170.26	66.93	237.19	3.54	273.89	152.06	85.13
127	0.9919	858.819	849.1	16.9	169.25	66.82	236.07	3.53	274.00	151.45	84.62
128	1.0039	861.166	851.5	17.2	169.20	66.66	235.86	3.54	274.16	151.26	84.60
129	1.0159	863.541	853.8	17.4	169.16	66.77	235.93	3.53	274.05	151.35	84.58
130	1.0279	865.431	855.7	17.7	169.01	66.89	235.90	3.53	273.93	151.39	84.51
131	1.0399	869.548	859.8	17.9	169.30	66.97	236.27	3.53	273.85	151.62	84.65
132	1.0519	871.263	861.6	18.2	169.12	66.99	236.11	3.52	273.83	151.55	84.56
133	1.0639	873.544	863.8	18.4	169.04	66.99	236.04	3.52	273.83	151.51	84.52
134	1.0759	877.875	868.2	18.7	169.37	67.00	236.37	3.53	273.82	151.68	84.68
135	1.0879	881.684	872.0	19.0	169.58	66.91	236.49	3.53	273.91	151.70	84.79
136	1.0999	884.778	875.1	19.2	169.65	66.98	236.63	3.53	273.84	151.80	84.83
137	1.1119	886.647	876.9	19.5	169.48	66.87	236.36	3.53	273.95	151.62	84.74
138	1.1239	885.026	875.3	19.7	168.64	66.79	235.43	3.52	274.03	151.11	84.32
139	1.1359	887.351	877.7	20.0	168.56	66.88	235.43	3.52	273.94	151.16	84.28
140	1.1473	884.558	874.9	20.2	167.52	66.98	234.49	3.50	273.84	150.74	83.76



	Total	Effective
C, kPa	29.2	10.1
ϕ, deg	20.3	36.7
Tan(ϕ)	0.37	0.75



	Sample No.	1	2	3	4
Initial	Water Content, %	9.0	8.7	7.7	8.6
	Dry Density, pcf	121.8	121.7	123.3	122.3
	Saturation, %	61.2	59.6	54.6	59.3
	Void Ratio	0.3991	0.4001	0.3824	0.3940
	Diameter, in.	6.00	6.01	6.00	6.00
	Height, in.	12.00	12.00	12.00	12.00
At Test	Water Content, %	13.3	10.6	12.4	10.4
	Dry Density, pcf	125.1	132.2	127.4	132.9
	Saturation, %	100.0	100.0	100.0	100.0
	Void Ratio	0.3628	0.2889	0.3378	0.2828
	Diameter, in.	5.95	5.84	5.93	5.84
	Height, in.	11.90	11.68	11.87	11.68
	Strain rate, %/min.	0.02	0.02	0.02	0.03
	Eff. Cell Pressure, kPa	99	203	399	803
	Fail. Stress, kPa	164	371	452	945
	Total Pore Pr., kPa	398	511	532	841
	Strain, %	20.0	19.9	20.0	19.3
	Ult. Stress, kPa				
	Total Pore Pr., kPa				
	Strain, %				
	$\bar{\sigma}_1$ Failure, kPa	208	476	596	1250
	$\bar{\sigma}_3$ Failure, kPa	44	104	143	305

Type of Test:
CU with Pore Pressures

Sample Type: Remolded

Description: clayey GRAVEL with sand

Assumed Specific Gravity= 2.73

Remarks: Failure tangents drawn at approximately 20% strain. Particles larger than 1" were removed and replaced with finer gravel prior to testing.

Figure _______

Client: KP Vancouver

Project: Yankee Doodle Dam

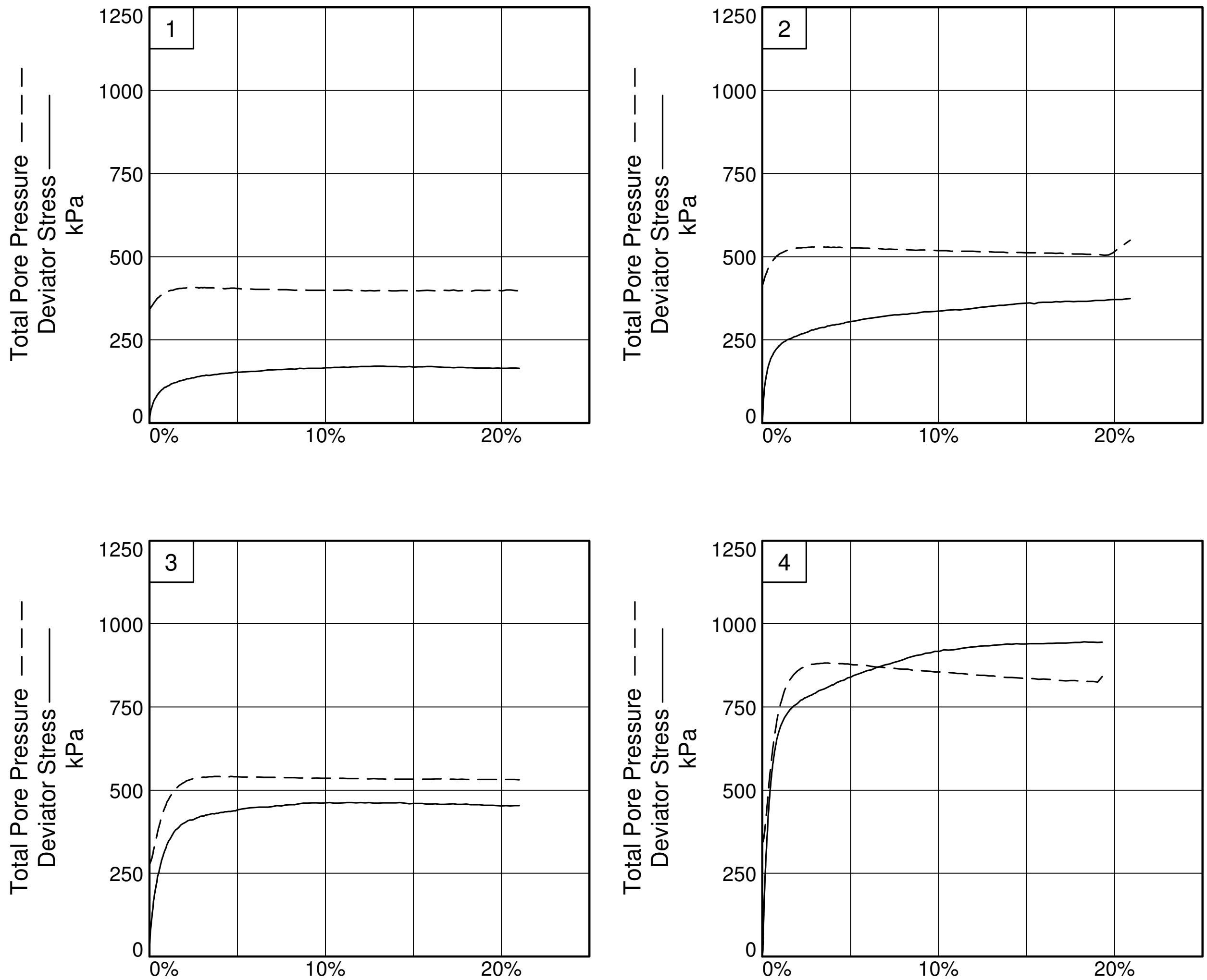
Location: TP14-01, TP14-02, TP14-03, TP14-04

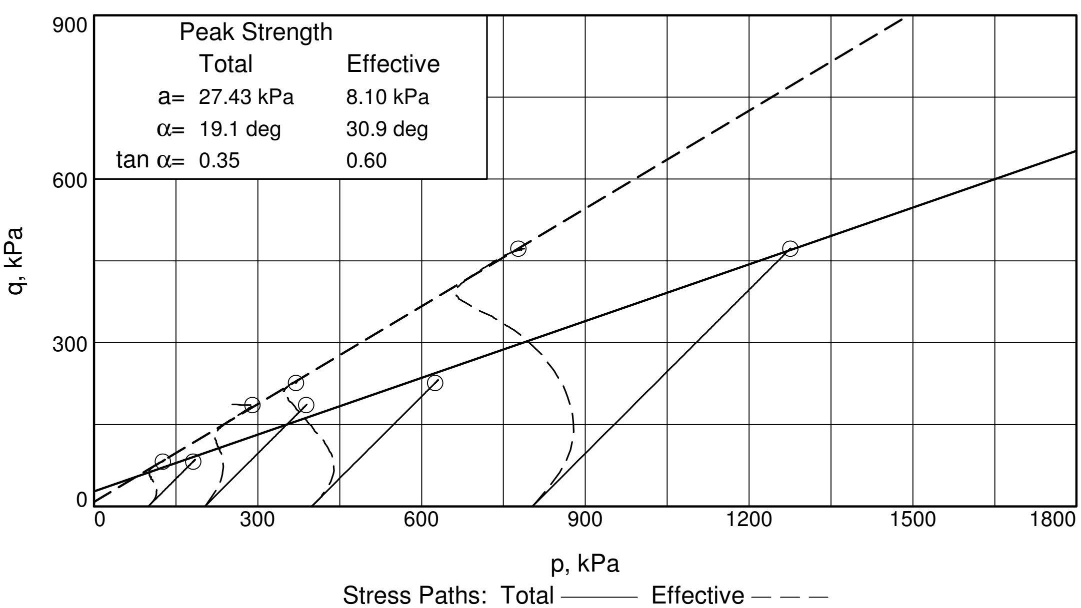
Sample Number: 400 kPa Trial 2 **Depth:** 6'-11'

Proj. No.: VA101-126/08 **Date Sampled:** 7/16/14

Knight Piésold CONSULTING

Tested By: DAB **Checked By:** JDB





Peak Strength	Total	Effective
a=	27.43 kPa	8.10 kPa
α=	19.1 deg	30.9 deg
tan α=	0.35	0.60

Client: KP Vancouver

Project: Yankee Doodle Dam

Location: TP14-01, TP14-02, TP14-03, TP14-04 **Depth:** 6'-11' **Sample Number:** 400 kPa Trial 2

Project No.: VA101-126/08 **Figure** _______

Knight Piesold Geotechnical Lab.

Tested By: DAB **Checked By:** JDB

TRIAXIAL COMPRESSION TEST

CU with Pore Pressures

9/8/2014
1:00 PM

Date: 7/16/14
Client: KP Vancouver
Project: Yankee Doodle Dam
Project No.: VA101-126/08
Location: TP14-01, TP14-02, TP14-03, TP14-04
Depth: 6'-11' **Sample Number:** 400 kPa Trial 2
Description: clayey GRAVEL with sand
Remarks: Failure tangents drawn at approximately 20% strain. Particles larger than 1" were removed and replaced with finer gravel prior to testing.
Type of Sample: Remolded
Assumed Specific Gravity=2.73 **LL=** **PL=** **PI=**
Test Method: COE uniform strain

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	11820.100			15047.500
Moisture content: Dry soil+tare, gms.	10849.000			13622.500
Moisture content: Tare, gms.	0.000			2775.500
Moisture, %	9.0	14.6	13.3	13.1
Moist specimen weight, gms.	11820.1			
Diameter, in.	6.00	6.00	5.95	
Area, in.^{2}	28.27	28.27	27.78	
Height, in.	12.00	12.00	11.90	
Net decrease in height, in.		0.00	0.10	
Wet density, pcf	132.7	139.6	141.7	
Dry density, pcf	121.8	121.8	125.1	
Void ratio	0.3991	0.3991	0.3628	
Saturation, %	61.2	100.0	100.0	

Test Readings for Specimen No. 1

Membrane modulus = 0.124105 kN/cm^2
Membrane thickness = 0.064 cm
Consolidation cell pressure = 64.06 psi (441.7 kPa)
Consolidation back pressure = 49.63 psi (342.2 kPa)
Consolidation effective confining stress = 99.5 kPa
Strain rate, %/min. = 0.02
Fail. Stress = 164.0 kPa **at reading no.** 141

Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress kPa	Minor Eff. Stress kPa	Major Eff. Stress kPa	1:3 Ratio	Pore Press. psi	P kPa	Q kPa
0	0.1045	42.719	0.0	0.0	0.0	99.5	99.5	1.00	49.63	99.5	0.0
1	0.1074	120.678	78.0	0.0	19.3	98.6	118.0	1.20	49.76	108.3	9.7
2	0.1104	164.195	121.5	0.0	30.1	97.0	127.2	1.31	49.99	112.1	15.1
3	0.1134	185.725	143.0	0.1	35.5	95.1	130.5	1.37	50.27	112.8	17.7
4	0.1164	208.196	165.5	0.1	41.0	93.0	134.1	1.44	50.57	113.5	20.5
5	0.1193	225.476	182.8	0.1	45.3	91.3	136.6	1.50	50.82	113.9	22.6
6	0.1223	241.183	198.5	0.1	49.2	89.4	138.6	1.55	51.09	114.0	24.6
7	0.1253	260.904	218.2	0.2	54.1	87.5	141.5	1.62	51.37	114.5	27.0
8	0.1283	278.273	235.6	0.2	58.3	85.4	143.8	1.68	51.67	114.6	29.2
9	0.1312	294.317	251.6	0.2	62.3	83.2	145.5	1.75	51.99	114.4	31.1
10	0.1342	306.038	263.3	0.2	65.2	81.1	146.3	1.80	52.29	113.7	32.6
11	0.1372	316.906	274.2	0.3	67.9	79.4	147.3	1.85	52.54	113.3	33.9
12	0.1402	329.378	286.7	0.3	70.9	77.4	148.3	1.92	52.83	112.9	35.5
13	0.1431	335.598	292.9	0.3	72.4	75.7	148.1	1.96	53.08	111.9	36.2
14	0.1461	348.967	306.2	0.3	75.7	73.9	149.7	2.02	53.34	111.8	37.9
15	0.1491	358.070	315.4	0.4	78.0	72.3	150.2	2.08	53.58	111.2	39.0
16	0.1521	364.849	322.1	0.4	79.6	70.6	150.2	2.13	53.82	110.4	39.8
17	0.1550	373.673	331.0	0.4	81.8	68.9	150.7	2.19	54.06	109.8	40.9
18	0.1580	384.027	341.3	0.4	84.3	67.8	152.1	2.24	54.22	110.0	42.2
19	0.1610	390.806	348.1	0.5	86.0	66.0	152.0	2.30	54.48	109.0	43.0
20	0.1640	398.218	355.5	0.5	87.8	65.0	152.8	2.35	54.64	108.9	43.9
21	0.1669	406.983	364.3	0.5	89.9	64.1	154.0	2.40	54.77	109.0	45.0
22	0.1699	411.337	368.6	0.5	91.0	62.7	153.6	2.45	54.97	108.2	45.5
23	0.1729	417.278	374.6	0.6	92.4	61.6	154.0	2.50	55.13	107.8	46.2
24	0.1759	424.984	382.3	0.6	94.3	60.2	154.5	2.57	55.33	107.3	47.1
25	0.1788	429.455	386.7	0.6	95.4	59.4	154.8	2.61	55.45	107.1	47.7
26	0.1818	435.617	392.9	0.6	96.9	58.7	155.5	2.65	55.55	107.1	48.4
27	0.1848	439.911	397.2	0.7	97.9	57.9	155.8	2.69	55.66	106.8	49.0
28	0.1878	445.691	403.0	0.7	99.3	54.6	153.9	2.82	56.14	104.2	49.7
29	0.1907	451.397	408.7	0.7	100.7	54.1	154.8	2.86	56.22	104.4	50.3
30	0.1937	454.574	411.9	0.7	101.4	53.6	155.0	2.89	56.29	104.3	50.7
31	0.1967	458.044	415.3	0.8	102.3	53.1	155.4	2.93	56.36	104.2	51.1
32	0.1996	464.250	421.5	0.8	103.8	52.4	156.1	2.98	56.46	104.3	51.9
33	0.2026	468.927	426.2	0.8	104.9	52.0	156.9	3.02	56.51	104.5	52.5
34	0.2056	473.398	430.7	0.8	106.0	51.6	157.5	3.06	56.58	104.5	53.0
35	0.2086	478.575	435.9	0.9	107.2	50.9	158.2	3.10	56.67	104.6	53.6
36	0.2116	480.045	437.3	0.9	107.6	50.2	157.7	3.14	56.78	104.0	53.8
37	0.2145	478.692	436.0	0.9	107.2	49.6	156.8	3.16	56.87	103.2	53.6
38	0.2175	482.398	439.7	0.9	108.1	48.8	156.9	3.21	56.98	102.9	54.0
39	0.2205	485.442	442.7	1.0	108.8	48.1	156.9	3.26	57.08	102.5	54.4
40	0.2234	490.104	447.4	1.0	109.9	47.3	157.2	3.32	57.20	102.2	55.0
41	0.2264	493.384	450.7	1.0	110.7	47.0	157.7	3.36	57.25	102.3	55.3
42	0.2383	502.914	460.2	1.1	112.9	44.9	157.8	3.51	57.55	101.4	56.5
43	0.2502	519.738	477.0	1.2	116.9	43.1	160.1	3.71	57.80	101.6	58.5
44	0.2621	530.224	487.5	1.3	119.4	42.3	161.7	3.82	57.93	102.0	59.7
45	0.2740	535.856	493.1	1.4	120.6	40.8	161.5	3.96	58.14	101.1	60.3
46	0.2859	541.209	498.5	1.5	121.8	39.5	161.3	4.09	58.34	100.4	60.9

Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress kPa	Minor Eff. Stress kPa	Major Eff. Stress kPa	1:3 Ratio	Pore Press. psi	P kPa	Q kPa
47	0.2978	553.872	511.2	1.6	124.8	37.8	162.6	4.30	58.58	100.2	62.4
48	0.3097	561.034	518.3	1.7	126.4	37.4	163.8	4.38	58.63	100.6	63.2
49	0.3216	566.137	523.4	1.8	127.5	37.4	165.0	4.41	58.63	101.2	63.8
50	0.3335	573.461	530.7	1.9	129.2	36.6	165.7	4.53	58.76	101.2	64.6
51	0.3454	579.696	537.0	2.0	130.6	36.4	167.0	4.59	58.78	101.7	65.3
52	0.3573	588.329	545.6	2.1	132.5	35.7	168.2	4.72	58.89	101.9	66.3
53	0.3692	589.873	547.2	2.2	132.8	35.5	168.2	4.74	58.92	101.9	66.4
54	0.3811	595.932	553.2	2.3	134.1	35.2	169.3	4.81	58.96	102.2	67.1
55	0.3930	601.403	558.7	2.4	135.3	35.5	170.7	4.82	58.92	103.1	67.6
56	0.4049	603.153	560.4	2.5	135.6	34.6	170.2	4.92	59.04	102.4	67.8
57	0.4168	612.815	570.1	2.6	137.8	34.6	172.4	4.98	59.04	103.5	68.9
58	0.4287	620.036	577.3	2.7	139.4	34.6	174.0	5.03	59.04	104.3	69.7
59	0.4406	619.462	576.7	2.8	139.1	36.2	175.3	4.84	58.80	105.8	69.5
60	0.4525	627.227	584.5	2.9	140.8	34.9	175.7	5.04	59.00	105.3	70.4
61	0.4644	633.051	590.3	3.0	142.1	35.0	177.1	5.06	58.98	106.1	71.0
62	0.4763	635.801	593.1	3.1	142.6	34.7	177.3	5.10	59.02	106.0	71.3
63	0.4882	641.684	599.0	3.2	143.9	35.4	179.3	5.06	58.92	107.3	71.9
64	0.5001	638.934	596.2	3.3	143.0	34.9	178.0	5.10	59.00	106.4	71.5
65	0.5120	638.625	595.9	3.4	142.8	35.1	178.0	5.06	58.96	106.6	71.4
66	0.5239	644.699	602.0	3.5	144.1	35.2	179.3	5.09	58.95	107.3	72.1
67	0.5358	647.522	604.8	3.6	144.7	35.6	180.3	5.06	58.89	107.9	72.3
68	0.5477	652.875	610.2	3.7	145.8	35.9	181.7	5.06	58.85	108.8	72.9
69	0.5596	654.037	611.3	3.8	145.9	35.7	181.6	5.09	58.89	108.6	73.0
70	0.5715	659.464	616.7	3.9	147.1	36.2	183.3	5.06	58.81	109.8	73.5
71	0.5834	663.758	621.0	4.0	147.9	36.1	184.0	5.10	58.83	110.1	74.0
72	0.5953	667.052	624.3	4.1	148.6	36.7	185.2	5.05	58.74	110.9	74.3
73	0.6072	669.155	626.4	4.2	148.9	37.7	186.6	4.95	58.59	112.2	74.4
74	0.6191	672.406	629.7	4.3	149.5	37.9	187.4	4.94	58.56	112.7	74.8
75	0.6310	674.273	631.6	4.4	149.8	37.1	186.9	5.04	58.68	112.0	74.9
76	0.6429	679.509	636.8	4.5	150.9	37.3	188.2	5.04	58.65	112.8	75.4
77	0.6549	680.038	637.3	4.6	150.8	36.4	187.3	5.14	58.78	111.9	75.4
78	0.6668	681.641	638.9	4.7	151.1	36.3	187.4	5.16	58.79	111.9	75.5
79	0.6787	686.700	644.0	4.8	152.1	36.3	188.4	5.19	58.80	112.4	76.1
80	0.6906	692.171	649.5	4.9	153.2	36.9	190.1	5.16	58.71	113.5	76.6
81	0.7025	689.230	646.5	5.0	152.4	37.2	189.6	5.10	58.66	113.4	76.2
82	0.7322	692.877	650.2	5.3	152.8	39.2	192.0	4.90	58.38	115.6	76.4
83	0.7619	700.980	658.3	5.5	154.3	38.5	192.9	5.01	58.47	115.7	77.2
84	0.7917	705.274	662.6	5.8	154.9	38.8	193.7	5.00	58.44	116.2	77.5
85	0.8214	709.701	667.0	6.0	155.6	39.9	195.5	4.89	58.27	117.7	77.8
86	0.8511	715.157	672.4	6.3	156.4	39.6	196.0	4.95	58.31	117.8	78.2
87	0.8809	723.393	680.7	6.5	157.9	39.6	197.5	4.99	58.32	118.6	79.0
88	0.9107	732.084	689.4	6.8	159.5	39.9	199.3	5.00	58.28	119.6	79.7
89	0.9404	736.937	694.2	7.0	160.2	40.5	200.7	4.96	58.19	120.6	80.1
90	0.9702	741.055	698.3	7.3	160.7	40.7	201.4	4.95	58.15	121.1	80.3
91	0.9999	744.085	701.4	7.5	161.0	40.6	201.5	4.97	58.18	121.0	80.5
92	1.0296	747.585	704.9	7.8	161.3	41.0	202.3	4.93	58.11	121.7	80.7
93	1.0594	753.291	710.6	8.0	162.2	41.5	203.7	4.91	58.05	122.6	81.1

Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress kPa	Minor Eff. Stress kPa	Major Eff. Stress kPa	1:3 Ratio	Pore Press. psi	P kPa	Q kPa
94	1.0891	752.350	709.6	8.3	161.5	42.7	204.2	4.78	57.87	123.5	80.8
95	1.1189	765.571	722.9	8.5	164.1	41.9	206.0	4.92	57.98	123.9	82.0
96	1.1486	764.409	721.7	8.8	163.4	42.0	205.4	4.89	57.96	123.7	81.7
97	1.1783	768.748	726.0	9.0	163.9	42.3	206.3	4.87	57.92	124.3	82.0
98	1.2081	772.159	729.4	9.3	164.2	42.6	206.9	4.85	57.87	124.8	82.1
99	1.2378	776.351	733.6	9.5	164.7	43.1	207.8	4.82	57.81	125.5	82.4
100	1.2676	778.336	735.6	9.8	164.7	42.6	207.3	4.87	57.88	125.0	82.4
101	1.2973	784.939	742.2	10.0	165.7	42.9	208.6	4.87	57.84	125.7	82.9
102	1.3271	790.940	748.2	10.3	166.6	43.1	209.7	4.87	57.81	126.4	83.3
103	1.3568	796.175	753.5	10.5	167.3	42.5	209.8	4.94	57.90	126.1	83.7
104	1.3865	799.337	756.6	10.8	167.5	42.3	209.9	4.96	57.92	126.1	83.8
105	1.4163	802.984	760.3	11.0	167.9	42.5	210.4	4.95	57.90	126.4	83.9
106	1.4460	802.749	760.0	11.3	167.3	42.3	209.6	4.96	57.93	125.9	83.7
107	1.4758	811.455	768.7	11.5	168.8	44.1	212.9	4.83	57.66	128.5	84.4
108	1.5055	815.293	772.6	11.8	169.2	44.0	213.2	4.84	57.68	128.6	84.6
109	1.5353	818.764	776.0	12.0	169.4	43.9	213.3	4.86	57.69	128.6	84.7
110	1.5650	824.691	782.0	12.3	170.2	44.2	214.4	4.85	57.65	129.3	85.1
111	1.5948	826.867	784.1	12.5	170.2	44.0	214.2	4.87	57.68	129.1	85.1
112	1.6245	831.471	788.8	12.8	170.7	44.7	215.4	4.82	57.58	130.0	85.4
113	1.6542	834.044	791.3	13.0	170.8	43.8	214.6	4.90	57.70	129.2	85.4
114	1.6840	837.588	794.9	13.3	171.1	43.5	214.6	4.93	57.75	129.0	85.5
115	1.7137	835.750	793.0	13.5	170.2	43.8	214.0	4.89	57.71	128.9	85.1
116	1.7435	836.809	794.1	13.8	169.9	44.4	214.3	4.83	57.62	129.4	85.0
117	1.7732	837.530	794.8	14.0	169.6	44.3	213.8	4.83	57.64	129.1	84.8
118	1.8030	836.647	793.9	14.3	168.9	44.0	212.9	4.84	57.68	128.5	84.5
119	1.8327	837.941	795.2	14.5	168.7	43.9	212.6	4.84	57.69	128.2	84.3
120	1.8624	843.765	801.0	14.8	169.4	44.5	213.9	4.81	57.61	129.2	84.7
121	1.8922	838.339	795.6	15.0	167.8	43.9	211.7	4.82	57.69	127.8	83.9
122	1.9219	846.118	803.4	15.3	168.9	44.4	213.3	4.80	57.62	128.9	84.5
123	1.9517	848.295	805.6	15.5	168.9	43.7	212.6	4.87	57.73	128.1	84.4
124	1.9814	853.942	811.2	15.8	169.6	43.2	212.7	4.93	57.80	128.0	84.8
125	2.0112	855.869	813.1	16.0	169.5	43.4	212.8	4.91	57.77	128.1	84.7
126	2.0409	854.810	812.1	16.3	168.7	44.3	213.0	4.81	57.64	128.6	84.4
127	2.0707	853.574	810.9	16.5	168.0	43.9	211.8	4.83	57.70	127.8	84.0
128	2.1004	851.515	808.8	16.8	167.0	43.1	210.2	4.87	57.81	126.6	83.5
129	2.1302	854.060	811.3	17.0	167.1	43.3	210.4	4.86	57.78	126.8	83.5
130	2.1599	854.177	811.5	17.3	166.6	42.2	208.8	4.95	57.94	125.5	83.3
131	2.1896	859.295	816.6	17.5	167.1	44.6	211.7	4.75	57.60	128.1	83.6
132	2.2194	862.222	819.5	17.8	167.2	43.3	210.5	4.86	57.78	126.9	83.6
133	2.2491	861.104	818.4	18.0	166.5	45.2	211.7	4.68	57.50	128.5	83.2
134	2.2789	863.884	821.2	18.3	166.5	45.5	212.0	4.66	57.46	128.8	83.3
135	2.3086	860.575	817.9	18.5	165.4	42.7	208.1	4.87	57.86	125.4	82.7
136	2.3384	860.795	818.1	18.8	164.9	42.5	207.4	4.88	57.90	124.9	82.4
137	2.3681	866.472	823.8	19.0	165.5	43.9	209.4	4.77	57.69	126.7	82.8
138	2.3978	868.472	825.8	19.3	165.4	42.8	208.3	4.86	57.85	125.5	82.7
139	2.4276	865.810	823.1	19.5	164.4	43.1	207.4	4.82	57.82	125.2	82.2
140	2.4573	874.296	831.6	19.8	165.6	42.5	208.1	4.89	57.89	125.3	82.8

Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress kPa	Minor Eff. Stress kPa	Major Eff. Stress kPa	1:3 Ratio	Pore Press. psi	P kPa	Q kPa
141	2.4871	869.237	826.5	20.0	164.0	44.2	208.2	4.71	57.65	126.2	82.0
142	2.5168	874.987	832.3	20.3	164.7	42.1	206.8	4.91	57.95	124.4	82.3
143	2.5465	880.884	838.2	20.5	165.3	42.2	207.6	4.91	57.93	124.9	82.7
144	2.5763	882.178	839.5	20.8	165.0	43.6	208.6	4.79	57.74	126.1	82.5
145	2.6034	881.517	838.8	21.0	164.4	44.8	209.2	4.67	57.57	127.0	82.2

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	11820.100			14308.500
Moisture content: Dry soil+tare, gms.	10870.000			13004.000
Moisture content: Tare, gms.	0.000			2134.000
Moisture, %	8.7	14.7	10.6	12.0
Moist specimen weight, gms.	11820.1			
Diameter, in.	6.01	6.01	5.84	
Area, in.²	28.35	28.35	26.82	
Height, in.	12.00	12.00	11.68	
Net decrease in height, in.		0.00	0.32	
Wet density, pcf	132.4	139.6	146.2	
Dry density, pcf	121.7	121.7	132.2	
Void ratio	0.4001	0.4001	0.2889	
Saturation, %	59.6	100.0	100.0	

Test Readings for Specimen No. 2

Membrane modulus = 0.124105 kN/cm²

Membrane thickness = 0.064 cm

Consolidation cell pressure = 89.29 psi (615.6 kPa)

Consolidation back pressure = 59.83 psi (412.5 kPa)

Consolidation effective confining stress = 203.1 kPa

Strain rate, %/min. = 0.02

Fail. Stress = 371.4 kPa **at reading no.** 141

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress kPa	Minor Eff. Stress kPa	Major Eff. Stress kPa	1:3 Ratio	Pore Press. psi	P kPa	Q kPa
0	0.3236	102.019	0.0	0.0	0.0	203.1	203.1	1.00	59.83	203.1	0.0
1	0.3265	230.377	128.4	0.0	33.0	198.5	231.5	1.17	60.49	215.0	16.5
2	0.3294	343.028	241.0	0.0	61.9	193.2	255.1	1.32	61.27	224.2	31.0
3	0.3323	413.546	311.5	0.1	80.0	189.0	269.0	1.42	61.88	229.0	40.0
4	0.3352	469.621	367.6	0.1	94.4	184.8	279.2	1.51	62.48	232.0	47.2
5	0.3381	517.917	415.9	0.1	106.8	180.5	287.3	1.59	63.10	233.9	53.4
6	0.3410	558.095	456.1	0.1	117.1	176.3	293.4	1.66	63.72	234.8	58.5
7	0.3439	596.553	494.5	0.2	126.9	172.1	299.0	1.74	64.32	235.6	63.5
8	0.3468	626.613	524.6	0.2	134.6	168.9	303.5	1.80	64.80	236.2	67.3
9	0.3497	660.614	558.6	0.2	143.3	165.0	308.3	1.87	65.36	236.7	71.6
10	0.3526	685.791	583.8	0.2	149.7	162.1	311.8	1.92	65.79	236.9	74.8
11	0.3555	709.616	607.6	0.3	155.8	158.1	313.9	1.99	66.36	236.0	77.9
12	0.3584	736.867	634.8	0.3	162.7	155.1	317.8	2.05	66.79	236.5	81.4
13	0.3613	756.044	654.0	0.3	167.6	152.0	319.6	2.10	67.25	235.8	83.8
14	0.3642	775.560	673.5	0.3	172.5	148.7	321.2	2.16	67.72	235.0	86.3
15	0.3671	793.325	691.3	0.4	177.0	146.6	323.7	2.21	68.02	235.2	88.5

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress kPa	Minor Eff. Stress kPa	Major Eff. Stress kPa	1:3 Ratio	Pore Press. psi	P kPa	Q kPa
16	0.3700	812.870	710.9	0.4	182.0	143.6	325.6	2.27	68.46	234.6	91.0
17	0.3729	826.400	724.4	0.4	185.4	141.8	327.2	2.31	68.73	234.5	92.7
18	0.3758	840.047	738.0	0.4	188.9	139.2	328.1	2.36	69.10	233.7	94.4
19	0.3787	854.621	752.6	0.5	192.6	137.2	329.7	2.40	69.39	233.5	96.3
20	0.3816	868.225	766.2	0.5	196.0	134.6	330.6	2.46	69.76	232.6	98.0
21	0.3845	877.093	775.1	0.5	198.2	132.1	330.3	2.50	70.13	231.2	99.1
22	0.3874	888.520	786.5	0.5	201.1	130.2	331.3	2.54	70.40	230.8	100.5
23	0.3904	897.564	795.5	0.6	203.3	128.5	331.8	2.58	70.65	230.2	101.7
24	0.3933	909.447	807.4	0.6	206.3	126.6	333.0	2.63	70.92	229.8	103.2
25	0.3962	921.271	819.3	0.6	209.3	125.4	334.7	2.67	71.10	230.0	104.6
26	0.3991	925.286	823.3	0.6	210.3	123.4	333.6	2.70	71.40	228.5	105.1
27	0.4020	936.051	834.0	0.7	213.0	122.5	335.4	2.74	71.53	229.0	106.5
28	0.4049	948.110	846.1	0.7	216.0	120.4	336.3	2.79	71.83	228.3	108.0
29	0.4078	952.699	850.7	0.7	217.1	119.3	336.4	2.82	71.98	227.9	108.6
30	0.4107	958.096	856.1	0.7	218.4	117.8	336.2	2.85	72.21	227.0	109.2
31	0.4136	965.523	863.5	0.8	220.3	116.2	336.4	2.90	72.44	226.3	110.1
32	0.4165	974.347	872.3	0.8	222.5	115.2	337.7	2.93	72.58	226.4	111.2
33	0.4194	982.053	880.0	0.8	224.4	113.7	338.1	2.97	72.80	225.9	112.2
34	0.4223	987.450	885.4	0.8	225.7	112.5	338.2	3.01	72.97	225.4	112.8
35	0.4252	992.980	891.0	0.9	227.0	112.0	339.1	3.03	73.04	225.5	113.5
36	0.4281	999.407	897.4	0.9	228.6	110.8	339.4	3.06	73.22	225.1	114.3
37	0.4310	1006.877	904.9	0.9	230.5	109.9	340.4	3.10	73.35	225.1	115.2
38	0.4339	1011.760	909.7	0.9	231.7	108.7	340.4	3.13	73.52	224.6	115.8
39	0.4368	1013.642	911.6	1.0	232.1	107.9	339.9	3.15	73.64	223.9	116.0
40	0.4397	1021.437	919.4	1.0	234.0	107.1	341.1	3.18	73.75	224.1	117.0
41	0.4426	1026.687	924.7	1.0	235.3	106.0	341.3	3.22	73.92	223.6	117.6
42	0.4542	1045.320	943.3	1.1	239.8	103.7	343.5	3.31	74.24	223.6	119.9
43	0.4659	1061.880	959.9	1.2	243.7	100.8	344.5	3.42	74.67	222.7	121.9
44	0.4775	1074.395	972.4	1.3	246.7	98.4	345.1	3.51	75.02	221.8	123.3
45	0.4891	1087.925	985.9	1.4	249.9	96.5	346.4	3.59	75.29	221.4	124.9
46	0.5007	1097.028	995.0	1.5	251.9	95.3	347.2	3.64	75.47	221.2	126.0
47	0.5123	1105.411	1003.4	1.6	253.8	93.6	347.4	3.71	75.71	220.5	126.9
48	0.5239	1118.235	1016.2	1.7	256.8	93.2	349.9	3.76	75.78	221.5	128.4
49	0.5356	1128.338	1026.3	1.8	259.0	91.6	350.6	3.83	76.01	221.1	129.5
50	0.5472	1136.000	1034.0	1.9	260.7	90.4	351.1	3.88	76.17	220.8	130.4
51	0.5588	1144.986	1043.0	2.0	262.7	89.5	352.2	3.94	76.31	220.9	131.4
52	0.5704	1155.633	1053.6	2.1	265.1	89.6	354.8	3.96	76.29	222.2	132.6
53	0.5820	1165.516	1063.5	2.2	267.3	89.3	356.6	3.99	76.34	223.0	133.7
54	0.5936	1172.281	1070.3	2.3	268.8	88.1	356.8	4.05	76.52	222.4	134.4
55	0.6053	1180.355	1078.3	2.4	270.5	87.9	358.4	4.08	76.55	223.1	135.3
56	0.6168	1190.635	1088.6	2.5	272.8	87.9	360.7	4.10	76.54	224.3	136.4
57	0.6285	1197.355	1095.3	2.6	274.2	87.1	361.3	4.15	76.66	224.2	137.1
58	0.6401	1208.238	1106.2	2.7	276.7	87.7	364.4	4.15	76.57	226.0	138.3
59	0.6517	1220.445	1118.4	2.8	279.4	86.8	366.2	4.22	76.70	226.5	139.7
60	0.6633	1224.768	1122.7	2.9	280.2	86.3	366.6	4.25	76.77	226.4	140.1
61	0.6749	1234.298	1132.3	3.0	282.3	86.7	369.0	4.26	76.71	227.9	141.2
62	0.6865	1236.828	1134.8	3.1	282.7	86.4	369.0	4.27	76.76	227.7	141.3

Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress kPa	Minor Eff. Stress kPa	Major Eff. Stress kPa	1:3 Ratio	Pore Press. psi	P kPa	Q kPa
63	0.6982	1247.622	1145.6	3.2	285.1	86.5	371.6	4.29	76.74	229.0	142.5
64	0.7098	1252.240	1150.2	3.3	285.9	86.6	372.5	4.30	76.73	229.5	143.0
65	0.7214	1257.755	1155.7	3.4	287.0	87.1	374.1	4.29	76.65	230.6	143.5
66	0.7330	1260.358	1158.3	3.5	287.3	86.5	373.8	4.32	76.75	230.1	143.7
67	0.7446	1269.888	1167.9	3.6	289.4	87.0	376.4	4.33	76.67	231.7	144.7
68	0.7562	1279.300	1177.3	3.7	291.4	86.5	378.0	4.37	76.74	232.3	145.7
69	0.7678	1281.123	1179.1	3.8	291.6	87.4	378.9	4.34	76.62	233.2	145.8
70	0.7794	1290.050	1188.0	3.9	293.5	88.3	381.8	4.32	76.48	235.0	146.7
71	0.7911	1295.742	1193.7	4.0	294.6	87.4	382.0	4.37	76.61	234.7	147.3
72	0.8027	1297.286	1195.3	4.1	294.7	87.7	382.4	4.36	76.57	235.0	147.3
73	0.8143	1304.168	1202.1	4.2	296.0	88.1	384.2	4.36	76.51	236.1	148.0
74	0.8259	1306.227	1204.2	4.3	296.2	87.7	384.0	4.38	76.57	235.8	148.1
75	0.8375	1313.419	1211.4	4.4	297.7	87.2	384.9	4.41	76.64	236.0	148.9
76	0.8491	1320.154	1218.1	4.5	299.0	87.9	386.9	4.40	76.54	237.4	149.5
77	0.8607	1323.301	1221.3	4.6	299.5	88.3	387.8	4.39	76.48	238.0	149.8
78	0.8724	1334.008	1232.0	4.7	301.8	88.4	390.2	4.42	76.47	239.3	150.9
79	0.8839	1338.949	1236.9	4.8	302.7	88.5	391.2	4.42	76.46	239.8	151.4
80	0.8956	1345.464	1243.4	4.9	304.0	89.2	393.2	4.41	76.35	241.2	152.0
81	0.9072	1350.111	1248.1	5.0	304.8	89.3	394.1	4.41	76.34	241.7	152.4
82	0.9362	1360.053	1258.0	5.2	306.4	89.4	395.9	4.43	76.32	242.7	153.2
83	0.9652	1374.289	1272.3	5.5	309.1	89.3	398.4	4.46	76.34	243.8	154.5
84	0.9943	1390.069	1288.1	5.7	312.1	90.5	402.6	4.45	76.16	246.5	156.0
85	1.0233	1401.937	1299.9	6.0	314.1	90.0	404.2	4.49	76.23	247.1	157.1
86	1.0523	1411.834	1309.8	6.2	315.7	91.0	406.7	4.47	76.09	248.8	157.8
87	1.0813	1423.364	1321.3	6.5	317.6	91.4	409.1	4.47	76.03	250.2	158.8
88	1.1104	1435.365	1333.3	6.7	319.7	92.2	411.9	4.47	75.91	252.1	159.8
89	1.1394	1444.997	1343.0	7.0	321.1	93.5	414.6	4.44	75.74	254.0	160.6
90	1.1684	1456.160	1354.1	7.2	322.9	92.6	415.5	4.49	75.86	254.1	161.5
91	1.1974	1467.719	1365.7	7.5	324.8	93.7	418.5	4.47	75.70	256.1	162.4
92	1.2265	1470.704	1368.7	7.7	324.6	94.1	418.7	4.45	75.64	256.4	162.3
93	1.2555	1482.469	1380.5	8.0	326.5	94.0	420.6	4.47	75.66	257.3	163.3
94	1.2845	1489.543	1387.5	8.2	327.3	94.6	421.9	4.46	75.57	258.2	163.7
95	1.3135	1502.838	1400.8	8.5	329.6	95.4	425.0	4.45	75.45	260.2	164.8
96	1.3426	1506.706	1404.7	8.7	329.6	96.6	426.2	4.41	75.28	261.4	164.8
97	1.3716	1520.839	1418.8	9.0	332.0	95.9	427.9	4.46	75.39	261.9	166.0
98	1.4006	1532.663	1430.6	9.2	333.8	95.9	429.8	4.48	75.38	262.8	166.9
99	1.4296	1537.825	1435.8	9.5	334.1	97.0	431.1	4.44	75.22	264.1	167.1
100	1.4587	1546.825	1444.8	9.7	335.3	96.8	432.1	4.47	75.26	264.4	167.7
101	1.4877	1554.943	1452.9	10.0	336.3	97.2	433.4	4.46	75.19	265.3	168.1
102	1.5167	1563.840	1461.8	10.2	337.4	97.1	434.5	4.47	75.21	265.8	168.7
103	1.5458	1573.076	1471.1	10.5	338.6	97.7	436.3	4.46	75.12	267.0	169.3
104	1.5748	1584.341	1482.3	10.7	340.2	99.0	439.2	4.44	74.93	269.1	170.1
105	1.6038	1590.724	1488.7	11.0	340.7	98.6	439.3	4.46	74.99	269.0	170.4
106	1.6328	1590.547	1488.5	11.2	339.7	99.4	439.1	4.42	74.88	269.2	169.9
107	1.6619	1604.371	1502.4	11.5	341.9	99.1	441.0	4.45	74.92	270.1	171.0
108	1.6909	1612.710	1510.7	11.7	342.9	99.0	441.9	4.46	74.92	270.5	171.4
109	1.7199	1625.357	1523.3	12.0	344.8	99.6	444.4	4.46	74.84	272.0	172.4

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress kPa	Minor Eff. Stress kPa	Major Eff. Stress kPa	1:3 Ratio	Pore Press. psi	P kPa	Q kPa
110	1.7489	1637.770	1535.8	12.2	346.6	100.5	447.1	4.45	74.72	273.8	173.3
111	1.7780	1649.299	1547.3	12.5	348.2	100.8	449.0	4.45	74.67	274.9	174.1
112	1.8070	1658.594	1556.6	12.7	349.3	100.6	449.9	4.47	74.70	275.3	174.7
113	1.8360	1670.315	1568.3	13.0	350.9	101.3	452.2	4.47	74.60	276.7	175.5
114	1.8651	1679.727	1577.7	13.2	352.0	101.8	453.8	4.46	74.53	277.8	176.0
115	1.8941	1690.610	1588.6	13.5	353.4	102.4	455.9	4.45	74.44	279.1	176.7
116	1.9231	1697.948	1595.9	13.7	354.1	102.5	456.6	4.45	74.42	279.6	177.0
117	1.9521	1710.008	1608.0	13.9	355.7	103.6	459.3	4.43	74.26	281.5	177.9
118	1.9812	1717.317	1615.3	14.2	356.3	103.4	459.7	4.44	74.29	281.6	178.1
119	2.0102	1730.714	1628.7	14.4	358.2	103.4	461.6	4.47	74.30	282.5	179.1
120	2.0392	1740.244	1638.2	14.7	359.3	103.4	462.7	4.47	74.29	283.1	179.6
121	2.0682	1750.362	1648.3	14.9	360.4	103.7	464.1	4.48	74.25	283.9	180.2
122	2.0973	1757.421	1655.4	15.2	360.9	104.3	465.2	4.46	74.17	284.7	180.5
123	2.1263	1751.877	1649.9	15.4	358.6	104.4	463.1	4.44	74.15	283.7	179.3
124	2.1553	1772.893	1670.9	15.7	362.1	104.2	466.4	4.47	74.17	285.3	181.1
125	2.1843	1779.349	1677.3	15.9	362.5	104.8	467.2	4.46	74.10	286.0	181.2
126	2.2134	1784.540	1682.5	16.2	362.5	105.0	467.5	4.45	74.06	286.2	181.3
127	2.2424	1792.849	1690.8	16.4	363.2	105.2	468.4	4.45	74.04	286.8	181.6
128	2.2714	1803.011	1701.0	16.7	364.3	105.6	470.0	4.45	73.97	287.8	182.2
129	2.3004	1806.600	1704.6	16.9	364.0	105.1	469.1	4.46	74.04	287.1	182.0
130	2.3295	1817.953	1715.9	17.2	365.3	106.5	471.9	4.43	73.84	289.2	182.7
131	2.3585	1826.439	1724.4	17.4	366.0	106.5	472.6	4.44	73.84	289.5	183.0
132	2.3875	1827.851	1725.8	17.7	365.2	107.5	472.8	4.40	73.69	290.1	182.6
133	2.4165	1834.557	1732.5	17.9	365.5	107.7	473.2	4.39	73.67	290.5	182.8
134	2.4456	1841.322	1739.3	18.2	365.9	108.0	473.9	4.39	73.62	291.0	182.9
135	2.4746	1847.145	1745.1	18.4	366.0	108.6	474.5	4.37	73.54	291.6	183.0
136	2.5036	1857.322	1755.3	18.7	367.0	108.6	475.6	4.38	73.54	292.1	183.5
137	2.5326	1869.382	1767.4	18.9	368.4	109.1	477.5	4.38	73.46	293.3	184.2
138	2.5617	1875.014	1773.0	19.2	368.4	109.6	478.1	4.36	73.39	293.9	184.2
139	2.5907	1882.956	1780.9	19.4	368.9	111.0	480.0	4.32	73.19	295.5	184.5
140	2.6198	1893.897	1791.9	19.7	370.1	110.1	480.1	4.36	73.32	295.1	185.0
141	2.6488	1905.839	1803.8	19.9	371.4	104.3	475.6	4.56	74.17	290.0	185.7
142	2.6778	1909.604	1807.6	20.2	371.0	93.7	464.7	4.96	75.69	279.2	185.5
143	2.7068	1914.442	1812.4	20.4	370.8	84.4	455.2	5.40	77.06	269.8	185.4
144	2.7359	1930.796	1828.8	20.7	373.0	74.7	447.7	6.00	78.46	261.2	186.5
145	2.7621	1939.502	1837.5	20.9	373.7	66.6	440.3	6.61	79.64	253.4	186.9

Knight Piesold Geotechnical Lab.

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	11820.100			15014.000
Moisture content: Dry soil+tare, gms.	10980.000			13821.500
Moisture content: Tare, gms.	0.000			2841.500
Moisture, %	7.7	14.0	12.4	10.9
Moist specimen weight, gms.	11820.1			
Diameter, in.	6.00	6.00	5.93	
Area, in.²	28.27	28.27	27.66	
Height, in.	12.00	12.00	11.87	
Net decrease in height, in.		0.00	0.13	
Wet density, pcf	132.7	140.6	143.2	
Dry density, pcf	123.3	123.3	127.4	
Void ratio	0.3824	0.3824	0.3378	
Saturation, %	54.6	100.0	100.0	

Test Readings for Specimen No. 3

Membrane modulus = 0.124105 kN/cm²

Membrane thickness = 0.064 cm

Consolidation cell pressure = 97.94 psi (675.3 kPa)

Consolidation back pressure = 40.10 psi (276.5 kPa)

Consolidation effective confining stress = 398.8 kPa

Strain rate, %/min. = 0.02

Fail. Stress = 452.5 kPa **at reading no.** 143

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress kPa	Minor Eff. Stress kPa	Major Eff. Stress kPa	1:3 Ratio	Pore Press. psi	P kPa	Q kPa
0	0.1283	50.000	0.0	0.0	0.0	398.8	398.8	1.00	40.10	398.8	0.0
1	0.1285	165.946	115.9	0.0	28.9	399.1	428.0	1.07	40.05	413.6	14.4
2	0.1285	170.535	120.5	0.0	30.0	398.8	428.9	1.08	40.09	413.9	15.0
3	0.1294	195.183	145.2	0.0	36.2	399.0	435.2	1.09	40.07	417.1	18.1
4	0.1302	212.904	162.9	0.0	40.6	397.2	437.8	1.10	40.32	417.5	20.3
5	0.1332	287.201	237.2	0.0	59.1	394.8	453.9	1.15	40.68	424.4	29.5
6	0.1362	352.262	302.3	0.1	75.3	391.9	467.2	1.19	41.10	429.6	37.6
7	0.1392	415.412	365.4	0.1	91.0	388.1	479.1	1.23	41.64	433.6	45.5
8	0.1421	469.429	419.4	0.1	104.4	383.8	488.3	1.27	42.27	436.1	52.2
9	0.1451	526.196	476.2	0.1	118.5	379.4	498.0	1.31	42.91	438.7	59.3
10	0.1481	576.786	526.8	0.2	131.1	374.2	505.3	1.35	43.66	439.8	65.5
11	0.1510	623.626	573.6	0.2	142.7	367.7	510.4	1.39	44.60	439.1	71.4
12	0.1540	667.922	617.9	0.2	153.7	362.0	515.7	1.42	45.43	438.9	76.8
13	0.1570	720.262	670.3	0.2	166.7	355.9	522.6	1.47	46.32	439.2	83.3
14	0.1599	757.263	707.3	0.3	175.8	349.6	525.4	1.50	47.24	437.5	87.9
15	0.1629	792.971	743.0	0.3	184.6	343.5	528.1	1.54	48.12	435.8	92.3
16	0.1659	830.325	780.3	0.3	193.9	337.2	531.1	1.57	49.03	434.2	96.9
17	0.1689	860.370	810.4	0.3	201.3	330.5	531.8	1.61	50.00	431.2	100.6
18	0.1718	890.695	840.7	0.4	208.8	325.1	533.9	1.64	50.78	429.5	104.4
19	0.1748	920.637	870.6	0.4	216.2	319.5	535.7	1.68	51.60	427.6	108.1
20	0.1778	951.153	901.2	0.4	223.7	313.5	537.1	1.71	52.48	425.3	111.8
21	0.1808	981.390	931.4	0.4	231.1	307.2	538.3	1.75	53.38	422.8	115.6
22	0.1837	1012.744	962.7	0.5	238.8	301.8	540.7	1.79	54.16	421.2	119.4
23	0.1867	1038.804	988.8	0.5	245.3	295.6	540.9	1.83	55.06	418.3	122.6
24	0.1897	1048.922	998.9	0.5	247.7	290.2	537.9	1.85	55.84	414.1	123.8

Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress kPa	Minor Eff. Stress kPa	Major Eff. Stress kPa	1:3 Ratio	Pore Press. psi	P kPa	Q kPa
25	0.1926	1074.996	1025.0	0.5	254.1	285.3	539.4	1.89	56.56	412.3	127.0
26	0.1956	1102.350	1052.4	0.6	260.8	279.6	540.4	1.93	57.39	410.0	130.4
27	0.1986	1126.572	1076.6	0.6	266.8	275.6	542.4	1.97	57.96	409.0	133.4
28	0.2015	1145.176	1095.2	0.6	271.3	270.4	541.7	2.00	58.73	406.0	135.6
29	0.2045	1165.573	1115.6	0.6	276.3	265.8	542.1	2.04	59.38	404.0	138.1
30	0.2075	1190.869	1140.9	0.7	282.5	261.3	543.7	2.08	60.05	402.5	141.2
31	0.2105	1212.472	1162.5	0.7	287.7	256.7	544.4	2.12	60.71	400.5	143.9
32	0.2134	1234.650	1184.6	0.7	293.2	252.6	545.8	2.16	61.30	399.2	146.6
33	0.2164	1253.886	1203.9	0.7	297.8	248.4	546.2	2.20	61.92	397.3	148.9
34	0.2194	1266.298	1216.3	0.8	300.8	244.3	545.2	2.23	62.51	394.7	150.4
35	0.2223	1287.534	1237.5	0.8	306.0	239.7	545.7	2.28	63.18	392.7	153.0
36	0.2253	1298.226	1248.2	0.8	308.6	236.7	545.2	2.30	63.62	391.0	154.3
37	0.2283	1317.006	1267.0	0.8	313.1	233.0	546.2	2.34	64.14	389.6	156.6
38	0.2312	1332.992	1283.0	0.9	317.0	229.4	546.4	2.38	64.66	387.9	158.5
39	0.2342	1346.757	1296.8	0.9	320.3	226.1	546.5	2.42	65.14	386.3	160.2
40	0.2372	1357.522	1307.5	0.9	322.9	222.2	545.1	2.45	65.71	383.7	161.5
41	0.2401	1372.773	1322.8	0.9	326.6	219.6	546.2	2.49	66.09	382.9	163.3
42	0.2431	1390.288	1340.3	1.0	330.8	216.3	547.1	2.53	66.57	381.7	165.4
43	0.2461	1403.406	1353.4	1.0	334.0	212.3	546.3	2.57	67.14	379.3	167.0
44	0.2580	1455.541	1405.5	1.1	346.5	203.0	549.6	2.71	68.49	376.3	173.3
45	0.2698	1490.895	1440.9	1.2	354.9	193.3	548.2	2.84	69.90	370.8	177.4
46	0.2817	1533.352	1483.4	1.3	365.0	185.4	550.4	2.97	71.04	367.9	182.5
47	0.2936	1567.957	1518.0	1.4	373.1	177.9	551.0	3.10	72.13	364.5	186.5
48	0.3055	1599.664	1549.7	1.5	380.5	171.4	551.9	3.22	73.07	361.7	190.2
49	0.3174	1616.297	1566.3	1.6	384.2	165.9	550.1	3.32	73.88	358.0	192.1
50	0.3292	1642.018	1592.0	1.7	390.1	160.7	550.8	3.43	74.64	355.7	195.0
51	0.3411	1666.534	1616.5	1.8	395.7	158.1	553.8	3.50	75.01	356.0	197.9
52	0.3530	1680.844	1630.8	1.9	398.8	154.3	553.1	3.58	75.56	353.7	199.4
53	0.3648	1696.006	1646.0	2.0	402.1	151.2	553.3	3.66	76.01	352.3	201.0
54	0.3767	1709.595	1659.6	2.1	405.0	148.3	553.3	3.73	76.43	350.8	202.5
55	0.3886	1723.125	1673.1	2.2	407.9	145.9	553.7	3.80	76.78	349.8	203.9
56	0.4005	1733.375	1683.4	2.3	410.0	144.1	554.0	3.85	77.05	349.0	205.0
57	0.4123	1736.066	1686.1	2.4	410.2	142.3	552.5	3.88	77.30	347.4	205.1
58	0.4242	1740.846	1690.8	2.5	410.9	140.4	551.3	3.93	77.58	345.9	205.5
59	0.4361	1753.552	1703.6	2.6	413.6	139.1	552.7	3.97	77.76	345.9	206.8
60	0.4480	1767.773	1717.8	2.7	416.6	138.9	555.5	4.00	77.80	347.2	208.3
61	0.4598	1777.965	1728.0	2.8	418.7	138.2	556.9	4.03	77.90	347.5	209.3
62	0.4717	1791.318	1741.3	2.9	421.5	137.2	558.7	4.07	78.04	347.9	210.7
63	0.4836	1794.524	1744.5	3.0	421.8	136.3	558.1	4.09	78.17	347.2	210.9
64	0.4955	1796.127	1746.1	3.1	421.8	135.9	557.7	4.10	78.23	346.8	210.9
65	0.5074	1809.069	1759.1	3.2	424.5	136.5	561.0	4.11	78.14	348.8	212.2
66	0.5192	1815.202	1765.2	3.3	425.5	135.8	561.3	4.13	78.25	348.5	212.7
67	0.5311	1823.246	1773.2	3.4	427.0	135.0	562.0	4.16	78.36	348.5	213.5
68	0.5430	1831.026	1781.0	3.5	428.4	135.0	563.4	4.17	78.37	349.2	214.2
69	0.5549	1837.188	1787.2	3.6	429.5	135.0	564.5	4.18	78.35	349.8	214.7
70	0.5667	1836.908	1786.9	3.7	428.9	134.4	563.4	4.19	78.44	348.9	214.5
71	0.5786	1845.144	1795.1	3.8	430.5	134.4	564.9	4.20	78.44	349.7	215.2

Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress kPa	Minor Eff. Stress kPa	Major Eff. Stress kPa	1:3 Ratio	Pore Press. psi	P kPa	Q kPa
72	0.5905	1846.247	1796.2	3.9	430.3	134.3	564.6	4.20	78.46	349.4	215.1
73	0.6023	1855.909	1805.9	4.0	432.2	134.1	566.2	4.22	78.50	350.1	216.1
74	0.6142	1862.071	1812.1	4.1	433.2	135.8	568.9	4.19	78.25	352.4	216.6
75	0.6261	1865.836	1815.8	4.2	433.6	134.0	567.6	4.24	78.51	350.8	216.8
76	0.6380	1872.130	1822.1	4.3	434.7	134.2	568.9	4.24	78.47	351.5	217.3
77	0.6498	1876.145	1826.1	4.4	435.2	134.3	569.5	4.24	78.46	351.9	217.6
78	0.6617	1879.969	1830.0	4.5	435.6	135.5	571.1	4.22	78.29	353.3	217.8
79	0.6736	1883.013	1833.0	4.6	435.9	134.1	570.0	4.25	78.48	352.1	217.9
80	0.6855	1887.910	1837.9	4.7	436.6	134.3	570.9	4.25	78.46	352.6	218.3
81	0.6973	1894.969	1845.0	4.8	437.8	135.1	572.9	4.24	78.35	354.0	218.9
82	0.7092	1898.543	1848.5	4.9	438.2	134.8	573.0	4.25	78.39	353.9	219.1
83	0.7211	1910.249	1860.2	5.0	440.5	134.7	575.3	4.27	78.40	355.0	220.3
84	0.7508	1926.662	1876.7	5.2	443.2	135.8	579.1	4.26	78.24	357.5	221.6
85	0.7805	1941.177	1891.2	5.5	445.5	135.6	581.1	4.29	78.27	358.3	222.7
86	0.8101	1953.957	1904.0	5.7	447.3	135.7	583.0	4.30	78.25	359.4	223.7
87	0.8398	1961.546	1911.5	6.0	447.9	136.0	583.9	4.29	78.22	359.9	223.9
88	0.8695	1971.605	1921.6	6.2	449.1	136.2	585.2	4.30	78.19	360.7	224.5
89	0.8992	1977.017	1927.0	6.5	449.1	136.4	585.5	4.29	78.16	360.9	224.6
90	0.9289	1981.502	1931.5	6.7	449.0	136.7	585.7	4.28	78.11	361.2	224.5
91	0.9586	1993.267	1943.3	7.0	450.5	136.8	587.2	4.29	78.10	362.0	225.2
92	0.9883	2010.445	1960.4	7.2	453.2	136.9	590.1	4.31	78.09	363.5	226.6
93	1.0180	2014.621	1964.6	7.5	453.0	137.5	590.5	4.30	78.00	364.0	226.5
94	1.0476	2030.960	1981.0	7.7	455.5	137.4	592.9	4.31	78.01	365.2	227.8
95	1.0773	2041.740	1991.7	8.0	456.8	137.8	594.6	4.31	77.95	366.2	228.4
96	1.1070	2046.608	1996.6	8.2	456.6	137.7	594.4	4.32	77.96	366.1	228.3
97	1.1367	2063.373	2013.4	8.5	459.2	138.7	597.9	4.31	77.82	368.3	229.6
98	1.1664	2076.682	2026.7	8.7	461.0	138.5	599.5	4.33	77.85	369.0	230.5
99	1.1961	2080.977	2031.0	9.0	460.7	139.0	599.7	4.31	77.77	369.4	230.3
100	1.2257	2090.139	2040.1	9.2	461.5	139.2	600.7	4.32	77.75	369.9	230.7
101	1.2554	2098.154	2048.2	9.5	462.0	139.0	601.0	4.33	77.79	370.0	231.0
102	1.2851	2100.080	2050.1	9.7	461.2	139.2	600.4	4.31	77.75	369.8	230.6
103	1.3148	2109.095	2059.1	10.0	461.9	139.1	601.1	4.32	77.76	370.1	231.0
104	1.3445	2120.022	2070.0	10.2	463.1	139.4	602.5	4.32	77.72	370.9	231.5
105	1.3742	2116.684	2066.7	10.5	461.1	139.5	600.5	4.31	77.71	370.0	230.5
106	1.4039	2120.258	2070.3	10.7	460.6	139.9	600.5	4.29	77.65	370.2	230.3
107	1.4335	2130.552	2080.6	11.0	461.6	140.0	601.5	4.30	77.64	370.8	230.8
108	1.4633	2140.508	2090.5	11.2	462.5	140.3	602.7	4.30	77.60	371.5	231.2
109	1.4929	2148.803	2098.8	11.5	463.0	140.4	603.4	4.30	77.57	371.9	231.5
110	1.5226	2148.744	2098.7	11.7	461.7	140.9	602.6	4.28	77.51	371.7	230.8
111	1.5523	2160.627	2110.6	12.0	463.0	140.9	603.9	4.29	77.50	372.4	231.5
112	1.5820	2163.318	2113.3	12.2	462.2	141.2	603.4	4.27	77.47	372.3	231.1
113	1.6117	2169.745	2119.7	12.5	462.3	141.8	604.1	4.26	77.38	372.9	231.2
114	1.6413	2167.907	2117.9	12.7	460.6	140.9	601.5	4.27	77.50	371.2	230.3
115	1.6710	2176.319	2126.3	13.0	461.1	141.3	602.4	4.26	77.45	371.8	230.6
116	1.7007	2185.040	2135.0	13.2	461.7	141.5	603.2	4.26	77.42	372.3	230.8
117	1.7304	2192.393	2142.4	13.5	461.9	142.0	603.9	4.25	77.34	373.0	231.0
118	1.7601	2198.746	2148.7	13.7	462.0	141.5	603.5	4.26	77.41	372.5	231.0

Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress kPa	Minor Eff. Stress kPa	Major Eff. Stress kPa	1:3 Ratio	Pore Press. psi	P kPa	Q kPa
119	1.7897	2203.570	2153.6	14.0	461.6	142.4	604.0	4.24	77.29	373.2	230.8
120	1.8195	2213.717	2163.7	14.2	462.5	142.1	604.6	4.25	77.33	373.4	231.2
121	1.8491	2212.438	2162.4	14.5	460.9	142.4	603.2	4.24	77.29	372.8	230.4
122	1.8788	2211.614	2161.6	14.7	459.3	142.4	601.7	4.23	77.29	372.1	229.7
123	1.9085	2220.262	2170.3	15.0	459.8	142.7	602.5	4.22	77.24	372.6	229.9
124	1.9382	2226.453	2176.5	15.2	459.8	142.5	602.3	4.23	77.27	372.4	229.9
125	1.9679	2234.394	2184.4	15.5	460.1	142.3	602.4	4.23	77.30	372.4	230.0
126	1.9976	2232.983	2183.0	15.7	458.4	142.1	600.5	4.23	77.33	371.3	229.2
127	2.0272	2237.615	2187.6	16.0	458.0	142.0	600.0	4.23	77.35	371.0	229.0
128	2.0569	2247.733	2197.7	16.2	458.8	141.7	600.5	4.24	77.39	371.1	229.4
129	2.0866	2247.336	2197.3	16.5	457.3	141.7	599.0	4.23	77.39	370.3	228.7
130	2.1163	2252.910	2202.9	16.7	457.1	141.6	598.8	4.23	77.40	370.2	228.6
131	2.1460	2262.969	2213.0	17.0	457.8	142.5	600.4	4.21	77.27	371.5	228.9
132	2.1757	2274.367	2224.4	17.2	458.8	142.7	601.5	4.21	77.24	372.1	229.4
133	2.2054	2273.749	2223.7	17.5	457.3	142.9	600.2	4.20	77.22	371.5	228.6
134	2.2350	2278.984	2229.0	17.7	457.0	142.7	599.6	4.20	77.25	371.1	228.5
135	2.2647	2291.220	2241.2	18.0	458.1	142.9	601.0	4.21	77.22	371.9	229.0
136	2.2944	2290.455	2240.5	18.2	456.5	142.9	599.5	4.19	77.21	371.2	228.3
137	2.3241	2295.573	2245.6	18.5	456.2	142.8	599.0	4.19	77.23	370.9	228.1
138	2.3538	2302.044	2252.0	18.7	456.1	143.0	599.1	4.19	77.19	371.1	228.0
139	2.3835	2302.382	2252.4	19.0	454.7	143.3	598.1	4.17	77.15	370.7	227.4
140	2.4132	2306.324	2256.3	19.2	454.1	143.2	597.3	4.17	77.17	370.2	227.1
141	2.4428	2315.103	2265.1	19.5	454.5	143.2	597.7	4.17	77.18	370.4	227.2
142	2.4725	2317.265	2267.3	19.7	453.5	143.2	596.7	4.17	77.17	370.0	226.8
143	2.5022	2319.221	2269.2	20.0	452.5	143.5	596.0	4.15	77.13	369.7	226.2
144	2.5319	2330.575	2280.6	20.2	453.3	143.5	596.8	4.16	77.13	370.2	226.7
145	2.5616	2334.384	2284.4	20.5	452.7	143.2	595.8	4.16	77.17	369.5	226.3
146	2.5912	2343.928	2293.9	20.7	453.1	143.6	596.7	4.16	77.11	370.2	226.6
147	2.6209	2353.870	2303.9	21.0	453.7	143.8	597.5	4.15	77.08	370.7	226.8
148	2.6228	2351.796	2301.8	21.0	453.2	143.7	596.9	4.15	77.10	370.3	226.6

Parameters for Specimen No. 4

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	11820.100			14435.500
Moisture content: Dry soil+tare, gms.	10889.000			13307.000
Moisture content: Tare, gms.	0.000			2418.000
Moisture, %	8.6	14.4	10.4	10.4
Moist specimen weight, gms.	11820.1			
Diameter, in.	6.00	6.00	5.84	
Area, in.²	28.27	28.27	26.74	
Height, in.	12.00	12.00	11.68	
Net decrease in height, in.		0.00	0.32	
Wet density, pcf	132.7	139.9	146.6	
Dry density, pcf	122.3	122.3	132.9	
Void ratio	0.3940	0.3940	0.2828	
Saturation, %	59.3	100.0	100.0	

Test Readings for Specimen No. 4

Membrane modulus = 0.124105 kN/cm²

Membrane thickness = 0.064 cm

Consolidation cell pressure = 166.22 psi (1146.0 kPa)

Consolidation back pressure = 49.75 psi (343.0 kPa)

Consolidation effective confining stress = 803.0 kPa

Strain rate, %/min. = 0.03

Fail. Stress = 945.1 kPa **at reading no.** 136

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress kPa	Minor Eff. Stress kPa	Major Eff. Stress kPa	1:3 Ratio	Pore Press. psi	P kPa	Q kPa
0	0.0000	123.239	0.0	0.0	0.0	803.1	803.1	1.00	49.75	803.1	0.0
1	0.0030	194.359	71.1	0.0	18.3	802.0	820.3	1.02	49.91	811.1	9.2
2	0.0060	395.117	271.9	0.1	70.1	798.1	868.2	1.09	50.46	833.1	35.0
3	0.0090	605.022	481.8	0.1	124.1	790.9	915.1	1.16	51.50	853.0	62.1
4	0.0120	776.720	653.5	0.1	168.3	781.2	949.5	1.22	52.92	865.3	84.2
5	0.0150	928.623	805.4	0.1	207.4	769.3	976.7	1.27	54.64	873.0	103.7
6	0.0180	1059.510	936.3	0.2	241.0	756.0	997.0	1.32	56.57	876.5	120.5
7	0.0210	1185.618	1062.4	0.2	273.4	742.1	1015.5	1.37	58.58	878.8	136.7
8	0.0240	1297.696	1174.5	0.2	302.2	727.3	1029.5	1.42	60.73	878.4	151.1
9	0.0270	1403.877	1280.6	0.2	329.4	712.5	1041.9	1.46	62.88	877.2	164.7
10	0.0300	1503.469	1380.2	0.3	354.9	697.5	1052.4	1.51	65.06	874.9	177.5
11	0.0330	1594.414	1471.2	0.3	378.2	682.2	1060.4	1.55	67.28	871.3	189.1
12	0.0360	1679.932	1556.7	0.3	400.1	667.3	1067.4	1.60	69.44	867.3	200.0
13	0.0390	1767.361	1644.1	0.3	422.5	652.4	1074.8	1.65	71.60	863.6	211.2
14	0.0420	1847.129	1723.9	0.4	442.8	637.7	1080.5	1.69	73.73	859.1	221.4
15	0.0450	1920.764	1797.5	0.4	461.6	622.5	1084.1	1.74	75.93	853.3	230.8
16	0.0480	1991.885	1868.6	0.4	479.8	607.7	1087.5	1.79	78.07	847.6	239.9
17	0.0510	2056.534	1933.3	0.4	496.2	595.0	1091.2	1.83	79.92	843.1	248.1
18	0.0540	2116.199	1993.0	0.5	511.4	581.6	1093.1	1.88	81.86	837.4	255.7
19	0.0570	2173.848	2050.6	0.5	526.1	568.0	1094.1	1.93	83.84	831.0	263.0
20	0.0600	2232.012	2108.8	0.5	540.9	556.2	1097.1	1.97	85.55	826.7	270.4
21	0.0630	2284.705	2161.5	0.5	554.2	544.0	1098.2	2.02	87.32	821.1	277.1
22	0.0660	2330.663	2207.4	0.6	565.9	532.2	1098.1	2.06	89.03	815.1	282.9
23	0.0690	2379.018	2255.8	0.6	578.1	520.0	1098.1	2.11	90.80	809.0	289.1
24	0.0720	2418.269	2295.0	0.6	588.0	509.6	1097.6	2.15	92.31	803.6	294.0

Test Readings for Specimen No. 4

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress kPa	Minor Eff. Stress kPa	Major Eff. Stress kPa	1:3 Ratio	Pore Press. psi	P kPa	Q kPa
25	0.075	12455.800	2332.6	0.6	597.5	499.6	1097.1	2.20	93.76	798.3	298.7
26	0.078	12499.272	2376.0	0.7	608.5	489.2	1097.7	2.24	95.26	793.5	304.2
27	0.081	12532.685	2409.4	0.7	616.9	480.1	1097.0	2.28	96.58	788.6	308.4
28	0.084	12567.201	2444.0	0.7	625.5	470.3	1095.9	2.33	98.00	783.1	312.8
29	0.087	12596.452	2473.2	0.7	632.9	462.2	1095.1	2.37	99.18	778.7	316.4
30	0.090	12625.807	2502.6	0.8	640.2	453.6	1093.8	2.41	100.43	773.7	320.1
31	0.093	12651.396	2528.2	0.8	646.6	445.5	1092.1	2.45	101.60	768.8	323.3
32	0.096	12676.809	2553.6	0.8	652.9	437.6	1090.5	2.49	102.75	764.1	326.5
33	0.099	12698.398	2575.2	0.8	658.3	430.7	1088.9	2.53	103.76	759.8	329.1
34	0.102	12719.516	2596.3	0.9	663.5	423.0	1086.5	2.57	104.87	754.7	331.7
35	0.105	12744.752	2621.5	0.9	669.8	416.3	1086.1	2.61	105.84	751.2	334.9
36	0.108	12758.753	2635.5	0.9	673.2	409.4	1082.6	2.64	106.84	746.0	336.6
37	0.111	12780.327	2657.1	1.0	678.5	403.6	1082.1	2.68	107.68	742.9	339.3
38	0.114	12796.975	2673.7	1.0	682.6	397.8	1080.4	2.72	108.52	739.1	341.3
39	0.117	12814.740	2691.5	1.0	686.9	392.6	1079.5	2.75	109.28	736.0	343.5
40	0.120	12831.668	2708.4	1.0	691.1	386.4	1077.5	2.79	110.17	732.0	345.5
41	0.123	12850.345	2727.1	1.1	695.7	381.9	1077.5	2.82	110.83	729.7	347.8
42	0.135	12900.700	2777.5	1.2	707.8	362.6	1070.3	2.95	113.64	716.4	353.9
43	0.147	12942.113	2818.9	1.3	717.6	347.2	1064.7	3.07	115.87	706.0	358.8
44	0.159	12979.938	2856.7	1.4	726.4	333.9	1060.4	3.18	117.79	697.1	363.2
45	0.171	13014.292	2891.1	1.5	734.4	323.5	1057.9	3.27	119.30	690.7	367.2
46	0.183	13046.941	2923.7	1.6	741.9	313.9	1055.8	3.36	120.70	684.8	371.0
47	0.195	13071.692	2948.5	1.7	747.4	306.0	1053.4	3.44	121.84	679.7	373.7
48	0.207	13096.090	2972.9	1.8	752.8	299.1	1052.0	3.52	122.83	675.6	376.4
49	0.219	13113.340	2990.1	1.9	756.4	293.4	1049.8	3.58	123.66	671.6	378.2
50	0.231	13131.517	3008.3	2.0	760.2	288.2	1048.4	3.64	124.42	668.3	380.1
51	0.243	13157.754	3034.5	2.1	766.0	284.1	1050.1	3.70	125.02	667.1	383.0
52	0.255	13177.755	3054.5	2.2	770.3	280.6	1050.9	3.74	125.52	665.7	385.1
53	0.267	23189.123	3065.9	2.3	772.3	277.5	1049.8	3.78	125.98	663.6	386.2
54	0.279	23210.521	3087.3	2.4	776.9	274.8	1051.7	3.83	126.36	663.3	388.4
55	0.291	23222.050	3098.8	2.5	779.0	273.2	1052.1	3.85	126.60	662.7	389.5
56	0.303	23235.169	3111.9	2.6	781.4	270.8	1052.3	3.89	126.94	661.6	390.7
57	0.315	13248.934	3125.7	2.7	784.1	269.4	1053.5	3.91	127.15	661.4	392.0
58	0.327	23261.302	3138.1	2.8	786.3	267.7	1054.1	3.94	127.39	660.9	393.2
59	0.339	23279.126	3155.9	2.9	790.0	267.3	1057.3	3.96	127.45	662.3	395.0
60	0.351	23290.362	3167.1	3.0	792.0	266.7	1058.6	3.97	127.54	662.6	396.0
61	0.363	23308.068	3184.8	3.1	795.5	265.8	1061.4	3.99	127.67	663.6	397.8
62	0.375	23324.819	3201.6	3.2	798.9	265.5	1064.4	4.01	127.71	665.0	399.4
63	0.387	23335.114	3211.9	3.3	800.6	264.7	1065.3	4.02	127.83	665.0	400.3
64	0.399	23347.702	3224.5	3.4	802.9	264.6	1067.5	4.03	127.84	666.1	401.4
65	0.411	23358.600	3235.4	3.5	804.7	264.4	1069.1	4.04	127.87	666.8	402.4
66	0.423	23374.189	3251.0	3.6	807.7	264.1	1071.9	4.06	127.91	668.0	403.9
67	0.435	23387.704	3264.5	3.7	810.2	264.2	1074.4	4.07	127.91	669.3	405.1
68	0.447	23401.249	3278.0	3.8	812.7	264.7	1077.4	4.07	127.83	671.0	406.4
69	0.459	23414.720	3291.5	3.9	815.2	264.3	1079.5	4.08	127.88	671.9	407.6
70	0.471	23424.249	3301.0	4.0	816.7	264.9	1081.6	4.08	127.80	673.2	408.3
71	0.483	23443.309	3320.1	4.1	820.5	264.6	1085.1	4.10	127.85	674.8	410.3

Knight Piesold Geotechnical Lab.

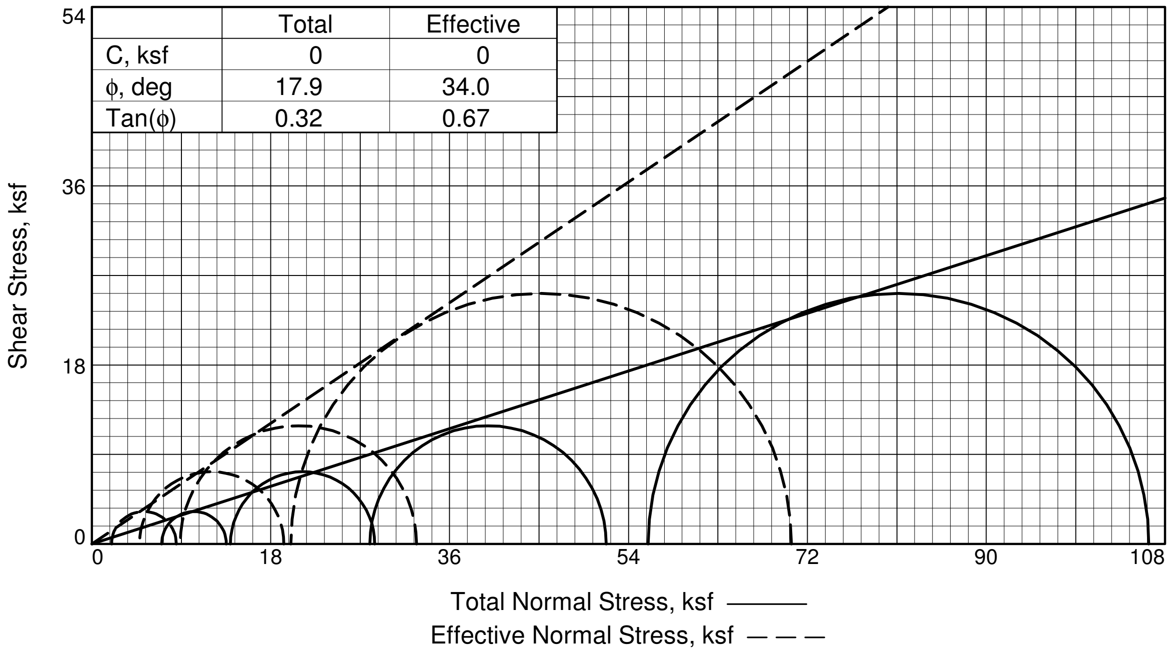
Test Readings for Specimen No. 4

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress kPa	Minor Eff. Stress kPa	Major Eff. Stress kPa	1:3 Ratio	Pore Press. psi	P kPa	Q kPa
72	0.4952	3461.530	3338.3	4.2	824.1	266.2	1090.3	4.10	127.62	678.2	412.1
73	0.5072	3472.354	3349.1	4.3	825.9	265.9	1091.8	4.11	127.65	678.9	413.0
74	0.5192	3484.722	3361.5	4.4	828.1	265.8	1093.9	4.12	127.67	679.8	414.0
75	0.5312	3495.649	3372.4	4.6	829.9	265.8	1095.7	4.12	127.67	680.7	414.9
76	0.5432	3506.061	3382.8	4.7	831.5	266.6	1098.1	4.12	127.55	682.4	415.8
77	0.5553	3522.121	3398.9	4.8	834.6	266.7	1101.3	4.13	127.53	684.0	417.3
78	0.5672	3537.666	3414.4	4.9	837.5	267.1	1104.6	4.14	127.48	685.8	418.7
79	0.5793	3547.372	3424.1	5.0	839.0	268.1	1107.1	4.13	127.34	687.6	419.5
80	0.5913	3559.196	3436.0	5.1	841.0	268.6	1109.5	4.13	127.27	689.1	420.5
81	0.6033	3577.785	3454.5	5.2	844.6	269.5	1114.1	4.13	127.14	691.8	422.3
82	0.6333	3605.609	3482.4	5.4	849.1	269.7	1118.8	4.15	127.11	694.2	424.5
83	0.6633	3634.125	3510.9	5.7	853.7	271.0	1124.8	4.15	126.91	697.9	426.9
84	0.6933	3665.788	3542.5	5.9	859.1	271.8	1130.8	4.16	126.80	701.3	429.5
85	0.7233	3686.436	3563.2	6.2	861.7	273.8	1135.5	4.15	126.51	704.6	430.9
86	0.7533	3723.496	3600.3	6.5	868.3	275.6	1143.9	4.15	126.25	709.7	434.1
87	0.7833	3748.703	3625.5	6.7	872.0	275.9	1147.9	4.16	126.20	711.9	436.0
88	0.8133	3777.425	3654.2	7.0	876.5	278.1	1154.5	4.15	125.89	716.3	438.2
89	0.8433	3800.543	3677.3	7.2	879.6	279.2	1158.7	4.15	125.73	719.0	439.8
90	0.8733	3827.795	3704.6	7.5	883.6	279.8	1163.4	4.16	125.64	721.6	441.8
91	0.9033	3855.487	3732.2	7.7	887.8	281.8	1169.6	4.15	125.34	725.7	443.9
92	0.9333	3884.664	3761.4	8.0	892.2	282.2	1174.5	4.16	125.28	728.4	446.1
93	0.9634	3919.210	3796.0	8.3	897.9	282.6	1180.5	4.18	125.23	731.6	448.9
94	0.9933	3944.387	3821.1	8.5	901.3	285.0	1186.3	4.16	124.88	735.7	450.7
95	1.0233	3970.962	3847.7	8.8	905.0	286.4	1191.5	4.16	124.67	739.0	452.5
96	1.0534	3992.095	3868.9	9.0	907.4	287.0	1194.4	4.16	124.60	740.7	453.7
97	1.0834	4020.258	3897.0	9.3	911.5	288.1	1199.5	4.16	124.44	743.8	455.7
98	1.1134	4037.906	3914.7	9.5	913.0	289.0	1201.9	4.16	124.31	745.4	456.5
99	1.1434	4066.083	3942.8	9.8	916.9	290.3	1207.3	4.16	124.11	748.8	458.5
100	1.1734	4080.040	3956.8	10.1	917.6	291.1	1208.7	4.15	124.00	749.9	458.8
101	1.2034	4107.923	3984.7	10.3	921.4	291.9	1213.3	4.16	123.89	752.6	460.7
102	1.2334	4118.571	3995.3	10.6	921.2	292.5	1213.8	4.15	123.79	753.1	460.6
103	1.2634	4133.851	4010.6	10.8	922.1	293.7	1215.8	4.14	123.62	754.8	461.0
104	1.2934	4153.984	4030.7	11.1	924.0	295.1	1219.2	4.13	123.42	757.1	462.0
105	1.3234	4175.440	4052.2	11.3	926.3	295.6	1221.9	4.13	123.34	758.8	463.1
106	1.3534	4194.323	4071.1	11.6	927.9	297.4	1225.3	4.12	123.08	761.4	463.9
107	1.3834	4216.839	4093.6	11.8	930.3	298.5	1228.9	4.12	122.92	763.7	465.2
108	1.4134	4233.854	4110.6	12.1	931.5	299.9	1231.4	4.11	122.72	765.7	465.7
109	1.4434	4251.796	4128.6	12.4	932.8	301.2	1234.0	4.10	122.53	767.6	466.4
110	1.4734	4267.915	4144.7	12.6	933.7	301.3	1235.0	4.10	122.52	768.1	466.8
111	1.5034	4282.224	4159.0	12.9	934.1	302.9	1237.0	4.08	122.29	769.9	467.1
112	1.5334	4299.342	4176.1	13.1	935.2	303.1	1238.4	4.09	122.26	770.7	467.6
113	1.5634	4316.872	4193.6	13.4	936.4	305.2	1241.6	4.07	121.95	773.4	468.2
114	1.5935	4335.858	4212.6	13.6	937.8	306.4	1244.2	4.06	121.78	775.3	468.9
115	1.6235	4353.741	4230.5	13.9	939.0	306.9	1245.9	4.06	121.70	776.4	469.5
116	1.6535	4364.683	4241.4	14.2	938.6	307.2	1245.8	4.06	121.67	776.5	469.3
117	1.6835	4383.448	4260.2	14.4	939.9	308.0	1247.9	4.05	121.55	778.0	470.0
118	1.7135	4394.331	4271.1	14.7	939.5	309.4	1248.9	4.04	121.35	779.2	469.8

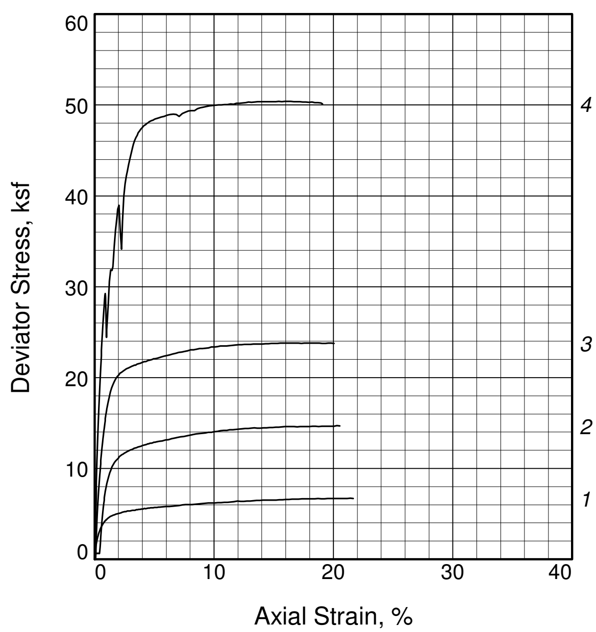
Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 4

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress kPa	Minor Eff. Stress kPa	Major Eff. Stress kPa	1:3 Ratio	Pore Press. psi	P kPa	Q kPa
119	1.7435	4407.861	4284.6	14.9	939.7	310.2	1249.8	4.03	121.24	780.0	469.8
120	1.7735	4425.862	4302.6	15.2	940.8	310.4	1251.1	4.03	121.20	780.8	470.4
121	1.8035	4438.039	4314.8	15.4	940.6	311.5	1252.1	4.02	121.04	781.8	470.3
122	1.8335	4450.407	4327.2	15.7	940.4	313.1	1253.5	4.00	120.81	783.3	470.2
123	1.8635	4464.922	4341.7	16.0	940.7	312.0	1252.7	4.01	120.97	782.3	470.3
124	1.8935	4482.276	4359.0	16.2	941.5	313.1	1254.7	4.01	120.80	783.9	470.8
125	1.9235	4493.703	4370.5	16.5	941.1	314.0	1255.1	4.00	120.68	784.5	470.6
126	1.9535	4513.704	4390.5	16.7	942.5	315.2	1257.7	3.99	120.50	786.5	471.3
127	1.9836	4525.866	4402.6	17.0	942.2	316.5	1258.7	3.98	120.31	787.6	471.1
128	2.0135	4541.102	4417.9	17.2	942.5	317.2	1259.7	3.97	120.22	788.4	471.3
129	2.0435	4559.470	4436.2	17.5	943.5	316.3	1259.8	3.98	120.34	788.1	471.8
130	2.0735	4576.985	4453.7	17.8	944.3	317.0	1261.3	3.98	120.24	789.2	472.1
131	2.1036	4591.692	4468.5	18.0	944.4	318.1	1262.5	3.97	120.09	790.3	472.2
132	2.1336	4610.296	4487.1	18.3	945.4	318.4	1263.8	3.97	120.04	791.1	472.7
133	2.1636	4622.355	4499.1	18.5	945.0	319.4	1264.4	3.96	119.90	791.9	472.5
134	2.1936	4638.238	4515.0	18.8	945.3	319.8	1265.1	3.96	119.84	792.4	472.7
135	2.2236	4647.518	4524.3	19.0	944.3	320.9	1265.2	3.94	119.68	793.0	472.1
136	2.2536	4666.107	4542.9	19.3	945.1	304.8	1249.9	4.10	122.02	777.3	472.6



	Total	Effective
C, ksf	0	0
ϕ, deg	17.9	34.0
Tan(ϕ)	0.32	0.67



	Specimen No.	1	2	3	4
Initial	Water Content, %	10.5	9.9	8.2	8.2
	Dry Density, pcf	93.0	93.5	95.0	95.0
	Saturation, %	33.7	32.2	27.6	27.6
	Void Ratio	0.8640	0.8543	0.8257	0.8257
	Diameter, in.	6.00	6.00	6.00	6.00
	Height, in.	13.00	13.00	13.00	13.00
At Test	Water Content, %	16.9	15.6	14.3	11.8
	Dry Density, pcf	118.1	121.0	124.1	130.5
	Saturation, %	100.0	100.0	100.0	100.0
	Void Ratio	0.4688	0.4331	0.3980	0.3289
	Diameter, in.	5.64	5.54	5.47	5.35
	Height, in.	11.58	11.79	11.98	11.89
	Strain rate, %/min.	0.02	0.03	0.03	0.03
	Eff. Cell Pressure, ksf	7.0	14.0	28.0	56.0
	Fail. Stress, ksf	6.5	14.5	23.8	50.4
	Excess Pore Pr., ksf	5.0	9.2	19.1	36.0
	Strain, %	14.9	14.9	15.1	14.9
	Ult. Stress, ksf				
	Excess Pore Pr., ksf				
	Strain, %				
	$\bar{\sigma}_1$ Failure, ksf	8.5	19.3	32.7	70.4
	$\bar{\sigma}_3$ Failure, ksf	2.0	4.8	8.9	20.0

Type of Test:
CU with Pore Pressures

Sample Type: Remolded

Description: clayey SAND with gravel

LL= 38 **PL=** 21 **PI=** 17

Specific Gravity= 2.778

Remarks: Failure chosen at 15% strain with no cohesion intercept.

Figure ________

Client: Montana Resources

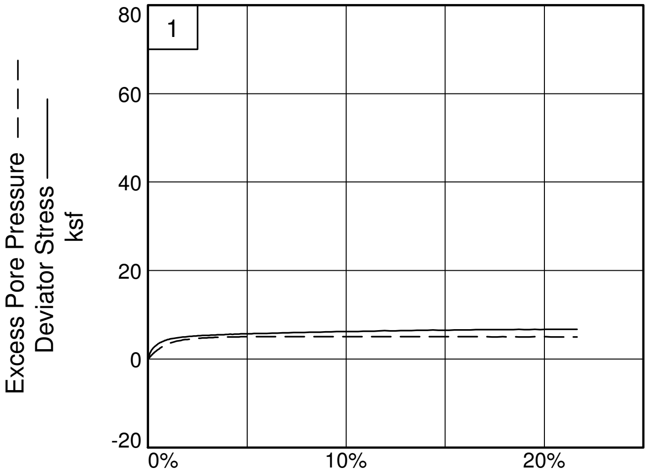
Project: Yankee Doodle Tailings Impoundment

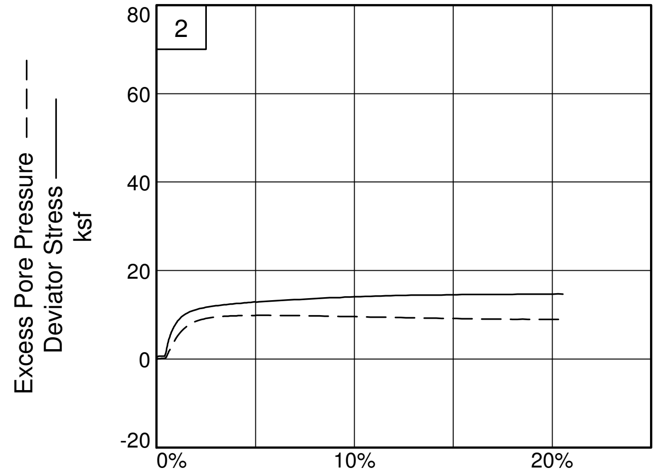
Location: Composite 1 through 4- Older Rockfill

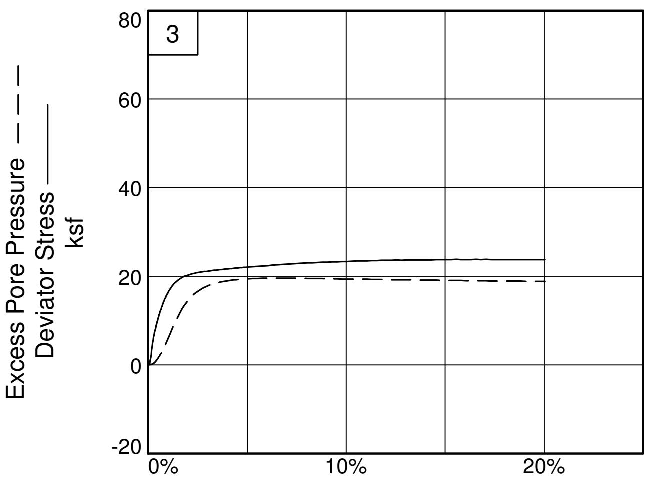
Proj. No.: VA101-00126/17 **Date Sampled:** 7/18/17

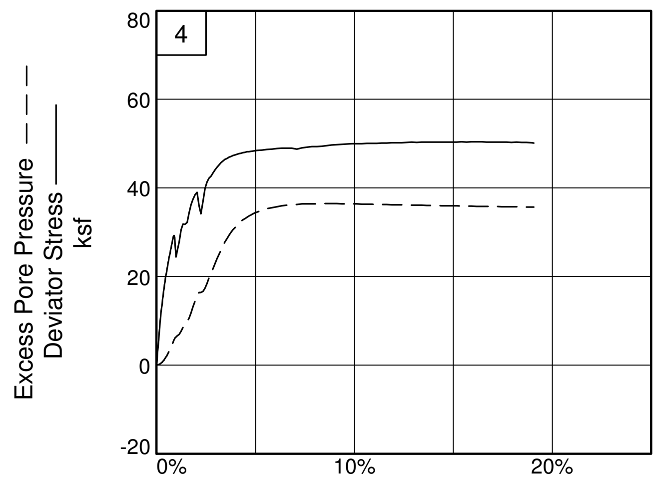
Knight Piésold CONSULTING

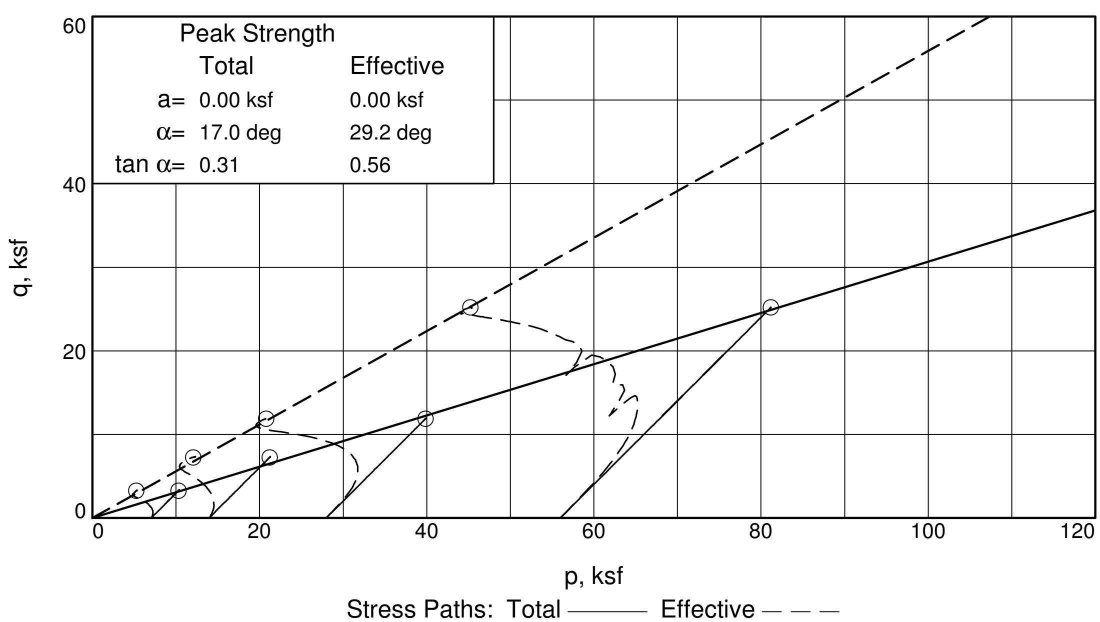
Tested By: JDH/JDB **Checked By:** JDB











Client: Montana Resources
Project: Yankee Doodle Tailings Impoundment
Location: Composite 1 through 4- Older Rockfill
Project No.: VA101-00126/17

Figure ________

Knight Piesold Geotechnical Lab.

Tested By: JDH/JDB **Checked By:** JDB

TRIAXIAL COMPRESSION TEST

CU with Pore Pressures

8/31/2017
3:48 PM

Date: 7/18/17
Client: Montana Resources
Project: Yankee Doodle Tailings Impoundment
Project No.: VA101-00126/17
Location: Composite 1 through 4- Older Rockfill
Description: clayey SAND with gravel
Remarks: Failure chosen at 15% strain with no cohesion intercept.
Type of Sample: Remolded
Specific Gravity=2.778 **LL=**38 **PL=**21 **PI=**17
Test Method: ASTM D 4767 Method A

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	9917.000			13301.500
Moisture content: Dry soil+tare, gms.	8977.000			11787.000
Moisture content: Tare, gms.	0.000			2810.000
Moisture, %	10.5	31.1	16.9	16.9
Moist specimen weight, gms.	9917.0			
Diameter, in.	6.00	6.00	5.64	
Area, in.^{2}	28.27	28.27	25.01	
Height, in.	13.00	13.00	11.58	
Net decrease in height, in.		0.00	1.42	
Net decrease in water volume, cc.			1277.00	
Wet density, pcf	102.8	122.0	138.0	
Dry density, pcf	93.0	93.0	118.1	
Void ratio	0.8640	0.8640	0.4688	
Saturation, %	33.7	100.0	100.0	

Test Readings for Specimen No. 1

Membrane modulus = 0.124105 kN/cm^2
Membrane thickness = 0.0635 cm
Consolidation cell pressure = 127.31 psi (18.33 ksf)
Consolidation back pressure = 78.50 psi (11.30 ksf)
Consolidation effective confining stress = 7.03 ksf
Strain rate, %/min. = 0.02
Fail. Stress = 6.50 ksf **at reading no.** 116

Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.8185	104.161	0.0	0.0	0.00	7.03	7.03	1.00	78.50	7.03	0.00
1	0.8217	177.576	73.4	0.0	0.42	6.93	7.35	1.06	79.20	7.14	0.21
2	0.8249	232.637	128.5	0.1	0.74	6.82	7.56	1.11	79.95	7.19	0.37
3	0.8280	293.081	188.9	0.1	1.09	6.69	7.77	1.16	80.87	7.23	0.54
4	0.8312	348.862	244.7	0.1	1.41	6.54	7.95	1.22	81.89	7.24	0.70
5	0.8343	395.982	291.8	0.1	1.68	6.40	8.07	1.26	82.89	7.24	0.84
6	0.8375	429.762	325.6	0.2	1.87	6.26	8.13	1.30	83.87	7.19	0.94
7	0.8406	465.764	361.6	0.2	2.08	6.12	8.20	1.34	84.80	7.16	1.04
8	0.8438	489.059	384.9	0.2	2.21	6.00	8.21	1.37	85.67	7.10	1.11
9	0.8470	518.648	414.5	0.2	2.38	5.87	8.26	1.41	86.51	7.07	1.19
10	0.8501	543.046	438.9	0.3	2.52	5.77	8.29	1.44	87.27	7.03	1.26
11	0.8532	564.297	460.1	0.3	2.64	5.65	8.29	1.47	88.09	6.97	1.32
12	0.8564	586.474	482.3	0.3	2.77	5.55	8.31	1.50	88.79	6.93	1.38
13	0.8595	605.049	500.9	0.4	2.87	5.44	8.31	1.53	89.54	6.88	1.44
14	0.8627	623.623	519.5	0.4	2.98	5.34	8.32	1.56	90.25	6.83	1.49
15	0.8658	641.300	537.1	0.4	3.08	5.24	8.32	1.59	90.90	6.78	1.54
16	0.8690	658.933	554.8	0.4	3.18	5.14	8.32	1.62	91.59	6.73	1.59
17	0.8721	675.360	571.2	0.5	3.27	5.05	8.32	1.65	92.24	6.69	1.64
18	0.8753	691.581	587.4	0.5	3.37	4.96	8.32	1.68	92.87	6.64	1.68
19	0.8784	707.714	603.6	0.5	3.46	4.87	8.33	1.71	93.48	6.60	1.73
20	0.8815	717.818	613.7	0.5	3.51	4.78	8.30	1.73	94.09	6.54	1.76
21	0.8847	731.524	627.4	0.6	3.59	4.70	8.29	1.76	94.70	6.49	1.80
22	0.8878	741.113	637.0	0.6	3.65	4.61	8.26	1.79	95.27	6.44	1.82
23	0.8910	754.996	650.8	0.6	3.72	4.54	8.26	1.82	95.81	6.40	1.86
24	0.8941	765.643	661.5	0.7	3.78	4.46	8.24	1.85	96.35	6.35	1.89
25	0.8973	777.408	673.2	0.7	3.85	4.38	8.23	1.88	96.87	6.31	1.93
26	0.9004	790.541	686.4	0.7	3.92	4.31	8.23	1.91	97.41	6.27	1.96
27	0.9036	795.350	691.2	0.7	3.95	4.23	8.19	1.93	97.90	6.21	1.98
28	0.9067	804.056	699.9	0.8	4.00	4.18	8.18	1.96	98.31	6.18	2.00
29	0.9098	811.483	707.3	0.8	4.04	4.10	8.14	1.98	98.82	6.12	2.02
30	0.9130	823.131	719.0	0.8	4.11	4.04	8.14	2.02	99.28	6.09	2.05
31	0.9161	830.293	726.1	0.8	4.15	3.98	8.12	2.04	99.70	6.05	2.07
32	0.9193	838.999	734.8	0.9	4.19	3.91	8.10	2.07	100.16	6.01	2.10
33	0.9224	848.234	744.1	0.9	4.25	3.85	8.10	2.10	100.55	5.98	2.12
34	0.9256	852.411	748.2	0.9	4.27	3.81	8.07	2.12	100.88	5.94	2.13
35	0.9287	859.603	755.4	1.0	4.31	3.74	8.05	2.15	101.31	5.90	2.15
36	0.9319	870.368	766.2	1.0	4.37	3.69	8.06	2.18	101.68	5.87	2.18
37	0.9350	873.485	769.3	1.0	4.39	3.64	8.03	2.20	102.03	5.83	2.19
38	0.9381	879.000	774.8	1.0	4.42	3.59	8.01	2.23	102.38	5.80	2.21
39	0.9413	883.662	779.5	1.1	4.44	3.54	7.98	2.25	102.72	5.76	2.22
40	0.9444	888.251	784.1	1.1	4.47	3.50	7.96	2.28	103.04	5.73	2.23
41	0.9476	896.060	791.9	1.1	4.51	3.45	7.96	2.31	103.36	5.70	2.25
42	0.9601	916.017	811.9	1.2	4.62	3.29	7.90	2.41	104.49	5.59	2.31
43	0.9727	931.899	827.7	1.3	4.70	3.15	7.85	2.49	105.43	5.50	2.35
44	0.9852	948.841	844.7	1.4	4.79	3.02	7.81	2.59	106.34	5.42	2.40
45	0.9978	961.651	857.5	1.5	4.86	2.91	7.77	2.67	107.10	5.34	2.43
46	1.0103	970.489	866.3	1.7	4.91	2.82	7.73	2.74	107.73	5.27	2.45

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
47	1.0228	981.887	877.7	1.8	4.96	2.74	7.70	2.82	108.31	5.22	2.48
48	1.0354	988.019	883.9	1.9	4.99	2.66	7.66	2.88	108.83	5.16	2.50
49	1.0479	998.887	894.7	2.0	5.05	2.60	7.65	2.94	109.25	5.13	2.52
50	1.0605	1006.417	902.3	2.1	5.09	2.54	7.63	3.00	109.65	5.09	2.54
51	1.0730	1014.020	909.9	2.2	5.12	2.49	7.61	3.06	110.03	5.05	2.56
52	1.0856	1024.491	920.3	2.3	5.18	2.44	7.62	3.12	110.36	5.03	2.59
53	1.0981	1031.771	927.6	2.4	5.21	2.39	7.61	3.18	110.68	5.00	2.61
54	1.1106	1039.007	934.8	2.5	5.25	2.35	7.60	3.23	110.97	4.98	2.62
55	1.1232	1041.551	937.4	2.6	5.26	2.32	7.57	3.27	111.22	4.94	2.63
56	1.1358	1052.889	948.7	2.7	5.31	2.28	7.60	3.33	111.44	4.94	2.66
57	1.1483	1055.728	951.6	2.8	5.32	2.26	7.58	3.36	111.63	4.92	2.66
58	1.1608	1056.669	952.5	3.0	5.32	2.23	7.56	3.38	111.80	4.90	2.66
59	1.1734	1066.258	962.1	3.1	5.37	2.21	7.58	3.43	111.97	4.89	2.69
60	1.1860	1070.964	966.8	3.2	5.39	2.19	7.58	3.46	112.10	4.89	2.70
61	1.1985	1073.611	969.4	3.3	5.40	2.17	7.57	3.49	112.25	4.87	2.70
62	1.2110	1075.846	971.7	3.4	5.41	2.15	7.55	3.52	112.40	4.85	2.70
63	1.2236	1088.185	984.0	3.5	5.47	2.13	7.60	3.57	112.53	4.86	2.73
64	1.2361	1089.126	985.0	3.6	5.47	2.11	7.58	3.59	112.63	4.85	2.73
65	1.2487	1096.774	992.6	3.7	5.50	2.10	7.60	3.62	112.73	4.85	2.75
66	1.2612	1097.318	993.2	3.8	5.50	2.09	7.59	3.64	112.83	4.84	2.75
67	1.2738	1102.583	998.4	3.9	5.52	2.07	7.60	3.66	112.91	4.84	2.76
68	1.2863	1106.906	1002.7	4.0	5.54	2.06	7.60	3.69	113.02	4.83	2.77
69	1.2988	1120.892	1016.7	4.1	5.61	2.05	7.66	3.74	113.09	4.85	2.81
70	1.3114	1111.715	1007.6	4.3	5.55	2.04	7.60	3.72	113.13	4.82	2.78
71	1.3239	1120.539	1016.4	4.4	5.60	2.04	7.64	3.75	113.16	4.84	2.80
72	1.3365	1128.966	1024.8	4.5	5.64	2.03	7.66	3.78	113.24	4.84	2.82
73	1.3491	1128.304	1024.1	4.6	5.63	2.02	7.64	3.79	113.31	4.83	2.81
74	1.3616	1138.540	1034.4	4.7	5.68	2.01	7.69	3.82	113.34	4.85	2.84
75	1.3742	1138.010	1033.8	4.8	5.67	2.00	7.67	3.83	113.42	4.83	2.83
76	1.3867	1142.717	1038.6	4.9	5.69	2.00	7.68	3.85	113.45	4.84	2.84
77	1.3992	1147.967	1043.8	5.0	5.71	1.99	7.70	3.87	113.51	4.84	2.85
78	1.4118	1150.364	1046.2	5.1	5.72	1.99	7.70	3.88	113.52	4.84	2.86
79	1.4244	1150.423	1046.3	5.2	5.71	1.98	7.69	3.88	113.55	4.84	2.85
80	1.4369	1157.585	1053.4	5.3	5.74	1.98	7.72	3.91	113.59	4.85	2.87
81	1.4494	1160.247	1056.1	5.4	5.75	1.97	7.72	3.92	113.62	4.85	2.87
82	1.4808	1169.835	1065.7	5.7	5.79	1.97	7.75	3.94	113.66	4.86	2.89
83	1.5122	1174.615	1070.5	6.0	5.79	1.96	7.75	3.96	113.71	4.86	2.90
84	1.5435	1182.424	1078.3	6.3	5.82	1.96	7.78	3.97	113.72	4.87	2.91
85	1.5749	1191.557	1087.4	6.5	5.85	1.96	7.81	3.99	113.72	4.88	2.93
86	1.6063	1201.057	1096.9	6.8	5.89	1.97	7.85	3.99	113.65	4.91	2.94
87	1.6376	1208.013	1103.9	7.1	5.91	1.97	7.88	4.00	113.64	4.92	2.95
88	1.6690	1224.264	1120.1	7.3	5.98	1.97	7.94	4.04	113.64	4.96	2.99
89	1.7003	1233.485	1129.3	7.6	6.01	1.98	7.98	4.04	113.59	4.98	3.00
90	1.7317	1238.308	1134.1	7.9	6.02	1.97	7.99	4.05	113.60	4.98	3.01
91	1.7630	1245.971	1141.8	8.2	6.04	1.99	8.03	4.04	113.51	5.01	3.02
92	1.7944	1251.559	1147.4	8.4	6.05	1.98	8.03	4.05	113.54	5.01	3.03
93	1.8257	1259.780	1155.6	8.7	6.08	1.99	8.07	4.05	113.49	5.03	3.04

Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
94	1.8571	1270.677	1166.5	9.0	6.11	1.99	8.11	4.07	113.47	5.05	3.06
95	1.8884	1282.913	1178.8	9.2	6.16	1.99	8.15	4.09	113.49	5.07	3.08
96	1.9198	1290.502	1186.3	9.5	6.18	1.99	8.17	4.11	113.51	5.08	3.09
97	1.9511	1300.311	1196.1	9.8	6.21	1.99	8.20	4.12	113.50	5.10	3.11
98	1.9825	1303.899	1199.7	10.0	6.21	1.99	8.20	4.13	113.50	5.10	3.11
99	2.0138	1311.429	1207.3	10.3	6.23	1.99	8.22	4.14	113.50	5.11	3.12
100	2.0452	1315.370	1211.2	10.6	6.24	1.98	8.22	4.14	113.53	5.10	3.12
101	2.0765	1327.327	1223.2	10.9	6.28	1.99	8.27	4.16	113.49	5.13	3.14
102	2.1079	1331.783	1227.6	11.1	6.28	1.99	8.27	4.16	113.52	5.13	3.14
103	2.1392	1340.371	1236.2	11.4	6.31	1.98	8.28	4.19	113.57	5.13	3.15
104	2.1706	1347.842	1243.7	11.7	6.33	1.99	8.31	4.19	113.52	5.15	3.16
105	2.2019	1366.916	1262.8	11.9	6.40	1.99	8.39	4.23	113.52	5.19	3.20
106	2.2333	1362.372	1258.2	12.2	6.36	1.98	8.34	4.21	113.54	5.16	3.18
107	2.2646	1368.446	1264.3	12.5	6.37	1.99	8.36	4.21	113.51	5.17	3.19
108	2.2960	1379.314	1275.2	12.8	6.41	1.99	8.39	4.22	113.50	5.19	3.20
109	2.3273	1386.858	1282.7	13.0	6.42	1.98	8.40	4.25	113.57	5.19	3.21
110	2.3587	1394.373	1290.2	13.3	6.44	1.98	8.42	4.26	113.57	5.20	3.22
111	2.3900	1404.844	1300.7	13.6	6.47	1.98	8.46	4.26	113.53	5.22	3.24
112	2.4214	1410.918	1306.8	13.8	6.48	1.98	8.46	4.27	113.55	5.22	3.24
113	2.4527	1418.801	1314.6	14.1	6.50	1.99	8.49	4.27	113.52	5.24	3.25
114	2.4841	1429.081	1324.9	14.4	6.53	2.00	8.53	4.27	113.45	5.26	3.27
115	2.5154	1427.154	1323.0	14.7	6.50	1.99	8.49	4.27	113.50	5.24	3.25
116	2.5468	1431.772	1327.6	14.9	6.50	1.99	8.50	4.27	113.48	5.24	3.25
117	2.5781	1439.802	1335.6	15.2	6.52	2.00	8.52	4.26	113.43	5.26	3.26
118	2.6095	1446.802	1342.6	15.5	6.54	2.00	8.53	4.27	113.43	5.27	3.27
119	2.6409	1456.258	1352.1	15.7	6.56	2.00	8.56	4.29	113.45	5.28	3.28
120	2.6722	1465.008	1360.8	16.0	6.58	2.00	8.58	4.29	113.40	5.29	3.29
121	2.7036	1471.494	1367.3	16.3	6.59	2.00	8.60	4.29	113.40	5.30	3.30
122	2.7349	1479.038	1374.9	16.5	6.61	2.01	8.62	4.29	113.36	5.31	3.30
123	2.7663	1486.862	1382.7	16.8	6.62	2.01	8.63	4.30	113.36	5.32	3.31
124	2.7976	1494.363	1390.2	17.1	6.64	2.01	8.65	4.30	113.34	5.33	3.32
125	2.8290	1500.628	1396.5	17.4	6.65	2.02	8.66	4.30	113.31	5.34	3.32
126	2.8603	1509.863	1405.7	17.6	6.67	2.02	8.68	4.30	113.30	5.35	3.33
127	2.8917	1514.613	1410.5	17.9	6.67	2.01	8.68	4.31	113.32	5.35	3.33
128	2.9230	1520.511	1416.3	18.2	6.67	2.02	8.69	4.30	113.28	5.36	3.34
129	2.9543	1524.555	1420.4	18.4	6.67	2.01	8.68	4.31	113.33	5.35	3.34
130	2.9857	1530.452	1426.3	18.7	6.68	2.02	8.70	4.31	113.29	5.36	3.34
131	3.0171	1532.202	1428.0	19.0	6.66	2.02	8.68	4.30	113.29	5.35	3.33
132	3.0484	1537.688	1433.5	19.3	6.67	2.02	8.68	4.31	113.31	5.35	3.33
133	3.0798	1546.262	1442.1	19.5	6.68	2.01	8.69	4.32	113.35	5.35	3.34
134	3.1111	1549.335	1445.2	19.8	6.67	2.02	8.69	4.31	113.31	5.35	3.34
135	3.1424	1556.791	1452.6	20.1	6.69	2.01	8.70	4.32	113.33	5.36	3.34
136	3.1738	1562.395	1458.2	20.3	6.69	2.02	8.71	4.32	113.31	5.36	3.34
137	3.2052	1566.395	1462.2	20.6	6.68	2.02	8.70	4.31	113.30	5.36	3.34
138	3.2365	1570.748	1466.6	20.9	6.68	2.02	8.70	4.31	113.31	5.36	3.34
139	3.2679	1580.278	1476.1	21.1	6.70	2.02	8.72	4.31	113.26	5.37	3.35
140	3.2992	1589.499	1485.3	21.4	6.72	2.02	8.74	4.32	113.26	5.38	3.36

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
141	3.3266	1586.146	1482.0	21.7	6.69	2.04	8.72	4.28	113.16	5.38	3.34

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	9917.000			13268.500
Moisture content: Dry soil+tare, gms.	9024.000			11862.000
Moisture content: Tare, gms.	0.000			2838.000
Moisture, %	9.9	30.7	15.6	15.6
Moist specimen weight, gms.	9917.0			
Diameter, in.	6.00	6.00	5.54	
Area, in.²	28.27	28.27	24.09	
Height, in.	13.00	13.00	11.79	
Net decrease in height, in.		0.00	1.21	
Net decrease in water volume, cc.			1368.00	
Wet density, pcf	102.8	122.3	139.9	
Dry density, pcf	93.5	93.5	121.0	
Void ratio	0.8543	0.8543	0.4331	
Saturation, %	32.2	100.0	100.0	

Test Readings for Specimen No. 2

Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.0635 cm
Consolidation cell pressure = 175.80 psi (25.32 ksf)
Consolidation back pressure = 78.92 psi (11.36 ksf)
Consolidation effective confining stress = 13.95 ksf
Strain rate, %/min. = 0.03
Fail. Stress = 14.52 ksf **at reading no.** 119

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	-0.0006	107.145	0.0	0.0	0.00	14.06	14.06	1.00	78.17	14.06	0.00
1	0.0024	200.693	93.5	0.0	0.56	13.95	14.51	1.04	78.92	14.23	0.28
2	0.0054	208.340	101.2	0.1	0.60	13.93	14.53	1.04	79.09	14.23	0.30
3	0.0084	205.811	98.7	0.1	0.59	13.90	14.49	1.04	79.24	14.20	0.29
4	0.0115	212.605	105.5	0.1	0.63	13.90	14.53	1.05	79.28	14.21	0.31
5	0.0145	213.017	105.9	0.1	0.63	13.88	14.51	1.05	79.40	14.20	0.32
6	0.0175	217.503	110.4	0.2	0.66	13.88	14.53	1.05	79.44	14.21	0.33
7	0.0206	216.811	109.7	0.2	0.65	13.86	14.52	1.05	79.53	14.19	0.33
8	0.0236	214.444	107.3	0.2	0.64	13.86	14.50	1.05	79.56	14.18	0.32
9	0.0266	216.738	109.6	0.2	0.65	13.85	14.50	1.05	79.64	14.17	0.33
10	0.0296	216.047	108.9	0.3	0.65	13.84	14.49	1.05	79.68	14.17	0.32
11	0.0327	218.091	110.9	0.3	0.66	13.84	14.50	1.05	79.70	14.17	0.33
12	0.0357	219.694	112.5	0.3	0.67	13.83	14.50	1.05	79.77	14.16	0.34
13	0.0387	216.032	108.9	0.3	0.65	13.82	14.47	1.05	79.79	14.15	0.32
14	0.0418	216.091	108.9	0.4	0.65	13.82	14.47	1.05	79.79	14.15	0.32
15	0.0448	214.385	107.2	0.4	0.64	13.82	14.45	1.05	79.85	14.14	0.32
16	0.0478	217.017	109.9	0.4	0.65	13.81	14.47	1.05	79.86	14.14	0.33
17	0.0508	267.916	160.8	0.4	0.96	13.75	14.71	1.07	80.29	14.23	0.48
18	0.0539	330.095	222.9	0.5	1.33	13.65	14.97	1.10	81.04	14.31	0.66

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
19	0.0569	417.099	310.0	0.5	1.84	13.49	15.34	1.14	82.11	14.41	0.92
20	0.0599	520.044	412.9	0.5	2.46	13.28	15.73	1.18	83.59	14.51	1.23
21	0.0629	606.871	499.7	0.5	2.97	13.05	16.02	1.23	85.19	14.53	1.49
22	0.0660	684.565	577.4	0.6	3.43	12.80	16.24	1.27	86.89	14.52	1.72
23	0.0690	765.774	658.6	0.6	3.91	12.57	16.48	1.31	88.54	14.52	1.96
24	0.0720	831.409	724.3	0.6	4.30	12.33	16.64	1.35	90.16	14.48	2.15
25	0.0751	896.485	789.3	0.6	4.69	12.10	16.78	1.39	91.80	14.44	2.34
26	0.0781	958.281	851.1	0.7	5.05	11.86	16.92	1.43	93.42	14.39	2.53
27	0.0811	1014.534	907.4	0.7	5.39	11.62	17.01	1.46	95.11	14.31	2.69
28	0.0841	1072.477	965.3	0.7	5.73	11.38	17.11	1.50	96.74	14.25	2.86
29	0.0872	1119.185	1012.0	0.7	6.01	11.15	17.16	1.54	98.35	14.16	3.00
30	0.0902	1165.378	1058.2	0.8	6.28	10.93	17.21	1.57	99.91	14.07	3.14
31	0.0932	1208.556	1101.4	0.8	6.53	10.71	17.24	1.61	101.42	13.98	3.27
32	0.0962	1249.087	1141.9	0.8	6.77	10.50	17.27	1.64	102.89	13.88	3.39
33	0.0993	1287.853	1180.7	0.8	7.00	10.29	17.29	1.68	104.34	13.79	3.50
34	0.1023	1324.825	1217.7	0.9	7.22	10.09	17.31	1.71	105.71	13.70	3.61
35	0.1053	1365.371	1258.2	0.9	7.45	9.89	17.35	1.75	107.11	13.62	3.73
36	0.1084	1394.901	1287.8	0.9	7.63	9.70	17.33	1.79	108.44	13.51	3.81
37	0.1114	1428.623	1321.5	0.9	7.83	9.51	17.34	1.82	109.75	13.42	3.91
38	0.1144	1459.154	1352.0	1.0	8.00	9.33	17.33	1.86	111.04	13.33	4.00
39	0.1174	1487.567	1380.4	1.0	8.17	9.15	17.32	1.89	112.25	13.24	4.08
40	0.1205	1515.730	1408.6	1.0	8.33	8.98	17.31	1.93	113.44	13.15	4.17
41	0.1235	1543.848	1436.7	1.1	8.50	8.81	17.31	1.96	114.60	13.06	4.25
42	0.1356	1633.793	1526.6	1.2	9.02	8.21	17.23	2.10	118.79	12.72	4.51
43	0.1477	1717.223	1610.1	1.3	9.50	7.67	17.17	2.24	122.57	12.42	4.75
44	0.1598	1779.563	1672.4	1.4	9.86	7.19	17.05	2.37	125.88	12.12	4.93
45	0.1719	1832.992	1725.8	1.5	10.17	6.77	16.94	2.50	128.79	11.85	5.08
46	0.1840	1878.876	1771.7	1.6	10.43	6.42	16.84	2.62	131.24	11.63	5.21
47	0.1961	1920.407	1813.3	1.7	10.66	6.12	16.78	2.74	133.32	11.45	5.33
48	0.2082	1951.291	1844.1	1.8	10.83	5.85	16.68	2.85	135.17	11.27	5.41
49	0.2203	1979.292	1872.1	1.9	10.98	5.63	16.61	2.95	136.70	11.12	5.49
50	0.2325	2006.057	1898.9	2.0	11.13	5.44	16.57	3.05	138.03	11.00	5.56
51	0.2446	2035.103	1928.0	2.1	11.29	5.27	16.56	3.14	139.18	10.92	5.64
52	0.2567	2057.059	1949.9	2.2	11.40	5.13	16.53	3.22	140.16	10.83	5.70
53	0.2688	2075.707	1968.6	2.3	11.50	5.01	16.51	3.30	141.03	10.76	5.75
54	0.2809	2090.531	1983.4	2.4	11.57	4.90	16.47	3.36	141.80	10.68	5.79
55	0.2930	2110.576	2003.4	2.5	11.68	4.80	16.47	3.44	142.50	10.63	5.84
56	0.3051	2125.400	2018.3	2.6	11.75	4.72	16.47	3.49	143.06	10.59	5.88
57	0.3172	2141.886	2034.7	2.7	11.84	4.64	16.47	3.55	143.60	10.56	5.92
58	0.3293	2156.049	2048.9	2.8	11.91	4.57	16.48	3.60	144.05	10.52	5.95
59	0.3414	2171.755	2064.6	2.9	11.98	4.51	16.50	3.65	144.45	10.51	5.99
60	0.3535	2181.005	2073.9	3.0	12.03	4.46	16.49	3.69	144.80	10.48	6.01
61	0.3656	2190.873	2083.7	3.1	12.07	4.42	16.49	3.73	145.13	10.45	6.04
62	0.3778	2205.462	2098.3	3.2	12.14	4.38	16.52	3.77	145.41	10.45	6.07
63	0.3899	2219.463	2112.3	3.3	12.21	4.33	16.54	3.82	145.70	10.44	6.10
64	0.4020	2230.713	2123.6	3.4	12.26	4.30	16.56	3.85	145.92	10.43	6.13
65	0.4141	2237.537	2130.4	3.5	12.29	4.28	16.56	3.87	146.10	10.42	6.14

Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
66	0.4262	2251.185	2144.0	3.6	12.35	4.26	16.61	3.90	146.24	10.43	6.18
67	0.4383	2263.303	2156.2	3.7	12.41	4.23	16.64	3.93	146.43	10.43	6.21
68	0.4504	2268.421	2161.3	3.8	12.43	4.21	16.64	3.95	146.56	10.42	6.21
69	0.4625	2280.039	2172.9	3.9	12.48	4.19	16.67	3.98	146.69	10.43	6.24
70	0.4746	2291.069	2183.9	4.0	12.53	4.18	16.71	4.00	146.77	10.45	6.26
71	0.4867	2301.819	2194.7	4.1	12.58	4.16	16.74	4.02	146.90	10.45	6.29
72	0.4988	2306.304	2199.2	4.2	12.59	4.15	16.74	4.03	146.99	10.44	6.30
73	0.5110	2318.187	2211.0	4.3	12.64	4.14	16.78	4.05	147.05	10.46	6.32
74	0.5231	2329.776	2222.6	4.4	12.70	4.13	16.83	4.07	147.12	10.48	6.35
75	0.5352	2337.012	2229.9	4.5	12.73	4.12	16.84	4.09	147.19	10.48	6.36
76	0.5473	2346.644	2239.5	4.6	12.77	4.11	16.88	4.10	147.23	10.50	6.38
77	0.5594	2353.350	2246.2	4.7	12.79	4.10	16.89	4.12	147.30	10.50	6.40
78	0.5715	2361.527	2254.4	4.9	12.82	4.10	16.92	4.13	147.32	10.51	6.41
79	0.5836	2376.131	2269.0	5.0	12.89	4.10	16.99	4.15	147.34	10.54	6.45
80	0.5957	2377.454	2270.3	5.1	12.89	4.10	16.98	4.15	147.36	10.54	6.44
81	0.6078	2386.072	2278.9	5.2	12.92	4.09	17.01	4.16	147.39	10.55	6.46
82	0.6381	2404.897	2297.8	5.4	12.99	4.09	17.08	4.18	147.41	10.58	6.50
83	0.6684	2420.235	2313.1	5.7	13.04	4.10	17.14	4.18	147.36	10.62	6.52
84	0.6986	2439.780	2332.6	5.9	13.12	4.10	17.22	4.20	147.33	10.66	6.56
85	0.7289	2457.884	2350.7	6.2	13.18	4.10	17.29	4.21	147.30	10.70	6.59
86	0.7592	2477.164	2370.0	6.4	13.26	4.12	17.37	4.22	147.22	10.74	6.63
87	0.7894	2500.827	2393.7	6.7	13.35	4.13	17.48	4.24	147.14	10.80	6.68
88	0.8197	2517.416	2410.3	7.0	13.41	4.15	17.55	4.23	147.01	10.85	6.70
89	0.8500	2534.872	2427.7	7.2	13.47	4.16	17.63	4.23	146.89	10.90	6.73
90	0.8802	2551.961	2444.8	7.5	13.52	4.18	17.71	4.23	146.75	10.94	6.76
91	0.9105	2571.079	2463.9	7.7	13.59	4.20	17.79	4.24	146.64	11.00	6.80
92	0.9408	2591.492	2484.3	8.0	13.67	4.22	17.88	4.24	146.52	11.05	6.83
93	0.9711	2612.772	2505.6	8.2	13.75	4.24	17.98	4.24	146.37	11.11	6.87
94	1.0014	2629.008	2521.9	8.5	13.80	4.26	18.06	4.24	146.20	11.16	6.90
95	1.0316	2643.200	2536.1	8.8	13.83	4.29	18.12	4.23	146.04	11.20	6.92
96	1.0619	2658.318	2551.2	9.0	13.88	4.31	18.18	4.22	145.89	11.25	6.94
97	1.0921	2669.730	2562.6	9.3	13.90	4.33	18.23	4.21	145.76	11.28	6.95
98	1.1224	2690.966	2583.8	9.5	13.98	4.35	18.32	4.21	145.61	11.34	6.99
99	1.1527	2700.908	2593.8	9.8	13.99	4.36	18.35	4.21	145.51	11.36	6.99
100	1.1830	2718.835	2611.7	10.0	14.05	4.38	18.43	4.21	145.37	11.40	7.02
101	1.2132	2732.850	2625.7	10.3	14.08	4.42	18.50	4.19	145.13	11.46	7.04
102	1.2435	2752.057	2644.9	10.5	14.14	4.43	18.58	4.19	145.01	11.51	7.07
103	1.2738	2766.896	2659.8	10.8	14.18	4.46	18.64	4.18	144.84	11.55	7.09
104	1.3041	2778.661	2671.5	11.1	14.20	4.48	18.68	4.17	144.69	11.58	7.10
105	1.3343	2794.559	2687.4	11.3	14.25	4.50	18.75	4.16	144.53	11.63	7.12
106	1.3646	2807.015	2699.9	11.6	14.27	4.52	18.80	4.15	144.38	11.66	7.14
107	1.3949	2822.133	2715.0	11.8	14.31	4.55	18.86	4.15	144.24	11.70	7.16
108	1.4251	2836.266	2729.1	12.1	14.34	4.57	18.91	4.14	144.07	11.74	7.17
109	1.4554	2849.193	2742.0	12.3	14.37	4.59	18.96	4.13	143.94	11.77	7.18
110	1.4857	2863.782	2756.6	12.6	14.40	4.60	19.01	4.13	143.84	11.80	7.20
111	1.5159	2874.253	2767.1	12.9	14.42	4.62	19.03	4.12	143.72	11.83	7.21
112	1.5462	2888.371	2781.2	13.1	14.45	4.65	19.09	4.11	143.53	11.87	7.22

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
113	1.5765	2898.019	2790.9	13.4	14.45	4.68	19.13	4.09	143.32	11.90	7.23
114	1.6067	2904.725	2797.6	13.6	14.45	4.70	19.14	4.08	143.20	11.92	7.22
115	1.6370	2912.710	2805.6	13.9	14.44	4.72	19.16	4.06	143.05	11.94	7.22
116	1.6673	2925.623	2818.5	14.1	14.47	4.74	19.21	4.05	142.86	11.98	7.23
117	1.6976	2933.844	2826.7	14.4	14.47	4.76	19.23	4.04	142.73	12.00	7.23
118	1.7278	2951.727	2844.6	14.7	14.51	4.77	19.29	4.04	142.64	12.03	7.26
119	1.7581	2961.036	2853.9	14.9	14.52	4.80	19.31	4.03	142.49	12.05	7.26
120	1.7884	2971.727	2864.6	15.2	14.53	4.81	19.33	4.02	142.42	12.07	7.26
121	1.8187	2985.507	2878.4	15.4	14.55	4.83	19.38	4.01	142.27	12.11	7.28
122	1.8490	3000.434	2893.3	15.7	14.58	4.84	19.42	4.02	142.21	12.13	7.29
123	1.8792	3012.626	2905.5	15.9	14.60	4.85	19.46	4.01	142.09	12.15	7.30
124	1.9095	3022.259	2915.1	16.2	14.60	4.87	19.47	4.00	141.99	12.17	7.30
125	1.9397	3034.318	2927.2	16.5	14.62	4.89	19.51	3.99	141.83	12.20	7.31
126	1.9700	3037.921	2930.8	16.7	14.59	4.90	19.50	3.98	141.75	12.20	7.30
127	2.0003	3045.804	2938.7	17.0	14.59	4.92	19.51	3.97	141.64	12.21	7.29
128	2.0305	3058.040	2950.9	17.2	14.60	4.93	19.53	3.96	141.56	12.23	7.30
129	2.0608	3067.378	2960.2	17.5	14.60	4.94	19.54	3.96	141.52	12.24	7.30
130	2.0911	3074.423	2967.3	17.7	14.59	4.95	19.54	3.95	141.43	12.25	7.30
131	2.1214	3084.673	2977.5	18.0	14.60	4.97	19.56	3.94	141.32	12.26	7.30
132	2.1516	3100.453	2993.3	18.2	14.63	4.96	19.59	3.95	141.33	12.28	7.31
133	2.1819	3110.027	3002.9	18.5	14.63	4.96	19.59	3.95	141.36	12.27	7.31
134	2.2122	3118.851	3011.7	18.8	14.63	4.97	19.60	3.94	141.25	12.29	7.31
135	2.2424	3128.851	3021.7	19.0	14.63	4.98	19.61	3.94	141.20	12.30	7.31
136	2.2727	3140.734	3033.6	19.3	14.64	4.98	19.62	3.94	141.20	12.30	7.32
137	2.3030	3150.690	3043.5	19.5	14.64	4.98	19.62	3.94	141.20	12.30	7.32
138	2.3332	3161.676	3054.5	19.8	14.65	4.97	19.62	3.95	141.27	12.30	7.32
139	2.3635	3170.632	3063.5	20.0	14.64	4.99	19.63	3.94	141.18	12.31	7.32
140	2.3938	3192.162	3085.0	20.3	14.70	4.98	19.68	3.95	141.23	12.33	7.35
141	2.4208	3196.266	3089.1	20.5	14.68	4.99	19.66	3.94	141.15	12.33	7.34

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	9917.000			12658.500
Moisture content: Dry soil+tare, gms.	9165.400			11338.000
Moisture content: Tare, gms.	0.000			2121.500
Moisture, %	8.2	29.7	14.3	14.3
Moist specimen weight, gms.	9917.0			
Diameter, in.	6.00	6.00	5.47	
Area, in.²	28.27	28.27	23.50	
Height, in.	13.00	13.00	11.98	
Net decrease in height, in.		0.00	1.02	
Net decrease in water volume, cc.			1410.90	
Wet density, pcf	102.8	123.2	141.8	
Dry density, pcf	95.0	95.0	124.1	
Void ratio	0.8257	0.8257	0.3980	
Saturation, %	27.6	100.0	100.0	

Test Readings for Specimen No. 3

Membrane modulus = 0.124105 kN/cm²

Membrane thickness = 0.0635 cm

Consolidation cell pressure = 244.10 psi (35.15 ksf)

Consolidation back pressure = 49.80 psi (7.17 ksf)

Consolidation effective confining stress = 27.98 ksf

Strain rate, %/min. = 0.03

Fail. Stress = 23.77 ksf **at reading no.** 121

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	-0.0032	177.645	0.0	0.0	0.00	27.98	27.98	1.00	49.80	27.98	0.00
1	-0.0001	208.838	31.2	0.0	0.19	27.97	28.16	1.01	49.89	28.06	0.10
2	0.0028	208.073	30.4	0.1	0.19	27.96	28.14	1.01	49.96	28.05	0.09
3	0.0058	202.661	25.0	0.1	0.15	27.96	28.11	1.01	49.97	28.03	0.08
4	0.0088	311.371	133.7	0.1	0.82	27.95	28.77	1.03	49.98	28.36	0.41
5	0.0118	419.669	242.0	0.1	1.48	27.93	29.42	1.05	50.11	28.67	0.74
6	0.0148	554.322	376.7	0.2	2.30	27.91	30.22	1.08	50.27	29.06	1.15
7	0.0178	727.034	549.4	0.2	3.36	27.88	31.24	1.12	50.49	29.56	1.68
8	0.0208	868.334	690.7	0.2	4.22	27.83	32.06	1.15	50.83	29.94	2.11
9	0.0238	990.456	812.8	0.2	4.97	27.77	32.74	1.18	51.24	30.26	2.48
10	0.0268	1101.299	923.7	0.3	5.65	27.70	33.35	1.20	51.71	30.53	2.82
11	0.0298	1201.773	1024.1	0.3	6.26	27.62	33.88	1.23	52.31	30.75	3.13
12	0.0328	1297.159	1119.5	0.3	6.84	27.52	34.36	1.25	52.97	30.94	3.42
13	0.0358	1387.222	1209.6	0.3	7.39	27.43	34.82	1.27	53.62	31.12	3.69
14	0.0388	1471.137	1293.5	0.4	7.90	27.31	35.21	1.29	54.45	31.26	3.95
15	0.0418	1549.478	1371.8	0.4	8.38	27.18	35.56	1.31	55.32	31.37	4.19
16	0.0449	1626.599	1449.0	0.4	8.84	27.05	35.89	1.33	56.25	31.47	4.42
17	0.0479	1698.498	1520.9	0.4	9.28	26.91	36.19	1.34	57.20	31.55	4.64
18	0.0509	1767.266	1589.6	0.5	9.70	26.77	36.47	1.36	58.21	31.62	4.85
19	0.0539	1833.254	1655.6	0.5	10.10	26.62	36.72	1.38	59.25	31.67	5.05
20	0.0569	1897.550	1719.9	0.5	10.49	26.46	36.95	1.40	60.35	31.70	5.24
21	0.0599	1961.141	1783.5	0.5	10.87	26.29	37.16	1.41	61.52	31.73	5.44
22	0.0629	2027.732	1850.1	0.6	11.28	26.12	37.40	1.43	62.71	31.76	5.64
23	0.0659	2083.793	1906.1	0.6	11.61	25.94	37.56	1.45	63.95	31.75	5.81

Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
24	0.0689	2140.398	1962.8	0.6	11.96	25.76	37.71	1.46	65.24	31.73	5.98
25	0.0719	2201.106	2023.5	0.6	12.32	25.56	37.88	1.48	66.60	31.72	6.16
26	0.0749	2254.167	2076.5	0.7	12.64	25.37	38.01	1.50	67.95	31.69	6.32
27	0.0779	2308.802	2131.2	0.7	12.97	25.16	38.13	1.52	69.40	31.64	6.49
28	0.0809	2364.760	2187.1	0.7	13.31	24.94	38.25	1.53	70.92	31.59	6.65
29	0.0839	2412.879	2235.2	0.7	13.60	24.72	38.32	1.55	72.45	31.52	6.80
30	0.0869	2466.749	2289.1	0.8	13.92	24.50	38.42	1.57	73.98	31.46	6.96
31	0.0899	2511.280	2333.6	0.8	14.19	24.27	38.46	1.58	75.57	31.36	7.09
32	0.0929	2553.179	2375.5	0.8	14.44	24.03	38.47	1.60	77.22	31.25	7.22
33	0.0959	2601.063	2423.4	0.8	14.73	23.79	38.52	1.62	78.90	31.15	7.36
34	0.0989	2643.241	2465.6	0.9	14.98	23.55	38.53	1.64	80.54	31.04	7.49
35	0.1019	2686.816	2509.2	0.9	15.24	23.31	38.55	1.65	82.22	30.93	7.62
36	0.1049	2730.009	2552.4	0.9	15.50	23.06	38.56	1.67	83.98	30.81	7.75
37	0.1079	2765.775	2588.1	0.9	15.71	22.81	38.52	1.69	85.70	30.67	7.86
38	0.1109	2807.703	2630.1	1.0	15.96	22.55	38.52	1.71	87.48	30.54	7.98
39	0.1139	2836.602	2659.0	1.0	16.14	22.30	38.44	1.72	89.22	30.37	8.07
40	0.1169	2870.779	2693.1	1.0	16.34	22.04	38.38	1.74	91.04	30.21	8.17
41	0.1199	2911.884	2734.2	1.0	16.58	21.78	38.37	1.76	92.84	30.07	8.29
42	0.1319	3030.374	2852.7	1.1	17.28	20.74	38.03	1.83	100.05	29.39	8.64
43	0.1439	3136.260	2958.6	1.2	17.91	19.71	37.62	1.91	107.23	28.66	8.95
44	0.1559	3220.411	3042.8	1.3	18.40	18.69	37.09	1.98	114.28	27.89	9.20
45	0.1679	3300.017	3122.4	1.4	18.86	17.74	36.60	2.06	120.90	27.17	9.43
46	0.1799	3362.269	3184.6	1.5	19.22	16.84	36.05	2.14	127.18	26.44	9.61
47	0.1919	3416.139	3238.5	1.6	19.52	15.99	35.52	2.22	133.03	25.76	9.76
48	0.2039	3459.214	3281.6	1.7	19.76	15.23	34.99	2.30	138.35	25.11	9.88
49	0.2159	3499.436	3321.8	1.8	19.98	14.52	34.51	2.38	143.25	24.52	9.99
50	0.2279	3534.614	3357.0	1.9	20.18	13.90	34.07	2.45	147.61	23.98	10.09
51	0.2399	3561.277	3383.6	2.0	20.31	13.34	33.66	2.52	151.45	23.50	10.16
52	0.2520	3590.851	3413.2	2.1	20.47	12.83	33.31	2.60	154.97	23.07	10.24
53	0.2640	3611.749	3434.1	2.2	20.58	12.38	32.96	2.66	158.12	22.67	10.29
54	0.2759	3632.677	3455.0	2.3	20.68	11.97	32.65	2.73	160.99	22.31	10.34
55	0.2880	3651.501	3473.9	2.4	20.77	11.60	32.37	2.79	163.56	21.98	10.39
56	0.3000	3668.399	3490.8	2.5	20.85	11.27	32.12	2.85	165.85	21.69	10.43
57	0.3120	3685.561	3507.9	2.6	20.93	10.98	31.91	2.91	167.86	21.44	10.47
58	0.3240	3702.488	3524.8	2.7	21.01	10.72	31.73	2.96	169.68	21.22	10.51
59	0.3360	3714.989	3537.3	2.8	21.06	10.49	31.55	3.01	171.24	21.02	10.53
60	0.3480	3728.504	3550.9	2.9	21.12	10.28	31.40	3.05	172.69	20.84	10.56
61	0.3600	3742.931	3565.3	3.0	21.19	10.09	31.28	3.10	174.01	20.69	10.59
62	0.3720	3759.505	3581.9	3.1	21.26	9.93	31.19	3.14	175.17	20.56	10.63
63	0.3840	3766.932	3589.3	3.2	21.28	9.77	31.05	3.18	176.28	20.41	10.64
64	0.3960	3783.638	3606.0	3.3	21.36	9.63	30.99	3.22	177.22	20.31	10.68
65	0.4080	3790.933	3613.3	3.4	21.38	9.52	30.90	3.25	177.98	20.21	10.69
66	0.4200	3807.801	3630.2	3.5	21.46	9.40	30.87	3.28	178.79	20.14	10.73
67	0.4320	3819.228	3641.6	3.6	21.51	9.31	30.81	3.31	179.47	20.06	10.75
68	0.4440	3829.699	3652.1	3.7	21.54	9.22	30.76	3.34	180.10	19.99	10.77
69	0.4560	3841.214	3663.6	3.8	21.59	9.13	30.72	3.37	180.71	19.92	10.80
70	0.4680	3853.568	3675.9	3.9	21.64	9.05	30.69	3.39	181.26	19.87	10.82

Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
71	0.4800	3867.083	3689.4	4.0	21.70	8.97	30.67	3.42	181.78	19.82	10.85
72	0.4920	3880.275	3702.6	4.1	21.75	8.92	30.67	3.44	182.18	19.79	10.88
73	0.5040	3884.113	3706.5	4.2	21.75	8.86	30.61	3.46	182.58	19.73	10.88
74	0.5160	3894.702	3717.1	4.3	21.79	8.81	30.60	3.47	182.94	19.70	10.90
75	0.5280	3908.879	3731.2	4.4	21.85	8.76	30.61	3.49	183.28	19.68	10.93
76	0.5400	3920.644	3743.0	4.5	21.90	8.72	30.62	3.51	183.52	19.67	10.95
77	0.5520	3927.997	3750.4	4.6	21.92	8.68	30.60	3.52	183.81	19.64	10.96
78	0.5640	3942.689	3765.0	4.7	21.98	8.64	30.62	3.54	184.10	19.63	10.99
79	0.5760	3950.513	3772.9	4.8	22.00	8.62	30.62	3.55	184.26	19.62	11.00
80	0.5880	3964.557	3786.9	4.9	22.06	8.58	30.64	3.57	184.51	19.61	11.03
81	0.6001	3969.528	3791.9	5.0	22.07	8.55	30.62	3.58	184.70	19.59	11.03
82	0.6301	3993.764	3816.1	5.3	22.15	8.50	30.65	3.61	185.10	19.57	11.07
83	0.6601	4021.177	3843.5	5.5	22.25	8.46	30.71	3.63	185.38	19.58	11.12
84	0.6901	4047.046	3869.4	5.8	22.34	8.42	30.76	3.65	185.60	19.59	11.17
85	0.7201	4069.988	3892.3	6.0	22.41	8.42	30.83	3.66	185.64	19.62	11.21
86	0.7501	4096.401	3918.8	6.3	22.50	8.41	30.91	3.68	185.71	19.66	11.25
87	0.7801	4122.034	3944.4	6.5	22.59	8.40	30.99	3.69	185.79	19.69	11.30
88	0.8101	4147.344	3969.7	6.8	22.68	8.40	31.07	3.70	185.78	19.74	11.34
89	0.8401	4174.007	3996.4	7.0	22.77	8.41	31.17	3.71	185.72	19.79	11.38
90	0.8702	4194.654	4017.0	7.3	22.82	8.41	31.23	3.71	185.68	19.82	11.41
91	0.9002	4218.773	4041.1	7.5	22.90	8.42	31.32	3.72	185.60	19.87	11.45
92	0.9302	4239.230	4061.6	7.8	22.95	8.45	31.40	3.72	185.45	19.92	11.48
93	0.9602	4266.598	4089.0	8.0	23.04	8.45	31.49	3.73	185.43	19.97	11.52
94	0.9902	4283.055	4105.4	8.3	23.07	8.47	31.54	3.72	185.29	20.00	11.54
95	1.0202	4302.820	4125.2	8.5	23.12	8.49	31.61	3.72	185.16	20.05	11.56
96	1.0502	4328.101	4150.5	8.8	23.20	8.50	31.70	3.73	185.05	20.10	11.60
97	1.0802	4342.645	4165.0	9.0	23.22	8.52	31.73	3.73	184.94	20.13	11.61
98	1.1103	4360.352	4182.7	9.3	23.25	8.54	31.79	3.72	184.81	20.16	11.62
99	1.1403	4375.426	4197.8	9.5	23.27	8.56	31.83	3.72	184.63	20.20	11.63
100	1.1703	4403.765	4226.1	9.8	23.36	8.59	31.95	3.72	184.43	20.27	11.68
101	1.2003	4415.134	4237.5	10.0	23.36	8.60	31.96	3.72	184.37	20.28	11.68
102	1.2303	4437.429	4259.8	10.3	23.42	8.62	32.04	3.72	184.21	20.33	11.71
103	1.2603	4460.768	4283.1	10.5	23.48	8.64	32.12	3.72	184.10	20.38	11.74
104	1.2903	4474.180	4296.5	10.8	23.49	8.65	32.13	3.72	184.06	20.39	11.74
105	1.3203	4486.357	4308.7	11.0	23.49	8.66	32.14	3.71	183.98	20.40	11.74
106	1.3504	4504.372	4326.7	11.3	23.52	8.67	32.19	3.71	183.87	20.43	11.76
107	1.3804	4521.491	4343.8	11.6	23.55	8.69	32.24	3.71	183.74	20.46	11.77
108	1.4104	4541.197	4363.6	11.8	23.59	8.72	32.30	3.71	183.56	20.51	11.79
109	1.4404	4560.948	4383.3	12.1	23.62	8.73	32.35	3.71	183.48	20.54	11.81
110	1.4704	4575.522	4397.9	12.3	23.64	8.74	32.38	3.70	183.39	20.56	11.82
111	1.5004	4592.126	4414.5	12.6	23.66	8.76	32.41	3.70	183.28	20.59	11.83
112	1.5304	4602.494	4424.8	12.8	23.64	8.78	32.42	3.69	183.16	20.60	11.82
113	1.5604	4617.127	4439.5	13.1	23.65	8.79	32.45	3.69	183.04	20.62	11.83
114	1.5904	4635.995	4458.3	13.3	23.69	8.80	32.48	3.69	183.01	20.64	11.84
115	1.6204	4647.481	4469.8	13.6	23.68	8.81	32.49	3.69	182.89	20.65	11.84
116	1.6505	4664.202	4486.6	13.8	23.70	8.84	32.54	3.68	182.73	20.69	11.85
117	1.6805	4677.497	4499.9	14.1	23.70	8.85	32.55	3.68	182.66	20.70	11.85

Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
118	1.7105	4695.086	4517.4	14.3	23.72	8.86	32.58	3.68	182.56	20.72	11.86
119	1.7405	4710.674	4533.0	14.6	23.74	8.88	32.61	3.67	182.46	20.74	11.87
120	1.7705	4729.072	4551.4	14.8	23.76	8.89	32.65	3.67	182.38	20.77	11.88
121	1.8005	4743.543	4565.9	15.1	23.77	8.90	32.67	3.67	182.30	20.78	11.88
122	1.8305	4757.559	4579.9	15.3	23.77	8.91	32.68	3.67	182.20	20.80	11.89
123	1.8606	4777.662	4600.0	15.6	23.80	8.92	32.73	3.67	182.14	20.82	11.90
124	1.8906	4789.619	4612.0	15.8	23.79	8.95	32.74	3.66	181.96	20.85	11.90
125	1.9206	4803.560	4625.9	16.1	23.80	8.96	32.75	3.66	181.90	20.85	11.90
126	1.9506	4817.032	4639.4	16.3	23.79	8.97	32.76	3.65	181.82	20.86	11.90
127	1.9806	4833.032	4655.4	16.6	23.80	8.98	32.79	3.65	181.71	20.89	11.90
128	2.0106	4845.077	4667.4	16.8	23.79	9.00	32.79	3.64	181.62	20.89	11.90
129	2.0406	4860.563	4682.9	17.1	23.80	9.01	32.81	3.64	181.55	20.91	11.90
130	2.0706	4868.916	4691.3	17.3	23.77	9.02	32.80	3.63	181.43	20.91	11.89
131	2.1006	4886.255	4708.6	17.6	23.79	9.03	32.82	3.63	181.39	20.92	11.89
132	2.1306	4899.491	4721.8	17.8	23.78	9.05	32.83	3.63	181.25	20.94	11.89
133	2.1606	4916.447	4738.8	18.1	23.79	9.06	32.85	3.63	181.20	20.96	11.90
134	2.1907	4930.845	4753.2	18.3	23.79	9.07	32.87	3.62	181.10	20.97	11.90
135	2.2207	4942.551	4764.9	18.6	23.78	9.08	32.86	3.62	181.05	20.97	11.89
136	2.2507	4959.978	4782.3	18.8	23.79	9.09	32.88	3.62	180.99	20.98	11.90
137	2.2807	4971.023	4793.4	19.1	23.77	9.10	32.87	3.61	180.90	20.99	11.89
138	2.3107	4986.450	4808.8	19.3	23.78	9.10	32.88	3.61	180.89	20.99	11.89
139	2.3407	5003.436	4825.8	19.6	23.79	9.11	32.90	3.61	180.82	21.01	11.89
140	2.3707	5017.569	4839.9	19.8	23.78	9.13	32.91	3.60	180.68	21.02	11.89
141	2.3976	5029.496	4851.9	20.0	23.77	9.14	32.91	3.60	180.66	21.02	11.89

Parameters for Specimen No. 4

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	9917.000			13162.000
Moisture content: Dry soil+tare, gms.	9165.400			12061.000
Moisture content: Tare, gms.	0.000			2758.000
Moisture, %	8.2	29.7	11.8	11.8
Moist specimen weight, gms.	9917.0			
Diameter, in.	6.00	6.00	5.35	
Area, in.²	28.27	28.27	22.50	
Height, in.	13.00	13.00	11.89	
Net decrease in height, in.		0.00	1.11	
Net decrease in water volume, cc.			1639.00	
Wet density, pcf	102.8	123.2	146.0	
Dry density, pcf	95.0	95.0	130.5	
Void ratio	0.8257	0.8257	0.3289	
Saturation, %	27.6	100.0	100.0	

Test Readings for Specimen No. 4

Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.0635 cm
Consolidation cell pressure = 448.70 psi (64.61 ksf)
Consolidation back pressure = 59.93 psi (8.63 ksf)
Consolidation effective confining stress = 55.98 ksf
Strain rate, %/min. = 0.03
Fail. Stress = 50.37 ksf **at reading no.** 120

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	403.272	0.0	0.0	0.00	55.98	55.98	1.00	59.93	55.98	0.00
1	0.0030	610.750	207.5	0.0	1.33	55.96	57.29	1.02	60.10	56.62	0.66
2	0.0060	818.038	414.8	0.1	2.65	55.94	58.59	1.05	60.26	57.26	1.33
3	0.0090	1045.694	642.4	0.1	4.11	55.91	60.02	1.07	60.44	57.96	2.05
4	0.0120	1277.247	874.0	0.1	5.59	55.88	61.46	1.10	60.68	58.67	2.79
5	0.0150	1502.888	1099.6	0.1	7.03	55.85	62.88	1.13	60.88	59.36	3.51
6	0.0180	1710.778	1307.5	0.2	8.36	55.81	64.16	1.15	61.15	59.98	4.18
7	0.0210	1911.668	1508.4	0.2	9.64	55.72	65.36	1.17	61.72	60.54	4.82
8	0.0240	2098.985	1695.7	0.2	10.83	55.64	66.47	1.19	62.32	61.05	5.42
9	0.0270	2269.329	1866.1	0.2	11.92	55.55	67.47	1.21	62.93	61.51	5.96
10	0.0300	2425.703	2022.4	0.3	12.91	55.44	68.36	1.23	63.67	61.90	6.46
11	0.0330	2578.694	2175.4	0.3	13.88	55.33	69.22	1.25	64.43	62.28	6.94
12	0.0360	2729.892	2326.6	0.3	14.85	55.21	70.06	1.27	65.26	62.64	7.42
13	0.0390	2872.250	2469.0	0.3	15.75	55.09	70.84	1.29	66.15	62.96	7.88
14	0.0420	3007.138	2603.9	0.4	16.61	54.95	71.56	1.30	67.09	63.26	8.30
15	0.0450	3132.907	2729.6	0.4	17.40	54.81	72.22	1.32	68.07	63.51	8.70
16	0.0480	3259.250	2856.0	0.4	18.21	54.66	72.86	1.33	69.13	63.76	9.10
17	0.0510	3376.549	2973.3	0.4	18.95	54.50	73.45	1.35	70.24	63.97	9.47
18	0.0540	3494.730	3091.5	0.5	19.70	54.33	74.03	1.36	71.42	64.18	9.85
19	0.0570	3611.617	3208.3	0.5	20.44	54.15	74.58	1.38	72.68	64.37	10.22
20	0.0600	3718.812	3315.5	0.5	21.11	53.96	75.07	1.39	73.98	64.52	10.56
21	0.0630	3820.640	3417.4	0.5	21.76	53.76	75.52	1.40	75.33	64.64	10.88
22	0.0660	3923.438	3520.2	0.6	22.41	53.56	75.97	1.42	76.72	64.77	11.20
23	0.0690	4024.060	3620.8	0.6	23.04	53.36	76.40	1.43	78.17	64.88	11.52

Test Readings for Specimen No. 4

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
24	0.0720	4116.063	3712.8	0.6	23.62	53.14	76.76	1.44	79.67	64.95	11.81
25	0.0750	4214.420	3811.1	0.6	24.24	52.92	77.15	1.46	81.23	65.03	12.12
26	0.0780	4304.894	3901.6	0.7	24.81	52.69	77.50	1.47	82.79	65.09	12.40
27	0.0810	4401.251	3998.0	0.7	25.41	52.45	77.86	1.48	84.47	65.16	12.71
28	0.0840	4494.769	4091.5	0.7	26.00	52.20	78.20	1.50	86.21	65.20	13.00
29	0.0870	4578.537	4175.3	0.7	26.53	51.95	78.48	1.51	87.94	65.21	13.26
30	0.0900	4664.202	4260.9	0.8	27.06	51.67	78.74	1.52	89.85	65.21	13.53
31	0.0930	4751.661	4348.4	0.8	27.61	51.41	79.02	1.54	91.69	65.22	13.81
32	0.0961	4830.194	4426.9	0.8	28.10	51.14	79.24	1.55	93.58	65.19	14.05
33	0.0991	4917.315	4514.0	0.8	28.65	50.85	79.50	1.56	95.56	65.18	14.33
34	0.1021	4985.259	4582.0	0.9	29.07	50.56	79.64	1.58	97.58	65.10	14.54
35	0.1051	5011.980	4608.7	0.9	29.24	50.27	79.51	1.58	99.60	64.89	14.62
36	0.1081	4949.566	4546.3	0.9	28.83	50.01	78.85	1.58	101.38	64.43	14.42
37	0.1111	4716.498	4313.2	0.9	27.35	49.82	77.17	1.55	102.71	63.50	13.67
38	0.1141	4446.135	4042.9	1.0	25.63	49.71	75.33	1.52	103.52	62.52	12.81
39	0.1171	4258.304	3855.0	1.0	24.43	49.63	74.06	1.49	104.08	61.84	12.22
40	0.1201	4352.646	3949.4	1.0	25.02	49.54	74.56	1.51	104.67	62.05	12.51
41	0.1231	4425.296	4022.0	1.0	25.48	49.46	74.93	1.52	105.26	62.19	12.74
42	0.1351	4797.443	4394.2	1.1	27.80	49.04	76.84	1.57	108.14	62.94	13.90
43	0.1471	5240.577	4837.3	1.2	30.58	48.37	78.94	1.63	112.82	63.65	15.29
44	0.1591	5449.762	5046.5	1.3	31.87	47.50	79.37	1.67	118.85	63.43	15.93
45	0.1711	5441.041	5037.8	1.4	31.78	46.71	78.49	1.68	124.31	62.60	15.89
46	0.1831	5513.632	5110.4	1.5	32.20	46.15	78.35	1.70	128.23	62.25	16.10
47	0.1951	5866.661	5463.4	1.6	34.39	45.35	79.74	1.76	133.77	62.55	17.20
48	0.2071	6157.143	5753.9	1.7	36.19	44.20	80.38	1.82	141.77	62.29	18.09
49	0.2191	6363.562	5960.3	1.8	37.44	42.86	80.31	1.87	151.04	61.59	18.72
50	0.2311	6542.569	6139.3	1.9	38.53	41.49	80.02	1.93	160.54	60.76	19.26
51	0.2431	6619.866	6216.6	2.0	38.97	40.24	79.22	1.97	169.23	59.73	19.49
52	0.2551	6163.613	5760.3	2.1	36.08	39.62	75.70	1.91	173.56	57.66	18.04
53	0.2671	5860.366	5457.1	2.2	34.14	39.59	73.73	1.86	173.77	56.66	17.07
54	0.2791	6360.900	5957.6	2.3	37.24	39.33	76.56	1.95	175.61	57.94	18.62
55	0.2912	6801.932	6398.7	2.4	39.95	38.62	78.57	2.03	180.52	58.59	19.98
56	0.3032	7026.412	6623.1	2.5	41.31	37.56	78.87	2.10	187.87	58.21	20.65
57	0.3151	7175.417	6772.1	2.7	42.20	36.37	78.57	2.16	196.11	57.47	21.10
58	0.3272	7263.186	6859.9	2.8	42.70	35.22	77.92	2.21	204.10	56.57	21.35
59	0.3392	7387.646	6984.4	2.9	43.43	34.14	77.57	2.27	211.58	55.86	21.71
60	0.3512	7496.768	7093.5	3.0	44.06	33.09	77.15	2.33	218.93	55.12	22.03
61	0.3632	7602.713	7199.4	3.1	44.67	32.02	76.69	2.40	226.33	54.36	22.34
62	0.3752	7704.262	7301.0	3.2	45.25	30.96	76.21	2.46	233.71	53.58	22.63
63	0.3872	7783.603	7380.3	3.3	45.70	29.96	75.66	2.53	240.64	52.81	22.85
64	0.3992	7856.194	7452.9	3.4	46.10	29.02	75.12	2.59	247.19	52.07	23.05
65	0.4112	7914.917	7511.6	3.5	46.41	28.16	74.57	2.65	253.15	51.37	23.21
66	0.4232	7964.566	7561.3	3.6	46.67	27.38	74.05	2.70	258.56	50.72	23.34
67	0.4352	8016.215	7612.9	3.7	46.94	26.66	73.61	2.76	263.53	50.13	23.47
68	0.4472	8052.907	7649.6	3.8	47.12	26.02	73.13	2.81	268.04	49.57	23.56
69	0.4592	8095.674	7692.4	3.9	47.33	25.43	72.76	2.86	272.09	49.10	23.67
70	0.4712	8127.072	7723.8	4.0	47.48	24.90	72.37	2.91	275.80	48.64	23.74

Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 4

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
71	0.4832	8159.338	7756.1	4.1	47.62	24.40	72.03	2.95	279.23	48.22	23.81
72	0.4952	8187.677	7784.4	4.2	47.75	23.97	71.72	2.99	282.25	47.84	23.87
73	0.5072	8211.458	7808.2	4.3	47.84	23.57	71.42	3.03	285.00	47.49	23.92
74	0.5192	8238.871	7835.6	4.4	47.96	23.21	71.17	3.07	287.50	47.19	23.98
75	0.5312	8260.504	7857.2	4.5	48.04	22.89	70.93	3.10	289.73	46.91	24.02
76	0.5432	8286.461	7883.2	4.6	48.15	22.59	70.74	3.13	291.79	46.67	24.08
77	0.5552	8304.608	7901.3	4.7	48.21	22.32	70.53	3.16	293.71	46.42	24.10
78	0.5672	8323.756	7920.5	4.8	48.28	22.07	70.35	3.19	295.42	46.21	24.14
79	0.5792	8342.801	7939.5	4.9	48.34	21.84	70.18	3.21	297.05	46.01	24.17
80	0.5912	8361.272	7958.0	5.0	48.40	21.62	70.02	3.24	298.55	45.82	24.20
81	0.6033	8380.935	7977.7	5.1	48.47	21.43	69.90	3.26	299.86	45.67	24.23
82	0.6332	8416.995	8013.7	5.3	48.56	21.03	69.58	3.31	302.69	45.31	24.28
83	0.6633	8458.056	8054.8	5.6	48.68	20.69	69.37	3.35	305.02	45.03	24.34
84	0.6933	8493.880	8090.6	5.8	48.76	20.43	69.19	3.39	306.86	44.81	24.38
85	0.7233	8535.103	8131.8	6.1	48.88	20.21	69.09	3.42	308.34	44.65	24.44
86	0.7533	8567.869	8164.6	6.3	48.95	20.04	68.98	3.44	309.56	44.51	24.47
87	0.7833	8600.708	8197.4	6.6	49.01	19.90	68.91	3.46	310.51	44.40	24.51
88	0.8133	8613.341	8210.1	6.8	48.95	19.80	68.75	3.47	311.22	44.27	24.48
89	0.8433	8602.105	8198.8	7.1	48.75	19.71	68.47	3.47	311.79	44.09	24.38
90	0.8733	8677.652	8274.4	7.3	49.07	19.58	68.65	3.51	312.71	44.12	24.53
91	0.9033	8724.066	8320.8	7.6	49.21	19.59	68.80	3.51	312.65	44.20	24.61
92	0.9333	8772.538	8369.3	7.8	49.36	19.57	68.93	3.52	312.81	44.25	24.68
93	0.9633	8797.113	8393.8	8.1	49.37	19.56	68.93	3.52	312.84	44.25	24.69
94	0.9933	8821.129	8417.9	8.4	49.38	19.50	68.87	3.53	313.32	44.18	24.69
95	1.0233	8879.940	8476.7	8.6	49.58	19.52	69.11	3.54	313.12	44.32	24.79
96	1.0533	8921.191	8517.9	8.9	49.69	19.54	69.23	3.54	313.02	44.38	24.84
97	1.0833	8958.193	8554.9	9.1	49.77	19.54	69.31	3.55	313.00	44.42	24.88
98	1.1133	8991.885	8588.6	9.4	49.82	19.56	69.38	3.55	312.89	44.47	24.91
99	1.1433	9032.946	8629.7	9.6	49.92	19.57	69.50	3.55	312.77	44.53	24.96
100	1.1733	9063.711	8660.4	9.9	49.96	19.59	69.55	3.55	312.66	44.57	24.98
101	1.2033	9094.698	8691.4	10.1	50.00	19.60	69.60	3.55	312.56	44.60	25.00
102	1.2334	9123.067	8719.8	10.4	50.02	19.63	69.65	3.55	312.36	44.64	25.01
103	1.2634	9149.421	8746.1	10.6	50.03	19.65	69.68	3.55	312.24	44.67	25.02
104	1.2933	9176.407	8773.1	10.9	50.04	19.67	69.71	3.54	312.12	44.69	25.02
105	1.3233	9204.026	8800.8	11.1	50.06	19.70	69.75	3.54	311.92	44.73	25.03
106	1.3533	9240.292	8837.0	11.4	50.12	19.72	69.84	3.54	311.79	44.78	25.06
107	1.3833	9262.322	8859.1	11.6	50.10	19.74	69.84	3.54	311.63	44.79	25.05
108	1.4134	9304.912	8901.6	11.9	50.20	19.76	69.97	3.54	311.45	44.86	25.10
109	1.4434	9328.560	8925.3	12.1	50.19	19.79	69.98	3.54	311.30	44.88	25.10
110	1.4734	9362.208	8958.9	12.4	50.24	19.81	70.04	3.54	311.14	44.93	25.12
111	1.5034	9395.739	8992.5	12.6	50.28	19.83	70.10	3.54	311.02	44.96	25.14
112	1.5334	9430.270	9027.0	12.9	50.33	19.85	70.18	3.53	310.82	45.02	25.16
113	1.5634	9452.727	9049.5	13.1	50.30	19.87	70.18	3.53	310.69	45.03	25.15
114	1.5934	9481.272	9078.0	13.4	50.32	19.89	70.21	3.53	310.56	45.05	25.16
115	1.6234	9515.273	9112.0	13.7	50.36	19.92	70.27	3.53	310.40	45.09	25.18
116	1.6534	9544.804	9141.5	13.9	50.37	19.95	70.32	3.53	310.19	45.13	25.19
117	1.6834	9573.158	9169.9	14.2	50.38	19.96	70.34	3.52	310.10	45.15	25.19

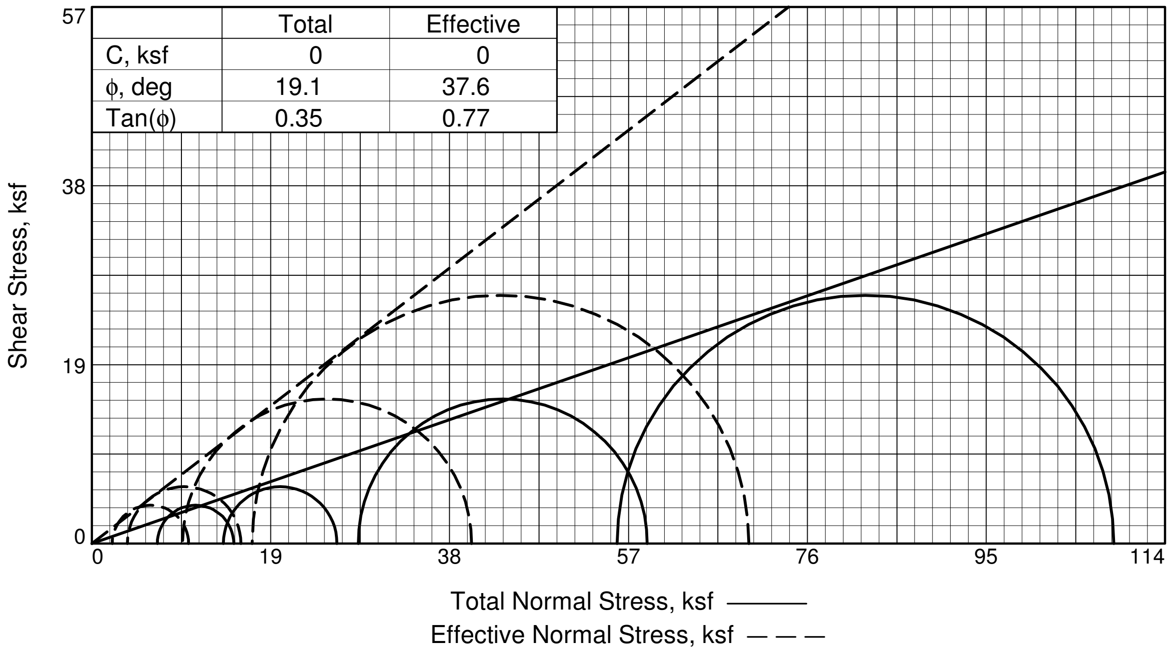
Knight Piesold Geotechnical Lab.

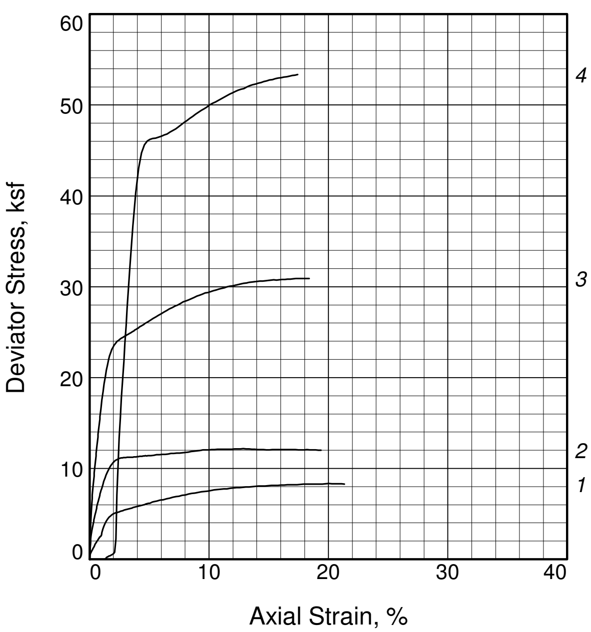
Test Readings for Specimen No. 4

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
118	1.7134	9595.967	9192.7	14.4	50.36	19.98	70.34	3.52	309.94	45.16	25.18
119	1.7434	9622.733	9219.5	14.7	50.36	20.01	70.36	3.52	309.77	45.18	25.18
120	1.7735	9653.279	9250.0	14.9	50.37	20.02	70.40	3.52	309.64	45.21	25.19
121	1.8035	9680.559	9277.3	15.2	50.37	20.04	70.41	3.51	309.52	45.23	25.19
122	1.8334	9712.501	9309.2	15.4	50.40	20.06	70.46	3.51	309.39	45.26	25.20
123	1.8634	9736.282	9333.0	15.7	50.37	20.09	70.46	3.51	309.22	45.27	25.19
124	1.8934	9769.033	9365.8	15.9	50.40	20.09	70.49	3.51	309.16	45.29	25.20
125	1.9235	9795.813	9392.5	16.2	50.39	20.12	70.51	3.50	308.98	45.32	25.20
126	1.9534	9826.976	9423.7	16.4	50.41	20.13	70.54	3.50	308.91	45.33	25.20
127	1.9835	9849.345	9446.1	16.7	50.37	20.15	70.53	3.50	308.75	45.34	25.19
128	2.0135	9876.875	9473.6	16.9	50.37	20.17	70.54	3.50	308.61	45.36	25.18
129	2.0435	9903.568	9500.3	17.2	50.36	20.19	70.55	3.49	308.49	45.37	25.18
130	2.0735	9929.701	9526.4	17.4	50.34	20.20	70.54	3.49	308.42	45.37	25.17
131	2.1035	9955.526	9552.3	17.7	50.32	20.22	70.54	3.49	308.28	45.38	25.16
132	2.1335	9980.615	9577.3	17.9	50.30	20.24	70.54	3.48	308.13	45.39	25.15
133	2.1635	10014.278	9611.0	18.2	50.32	20.25	70.57	3.49	308.08	45.41	25.16
134	2.1935	10033.043	9629.8	18.4	50.26	20.26	70.53	3.48	307.97	45.40	25.13
135	2.2235	10059.691	9656.4	18.7	50.25	20.28	70.53	3.48	307.83	45.41	25.12
136	2.2535	10085.987	9682.7	19.0	50.23	20.30	70.53	3.47	307.72	45.41	25.11
137	2.2680	10082.089	9678.8	19.1	50.13	20.32	70.45	3.47	307.59	45.39	25.07

Knight Piesold Geotechnical Lab.

	Total	Effective
C, ksf	0	0
φ, deg	19.1	37.6
Tan(φ)	0.35	0.77





Specimen No.		1	2	3	4
Initial	Water Content, %	3.4	3.4	4.0	3.9
	Dry Density, pcf	102.9	102.9	102.3	102.9
	Saturation, %	14.3	14.3	16.5	16.5
	Void Ratio	0.6413	0.6416	0.6508	0.6407
	Diameter, in.	6.00	6.00	6.00	6.00
	Height, in.	13.00	13.00	13.00	13.00
At Test	Water Content, %	11.9	12.5	9.8	8.3
	Dry Density, pcf	127.7	126.3	133.4	137.9
	Saturation, %	100.0	100.0	100.0	100.0
	Void Ratio	0.3225	0.3374	0.2657	0.2247
	Diameter, in.	5.47	5.55	5.38	5.34
	Height, in.	12.58	12.38	12.39	12.23
Strain rate, %/min.		0.03	0.03	0.03	0.03
Eff. Cell Pressure, ksf		7.0	14.0	28.3	55.8
Fail. Stress, ksf		8.1	12.1	30.7	52.7
Excess Pore Pr., ksf		4.8	10.2	18.7	38.8
Strain, %		15.0	15.1	15.0	15.1
Ult. Stress, ksf					
Excess Pore Pr., ksf					
Strain, %					
$\bar{\sigma}_1$ Failure, ksf		10.3	15.8	40.3	69.8
$\bar{\sigma}_3$ Failure, ksf		2.2	3.8	9.6	17.0

Type of Test:
CU with Pore Pressures

Sample Type: Remolded

Description: clayey SAND with gravel

LL= 45 **PL=** 16 **PI=** 29

Specific Gravity= 2.705

Remarks: Failure chosen at 15% strain with no cohesion intercept.

Figure ________

Client: Montana Resources

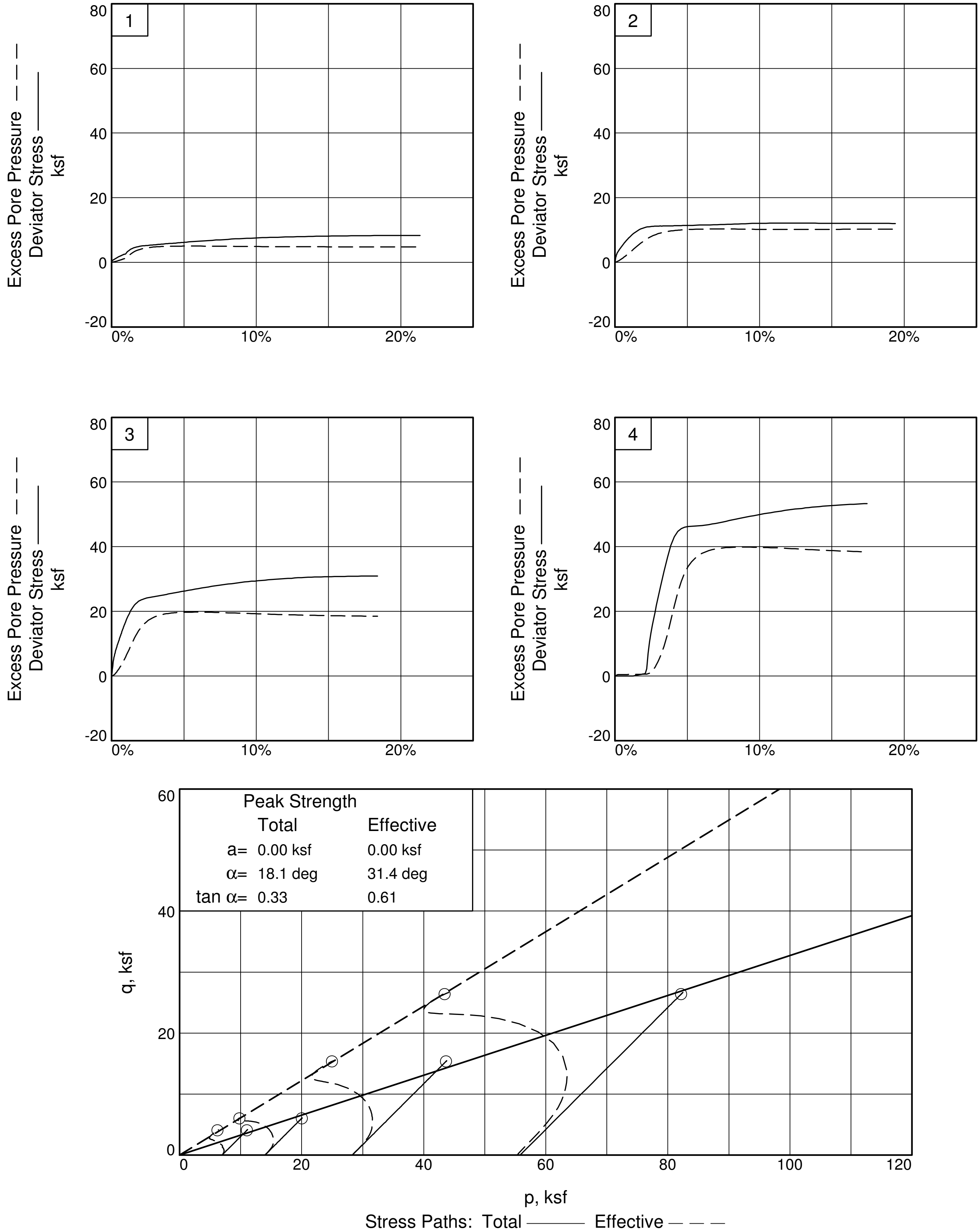
Project: Yankee Doodle Tailings Impoundment

Location: Composite 5 through 8- Newer Rockfill

Proj. No.: VA101-00126/17 **Date Sampled:** 7/18/17

Knight Piésold CONSULTING

Tested By: JDH/JDB **Checked By:** JDB



Client: Montana Resources
Project: Yankee Doodle Tailings Impoundment
Location: Composite 5 through 8- Newer Rockfill
Project No.: VA101-00126/17 **Figure** ________

Knight Piesold Geotechnical Lab.

Cursory interpretations provided require review by a professional engineer. Knight Piesold accepts no responsibility in subsequent analyses.

Tested By: JDH/JDB **Checked By:** JDB

TRIAXIAL COMPRESSION TEST

CU with Pore Pressures

9/20/2017
11:38 AM

Date: 7/18/17
Client: Montana Resources
Project: Yankee Doodle Tailings Impoundment
Project No.: VA101-00126/17
Location: Composite 5 through 8- Newer Rockfill
Description: clayey SAND with gravel
Remarks: Failure chosen at 15% strain with no cohesion intercept.
Type of Sample: Remolded
Specific Gravity=2.705 **LL=**45 **PL=**16 **PI=**29
Test Method: ASTM D 4767 Method A

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	10262.800			13229.000
Moisture content: Dry soil+tare, gms.	9927.000			12045.000
Moisture content: Tare, gms.	0.000			2118.000
Moisture, %	3.4	23.7	11.9	11.9
Moist specimen weight, gms.	10262.8			
Diameter, in.	6.00	6.00	5.47	
Area, in.^{2}	28.27	28.27	23.54	
Height, in.	13.00	13.00	12.58	
Net decrease in height, in.		0.00	0.42	
Net decrease in water volume, cc.			1170.00	
Wet density, pcf	106.4	127.3	142.9	
Dry density, pcf	102.9	102.9	127.7	
Void ratio	0.6413	0.6413	0.3225	
Saturation, %	14.3	100.0	100.0	

Test Readings for Specimen No. 1

Membrane modulus = 0.124105 kN/cm^2
Membrane thickness = 0.0635 cm
Consolidation cell pressure = 108.00 psi (15.55 ksf)
Consolidation back pressure = 59.69 psi (8.60 ksf)
Consolidation effective confining stress = 6.96 ksf
Strain rate, %/min. = 0.03
Fail. Stress = 8.11 ksf **at reading no.** 117

Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.0000	111.422	0.0	0.0	0.00	6.96	6.96	1.00	59.69	6.96	0.00
1	0.0034	196.366	84.9	0.0	0.52	6.91	7.42	1.08	60.05	7.16	0.26
2	0.0067	206.382	95.0	0.1	0.58	6.88	7.46	1.08	60.19	7.17	0.29
3	0.0101	220.720	109.3	0.1	0.67	6.86	7.53	1.10	60.35	7.20	0.33
4	0.0134	231.618	120.2	0.1	0.73	6.84	7.57	1.11	60.51	7.21	0.37
5	0.0168	246.545	135.1	0.1	0.83	6.82	7.64	1.12	60.65	7.23	0.41
6	0.0201	255.736	144.3	0.2	0.88	6.79	7.67	1.13	60.83	7.23	0.44
7	0.0235	266.972	155.6	0.2	0.95	6.78	7.73	1.14	60.94	7.25	0.47
8	0.0269	278.737	167.3	0.2	1.02	6.75	7.77	1.15	61.15	7.26	0.51
9	0.0302	286.370	174.9	0.2	1.07	6.73	7.80	1.16	61.27	7.26	0.53
10	0.0336	299.679	188.3	0.3	1.15	6.70	7.85	1.17	61.46	7.28	0.57
11	0.0369	312.430	201.0	0.3	1.23	6.67	7.90	1.18	61.68	7.28	0.61
12	0.0403	320.607	209.2	0.3	1.28	6.64	7.91	1.19	61.91	7.27	0.64
13	0.0436	333.975	222.6	0.3	1.36	6.61	7.97	1.21	62.09	7.29	0.68
14	0.0470	345.313	233.9	0.4	1.43	6.58	8.00	1.22	62.31	7.29	0.71
15	0.0504	356.373	245.0	0.4	1.49	6.54	8.03	1.23	62.60	7.28	0.75
16	0.0537	370.859	259.4	0.4	1.58	6.50	8.08	1.24	62.89	7.29	0.79
17	0.0571	385.741	274.3	0.5	1.67	6.45	8.12	1.26	63.20	7.29	0.84
18	0.0604	392.904	281.5	0.5	1.71	6.42	8.14	1.27	63.41	7.28	0.86
19	0.0638	402.727	291.3	0.5	1.77	6.38	8.15	1.28	63.71	7.26	0.89
20	0.0671	412.316	300.9	0.5	1.83	6.34	8.17	1.29	64.00	7.25	0.92
21	0.0705	420.743	309.3	0.6	1.88	6.29	8.17	1.30	64.31	7.23	0.94
22	0.0738	429.846	318.4	0.6	1.94	6.26	8.20	1.31	64.54	7.23	0.97
23	0.0772	439.861	328.4	0.6	2.00	6.22	8.22	1.32	64.79	7.22	1.00
24	0.0806	445.803	334.4	0.6	2.03	6.18	8.22	1.33	65.06	7.20	1.02
25	0.0839	456.362	344.9	0.7	2.10	6.14	8.24	1.34	65.33	7.19	1.05
26	0.0873	466.024	354.6	0.7	2.15	6.10	8.26	1.35	65.63	7.18	1.08
27	0.0906	477.495	366.1	0.7	2.22	6.06	8.29	1.37	65.89	7.18	1.11
28	0.0940	482.848	371.4	0.7	2.26	6.02	8.28	1.37	66.17	7.15	1.13
29	0.0973	491.275	379.9	0.8	2.31	5.98	8.29	1.39	66.45	7.14	1.15
30	0.1007	504.673	393.3	0.8	2.39	5.94	8.32	1.40	66.78	7.13	1.19
31	0.1040	510.511	399.1	0.8	2.42	5.90	8.32	1.41	67.05	7.11	1.21
32	0.1074	510.776	399.4	0.9	2.42	5.86	8.28	1.41	67.30	7.07	1.21
33	0.1108	521.320	409.9	0.9	2.49	5.82	8.31	1.43	67.58	7.06	1.24
34	0.1141	532.556	421.1	0.9	2.55	5.78	8.33	1.44	67.88	7.05	1.28
35	0.1175	532.453	421.0	0.9	2.55	5.74	8.29	1.44	68.12	7.02	1.28
36	0.1208	541.498	430.1	1.0	2.61	5.71	8.32	1.46	68.34	7.01	1.30
37	0.1242	554.483	443.1	1.0	2.68	5.67	8.35	1.47	68.64	7.01	1.34
38	0.1276	592.852	481.4	1.0	2.92	5.60	8.51	1.52	69.13	7.06	1.46
39	0.1309	616.618	505.2	1.0	3.06	5.49	8.55	1.56	69.86	7.02	1.53
40	0.1343	637.398	526.0	1.1	3.18	5.38	8.56	1.59	70.67	6.97	1.59
41	0.1376	657.620	546.2	1.1	3.31	5.26	8.57	1.63	71.45	6.92	1.65
42	0.1510	721.460	610.0	1.2	3.69	4.83	8.52	1.76	74.46	6.67	1.84
43	0.1645	775.683	664.3	1.3	4.01	4.43	8.45	1.90	77.20	6.44	2.01
44	0.1779	820.405	709.0	1.4	4.28	4.09	8.36	2.05	79.62	6.22	2.14
45	0.1913	851.818	740.4	1.5	4.46	3.78	8.25	2.18	81.72	6.02	2.23
46	0.2047	882.349	770.9	1.6	4.64	3.52	8.16	2.32	83.53	5.84	2.32

Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
47	0.2182	900.762	789.3	1.7	4.75	3.30	8.05	2.44	85.08	5.67	2.37
48	0.2316	919.703	808.3	1.8	4.85	3.12	7.97	2.56	86.36	5.54	2.43
49	0.2450	936.586	825.2	1.9	4.95	2.96	7.91	2.67	87.48	5.43	2.48
50	0.2584	954.822	843.4	2.1	5.05	2.82	7.88	2.79	88.39	5.35	2.53
51	0.2719	962.337	850.9	2.2	5.09	2.71	7.80	2.88	89.21	5.25	2.55
52	0.2853	966.455	855.0	2.3	5.11	2.61	7.72	2.96	89.90	5.16	2.56
53	0.2987	978.117	866.7	2.4	5.18	2.52	7.69	3.06	90.52	5.11	2.59
54	0.3121	987.221	875.8	2.5	5.23	2.45	7.67	3.13	91.00	5.06	2.61
55	0.3256	999.457	888.0	2.6	5.29	2.38	7.67	3.22	91.48	5.03	2.65
56	0.3390	1004.913	893.5	2.7	5.32	2.32	7.64	3.29	91.87	4.98	2.66
57	0.3524	1011.339	899.9	2.8	5.35	2.28	7.63	3.35	92.18	4.95	2.68
58	0.3658	1025.693	914.3	2.9	5.43	2.23	7.66	3.44	92.52	4.94	2.72
59	0.3792	1028.708	917.3	3.0	5.44	2.19	7.63	3.49	92.79	4.91	2.72
60	0.3927	1037.340	925.9	3.1	5.49	2.16	7.65	3.54	93.02	4.90	2.74
61	0.4061	1043.752	932.3	3.2	5.52	2.13	7.65	3.59	93.18	4.89	2.76
62	0.4196	1051.694	940.3	3.3	5.56	2.10	7.66	3.65	93.42	4.88	2.78
63	0.4330	1060.768	949.3	3.4	5.61	2.08	7.68	3.70	93.58	4.88	2.80
64	0.4464	1064.753	953.3	3.5	5.63	2.06	7.68	3.74	93.72	4.87	2.81
65	0.4598	1079.460	968.0	3.7	5.71	2.04	7.75	3.79	93.80	4.90	2.85
66	0.4732	1086.533	975.1	3.8	5.74	2.03	7.77	3.83	93.90	4.90	2.87
67	0.4866	1091.122	979.7	3.9	5.76	2.02	7.78	3.85	93.97	4.90	2.88
68	0.5001	1103.181	991.8	4.0	5.83	2.01	7.83	3.91	94.08	4.92	2.91
69	0.5135	1105.828	994.4	4.1	5.84	2.00	7.83	3.92	94.13	4.91	2.92
70	0.5269	1114.240	1002.8	4.2	5.88	1.98	7.86	3.97	94.27	4.92	2.94
71	0.5403	1122.579	1011.2	4.3	5.92	1.97	7.89	4.01	94.33	4.93	2.96
72	0.5538	1128.947	1017.5	4.4	5.95	1.96	7.92	4.03	94.36	4.94	2.98
73	0.5672	1135.771	1024.3	4.5	5.98	1.96	7.94	4.06	94.42	4.95	2.99
74	0.5806	1146.286	1034.9	4.6	6.04	1.96	7.99	4.09	94.42	4.98	3.02
75	0.5940	1153.918	1042.5	4.7	6.08	1.95	8.02	4.12	94.48	4.99	3.04
76	0.6075	1161.639	1050.2	4.8	6.12	1.95	8.06	4.14	94.49	5.00	3.06
77	0.6209	1171.169	1059.7	4.9	6.16	1.94	8.10	4.18	94.52	5.02	3.08
78	0.6343	1175.346	1063.9	5.0	6.18	1.94	8.12	4.19	94.54	5.03	3.09
79	0.6477	1185.876	1074.5	5.1	6.24	1.94	8.17	4.22	94.56	5.05	3.12
80	0.6612	1196.244	1084.8	5.3	6.29	1.94	8.23	4.24	94.53	5.08	3.14
81	0.6746	1203.362	1091.9	5.4	6.32	1.93	8.26	4.27	94.57	5.09	3.16
82	0.7082	1221.465	1110.0	5.6	6.41	1.93	8.34	4.31	94.57	5.14	3.20
83	0.7417	1240.598	1129.2	5.9	6.50	1.94	8.44	4.36	94.55	5.19	3.25
84	0.7753	1253.643	1142.2	6.2	6.56	1.94	8.50	4.38	94.54	5.22	3.28
85	0.8088	1275.306	1163.9	6.4	6.66	1.95	8.61	4.42	94.47	5.28	3.33
86	0.8424	1290.527	1179.1	6.7	6.73	1.95	8.68	4.45	94.43	5.32	3.37
87	0.8759	1308.807	1197.4	7.0	6.82	1.97	8.78	4.46	94.33	5.38	3.41
88	0.9095	1326.116	1214.7	7.2	6.89	1.98	8.87	4.49	94.27	5.42	3.45
89	0.9431	1340.132	1228.7	7.5	6.95	1.98	8.94	4.50	94.22	5.46	3.48
90	0.9766	1357.720	1246.3	7.8	7.03	1.99	9.02	4.53	94.17	5.51	3.52
91	1.0102	1371.883	1260.5	8.0	7.09	2.00	9.09	4.55	94.12	5.55	3.55
92	1.0437	1391.722	1280.3	8.3	7.18	2.01	9.20	4.57	94.01	5.61	3.59
93	1.0773	1408.722	1297.3	8.6	7.26	2.02	9.28	4.58	93.94	5.65	3.63

Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
94	1.1109	1418.076	1306.7	8.8	7.29	2.04	9.32	4.58	93.86	5.68	3.64
95	1.1444	1432.179	1320.8	9.1	7.35	2.05	9.40	4.58	93.75	5.72	3.67
96	1.1780	1450.415	1339.0	9.4	7.43	2.06	9.48	4.61	93.71	5.77	3.71
97	1.2116	1461.651	1350.2	9.6	7.47	2.07	9.53	4.61	93.65	5.80	3.73
98	1.2451	1473.593	1362.2	9.9	7.51	2.07	9.58	4.62	93.61	5.83	3.75
99	1.2787	1490.579	1379.2	10.2	7.58	2.08	9.66	4.64	93.54	5.87	3.79
100	1.3122	1505.962	1394.5	10.4	7.64	2.09	9.73	4.65	93.48	5.91	3.82
101	1.3458	1515.256	1403.8	10.7	7.67	2.09	9.76	4.67	93.47	5.93	3.84
102	1.3793	1529.257	1417.8	11.0	7.72	2.10	9.82	4.68	93.42	5.96	3.86
103	1.4129	1535.477	1424.1	11.2	7.73	2.10	9.84	4.67	93.38	5.97	3.87
104	1.4464	1543.537	1432.1	11.5	7.75	2.11	9.87	4.67	93.32	5.99	3.88
105	1.4800	1557.846	1446.4	11.8	7.81	2.12	9.93	4.68	93.27	6.03	3.90
106	1.5136	1569.714	1458.3	12.0	7.85	2.13	9.98	4.69	93.22	6.05	3.92
107	1.5471	1579.111	1467.7	12.3	7.88	2.13	10.01	4.70	93.20	6.07	3.94
108	1.5807	1588.185	1476.8	12.6	7.90	2.13	10.03	4.70	93.19	6.08	3.95
109	1.6143	1597.612	1486.2	12.8	7.93	2.14	10.06	4.71	93.15	6.10	3.96
110	1.6478	1605.774	1494.4	13.1	7.95	2.14	10.09	4.71	93.13	6.11	3.97
111	1.6814	1615.436	1504.0	13.4	7.97	2.15	10.12	4.71	93.08	6.13	3.99
112	1.7149	1626.246	1514.8	13.6	8.00	2.15	10.15	4.72	93.07	6.15	4.00
113	1.7485	1634.084	1522.7	13.9	8.02	2.16	10.18	4.72	93.03	6.17	4.01
114	1.7820	1645.379	1534.0	14.2	8.06	2.15	10.21	4.74	93.06	6.18	4.03
115	1.8156	1653.467	1542.0	14.4	8.07	2.16	10.23	4.74	93.01	6.20	4.04
116	1.8491	1659.247	1547.8	14.7	8.08	2.16	10.24	4.74	93.01	6.20	4.04
117	1.8827	1671.012	1559.6	15.0	8.11	2.16	10.27	4.75	92.99	6.22	4.06
118	1.9163	1679.145	1567.7	15.2	8.13	2.16	10.29	4.76	92.97	6.23	4.07
119	1.9499	1683.013	1571.6	15.5	8.13	2.16	10.28	4.76	93.00	6.22	4.06
120	1.9834	1692.425	1581.0	15.8	8.15	2.16	10.31	4.77	93.00	6.23	4.07
121	2.0170	1702.440	1591.0	16.0	8.17	2.18	10.36	4.74	92.83	6.27	4.09
122	2.0505	1707.661	1596.2	16.3	8.17	2.18	10.36	4.75	92.84	6.27	4.09
123	2.0841	1717.293	1605.9	16.6	8.20	2.19	10.39	4.74	92.79	6.29	4.10
124	2.1176	1724.088	1612.7	16.8	8.21	2.18	10.39	4.76	92.83	6.29	4.10
125	2.1512	1730.029	1618.6	17.1	8.21	2.18	10.39	4.76	92.85	6.29	4.10
126	2.1848	1736.559	1625.1	17.4	8.22	2.18	10.39	4.78	92.89	6.28	4.11
127	2.2183	1745.177	1633.8	17.6	8.23	2.19	10.42	4.76	92.79	6.31	4.12
128	2.2519	1755.559	1644.1	17.9	8.26	2.19	10.45	4.77	92.77	6.32	4.13
129	2.2854	1763.207	1651.8	18.2	8.27	2.19	10.46	4.77	92.78	6.33	4.14
130	2.3190	1768.192	1656.8	18.4	8.27	2.19	10.46	4.78	92.80	6.32	4.13
131	2.3525	1774.384	1663.0	18.7	8.27	2.19	10.46	4.79	92.83	6.32	4.14
132	2.3861	1781.781	1670.4	19.0	8.28	2.18	10.46	4.80	92.85	6.32	4.14
133	2.4197	1787.664	1676.2	19.2	8.28	2.20	10.48	4.76	92.71	6.34	4.14
134	2.4532	1795.032	1683.6	19.5	8.29	2.20	10.49	4.77	92.74	6.34	4.15
135	2.4868	1802.429	1691.0	19.8	8.30	2.19	10.49	4.78	92.77	6.34	4.15
136	2.5203	1814.238	1702.8	20.0	8.33	2.20	10.53	4.79	92.73	6.36	4.17
137	2.5539	1818.724	1707.3	20.3	8.33	2.20	10.52	4.79	92.73	6.36	4.16
138	2.5874	1823.489	1712.1	20.6	8.32	2.20	10.52	4.78	92.70	6.36	4.16
139	2.6210	1825.592	1714.2	20.8	8.30	2.19	10.49	4.79	92.79	6.34	4.15
140	2.6546	1832.798	1721.4	21.1	8.31	2.19	10.50	4.79	92.78	6.35	4.15

Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
141	2.6848	1833.327	1721.9	21.3	8.29	2.20	10.49	4.77	92.72	6.34	4.14

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	10262.800			13254.500
Moisture content: Dry soil+tare, gms.	9925.300			12016.300
Moisture content: Tare, gms.	0.000			2091.000
Moisture, %	3.4	23.7	12.5	12.5
Moist specimen weight, gms.	10262.8			
Diameter, in.	6.00	6.00	5.55	
Area, in.²	28.27	28.27	24.19	
Height, in.	13.00	13.00	12.38	
Net decrease in height, in.		0.00	0.62	
Net decrease in water volume, cc.			1116.00	
Wet density, pcf	106.4	127.3	142.0	
Dry density, pcf	102.9	102.9	126.3	
Void ratio	0.6416	0.6416	0.3374	
Saturation, %	14.3	100.0	100.0	

Test Readings for Specimen No. 2

Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.0635 cm
Consolidation cell pressure = 127.05 psi (18.30 ksf)
Consolidation back pressure = 29.96 psi (4.31 ksf)
Consolidation effective confining stress = 13.98 ksf
Strain rate, %/min. = 0.03
Fail. Stress = 12.05 ksf **at reading no.** 123

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.6198	154.071	0.0	0.0	0.00	13.98	13.98	1.00	29.96	13.98	0.00
1	0.6228	302.312	148.2	0.0	0.88	13.95	14.83	1.06	30.19	14.39	0.44
2	0.6258	391.653	237.6	0.0	1.41	13.93	15.34	1.10	30.33	14.63	0.71
3	0.6288	462.686	308.6	0.1	1.84	13.90	15.73	1.13	30.55	14.81	0.92
4	0.6318	525.320	371.2	0.1	2.21	13.85	16.06	1.16	30.88	14.95	1.10
5	0.6348	578.440	424.4	0.1	2.52	13.81	16.33	1.18	31.16	15.07	1.26
6	0.6378	622.633	468.6	0.1	2.79	13.76	16.55	1.20	31.47	15.16	1.39
7	0.6409	659.134	505.1	0.2	3.00	13.71	16.71	1.22	31.87	15.21	1.50
8	0.6438	693.268	539.2	0.2	3.20	13.65	16.85	1.23	32.26	15.25	1.60
9	0.6468	721.446	567.4	0.2	3.37	13.59	16.96	1.25	32.68	15.28	1.69
10	0.6498	753.815	599.7	0.2	3.56	13.53	17.09	1.26	33.11	15.31	1.78
11	0.6528	778.213	624.1	0.3	3.71	13.46	17.17	1.28	33.58	15.31	1.85
12	0.6559	811.405	657.3	0.3	3.90	13.40	17.30	1.29	34.02	15.35	1.95
13	0.6589	834.582	680.5	0.3	4.04	13.33	17.37	1.30	34.48	15.35	2.02
14	0.6619	859.230	705.2	0.3	4.18	13.26	17.45	1.32	34.95	15.35	2.09
15	0.6649	885.393	731.3	0.4	4.34	13.18	17.52	1.33	35.50	15.35	2.17
16	0.6679	911.409	757.3	0.4	4.49	13.12	17.61	1.34	35.96	15.36	2.25
17	0.6709	935.219	781.1	0.4	4.63	13.04	17.67	1.36	36.48	15.36	2.32
18	0.6739	961.176	807.1	0.4	4.78	12.97	17.75	1.37	37.00	15.36	2.39

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
19	0.6769	986.574	832.5	0.5	4.93	12.89	17.82	1.38	37.52	15.36	2.47
20	0.6799	1008.104	854.0	0.5	5.06	12.82	17.88	1.39	38.01	15.35	2.53
21	0.6829	1029.575	875.5	0.5	5.19	12.74	17.93	1.41	38.56	15.33	2.59
22	0.6859	1057.518	903.4	0.5	5.35	12.66	18.01	1.42	39.10	15.34	2.67
23	0.6889	1081.004	926.9	0.6	5.49	12.60	18.08	1.44	39.58	15.34	2.74
24	0.6919	1104.652	950.6	0.6	5.63	12.51	18.14	1.45	40.15	15.33	2.81
25	0.6949	1128.241	974.2	0.6	5.76	12.43	18.19	1.46	40.75	15.31	2.88
26	0.6979	1153.051	999.0	0.6	5.91	12.35	18.26	1.48	41.31	15.30	2.95
27	0.7009	1176.684	1022.6	0.7	6.05	12.26	18.31	1.49	41.88	15.29	3.02
28	0.7039	1198.303	1044.2	0.7	6.17	12.18	18.35	1.51	42.47	15.27	3.09
29	0.7069	1219.656	1065.6	0.7	6.30	12.10	18.40	1.52	43.03	15.25	3.15
30	0.7099	1240.716	1086.6	0.7	6.42	12.01	18.43	1.53	43.64	15.22	3.21
31	0.7129	1263.643	1109.6	0.8	6.56	11.93	18.49	1.55	44.18	15.21	3.28
32	0.7159	1286.409	1132.3	0.8	6.69	11.83	18.52	1.57	44.88	15.18	3.34
33	0.7189	1304.645	1150.6	0.8	6.79	11.76	18.55	1.58	45.39	15.16	3.40
34	0.7219	1327.131	1173.1	0.8	6.93	11.67	18.60	1.59	45.99	15.14	3.46
35	0.7250	1350.838	1196.8	0.8	7.06	11.57	18.64	1.61	46.67	15.11	3.53
36	0.7279	1369.309	1215.2	0.9	7.17	11.49	18.66	1.62	47.28	15.07	3.59
37	0.7310	1389.119	1235.0	0.9	7.29	11.40	18.69	1.64	47.86	15.05	3.64
38	0.7340	1409.870	1255.8	0.9	7.41	11.31	18.71	1.66	48.52	15.01	3.70
39	0.7370	1430.017	1275.9	0.9	7.52	11.21	18.74	1.67	49.19	14.97	3.76
40	0.7400	1448.415	1294.3	1.0	7.63	11.12	18.75	1.69	49.81	14.94	3.82
41	0.7430	1464.533	1310.5	1.0	7.72	11.04	18.76	1.70	50.40	14.90	3.86
42	0.7550	1544.139	1390.1	1.1	8.18	10.66	18.85	1.77	53.00	14.76	4.09
43	0.7670	1612.789	1458.7	1.2	8.58	10.30	18.88	1.83	55.55	14.59	4.29
44	0.7790	1674.542	1520.5	1.3	8.94	9.88	18.82	1.90	58.41	14.35	4.47
45	0.7910	1732.309	1578.2	1.4	9.27	9.50	18.77	1.97	61.05	14.14	4.63
46	0.8030	1784.899	1630.8	1.5	9.56	9.14	18.71	2.05	63.57	13.92	4.78
47	0.8150	1835.857	1681.8	1.6	9.85	8.77	18.62	2.12	66.15	13.70	4.93
48	0.8270	1876.197	1722.1	1.7	10.08	8.42	18.50	2.20	68.56	13.46	5.04
49	0.8390	1915.683	1761.6	1.8	10.30	8.08	18.38	2.28	70.95	13.23	5.15
50	0.8510	1949.493	1795.4	1.9	10.49	7.75	18.24	2.35	73.20	13.00	5.24
51	0.8630	1975.509	1821.4	2.0	10.63	7.45	18.08	2.43	75.29	12.77	5.32
52	0.8750	2001.378	1847.3	2.1	10.77	7.16	17.93	2.50	77.31	12.55	5.39
53	0.8870	2020.614	1866.5	2.2	10.87	6.89	17.77	2.58	79.17	12.33	5.44
54	0.8990	2036.835	1882.8	2.3	10.96	6.60	17.56	2.66	81.21	12.08	5.48
55	0.9111	2047.453	1893.4	2.4	11.01	6.35	17.36	2.73	82.93	11.86	5.50
56	0.9230	2061.792	1907.7	2.4	11.08	6.11	17.19	2.81	84.59	11.65	5.54
57	0.9350	2071.219	1917.1	2.5	11.12	5.90	17.02	2.89	86.08	11.46	5.56
58	0.9471	2077.954	1923.9	2.6	11.15	5.70	16.85	2.96	87.45	11.28	5.58
59	0.9591	2080.852	1926.8	2.7	11.16	5.51	16.67	3.02	88.77	11.09	5.58
60	0.9711	2088.867	1934.8	2.8	11.19	5.36	16.55	3.09	89.84	10.95	5.60
61	0.9831	2093.028	1939.0	2.9	11.20	5.20	16.40	3.16	90.96	10.80	5.60
62	0.9951	2093.220	1939.1	3.0	11.19	5.06	16.25	3.21	91.91	10.66	5.60
63	1.0071	2102.735	1948.7	3.1	11.24	4.94	16.17	3.28	92.76	10.56	5.62
64	1.0191	2101.264	1947.2	3.2	11.22	4.82	16.04	3.33	93.57	10.43	5.61
65	1.0311	2107.044	1953.0	3.3	11.24	4.72	15.96	3.38	94.26	10.34	5.62

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
66	1.04312	107.735	1953.7	3.4	11.23	4.63	15.86	3.43	94.88	10.25	5.62
67	1.05512	109.044	1955.0	3.5	11.23	4.55	15.78	3.47	95.46	10.16	5.61
68	1.06712	114.220	1960.1	3.6	11.25	4.46	15.71	3.52	96.05	10.09	5.62
69	1.07912	117.868	1963.8	3.7	11.26	4.39	15.65	3.56	96.55	10.02	5.63
70	1.09112	119.221	1965.1	3.8	11.25	4.32	15.58	3.60	97.04	9.95	5.63
71	1.10312	121.500	1967.4	3.9	11.26	4.27	15.52	3.64	97.42	9.89	5.63
72	1.11512	129.692	1975.6	4.0	11.29	4.21	15.50	3.68	97.80	9.86	5.65
73	1.12712	135.221	1981.2	4.1	11.31	4.16	15.48	3.72	98.13	9.82	5.66
74	1.13912	139.089	1985.0	4.2	11.32	4.12	15.45	3.74	98.41	9.79	5.66
75	1.15112	141.751	1987.7	4.3	11.33	4.08	15.40	3.78	98.75	9.74	5.66
76	1.16312	147.339	1993.3	4.4	11.35	4.04	15.39	3.81	98.99	9.71	5.67
77	1.17522	152.457	1998.4	4.5	11.36	4.00	15.36	3.84	99.30	9.68	5.68
78	1.18712	153.104	1999.0	4.6	11.36	3.97	15.33	3.86	99.46	9.65	5.68
79	1.19912	161.281	2007.2	4.7	11.39	3.94	15.33	3.89	99.69	9.64	5.70
80	1.21112	161.443	2007.4	4.8	11.38	3.92	15.30	3.90	99.84	9.61	5.69
81	1.22312	165.575	2011.5	4.9	11.39	3.89	15.28	3.93	100.02	9.59	5.70
82	1.25312	175.517	2021.4	5.1	11.42	3.83	15.25	3.98	100.45	9.54	5.71
83	1.28312	184.870	2030.8	5.4	11.44	3.79	15.23	4.02	100.75	9.51	5.72
84	1.31322	200.444	2046.4	5.6	11.50	3.76	15.26	4.06	100.97	9.51	5.75
85	1.34322	209.048	2055.0	5.8	11.52	3.73	15.25	4.08	101.12	9.49	5.76
86	1.37322	217.225	2063.2	6.1	11.53	3.70	15.24	4.11	101.32	9.47	5.77
87	1.40322	227.048	2073.0	6.3	11.56	3.69	15.25	4.13	101.42	9.47	5.78
88	1.43322	236.931	2082.9	6.6	11.58	3.68	15.26	4.15	101.50	9.47	5.79
89	1.46322	252.623	2098.6	6.8	11.64	3.68	15.32	4.16	101.50	9.50	5.82
90	1.49322	261.035	2107.0	7.1	11.66	3.67	15.33	4.18	101.57	9.50	5.83
91	1.52322	269.285	2115.2	7.3	11.67	3.68	15.35	4.18	101.52	9.51	5.84
92	1.55322	280.742	2126.7	7.5	11.71	3.67	15.37	4.19	101.59	9.52	5.85
93	1.58322	292.875	2138.8	7.8	11.74	3.66	15.41	4.21	101.61	9.53	5.87
94	1.61322	300.875	2146.8	8.0	11.75	3.67	15.42	4.21	101.59	9.54	5.88
95	1.64322	316.802	2162.7	8.3	11.81	3.67	15.48	4.21	101.54	9.58	5.91
96	1.67322	332.450	2178.4	8.5	11.86	3.70	15.56	4.21	101.36	9.63	5.93
97	1.70322	347.862	2193.8	8.8	11.92	3.71	15.63	4.21	101.30	9.67	5.96
98	1.73322	356.583	2202.5	9.0	11.93	3.72	15.65	4.21	101.21	9.69	5.97
99	1.76322	371.995	2217.9	9.2	11.98	3.74	15.72	4.21	101.08	9.73	5.99
100	1.79332	387.761	2233.7	9.5	12.04	3.75	15.78	4.21	101.04	9.76	6.02
101	1.82322	396.393	2242.3	9.7	12.05	3.77	15.82	4.20	100.90	9.79	6.03
102	1.85322	403.349	2249.3	10.0	12.06	3.79	15.84	4.18	100.75	9.82	6.03
103	1.88332	413.159	2259.1	10.2	12.08	3.78	15.86	4.19	100.78	9.82	6.04
104	1.91332	422.512	2268.4	10.4	12.09	3.80	15.89	4.18	100.67	9.85	6.05
105	1.94332	431.880	2277.8	10.7	12.11	3.81	15.92	4.18	100.60	9.86	6.06
106	1.97332	441.351	2287.3	10.9	12.13	3.81	15.93	4.19	100.61	9.87	6.06
107	2.00332	447.631	2293.6	11.2	12.13	3.81	15.94	4.18	100.56	9.88	6.06
108	2.03332	450.704	2296.6	11.4	12.11	3.82	15.93	4.17	100.51	9.88	6.06
109	2.06332	459.219	2305.1	11.7	12.12	3.82	15.94	4.18	100.54	9.88	6.06
110	2.09332	463.513	2309.4	11.9	12.11	3.82	15.93	4.17	100.51	9.88	6.06
111	2.12332	476.058	2322.0	12.1	12.14	3.82	15.97	4.18	100.52	9.89	6.07
112	2.15332	482.102	2328.0	12.4	12.14	3.82	15.96	4.18	100.52	9.89	6.07

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
113	2.1833	2489.338	2335.3	12.6	12.15	3.82	15.97	4.18	100.51	9.89	6.07
114	2.2133	2499.706	2345.6	12.9	12.17	3.83	15.99	4.18	100.48	9.91	6.08
115	2.2434	2499.235	2345.2	13.1	12.13	3.82	15.95	4.17	100.52	9.89	6.07
116	2.2733	2506.750	2352.7	13.4	12.14	3.82	15.96	4.18	100.51	9.89	6.07
117	2.3033	2510.692	2356.6	13.6	12.12	3.81	15.93	4.18	100.57	9.87	6.06
118	2.3334	2516.751	2362.7	13.8	12.12	3.81	15.92	4.18	100.63	9.86	6.06
119	2.3634	2518.589	2364.5	14.1	12.09	3.80	15.89	4.18	100.67	9.85	6.05
120	2.3934	2525.119	2371.0	14.3	12.09	3.79	15.88	4.19	100.74	9.84	6.05
121	2.4234	2526.060	2372.0	14.6	12.06	3.78	15.85	4.19	100.79	9.81	6.03
122	2.4534	2531.707	2377.6	14.8	12.06	3.77	15.83	4.20	100.85	9.80	6.03
123	2.4834	2537.590	2383.5	15.1	12.05	3.77	15.83	4.19	100.84	9.80	6.03
124	2.5134	2550.237	2396.2	15.3	12.08	3.77	15.85	4.20	100.87	9.81	6.04
125	2.5434	2556.297	2402.2	15.5	12.08	3.77	15.85	4.20	100.87	9.81	6.04
126	2.5734	2563.459	2409.4	15.8	12.08	3.76	15.84	4.21	100.91	9.80	6.04
127	2.6034	2570.297	2416.2	16.0	12.08	3.75	15.83	4.22	101.02	9.79	6.04
128	2.6334	2574.238	2420.2	16.3	12.06	3.75	15.81	4.22	101.04	9.78	6.03
129	2.6634	2584.342	2430.3	16.5	12.08	3.75	15.83	4.22	101.00	9.79	6.04
130	2.6934	2591.636	2437.6	16.7	12.08	3.74	15.82	4.23	101.06	9.78	6.04
131	2.7235	2595.298	2441.2	17.0	12.06	3.73	15.80	4.23	101.13	9.76	6.03
132	2.7534	2603.181	2449.1	17.2	12.07	3.74	15.80	4.23	101.10	9.77	6.03
133	2.7834	2605.754	2451.7	17.5	12.04	3.73	15.78	4.23	101.14	9.75	6.02
134	2.8135	2613.181	2459.1	17.7	12.05	3.73	15.77	4.23	101.15	9.75	6.02
135	2.8435	2622.299	2468.2	18.0	12.05	3.73	15.78	4.23	101.14	9.76	6.03
136	2.8735	2630.814	2476.7	18.2	12.06	3.72	15.78	4.24	101.20	9.75	6.03
137	2.9035	2637.520	2483.4	18.4	12.06	3.71	15.77	4.25	101.27	9.74	6.03
138	2.9335	2642.006	2487.9	18.7	12.04	3.71	15.75	4.24	101.28	9.73	6.02
139	2.9635	2646.653	2492.6	18.9	12.03	3.71	15.74	4.24	101.30	9.72	6.01
140	2.9935	2651.859	2497.8	19.2	12.02	3.70	15.72	4.25	101.33	9.71	6.01
141	3.0202	2656.168	2502.1	19.4	12.01	3.68	15.69	4.26	101.49	9.68	6.00

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	10262.800			13243.000
Moisture content: Dry soil+tare, gms.	9870.000			12273.500
Moisture content: Tare, gms.	0.000			2403.500
Moisture, %	4.0	24.1	9.8	9.8
Moist specimen weight, gms.	10262.8			
Diameter, in.	6.00	6.00	5.38	
Area, in.²	28.27	28.27	22.75	
Height, in.	13.00	13.00	12.39	
Net decrease in height, in.		0.00	0.61	
Net decrease in water volume, cc.			1405.00	
Wet density, pcf	106.4	126.9	146.5	
Dry density, pcf	102.3	102.3	133.4	
Void ratio	0.6508	0.6508	0.2657	
Saturation, %	16.5	100.0	100.0	

Test Readings for Specimen No. 3

Membrane modulus = 0.124105 kN/cm²
Membrane thickness = 0.0635 cm
Consolidation cell pressure = 244.10 psi (35.15 ksf)
Consolidation back pressure = 47.61 psi (6.86 ksf)
Consolidation effective confining stress = 28.29 ksf
Strain rate, %/min. = 0.03
Fail. Stress = 30.70 ksf **at reading no.** 126

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.6118	178.498	0.0	0.0	0.00	28.29	28.29	1.00	47.61	28.29	0.00
1	0.6147	322.798	144.3	0.0	0.91	28.28	29.19	1.03	47.74	28.73	0.46
2	0.6175	485.863	307.4	0.0	1.94	28.27	30.22	1.07	47.76	29.25	0.97
3	0.6203	642.928	464.4	0.1	2.94	28.23	31.17	1.10	48.04	29.70	1.47
4	0.6232	778.742	600.2	0.1	3.80	28.18	31.97	1.13	48.42	30.08	1.90
5	0.6260	893.982	715.5	0.1	4.52	28.12	32.64	1.16	48.83	30.38	2.26
6	0.6289	998.589	820.1	0.1	5.18	28.05	33.23	1.18	49.32	30.64	2.59
7	0.6317	1085.519	907.0	0.2	5.73	27.98	33.71	1.20	49.82	30.84	2.87
8	0.6346	1164.007	985.5	0.2	6.23	27.88	34.11	1.22	50.50	30.99	3.11
9	0.6374	1235.936	1057.4	0.2	6.68	27.79	34.47	1.24	51.13	31.13	3.34
10	0.6403	1300.292	1121.8	0.2	7.08	27.67	34.76	1.26	51.92	31.22	3.54
11	0.6431	1363.353	1184.9	0.3	7.48	27.57	35.05	1.27	52.63	31.31	3.74
12	0.6460	1418.899	1240.4	0.3	7.83	27.45	35.28	1.29	53.48	31.36	3.92
13	0.6488	1476.299	1297.8	0.3	8.19	27.32	35.51	1.30	54.35	31.42	4.10
14	0.6517	1528.477	1350.0	0.3	8.52	27.20	35.72	1.31	55.22	31.46	4.26
15	0.6545	1582.259	1403.8	0.3	8.86	27.07	35.93	1.33	56.11	31.50	4.43
16	0.6573	1631.172	1452.7	0.4	9.16	26.93	36.10	1.34	57.06	31.51	4.58
17	0.6602	1684.616	1506.1	0.4	9.50	26.80	36.30	1.35	57.99	31.55	4.75
18	0.6630	1735.853	1557.4	0.4	9.82	26.66	36.48	1.37	58.95	31.57	4.91
19	0.6659	1786.899	1608.4	0.4	10.14	26.52	36.65	1.38	59.96	31.59	5.07
20	0.6687	1839.783	1661.3	0.5	10.47	26.38	36.84	1.40	60.94	31.61	5.23
21	0.6716	1887.270	1708.8	0.5	10.76	26.22	36.98	1.41	62.03	31.60	5.38
22	0.6744	1935.331	1756.8	0.5	11.06	26.07	37.13	1.42	63.06	31.60	5.53
23	0.6773	1981.892	1803.4	0.5	11.36	25.92	37.27	1.44	64.13	31.59	5.68

Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
24	0.6801	2030.335	1851.8	0.6	11.66	25.76	37.42	1.45	65.20	31.59	5.83
25	0.6830	2081.219	1902.7	0.6	11.98	25.59	37.57	1.47	66.36	31.58	5.99
26	0.6858	2130.456	1952.0	0.6	12.28	25.44	37.72	1.48	67.45	31.58	6.14
27	0.6887	2179.738	2001.2	0.6	12.59	25.26	37.85	1.50	68.66	31.56	6.29
28	0.6915	2227.269	2048.8	0.6	12.89	25.08	37.97	1.51	69.91	31.53	6.44
29	0.6944	2273.447	2094.9	0.7	13.17	24.91	38.09	1.53	71.08	31.50	6.59
30	0.6972	2319.640	2141.1	0.7	13.46	24.74	38.20	1.54	72.30	31.47	6.73
31	0.7001	2367.524	2189.0	0.7	13.76	24.56	38.32	1.56	73.54	31.44	6.88
32	0.7029	2413.291	2234.8	0.7	14.04	24.38	38.42	1.58	74.82	31.40	7.02
33	0.7058	2461.822	2283.3	0.8	14.34	24.19	38.53	1.59	76.14	31.36	7.17
34	0.7086	2506.530	2328.0	0.8	14.62	24.00	38.62	1.61	77.46	31.31	7.31
35	0.7114	2549.943	2371.4	0.8	14.89	23.81	38.70	1.63	78.77	31.25	7.45
36	0.7143	2593.504	2415.0	0.8	15.16	23.61	38.77	1.64	80.11	31.19	7.58
37	0.7171	2637.932	2459.4	0.9	15.44	23.41	38.85	1.66	81.50	31.13	7.72
38	0.7200	2682.184	2503.7	0.9	15.71	23.22	38.93	1.68	82.87	31.07	7.86
39	0.7229	2724.053	2545.6	0.9	15.97	23.01	38.98	1.69	84.28	31.00	7.98
40	0.7257	2768.187	2589.7	0.9	16.24	22.81	39.05	1.71	85.70	30.93	8.12
41	0.7285	2809.718	2631.2	0.9	16.50	22.60	39.10	1.73	87.14	30.85	8.25
42	0.7399	2976.019	2797.5	1.0	17.53	21.75	39.28	1.81	93.04	30.52	8.76
43	0.7513	3128.892	2950.4	1.1	18.47	20.87	39.34	1.88	99.16	30.10	9.23
44	0.7627	3267.089	3088.6	1.2	19.31	19.97	39.28	1.97	105.41	29.63	9.66
45	0.7741	3398.903	3220.4	1.3	20.12	19.08	39.20	2.05	111.61	29.14	10.06
46	0.7855	3510.672	3332.2	1.4	20.80	18.20	39.00	2.14	117.68	28.60	10.40
47	0.7969	3615.367	3436.9	1.5	21.43	17.34	38.77	2.24	123.72	28.05	10.72
48	0.8083	3702.400	3523.9	1.6	21.95	16.52	38.48	2.33	129.36	27.50	10.98
49	0.8197	3777.976	3599.5	1.7	22.40	15.74	38.14	2.42	134.82	26.94	11.20
50	0.8310	3842.758	3664.3	1.8	22.78	15.02	37.80	2.52	139.82	26.41	11.39
51	0.8424	3897.510	3719.0	1.9	23.10	14.35	37.46	2.61	144.42	25.91	11.55
52	0.8538	3941.747	3763.2	2.0	23.36	13.76	37.11	2.70	148.56	25.44	11.68
53	0.8652	3974.234	3795.7	2.0	23.54	13.20	36.74	2.78	152.41	24.97	11.77
54	0.8766	4007.882	3829.4	2.1	23.72	12.72	36.44	2.87	155.79	24.58	11.86
55	0.8880	4033.354	3854.9	2.2	23.86	12.27	36.13	2.94	158.88	24.20	11.93
56	0.8994	4058.826	3880.3	2.3	23.99	11.87	35.86	3.02	161.66	23.87	12.00
57	0.9108	4077.812	3899.3	2.4	24.09	11.53	35.61	3.09	164.06	23.57	12.04
58	0.9222	4098.224	3919.7	2.5	24.19	11.19	35.38	3.16	166.36	23.29	12.10
59	0.9335	4116.063	3937.6	2.6	24.28	10.91	35.19	3.22	168.32	23.05	12.14
60	0.9449	4132.181	3953.7	2.7	24.35	10.65	35.01	3.29	170.13	22.83	12.18
61	0.9563	4148.579	3970.1	2.8	24.43	10.43	34.86	3.34	171.68	22.64	12.22
62	0.9677	4165.344	3986.8	2.9	24.51	10.21	34.73	3.40	173.17	22.47	12.26
63	0.9791	4178.007	3999.5	3.0	24.57	10.04	34.61	3.45	174.38	22.32	12.28
64	0.9905	4194.419	4015.9	3.1	24.64	9.88	34.52	3.49	175.50	22.20	12.32
65	1.0019	4209.228	4030.7	3.1	24.71	9.74	34.45	3.54	176.47	22.09	12.36
66	1.0133	4224.229	4045.7	3.2	24.78	9.60	34.38	3.58	177.45	21.99	12.39
67	1.0247	4240.656	4062.2	3.3	24.86	9.48	34.33	3.62	178.29	21.90	12.43
68	1.0360	4254.010	4075.5	3.4	24.91	9.37	34.28	3.66	179.06	21.82	12.46
69	1.0474	4271.937	4093.4	3.5	25.00	9.27	34.28	3.70	179.69	21.78	12.50
70	1.0588	4284.996	4106.5	3.6	25.06	9.18	34.24	3.73	180.34	21.71	12.53

Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
71	1.0702	4303.894	4125.4	3.7	25.15	9.11	34.26	3.76	180.82	21.69	12.57
72	1.0816	4322.233	4143.7	3.8	25.24	9.04	34.27	3.79	181.34	21.66	12.62
73	1.0930	4339.351	4160.9	3.9	25.32	8.98	34.30	3.82	181.73	21.64	12.66
74	1.1044	4355.705	4177.2	4.0	25.39	8.92	34.31	3.85	182.18	21.61	12.70
75	1.1158	4371.779	4193.3	4.1	25.46	8.87	34.33	3.87	182.50	21.60	12.73
76	1.1272	4390.765	4212.3	4.2	25.55	8.82	34.37	3.90	182.88	21.59	12.78
77	1.1385	4406.236	4227.7	4.3	25.62	8.78	34.41	3.92	183.12	21.59	12.81
78	1.1499	4423.766	4245.3	4.3	25.71	8.74	34.44	3.94	183.41	21.59	12.85
79	1.1613	4440.473	4262.0	4.4	25.78	8.71	34.49	3.96	183.62	21.60	12.89
80	1.1727	4456.429	4277.9	4.5	25.85	8.68	34.53	3.98	183.85	21.60	12.93
81	1.1841	4474.724	4296.2	4.6	25.94	8.66	34.60	4.00	183.98	21.63	12.97
82	1.2126	4517.608	4339.1	4.8	26.13	8.61	34.75	4.03	184.30	21.68	13.07
83	1.2410	4556.713	4378.2	5.1	26.31	8.57	34.88	4.07	184.55	21.73	13.15
84	1.2695	4598.655	4420.2	5.3	26.49	8.55	35.05	4.10	184.71	21.80	13.25
85	1.2980	4641.128	4462.6	5.5	26.68	8.55	35.24	4.12	184.72	21.89	13.34
86	1.3265	4681.012	4502.5	5.8	26.86	8.54	35.40	4.14	184.78	21.97	13.43
87	1.3549	4722.190	4543.7	6.0	27.04	8.53	35.57	4.17	184.84	22.05	13.52
88	1.3834	4764.500	4586.0	6.2	27.22	8.56	35.78	4.18	184.67	22.17	13.61
89	1.4119	4804.502	4626.0	6.5	27.39	8.57	35.96	4.20	184.58	22.27	13.70
90	1.4403	4841.900	4663.4	6.7	27.55	8.59	36.13	4.21	184.48	22.36	13.77
91	1.4688	4879.563	4701.1	6.9	27.70	8.61	36.31	4.22	184.32	22.46	13.85
92	1.4973	4920.153	4741.7	7.1	27.87	8.63	36.50	4.23	184.14	22.57	13.93
93	1.5258	4953.257	4774.8	7.4	27.99	8.66	36.66	4.23	183.96	22.66	14.00
94	1.5542	4992.024	4813.5	7.6	28.15	8.68	36.84	4.24	183.79	22.76	14.08
95	1.5827	5035.143	4856.6	7.8	28.33	8.74	37.07	4.24	183.41	22.91	14.17
96	1.6112	5065.806	4887.3	8.1	28.44	8.77	37.21	4.24	183.19	22.99	14.22
97	1.6397	5099.219	4920.7	8.3	28.56	8.79	37.35	4.25	183.06	23.07	14.28
98	1.6681	5135.926	4957.4	8.5	28.71	8.82	37.53	4.25	182.84	23.17	14.35
99	1.6966	5169.928	4991.4	8.8	28.83	8.87	37.70	4.25	182.48	23.29	14.41
100	1.7251	5206.561	5028.1	9.0	28.97	8.90	37.87	4.25	182.27	23.39	14.48
101	1.7535	5239.813	5061.3	9.2	29.09	8.93	38.02	4.26	182.07	23.48	14.54
102	1.7820	5270.520	5092.0	9.4	29.19	8.97	38.16	4.25	181.79	23.57	14.59
103	1.8105	5304.462	5126.0	9.7	29.31	9.01	38.32	4.25	181.51	23.67	14.65
104	1.8390	5325.169	5146.7	9.9	29.35	9.04	38.39	4.25	181.31	23.72	14.68
105	1.8674	5356.803	5178.3	10.1	29.46	9.07	38.53	4.25	181.12	23.80	14.73
106	1.8959	5390.701	5212.2	10.4	29.57	9.12	38.70	4.24	180.76	23.91	14.79
107	1.9244	5415.643	5237.1	10.6	29.64	9.15	38.79	4.24	180.55	23.97	14.82
108	1.9528	5445.747	5267.2	10.8	29.73	9.19	38.92	4.24	180.29	24.05	14.87
109	1.9813	5475.410	5296.9	11.1	29.82	9.22	39.05	4.23	180.05	24.13	14.91
110	2.0098	5500.470	5322.0	11.3	29.89	9.25	39.14	4.23	179.85	24.19	14.94
111	2.0383	5530.736	5352.2	11.5	29.98	9.27	39.25	4.23	179.73	24.26	14.99
112	2.0667	5557.222	5378.7	11.7	30.05	9.30	39.35	4.23	179.51	24.33	15.02
113	2.0952	5582.414	5403.9	12.0	30.11	9.33	39.44	4.23	179.33	24.38	15.06
114	2.1237	5604.812	5426.3	12.2	30.16	9.35	39.51	4.22	179.15	24.43	15.08
115	2.1522	5630.387	5451.9	12.4	30.22	9.38	39.60	4.22	178.96	24.49	15.11
116	2.1806	5662.241	5483.7	12.7	30.32	9.41	39.73	4.22	178.76	24.57	15.16
117	2.2091	5689.521	5511.0	12.9	30.39	9.43	39.81	4.22	178.63	24.62	15.19

Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
118	2.2376	5710.419	5531.9	13.1	30.42	9.45	39.87	4.22	178.50	24.66	15.21
119	2.2661	5735.406	5556.9	13.4	30.48	9.49	39.97	4.21	178.22	24.73	15.24
120	2.2945	5759.406	5580.9	13.6	30.53	9.50	40.03	4.21	178.12	24.77	15.26
121	2.3230	5777.598	5599.1	13.8	30.55	9.52	40.06	4.21	178.02	24.79	15.27
122	2.3515	5802.599	5624.1	14.0	30.60	9.55	40.15	4.21	177.80	24.85	15.30
123	2.3799	5821.232	5642.7	14.3	30.62	9.57	40.19	4.20	177.65	24.88	15.31
124	2.4084	5839.645	5661.1	14.5	30.64	9.59	40.23	4.19	177.49	24.91	15.32
125	2.4369	5861.293	5682.8	14.7	30.67	9.61	40.28	4.19	177.37	24.95	15.34
126	2.4654	5881.646	5703.1	15.0	30.70	9.63	40.33	4.19	177.23	24.98	15.35
127	2.4938	5902.191	5723.7	15.2	30.73	9.64	40.36	4.19	177.18	25.00	15.36
128	2.5223	5922.766	5744.3	15.4	30.75	9.65	40.40	4.19	177.10	25.03	15.38
129	2.5508	5936.046	5757.5	15.7	30.74	9.67	40.41	4.18	176.96	25.04	15.37
130	2.5793	5956.826	5778.3	15.9	30.77	9.69	40.46	4.18	176.81	25.07	15.38
131	2.6077	5976.077	5797.6	16.1	30.79	9.71	40.49	4.17	176.69	25.10	15.39
132	2.6362	5996.180	5817.7	16.3	30.81	9.69	40.50	4.18	176.79	25.10	15.40
133	2.6647	6018.358	5839.9	16.6	30.84	9.73	40.57	4.17	176.55	25.15	15.42
134	2.6931	6034.667	5856.2	16.8	30.84	9.74	40.58	4.17	176.49	25.16	15.42
135	2.7216	6056.550	5878.1	17.0	30.87	9.74	40.61	4.17	176.45	25.18	15.44
136	2.7501	6077.184	5898.7	17.3	30.89	9.76	40.66	4.16	176.29	25.21	15.45
137	2.7786	6094.478	5916.0	17.5	30.90	9.78	40.68	4.16	176.21	25.23	15.45
138	2.8070	6110.788	5932.3	17.7	30.90	9.77	40.67	4.16	176.22	25.22	15.45
139	2.8355	6127.656	5949.2	17.9	30.90	9.79	40.69	4.16	176.11	25.24	15.45
140	2.8640	6147.833	5969.3	18.2	30.92	9.81	40.72	4.15	176.00	25.27	15.46
141	2.8907	6162.834	5984.3	18.4	30.91	9.79	40.70	4.16	176.11	25.25	15.46

Parameters for Specimen No. 4

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	10318.000			13592.500
Moisture content: Dry soil+tare, gms.	9930.700			12767.700
Moisture content: Tare, gms.	0.000			2837.000
Moisture, %	3.9	23.7	8.3	8.3
Moist specimen weight, gms.	10318.0			
Diameter, in.	6.00	6.00	5.34	
Area, in.²	28.27	28.27	22.43	
Height, in.	13.00	13.00	12.23	
Net decrease in height, in.		0.00	0.77	
Net decrease in water volume, cc.			1527.00	
Wet density, pcf	106.9	127.3	149.3	
Dry density, pcf	102.9	102.9	137.9	
Void ratio	0.6407	0.6407	0.2247	
Saturation, %	16.5	100.0	100.0	

Test Readings for Specimen No. 4

Membrane modulus = 0.124105 kN/cm²

Membrane thickness = 0.0635 cm

Consolidation cell pressure = 438.73 psi (63.18 ksf)

Consolidation back pressure = 51.28 psi (7.38 ksf)

Consolidation effective confining stress = 55.79 ksf

Strain rate, %/min. = 0.03

Fail. Stress = 52.75 ksf **at reading no.** 83

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
0	0.5353	463.249	0.0	0.0	0.00	55.79	55.79	1.00	51.28	55.79	0.00
1	0.5470	451.116	-12.1	0.1	0.00	55.62	55.62	1.00	52.50	55.62	0.00
2	0.5586	452.131	-11.1	0.2	0.00	55.40	55.40	1.00	53.99	55.40	0.00
3	0.5703	449.410	-13.8	0.3	0.00	55.40	55.40	1.00	54.02	55.40	0.00
4	0.5820	453.249	-10.0	0.4	0.00	55.39	55.39	1.00	54.07	55.39	0.00
5	0.5936	448.307	-14.9	0.5	0.00	55.39	55.39	1.00	54.11	55.39	0.00
6	0.6053	450.704	-12.5	0.6	0.00	55.37	55.37	1.00	54.22	55.37	0.00
7	0.6170	449.572	-13.7	0.7	0.00	55.36	55.36	1.00	54.31	55.36	0.00
8	0.6286	449.175	-14.1	0.8	0.00	55.36	55.36	1.00	54.31	55.36	0.00
9	0.6403	454.484	-8.8	0.9	0.00	55.35	55.35	1.00	54.36	55.35	0.00
10	0.6520	454.116	-9.1	1.0	0.00	55.34	55.34	1.00	54.45	55.34	0.00
11	0.6636	456.513	-6.7	1.0	0.00	55.33	55.33	1.00	54.52	55.33	0.00
12	0.6753	458.293	-5.0	1.1	0.00	55.32	55.32	1.00	54.56	55.32	0.00
13	0.6870	462.131	-1.1	1.2	0.00	55.32	55.32	1.00	54.56	55.32	0.00
14	0.6986	474.367	11.1	1.3	0.06	55.32	55.38	1.00	54.59	55.35	0.03
15	0.7103	494.882	31.6	1.4	0.20	55.30	55.50	1.00	54.69	55.40	0.10
16	0.7220	508.074	44.8	1.5	0.28	55.30	55.58	1.01	54.72	55.44	0.14
17	0.7336	520.781	57.5	1.6	0.36	55.29	55.65	1.01	54.80	55.47	0.18
18	0.7453	526.957	63.7	1.7	0.40	55.28	55.69	1.01	54.81	55.49	0.20
19	0.7570	537.605	74.4	1.8	0.47	55.27	55.74	1.01	54.92	55.50	0.23
20	0.7686	548.590	85.3	1.9	0.54	55.25	55.79	1.01	55.03	55.52	0.27
21	0.7803	566.415	103.2	2.0	0.65	55.25	55.90	1.01	55.06	55.57	0.32
22	0.7920	587.224	124.0	2.1	0.78	55.24	56.02	1.01	55.13	55.63	0.39
23	0.8036	816.954	353.7	2.2	2.22	55.22	57.44	1.04	55.27	56.33	1.11

Test Readings for Specimen No. 4

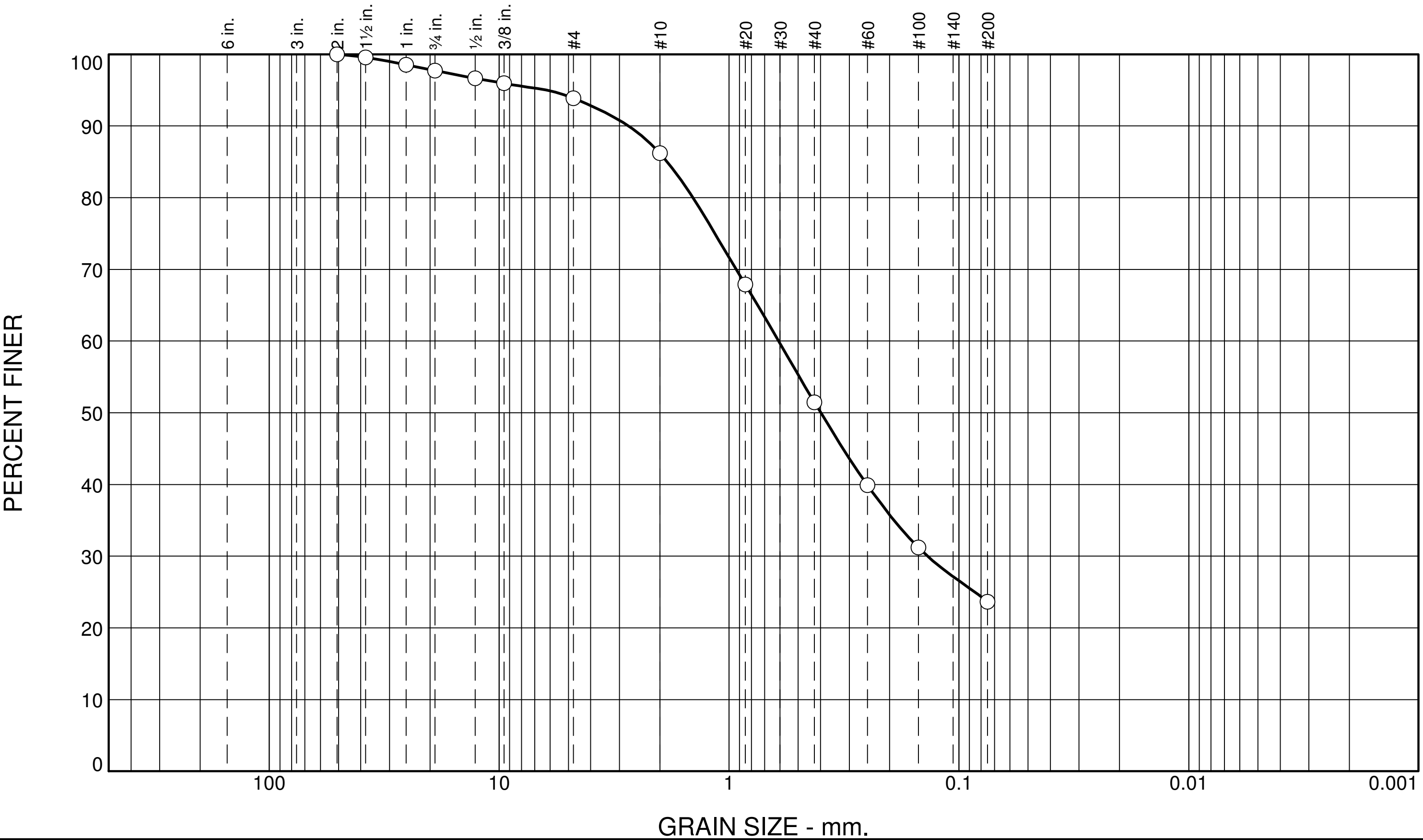
No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
24	0.8153	1590.881	1127.6	2.3	7.07	55.11	62.18	1.13	56.03	58.65	3.54
25	0.8270	2148.667	1685.4	2.4	10.56	54.92	65.48	1.19	57.37	60.20	5.28
26	0.8386	2590.670	2127.4	2.5	13.32	54.61	67.93	1.24	59.49	61.27	6.66
27	0.8503	2967.567	2504.3	2.6	15.66	54.20	69.86	1.29	62.36	62.03	7.83
28	0.8620	3309.536	2846.3	2.7	17.78	53.67	71.45	1.33	66.01	62.56	8.89
29	0.8736	3632.063	3168.8	2.8	19.78	53.05	72.83	1.37	70.31	62.94	9.89
30	0.8853	3956.150	3492.9	2.9	21.78	52.33	74.11	1.42	75.31	63.22	10.89
31	0.8970	4281.383	3818.1	3.0	23.78	51.52	75.30	1.46	80.98	63.41	11.89
32	0.9086	4599.042	4135.8	3.1	25.74	50.61	76.35	1.51	87.25	63.48	12.87
33	0.9203	4911.937	4448.7	3.1	27.66	49.60	77.26	1.56	94.26	63.43	13.83
34	0.9495	5679.628	5216.4	3.4	32.35	46.61	78.96	1.69	115.06	62.78	16.17
35	0.9786	6399.818	5936.6	3.6	36.72	42.90	79.62	1.86	140.85	61.26	18.36
36	1.0078	7003.680	6540.4	3.9	40.36	38.59	78.95	2.05	170.71	58.77	20.18
37	1.0370	7459.051	6995.8	4.1	43.06	34.10	77.16	2.26	201.93	55.63	21.53
38	1.0661	7750.106	7286.9	4.3	44.74	29.96	74.70	2.49	230.71	52.33	22.37
39	1.0953	7910.186	7446.9	4.6	45.61	26.54	72.15	2.72	254.42	49.35	22.81
40	1.1245	7996.954	7533.7	4.8	46.03	23.91	69.94	2.93	272.69	46.92	23.01
41	1.1536	8044.603	7581.4	5.1	46.20	21.95	68.15	3.11	286.33	45.05	23.10
42	1.1828	8083.545	7620.3	5.3	46.32	20.48	66.80	3.26	296.50	43.64	23.16
43	1.2120	8110.605	7647.4	5.5	46.37	19.39	65.76	3.39	304.09	42.57	23.19
44	1.2412	8146.886	7683.6	5.8	46.47	18.55	65.02	3.51	309.93	41.78	23.24
45	1.2703	8179.902	7716.7	6.0	46.55	17.88	64.44	3.60	314.53	41.16	23.28
46	1.2995	8223.654	7760.4	6.2	46.70	17.40	64.10	3.68	317.89	40.75	23.35
47	1.3286	8265.420	7802.2	6.5	46.83	17.01	63.84	3.75	320.60	40.43	23.42
48	1.3578	8315.407	7852.2	6.7	47.01	16.72	63.73	3.81	322.64	40.22	23.51
49	1.3870	8365.145	7901.9	7.0	47.19	16.49	63.67	3.86	324.24	40.08	23.59
50	1.4161	8419.794	7956.5	7.2	47.39	16.32	63.71	3.90	325.40	40.02	23.70
51	1.4453	8472.546	8009.3	7.4	47.58	16.18	63.77	3.94	326.35	39.98	23.79
52	1.4745	8536.857	8073.6	7.7	47.84	16.09	63.93	3.97	326.98	40.01	23.92
53	1.5037	8597.551	8134.3	7.9	48.08	16.03	64.11	4.00	327.41	40.07	24.04
54	1.5328	8657.097	8193.8	8.2	48.30	15.98	64.28	4.02	327.77	40.13	24.15
55	1.5620	8719.923	8256.7	8.4	48.55	15.95	64.50	4.04	327.98	40.22	24.27
56	1.5912	8776.264	8313.0	8.6	48.75	15.94	64.69	4.06	328.06	40.31	24.38
57	1.6203	8842.340	8379.1	8.9	49.01	15.93	64.94	4.08	328.11	40.43	24.51
58	1.6495	8898.739	8435.5	9.1	49.21	15.94	65.15	4.09	328.07	40.54	24.61
59	1.6787	8955.991	8492.7	9.3	49.42	15.95	65.36	4.10	327.99	40.66	24.71
60	1.7078	9006.375	8543.1	9.6	49.58	15.96	65.54	4.11	327.87	40.75	24.79
61	1.7370	9063.760	8600.5	9.8	49.78	15.98	65.76	4.12	327.78	40.87	24.89
62	1.7661	9125.630	8662.4	10.1	50.01	16.01	66.02	4.12	327.55	41.01	25.00
63	1.7953	9178.279	8715.0	10.3	50.18	16.05	66.22	4.13	327.30	41.13	25.09
64	1.8245	9228.766	8765.5	10.5	50.33	16.08	66.41	4.13	327.07	41.25	25.17
65	1.8536	9284.239	8821.0	10.8	50.52	16.12	66.64	4.13	326.79	41.38	25.26
66	1.8828	9337.888	8874.6	11.0	50.69	16.16	66.85	4.14	326.50	41.51	25.34
67	1.9120	9391.758	8928.5	11.3	50.86	16.16	67.02	4.15	326.48	41.59	25.43
68	1.9411	9446.231	8983.0	11.5	51.03	16.23	67.26	4.14	326.01	41.75	25.52
69	1.9703	9499.645	9036.4	11.7	51.20	16.29	67.49	4.14	325.59	41.89	25.60
70	1.9995	9551.367	9088.1	12.0	51.35	16.35	67.70	4.14	325.19	42.02	25.68

Test Readings for Specimen No. 4

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress ksf	Minor Eff. Stress ksf	Major Eff. Stress ksf	1:3 Ratio	Pore Press. psi	P ksf	Q ksf
71	2.0287	9602.134	9138.9	12.2	51.50	16.39	67.89	4.14	324.88	42.14	25.75
72	2.0578	9652.298	9189.0	12.4	51.64	16.44	68.08	4.14	324.55	42.26	25.82
73	2.0870	9698.608	9235.4	12.7	51.76	16.51	68.27	4.14	324.10	42.39	25.88
74	2.1162	9735.757	9272.5	12.9	51.82	16.57	68.39	4.13	323.69	42.48	25.91
75	2.1453	9788.671	9325.4	13.2	51.98	16.62	68.60	4.13	323.28	42.61	25.99
76	2.1745	9839.320	9376.1	13.4	52.12	16.68	68.80	4.12	322.90	42.74	26.06
77	2.2037	9884.130	9420.9	13.6	52.22	16.72	68.94	4.12	322.61	42.83	26.11
78	2.2328	9926.205	9463.0	13.9	52.31	16.78	69.09	4.12	322.23	42.93	26.15
79	2.2620	9970.266	9507.0	14.1	52.41	16.83	69.24	4.11	321.83	43.04	26.20
80	2.2912	10013.150	9549.9	14.4	52.50	16.88	69.38	4.11	321.49	43.13	26.25
81	2.3203	10058.725	9595.5	14.6	52.60	16.94	69.55	4.10	321.06	43.25	26.30
82	2.3495	10092.594	9629.3	14.8	52.64	16.98	69.62	4.10	320.79	43.30	26.32
83	2.3787	10139.302	9676.1	15.1	52.75	17.03	69.77	4.10	320.48	43.40	26.37
84	2.4078	10176.259	9713.0	15.3	52.80	17.07	69.87	4.09	320.17	43.47	26.40
85	2.4370	10221.070	9757.8	15.5	52.89	17.12	70.01	4.09	319.87	43.56	26.45
86	2.4662	10260.851	9797.6	15.8	52.96	17.16	70.12	4.09	319.58	43.64	26.48
87	2.4953	10300.558	9837.3	16.0	53.02	17.18	70.21	4.09	319.40	43.70	26.51
88	2.5245	10340.810	9877.6	16.3	53.09	17.23	70.32	4.08	319.09	43.77	26.54
89	2.5537	10375.149	9911.9	16.5	53.12	17.27	70.40	4.08	318.77	43.84	26.56
90	2.5828	10412.812	9949.6	16.7	53.17	17.31	70.49	4.07	318.49	43.90	26.59
91	2.6120	10454.638	9991.4	17.0	53.24	17.35	70.60	4.07	318.21	43.98	26.62
92	2.6412	10494.154	10030.9	17.2	53.30	17.39	70.69	4.06	317.96	44.04	26.65
93	2.6673	10528.273	10065.0	17.4	53.34	17.43	70.78	4.06	317.67	44.10	26.67

PHASE 2 LABORATORY TESTING SHEETS

Particle Size Distribution ASTM D6913



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	2.3	3.8	7.7	34.7	27.9	23.6	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
2	100.0		
1.5	99.6		
1	98.5		
.75	97.7		
.5	96.6		
.375	95.9		
#4	93.9		
#10	86.2		
#20	67.9		
#40	51.5		
#60	39.9		
#100	31.2		
#200	23.6		

* (no specification provided)

Soil Description

silty sand

Atterberg Limits

PL= NP LL= NP PI= NP

Coefficients

D_{90}= 2.7392 D_{85}= 1.8559 D_{60}= 0.6083
D_{50}= 0.3985 D_{30}= 0.1367 D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SM AASHTO= A-2-4(0)

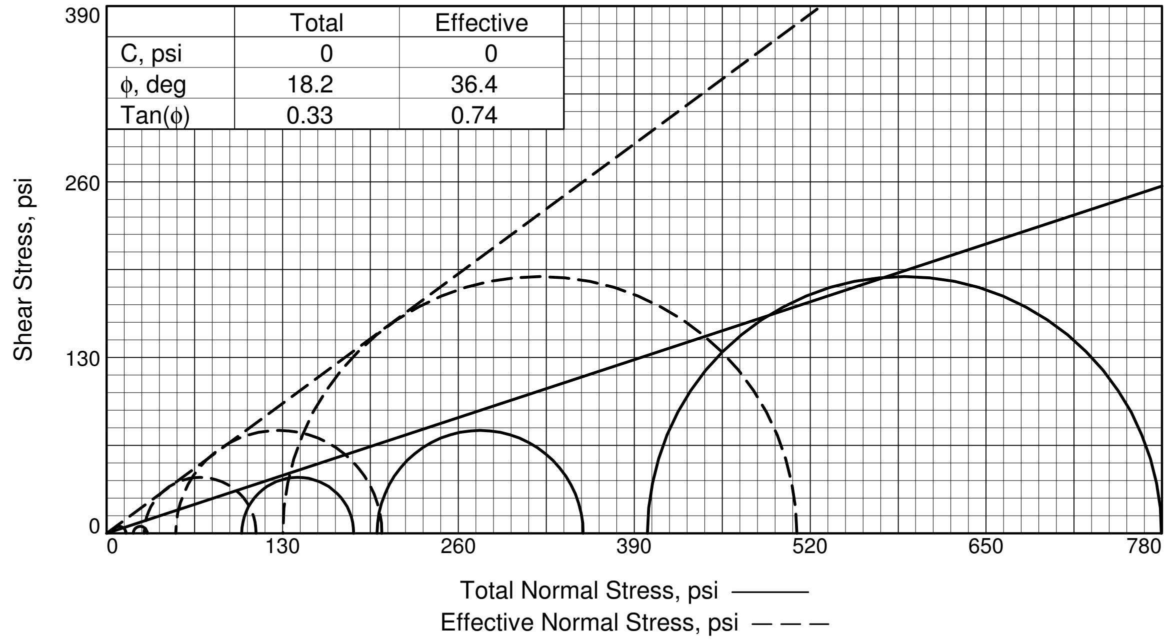
Remarks

Sample No.: DH18-01 **Source of Sample:** **Date:** 6/2/22
Location: **Elev./Depth:** 18-37'

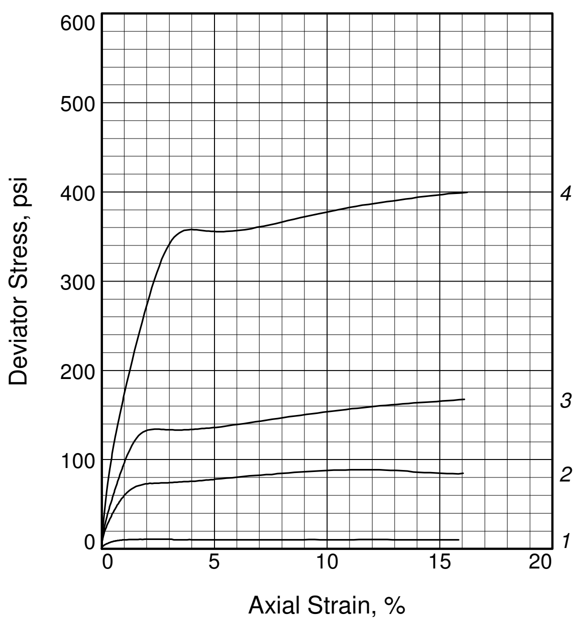
Knight Piésold CONSULTING

Client: KP Vancouver
Project: Montana Resources - Yankee Doodle Tailings Impoundment
Project No: VA101-00126/27 **Figure**

Tested By: MFreund **Checked By:** JBruce



	Total	Effective
C, psi	0	0
ϕ, deg	18.2	36.4
Tan(ϕ)	0.33	0.74



Specimen No.		1	2	3	4
Initial	Water Content, %	8.3	9.9	9.5	9.6
	Dry Density, pcf	90.6	89.6	89.8	89.1
	Saturation, %	26.7	30.9	30.0	29.6
	Void Ratio	0.8256	0.8468	0.8423	0.8558
	Diameter, in.	6.000	6.000	6.000	6.000
	Height, in.	12.010	11.980	11.990	12.080
At Test	Water Content, %	16.6	13.9	12.8	10.9
	Dry Density, pcf	114.3	119.4	123.5	127.6
	Saturation, %	98.5	95.3	99.9	97.3
	Void Ratio	0.4480	0.3860	0.3394	0.2967
	Diameter, in.	5.483	5.330	5.351	5.314
	Height, in.	11.408	11.395	10.959	10.762
Strain rate, %/min.		0.03	0.03	0.03	0.03
Eff. Cell Pressure, psi		20	100	200	400
Fail. Stress, psi		10	83	152	380
Excess Pore Pr., psi		16	72	149	269
Strain, %		7.7	7.0	9.6	10.5
Ult. Stress, psi					
Excess Pore Pr., psi					
Strain, %					
$\bar{\sigma}_1$ Failure, psi		14	111	203	510
$\bar{\sigma}_3$ Failure, psi		4	28	51	130

Type of Test:
CU with Pore Pressures

Sample Type: Reconstituted "Loose"

Description: silty sand

LL= NP **PI=** NP

Assumed Specific Gravity= 2.65

Remarks: Failure chosen at peak principal stress ratio with no cohesion intercept. Particles larger than 1" were removed prior to test.

Figure ________

Client: KP Vancouver

Project: Montana Resources - Yankee Doodle Tailings Impoundment

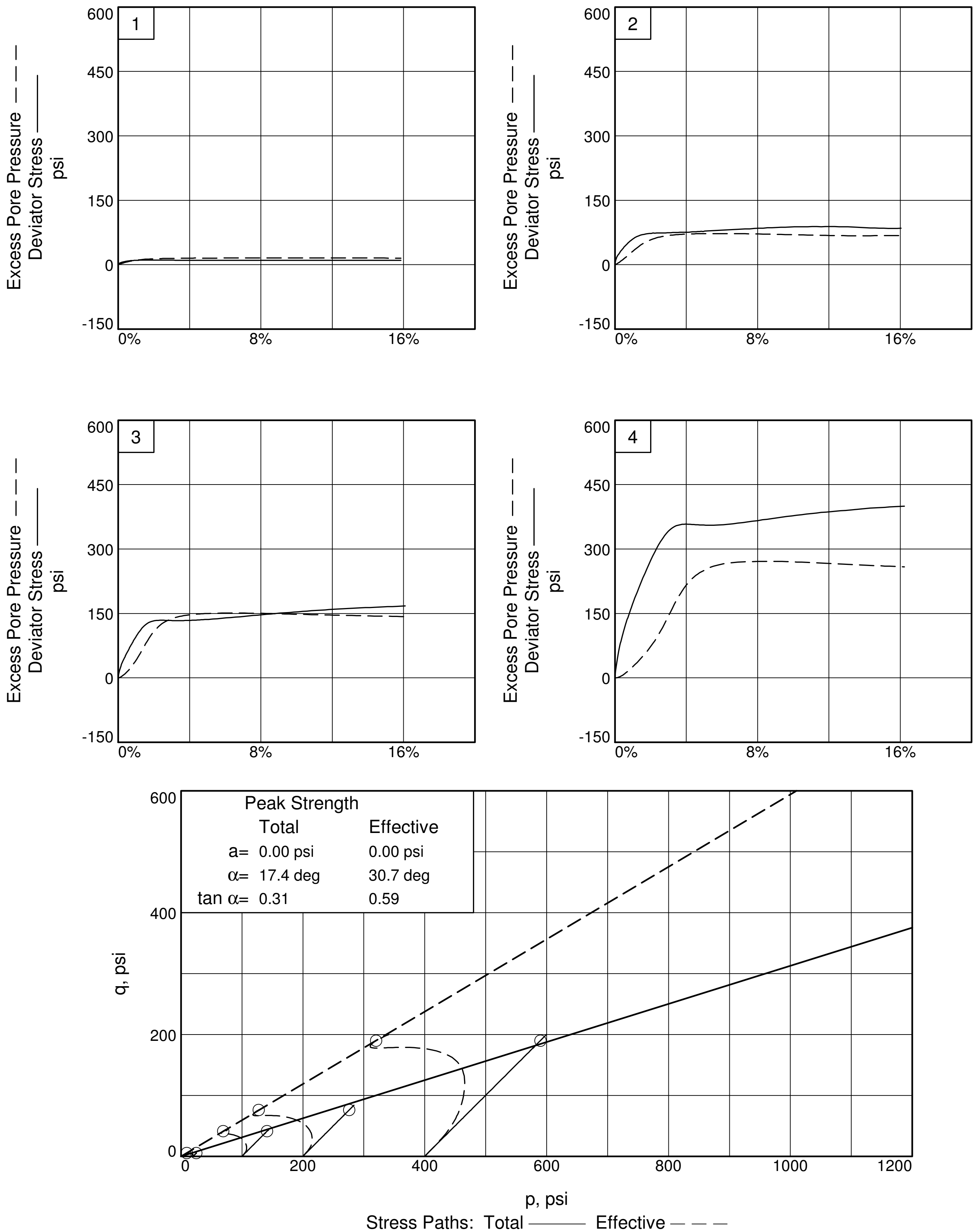
Sample Number: DH18-01 **Depth:** 18-37'

Proj. No.: VA101-00126/27 **Date Sampled:** 6/2/22

Knight Piésold CONSULTING

Tested By: MFreund/JStaley **Checked By:** JBruce

Cursory interpretations provided require review by a professional engineer. Knight Piesold accepts no responsibility in subsequent analyses.



Client: KP Vancouver

Project: Montana Resources - Yankee Doodle Tailings Impoundment

Depth: 18-37' **Sample Number:** DH18-01

Project No.: VA101-00126/27 **Figure** ________ **Knight Piesold Geotechnical Lab.**

Tested By: MFreund/JStaley **Checked By:** JBruce

TRIAXIAL COMPRESSION TEST

CU with Pore Pressures

6/27/2022
8:48 AM

Date: 6/2/22
Client: KP Vancouver
Project: Montana Resources - Yankee Doodle Tailings Impoundment
Project No.: VA101-00126/27
Depth: 18-37' **Sample Number:** DH18-01
Description: silty sand
Remarks: Failure chosen at peak principal stress ratio with no cohesion intercept. Particles larger than 1" were removed prior to test.
Type of Sample: Reconstituted "Loose"
Assumed Specific Gravity=2.65 **LL=**NP **PL=** **PI=**NP
Test Method: ASTM D 4767 Method A

Parameters for Specimen No. 1

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	8749.500			11524.200
Moisture content: Dry soil+tare, gms.	8077.500			10179.500
Moisture content: Tare, gms.	0.000			2102.000
Moisture, %	8.3	29.6	16.6	16.6
Moist specimen weight, gms.	8749.50			
Diameter, in.	6.000	5.961	5.483	
Area, in.²	28.274	27.909	23.610	
Height, in.	12.010	11.933	11.408	
Net decrease in height, in.		0.077	0.525	
Net decrease in water volume, cc.			1044.000	
Wet density, pcf	98.2	119.7	133.3	
Dry density, pcf	90.6	92.4	114.3	
Void ratio	0.8256	0.7905	0.4480	
Saturation, %	26.7	99.1	98.5	

Test Readings for Specimen No. 1

Membrane modulus = 0.652 kN/cm²
Membrane thickness = .0625 cm
Consolidation cell pressure = 59.78 psi
Consolidation back pressure = 40.01 psi
Consolidation effective confining stress = 19.77 psi
Strain rate, %/min. = 0.03
Fail. Stress = 10.28 psi **at reading no.** 91

Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
0	0.7022	55.000	0.0	0.0	0.00	19.77	19.77	1.00	40.01	19.77	0.00
1	0.7051	109.961	55.0	0.0	2.33	19.12	21.45	1.12	40.66	20.29	1.16
2	0.7079	123.086	68.1	0.0	2.88	18.74	21.63	1.15	41.04	20.19	1.44
3	0.7107	137.404	82.4	0.1	3.49	18.48	21.97	1.19	41.30	20.23	1.74
4	0.7136	148.133	93.1	0.1	3.94	18.10	22.04	1.22	41.68	20.07	1.97
5	0.7164	157.323	102.3	0.1	4.33	17.75	22.08	1.24	42.03	19.91	2.16
6	0.7192	165.496	110.5	0.1	4.67	17.38	22.06	1.27	42.40	19.72	2.34
7	0.7220	175.653	120.7	0.2	5.10	17.13	22.23	1.30	42.65	19.68	2.55
8	0.7249	183.420	128.4	0.2	5.43	16.72	22.14	1.32	43.06	19.43	2.71
9	0.7277	191.681	136.7	0.2	5.78	16.40	22.18	1.35	43.38	19.29	2.89
10	0.7305	196.561	141.6	0.2	5.98	16.12	22.10	1.37	43.66	19.11	2.99
11	0.7334	204.053	149.1	0.3	6.30	15.73	22.03	1.40	44.05	18.88	3.15
12	0.7363	210.434	155.4	0.3	6.56	15.48	22.04	1.42	44.30	18.76	3.28
13	0.7391	215.782	160.8	0.3	6.79	15.22	22.01	1.45	44.56	18.61	3.39
14	0.7419	222.400	167.4	0.3	7.07	14.86	21.92	1.48	44.92	18.39	3.53
15	0.7448	226.687	171.7	0.4	7.24	14.60	21.85	1.50	45.18	18.23	3.62
16	0.7476	233.436	178.4	0.4	7.53	14.29	21.82	1.53	45.49	18.06	3.76
17	0.7504	237.080	182.1	0.4	7.68	13.98	21.66	1.55	45.80	17.82	3.84
18	0.7533	242.121	187.1	0.4	7.89	13.78	21.67	1.57	46.00	17.72	3.95
19	0.7561	246.804	191.8	0.5	8.09	13.49	21.57	1.60	46.29	17.53	4.04
20	0.7589	250.558	195.6	0.5	8.24	13.31	21.55	1.62	46.47	17.43	4.12
21	0.7617	253.245	198.2	0.5	8.35	13.01	21.36	1.64	46.77	17.19	4.18
22	0.7645	257.835	202.8	0.5	8.54	12.78	21.32	1.67	47.00	17.05	4.27
23	0.7674	260.940	205.9	0.6	8.67	12.58	21.25	1.69	47.20	16.92	4.34
24	0.7702	263.969	209.0	0.6	8.80	12.28	21.08	1.72	47.50	16.68	4.40
25	0.7731	266.832	211.8	0.6	8.92	12.07	20.99	1.74	47.71	16.53	4.46
26	0.7759	271.026	216.0	0.6	9.09	11.85	20.94	1.77	47.93	16.40	4.55
27	0.7788	272.373	217.4	0.7	9.15	11.64	20.78	1.79	48.14	16.21	4.57
28	0.7816	276.215	221.2	0.7	9.30	11.42	20.73	1.81	48.36	16.08	4.65
29	0.7845	278.391	223.4	0.7	9.39	11.24	20.63	1.84	48.54	15.93	4.70
30	0.7873	281.211	226.2	0.7	9.51	11.09	20.60	1.86	48.69	15.84	4.75
31	0.7902	281.645	226.6	0.8	9.53	10.88	20.40	1.88	48.90	15.64	4.76
32	0.7930	283.871	228.9	0.8	9.62	10.65	20.27	1.90	49.13	15.46	4.81
33	0.7958	285.762	230.8	0.8	9.69	10.50	20.20	1.92	49.28	15.35	4.85
34	0.7987	288.395	233.4	0.8	9.80	10.34	20.15	1.95	49.44	15.25	4.90
35	0.8044	291.566	236.6	0.9	9.93	9.79	19.72	2.01	49.99	14.75	4.97
36	0.8072	293.545	238.5	0.9	10.01	9.63	19.64	2.04	50.15	14.63	5.01
37	0.8100	294.440	239.4	0.9	10.05	9.54	19.58	2.05	50.24	14.56	5.02
38	0.8129	296.359	241.4	1.0	10.12	9.37	19.49	2.08	50.41	14.43	5.06
39	0.8157	296.947	241.9	1.0	10.15	9.28	19.42	2.09	50.50	14.35	5.07
40	0.8185	297.964	243.0	1.0	10.19	9.24	19.43	2.10	50.54	14.33	5.09
41	0.8298	300.690	245.7	1.1	10.29	8.69	18.98	2.18	51.09	13.83	5.14
42	0.8412	304.994	250.0	1.2	10.46	8.27	18.73	2.27	51.51	13.50	5.23
43	0.8525	307.412	252.4	1.3	10.55	7.83	18.38	2.35	51.95	13.11	5.28
44	0.8638	308.775	253.8	1.4	10.60	7.47	18.07	2.42	52.31	12.77	5.30
45	0.8751	310.517	255.5	1.5	10.66	7.09	17.75	2.50	52.69	12.42	5.33
46	0.8864	311.309	256.3	1.6	10.68	6.91	17.59	2.55	52.87	12.25	5.34

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
47	0.8977	311.919	256.9	1.7	10.70	6.69	17.38	2.60	53.09	12.04	5.35
48	0.9090	311.149	256.1	1.8	10.65	6.45	17.10	2.65	53.33	11.78	5.33
49	0.9203	312.804	257.8	1.9	10.71	6.26	16.97	2.71	53.52	11.62	5.36
50	0.9317	313.524	258.5	2.0	10.73	6.10	16.83	2.76	53.68	11.46	5.36
51	0.9430	314.958	260.0	2.1	10.78	5.95	16.73	2.81	53.83	11.34	5.39
52	0.9543	314.365	259.4	2.2	10.74	5.89	16.64	2.82	53.89	11.27	5.37
53	0.9656	314.513	259.5	2.3	10.74	5.75	16.49	2.87	54.03	11.12	5.37
54	0.9769	316.915	261.9	2.4	10.83	5.54	16.36	2.96	54.24	10.95	5.41
55	0.9882	316.954	262.0	2.5	10.82	5.47	16.29	2.98	54.31	10.88	5.41
56	0.9995	317.597	262.6	2.6	10.83	5.39	16.23	3.01	54.39	10.81	5.42
57	1.0108	316.888	261.9	2.7	10.79	5.30	16.09	3.04	54.48	10.69	5.40
58	1.0221	318.602	263.6	2.8	10.85	5.29	16.14	3.05	54.49	10.71	5.43
59	1.0334	318.383	263.4	2.9	10.83	5.17	16.01	3.09	54.61	10.59	5.42
60	1.0448	318.405	263.4	3.0	10.82	5.27	16.09	3.05	54.51	10.68	5.41
61	1.0561	318.361	263.4	3.1	10.81	5.20	16.01	3.08	54.58	10.61	5.40
62	1.0674	319.966	265.0	3.2	10.32	5.10	15.42	3.02	54.68	10.26	5.16
63	1.0787	319.927	264.9	3.3	10.29	5.02	15.31	3.05	54.76	10.16	5.15
64	1.0900	321.004	266.0	3.4	10.31	4.98	15.29	3.07	54.80	10.14	5.15
65	1.1013	322.010	267.0	3.5	10.32	4.86	15.18	3.12	54.92	10.02	5.16
66	1.1126	321.461	266.5	3.6	10.27	4.84	15.11	3.12	54.94	9.97	5.13
67	1.1240	323.329	268.3	3.7	10.32	4.75	15.06	3.17	55.03	9.90	5.16
68	1.1353	323.313	268.3	3.8	10.29	4.69	14.98	3.19	55.09	9.84	5.14
69	1.1466	325.907	270.9	3.9	10.37	4.52	14.88	3.30	55.26	9.70	5.18
70	1.1579	324.187	269.2	4.0	10.27	4.53	14.80	3.27	55.25	9.67	5.13
71	1.1692	325.198	270.2	4.1	10.28	4.52	14.80	3.28	55.26	9.66	5.14
72	1.1805	326.578	271.6	4.2	10.31	4.41	14.72	3.34	55.37	9.56	5.15
73	1.1918	327.039	272.0	4.3	10.30	4.36	14.66	3.36	55.42	9.51	5.15
74	1.2031	328.474	273.5	4.4	10.33	4.28	14.60	3.42	55.50	9.44	5.16
75	1.2144	327.754	272.8	4.5	10.27	4.42	14.69	3.32	55.36	9.56	5.14
76	1.2257	328.254	273.3	4.6	10.26	4.34	14.60	3.37	55.44	9.47	5.13
77	1.2370	328.919	273.9	4.7	10.26	4.42	14.68	3.32	55.36	9.55	5.13
78	1.2484	329.381	274.4	4.8	10.25	4.48	14.74	3.29	55.30	9.61	5.13
79	1.2597	329.711	274.7	4.9	10.24	4.55	14.79	3.25	55.23	9.67	5.12
80	1.2710	331.184	276.2	5.0	10.27	4.54	14.81	3.26	55.24	9.67	5.13
81	1.2993	332.371	277.4	5.2	10.24	4.62	14.86	3.22	55.16	9.74	5.12
82	1.3275	332.189	277.2	5.5	10.17	4.53	14.70	3.24	55.25	9.62	5.08
83	1.3558	333.685	278.7	5.7	10.16	4.35	14.50	3.34	55.43	9.42	5.08
84	1.3841	335.839	280.8	6.0	10.17	4.25	14.42	3.39	55.53	9.33	5.08
85	1.4123	337.164	282.2	6.2	10.15	4.25	14.41	3.39	55.53	9.33	5.08
86	1.4406	338.285	283.3	6.5	10.12	4.25	14.37	3.38	55.53	9.31	5.06
87	1.4688	341.781	286.8	6.7	10.19	4.18	14.37	3.44	55.60	9.28	5.09
88	1.4971	344.062	289.1	7.0	10.21	4.27	14.48	3.39	55.51	9.38	5.10
89	1.5254	345.469	290.5	7.2	10.19	4.24	14.43	3.40	55.54	9.34	5.10
90	1.5536	346.639	291.6	7.5	10.16	4.21	14.37	3.42	55.57	9.29	5.08
91	1.5819	351.405	296.4	7.7	10.28	4.10	14.37	3.51	55.68	9.24	5.14
92	1.6102	352.707	297.7	8.0	10.25	4.12	14.37	3.49	55.66	9.24	5.13
93	1.6384	354.917	299.9	8.2	10.27	4.18	14.45	3.46	55.60	9.31	5.13

Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 1

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
94	1.6667	356.483	301.5	8.5	10.25	4.13	14.39	3.48	55.65	9.26	5.13
95	1.6950	359.501	304.5	8.7	10.30	4.21	14.50	3.45	55.57	9.36	5.15
96	1.7232	361.699	306.7	8.9	10.31	4.10	14.41	3.51	55.68	9.26	5.15
97	1.7515	364.442	309.4	9.2	10.34	4.20	14.54	3.46	55.58	9.37	5.17
98	1.7797	366.360	311.4	9.4	10.34	4.17	14.51	3.48	55.61	9.34	5.17
99	1.8080	365.877	310.9	9.7	10.25	4.24	14.49	3.42	55.54	9.36	5.12
100	1.8363	368.328	313.3	9.9	10.26	4.10	14.37	3.50	55.68	9.23	5.13
101	1.8645	369.306	314.3	10.2	10.23	4.21	14.44	3.43	55.57	9.33	5.11
102	1.8928	371.296	316.3	10.4	10.23	4.23	14.45	3.42	55.55	9.34	5.11
103	1.9211	375.589	320.6	10.7	10.31	4.14	14.45	3.49	55.64	9.30	5.16
104	1.9493	376.204	321.2	10.9	10.26	4.17	14.43	3.46	55.61	9.30	5.13
105	1.9776	379.486	324.5	11.2	10.31	4.17	14.48	3.47	55.61	9.33	5.15
106	2.0059	382.597	327.6	11.4	10.35	4.27	14.62	3.43	55.51	9.44	5.17
107	2.0341	384.498	329.5	11.7	10.34	4.22	14.56	3.45	55.56	9.39	5.17
108	2.0624	386.961	332.0	11.9	10.36	4.29	14.65	3.42	55.49	9.47	5.18
109	2.0906	389.599	334.6	12.2	10.38	4.29	14.67	3.42	55.49	9.48	5.19
110	2.1189	391.050	336.0	12.4	10.36	4.22	14.58	3.46	55.56	9.40	5.18
111	2.1472	393.095	338.1	12.7	10.36	4.26	14.62	3.43	55.52	9.44	5.18
112	2.1754	394.458	339.5	12.9	10.33	4.28	14.61	3.42	55.50	9.44	5.16
113	2.2037	394.502	339.5	13.2	10.25	4.33	14.58	3.37	55.45	9.46	5.13
114	2.2319	396.101	341.1	13.4	10.23	4.21	14.45	3.43	55.57	9.33	5.12
115	2.2602	398.063	343.1	13.7	10.23	4.22	14.45	3.42	55.56	9.33	5.11
116	2.2884	399.619	344.6	13.9	10.21	4.32	14.52	3.36	55.46	9.42	5.10
117	2.3167	403.736	348.7	14.2	10.28	4.34	14.62	3.37	55.44	9.48	5.14
118	2.3450	405.555	350.6	14.4	10.27	4.34	14.61	3.37	55.44	9.47	5.13
119	2.3732	407.753	352.8	14.6	10.27	4.32	14.58	3.38	55.46	9.45	5.13
120	2.4015	409.562	354.6	14.9	10.25	4.21	14.46	3.44	55.57	9.33	5.13
121	2.4297	413.189	358.2	15.1	10.30	4.45	14.76	3.31	55.33	9.60	5.15
122	2.4580	415.586	360.6	15.4	10.31	4.47	14.78	3.31	55.31	9.63	5.15
123	2.4862	416.058	361.1	15.6	10.25	4.48	14.72	3.29	55.30	9.60	5.12
124	2.5100	419.164	364.2	15.8	10.29	4.51	14.80	3.28	55.27	9.66	5.14

Parameters for Specimen No. 2

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	8752.000			11180.500
Moisture content: Dry soil+tare, gms.	7965.000			10074.500
Moisture content: Tare, gms.	0.000			2109.500
Moisture, %	9.9	30.1	13.9	13.9
Moist specimen weight, gms.	8752.00			
Diameter, in.	6.000	5.965	5.330	
Area, in.²	28.274	27.947	22.310	
Height, in.	11.980	11.911	11.395	
Net decrease in height, in.		0.069	0.516	
Net decrease in water volume, cc.			1289.000	
Wet density, pcf	98.4	118.6	135.9	
Dry density, pcf	89.6	91.2	119.4	
Void ratio	0.8468	0.8149	0.3860	
Saturation, %	30.9	97.8	95.3	

Test Readings for Specimen No. 2

Membrane modulus = 0.652 kN/cm²
Membrane thickness = .0625 cm
Consolidation cell pressure = 140.14 psi
Consolidation back pressure = 40.21 psi
Consolidation effective confining stress = 99.93 psi
Strain rate, %/min. = 0.03
Fail. Stress = 82.74 psi **at reading no.** 89

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
0	0.5849	114.000	0.0	0.0	0.00	99.93	99.93	1.00	40.21	99.93	0.00
1	0.5878	307.341	193.3	0.0	8.66	99.65	108.32	1.09	40.49	103.98	4.33
2	0.5906	384.509	270.5	0.1	12.12	99.22	111.34	1.12	40.92	105.28	6.06
3	0.5935	446.103	332.1	0.1	14.87	98.69	113.57	1.15	41.45	106.13	7.44
4	0.5963	497.553	383.6	0.1	17.17	98.11	115.29	1.18	42.03	106.70	8.59
5	0.5992	542.249	428.2	0.1	19.17	97.45	116.63	1.20	42.69	107.04	9.59
6	0.6021	582.485	468.5	0.2	20.97	96.80	117.76	1.22	43.34	107.28	10.48
7	0.6049	620.500	506.5	0.2	22.66	96.13	118.80	1.24	44.01	107.46	11.33
8	0.6078	653.821	539.8	0.2	24.15	95.44	119.59	1.25	44.70	107.52	12.07
9	0.6106	688.325	574.3	0.2	25.68	94.75	120.44	1.27	45.39	107.60	12.84
10	0.6135	723.159	609.2	0.3	27.24	94.01	121.25	1.29	46.13	107.63	13.62
11	0.6164	757.544	643.5	0.3	28.77	93.24	122.00	1.31	46.90	107.62	14.38
12	0.6192	790.314	676.3	0.3	30.22	92.50	122.72	1.33	47.64	107.61	15.11
13	0.6221	819.989	706.0	0.3	31.54	91.73	123.27	1.34	48.41	107.50	15.77
14	0.6249	849.964	736.0	0.4	32.87	90.94	123.82	1.36	49.20	107.38	16.44
15	0.6278	878.476	764.5	0.4	34.14	90.16	124.30	1.38	49.98	107.23	17.07
16	0.6307	906.988	793.0	0.4	35.40	89.40	124.80	1.40	50.74	107.10	17.70
17	0.6335	937.553	823.6	0.4	36.76	88.60	125.36	1.41	51.54	106.98	18.38
18	0.6364	966.966	853.0	0.5	38.06	87.75	125.81	1.43	52.39	106.78	19.03
19	0.6393	997.409	883.4	0.5	39.41	86.93	126.34	1.45	53.21	106.63	19.70
20	0.6421	1024.959	911.0	0.5	40.63	86.07	126.69	1.47	54.07	106.38	20.31
21	0.6450	1049.917	935.9	0.5	41.73	85.21	126.94	1.49	54.93	106.08	20.86
22	0.6479	1075.064	961.1	0.6	42.84	84.39	127.23	1.51	55.75	105.81	21.42
23	0.6507	1099.622	985.6	0.6	43.92	83.56	127.49	1.53	56.58	105.52	21.96

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
24	0.6536	1126.234	1012.2	0.6	45.10	82.71	127.81	1.55	57.43	105.26	22.55
25	0.6564	1152.024	1038.0	0.6	46.24	81.82	128.06	1.57	58.32	104.94	23.12
26	0.6593	1176.403	1062.4	0.7	47.31	80.96	128.27	1.58	59.18	104.61	23.65
27	0.6622	1203.486	1089.5	0.7	48.50	80.04	128.54	1.61	60.10	104.29	24.25
28	0.6650	1226.234	1112.2	0.7	49.50	79.14	128.64	1.63	61.00	103.89	24.75
29	0.6679	1246.307	1132.3	0.7	50.38	78.25	128.64	1.64	61.89	103.45	25.19
30	0.6707	1268.371	1154.4	0.8	51.35	77.41	128.76	1.66	62.73	103.09	25.68
31	0.6736	1291.770	1177.8	0.8	52.38	76.54	128.93	1.68	63.60	102.73	26.19
32	0.6765	1312.454	1198.5	0.8	53.29	75.66	128.95	1.70	64.48	102.31	26.64
33	0.6793	1334.230	1220.2	0.8	54.24	74.75	128.99	1.73	65.39	101.87	27.12
34	0.6822	1355.291	1241.3	0.9	55.16	73.81	128.97	1.75	66.33	101.39	27.58
35	0.6850	1374.036	1260.0	0.9	55.98	72.87	128.86	1.77	67.27	100.87	27.99
36	0.6879	1392.238	1278.2	0.9	56.78	72.01	128.79	1.79	68.13	100.40	28.39
37	0.6908	1408.600	1294.6	0.9	57.49	71.14	128.63	1.81	69.00	99.89	28.74
38	0.6936	1425.514	1311.5	1.0	58.23	70.26	128.49	1.83	69.88	99.38	29.11
39	0.6965	1445.871	1331.9	1.0	59.11	69.40	128.51	1.85	70.74	98.95	29.56
40	0.6993	1464.640	1350.6	1.0	59.93	68.52	128.45	1.87	71.62	98.49	29.97
41	0.7022	1479.481	1365.5	1.0	60.58	67.60	128.18	1.90	72.54	97.89	30.29
42	0.7136	1537.490	1423.5	1.1	63.08	64.11	127.20	1.98	76.03	95.65	31.54
43	0.7251	1591.856	1477.9	1.2	65.43	60.77	126.20	2.08	79.37	93.48	32.71
44	0.7365	1630.313	1516.3	1.3	67.06	57.60	124.67	2.16	82.54	91.14	33.53
45	0.7479	1667.398	1553.4	1.4	68.63	54.56	123.19	2.26	85.58	88.87	34.32
46	0.7594	1697.115	1583.1	1.5	69.87	51.83	121.70	2.35	88.31	86.77	34.94
47	0.7708	1718.479	1604.5	1.6	70.74	49.28	120.03	2.44	90.86	84.66	35.37
48	0.7822	1739.886	1625.9	1.7	71.62	46.97	118.59	2.52	93.17	82.78	35.81
49	0.7937	1754.899	1640.9	1.8	72.20	45.00	117.20	2.60	95.14	81.10	36.10
50	0.8051	1769.326	1655.3	1.9	72.76	43.08	115.85	2.69	97.06	79.47	36.38
51	0.8165	1776.248	1662.2	2.0	72.99	41.36	114.36	2.76	98.78	77.86	36.50
52	0.8280	1792.033	1678.0	2.1	73.61	39.81	113.42	2.85	100.33	76.61	36.81
53	0.8394	1787.224	1673.2	2.2	73.32	38.56	111.88	2.90	101.58	75.22	36.66
54	0.8508	1795.804	1681.8	2.3	73.62	37.31	110.93	2.97	102.83	74.12	36.81
55	0.8622	1801.366	1687.4	2.4	73.79	36.22	110.01	3.04	103.92	73.11	36.90
56	0.8737	1802.312	1688.3	2.5	73.76	35.27	109.03	3.09	104.87	72.15	36.88
57	0.8851	1807.482	1693.5	2.6	73.91	34.47	108.37	3.14	105.67	71.42	36.95
58	0.8965	1814.249	1700.2	2.7	74.13	33.65	107.78	3.20	106.49	70.72	37.06
59	0.9080	1809.535	1695.5	2.8	73.84	33.04	106.88	3.24	107.10	69.96	36.92
60	0.9194	1817.929	1703.9	2.9	74.13	32.38	106.51	3.29	107.76	69.45	37.07
61	0.9308	1822.430	1708.4	3.0	74.25	31.87	106.12	3.33	108.27	69.00	37.13
62	0.9423	1826.350	1712.3	3.1	74.35	31.34	105.68	3.37	108.80	68.51	37.17
63	0.9537	1840.024	1726.0	3.2	74.86	30.93	105.79	3.42	109.21	68.36	37.43
64	0.9651	1839.188	1725.2	3.3	74.75	30.53	105.28	3.45	109.61	67.90	37.37
65	0.9766	1844.871	1730.9	3.4	74.92	30.15	105.07	3.48	109.99	67.61	37.46
66	0.9880	1847.182	1733.2	3.5	74.94	29.84	104.78	3.51	110.30	67.31	37.47
67	0.9994	1857.800	1743.8	3.6	75.32	29.57	104.89	3.55	110.57	67.23	37.66
68	1.0109	1864.213	1750.2	3.7	75.52	29.24	104.76	3.58	110.90	67.00	37.76
69	1.0223	1861.872	1747.9	3.8	75.34	29.06	104.39	3.59	111.08	66.72	37.67
70	1.0337	1870.220	1756.2	3.9	75.62	28.79	104.40	3.63	111.35	66.60	37.81

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
71	1.0452	1872.972	1759.0	4.0	75.66	28.60	104.26	3.65	111.54	66.43	37.83
72	1.0566	1877.797	1763.8	4.1	75.79	28.45	104.24	3.66	111.69	66.34	37.89
73	1.0680	1888.407	1774.4	4.2	76.16	28.27	104.44	3.69	111.87	66.36	38.08
74	1.0795	1897.379	1783.4	4.3	76.47	28.15	104.61	3.72	111.99	66.38	38.23
75	1.0909	1901.332	1787.3	4.4	76.56	28.03	104.59	3.73	112.11	66.31	38.28
76	1.1023	1906.316	1792.3	4.5	76.69	27.94	104.63	3.74	112.20	66.28	38.34
77	1.1138	1917.439	1803.4	4.6	77.08	27.85	104.93	3.77	112.29	66.39	38.54
78	1.1252	1919.032	1805.0	4.7	77.07	27.77	104.84	3.78	112.37	66.31	38.54
79	1.1366	1934.817	1820.8	4.8	77.66	27.72	105.38	3.80	112.42	66.55	38.83
80	1.1481	1930.684	1816.7	4.9	77.41	27.63	105.03	3.80	112.51	66.33	38.70
81	1.1595	1953.281	1839.3	5.0	78.29	27.58	105.86	3.84	112.56	66.72	39.14
82	1.1880	1968.985	1855.0	5.3	78.75	27.51	106.26	3.86	112.63	66.88	39.37
83	1.2166	1991.780	1877.8	5.5	79.50	27.49	106.99	3.89	112.65	67.24	39.75
84	1.2452	2005.104	1891.1	5.8	79.85	27.47	107.33	3.91	112.67	67.40	39.93
85	1.2738	2021.101	1907.1	6.0	80.31	27.48	107.79	3.92	112.66	67.63	40.16
86	1.3023	2047.743	1933.7	6.3	81.22	27.48	108.70	3.96	112.66	68.09	40.61
87	1.3309	2066.097	1952.1	6.5	81.77	27.62	109.39	3.96	112.52	68.51	40.89
88	1.3595	2086.017	1972.0	6.8	82.38	27.70	110.08	3.97	112.44	68.89	41.19
89	1.3881	2099.984	1986.0	7.0	82.74	27.79	110.53	3.98	112.35	69.16	41.37
90	1.4166	2114.848	2000.8	7.3	83.14	27.99	111.12	3.97	112.15	69.56	41.57
91	1.4452	2128.625	2014.6	7.5	83.48	28.12	111.60	3.97	112.02	69.86	41.74
92	1.4738	2155.130	2041.1	7.8	84.35	28.26	112.62	3.98	111.88	70.44	42.18
93	1.5023	2168.177	2054.2	8.1	84.66	28.48	113.14	3.97	111.66	70.81	42.33
94	1.5309	2186.105	2072.1	8.3	85.17	28.66	113.83	3.97	111.48	71.24	42.58
95	1.5595	2210.280	2096.3	8.6	85.93	28.89	114.81	3.97	111.25	71.85	42.96
96	1.5881	2223.300	2109.3	8.8	86.22	29.06	115.29	3.97	111.08	72.18	43.11
97	1.6166	2235.112	2121.1	9.1	86.47	29.29	115.76	3.95	110.85	72.53	43.23
98	1.6452	2251.067	2137.1	9.3	86.88	29.49	116.37	3.95	110.65	72.93	43.44
99	1.6738	2263.551	2149.6	9.6	87.14	29.72	116.86	3.93	110.42	73.29	43.57
100	1.7023	2278.925	2164.9	9.8	87.52	29.99	117.51	3.92	110.15	73.75	43.76
101	1.7309	2299.648	2185.6	10.1	88.12	30.21	118.32	3.92	109.93	74.27	44.06
102	1.7595	2307.072	2193.1	10.3	88.17	30.40	118.56	3.90	109.74	74.48	44.08
103	1.7880	2313.725	2199.7	10.6	88.19	30.65	118.84	3.88	109.49	74.75	44.09
104	1.8166	2326.339	2212.3	10.8	88.45	30.84	119.29	3.87	109.30	75.06	44.22
105	1.8452	2335.428	2221.4	11.1	88.56	31.12	119.68	3.85	109.02	75.40	44.28
106	1.8738	2348.814	2234.8	11.3	88.84	31.30	120.14	3.84	108.84	75.72	44.42
107	1.9023	2347.080	2233.1	11.6	88.52	31.54	120.06	3.81	108.60	75.80	44.26
108	1.9309	2354.790	2240.8	11.8	88.58	31.77	120.34	3.79	108.37	76.05	44.29
109	1.9595	2363.868	2249.9	12.1	88.68	31.93	120.61	3.78	108.21	76.27	44.34
110	1.9880	2371.984	2258.0	12.3	88.75	32.15	120.90	3.76	107.99	76.52	44.37
111	2.0166	2364.856	2250.9	12.6	88.21	32.28	120.49	3.73	107.86	76.38	44.11
112	2.0452	2368.243	2254.2	12.8	88.09	32.40	120.49	3.72	107.74	76.45	44.05
113	2.0738	2373.007	2259.0	13.1	88.03	32.53	120.56	3.71	107.61	76.54	44.01
114	2.1023	2365.491	2251.5	13.3	87.48	32.63	120.11	3.68	107.51	76.37	43.74
115	2.1309	2362.743	2248.7	13.6	87.12	32.63	119.75	3.67	107.51	76.19	43.56
116	2.1595	2349.285	2235.3	13.8	86.35	32.66	119.01	3.64	107.48	75.83	43.17
117	2.1881	2343.795	2229.8	14.1	85.89	32.58	118.47	3.64	107.56	75.53	42.94

Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 2

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
118	2.2166	2337.241	2223.2	14.3	85.38	32.51	117.89	3.63	107.63	75.20	42.69
119	2.2452	2345.848	2231.8	14.6	85.46	32.40	117.86	3.64	107.74	75.13	42.73
120	2.2738	2338.884	2224.9	14.8	84.95	32.35	117.29	3.63	107.79	74.82	42.47
121	2.3024	2338.230	2224.2	15.1	84.67	32.28	116.95	3.62	107.86	74.61	42.34
122	2.3309	2332.965	2219.0	15.3	84.22	32.17	116.39	3.62	107.97	74.28	42.11
123	2.3595	2346.183	2232.2	15.6	84.47	32.08	116.56	3.63	108.06	74.32	42.24
124	2.3881	2343.263	2229.3	15.8	84.11	32.00	116.11	3.63	108.14	74.05	42.06
125	2.4131	2365.077	2251.1	16.0	84.71	31.94	116.65	3.65	108.20	74.29	42.36

Parameters for Specimen No. 3

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	8754.000			11180.000
Moisture content: Dry soil+tare, gms.	7991.000			10157.500
Moisture content: Tare, gms.	0.000			2166.500
Moisture, %	9.5	29.4	12.8	12.8
Moist specimen weight, gms.	8754.00			
Diameter, in.	6.000	5.930	5.351	
Area, in.²	28.274	27.617	22.489	
Height, in.	11.990	11.852	10.959	
Net decrease in height, in.		0.138	0.893	
Net decrease in water volume, cc.			1325.000	
Wet density, pcf	98.4	120.3	139.3	
Dry density, pcf	89.8	93.0	123.5	
Void ratio	0.8423	0.7788	0.3394	
Saturation, %	30.0	100.0	99.9	

Test Readings for Specimen No. 3

Membrane modulus = 0.652 kN/cm²

Membrane thickness = .0625 cm

Consolidation cell pressure = 249.98 psi

Consolidation back pressure = 50.09 psi

Consolidation effective confining stress = 199.89 psi

Strain rate, %/min. = 0.03

Fail. Stress = 152.30 psi **at reading no.** 99

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
0	1.0306	196.000	0.0	0.0	0.00	199.89	199.89	1.00	50.09	199.89	0.00
1	1.0333	385.805	189.8	0.0	8.44	199.58	208.02	1.04	50.40	203.80	4.22
2	1.0361	498.991	303.0	0.1	13.47	199.46	212.92	1.07	50.52	206.19	6.73
3	1.0389	594.293	398.3	0.1	17.70	199.03	216.73	1.09	50.95	207.88	8.85
4	1.0416	676.430	480.4	0.1	21.34	198.63	219.97	1.11	51.35	209.30	10.67
5	1.0444	752.835	556.8	0.1	24.73	198.11	222.84	1.12	51.87	210.47	12.36
6	1.0472	822.194	626.2	0.2	27.80	197.50	225.31	1.14	52.48	211.40	13.90
7	1.0500	886.353	690.4	0.2	30.64	196.87	227.52	1.16	53.11	212.20	15.32
8	1.0527	946.725	750.7	0.2	33.31	196.24	229.55	1.17	53.74	212.89	16.66
9	1.0555	1003.535	807.5	0.2	35.83	195.34	231.16	1.18	54.64	213.25	17.91
10	1.0582	1057.773	861.8	0.3	38.22	194.59	232.82	1.20	55.39	213.71	19.11
11	1.0610	1110.483	914.5	0.3	40.55	193.82	234.37	1.21	56.16	214.10	20.28

Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
12	1.0638	1161.517	965.5	0.3	42.80	192.99	235.79	1.22	56.99	214.39	21.40
13	1.0665	1211.336	1015.3	0.3	45.00	192.04	237.04	1.23	57.94	214.54	22.50
14	1.0693	1260.215	1064.2	0.4	47.15	191.28	238.44	1.25	58.70	214.86	23.58
15	1.0721	1305.302	1109.3	0.4	49.14	190.31	239.45	1.26	59.67	214.88	24.57
16	1.0748	1351.301	1155.3	0.4	51.16	189.55	240.71	1.27	60.43	215.13	25.58
17	1.0776	1398.036	1202.0	0.4	53.22	188.51	241.73	1.28	61.47	215.12	26.61
18	1.0804	1448.454	1252.5	0.5	55.44	187.44	242.88	1.30	62.54	215.16	27.72
19	1.0832	1496.734	1300.7	0.5	57.56	186.44	244.00	1.31	63.54	215.22	28.78
20	1.0859	1543.382	1347.4	0.5	59.61	185.35	244.96	1.32	64.63	215.15	29.81
21	1.0887	1589.865	1393.9	0.5	61.65	184.19	245.85	1.33	65.79	215.02	30.83
22	1.0915	1635.221	1439.2	0.6	63.64	183.12	246.76	1.35	66.86	214.94	31.82
23	1.0942	1680.588	1484.6	0.6	65.63	181.93	247.57	1.36	68.05	214.75	32.82
24	1.0970	1725.130	1529.1	0.6	67.58	180.76	248.35	1.37	69.22	214.55	33.79
25	1.0997	1770.695	1574.7	0.6	69.58	179.71	249.29	1.39	70.27	214.50	34.79
26	1.1025	1816.441	1620.4	0.7	71.58	178.44	250.02	1.40	71.54	214.23	35.79
27	1.1053	1861.308	1665.3	0.7	73.55	177.19	250.74	1.42	72.79	213.97	36.77
28	1.1080	1905.663	1709.7	0.7	75.49	175.92	251.40	1.43	74.06	213.66	37.74
29	1.1108	1947.733	1751.7	0.7	77.32	174.64	251.97	1.44	75.34	213.30	38.66
30	1.1135	1989.532	1793.5	0.8	79.15	173.14	252.29	1.46	76.84	212.72	39.57
31	1.1163	2032.717	1836.7	0.8	81.03	171.84	252.88	1.47	78.14	212.36	40.52
32	1.1190	2074.742	1878.7	0.8	82.87	170.47	253.33	1.49	79.51	211.90	41.43
33	1.1218	2117.339	1921.3	0.8	84.72	169.03	253.75	1.50	80.95	211.39	42.36
34	1.1246	2159.040	1963.0	0.9	86.54	167.58	254.12	1.52	82.40	210.85	43.27
35	1.1273	2200.466	2004.5	0.9	88.34	166.07	254.42	1.53	83.91	210.25	44.17
36	1.1301	2239.441	2043.4	0.9	90.04	164.48	254.52	1.55	85.50	209.50	45.02
37	1.1329	2280.053	2084.1	0.9	91.81	163.00	254.81	1.56	86.98	208.90	45.90
38	1.1357	2319.248	2123.2	1.0	93.51	161.44	254.95	1.58	88.54	208.19	46.75
39	1.1384	2358.366	2162.4	1.0	95.21	159.89	255.10	1.60	90.09	207.49	47.60
40	1.1412	2398.643	2202.6	1.0	96.96	158.28	255.24	1.61	91.70	206.76	48.48
41	1.1439	2436.920	2240.9	1.0	98.62	156.56	255.18	1.63	93.42	205.87	49.31
42	1.1550	2582.485	2386.5	1.1	104.91	149.69	254.60	1.70	100.29	202.14	52.46
43	1.1660	2716.618	2520.6	1.2	110.70	142.74	253.44	1.78	107.24	198.09	55.35
44	1.1770	2834.988	2639.0	1.3	115.78	135.28	251.06	1.86	114.70	193.17	57.89
45	1.1880	2938.973	2743.0	1.4	120.22	127.99	248.20	1.94	121.99	188.09	60.11
46	1.1991	3026.217	2830.2	1.5	123.91	120.70	244.62	2.03	129.28	182.66	61.96
47	1.2101	3098.483	2902.5	1.6	126.95	113.61	240.56	2.12	136.37	177.08	63.47
48	1.2211	3154.079	2958.1	1.7	129.25	107.01	236.26	2.21	142.97	171.64	64.62
49	1.2322	3196.582	3000.6	1.8	130.97	100.74	231.71	2.30	149.24	166.23	65.49
50	1.2432	3228.983	3033.0	1.9	132.25	95.10	227.35	2.39	154.88	161.23	66.12
51	1.2542	3252.997	3057.0	2.0	133.16	89.86	223.02	2.48	160.12	156.44	66.58
52	1.2652	3268.079	3072.1	2.1	133.68	85.27	218.95	2.57	164.71	152.11	66.84
53	1.2763	3277.901	3081.9	2.2	133.97	81.07	215.04	2.65	168.91	148.05	66.98
54	1.2873	3284.128	3088.1	2.3	134.10	77.37	211.47	2.73	172.61	144.42	67.05
55	1.2983	3287.250	3091.3	2.4	134.10	74.16	208.26	2.81	175.82	141.21	67.05
56	1.3093	3290.235	3094.2	2.5	134.09	71.38	205.47	2.88	178.60	138.42	67.04
57	1.3203	3290.477	3094.5	2.6	133.96	68.90	202.86	2.94	181.08	135.88	66.98
58	1.3314	3290.389	3094.4	2.7	133.82	66.72	200.54	3.01	183.26	133.63	66.91

Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
59	1.3424	3290.328	3094.3	2.8	133.68	64.79	198.47	3.06	185.19	131.63	66.84
60	1.3534	3291.642	3095.6	2.9	133.60	63.16	196.76	3.12	186.82	129.96	66.80
61	1.3644	3291.774	3095.8	3.0	133.46	61.57	195.03	3.17	188.41	128.30	66.73
62	1.3755	3293.247	3097.2	3.1	133.39	60.12	193.51	3.22	189.86	126.82	66.69
63	1.3865	3293.379	3097.4	3.2	133.26	59.02	192.28	3.26	190.96	125.65	66.63
64	1.3975	3296.325	3100.3	3.3	133.24	57.76	191.01	3.31	192.22	124.38	66.62
65	1.4086	3299.848	3103.8	3.4	133.26	56.79	190.05	3.35	193.19	123.42	66.63
66	1.4196	3304.927	3108.9	3.5	133.34	56.14	189.47	3.38	193.84	122.81	66.67
67	1.4306	3309.763	3113.8	3.7	133.40	55.25	188.66	3.41	194.73	121.96	66.70
68	1.4416	3316.843	3120.8	3.8	133.57	54.55	188.12	3.45	195.43	121.33	66.78
69	1.4526	3322.669	3126.7	3.9	133.68	53.91	187.58	3.48	196.07	120.75	66.84
70	1.4636	3329.561	3133.6	4.0	133.83	53.56	187.39	3.50	196.42	120.48	66.92
71	1.4747	3336.190	3140.2	4.1	133.97	53.02	187.00	3.53	196.96	120.01	66.99
72	1.4857	3343.555	3147.6	4.2	134.15	52.62	186.77	3.55	197.36	119.70	67.07
73	1.4967	3351.756	3155.8	4.3	134.36	52.07	186.43	3.58	197.91	119.25	67.18
74	1.5078	3359.670	3163.7	4.4	134.55	51.88	186.44	3.59	198.10	119.16	67.28
75	1.5188	3368.899	3172.9	4.5	134.80	51.41	186.21	3.62	198.57	118.81	67.40
76	1.5298	3376.220	3180.2	4.6	134.97	50.97	185.94	3.65	199.01	118.45	67.49
77	1.5409	3386.267	3190.3	4.7	135.25	50.70	185.96	3.67	199.28	118.33	67.63
78	1.5519	3393.346	3197.3	4.8	135.41	50.46	185.87	3.68	199.52	118.16	67.71
79	1.5629	3403.949	3207.9	4.9	135.72	50.31	186.02	3.70	199.67	118.16	67.86
80	1.5739	3412.391	3216.4	5.0	135.93	49.97	185.90	3.72	200.01	117.94	67.97
81	1.5849	3421.048	3225.0	5.1	136.15	50.02	186.18	3.72	199.96	118.10	68.08
82	1.6125	3446.645	3250.6	5.3	136.87	49.34	186.21	3.77	200.64	117.77	68.43
83	1.6401	3479.024	3283.0	5.6	137.87	49.34	187.21	3.79	200.64	118.27	68.93
84	1.6676	3509.127	3313.1	5.8	138.76	48.98	187.74	3.83	201.00	118.36	69.38
85	1.6951	3537.994	3342.0	6.1	139.60	48.90	188.49	3.85	201.08	118.69	69.80
86	1.7227	3567.982	3372.0	6.3	140.47	49.11	189.58	3.86	200.87	119.35	70.24
87	1.7502	3598.608	3402.6	6.6	141.37	49.11	190.47	3.88	200.87	119.79	70.68
88	1.7778	3630.751	3434.8	6.8	142.32	49.02	191.33	3.90	200.96	120.18	71.16
89	1.8053	3662.140	3466.1	7.1	143.23	49.21	192.44	3.91	200.77	120.83	71.62
90	1.8329	3696.855	3500.9	7.3	144.27	49.43	193.71	3.92	200.55	121.57	72.14
91	1.8604	3728.492	3532.5	7.6	145.18	49.51	194.70	3.93	200.47	122.11	72.59
92	1.8880	3761.998	3566.0	7.8	146.16	49.55	195.71	3.95	200.43	122.63	73.08
93	1.9155	3795.020	3599.0	8.1	147.11	49.65	196.76	3.96	200.33	123.21	73.56
94	1.9431	3828.796	3632.8	8.3	148.09	50.00	198.09	3.96	199.98	124.05	74.04
95	1.9706	3858.872	3662.9	8.6	148.90	50.09	198.99	3.97	199.89	124.54	74.45
96	1.9982	3890.838	3694.8	8.8	149.79	50.50	200.29	3.97	199.48	125.39	74.90
97	2.0257	3923.135	3727.1	9.1	150.68	50.75	201.43	3.97	199.23	126.09	75.34
98	2.0533	3953.096	3757.1	9.3	151.47	50.94	202.41	3.97	199.04	126.68	75.74
99	2.0808	3984.183	3788.2	9.6	152.30	51.14	203.45	3.98	198.84	127.30	76.15
100	2.1083	4015.166	3819.2	9.8	153.12	51.53	204.65	3.97	198.45	128.09	76.56
101	2.1359	4044.802	3848.8	10.1	153.88	51.69	205.57	3.98	198.29	128.63	76.94
102	2.1635	4077.423	3881.4	10.3	154.75	51.97	206.72	3.98	198.01	129.34	77.38
103	2.1910	4107.725	3911.7	10.6	155.52	52.27	207.79	3.98	197.71	130.03	77.76
104	2.2185	4137.449	3941.4	10.8	156.26	52.58	208.85	3.97	197.40	130.72	78.13
105	2.2461	4167.437	3971.4	11.1	157.01	52.71	209.72	3.98	197.27	131.21	78.50

Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 3

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
106	2.2736	4196.304	4000.3	11.3	157.70	52.94	210.64	3.98	197.04	131.79	78.85
107	2.3012	4223.038	4027.0	11.6	158.31	53.25	211.55	3.97	196.73	132.40	79.15
108	2.3288	4252.164	4056.2	11.8	159.00	53.40	212.40	3.98	196.58	132.90	79.50
109	2.3563	4280.113	4084.1	12.1	159.64	53.74	213.38	3.97	196.24	133.56	79.82
110	2.3839	4309.155	4113.2	12.3	160.31	54.01	214.33	3.97	195.97	134.17	80.16
111	2.4114	4334.680	4138.7	12.6	160.85	54.30	215.14	3.96	195.68	134.72	80.42
112	2.4390	4362.728	4166.7	12.9	161.47	54.56	216.03	3.96	195.42	135.30	80.73
113	2.4665	4388.193	4192.2	13.1	161.99	54.73	216.72	3.96	195.25	135.72	80.99
114	2.4941	4414.900	4218.9	13.4	162.55	54.93	217.47	3.96	195.05	136.20	81.27
115	2.5216	4441.414	4245.4	13.6	163.09	55.19	218.28	3.96	194.79	136.74	81.55
116	2.5492	4464.169	4268.2	13.9	163.49	55.40	218.90	3.95	194.58	137.15	81.75
117	2.5767	4487.540	4291.5	14.1	163.91	55.60	219.51	3.95	194.38	137.56	81.95
118	2.6043	4511.597	4315.6	14.4	164.34	55.94	220.29	3.94	194.04	138.11	82.17
119	2.6318	4534.940	4338.9	14.6	164.75	56.10	220.85	3.94	193.88	138.48	82.37
120	2.6594	4558.646	4362.6	14.9	165.16	56.24	221.40	3.94	193.74	138.82	82.58
121	2.6869	4584.583	4388.6	15.1	165.65	56.42	222.07	3.94	193.56	139.24	82.83
122	2.7145	4608.861	4412.9	15.4	166.07	56.58	222.65	3.94	193.40	139.61	83.04
123	2.7420	4636.579	4440.6	15.6	166.62	56.94	223.56	3.93	193.04	140.25	83.31
124	2.7695	4666.089	4470.1	15.9	167.23	57.07	224.30	3.93	192.91	140.69	83.61
125	2.7938	4690.113	4494.1	16.1	167.69	57.23	224.91	3.93	192.75	141.07	83.84

Parameters for Specimen No. 4

Specimen Parameter	Initial	Saturated	Consolidated	Final
Moisture content: Moist soil+tare, gms.	8756.500			11178.000
Moisture content: Dry soil+tare, gms.	7992.500			10307.000
Moisture content: Tare, gms.	0.000			2314.500
Moisture, %	9.6	28.5	10.9	10.9
Moist specimen weight, gms.	8756.50			
Diameter, in.	6.000	5.898	5.314	
Area, in.²	28.274	27.320	22.176	
Height, in.	12.080	11.880	10.762	
Net decrease in height, in.		0.201	1.117	
Net decrease in water volume, cc.			1407.400	
Wet density, pcf	97.7	120.6	141.5	
Dry density, pcf	89.1	93.8	127.6	
Void ratio	0.8558	0.7634	0.2967	
Saturation, %	29.6	99.0	97.3	

Test Readings for Specimen No. 4

Membrane modulus = 0.652 kN/cm²

Membrane thickness = .0625 cm

Consolidation cell pressure = 449.91 psi

Consolidation back pressure = 50.19 psi

Consolidation effective confining stress = 399.72 psi

Strain rate, %/min. = 0.03

Fail. Stress = 379.89 psi **at reading no.** 99

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
0	0.2768	380.000	0.0	0.0	0.00	399.72	399.72	1.00	50.19	399.72	0.00
1	0.2797	720.032	340.0	0.0	15.33	399.77	415.10	1.04	50.14	407.44	7.66
2	0.2827	886.226	506.2	0.1	22.81	399.67	422.49	1.06	50.24	411.08	11.41
3	0.2857	1050.028	670.0	0.1	30.19	399.52	429.71	1.08	50.39	414.61	15.09
4	0.2886	1210.835	830.8	0.1	37.42	399.38	436.81	1.09	50.53	418.09	18.71
5	0.2916	1365.398	985.4	0.1	44.37	399.04	443.42	1.11	50.87	421.23	22.19
6	0.2945	1516.257	1136.3	0.2	51.15	398.70	449.86	1.13	51.21	424.28	25.58
7	0.2975	1661.075	1281.1	0.2	57.66	398.42	456.08	1.14	51.49	427.25	28.83
8	0.3005	1798.660	1418.7	0.2	63.83	397.99	461.82	1.16	51.92	429.91	31.92
9	0.3034	1926.379	1546.4	0.2	69.56	397.56	467.12	1.17	52.35	432.34	34.78
10	0.3064	2048.568	1668.6	0.3	75.03	397.15	472.18	1.19	52.76	434.67	37.52
11	0.3094	2163.596	1783.6	0.3	80.18	396.49	476.67	1.20	53.42	436.58	40.09
12	0.3123	2271.506	1891.5	0.3	85.01	395.83	480.85	1.21	54.08	438.34	42.51
13	0.3153	2375.690	1995.7	0.4	89.67	395.15	484.82	1.23	54.76	439.98	44.84
14	0.3183	2474.542	2094.5	0.4	94.09	394.47	488.55	1.24	55.44	441.51	47.04
15	0.3213	2569.733	2189.7	0.4	98.33	393.74	492.07	1.25	56.17	442.90	49.17
16	0.3242	2660.071	2280.1	0.4	102.36	393.16	495.53	1.26	56.75	444.34	51.18
17	0.3272	2752.608	2372.6	0.5	106.49	392.38	498.86	1.27	57.53	445.62	53.24
18	0.3302	2844.991	2465.0	0.5	110.60	391.57	502.17	1.28	58.34	446.87	55.30
19	0.3331	2934.361	2554.4	0.5	114.58	390.70	505.28	1.29	59.21	447.99	57.29
20	0.3361	3022.171	2642.2	0.6	118.49	389.93	508.41	1.30	59.98	449.17	59.24
21	0.3391	3105.809	2725.8	0.6	122.20	389.01	511.21	1.31	60.90	450.11	61.10
22	0.3421	3187.551	2807.6	0.6	125.83	388.15	513.98	1.32	61.76	451.07	62.92
23	0.3450	3267.754	2887.8	0.6	129.39	387.25	516.64	1.33	62.66	451.94	64.70

Test Readings for Specimen No. 4

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
24	0.3480	3348.017	2968.0	0.7	132.95	386.33	519.28	1.34	63.58	452.80	66.48
25	0.3509	3427.182	3047.2	0.7	136.46	385.40	521.86	1.35	64.51	453.63	68.23
26	0.3539	3506.291	3126.3	0.7	139.96	384.48	524.44	1.36	65.43	454.46	69.98
27	0.3569	3582.739	3202.7	0.7	143.35	383.52	526.87	1.37	66.39	455.19	71.67
28	0.3599	3656.479	3276.5	0.8	146.61	382.56	529.16	1.38	67.35	455.86	73.30
29	0.3628	3731.735	3351.7	0.8	149.93	381.59	531.52	1.39	68.32	456.56	74.97
30	0.3658	3805.117	3425.1	0.8	153.17	380.62	533.79	1.40	69.29	457.20	76.59
31	0.3688	3879.669	3499.7	0.9	156.46	379.55	536.01	1.41	70.36	457.78	78.23
32	0.3717	3952.117	3572.1	0.9	159.66	378.53	538.18	1.42	71.38	458.36	79.83
33	0.3747	4024.405	3644.4	0.9	162.84	377.47	540.31	1.43	72.44	458.89	81.42
34	0.3777	4097.017	3717.0	0.9	166.04	376.34	542.38	1.44	73.57	459.36	83.02
35	0.3806	4166.491	3786.5	1.0	169.10	375.27	544.37	1.45	74.64	459.82	84.55
36	0.3836	4239.005	3859.0	1.0	172.29	374.19	546.48	1.46	75.72	460.33	86.14
37	0.3865	4307.902	3927.9	1.0	175.32	373.08	548.40	1.47	76.83	460.74	87.66
38	0.3895	4378.107	3998.1	1.0	178.40	371.96	550.35	1.48	77.95	461.15	89.20
39	0.3925	4449.735	4069.7	1.1	181.54	370.82	552.36	1.49	79.09	461.59	90.77
40	0.3955	4519.891	4139.9	1.1	184.62	369.65	554.27	1.50	80.26	461.96	92.31
41	0.3984	4588.260	4208.3	1.1	187.62	368.54	556.16	1.51	81.37	462.35	93.81
42	0.4103	4853.096	4473.1	1.2	199.20	363.85	563.05	1.55	86.06	463.45	99.60
43	0.4221	5119.104	4739.1	1.3	210.82	359.06	569.88	1.59	90.85	464.47	105.41
44	0.4339	5375.031	4995.0	1.5	221.95	354.20	576.15	1.63	95.71	465.18	110.98
45	0.4457	5624.192	5244.2	1.6	232.77	349.09	581.86	1.67	100.82	465.48	116.38
46	0.4576	5873.424	5493.4	1.7	243.56	343.85	587.41	1.71	106.06	465.63	121.78
47	0.4694	6112.681	5732.7	1.8	253.88	338.38	592.26	1.75	111.53	465.32	126.94
48	0.4812	6351.387	5971.4	1.9	264.15	332.54	596.70	1.79	117.37	464.62	132.08
49	0.4930	6578.277	6198.3	2.0	273.88	326.39	600.27	1.84	123.52	463.33	136.94
50	0.5048	6804.254	6424.3	2.1	283.55	320.19	603.74	1.89	129.72	461.96	141.78
51	0.5167	7018.926	6638.9	2.2	292.70	313.45	606.15	1.93	136.46	459.80	146.35
52	0.5285	7225.259	6845.3	2.3	301.46	306.29	607.75	1.98	143.62	457.02	150.73
53	0.5403	7421.023	7041.0	2.4	309.73	298.70	608.43	2.04	151.21	453.56	154.86
54	0.5521	7601.496	7221.5	2.6	317.31	290.77	608.08	2.09	159.14	449.43	158.65
55	0.5639	7774.439	7394.4	2.7	324.54	282.37	606.91	2.15	167.54	444.64	162.27
56	0.5758	7927.831	7547.8	2.8	330.90	273.61	604.51	2.21	176.30	439.06	165.45
57	0.5876	8068.313	7688.3	2.9	336.68	264.70	601.38	2.27	185.21	433.04	168.34
58	0.5994	8189.095	7809.1	3.0	341.58	255.70	597.28	2.34	194.21	426.49	170.79
59	0.6112	8294.460	7914.5	3.1	345.80	246.43	592.23	2.40	203.48	419.33	172.90
60	0.6231	8384.265	8004.3	3.2	349.33	237.54	586.86	2.47	212.37	412.20	174.66
61	0.6349	8455.482	8075.5	3.3	352.03	228.46	580.50	2.54	221.45	404.48	176.02
62	0.6467	8513.589	8133.6	3.4	354.16	219.94	574.11	2.61	229.97	397.02	177.08
63	0.6585	8556.785	8176.8	3.5	355.64	211.77	567.41	2.68	238.14	389.59	177.82
64	0.6703	8592.726	8212.7	3.7	356.80	204.19	560.99	2.75	245.72	382.59	178.40
65	0.6822	8617.712	8237.7	3.8	357.47	197.06	554.54	2.81	252.85	375.80	178.74
66	0.6940	8635.432	8255.4	3.9	357.83	190.54	548.38	2.88	259.37	369.46	178.92
67	0.7058	8647.607	8267.6	4.0	357.95	184.39	542.34	2.94	265.52	363.36	178.98
68	0.7177	8652.009	8272.0	4.1	357.73	178.77	536.51	3.00	271.14	357.64	178.87
69	0.7295	8658.929	8278.9	4.2	357.62	173.70	531.32	3.06	276.21	352.51	178.81
70	0.7413	8659.193	8279.2	4.3	357.22	169.05	526.27	3.11	280.86	347.66	178.61

Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 4

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
71	0.7531	8663.464	8283.5	4.4	357.00	164.85	521.84	3.17	285.06	343.35	178.50
72	0.7649	8665.025	8285.0	4.5	356.65	161.14	517.80	3.21	288.77	339.47	178.33
73	0.7767	8666.036	8286.0	4.6	356.29	157.74	514.03	3.26	292.17	335.89	178.14
74	0.7886	8670.917	8290.9	4.8	356.09	154.63	510.72	3.30	295.28	332.68	178.04
75	0.8004	8673.731	8293.7	4.9	355.80	152.51	508.31	3.33	297.40	330.41	177.90
76	0.8122	8681.492	8301.5	5.0	355.72	149.97	505.69	3.37	299.94	327.83	177.86
77	0.8241	8686.087	8306.1	5.1	355.50	147.80	503.30	3.41	302.11	325.55	177.75
78	0.8359	8697.228	8317.2	5.2	355.57	145.66	501.23	3.44	304.25	323.44	177.78
79	0.8477	8704.197	8324.2	5.3	355.45	143.05	498.50	3.48	306.86	320.77	177.73
80	0.8596	8716.284	8336.3	5.4	355.55	141.38	496.93	3.51	308.53	319.15	177.78
81	0.8714	8729.618	8349.6	5.5	355.71	139.82	495.53	3.54	310.09	317.68	177.85
82	0.9009	8762.618	8382.6	5.8	356.08	136.63	492.70	3.61	313.28	314.67	178.04
83	0.9305	8803.753	8423.8	6.1	356.78	134.21	491.00	3.66	315.70	312.60	178.39
84	0.9600	8850.802	8470.8	6.3	357.73	132.25	489.98	3.70	317.66	311.12	178.86
85	0.9895	8900.835	8520.8	6.6	358.79	131.31	490.10	3.73	318.60	310.70	179.39
86	1.0191	8963.362	8583.4	6.9	360.36	130.39	490.75	3.76	319.52	310.57	180.18
87	1.0486	9019.056	8639.1	7.2	361.62	129.75	491.37	3.79	320.16	310.56	180.81
88	1.0782	9081.709	8701.7	7.4	363.17	129.32	492.49	3.81	320.59	310.91	181.59
89	1.1077	9141.801	8761.8	7.7	364.59	129.04	493.63	3.83	320.87	311.33	182.30
90	1.1373	9204.174	8824.2	8.0	366.10	128.41	494.51	3.85	321.50	311.46	183.05
91	1.1668	9274.302	8894.3	8.3	367.91	128.63	496.54	3.86	321.28	312.59	183.95
92	1.1963	9337.999	8958.0	8.5	369.43	128.69	498.13	3.87	321.22	313.41	184.72
93	1.2258	9406.593	9026.6	8.8	371.14	128.47	499.61	3.89	321.44	314.04	185.57
94	1.2553	9470.434	9090.4	9.1	372.64	128.62	501.27	3.90	321.29	314.94	186.32
95	1.2849	9536.104	9156.1	9.4	374.20	128.68	502.88	3.91	321.23	315.78	187.10
96	1.3144	9600.549	9220.5	9.6	375.70	128.90	504.60	3.91	321.01	316.75	187.85
97	1.3439	9661.163	9281.2	9.9	377.02	129.29	506.31	3.92	320.62	317.80	188.51
98	1.3735	9726.058	9346.1	10.2	378.50	129.94	508.44	3.91	319.97	319.19	189.25
99	1.4030	9789.272	9409.3	10.5	379.89	130.22	510.12	3.92	319.69	320.17	189.95
100	1.4326	9851.859	9471.9	10.7	381.25	130.83	512.07	3.91	319.08	321.45	190.62
101	1.4621	9916.601	9536.6	11.0	382.67	131.31	513.99	3.91	318.60	322.65	191.34
102	1.4916	9975.329	9595.3	11.3	383.84	131.80	515.64	3.91	318.11	323.72	191.92
103	1.5212	10036.954	9657.0	11.6	385.11	132.47	517.58	3.91	317.44	325.02	192.56
104	1.5507	10089.901	9709.9	11.8	386.02	132.92	518.95	3.90	316.99	325.94	193.01
105	1.5803	10147.371	9767.4	12.1	387.10	133.57	520.67	3.90	316.34	327.12	193.55
106	1.6098	10200.614	9820.6	12.4	387.99	134.03	522.02	3.89	315.88	328.03	194.00
107	1.6393	10258.348	9878.3	12.7	389.05	134.62	523.67	3.89	315.29	329.15	194.53
108	1.6689	10312.811	9932.8	12.9	389.97	135.13	525.10	3.89	314.78	330.11	194.98
109	1.6984	10368.605	9988.6	13.2	390.92	135.71	526.63	3.88	314.20	331.17	195.46
110	1.7279	10426.740	10046.7	13.5	391.95	136.23	528.18	3.88	313.68	332.20	195.98
111	1.7575	10484.006	10104.0	13.8	392.94	136.71	529.65	3.87	313.20	333.18	196.47
112	1.7870	10548.407	10168.4	14.0	394.18	137.21	531.39	3.87	312.70	334.30	197.09
113	1.8165	10604.096	10224.1	14.3	395.08	137.82	532.89	3.87	312.09	335.35	197.54
114	1.8461	10653.014	10273.0	14.6	395.69	138.26	533.95	3.86	311.65	336.11	197.85
115	1.8756	10707.158	10327.2	14.9	396.50	138.72	535.22	3.86	311.19	336.97	198.25
116	1.9052	10759.929	10379.9	15.1	397.24	139.33	536.58	3.85	310.58	337.96	198.62
117	1.9347	10816.536	10436.5	15.4	398.12	139.87	537.99	3.85	310.04	338.93	199.06

Knight Piesold Geotechnical Lab.

Test Readings for Specimen No. 4

No.	Def. Dial in.	Load Dial	Load lbs.	Strain %	Deviator Stress psi	Minor Eff. Stress psi	Major Eff. Stress psi	1:3 Ratio	Pore Press. psi	P psi	Q psi
118	1.9642	10863.761	10483.8	15.7	398.62	140.39	539.02	3.84	309.52	339.70	199.31
119	1.9938	10908.551	10528.6	16.0	399.02	140.67	539.69	3.84	309.24	340.18	199.51
120	2.0233	10956.429	10576.4	16.2	399.53	141.18	540.70	3.83	308.73	340.94	199.76

MAY 12, 2023

SUMMARY REPORT FOR LABORATORY TESTING OF OVERBURDEN AND ROCKFILL SOILS

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GMRL PROJECT NO. KP – 22 - 1

EXECUTIVE SUMMARY

This report contains descriptions of the procedures and the results of the geotechnical laboratory tests for samples provided by Knight Piesold Ltd. Samples of overburden and rockfill material recovered using sonic core drilling and sampling were tested to evaluate the particle size distribution, the moisture-density relationships, and the stress-strain-pore pressure response of the soils. Dry and wet sieve analyses, standard Proctor compaction, and large-scale direct simple shear (LS-DSS) tests were performed in general accordance with ASTM International standard test procedures where applicable. Additional details are provided below for the LS-DSS test procedures which fall outside of any existing ASTM standard.

1.0 SAMPLE DETAILS AND SPECIMEN PREPARATION

The bulk samples received consisted of 10 – 5 gallon buckets of soil labeled Rockfill and 6 – 5 gallon buckets of soil labeled Overburden. Both were obtained by sonic core drilling and sampling from an embankment in Butte Montana. The Rockfill samples were retrieved from depths ranging from 67 – 462 ft (20.4 – 140.8 m) and the soil color varied across the depth range as shown in Figure 1. The Overburden samples were retrieved from depths of 17 – 50 ft (5.2 – 15.2 m) and were much more consistent in terms of color (Figure 2). For more information regarding the labels and corresponding depths of the samples, the full sample inventory is provided in the Appendix.

Figure 1. Photographs of each bucket of Rockfill samples as delivered. Soil color varied for the samples at different depths.

Figure 2. Photographs of each bucket of Overburden samples as delivered. Soil color was quite consistent across all Overburden samples.

The samples were dried in the oven at 110 ± 5°C and then the Rockfill samples were combined and the Overburden samples were combined to create two main materials for testing. The clumps of soil were carefully broken up in each sample so that the particle sizes were as close to their actual individual sizes as possible to give a more representative initial gradation. Even with the effort spent in preparing the samples, clumps were still present in both samples as later detailed by the dry and wet sieve analyses. It was thought that these clumps, however, would likely break apart as the sample became saturated during the LS-DSS testing.

To obtain a representative specimen for testing from these larger combined field samples, quartering was used following the procedures set forth in AASHTO T 248, Method B. After each LS-DSS test, specimens were dried and any clumps were broken back up and the soil was combined back into the original sample. Test specimens were then obtained again by repeating the quartering procedures. This helped ensure that each specimen tested would have a particle size distribution that was representative of the field sample.

2.0 LABORATORY PROCEDURES AND RESULTS

2.1 Sieve Analysis

Initial sieve analyses were performed on oven-dried Rockfill and Overburden samples. The procedure followed ASTM D6913-17, Method A for composite sieving, given that the maximum particle size in each sample was greater than 0.75 in (19 mm). The Rockfill specimen sieved was 106.7 lbs (48.4 kg) and the Overburden specimen was 80.5 lbs (36.5 kg). The specimens were first sieved using a mechanical shaker and were not washed prior to the sieve analysis in an effort to preserve the sample composition for subsequent testing. This also gave an indication of the existing clumping in the dry state when compared to a wash sieve analysis. Multiple different screen and sieve sizes were used to obtain a comprehensive size distribution without overcrowding any given sieve.

Following ASTM D1140, a smaller subsample (1 kg) of each soil was washed through the No. 4 and No. 200 sieve to determine the percentage passing by weight on each sieve. These values were then compared to the dry sieve analysis. Figure A-1 located in the Appendix presents the data for the dry sieve analysis and Table 1 below compares the percentages passing the No. 4, No. 100, and No. 200 sieves for the initial dry and wash sieve analyses. As shown in Table 1, washing resulted in higher percentages of particles that passed the No. 4 (4.76 mm) compared with the dry sieve. Although the No. 200 sieve was not used in the dry sieve analyses, a comparison of the No. 100 sieve shows that a greater percentage of particles were washed through the No. 200 sieve. Therefore, despite efforts to carefully break them apart, the dry-sieved specimens still contained clumps of particles. These clumps made the gradation appear coarser than it actually was. Note that a large discrepancy in percent passing values was observed for the Rockfill specimens on the No. 4 sieve, but it is likely that 1 kg of soil used for the wash preparation may not have been enough to contain many of the larger particle sizes in the sample. Also note that although the dry specimens may contain clumps of particles, it is likely that these clumps will be further broken apart when the sample is saturated and better represent the field gradation during testing.

Table 1. Comparison of percentages passing each sieve size for the dry and wet sieve analyses prior to testing.

	Rockfill (Dry Sieve)	Rockfill (Wet Sieve)	Overburden (Dry Sieve)	Overburden (Wet Sieve)
No. 4 (4.76 mm)	55.4%	81.7%	76.8%	84.7%
No. 100 (mm)	7.33%	--	7.7%	--
No. 200 (0.075 mm)	--	27.5%	--	17.0%

Dry and wet sieve analyses were also conducted during testing and once all LS-DSS testing was completed to ensure that the gradation did not change due to particle breakage during shearing. Figure 3 presents a comparison of the initial, mid-testing, and final dry sieve analysis results for the Rockfill sample, and Figure 4 presents the same comparison for the Overburden sample. Table 2 shows a comparison of the initial and final wet sieve analyses for the two samples. Additional plots can also be found in Figures A-2 and A-3 in Appendix A and the data corresponding to the sieve analyses can be found in Appendix B.

As shown in Figures 3 and 4, there was some discrepancy in the initial and mid-testing gradations; however, the final and initial gradations look very similar in both cases. This is likely due to a difference in how fine the particles were separated for the sieve analyses and not related to actual particle size differences. There was a slight decrease in the percentages of large particles for the Rockfill sample specifically which may be due to some of the largest particles becoming fractured during testing. It was observed that some larger particles broke during compaction when preparing the dense rockfill specimens. This slight change could also be due to a different proportioning being obtained where some larger particles were not sampled, but it is hard to confirm without having a sieve analysis for the complete sample. Overall, the slight change is not expected to affect the testing results significantly and the majority of the gradation curve remained very similar to the initial curve.

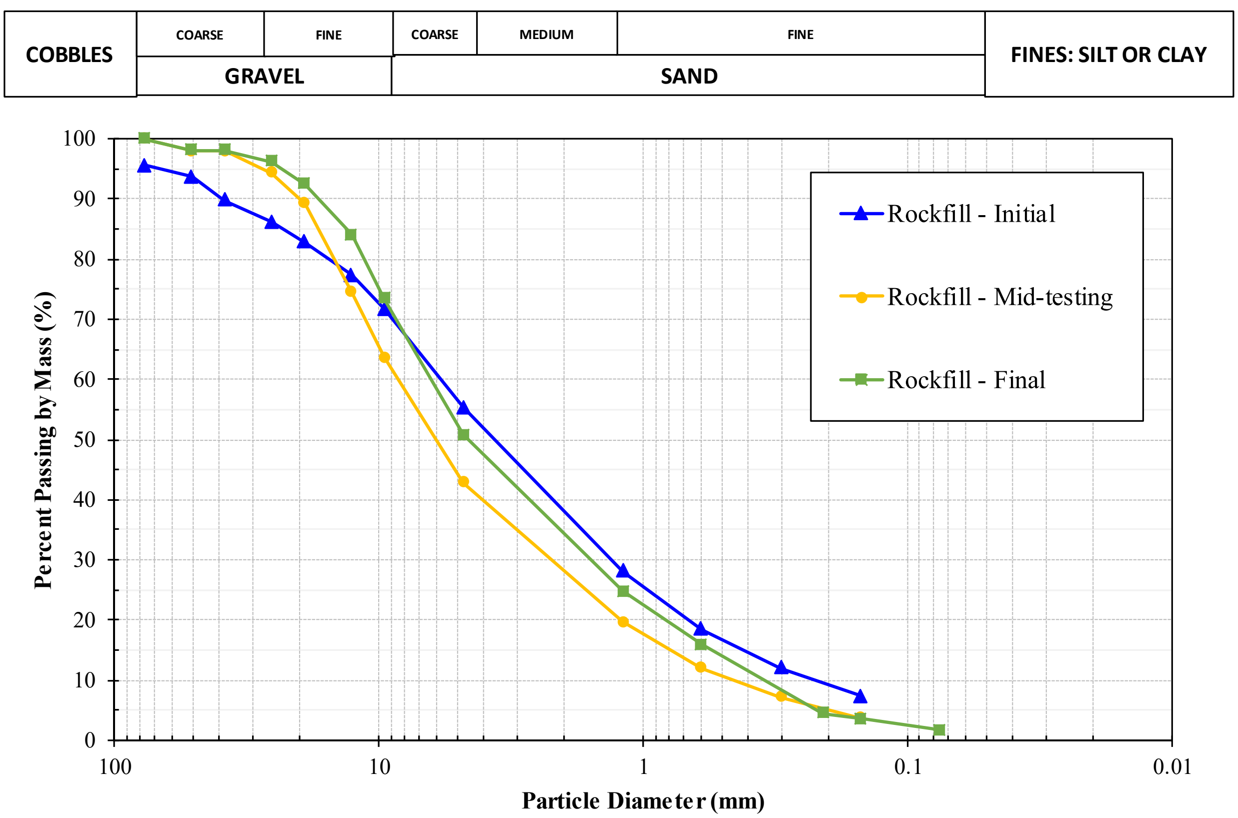


Figure 3. Comparison of initial, mid-testing, and final sieve analysis results for the Rockfill sample where the final sieve analysis was performed after all LS-DSS testing was complete.

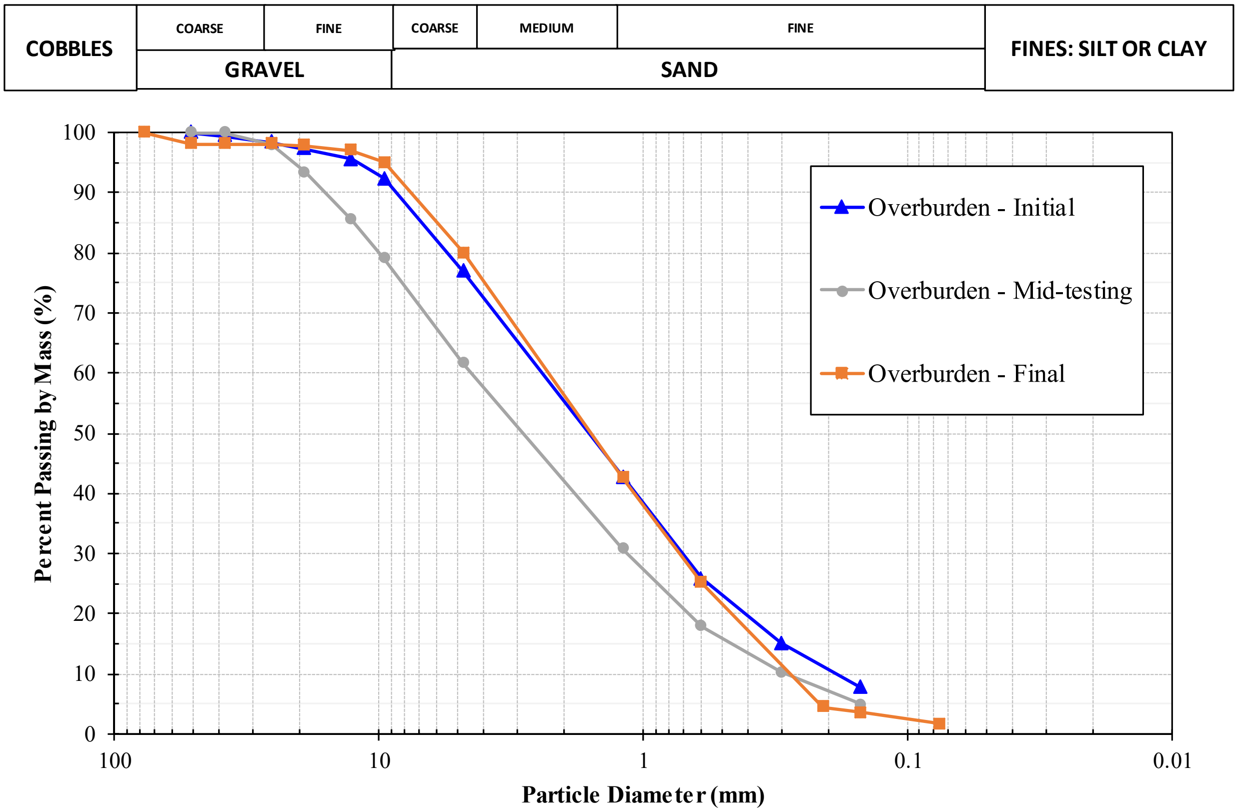


Figure 4. Comparison of initial, mid-testing, and final sieve analysis results for the Overburden sample where the final sieve analysis was performed after all LS-DSS testing was complete.

Table 2. Comparison of percentages passing each sieve size for the dry and wet sieve analyses prior to testing.

	Rockfill (Initial)	Rockfill (Final)	Overburden (Initial)	Overburden (Final)
No. 4 (4.76 mm)	81.7%	81.5%	84.7%	98.0%
No. 200 (0.075 mm)	27.5%	28.7%	17.0%	22.6%

The wet sieve analyses confirm that for the proportion tested, the Rockfill sample remained relatively unchanged for the percentages passing the No. 4 and No. 200 sieve. The Overburden specimen appears to have become slightly finer in particle size with a higher percentage passing both sieves after testing was complete. This could be due to particle breakage which was observed for these specimens, or it could also be an artifact of the proportioning differences for a smaller sample amount. These slight differences in gradation are not anticipated to affect the shearing results significantly, but it should be noted as a consideration in the analysis.

2.2 Minimum Density and Standard Proctor Compaction

The minimum density was determined for the Rockfill and Overburden soils to establish the loosest condition possible to prepare the LS-DSS tests. Procedures followed ASTM 4254 Method A. Moisture-density relationships were also determined for the Rockfill and Overburden soils using Standard effort following ASTM D698. Table 3 presents the minimum densities and unit weights determined, as well as the results from the standard Proctor compaction tests. Note that a relative compaction of 90% based on standard Proctor effort was used as the target density for the dense compacted Rockfill LS-DSS tests. The compaction curves are presented in Figures A-4 through A-6 in Appendix A and the data corresponding to the curves is located in Appendix B.

Table 3. Minimum density and moisture-density values determined for the Rockfill and Overburden samples.

		Rockfill	Overburden
Minimum Density	ρ_{min} (kg/m^3)	1515.93	1323.85
	γ_{min} (kN/m^3)	14.87	12.99
	γ_{min} (pcf)	94.66	82.69
Standard Proctor	w_{opt} (%)	8.63	9.89
	ρ_{dry} (kg/m^3)	2152.4	1991.8
	$\gamma_{dry, max}$ (kN/m^3)	21.1	19.54
	$\gamma_{dry, max}$ (pcf)	134.32	124.39
	ρ_{dry} @ 90% RC (kg/m^3)	1937.2	1792.7

2.3 Large-scale Direct Simple Shear

Large-scale direct simple shear (LS-DSS) tests were conducted on Rockfill and Overburden specimens. Because of the larger particle sizes contained within the samples, 600 mm diameter specimens were used. A target initial specimen height of 200 mm was chosen to try and balance at least a 3:1 specimen diameter-to-height ratio while still giving a specimen height-to-particle size of at least 8:1. Researchers recommend that the diameter be 3.7 times larger than the height and that at least 10 particles should stack across the specimen height (i.e., specimen size to particle size ratio of 10). With large particles such as those present in the Rockfill, both are difficult to satisfy even with this being the largest known direct simple shear device in the world with its capabilities. Table 4 presents the particle sizes for which 50% (D_{50}) and 85% (D_{85}) of the sample is smaller. D_{50} and D_{85} are used to help determine the proper specimen height for the LS-DSS testing, with D_{85} representing a good baseline for particle size in this testing. The target specimen height of 200 mm allowed an 8:1 specimen height-to-particle size ratio for the Rockfill specimens which was deemed sufficient. The same target initial specimen height was also used for the Overburden specimen which gives well above the 10:1 ratio, so in some tests, a smaller height was allowed to improve the specimen diameter-to-height ratio. Figure 5 shows a Rockfill specimen being prepared and provides a visual of the specimen size to particle size dimensions. Note that while 200 mm was the initial target height at which the specimens were prepared, the loose specimens often compressed during saturation and initial loading. Therefore, the starting specimen height was often below this value.

Table 4. Particle sizes for which 50% (D_{50}) and 85% (D_{85}) of the sample are smaller based on the dry sieve results.

	Overburden	Rockfill
D_{50} (in)	0.066	0.144
D_{50} (mm)	1.67	3.67
D_{85} (in)	0.276	0.988
D_{85} (mm)	7	25.1

Figure 5. Photographs of the Rockfill specimen to provide a visual of specimen diameter to particle size.

LS-DSS tests were performed on the Rockfill and Overburden samples at different stress and density conditions. Table 5 summarizes the tests performed and the densities measured at various stages of testing. The designations used for testing are as follows: R represents Rockfill and O represents Overburden, D and L represent either a loose or dense initial state (i.e., D represents 90% relative density), the vertical stress maintained during testing is the first number given in the Test Designation, and the second number represents the test number. The initial density was measured with a vertical stress of 10 kPa placed on the sample in a dry state just after loading the specimen into the frame and in a saturated state after flooding the specimen with water. The density was also recorded at the end of consolidation and at the end of shearing to evaluate the changes in the two stages.

Table 5. Summary of density conditions during LS-DSS testing.

Material	Test Designation	Date Performed	Sample Mass (kg)	Initial Density Dry (kg/m3)	Initial Density Saturated (kg/m3)	Density @ End of Consolidation (kg/m3)	Density @ End of Shearing (kg/m3)	% Difference during shearing
Rockfill	**RL-35-1**	11/22/2022	78.4	1638.08	1795.44	2025.21	2070.75	2.08
	RL-35-2	12/9/2022	78.4	1436.81	1704.82	1998.43	2028.32	1.39
	RL-100-1	12/16/2022	78.4	1403.48	1701.42	2082.16	2125.12	1.90
	RD-35-1	1/16/2023	109.6	1982.43	1991.33	2055.35	2100.16	2.04
	RD-35-2	2/13/2023	109.6	2011.66	2013.56	2095.12	2122.87	1.25
	RD-100-1	2/27/2023	109.6	1993.40	2019.00	2156.80	2197.96	1.79
Overburden	**OL-25-1**	11/30/2022	67.7	1255.35	1577.31	1796.06	1843.94	2.45
	OL-60-1	1/19/2023	69.9	1401.65	1679.15	1909.80	1950.87	1.98
	OL-60-2	1/27/2023	69.9	1279.70	1526.09	1858.43	1924.41	3.23
	OL-100-1	2/16/2023	69.9	1288.12	1472.60	1932.59	2012.88	3.75

Once the specimens were saturated, they were then consolidated to the target stress specified. To ensure saturation, the specimens were back-pressure saturated once more and then brought to a static pore pressure before shearing. Specimens were sheared at a rate of 0.0046mm/s which corresponds to a shear strain rate of 10%/hour based on a specimen height of approximately 166 mm which was more representative average height of the specimens once saturated. Note that the height of the specimens varied after consolidation, however, the rate was maintained constant for all tests conducted. The vertical stress was maintained throughout shearing and the drainage lines were closed to create undrained constant volume conditions. The top platen position was recorded to monitor any changes in the specimen volume and it was determined that these changes were 2% or less for all of the tests which is considered negligible. Two pore pressure sensors were positioned on the specimen, one located on the top platen and the other located on the bottom platen. In some tests, there was a discrepancy in the two sensors. The average of the two values was used for the stress ratio calculations, and additional calculations were performed using each sensors' response. Some small amounts of air in the system could have led to the differences measured. It is likely that the pore pressure measured at the bottom platen is more representative of the actual undrained conditions; however, the data should be careful analyzed to ensure a proper value is used in any design or field performance estimates. The results herein are reported "as recorded" and engineering judgement should be used when applying them to particular scenarios.

After each LS-DSS test, the samples were dried, and the clumps were carefully broken into individual particle sizes again to ensure the same gradation was used for all testing. The sample was then combined with the remaining material and reproportioned to obtain a representative sample for the next test. Additional sieve analyses were conducted periodically to confirm that the gradations remained similar to the initial field samples. Table 6 presents the results for each of the tests conducted and some comparison plots of the LS-DSS results are presented Figures 6-13. Additional figures and data summary sheets are located in Appendix A. Note that multiples of some tests were conducted due to leaks or other testing issues which may have occurred. Table 6 provides some notes related to the test success and any issues that may have occurred.

Table 6. Summary of LS-DSS testing results.

Test	Density (kg/m3)	Max Shear Stress (kPa)	Max Vertical Effective Stress, σ'v (kPa)	Max Excess Pore Pressure, Δu_{ex} (kPa)	Peak Effective Stress Ratio*, τ/σ'v	Peak Effective Stress Ratio (Top), τ/σ'v	Peak Effective Stress Ratio (Bottom), τ/σ'v	TESTING NOTES
RL-35-1	2025.21	98.16	244.84	80.57	0.51	0.52	0.51	Leak occurred at approximately 11% shear strain
RL-35-2	1998.43	76.27	251.42	115.25	0.56	0.53	0.6	Successful with no leaks
RL-100-1	2082.16	258.89	687.82	156.28	0.47	0.47	0.47	Successful with no leaks
RD-35-1	2055.35	121.73	241.38	107.75	0.7	0.70	0.69	Static backpressure lowered during shearing
RD-35-2	2095.12	103.93	245.84	92.2	0.65	0.60	0.73	Successful with no leaks
RD-100-1	2156.80	236.92	693.46	216.04	0.48	0.39	0.52	Successful with no leaks
OL-25-1	1796.06	62.55	160.23	54.67	0.59	0.62	0.57	Successful with no leaks
OL-60-1	1909.80	144.19	419.1	49.83	0.39	0.39	0.39	Leak occurred at approximately 9% shear strain
OL-60-2	1858.43	186.81	417.25	93.32	0.58	0.57	0.58	Successful with no leaks
OL-100-1	1932.59	342.8	694.32	110.33	0.57	0.57	0.57	Successful with no leaks

Rockfill LS-DSS Results

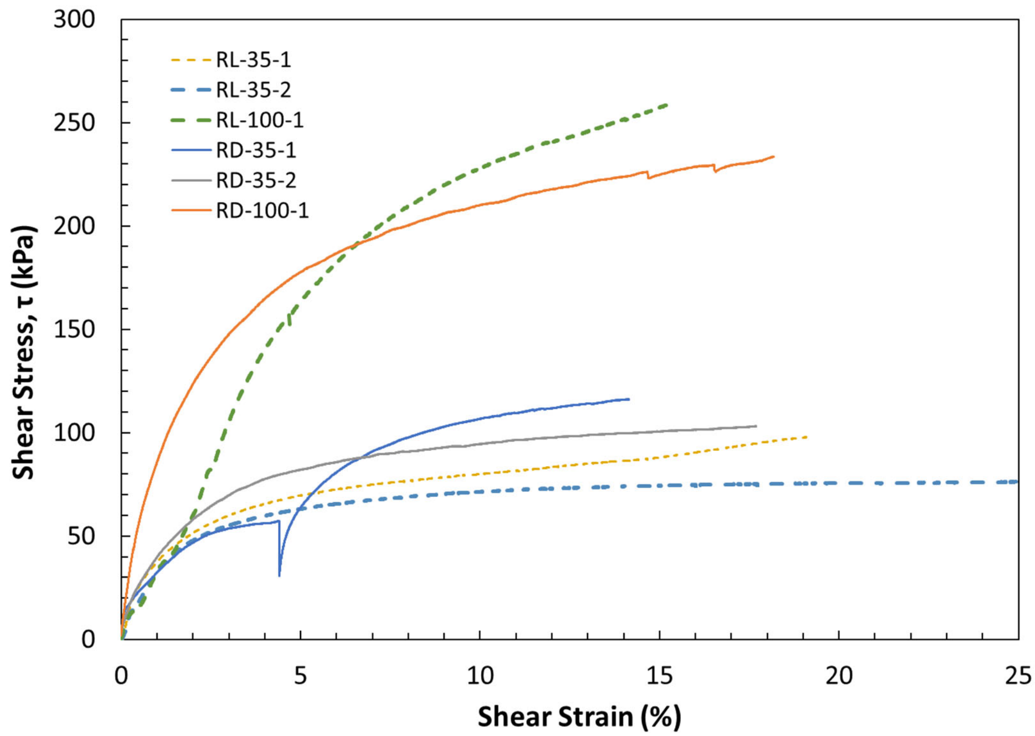


Figure 6. Shear stress response for all LS-DSS tests on Rockfill.

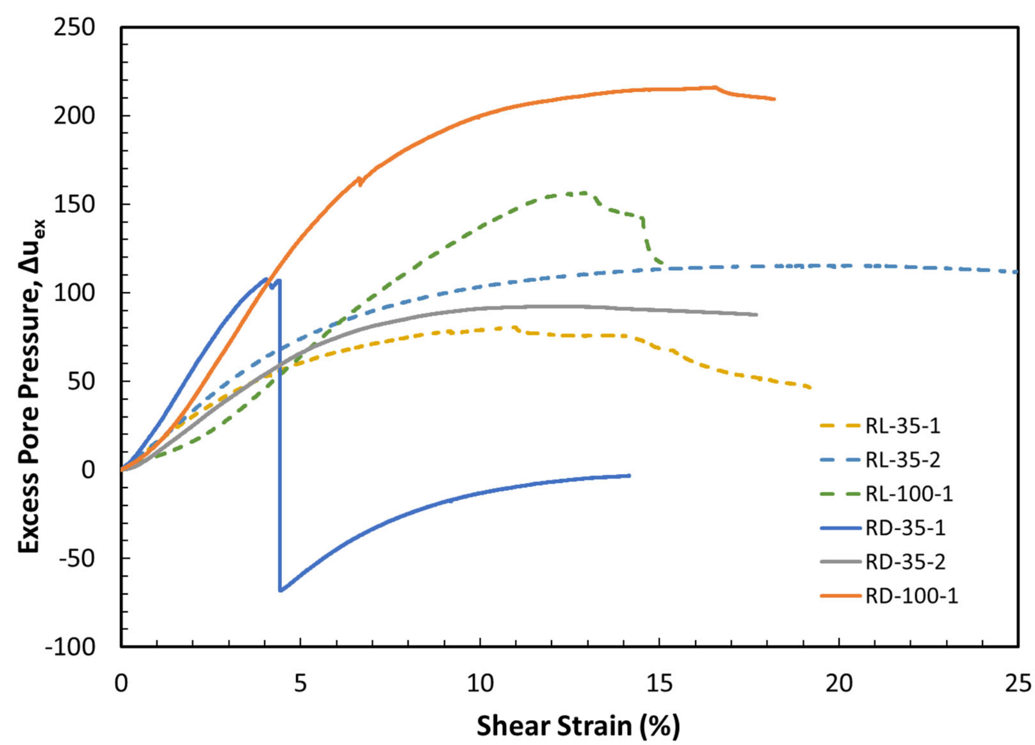


Figure 7. Average excess pore pressure response for all LS-DSS tests on Rockfill.

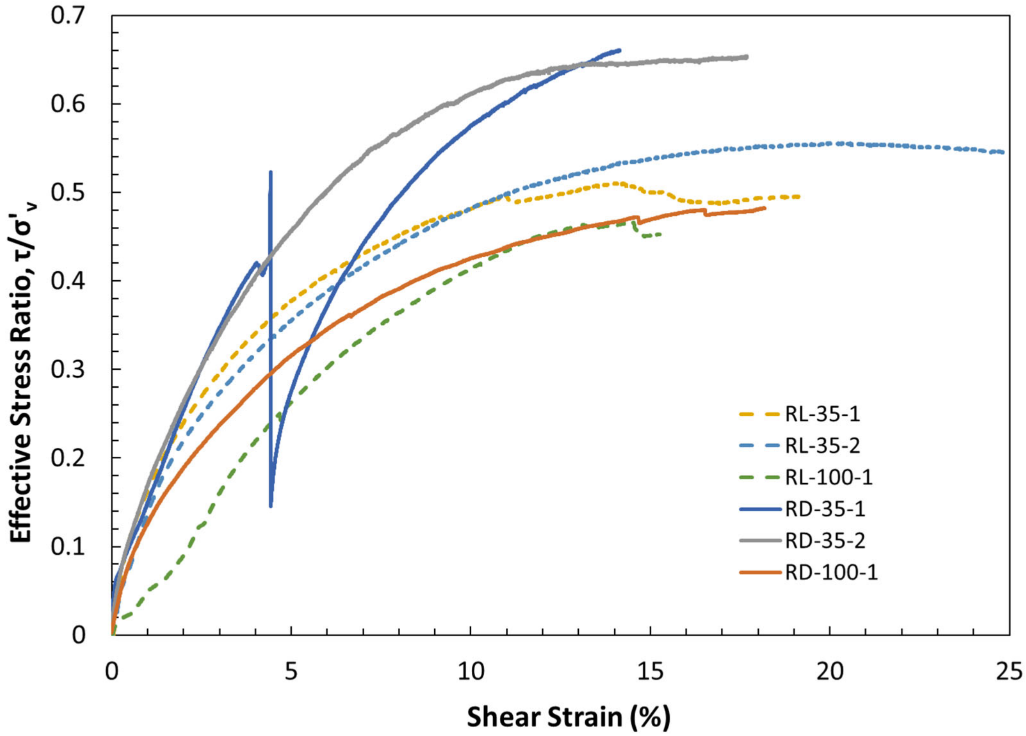


Figure 8. Effective stress ratio response for all LS-DSS tests on Rockfill.

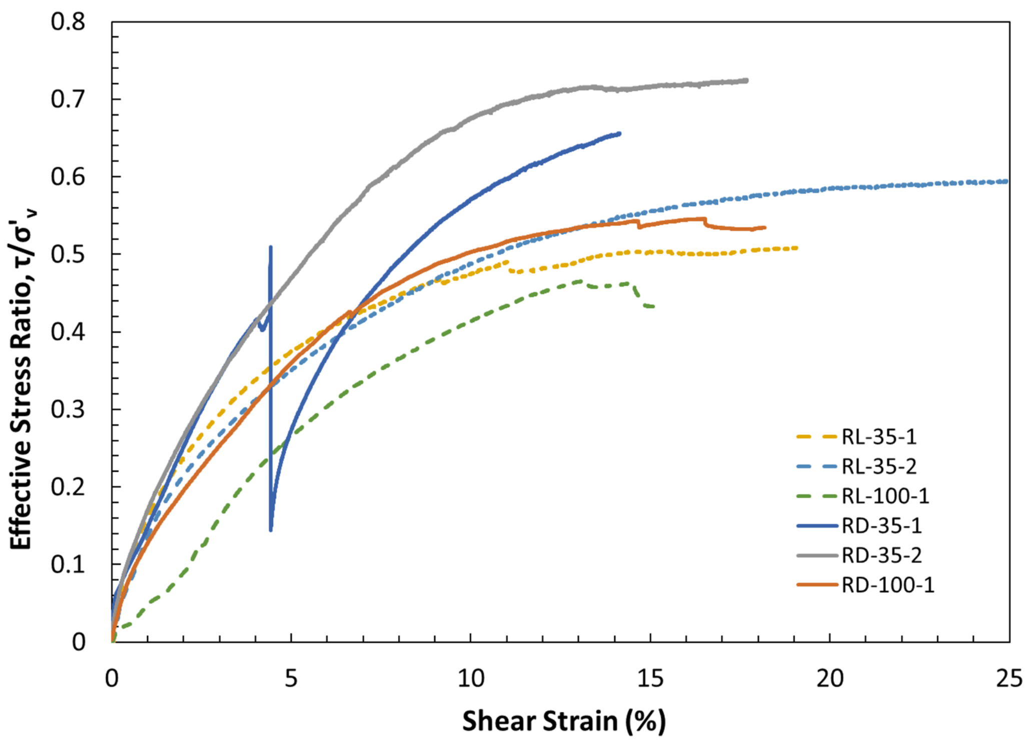


Figure 9. Effective stress ratio response calculated using the pore pressure measured at the bottom platen for all LS-DSS tests on Rockfill.

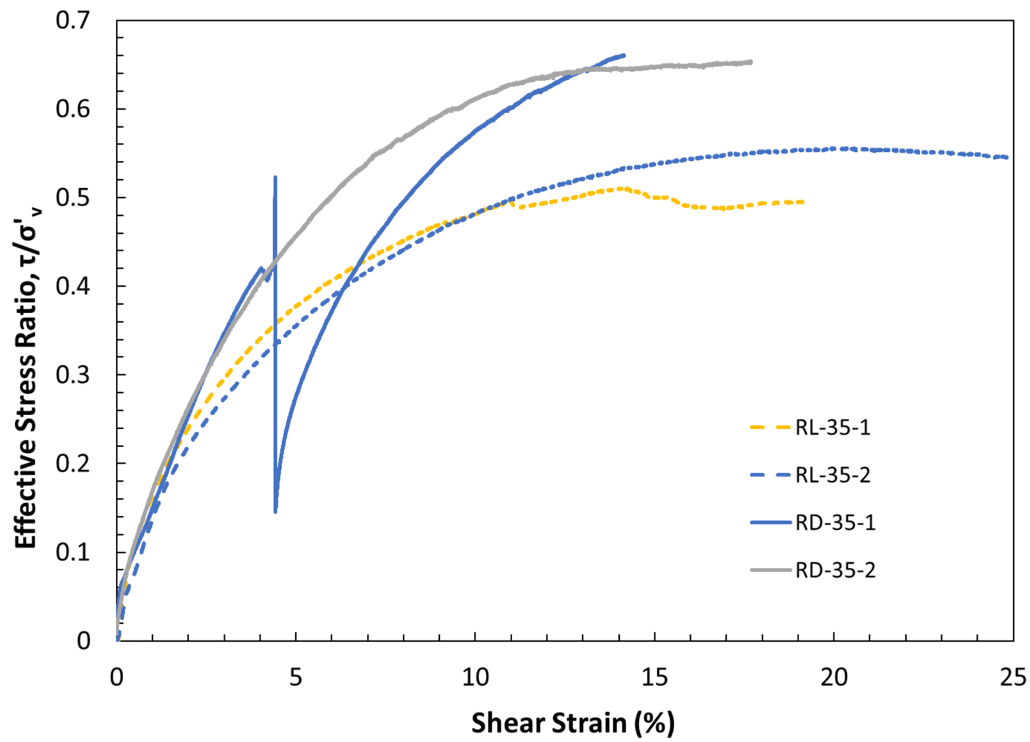


Figure 10. Effective stress ratio response for LS-DSS tests on Rockfill tested at a vertical effective stress of 35 psi.

Overburden LS-DSS Results

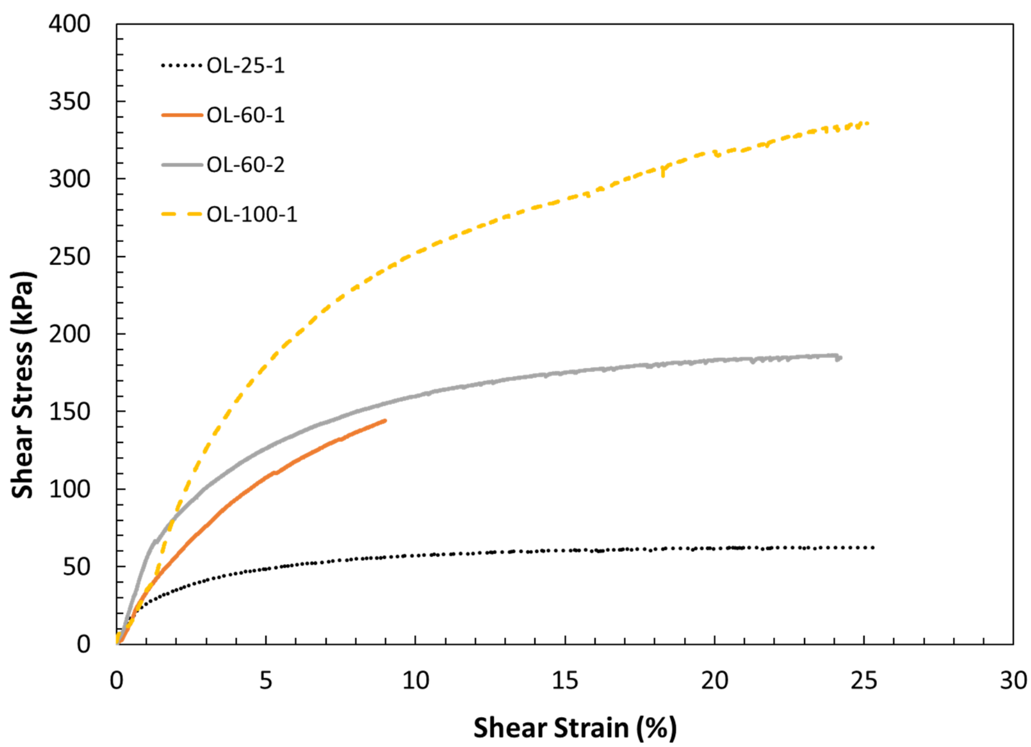


Figure 11. Shear stress response for all LS-DSS tests on Overburden.

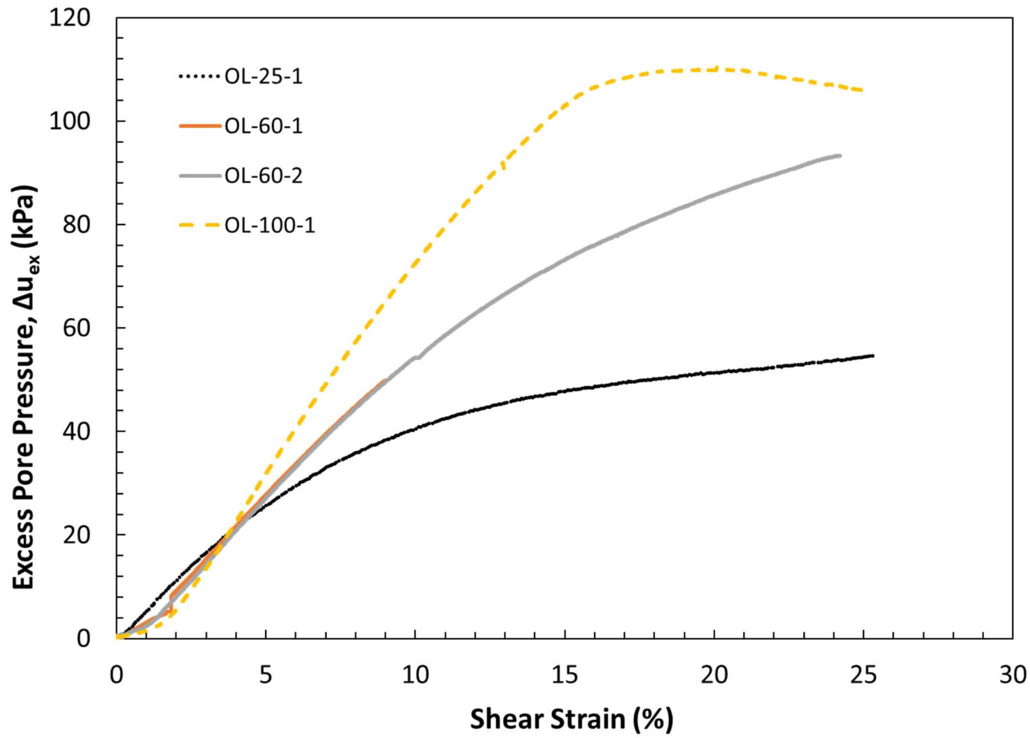


Figure 12. Average excess pore pressure response for all LS-DSS tests on Overburden.

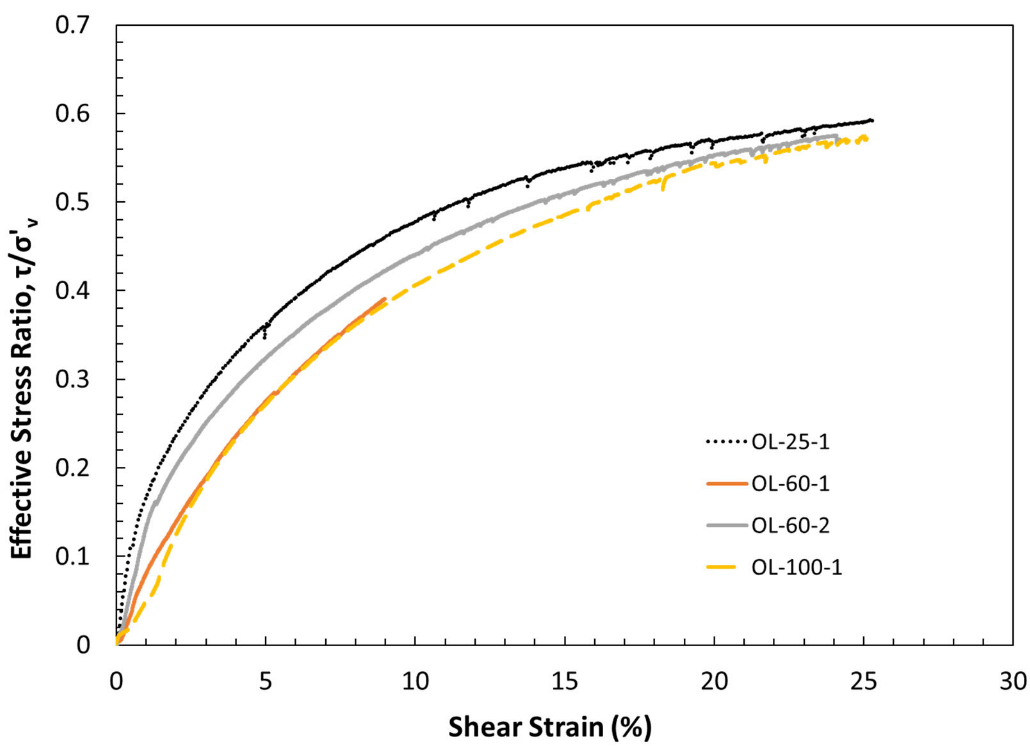


Figure 13. Effective stress ratio response for all LS-DSS tests on Overburden.

APPENDIX A. TESTING RESULTS AND PLOTS

Sieve Analysis

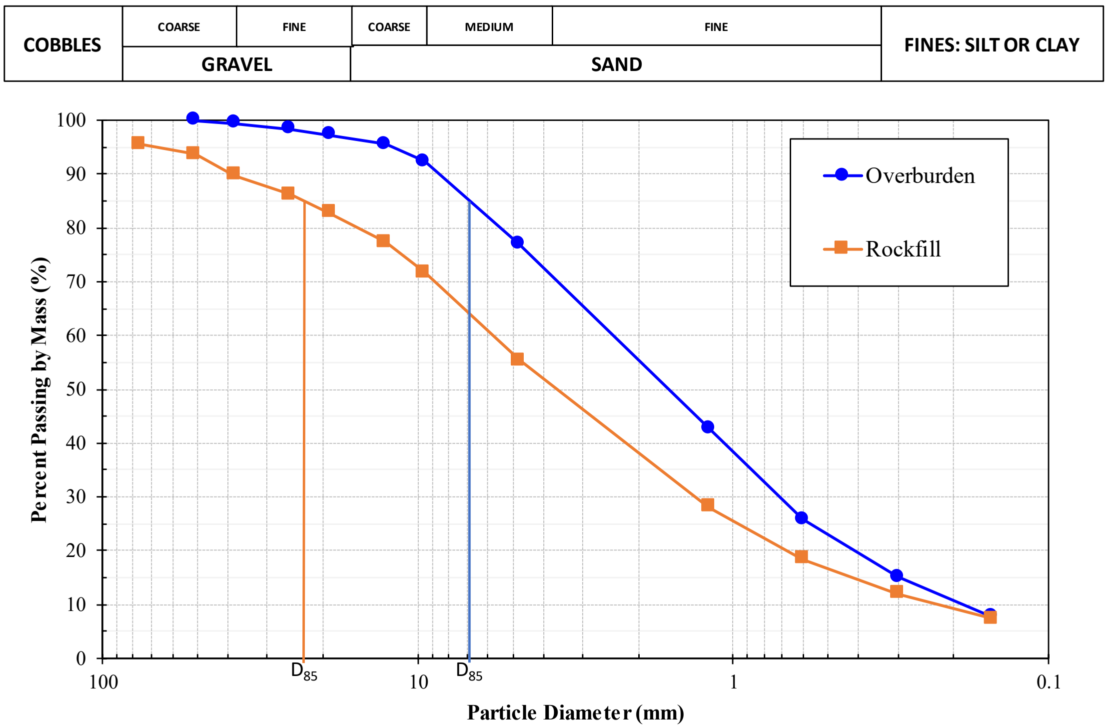


Figure A-1. Initial sieve analysis results for Overburden and Rockfill samples.

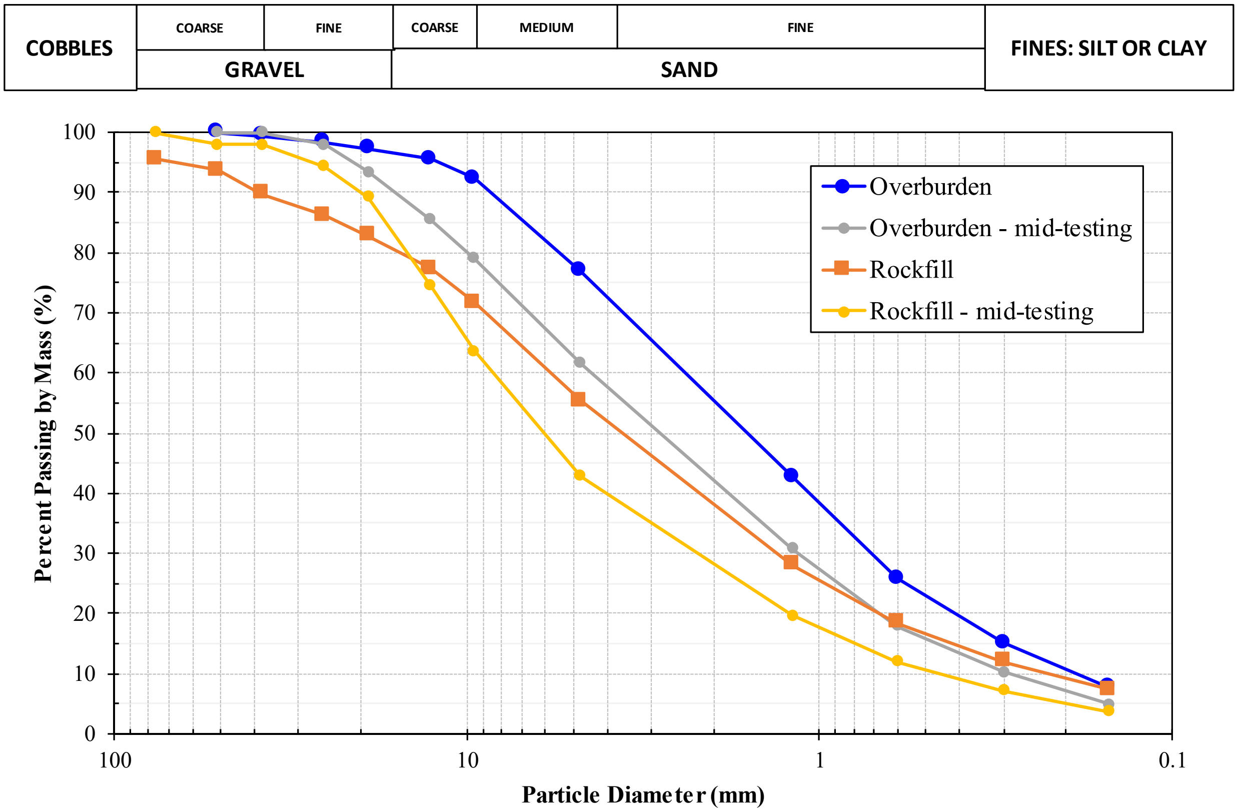


Figure A-2. Comparison of initial sieve analysis results for Overburden and Rockfill samples with those performed during LS-DSS testing.

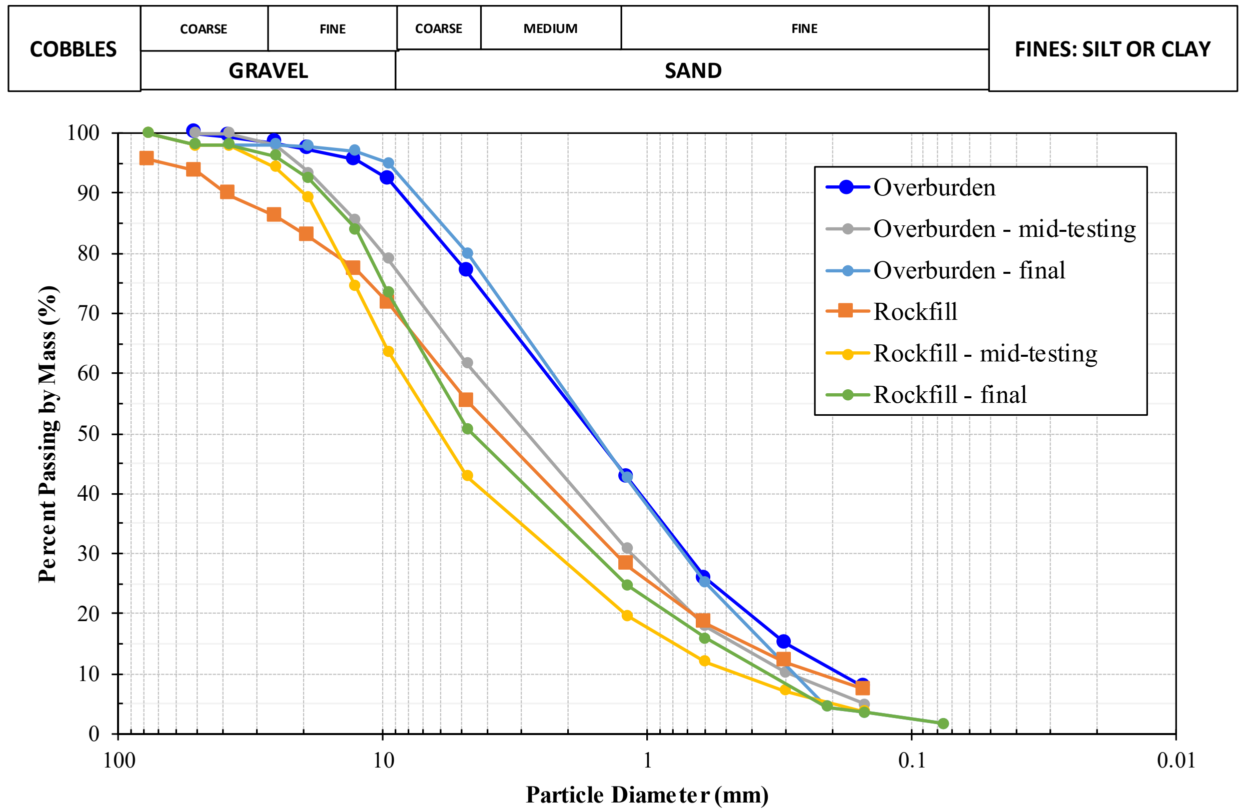


Figure A-3. Comparison of initial sieve analysis results for Overburden and Rockfill samples with the final sieve analysis results after all LS-DSS testing was complete.

Standard Proctor Compaction

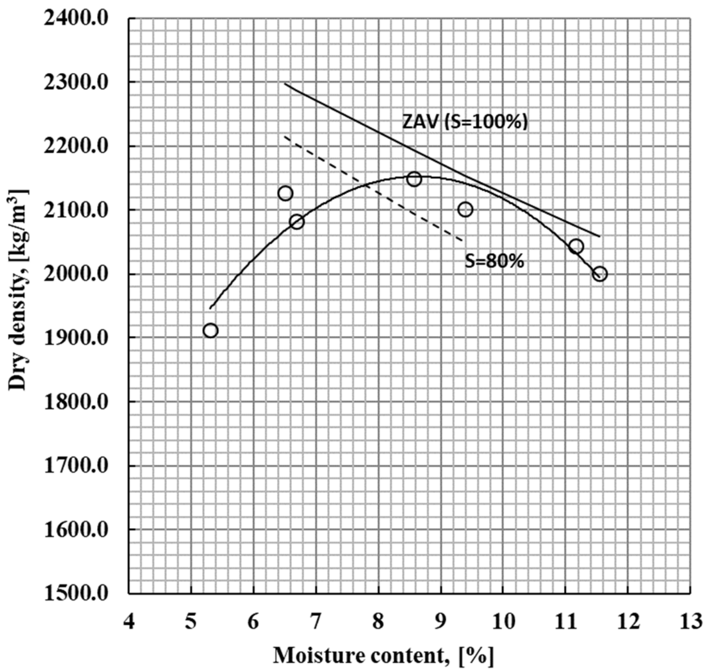


Figure A-4. Moisture-density relationship for Rockfill soil determined by Proctor compaction using standard effort.

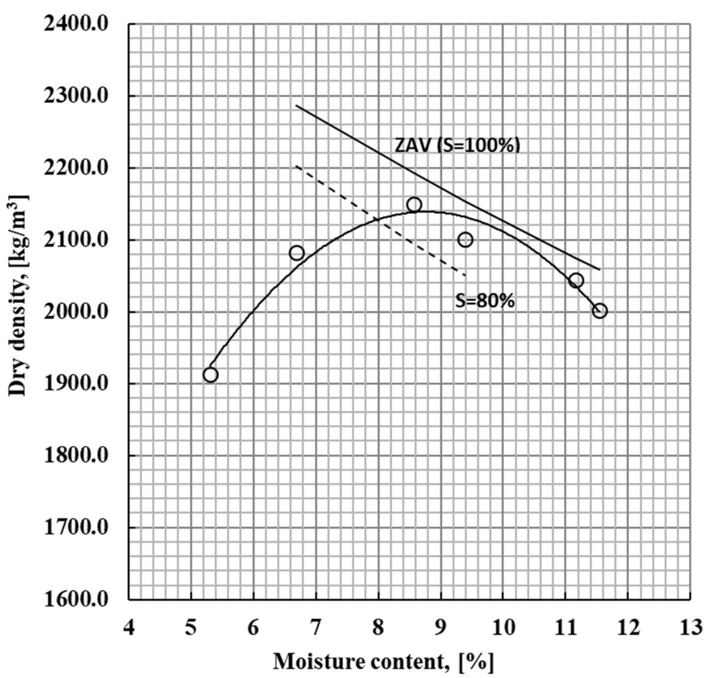


Figure A-5. Adjusted moisture-density relationship for Rockfill soil determined by Proctor compaction using standard effort. The curve was adjusted by removing the point at a water content of 6.5%. The new maximum density is 2138.7 kg/m^3 at an optimum water content of 8.76%.

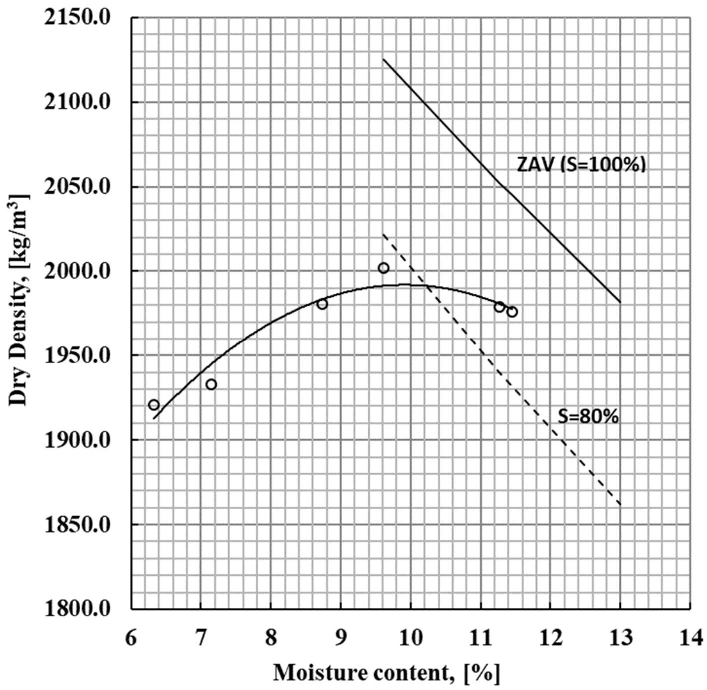


Figure A-6. Moisture-density relationship for Overburden soil determined by Proctor compaction using standard effort.

LS-DSS

LS-DSS Test Designation Results Summary Table

				@ End of Consolidation			Shearing						
Material	Test No.	Date	Sample Mass (kg)	Z stroke	Specimen Height (mm)	Density (kg/m3)	Maximum Shear Stress (kPa)	Maximum Vertical Effective Stress, σ'v (kPa)	Maximum Excess Pore Pressure, Δu_{ex} (kPa)	Peak Effective Stress Ratio*, τ/σ'v	Peak Effective Stress Ratio (Top), τ/σ'v	Peak Effective Stress Ratio (Bottom), τ/σ'v	TESTING NOTES
Rockfill	RL-35-1	11/22/2022	78.4	-50.51	140.59	2025.21	98.16	244.84	80.57	0.51	0.52	0.51	Leak occurred at approximately 11% shear strain
	RL-35-2	12/9/2022	78.4	-52.30	142.37	1998.43	76.27	251.42	115.25	0.56	0.53	0.6	Successful with no leaks
	RL-100-1	12/16/2022	78.4	-46.86	136.96	2082.16	258.89	687.82	156.28	0.47	0.47	0.47	Successful with no leaks
	RD-35-1	1/16/2023	109.6	-100.95	190.67	2055.35	121.73	241.38	107.75	0.7	0.70	0.69	Static backpressure lowered during shearing
	RD-35-2	2/13/2023	109.6	-97.46	187.20	2095.12	103.93	245.84	92.2	0.65	0.60	0.73	Successful with no leaks
	RD-100-1	2/27/2023	109.6	-92.29	182.07	2156.80	236.92	693.46	216.04	0.48	0.39	0.52	Successful with no leaks
Overburden	OL-25-1	11/30/2022	67.7	-47.00	137.10	1796.06	62.55	160.23	54.67	0.59	0.62	0.57	Successful with no leaks
	OL-60-1	1/19/2023	69.9	-43.23	133.35	1909.80	144.19	419.1	49.83	0.39	0.39	0.39	Leak occurred at approximately 9% shear strain
	OL-60-2	1/27/2023	69.9	-46.72	136.82	1858.43	186.81	417.25	93.32	0.58	0.57	0.58	Successful with no leaks
	OL-100-1	2/16/2023	69.9	-41.74	131.88	1932.59	342.8	694.32	110.33	0.57	0.57	0.57	Successful with no leaks

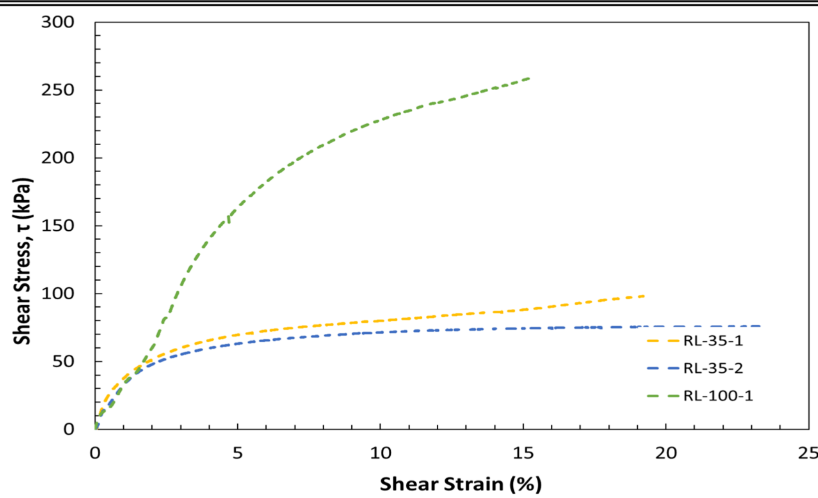
* NOTES: Peak Effective Stress Ratio determined using average excess pore pressure values

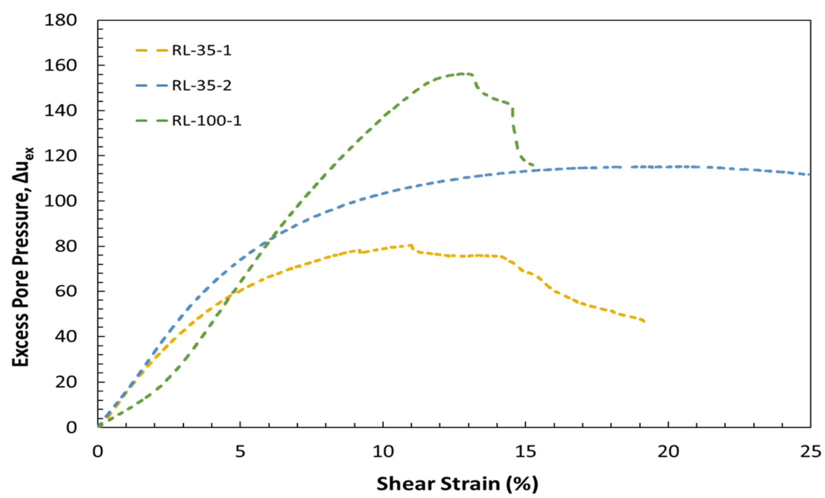
Rockfill LS-DSS Results

Consolidated Undrained Monotonic Direct Simple Shear

Shearing Stage Report	**Project:** KP-22-1		Report Date:	3/22/2023
Sample Designation:	Rockfill Loose			
Specimen Diameter:	24"			
Description:	Bulk sample from 67-462 ft, color varied, clayey or silty sand with gravel & cobbles			
Test Date:		11/22/2023	1/19/2023	1/27/2023

Sample Parameters:	Symbol	Units	***RL-35-1***	***RL-35-2***	***RL-100-1***
Initial Dry Density	ρ_d	(kg/m^3)	2025.21	1998.42	2082.16
Initial Sample Height	H_i	(mm)	140.59	142.37	136.96
Initial Pore Pressure (Top)	$u_{0,top}$	(kPa)	34.38	3.39	17.16
Initial Pore Pressure (Bottom)	$u_{0,top}$	(kPa)	27.54	3.92	13.79
Max Excess Pore (average)	$\Delta u_{ex,max}$	(psi)	80.57	115.25	156.28
Max Shear Stress	τ_{max}	(kPa)	98.16	76.27	258.89





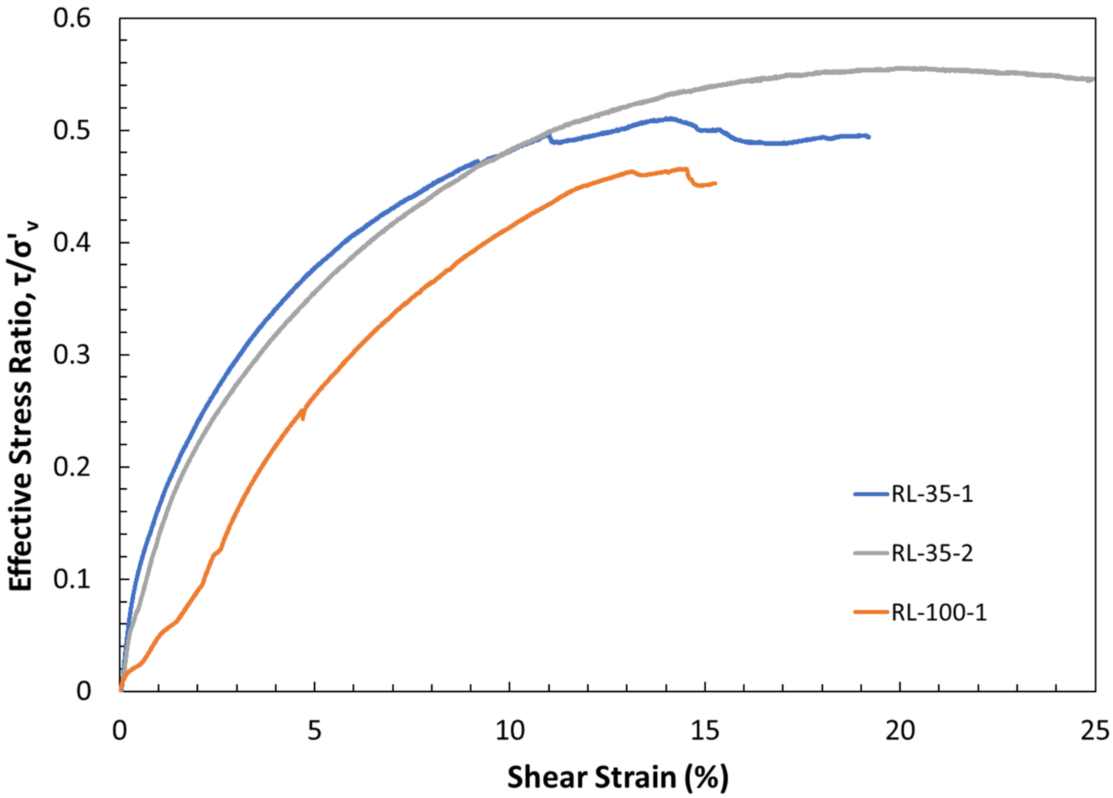
Date - Samples received:	5/13/2022			**University of Arkansas Granular Mechanics Research Laboratory**
Prepared by:	Ruimin Feng	Date:	3/2/2023	
Checked by:	Dr. Michelle Barry	Date:	5/10/2023	

Consolidated Undrained Monotonic Direct Simple Shear

Shearing Stage Report	**Project:** KP-22-1		Report Date:	3/22/2023
Sample Designation:	Rockfill Loose			
Specimen Diameter:	24"			
Description:	Bulk sample from 67-462 ft, color varied, clayey or silty sand with gravel & cobbles			
Test Date:		11/22/2023	1/19/2023	1/27/2023

Sample Parameters:	Symbol	Units	***RL-35-1***	***RL-35-2***	***RL-100-1***
Max Vertical Effective Stress **	$\sigma'_{v,max}$	(kPa)	244.84	251.42	687.82
Peak Effective Stress Ratio **	τ/σ	(-)	0.51	0.56	0.47
Peak Effective Stress Ratio (top)	τ/σ	(-)	0.52	0.53	0.47
Peak Effective Stress Ratio (bot)	τ/σ	(-)	0.51	0.60	0.47

**** Average Pore Pressure Used for Calculation**



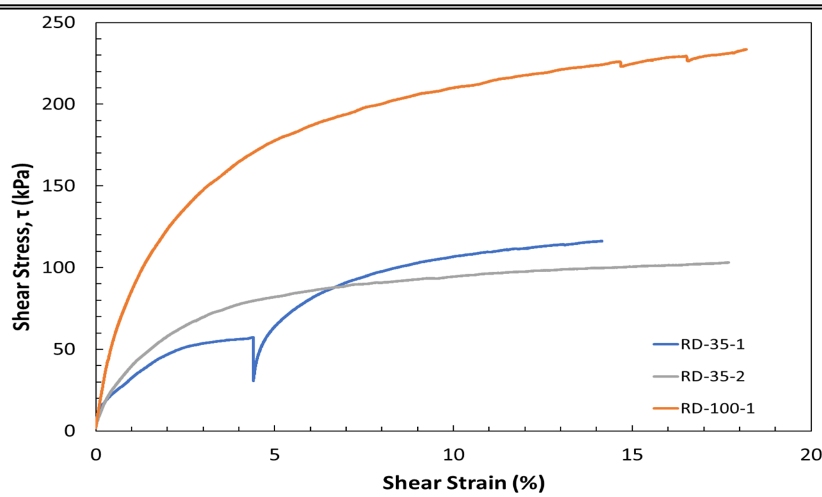
Date - Samples received:		5/13/2022		University of Arkansas Granular Mechanics Research Laboratory
Prepared by:	Ruimin Feng	Date:	3/2/2023	
Checked by:	Dr. Michelle Barry	Date:	5/10/2023	

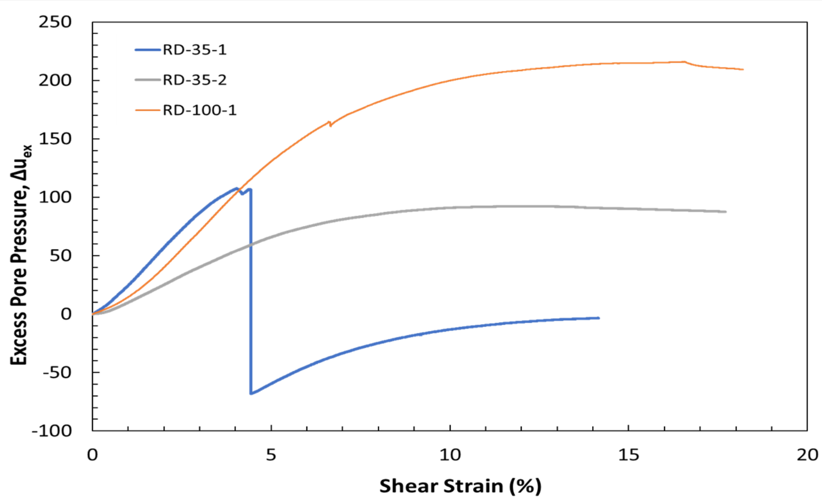
Consolidated Undrained Monotonic Direct Simple Shear

Shearing Stage Report | **Project:** KP-22-1 | Report Date: 3/22/2023

Sample Designation:	Rockfill Dense				
Specimen Diameter:	24"				
Description:	Bulk sample from 67-462 ft, color varied, clayey or silty sand with gravel & cobbles				
Test Date:			1/16/2023	2/13/2023	2/27/2023

Sample Parameters:	Symbol	Units	***RD-35-1***	***RD-35-2***	***RD-100-1***
Initial Dry Density	ρ_d	(kg/m^3)	2055.35	2095.12	2156.80
Initial Sample Height	H_i	(mm)	190.67	187.20	182.07
Initial Pore Pressure (Top)	$u_{0,top}$	(kPa)	105.25	29.21	9.31
Initial Pore Pressure (Bottom)	$u_{0,top}$	(kPa)	101.47	31.52	10.29
Max Excess Pore (average)	$\Delta u_{ex,max}$	(psi)	107.75	92.20	216.04
Max Shear Stress	τ_{max}	(kPa)	121.73	103.93	236.92





Date - Samples received:	5/13/2022		
Prepared by:	Ruimin Feng	Date:	3/2/2023
Checked by:	Dr. Michelle Barry	Date:	5/10/2023

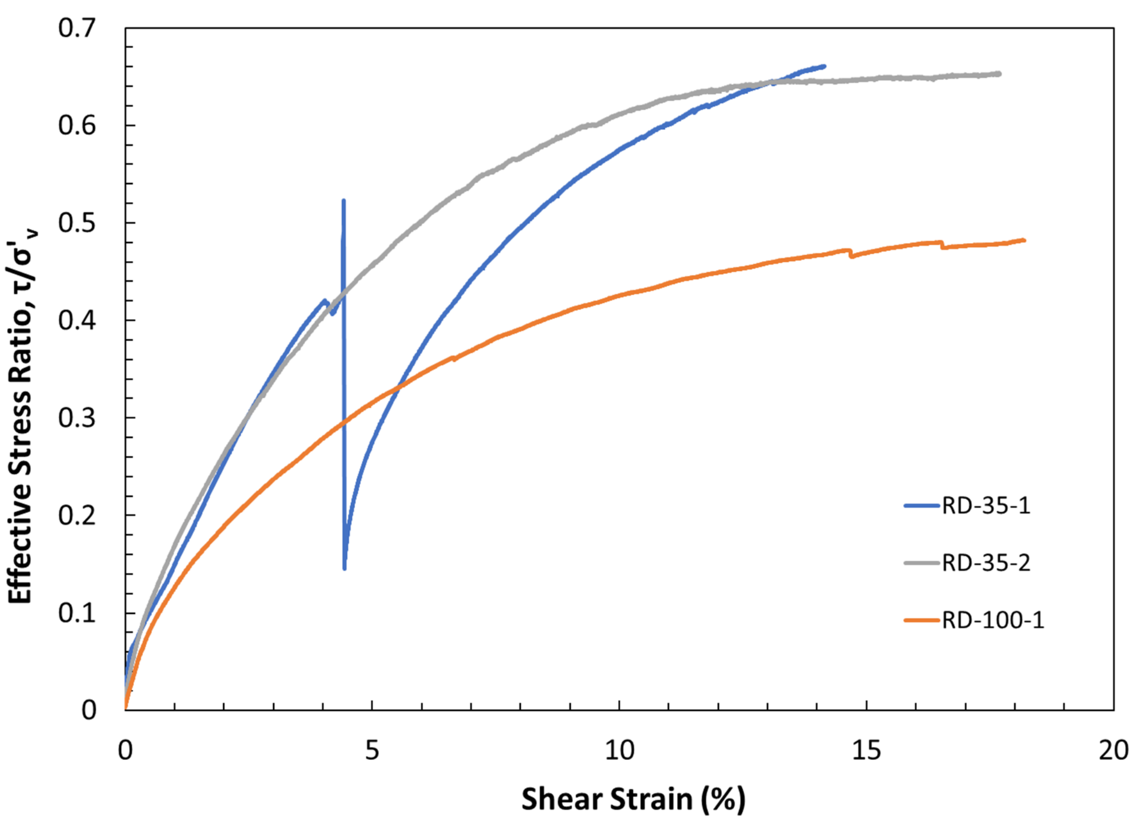
University of Arkansas Granular Mechanics Research Laboratory

Consolidated Undrained Monotonic Direct Simple Shear

Shearing Stage Report	**Project:** KP-22-1		Report Date:	3/22/2023
Sample Designation:	Rockfill Dense			
Specimen Diameter:	24"			
Description:	Bulk sample from 67-462 ft, color varied, clayey or silty sand with gravel & cobbles			
Test Date:		1/16/2023	2/13/2023	2/27/2023

Sample Parameters:	Symbol	Units	***RD-35-1***	***RD-35-2***	***RD-100-1***
Max Vertical Effective Stress **	$\sigma'_{v,max}$	(kPa)	241.38	245.84	693.46
Peak Effective Stress Ratio **	τ/σ	(-)	0.70	0.65	0.48
Peak Effective Stress Ratio (top	τ/σ	(-)	0.70	0.60	0.39
Peak Effective Stress Ratio (bot	τ/σ	(-)	0.69	0.73	0.52

** **Average Pore Pressure Used for Calculation**



Date - Samples received:	5/13/2022		
Prepared by:	Ruimin Feng	Date:	3/2/2023
Checked by:	Dr. Michelle Barry	Date:	5/10/2023

University of Arkansas
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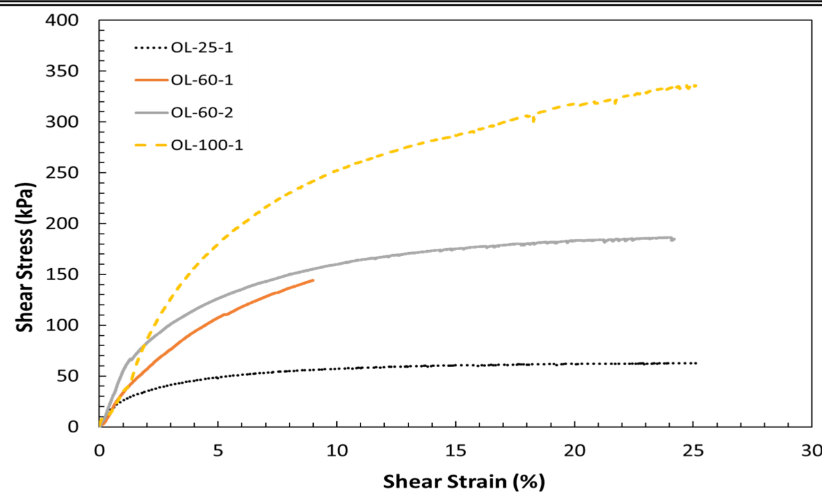
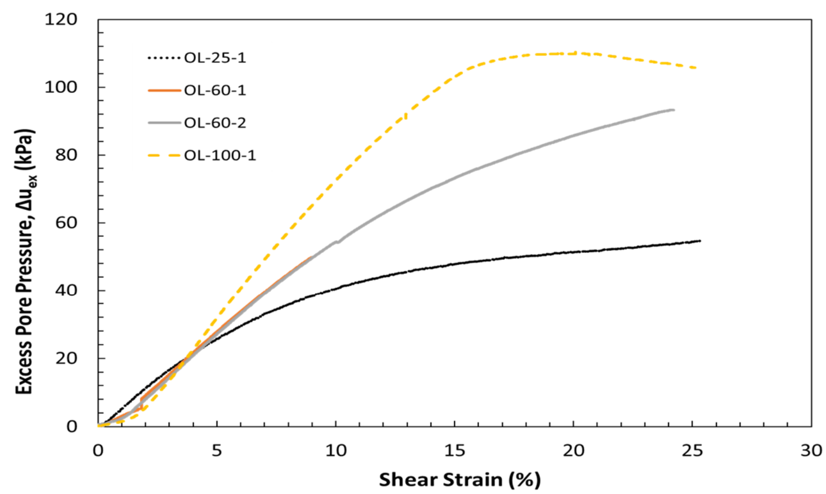
Research Laboratory

Overburden LS-DSS Results

Consolidated Undrained Monotonic Direct Simple Shear

Shearing Stage Report	**Project:** KP-22-1			Report Date:	3/22/2023	
Sample Designation:	Overburden					
Specimen Diameter:	24"					
Description:	Bulk sample retrieved from 17-50 ft, light brown clayey or silty sand with some gravel					
Test Date:			11/30/2022	1/19/2023	1/27/2023	2/16/2023
Sample Parameters:	Symbol	Units	***OL-25-1***	***OL-60-1***	***OL-60-2***	***OL-100-1***
Initial Dry Density	ρ_d	(kg/m^3)	1796.06	1909.80	1858.43	1932.59
Initial Sample Height	H_i	(mm)	137.1	133.35	136.82	131.88
Initial Pore Pressure (Top)	$u_{0,top}$	(kPa)	17.16	8.90	8.28	8.97
Initial Pore Pressure (Bottom)	$u_{0,top}$	(kPa)	7.32	8.87	12.40	10.53
Max Excess Pore (average)	$\Delta u_{ex,max}$	(psi)	54.67	49.83	93.32	110.33
Max Shear Stress	τ_{max}	(kPa)	62.55	144.19	186.81	342.80





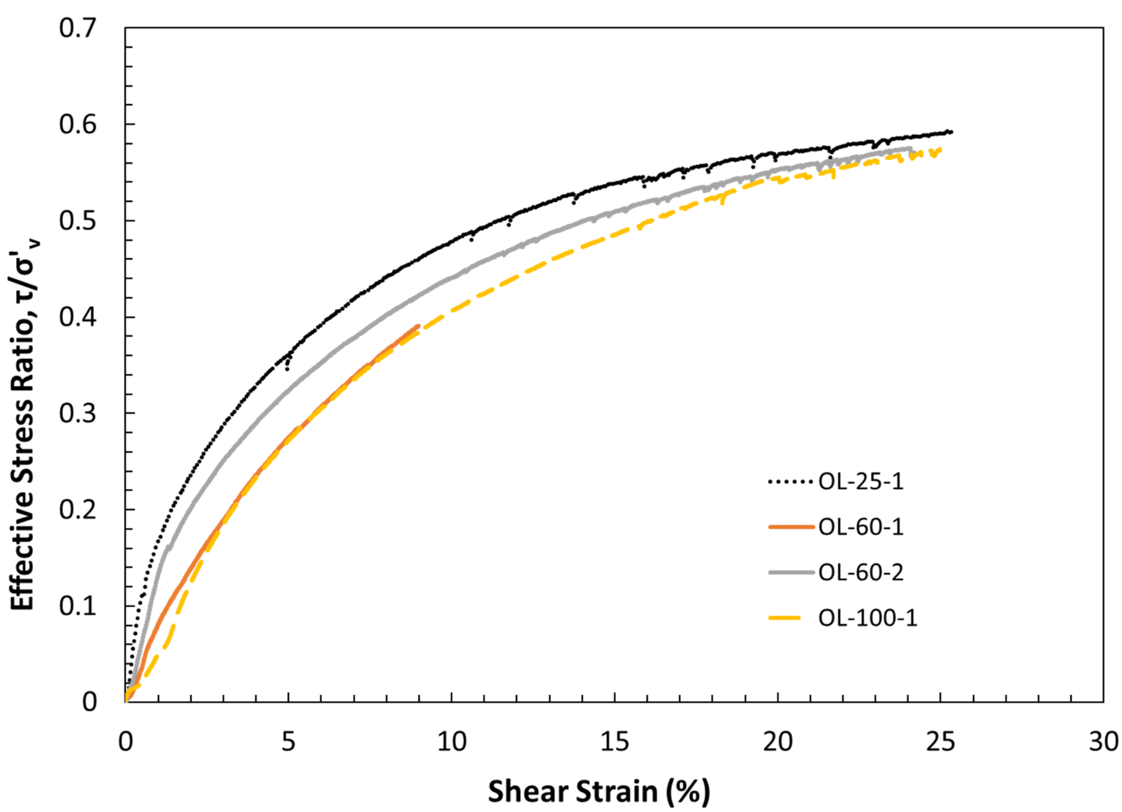
Date - Samples received:	5/13/2022		
Prepared by:	Ruimin Feng	Date:	3/2/2023
Checked by:	Dr. Michelle Barry	Date:	5/10/2023

University of Arkansas
Granular Mechanics
Research Laboratory

Consolidated Undrained Monotonic Direct Simple Shear

Shearing Stage Report	**Project:** KP-22-1		Report Date:	3/22/2023		
Sample Designation:	Overburden					
Specimen Diameter:	24"					
Description:	Bulk sample retrieved from 17-50 ft, light brown clayey or silty sand with some gravel					
Test Date:			11/30/2022	1/19/2023	1/27/2023	2/16/2023
Sample Parameters:	Symbol	Units	***OL-25-1***	***OL-60-1***	***OL-60-2***	***OL-100-1***
Max Vertical Effective Stress **	$\sigma'_{v,max}$	(kPa)	160.23	419.10	417.25	694.32
Peak Effective Stress Ratio **	τ/σ	(-)	0.59	0.39	0.58	0.57
Peak Effective Stress Ratio (top)	τ/σ	(-)	0.62	0.39	0.57	0.57
Peak Effective Stress Ratio (bot)	τ/σ	(-)	0.57	0.39	0.58	0.57

** **Average Pore Pressure Used for Calculation**



Date - Samples received:	5/13/2022			**University of Arkansas Granular Mechanics Research Laboratory**
Prepared by:	Ruimin Feng	Date:	3/2/2023	
Checked by:	Dr. Michelle Barry	Date:	5/10/2023	

APPENDIX B. DATASHEETS

SAMPLE INVENTORY
FOR: Julie Castellanos, Knight Piesold Ltd.
TESTING BY: University of Arkansas Granular Mehcanics Research Laboratory
GMRL Project No.: KP-22-1

Shipped From:	Cheri Galle	Shipped To:	Michelle Barry
	Montana Resources, Inc.		800 W. Dickson
	600 Shields		4190 Bell Engineering Center
	Butte, MT 59701		Fayetteville, AR 72701
	(406) 496-3222		(817) 487-2389

SAMPLES RECEIVED

No.	Sample Name	Sample Label	Sample Depth	Sample Type	Sampling Method	Other Identifiers	
1	Rockfill	DH15-S5	363-452	Bulk	Sonic	A	VA101-126/25
2	Rockfill	DH15-S5	453-457	Bulk	Sonic	A	VA101-126/26
3	Rockfill	DH15-S5	457-462	Bulk	Sonic	A	VA101-126/27
4	Rockfill	DH17-S2	408-412	Bulk	Sonic	A	VA101-126/28
5	Rockfill	DH19-S7	121-139	Bulk	Sonic	A	VA101-126/29
6	Rockfill	DH19-S7	170-177	Bulk	Sonic	A	VA101-126/30
7	Rockfill	DH19-S7	441-447	Bulk	Sonic	A	VA101-126/31
8	Rockfill	DH20-S1	67-73	Bulk	Sonic	A	VA101-126/32
9	Rockfill	DH20-S1	180-184	Bulk	Sonic	A	VA101-126/33
10	Rockfill	DH20-S1	203-204	Bulk	Sonic	A	VA101-126/34
11	Overburden	DH18-07	17-22	Bulk	Sonic	A - Older A1	VA101-126/35
12	Overburden	DH18-07	27-31	Bulk	Sonic	A - Older A1	VA101-126/36
13	Overburden	DH18-07	35-40	Bulk	Sonic	A - Older A1	VA101-126/37
14	Overburden	DH18-08	32-37	Bulk	Sonic	A - Older A1	VA101-126/38
15	Overburden	DH18-08	42-46	Bulk	Sonic	A - Older A1	VA101-126/39
16	Overburden	DH18-08	46-50	Bulk	Sonic	A - Older A1	VA101-126/40

Sieve Analysis – Rockfill

Initial Sieve Analysis

Project:	KP-22-1	
Soil Type/Name:	Rockfill	**Note:** Two 5-gal buckets of rockfill material (mass = 48.4 kg) was sieved to give a representative sample. Clumps were carefully broken up before sieving.
Date:	6/13/2022	
Max. Sieve Size:	3"	
Sieve Diameter/Length:	24"	
Mass of sample:	48.4 kg	

Sieve No.	Sieve Size (mm)	Mass of Material Retained (kg)	Mass of Material Passing (kg)	Percent of Material Passing, (%)
3.0 in	76.2	2.15	46.28	95.56
2.0 in	50.8	0.94	45.34	93.61
1.5 in	38.1	1.90	43.44	89.70
1 in	25.4	1.70	41.74	86.19
0.75 in	19.0	1.65	40.09	82.78
0.50 in	12.7	2.69	37.40	77.22
0.375 in	9.51	2.69	34.71	71.67
#4	4.76	7.90	26.81	55.36
#16	1.19	13.20	13.61	28.10
#30	0.6	4.65	8.96	18.50
#50	0.3	3.15	5.81	12.00
#100	0.15	2.26	3.55	7.33
Pan		3.55		
	Total=	48.43		----

Tested by : Ruimin Feng

Sieve Analysis Performed Mid-testing

Project:	**KP-22-1**	
Soil Type/Name:	Rockfill	**Note:** Two 5-gal buckets of rockfill material (mass = 48.4 kg) was sieved to give a representative sample. Clumps were carefully broken up before sieving.
Date:	1/9/2023	
Max. Sieve Size:	3"	
Sieve Diameter/Length:	24"	
Mass of sample:	77.5	

Sieve No.	**Sieve Size (mm)**	**Mass of Material Retained (kg)**	**Mass of Material Passing (kg)**	**Percent of Material Passing, (%)**
3.0 in	76.2	0.00	77.50	100.00
2.0 in	50.8	1.57	75.93	97.97
1.5 in	38.1	0.00	75.93	97.97
1 in	25.4	2.80	73.13	94.36
0.75 in	19.0	4.04	69.09	89.15
0.50 in	12.7	11.35	57.74	74.50
0.375 in	9.51	8.48	49.26	63.56
#4	4.76	16.02	33.24	42.89
#16	1.19	17.97	15.27	19.70
#30	0.6	5.93	9.34	12.05
#50	0.3	3.75	5.59	7.21
#100	0.15	2.74	2.85	3.68
Pan		2.85		
	Total=	77.50		----

Tested by : Ruimin Feng

Final Sieve Analysis

Project:	KP-22-1	
Soil Type/Name:	Rockfill	**Note:** One 5-gal bucket of rockfill material was sieved to give a representative sample. Clumps were carefully broken up before sieving.
Date:	4/1/2023	
Max. Sieve Size:	3"	
Sieve Diameter/Length:	24"	
Mass of sample:	23.15	

Sieve No.	Sieve Size (mm)	Mass of Material Retained (kg)	Mass of Material Passing (kg)	Percent of Material Passing, (%)
3.0 in	76.2	0.00	23.15	100.00
2.0 in	50.8	0.46	22.69	98.01
1.5 in	38.1	0.00	22.69	98.01
1 in	25.4	0.42	22.27	96.20
0.75 in	19.0	0.88	21.39	92.39
0.50 in	12.7	1.95	19.43	83.95
0.375 in	9.51	2.44	16.99	73.40
#4	4.76	5.26	11.73	50.69
#16	1.19	6.01	5.73	24.74
#30	0.6	2.05	3.68	15.90
#65	0.208	2.65	1.03	4.45
#100	0.15	0.20	0.83	3.59
#200	0.075	0.44	0.40	1.71
Pan		0.40	0.00	
	Total=	23.15		----

Tested by : Ben Davis

Sieve Analysis – Overburden

Initial Sieve Analysis

Project No:	KP-22-1	
Soil Type/Name:	Overburden	**Notes:** Two 5-gal buckets of overburden material (mass = 36.5 kg) was sieved to give a representative sample. Clumps were carefully broken up before sieving.
Date Tested:	6/13/2022	
Max. Sieve Size:	2"	
Sieve Diameter/Length:	24"	
Mass of sample:	36.5 kg	

Sieve No.	Sieve Size (mm)	Mass of Material Retained (kg)	Mass of Material Passing (kg)	Percent of Material Passing, (%)
2.0 in	50.8	0.00	36.48	100.00
1.5 in	38.1	0.24	36.24	99.36
1 in	25.4	0.36	35.88	98.36
0.75 in	19.0	0.40	35.48	97.27
0.50 in	12.7	0.62	34.86	95.57
0.375 in	9.51	1.22	33.64	92.23
#4	4.76	5.62	28.02	76.82
#16	1.19	12.46	15.56	42.66
#30	0.6	6.13	9.43	25.85
#50	0.3	3.92	5.51	15.11
#100	0.15	2.70	2.81	7.70
Pan		2.81		
	Total=	36.48		----

Tested by : Ruimin Feng

Sieve Analysis Performed Mid-testing

Project No:	**KP-22-1**	
Soil Type/Name:	Overburden	**Notes:** Two 5-gal buckets of overburden material (mass = 36.5 kg) was sieved to give a representative sample. Clumps were carefully broken up before sieving.
Date Tested:	1/9/2023	
Max. Sieve Size:	2"	
Sieve Diameter/Length:	24"	
Mass of sample:	67.95	

Sieve No.	Sieve Size (mm)	Mass of Material Retained (kg)	Mass of Material Passing (kg)	Percent of Material Passing, (%)
2.0 in	50.8	0.00	67.95	100.00
1.5 in	38.1	0.00	67.95	100.00
1 in	25.4	1.41	66.54	97.92
0.75 in	19.0	3.11	63.43	93.35
0.50 in	12.7	5.38	58.05	85.43
0.375 in	9.51	4.31	53.74	79.09
#4	4.76	11.89	41.85	61.59
#16	1.19	20.92	20.93	30.80
#30	0.6	8.73	12.20	17.95
#50	0.3	5.22	6.98	10.27
#100	0.15	3.66	3.32	4.89
Pan		3.32		
	Total=	67.95		----

Tested by : Ruimin Feng

Final Sieve Analysis

Project No:	KP-22-1	
Soil Type/Name:	Overburden	**Note:** One 5-gal bucket of rockfill material was sieved to give a representative sample. Clumps were carefully broken up before sieving.
Date Tested:	4/1/2023	
Max. Sieve Size:	3	
Sieve Diameter/Length:	8"	
Mass of sample:	23.5	

Sieve No.	Sieve Size (mm)	Mass of Material Retained (kg)	Mass of Material Passing (kg)	Percent of Material Passing, (%)
3.0 in	76.2	0.00	23.51	100.00
2.0 in	50.8	0.46	23.05	98.04
1.5 in	38.1	0.00	23.05	98.04
1 in	25.4	0.00	23.05	98.04
0.75 in	19.0	0.05	23.00	97.81
0.50 in	12.7	0.21	22.79	96.92
0.375 in	9.51	0.47	22.32	94.93
#4	4.76	3.52	18.80	79.96
#16	1.19	8.80	10.00	42.55
#30	0.6	4.09	5.92	25.16
#65	0.208	4.85	1.06	4.51
#100	0.15	0.23	0.83	3.52
#200	0.075	0.42	0.41	1.76
Pan		0.41	0.00	
	Total=	23.51		----

Tested by : Ben Davis

Wet Sieve Analysis

Initial Analysis

	Sieve No.	Sieve Size (mm)	Mass of Material Retained (kg)	Mass of Material Passing (kg)	Percent of Material Passing, (%)
Overburden	#4	4.76	0.15	0.85	84.73
	#200	0.0075	0.68	0.17	16.97
	Pan		0.17	----	----
		Total=	1.0	----	----
	Sieve No.	**Sieve Size (mm)**	**Mass of Material Retained (kg)**	**Mass of Material Passing (kg)**	**Percent of Material Passing, (%)**
Rockfill	#4	4.76	0.18	0.82	81.74
	#200	0.0075	0.54	0.28	27.45
	Pan		0.28	----	----
		Total=	1.0	----	----

Final Analysis

	Sieve No.	Sieve Size (mm)	Mass of Material Retained (kg)	Mass of Material Passing (kg)	Percent of Material Passing, (%)
Overburden	#4	4.76	0.21	10.39	98.02
	#200	0.0075	7.99	2.40	22.64
	Pan		2.40	----	----
		Total=	10.6	----	----
	Sieve No.	**Sieve Size (mm)**	**Mass of Material Retained (kg)**	**Mass of Material Passing (kg)**	**Percent of Material Passing, (%)**
Rockfill	#4	4.76	1.92	8.48	81.54
	#200	0.0075	5.50	2.98	28.65
	Pan		2.98	----	----
		Total=	10.4	----	----

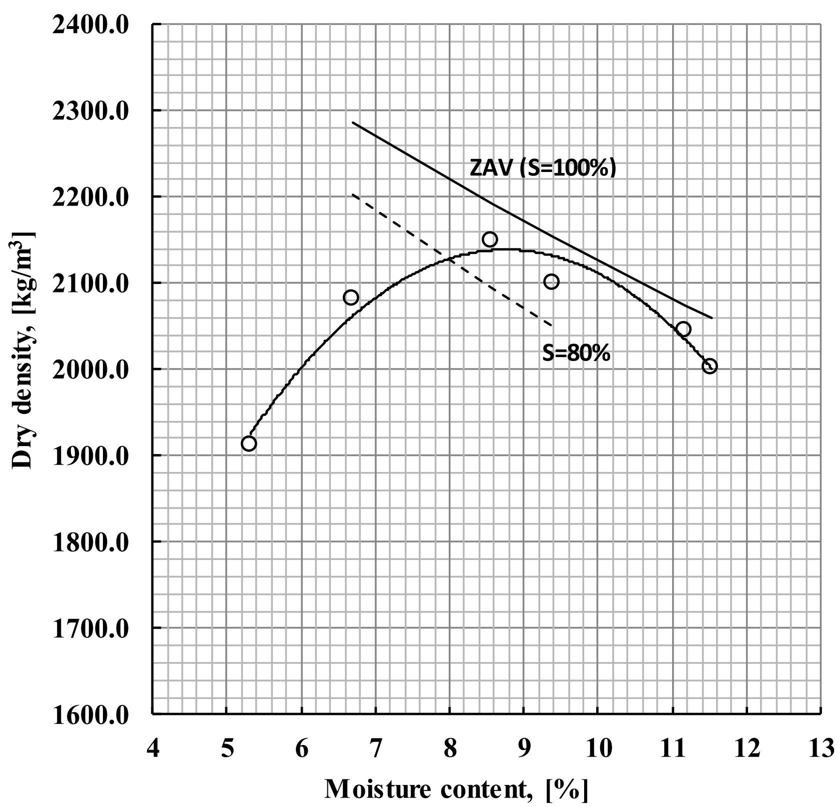
Moisture – Density Relationships

Rockfill

		Gs=	
		2.7	
wactual (%)	ρ_{dry} (kg/m^3)	Zero air voids(100%)	80% saturation
5.31	1912.98		
	2127.71	2700.00	2700.00
6.69	2082.81	2286.72	2202.44
8.56	2148.85	2192.96	2094.63
9.39	2101.21	2153.95	2050.29
11.16	2044.78	2074.63	1961.07
11.53	2001.73	2058.91	1943.54

ρ_{dry} (kg/m^3)	2138.7
$\gamma_{dry, max}$ (kN/m^3)	20.980647
w_{opt} (%)	8.76

90% RC
1924.83

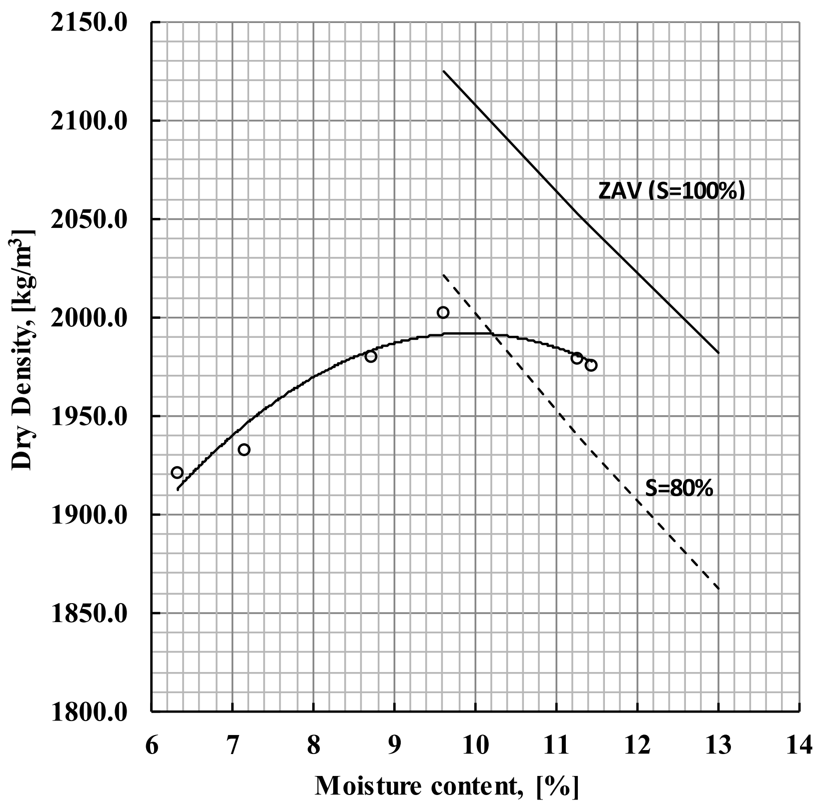


Overburden

		Gs=	
		2.67	
wactual (%)	ρ_{dry} (kg/m^3)	Zero air voids(100%)	80% saturation
6.32	1920.97		
7.15	1932.83		
8.73	1980.54		
9.61	2002.08	2124.87	2021.68
11.27	1978.90	2052.29	1940.08
11.45	1975.80	2044.98	1931.91
13		1982.04	1862.09

ρ_{dry} (kg/m^3)	1991.845056
$\gamma_{dry, max}$ (kN/m^3)	19.54
w_{opt} (%)	9.89

90% RC
1792.66055



LS-DSS Testing

LS-DSS Test Designation and Density Conditions Summary Tables

				@ 10 kPa (dry)			@ 10 kPa (saturated)		
Material	**Test Designation**	**Date**	**Sample Mass (kg)**	**Z stroke**	**Specimen Height (mm)**	**Density (kg/m3)**	**Z stroke**	**Specimen Height (mm)**	**Density (kg/m3)**
Rockfill	**RL-35-1**	11/22/2022	78.4	-82.09	171.94	1638.08	-67.61	157.57	**1795.44**
	RL-35-2	12/7/2022	78.4	-105.24	194.92	1436.81	-75.63	165.52	**1704.82**
	RL-100-1	12/16/2022	78.4	-109.71	199.36	1403.48	-75.94	165.84	**1701.42**
	RD-35-1	1/16/2023	109.6	-107.72	197.39	1982.43	-106.87	196.54	**1991.33**
	RD-35-2	2/13/2023	109.6	-104.95	194.63	2011.66	-104.77	194.46	**2013.56**
	RD-100-1	2/27/2023	109.6	-106.67	196.35	1993.40	-104.27	193.96	**2019.00**
Overburden	**OL-25-1**	11/30/2022	67.7	-103.04	192.74	1255.35	-65.04	155.01	**1577.31**
	OL-60-1	1/19/2023	69.9	-89.03	178.83	1401.65	-60.58	150.58	**1679.15**
	OL-60-2	1/27/2023	69.9	-105.43	195.11	1279.70	-74.99	164.89	**1526.09**
	OL-100-1	2/16/2023	69.9	-104.20	193.89	1288.12	-80.73	170.59	**1472.60**

		@ End of Consolidation			@ End of Shearing			
Material	**Test Designation**	**Z stroke**	**Specimen Height (mm)**	**Density (kg/m3)**	**Z stroke**	**Specimen Height (mm)**	**Density (kg/m3)**	**% Difference in specimen height during shearing**
Rockfill	**RL-35-1**	-50.51	140.59	2025.21	-47.57	137.67	2070.75	2.08
	RL-35-2	-52.30	142.37	1998.43	-50.31	140.39	2028.32	1.39
	RL-100-1	-46.86	136.96	2082.16	-44.23	134.35	2125.12	1.90
	RD-35-1	-100.95	190.67	2055.35	-97.03	186.77	2100.16	2.04
	RD-35-2	-97.46	187.20	2095.12	-95.10	184.85	2122.87	1.25
	RD-100-1	-92.29	182.07	2156.80	-89.01	178.81	2197.96	1.79
Overburden	**OL-25-1**	-47.00	137.10	1796.06	-43.62	133.75	1843.94	2.45
	OL-60-1	-43.23	133.35	1909.80	-40.57	130.71	1950.87	1.98
	OL-60-2	-46.72	136.82	1858.43	-42.27	132.40	1924.41	3.23
	OL-100-1	-41.74	131.88	1932.59	-36.76	126.93	2012.88	3.75

NOTES: Additional data for LS-DSS testing located in Excel spreadsheets and analysis summary spreadsheets

APPENDIX B2

Overburden Dynamic Strength Characterization

(Pages B2-1 to B2-93)

APPENDIX B2
OVERBURDEN DYNAMIC STRENGTH CHARACTERIZATION

1.0 INTRODUCTION

The stability assessment of the Yankee Doodle Tailings Impoundment (YDTI) considers three primary soil units: overburden, embankment rockfill, and tailings. The overburden unit overlies the bedrock beneath the YDTI. The rockfill unit forms the embankment dam and the tailings unit is impounded by the rockfill embankment.

Dynamic deformation analysis is an important component of the stability assessment to demonstrate the seismic response of the YDTI embankment during the design earthquake. The design studies for the proposed YDTI expansion incorporated laboratory testing programs to inform the selection of material parameters and numerical model calibration. This approach was successful for the overburden and tailings units; however, challenges were encountered with the cyclic testing program for the rockfill unit as described below.

Cyclic direct simple shear (CDSS) testing of overburden samples was completed in 2023 at the University of California, Berkeley (UC Berkeley) on 12-inch (diameter) specimens, which did not require modification of the particle size distribution (PSD). This appendix summarizes the cyclic strength characterization of the overburden unit and the associated laboratory testing data is included in the attached report by Zekkos and Sari (2023).

Laboratory testing (CDSS) was also successfully completed on samples of tailings. The tailings were tested in 2014, and the results are discussed in the attached University of British Columbia (UBC) report by Wijewickreme (2014).

Testing of rockfill samples were also attempted in 2023 at the University of Arkansas, where the 24-inch (diameter) direct simple shear (DSS) tests were successfully completed for the monotonic program (see Appendix B1). However, cyclic testing of the rockfill encountered challenges due to difficulty saturating the specimen, measuring pore pressures, and controlling the cyclic loading. The challenges were attributed to the larger particle size of the rockfill, which requires a larger (customized) apparatus to test without modifying the PSD. The testing was ultimately unsuccessful and as a result, rockfill properties for the dynamic analysis were assumed from literature and engineering judgement consistent with previous analyses (KP, 2018, 2022).

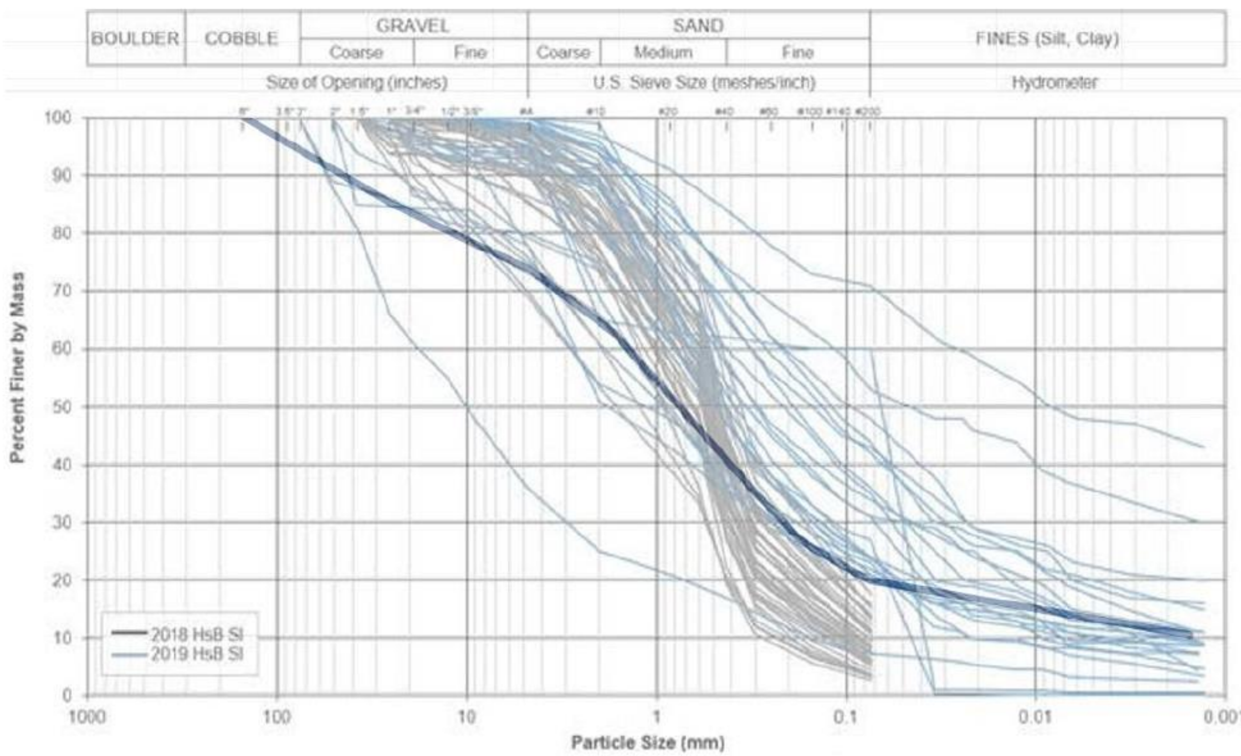
2.0 CYCLIC TESTING FRAMEWORK AND PROGRAM

The cyclic response of a saturated soil can be evaluated under DSS or triaxial loading conditions. The DSS mode focuses the evaluation on the horizontal component of the prescribed earthquake loading, which is consistent with the input used for the corresponding dynamic analysis. The triaxial mode considers complex multi-directional earthquake loading, which was not an evaluation goal for the current stability assessment.

The goal of the cyclic laboratory program was to estimate the undrained shear strength of the overburden under cyclic loading by estimating the number of cycles required for liquefaction at different cyclic stress ratios (CSR) and confining pressures. The triggering criteria used for defining liquefaction are based on industry experience. Liquefaction was defined at a single amplitude shear strain of 3.75% or an excess pore pressure ratio (r_u) of 0.9. These results are used to calibrate the constitutive model used in the dynamic analysis.

The CDSS testing was completed under constant volume and stress-controlled conditions. A cycling frequency of 0.033 Hz was used to maintain constant volume conditions of less than 0.025% vertical strain during shearing. Shear wave velocity measurements were taken following consolidation to estimate the stiffness of the specimen.

Six CDSS tests were conducted on older alluvium (overburden) specimens at consolidation (confinement) pressures that correspond to embankment heights of 15, 50, and 90 ft. These values of confinement are representative of the dam toe upstream of the unconfined HsB, with 90 ft (one third of the height of the Seep 10 bench) reaching the maximum limit of the testing apparatus. The test sample consisted of a composite of material collected from four drillholes (DH18-02, DH18-03, DH18-08 and DH18-09) completed during the 2018 Horseshoe Bend (HsB) site investigation program (KP, 2019). The PSD of the composite is compared to index testing from the 2018 and 2019 site investigations (KP, 2019, 2020) on Figure 2.1. The 2023 sample is well-graded with a medium plasticity index (PI) of 10. The sample material was initially placed as loose as possible to create the test specimens but compressed significantly during consolidation at higher confining pressures. Therefore, the samples were prepared to a denser initial state. The sample preparation is discussed in greater detail in the attached UC Berkeley report (Zekkos and Sari, 2023).



Note(s):

1. Thick blue line represents the PSD of the 2023 composite sample.

Figure 2.1 Overburden CDSS Particle Size Distribution

3.0 CYCLIC DIRECT SHEAR STRENGTH ESTIMATES

The overburden CDSS results are presented in Table 3.1 and the result sheets are included in the attached reports. The results generally indicate the expected trend that higher dynamic loads (CSR) require less cycles to trigger liquefaction.

Table 3.1 CDSS Test Results

Test No.	Consolidation stress, σ'_{vc} (kPa)	CSR	Dry Density[1] (kg/m^3)	Relative Density[1]	Vs[1] (m/sec)	Number of cycles to reach γ[2]= 3.75%	Number of cycles to reach r_u[3] = 0.9
1	100	0.10	1739.9	0.83	198	34	31
2	100	0.20	1677.3	0.72	177	2	2
3	100	0.15	1674.2	0.72	202	13	10
4	550	0.15	1808.1	0.95	292	2	3
5	550	0.10	1788.8	0.92	304	28	24
6	300	0.13	1734.7	0.83	246	20	16

Note(s):

1. After consolidation and prior to shearing.
2. Single amplitude shear strain.
3. Excess pore pressure ratio.

The strength of the overburden for resisting earthquakes was estimated from the CDSS results in the form of a cyclic resistance ratio (CRR), as shown on Figure 3.1. A power regression was fit through the data points of the lowest confining pressure of 100 kPa (2,090 psf), which represents an approximate embankment height of 15 ft. Two CRR values were determined with the first for a reference moment magnitude (M) 7.5 earthquake that is used to estimate the site-specific M 7.0 earthquake through scaling. The reference $CRR_{M=7.5}$ of 0.13 is associated with the CSR required to trigger liquefaction (3.75% strain) after 15 cycles. The corresponding site-specific $CRR_{M=7.0}$ was estimated at 0.16 by applying the revised Idriss Magnitude Scaling Factor of 1.19 (Youd et al., 2001) to the reference $CRR_{M=7.5}$.

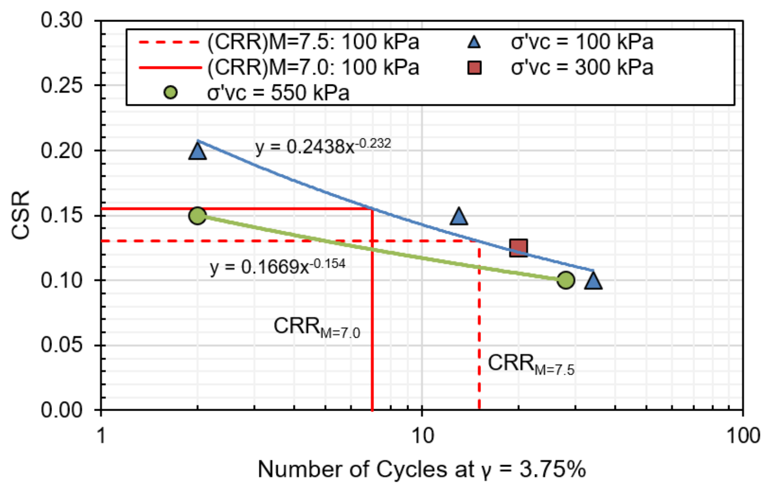


Figure 3.1 Number of Cycles Required to Liquefy Overburden Specimens

The effect of confinement was corrected by fitting a second curve through the data points of the highest confining pressure, which represents an approximate embankment height of 90 ft. The corresponding site-specific $CRR_{M=7.0}$ was reduced approximately 20%.

The number of cycles to reach a value of 0.9 for r_u is shown on Figure 3.2. The excess pore pressure ratio is defined as $r_u = \frac{\Delta u}{\sigma'_{vc}}$, which represents the change in pore pressure to the initial overburden stress. The results show similar trends to Figure 3.1, indicating a similar number of cycles is required to trigger liquefaction. The r_u trends also provide consistency for defining liquefaction at a shear strain of 3.75%, which was reached at a corresponding value of 0.9 for r_u.

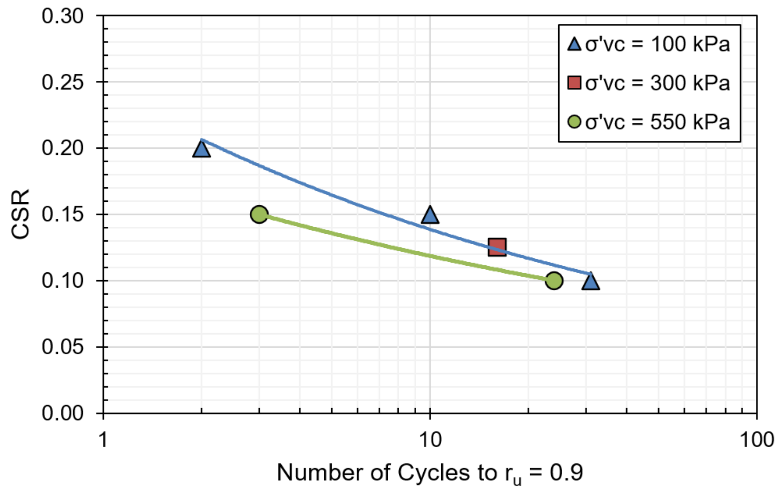


Figure 3.2 Number of Cycles to Generate an Excess Pore Water Pressure Ratio of 0.9

4.0 CONCLUSIONS AND RECOMMENDATIONS

The 2023 cyclic laboratory program on the composite overburden sample provided an initial estimate of its dynamic response and provides a sound basis for updating properties to complete the dynamic analysis. As expected, less cycles are required to trigger liquefaction with increasing earthquake loading. Consistency was demonstrated in the definition of the triggering criteria since a similar number of cycles was required to reach a shear strain of 3.75% and excess pore pressure ratio of 0.9.

Additional strength testing is recommended to fill knowledge gaps (rockfill) and increase the overburden database for a more comprehensive strength characterization. Current scoping with the UC Berkeley laboratory includes testing composite samples of both rockfill and overburden. Testing of 12-inch diameter rockfill specimens will require modification to the sample PSD; however, efforts will be made to minimize the modification. Testing of the overburden will focus on expanding the knowledge base to higher confining pressures and to evaluate possible size effects by utilizing a smaller apparatus of 4-inch diameter. Future testing of both units should evaluate variability, such as evaluating the differences between the recent and older alluvium as well as the source (Berkeley and Continental Pits) and construction variability of the embankment rockfill.

5.0 REFERENCES

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Knight Piésold Ltd. (KP), 2019. Yankee Doodle Tailings Impoundment – 2018 Horseshoe Bend Geotechnical Site Investigation. May 27. Vancouver, BC. Ref. No. VA101-126/20-1, Rev 0.

Knight Piésold Ltd. (KP), 2020. Yankee Doodle Tailings Impoundment – 2019 Horseshoe Bend Geotechnical Site Investigation. December 1. Vancouver, BC. Ref. No. VA101-126/22-1, Rev 0.

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Wijewickreme, D., 2014. Letter to: Graham Greenway, KP. Re: Constant Volume Cyclic Direct Simple Shear Testing Montana Resources Tailings. November 28. Project No. 14-KPL-001.

Zekkos, D. and Sari, S.B., 2023. Data Report on Large-Diameter Simple Shear Testing of Alluvial Soils at Montana Resources Site. Department of Civil and Environmental Engineering University of California at Berkeley. December 12. Berkeley, CA. Report No. UCB/GT/2023-02.

Attachments:
UBC Report - Constant Volume Cyclic Direct Simple Shear Testing, Montana Resources Tailings
UC Berkeley Report - Data Report on Large-Diameter Simple Shear Testing of Alluvial Soils at Montana Resources Site

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Our Project No: 14-KPL-001
November 28, 2014

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Attn: Graham Greenway, M.Sc, P.Eng
Specialist Engineer / Project Manager

RE: CONSTANT VOLUME CYCLIC DIRECT SIMPLE SHEAR TESTING MONTANA RESOURCES TAILINGS

Dear Mr. Greenway:

Further to your request, a series of laboratory constant volume (i.e., equivalent to undrained) cyclic direct simple shear (CDSS) tests were conducted on specimens prepared from two bag samples of tailings provided by Knight Piésold, Ltd. The CDSS tests were performed to determine the stress-strain and excess pore water pressure response of the materials under cyclic and post-cyclic monotonic loading conditions. In addition, some specific gravity tests, density tests analysis, and particle size distribution analysis were performed on a number of tailing samples contained in brass tubes as provided by Knight Piésold. This report is intended to present the results of these tests along with a summary of the specimen preparation and test procedure(s) of CDSS tests.

1.0 GENERAL INFORMATION

Two bulk samples of light grey tailings identified as “Fine Tailings – Area 2” and “Coarse Tailings - Area 3” in bags, and six brass tube samples labeled as “BT-04, 05, 06, 12, 13, and 14”, delivered to us by Knight Piésold was used for the requested CDSS and other index tests. As per instructions provided by Knight Piésold, the in-situ density and moisture content assessments were performed using the tailings materials provided in the brass tube samples; the specific gravity tests were conducted on the tailings specifically contained in the tubes BT-4 and BT-12. The particle size distribution analyses (i.e., sieve and hydrometer analyses) were performed on the tailings that were provided in bag samples labelled as Area-2 and Area-3.

The key test parameters including: initial consolidation stresses (σ'_{vc}), cyclic stress ratio (τ_{cyc}/σ'_{vc} = CSR), cyclic loading termination criteria, and post-cyclic testing requirements for the laboratory CDSS test program were also provided by Knight Piésold as appropriate.

All the tests were carried out at the University of British Columbia (UBC) Geotechnical Research Laboratory by engineering personnel experienced in the area of advanced geotechnical laboratory testing under the supervision of Dr. D. Wijewickreme, P.Eng.

2.0 TEST DEVICE

The cyclic direct simple shear test (DSS) device at the University of British Columbia (UBC) was used for the DSS testing; the device essentially follows the simple shear testing methodology of the NGI-type DSS apparatus described by Bjerrum and Landva (1966)[1]. In the test device, a cylindrical soil sample, 70 mm in diameter and ~20 mm in height, is placed in a reinforced rubber membrane. The reinforced rubber membrane is stiff enough to constrain any lateral deformations and therefore, the soil behavior is essentially in a state of zero lateral strain during consolidation and shear loading. Simple shear tests can be conducted in drained condition or constant volume condition. In constant-volume DSS tests, constant volume condition is enforced by constraining the sample boundaries (diameter and height) against changes. The sample diameter is already constrained against lateral strain using reinforced rubber membrane, and the height constraint is attained by clamping the vertical movement of the top and bottom loading caps. Previous research has shown that the decrease (or increase) of vertical stress in a constant-volume DSS test is essentially equal to the increase (or decrease) of excess pore water pressure in an undrained DSS test where the near constant volume condition is maintained by not allowing the mass of pore water to change.

The DSS apparatus consists of horizontal and vertical loading systems. The vertical loading system consists of a single acting air piston, which can be precisely controlled by an external manually controlled air pressure regulator. A double acting air piston that is coupled in series with a constant speed motor drive is used to apply the horizontal load. The coupled horizontal loading system enables the system to provide a smooth transition from stress-controlled to strain-controlled loading and vice versa. Cyclic loading in stress-controlled mode is applied by changing the pressure on one side of the double acting piston by means of an electro-pneumatic regulator, while holding the pressure on the other side constant. The electro-pneumatic regulator is coupled with a data acquisition system and computer, which enables to apply prescribed form of sinusoidal cyclic loading. Monotonic loading in strain-controlled mode is applied using a constant speed motor.

The device uses a high-speed data acquisition and control system. During a given test, a continuous record of the full time-histories of the following test variables are monitored: horizontal shear stress (τ_h), vertical effective stress (σ'_v), which is equivalent to induced excess pore water pressure (Δu) in constant volume tests, and horizontal shear strain (γ%).

[1] Bjerrum, L., and Landva, A. 1966. Direct simple shear testing on Norwegian quick clay. Geotechnique, 16(1): 1-20.

3.0 PREPARATION OF TEST SPECIMENS

The DSS tests were conducted on reconstituted specimens prepared from bulk samples, as per details given below.

According to the instructions given by Knight Piésold, the specimens for testing of soil from bag samples identified as “Coarse Tailings - Area 3” was reconstituted using the method of water pluviation (i.e., gravity deposition in a water medium) whereas soil from bag samples identified as “Fine Tailings - Area 2” was reconstituted using the method of slurry deposition.

The following actions were also undertaken in preparation of the DSS device to receive the reconstituted specimens: (i) the porous stones to be used for drainage at the two end platens were initially boiled in water, cooled to room temperature, and then placed in the DSS device; (ii) the reinforced rubber membrane, which would later enclose the specimen was initially placed on and sealed to the bottom specimen-base-pedestal using an o-ring; (iii) then, a split-mold was mounted around the base pedestal, so that the reinforced rubber membrane could be stretched to line the split-mold thus forming a cylindrical cavity (a vacuum is applied between the mold and the membrane to stretch the membrane and create the sample cavity).

3.1 Water Pluviation of “Coarse Tailings - Area 3”

Initially, a known weight (about 200g) of dry soil was placed in a flask. The soil was saturated by boiling with water in the flask and then cooled to room temperature. After cooling to room temperature, the sample was kept under vacuum until sample reconstitution.

The cylindrical cavity was then filled with de-aired water, with a cylindrical plexi-glass extension mounted on the split-mold essentially providing a reservoir of water above the mold-level during water pluviation. The already boiled/cooled saturated soil in the flask was then directly pluviated (deposited) into the membrane-lined, de-aired-water-filled, split-mold cavity prepared as per above. In the water pluviation process, the transfer of coarse-grain soil mass from the flask to the cavity occurs through the water medium by mutual displacement of water with coarse-grain soil under gravity. Once the mold was filled slightly in excess of the required specimen height, the excess coarse-grain soil was removed using a suction nozzle. The suction nozzle was kept at a constant height and traversed over the footprint of the specimen, and this process allows obtaining a final leveled soil surface at the top of the specimen.

3.2 Slurry Deposition of “Fine Tailings - Area 2”

Initially, the wet bulk soil sample for testing was thoroughly stirred to achieve a homogenous “paste”. The mixture was allowed to settle under its own weight and excess water on the top surface was siphoned out. The paste was then placed under vacuum until sample reconstitution. Porous stones for testing were boiled in water and cooled to room temperature. The paste prepared as per above was then carefully placed in the DSS cylindrical cavity using a spoon. Herein, careful attention was paid to avoid air being entrapped within the specimen during spooning and to achieve a uniform and even top surface.

After placement of sufficient amount of the material to achieve an initial specimen height of about 20 mm (using one of the methods above), the top surface of the specimen was brought to contact with the top pedestal of the test device so that the specimen would be subjected to a relatively small vertical confining stress (i.e., "seating" load less than 10 kPa).

At this point, after removing the split mold, the specimen is ready for consolidation to the desired vertical effective stress as described in Section 4.0.

4.0 TEST PROGRAM

4.1 CDSS Testing

The CDSS test program, presenting the desired vertical effective consolidation stress (σ'_{vc}) levels, cyclic stress ratio (τ_{cyc}/σ'_{vc}) amplitudes, etc., is presented in Table 1.

4.1.1 *Initial Consolidation*

The reconstituted soil paste placed in the mold was initially allowed to consolidate under its own weight and a small seating pressure of about 10 kPa. Since soil particles commence settling immediately upon placement, it was not possible to record the change in height of specimen vs. time during self-weight consolidation and initial setup. All the test specimens were then loaded to the desired vertical effective consolidation stress (σ'_{vc}) as per Table 1 in preparation for subsequent cyclic or monotonic loadings described below.

4.1.2 *Cyclic Loading*

All the test specimens listed in Table 1 were initially loaded to the desired vertical effective consolidation stress (σ'_{vc}) and then subjected to stress-controlled cyclic shear loading.

During cyclic loading, the specimens were subjected to symmetrical sinusoidal cycles of loadings having the desired constant cyclic stress ratio (τ_{cyc}/σ'_{vc}) amplitude at a frequency of 0.1 Hz. The cyclic shear loading phase of all specimens was terminated after an absolute value for shear strain of 3.75 % was reached.

4.1.3 *Post-cyclic Monotonic Loading*

Upon completion of cyclic loading, the specimens were subjected to post-cyclic constant volume monotonic loading at a horizontal shear strain rate of about 10% per hour.

4.2 Index Testing

Particle size distribution analysis, specific gravity tests and in-situ density computations were conducted in accordance to ASTM D422-63, D854-10 and D7263-09 respectively.

5.0 TEST RESULTS

A summary of CDSS test program and the results are presented in Table 1. The test results are shown graphically in Figures 1 through 35. Figure numbers corresponding to a given test are also outlined in Table 1 for your convenient reference. As may be noted, these figures essentially include a sequential presentation of the results of one or more of the following test phases, as appropriate, for each of the tests undertaken:

- Consolidation Phase: Vertical strain (ε_v) and vertical effective stress (σ'_{vc}) versus time during the consolidation process.

- Cyclic Loading Phase: Applied shear stress ratio (τ_{cyc}/σ'_{vc}), excess pore water pressure ratio ($\Delta u/\sigma'_{vc}$), and shear strain (γ%) versus number of cycles (N_{cyc}), effective stress paths in horizontal shear stress (τ) versus vertical effective stress (σ'_v) space, and cyclic shear stress-strain plots in horizontal shear stress (τ) versus shear strain (γ%)

- Post-cyclic Monotonic Loading Phase: Shear stress (τ), excess pore water pressure ratio ($\Delta u/\sigma'_{vc}$), vertical effective stress (σ'_v) versus shear strain (γ%), as well as effective stress paths in horizontal shear stress (τ) versus vertical effective stress (σ'_v) space.

A summary of the results of index tests are presented in Table 2 through 7 and Figure 36 to 39.

6.0 GENERAL COMMENTS AND CLOSURE

Data gathered from laboratory testing of a given specimen of soil reflect the mechanical response of that specimen subjected to a prescribed laboratory loading. Because of the field variability of soil/ground water conditions, sample disturbance, difference in loading modes, the observed behavior in the laboratory may not necessarily be representative of the response in situ, and interpretation of laboratory data should be undertaken with due consideration given to these factors.

I trust that this report provides an adequate summary of the testing program and test results meeting with your testing requirements. If you have any questions, or require additional information, please do not hesitate to contact me.

Yours truly,

Dharma Wijewickreme, Ph.D., P.Eng.

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Table 1: Summary of Test Program and Results

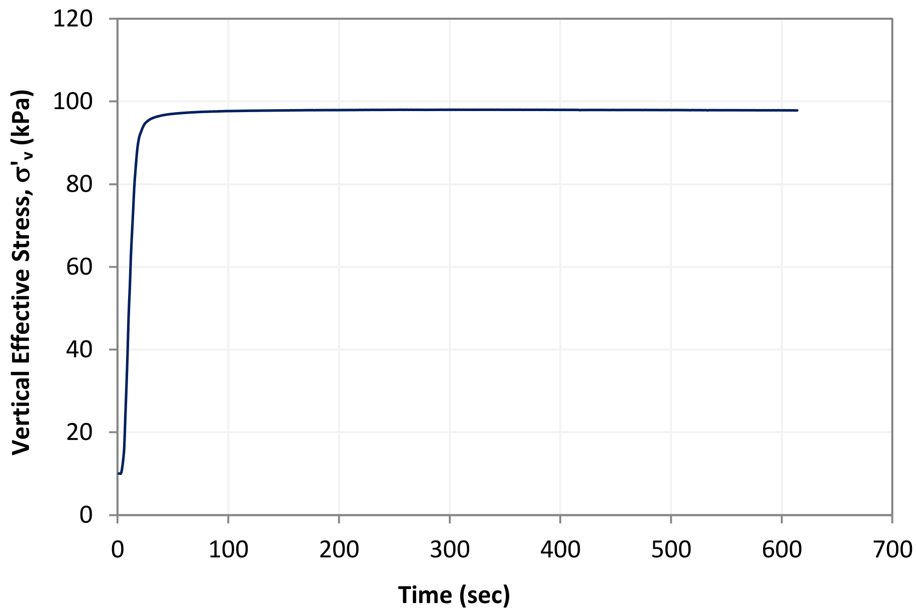
SAMPLE ID	Test ID	ρ_{do} g/cm^3	σ'_{vc} (kPa)	ρ_{dc} g/cm^3	Cyclic tests: τ_{cyc}/σ'_{vc}	Cyclic tests: No. cyc. to γ=3.75%	Cyclic tests: γ_{max} (%)	Cyclic tests: $\Delta u_r/\sigma'_{vc}$	Figure Nos. containing test results		
Coarser grained tailing composite : Bag sample (Area 3)	KPL-A3-100-01	1.430	98.1	1.498	0.105	15	5.6	0.96	1	through	5
	KPL-A3-100-02	1.497	96.4	1.567	0.083	43	6.0	0.99	6	through	10
	KPL-A3-100-03	1.416	99.6	1.493	0.122	6	6.9	0.93	11	through	15
	KPL-A3-200-01	1.377	200.0	1.486	0.104	18	5.3	0.90	16	through	20
	KPL-A3-400-01	1.426	395.7	1.532	0.106	47.5	4.3	0.91	21	through	25
Finer grained tailing composite : Bag sample (Area 2)	KPL-A2-100-01	1.575	97.6	1.648	0.108	12.5	5.6	0.96	26	through	30
	KPL-A2-400-01	1.468	398.0	1.627	0.1	54.5	7.3	0.95	31	through	35

σ'_{vc}	Initial vertical effective consolidation stress (recorded immediately prior to cyclic loading)
σ'_v	Vertical effective stress
τ	Shear stress
τ_{cyc}	Cyclic shear stress amplitude
ε_v	Vertical strain
γ	Shear strain
γ_{max}	Maximum shear strain during cyclic loading
Δu_r	Residual excess pore water pressure at the end of cyclic loading Pore
r_u	water pressure ratio ($\Delta u_r/\sigma'_{vc}$)
ρ_{do}	Dry density of the specimen at seating pressure (prior to consolidation)
ρ_{dc}	Dry density of the specimen at consolidated stress

Figure 1. CONSOLIDATION PHASE - TEST ID. KPL-A3-100-01

Sample ID : A3 -03

σ'_{vc} : 98.06 kPa



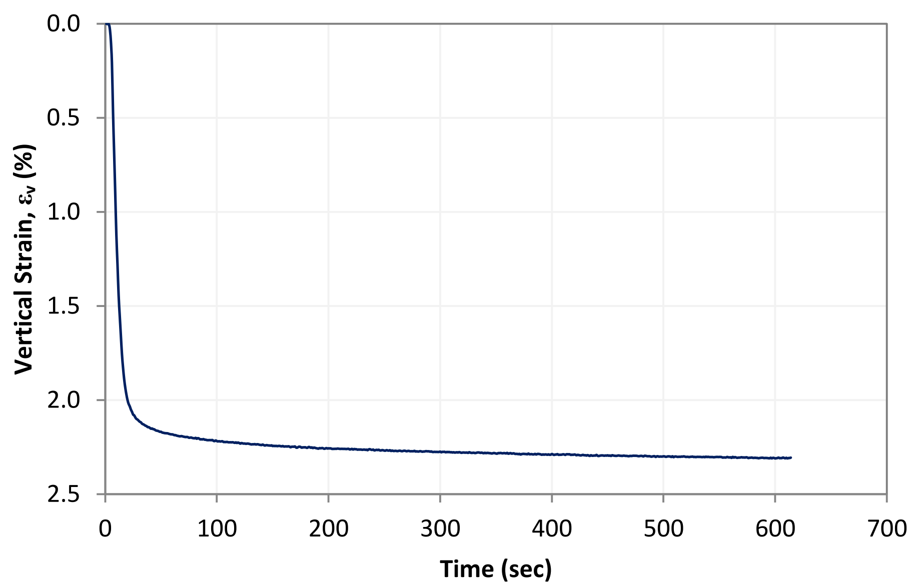


Figure 2. CYCLIC LOADING PHASE - TEST ID. KPL-A3-100-01

Sample ID : A3 -03

σ'_{vc} : 98.06 kPa

τ_{cyc}/σ'_{vc} : 0.105

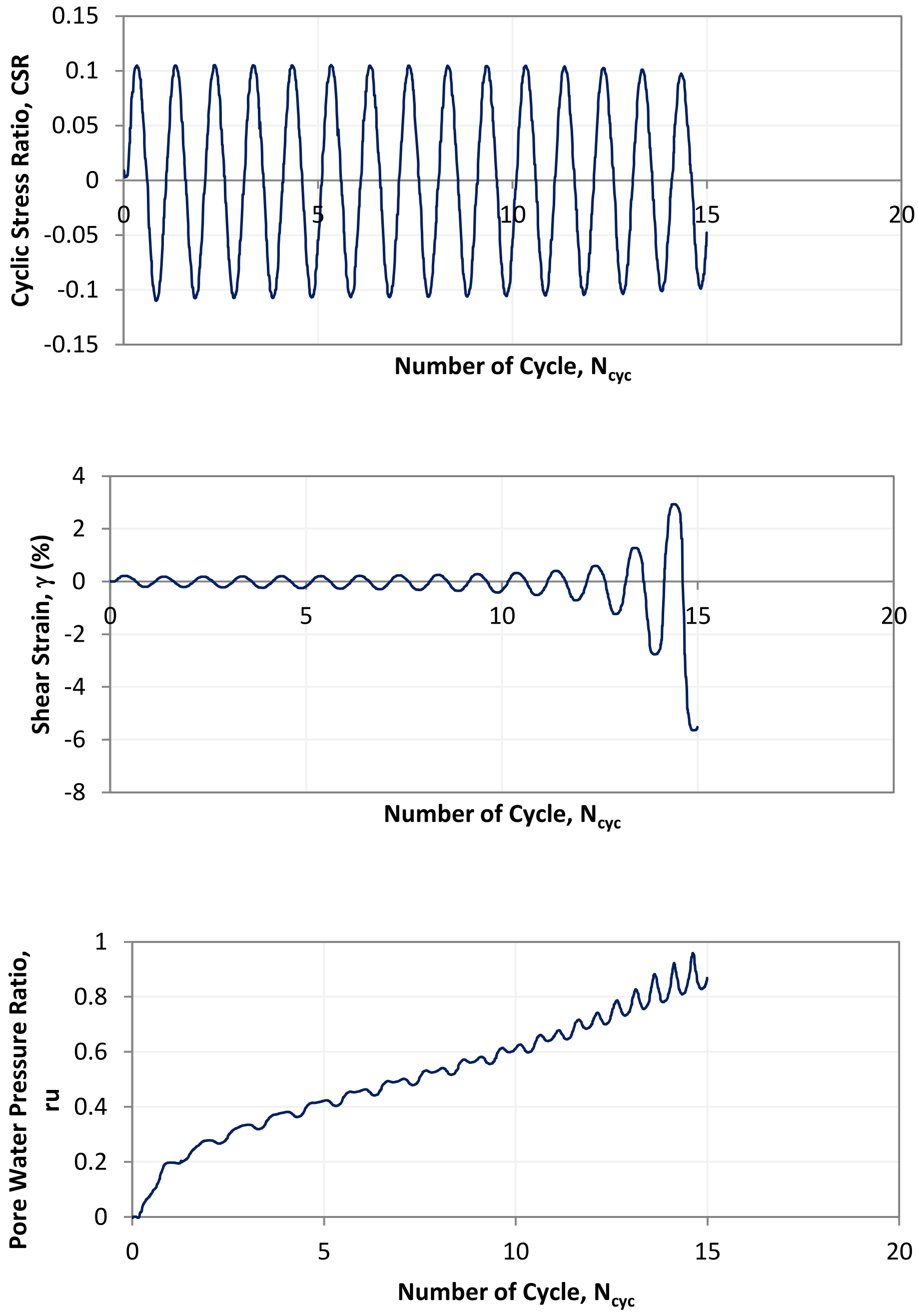
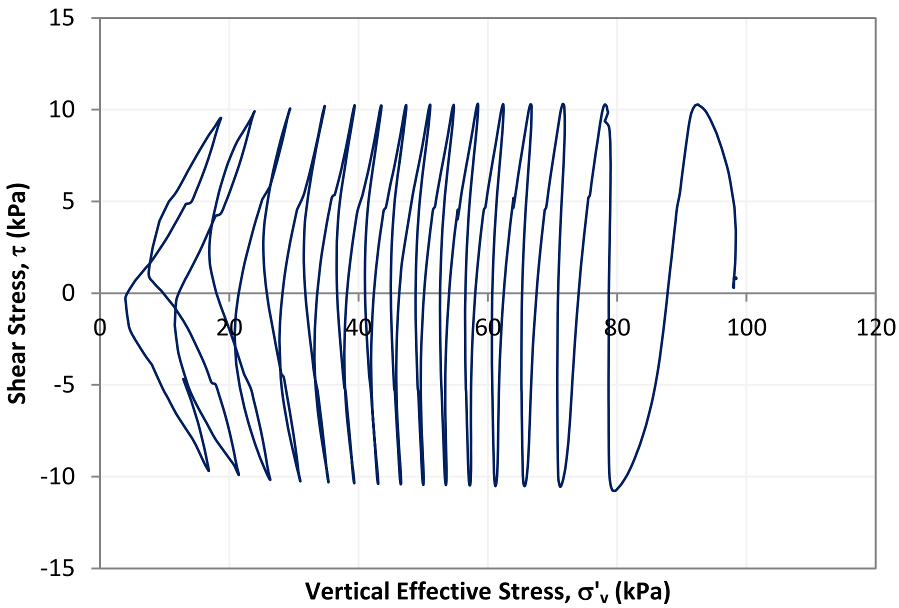


Figure 3. CYCLIC LOADING PHASE - TEST ID. KPL-A3-100-01

Sample ID : A3 -03

σ'_{vc} : 98.06 kPa

τ_{cyc}/σ'_{vc} : 0.105



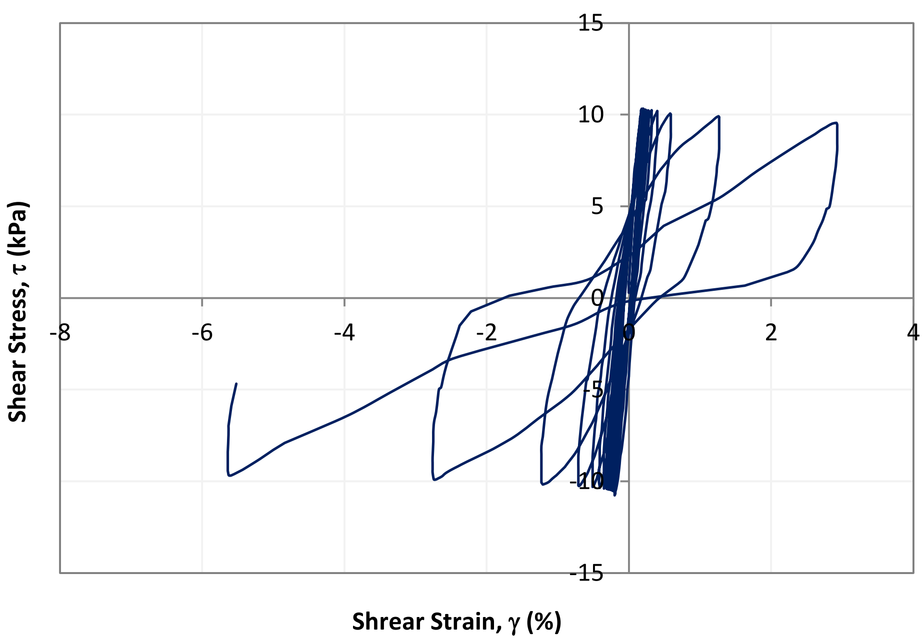


Figure 4. MONOTONIC LOADING PHASE - TEST ID. KPL-A3-100-01

Sample ID : A3 -03 σ'_{vc} : 98.06 kPa

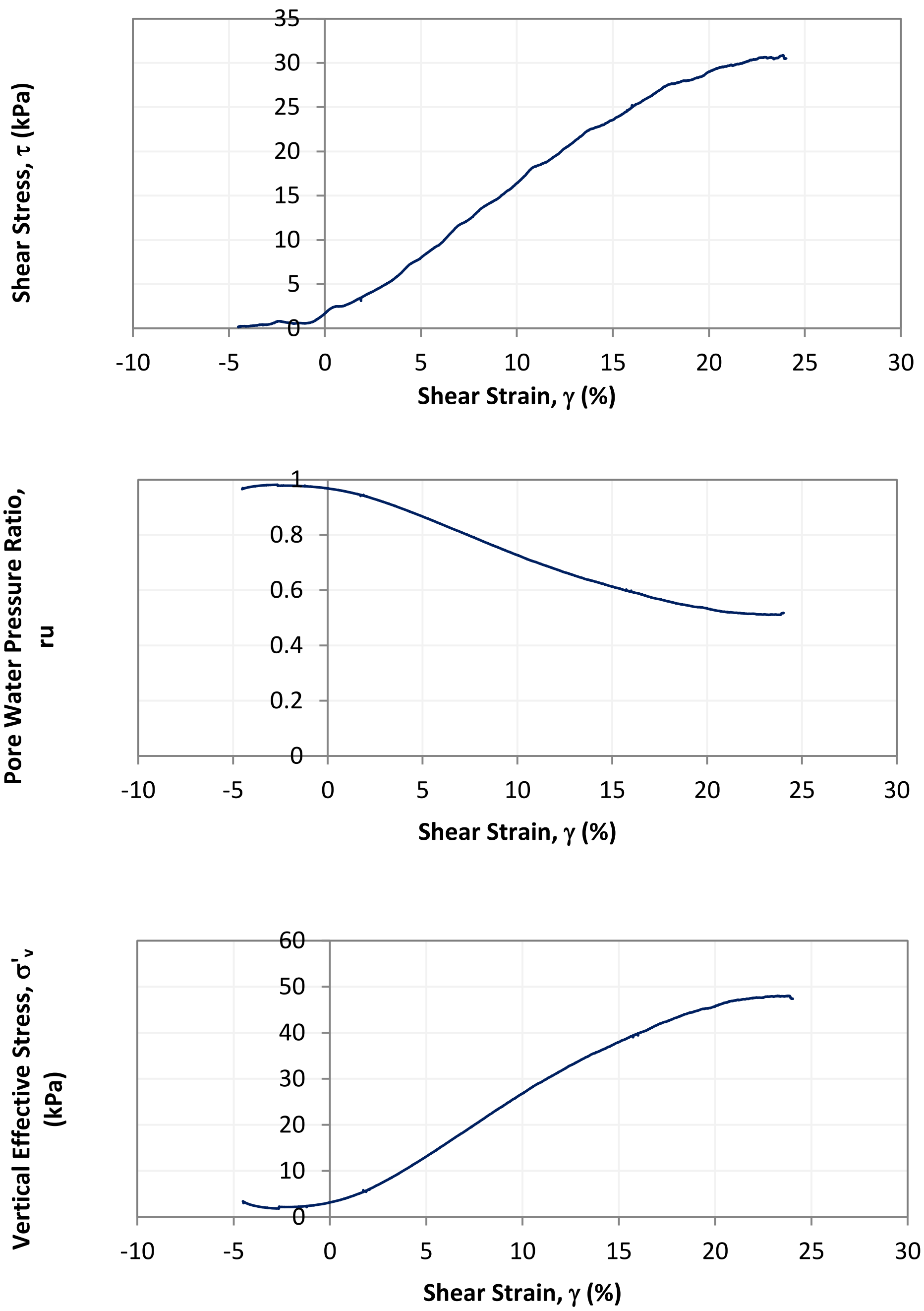


Figure 5. MONOTONIC LOADING PHASE - TEST ID. KPL-A3-100-01

Sample ID : A3 -03

σ'_{vc} : 98.06 kPa

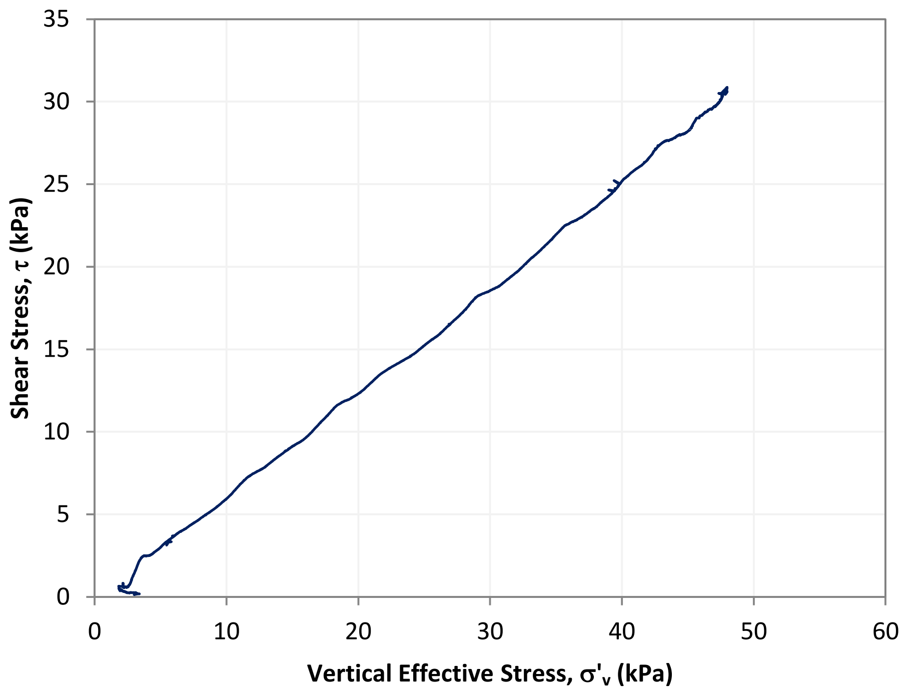
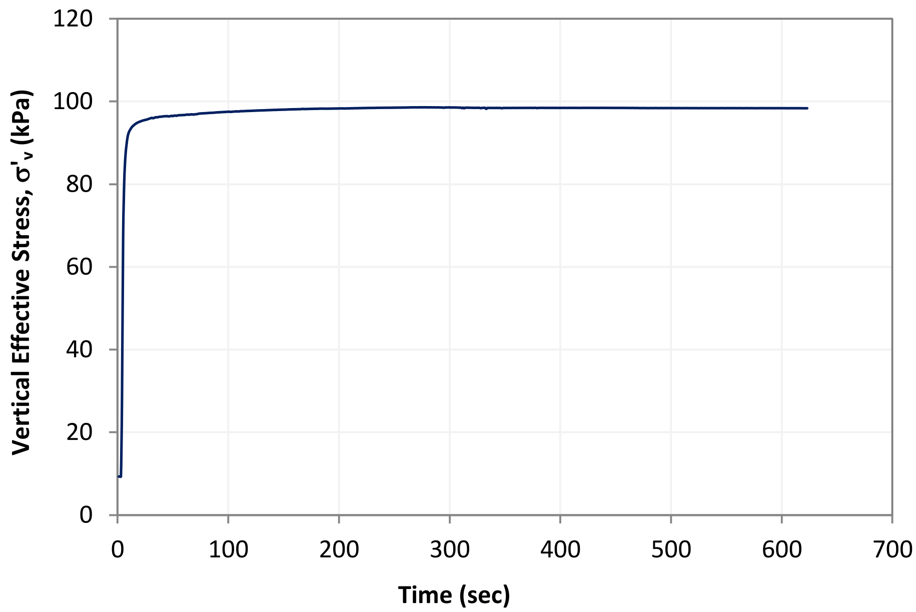


Figure 6. CONSOLIDATION PHASE - TEST ID. KPL-A3-100-02

Sample ID : A3 -05

σ'_{vc} : 96.41 kPa



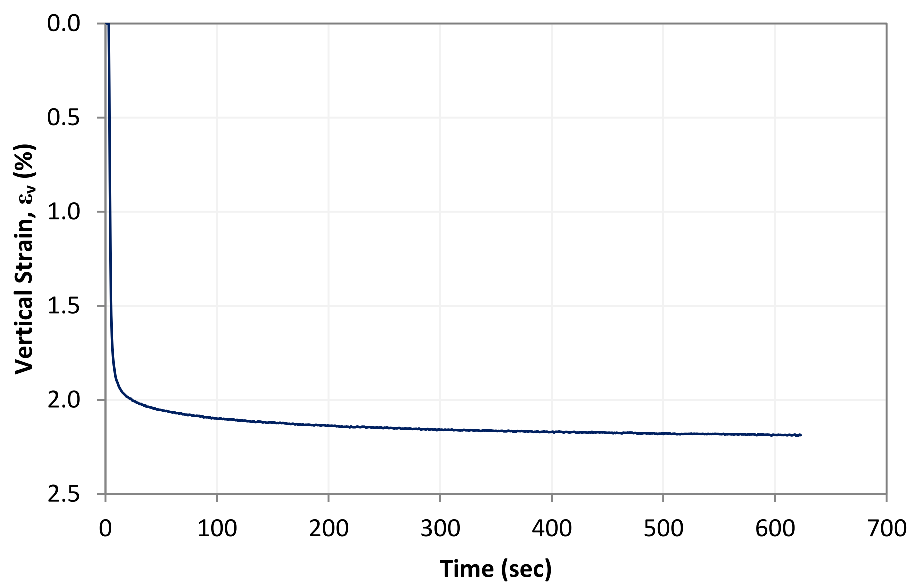
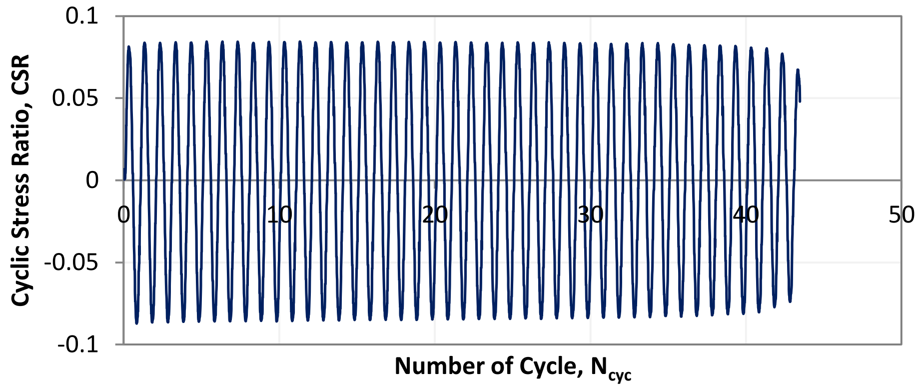


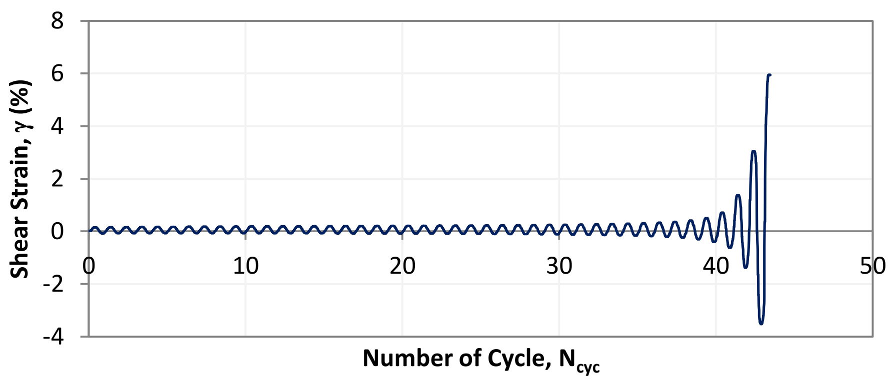
Figure 7. CYCLIC LOADING PHASE - TEST ID. KPL-A3-100-02

Sample ID : A3 -05

σ'_{vc} : 96.41 kPa

τ_{cyc}/σ'_{vc} : 0.083





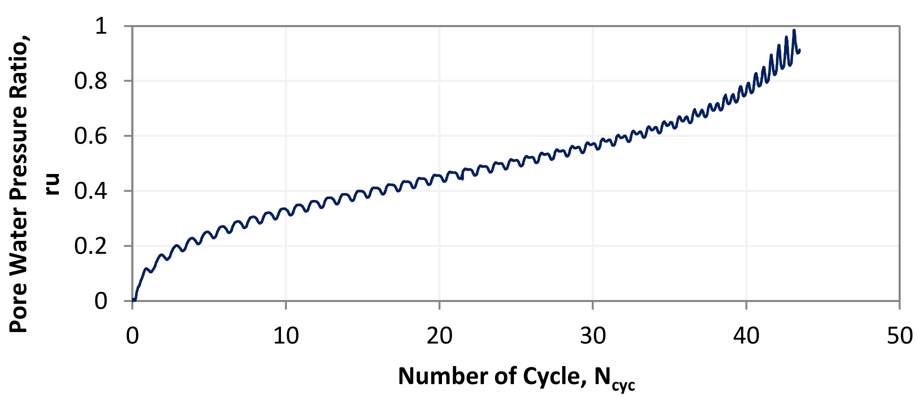
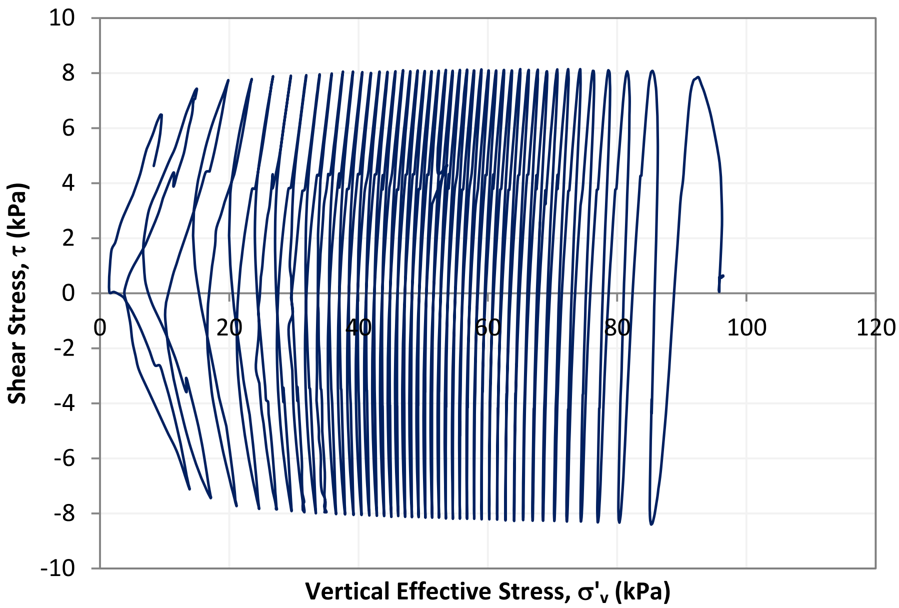


Figure 8. CYCLIC LOADING PHASE - TEST ID. KPL-A3-100-02

Sample ID : A3 -05

σ'_{vc} : 96.41 kPa

τ_{cyc}/σ'_{vc} : 0.083



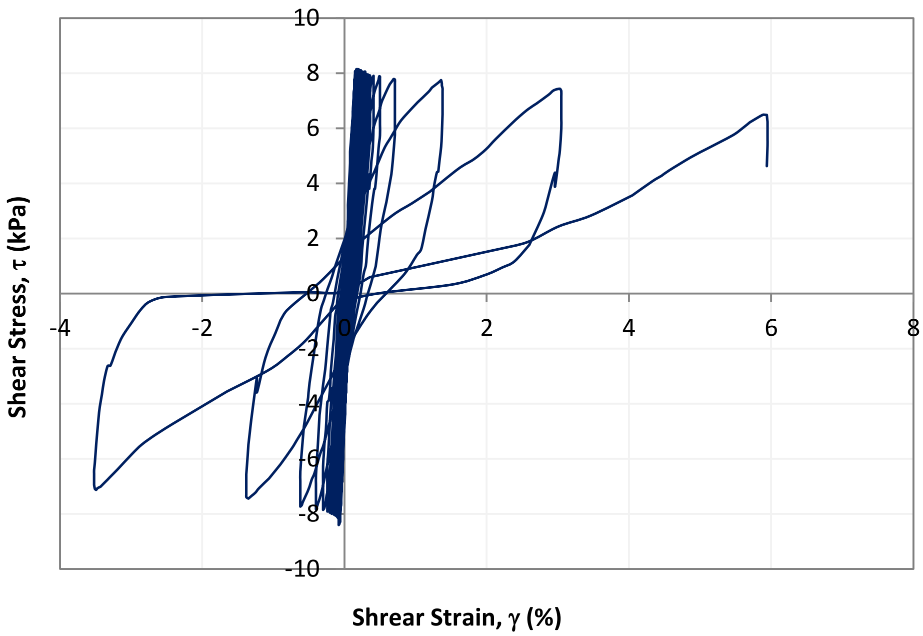
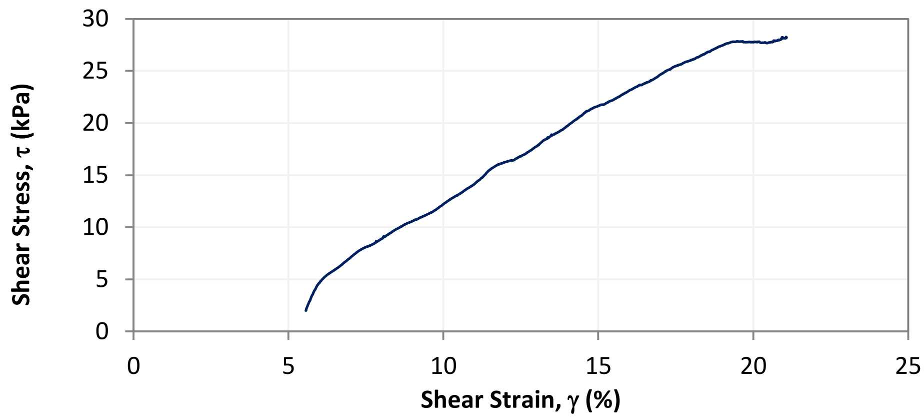
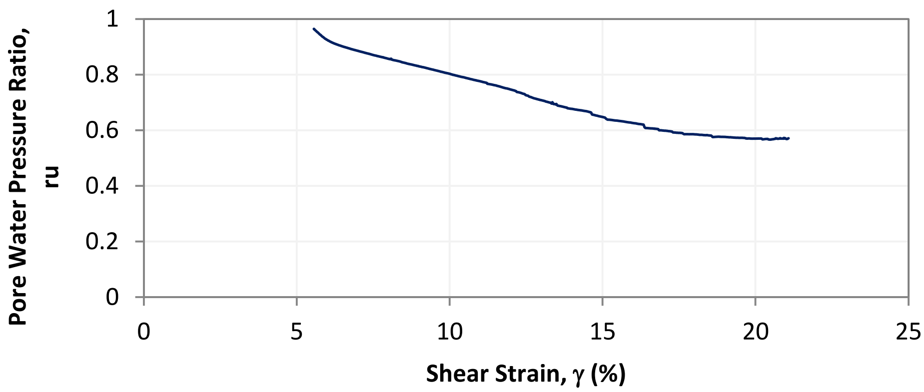


Figure 9. MONOTONIC LOADING PHASE - TEST ID. KPL-A3-100-02

Sample ID : A3 -05 σ'_{vc} : 96.41 kPa





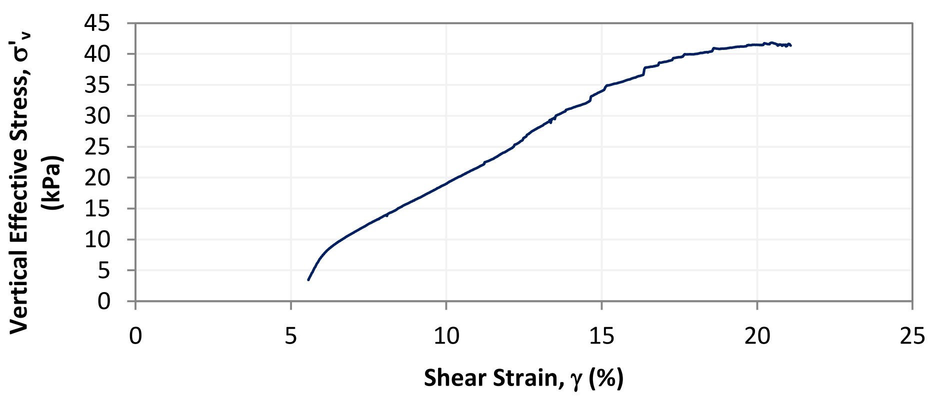


Figure 10. MONOTONIC LOADING PHASE - TEST ID. KPL-A3-100-02

Sample ID : A3 -05 σ'_{vc} : 96.41 kPa

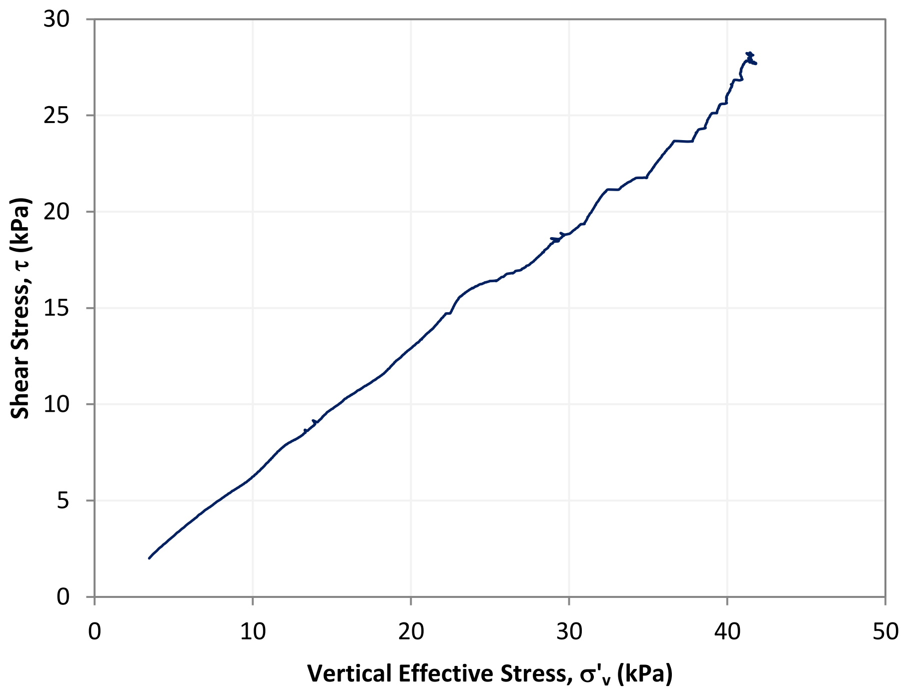
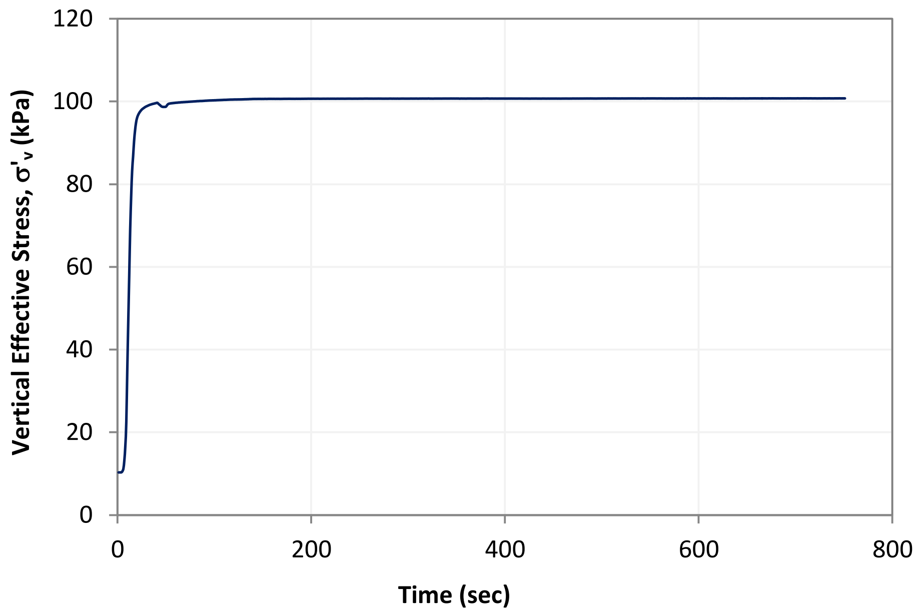


Figure 11. CONSOLIDATION PHASE - TEST ID. KPL-A3-100-03

Sample ID : A3 -02

σ'_{vc} : 99.6 kPa



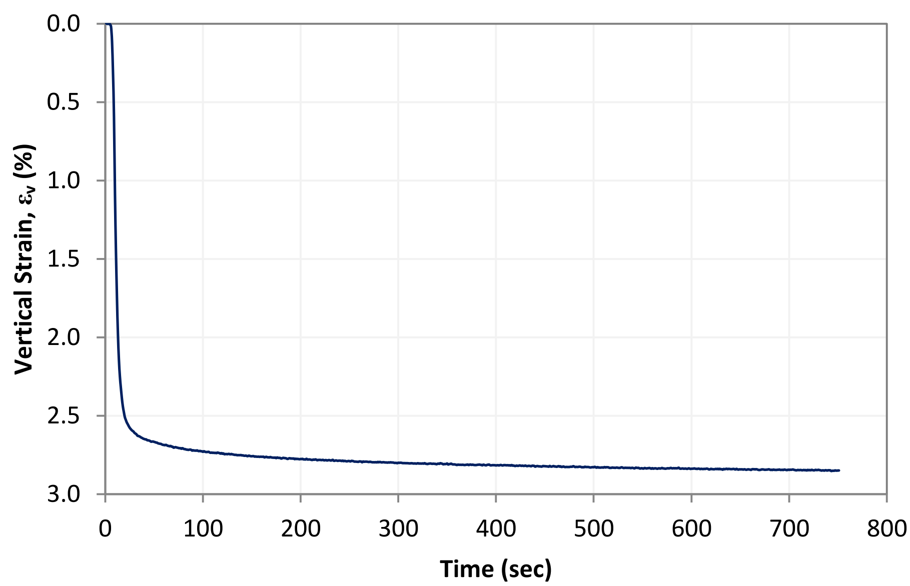


Figure 12. CYCLIC LOADING PHASE - TEST ID. KPL-A3-100-03

Sample ID : A3 -02

σ'_{vc} : 99.6 kPa

τ_{cyc}/σ'_{vc} : 0.122

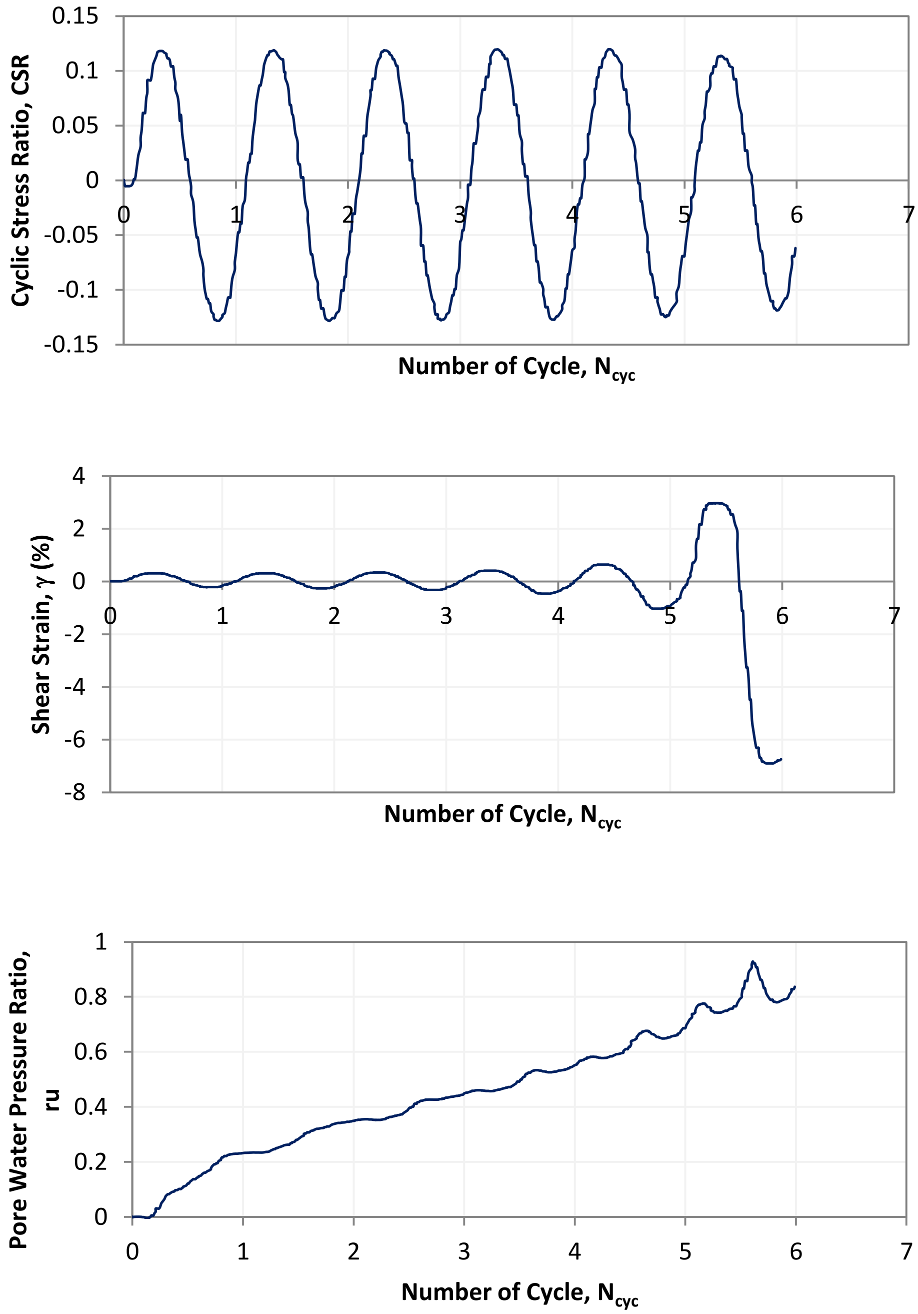


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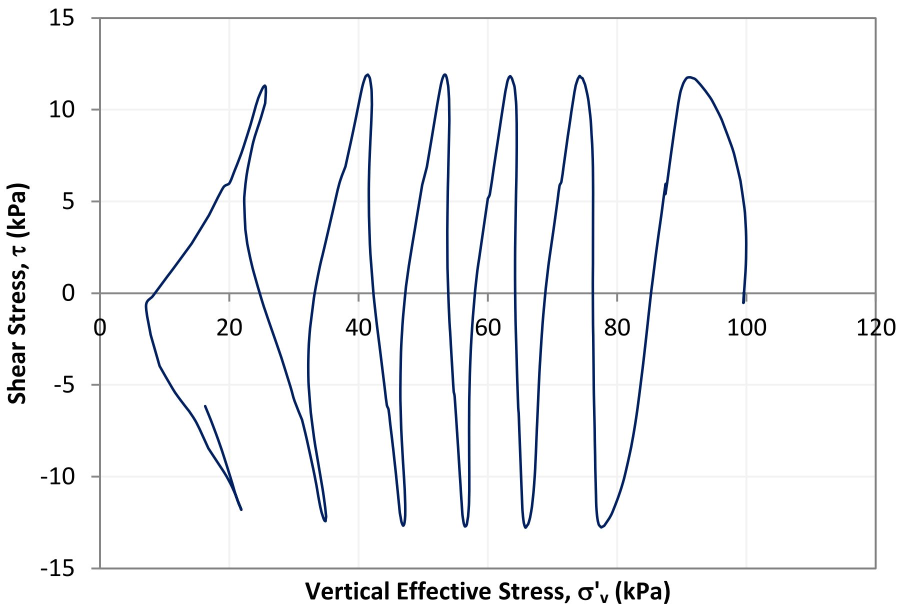
Figure 13. CYCLIC LOADING PHASE - TEST ID. KPL-A3-100-03

Sample ID : A3 -02

σ'_{vc} : 99.6 kPa

τ_{cyc}/σ'_{vc} : 0.122



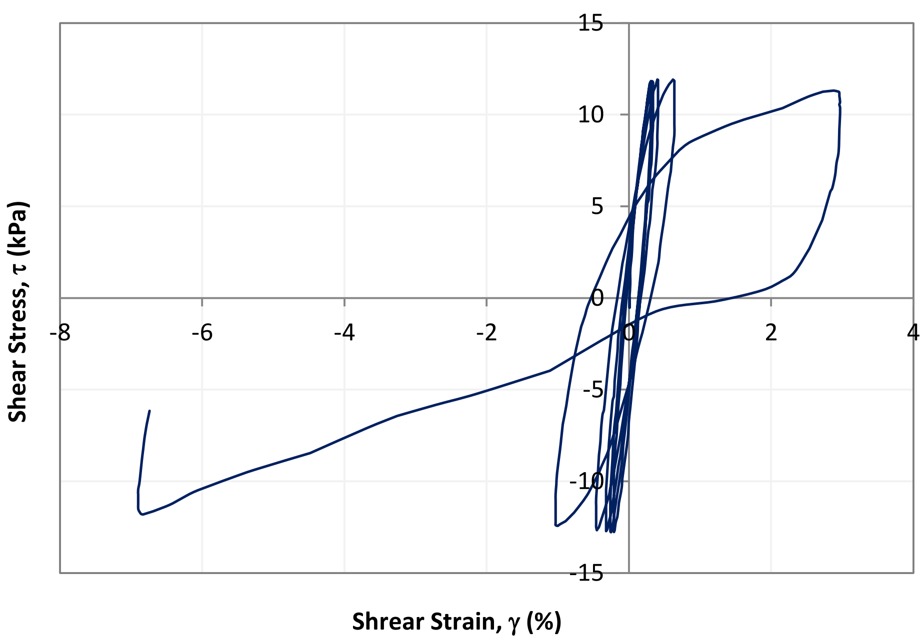


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Figure 14. MONOTONIC LOADING PHASE - TEST ID. KPL-A3-100-03

Sample ID : A3 -02

σ'_{vc} : 99.6 kPa

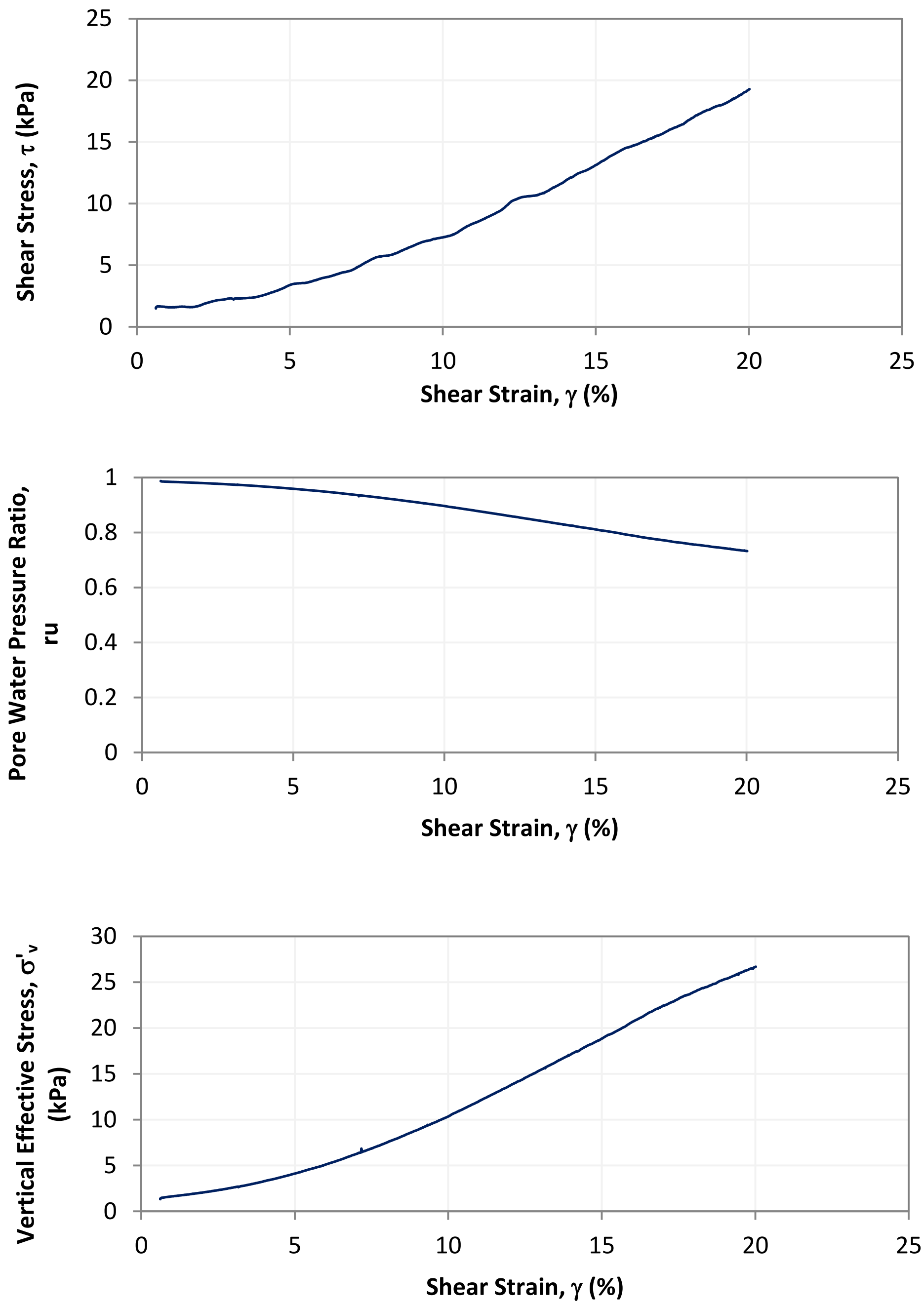

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Figure 15. MONOTONIC LOADING PHASE - TEST ID. KPL-A3-100-03

Sample ID : A3 -02

σ'_{vc} : 99.6 kPa

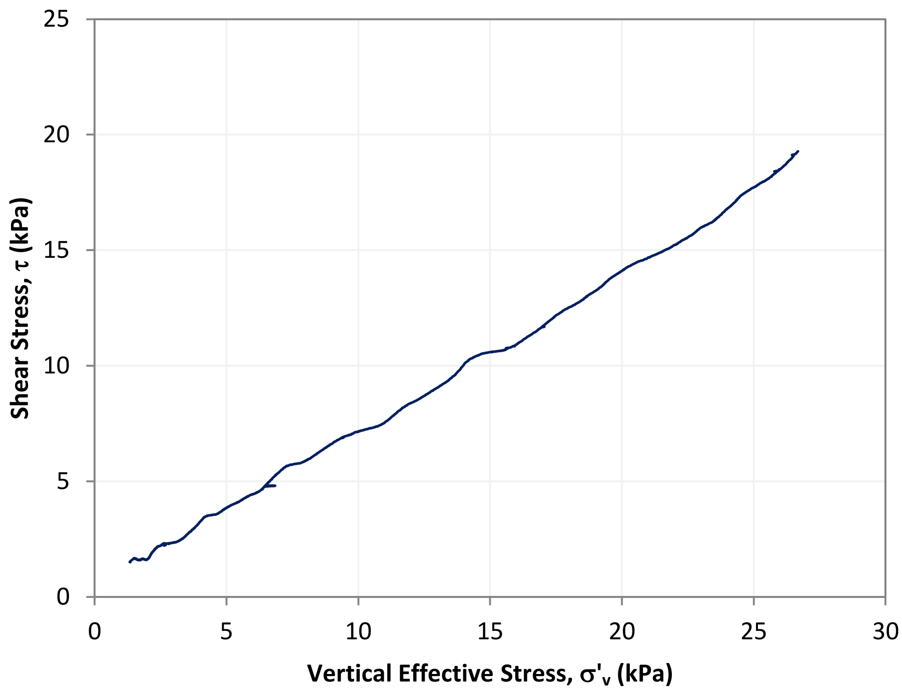
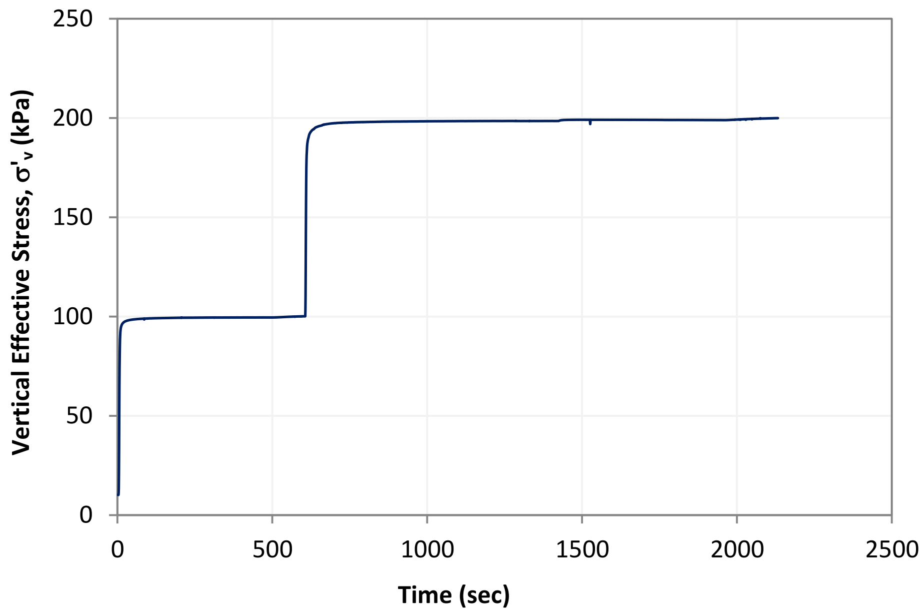


Figure 16. CONSOLIDATION PHASE - TEST ID. KPL-A3-200-01

Sample ID : A3 -06

σ'_{vc} : 199.97 kPa



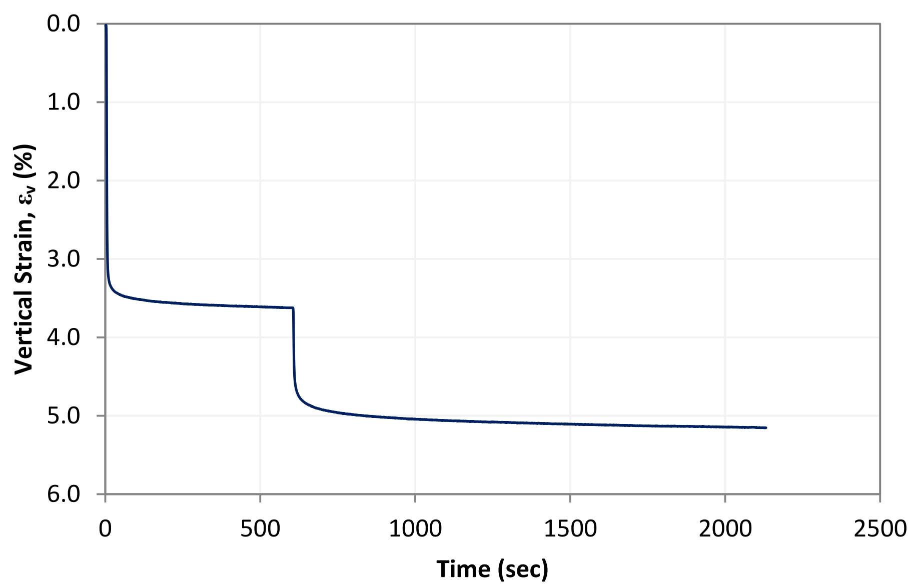


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Figure 17. CYCLIC LOADING PHASE - TEST ID. KPL-A3-200-01

Sample ID : A3 -06

σ'_{vc} : 199.97 kPa

τ_{cyc}/σ'_{vc} : 0.104

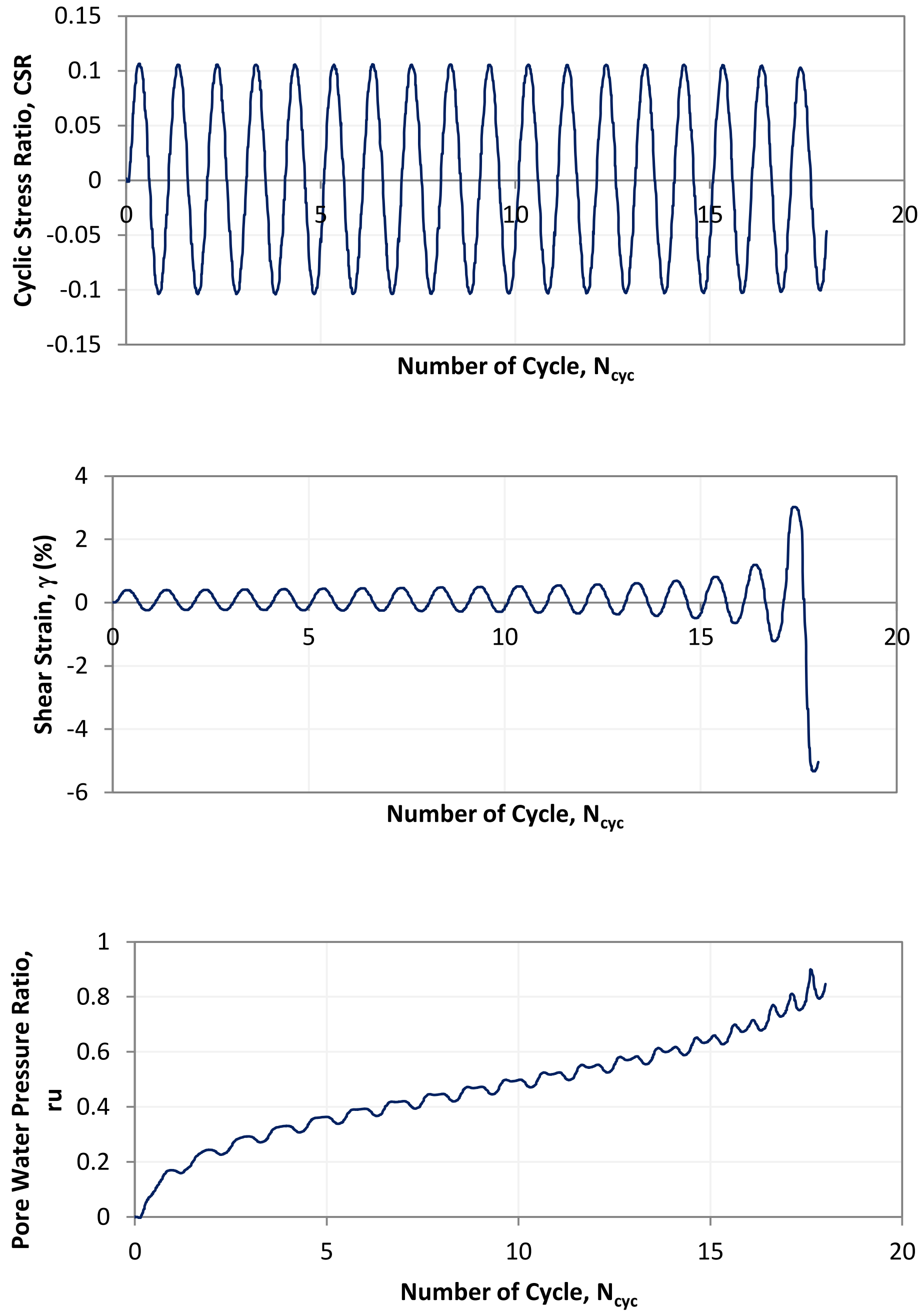

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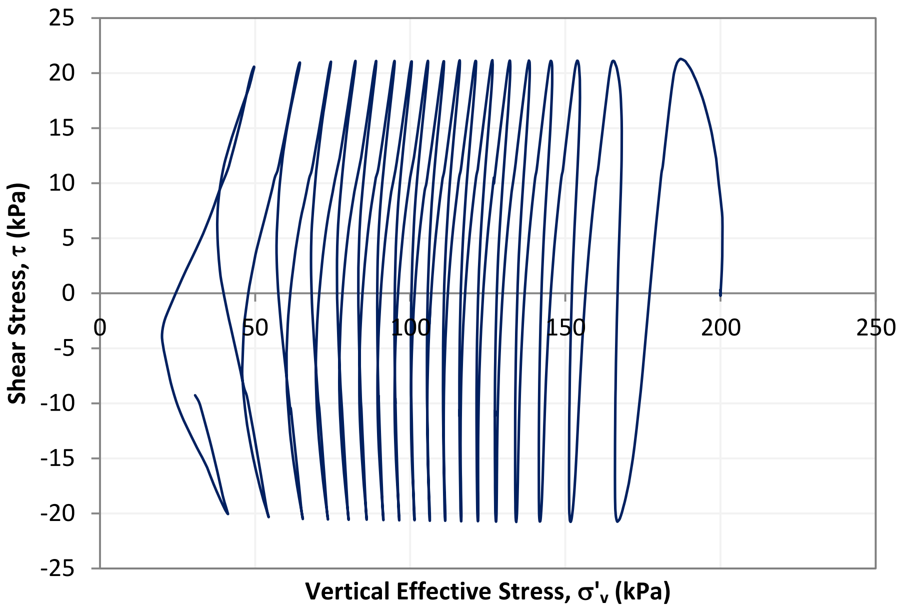
Figure 18. CYCLIC LOADING PHASE - TEST ID. KPL-A3-200-01

Sample ID : A3 -06

σ'_{vc} : 199.97 kPa

τ_{cyc}/σ'_{vc} : 0.104



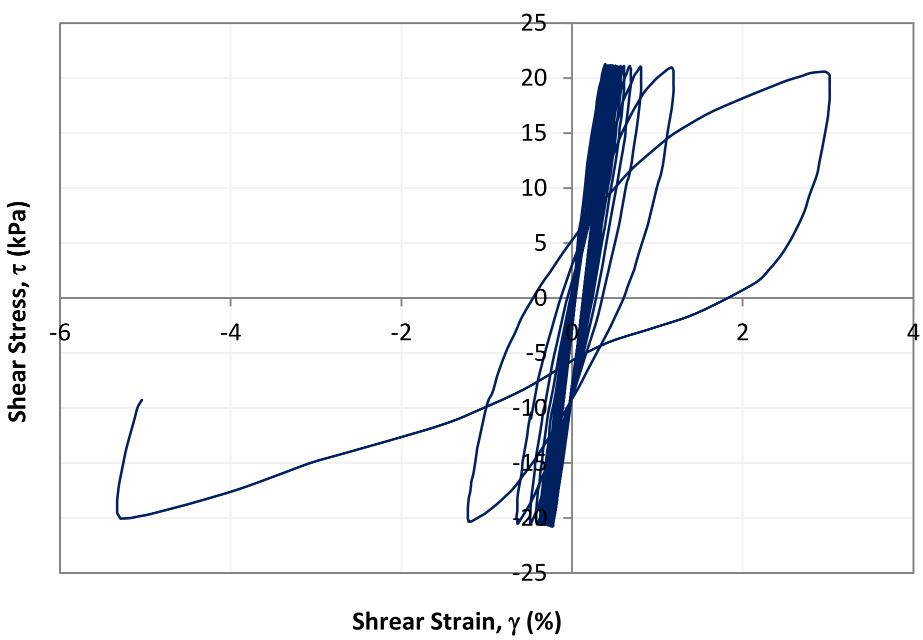


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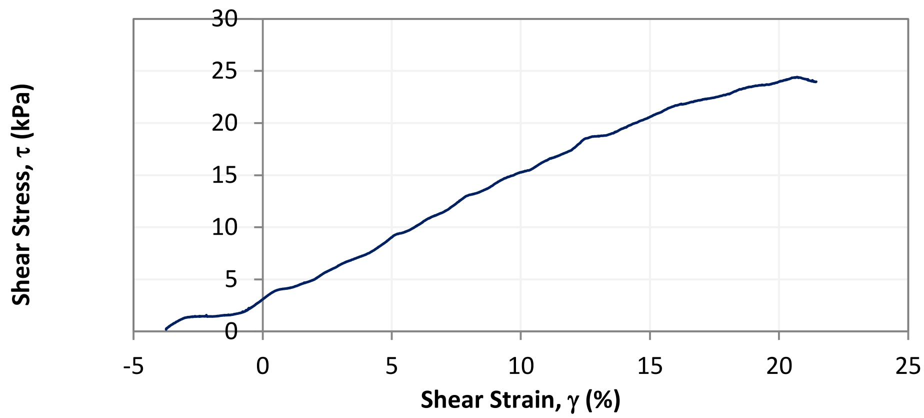
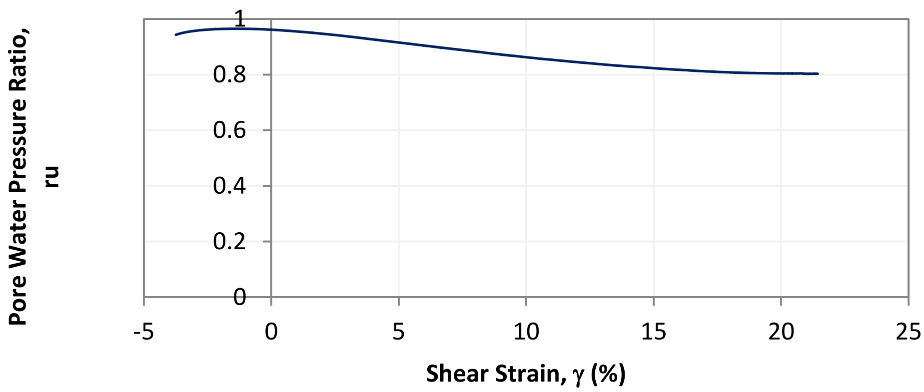
Figure 19. MONOTONIC LOADING PHASE - TEST ID. KPL-A3-200-01

Sample ID : A3 -06 σ'$_{vc}$: 199.97 kPa





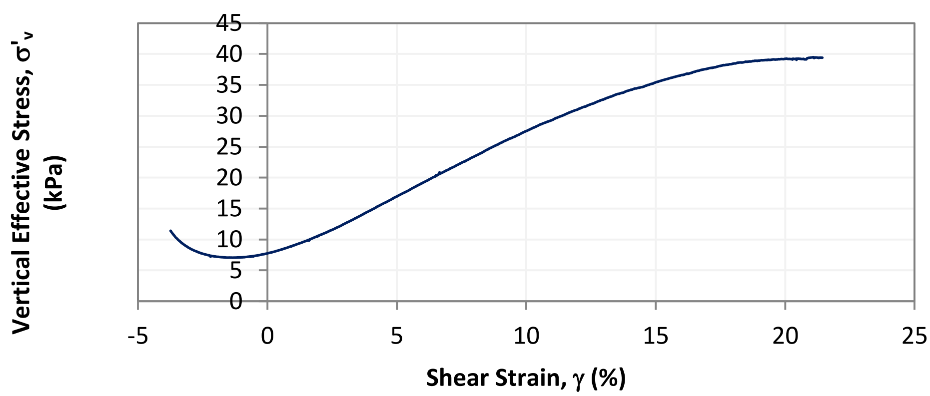


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Figure 20. MONOTONIC LOADING PHASE - TEST ID. KPL-A3-200-01

Sample ID : A3 -06

σ'_{vc} : 199.97 kPa

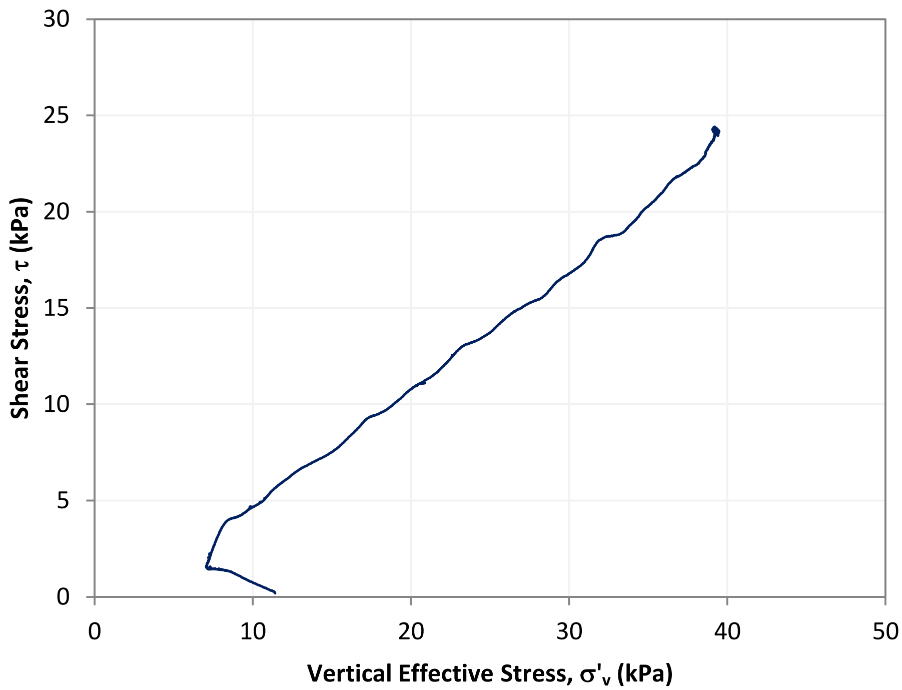
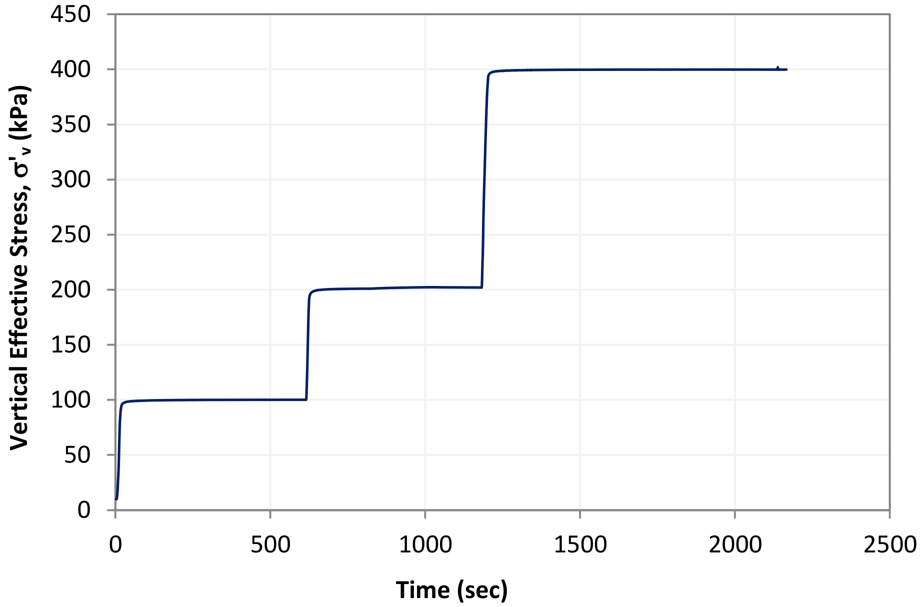


Figure 21. CONSOLIDATION PHASE - TEST ID. KPL-A3-400-01

Sample ID : A3 -04 σ'_{vc} : 395.71 kPa



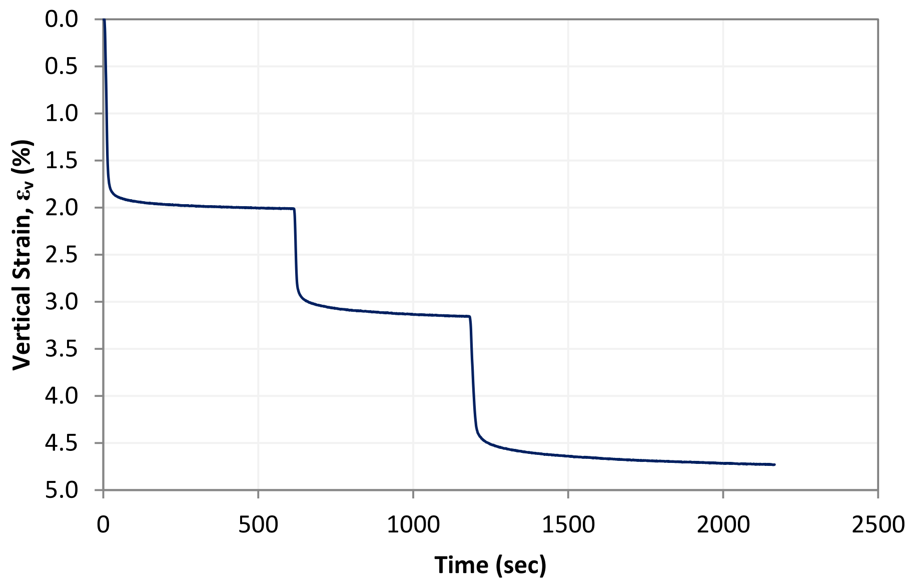
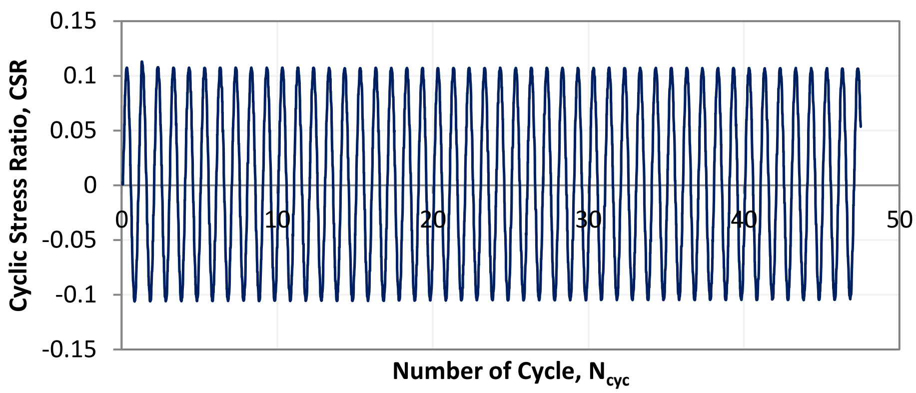


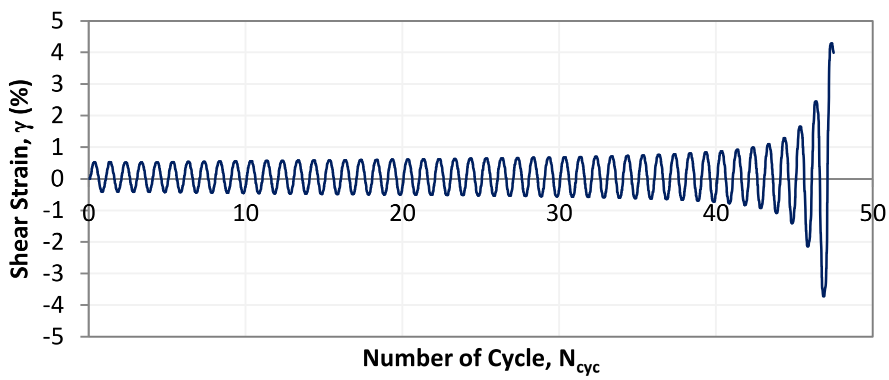
Figure 22. CYCLIC LOADING PHASE - TEST ID. KPL-A3-400-01

Sample ID : A3 -04

σ'_{vc} : 395.71 kPa

τ_{cyc}/σ'_{vc} : 0.106





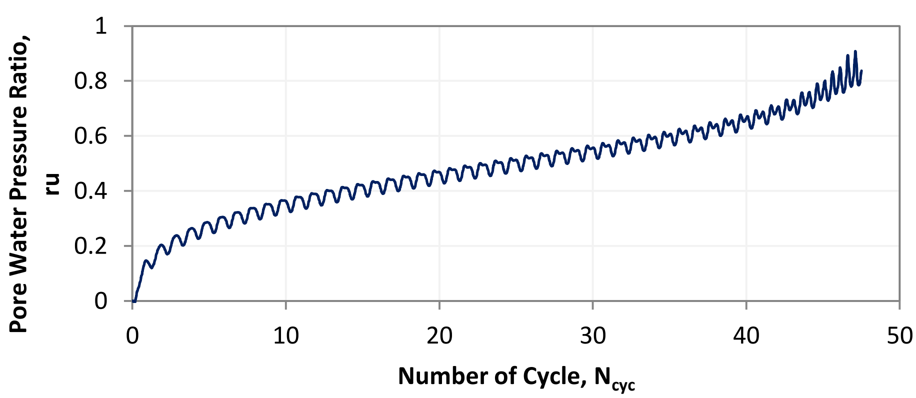
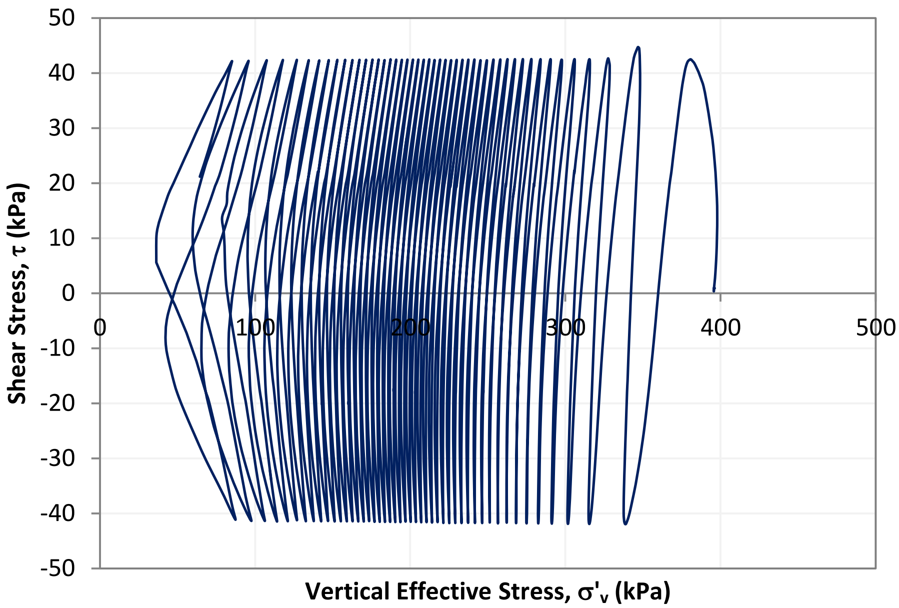


Figure 23. CYCLIC LOADING PHASE - TEST ID. KPL-A3-400-01

Sample ID : A3 -04

σ'_{vc} : 395.71 kPa

τ_{cyc}/σ'_{vc} : 0.106



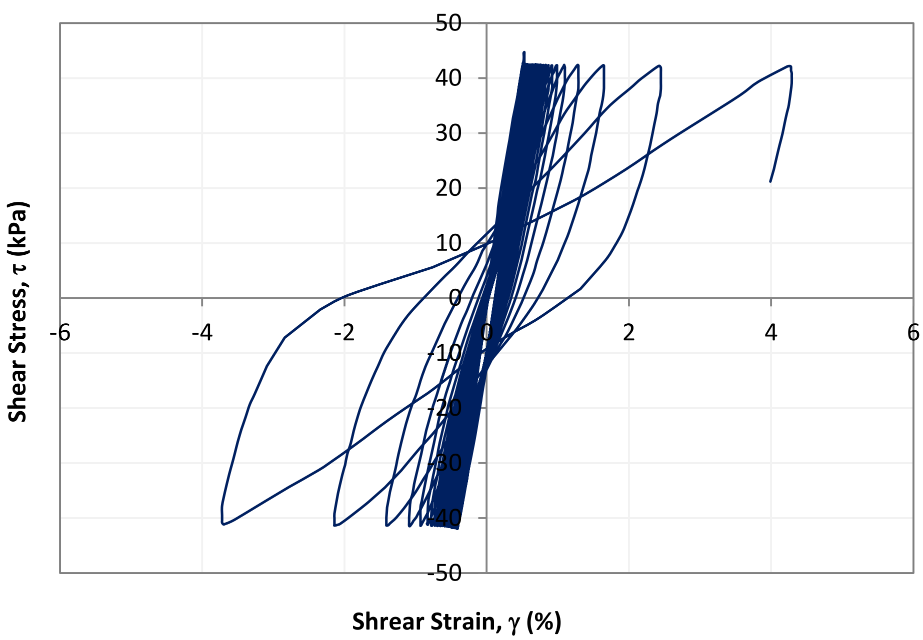
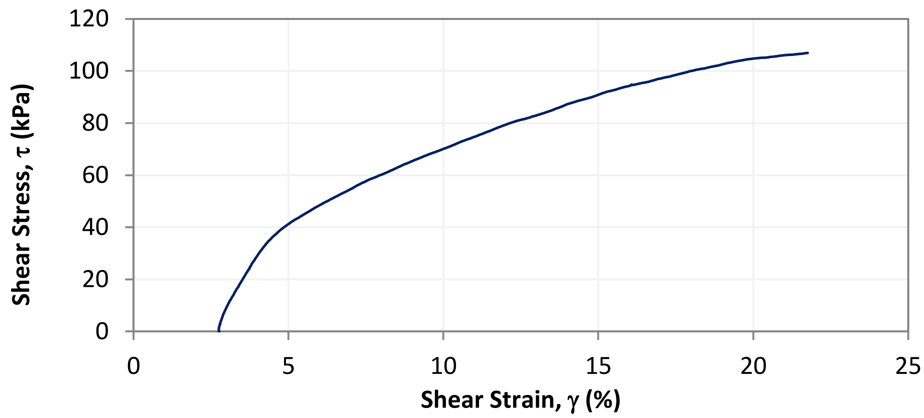
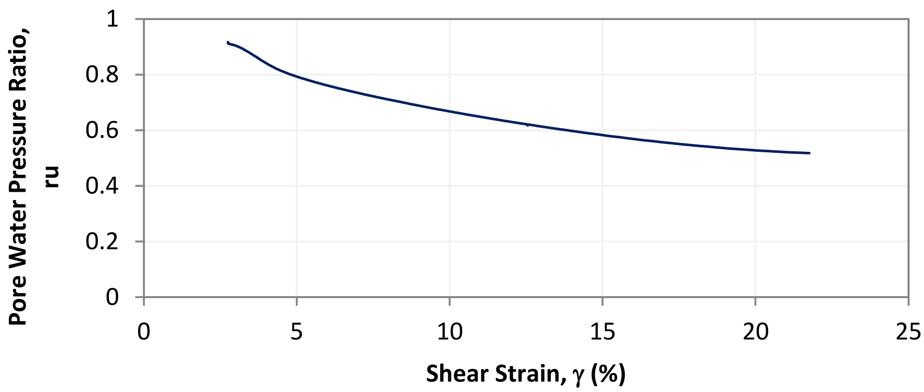


Figure 24. MONOTONIC LOADING PHASE - TEST ID. KPL-A3-400-01

Sample ID : A3 -04 σ'_{vc} : 395.71 kPa





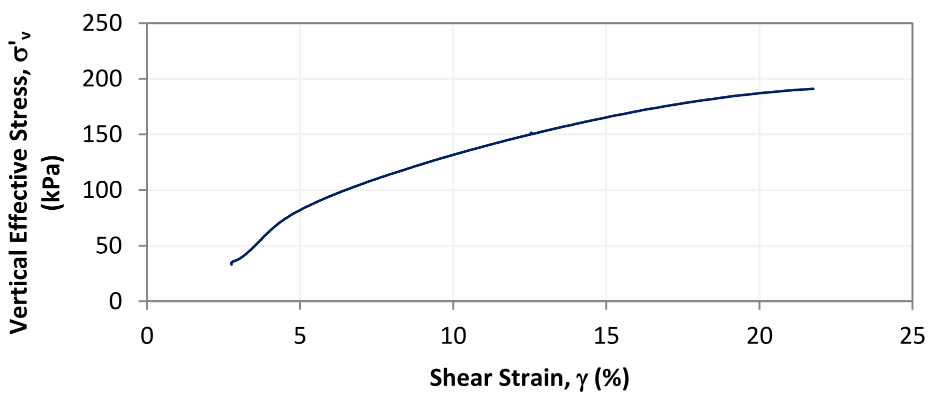


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Figure 25. MONOTONIC LOADING PHASE - TEST ID. KPL-A3-400-01

Sample ID : A3 -04

σ'_{vc} : 395.71 kPa

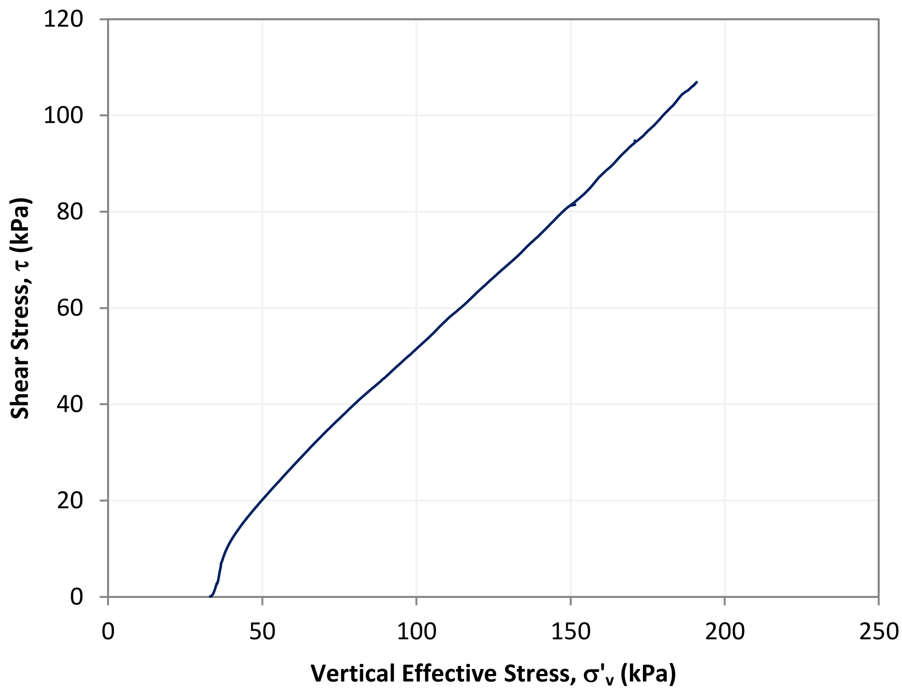
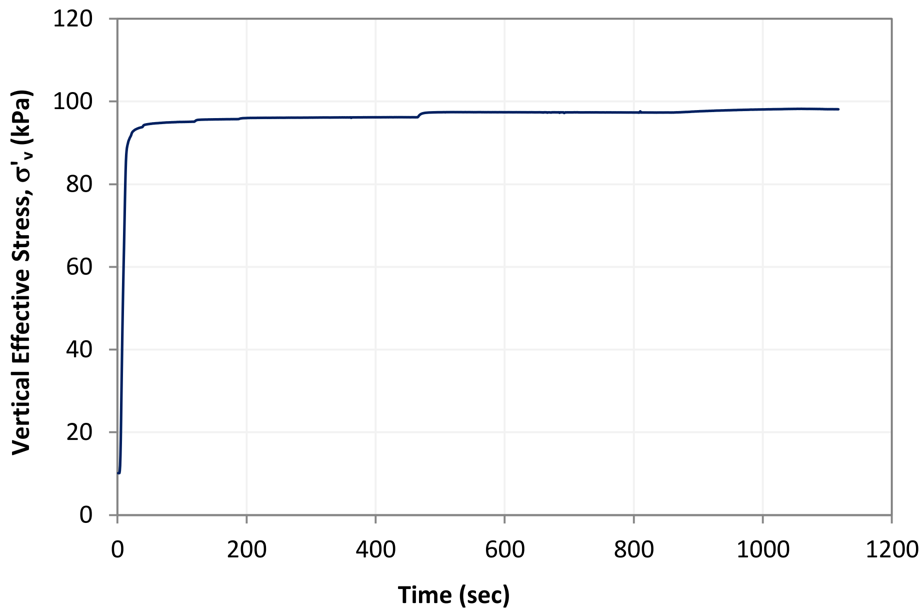


Figure 26. CONSOLIDATION PHASE - TEST ID. KPL-A2-100-01

Sample ID : A2 -04 σ'_{vc} : 97.63 kPa



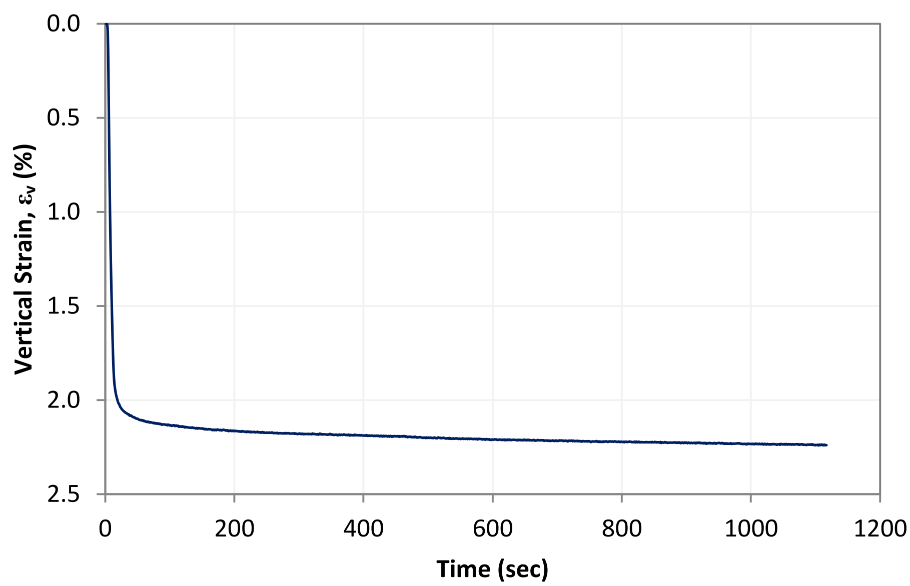
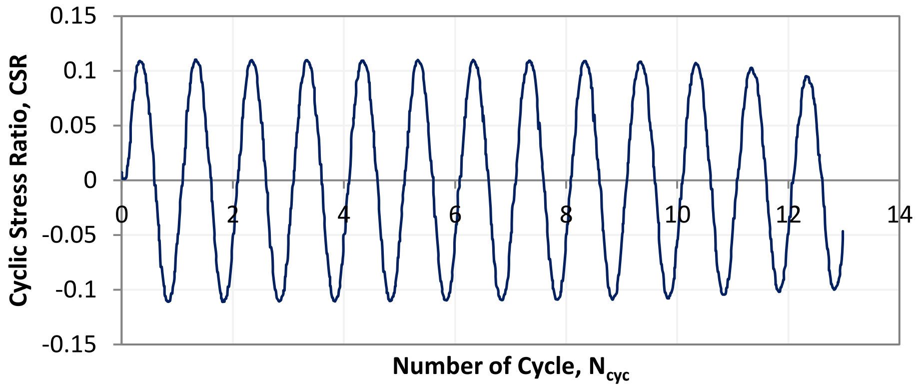


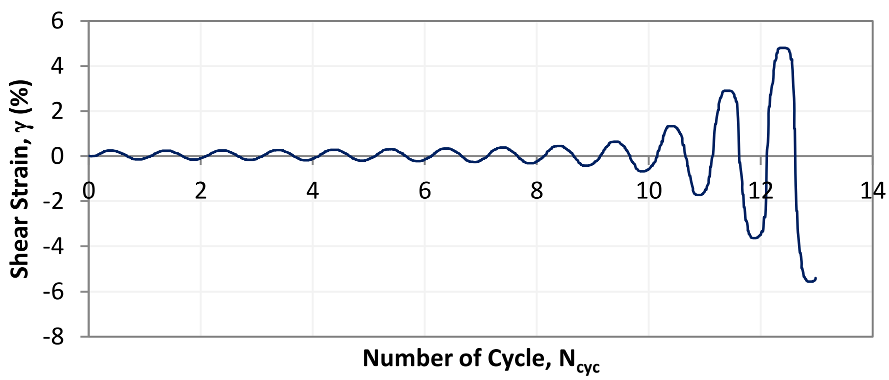
Figure 27. CYCLIC LOADING PHASE - TEST ID. KPL-A2-100-01

Sample ID : A2 -04

σ'_{vc} : 97.63 kPa

τ_{cyc}/σ'_{vc} : 0.108





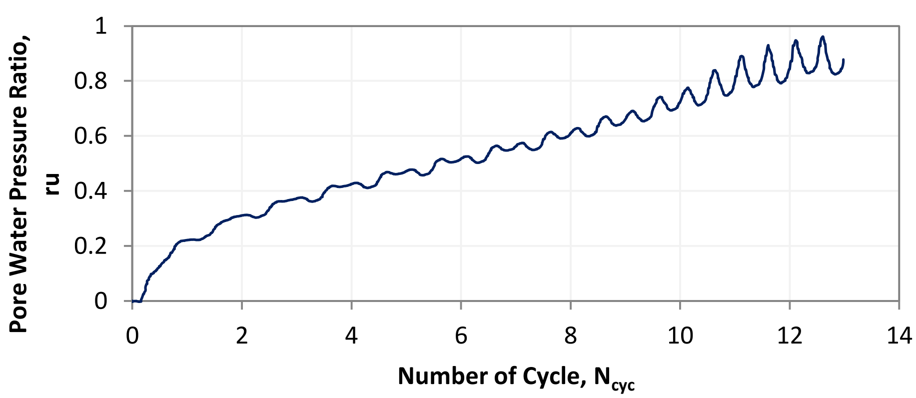
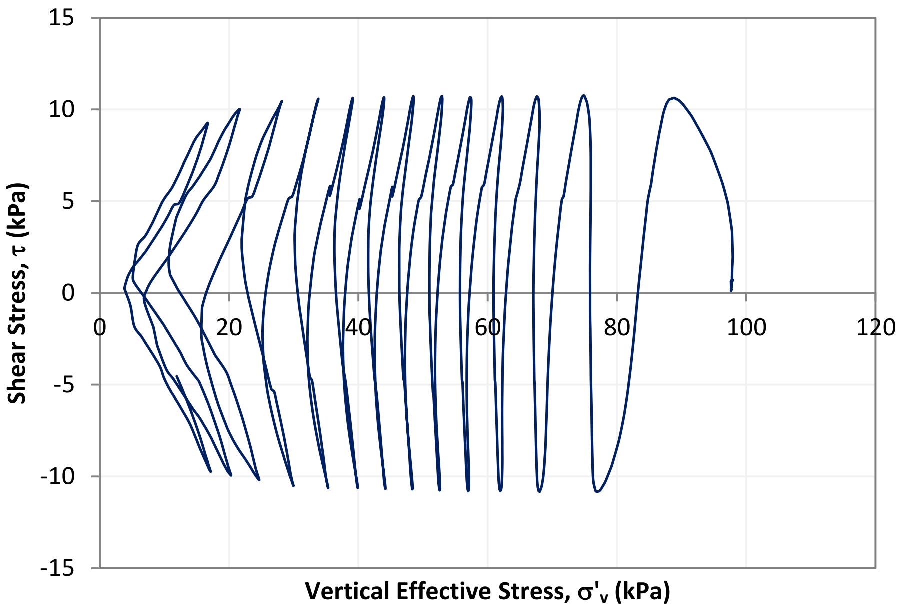


Figure 28. CYCLIC LOADING PHASE - TEST ID. KPL-A2-100-01

Sample ID : A2 -04

σ'_{vc} : 97.63 kPa

τ_{cyc}/σ'_{vc} : 0.108



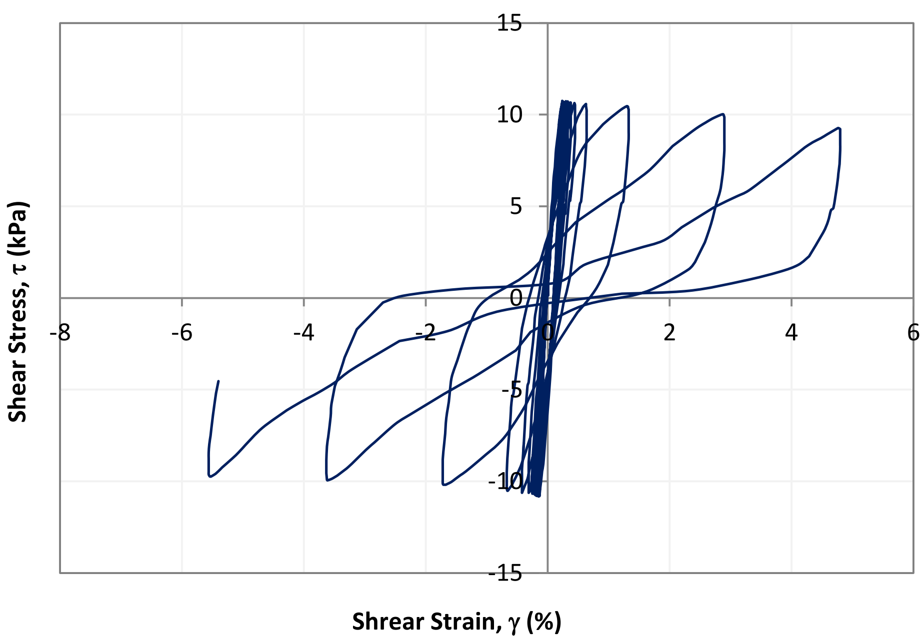
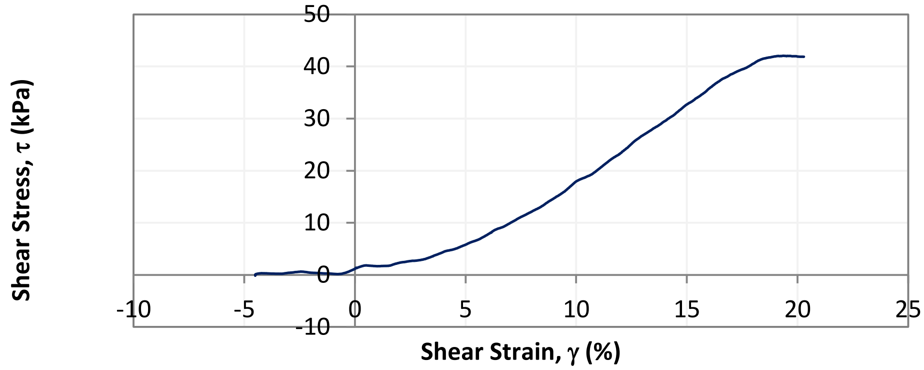
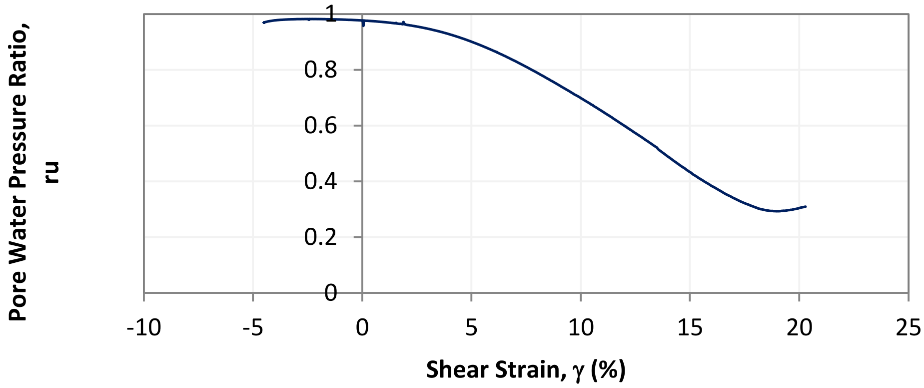


Figure 29. MONOTONIC LOADING PHASE - TEST ID. KPL-A2-100-01

Sample ID : A2 -04

σ'$_{vc}$: 97.63 kPa





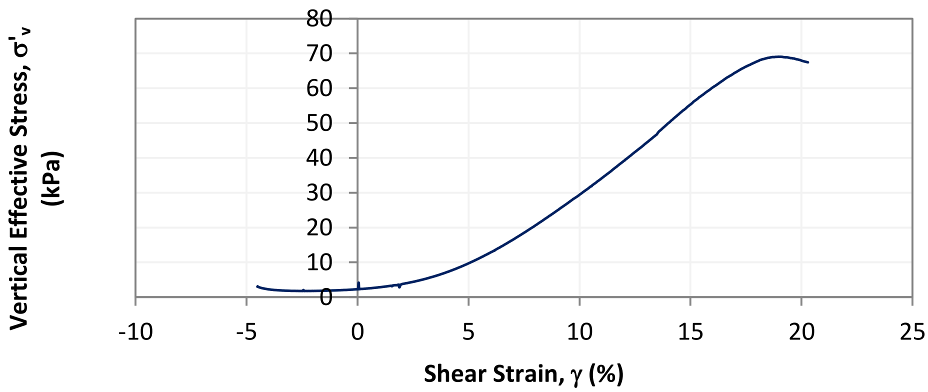


Figure 30. MONOTONIC LOADING PHASE - TEST ID. KPL-A2-100-01

Sample ID : A2 -04

σ'_{vc} : 97.63 kPa

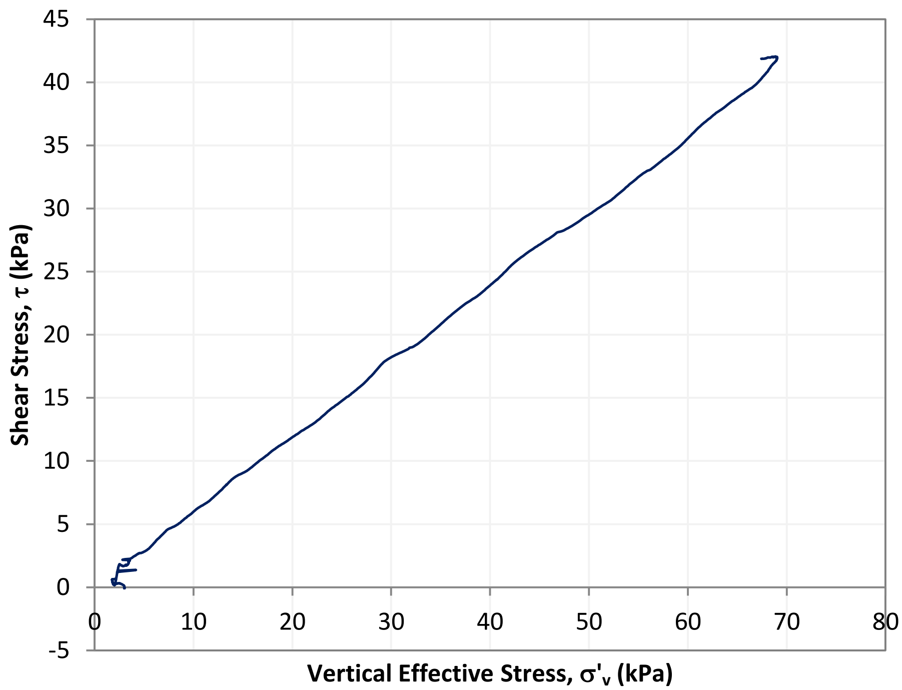


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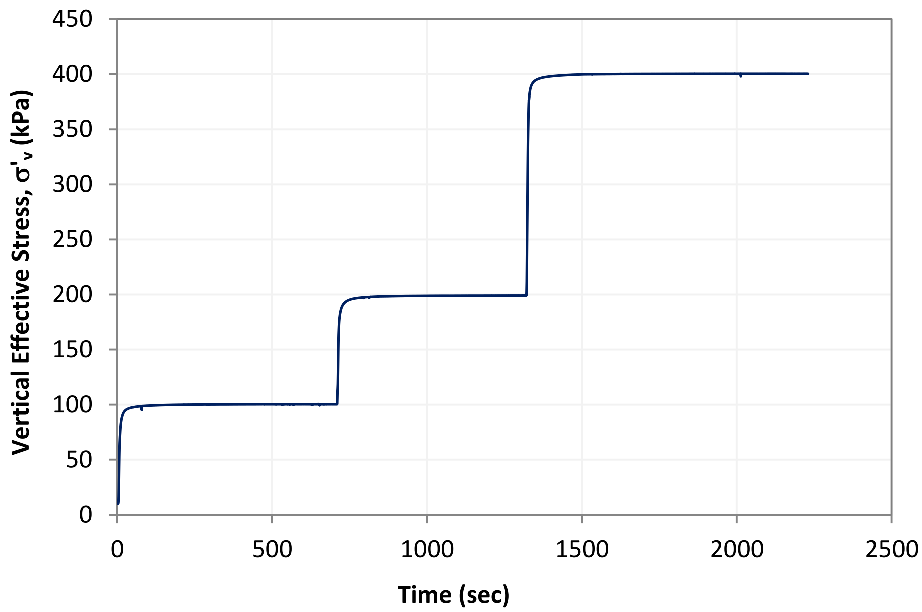
Figure 31. CONSOLIDATION PHASE - TEST ID. KPL-A2-400-01

Sample ID : A2 -R6

σ'_{vc} : 397.99 kPa



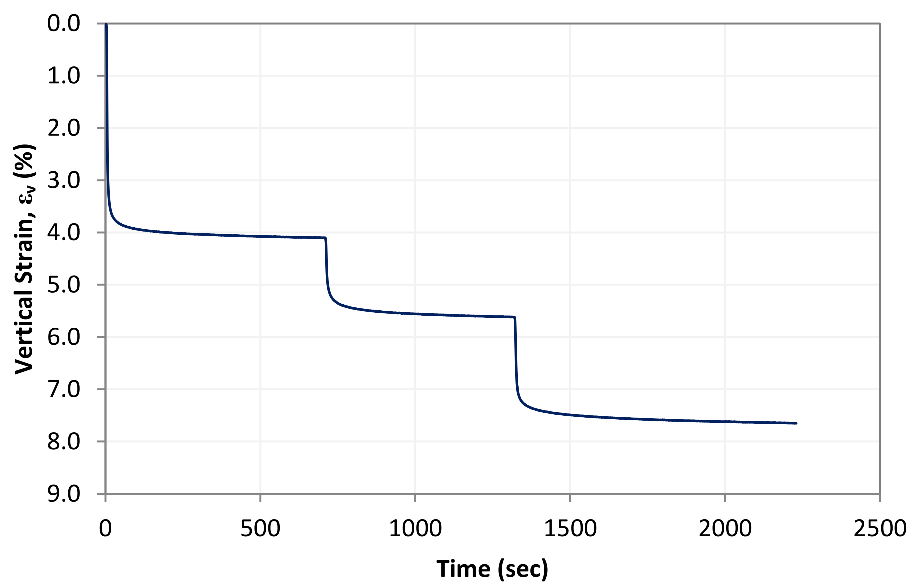
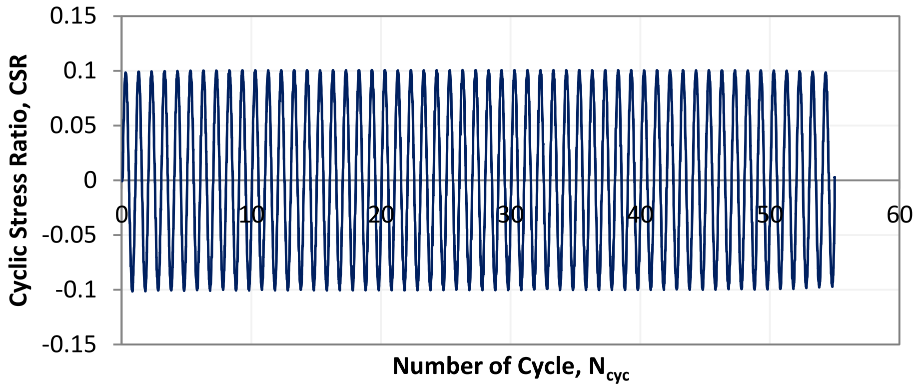


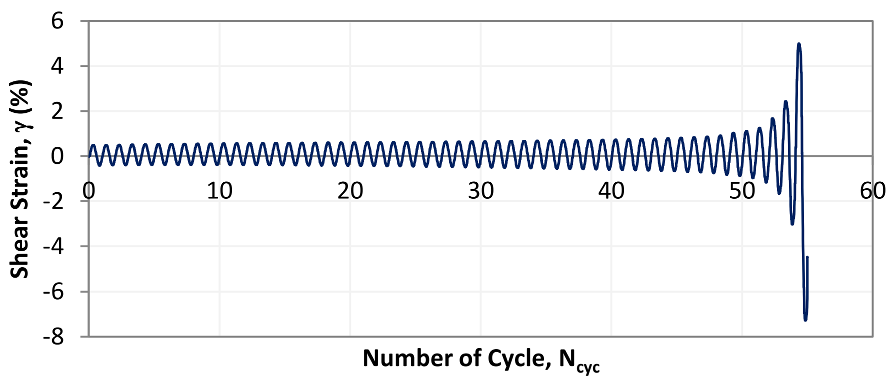
Figure 32. CYCLIC LOADING PHASE - TEST ID. KPL-A2-400-01

Sample ID : A2 -R6

σ'_{vc} : 397.99 kPa

τ_{cyc}/σ'_{vc} : 0.100





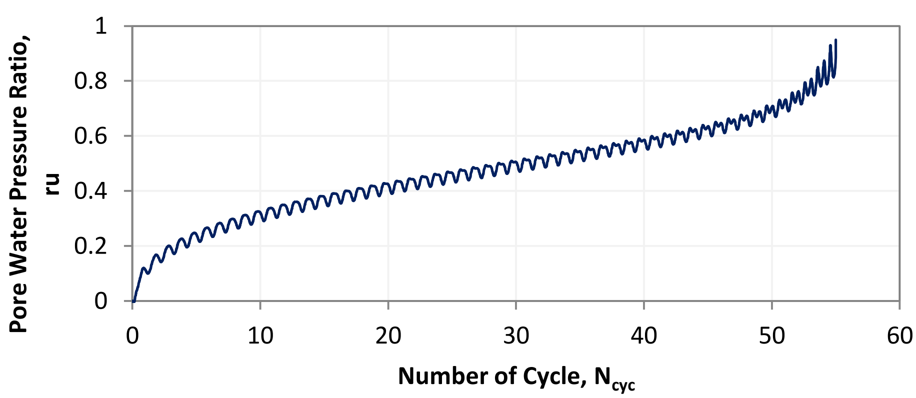
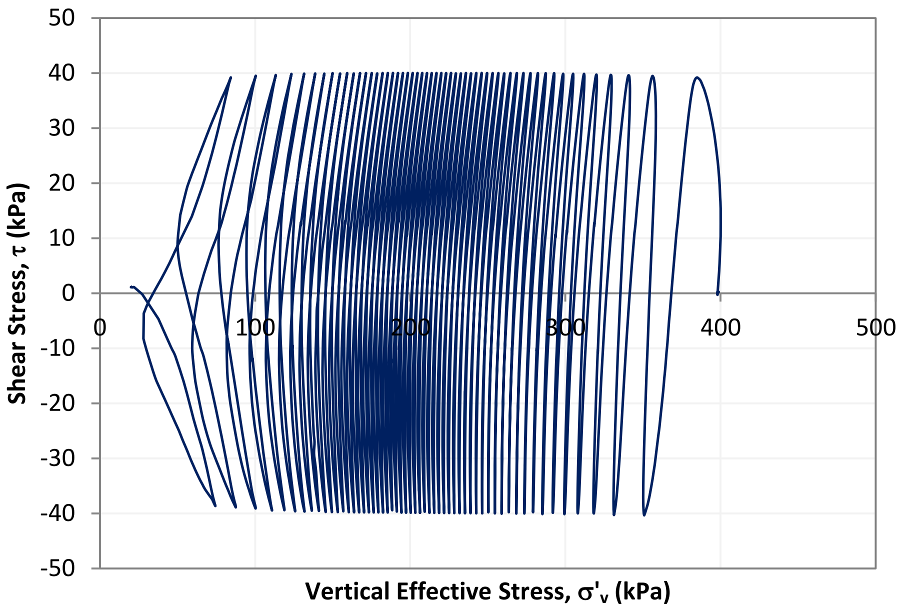


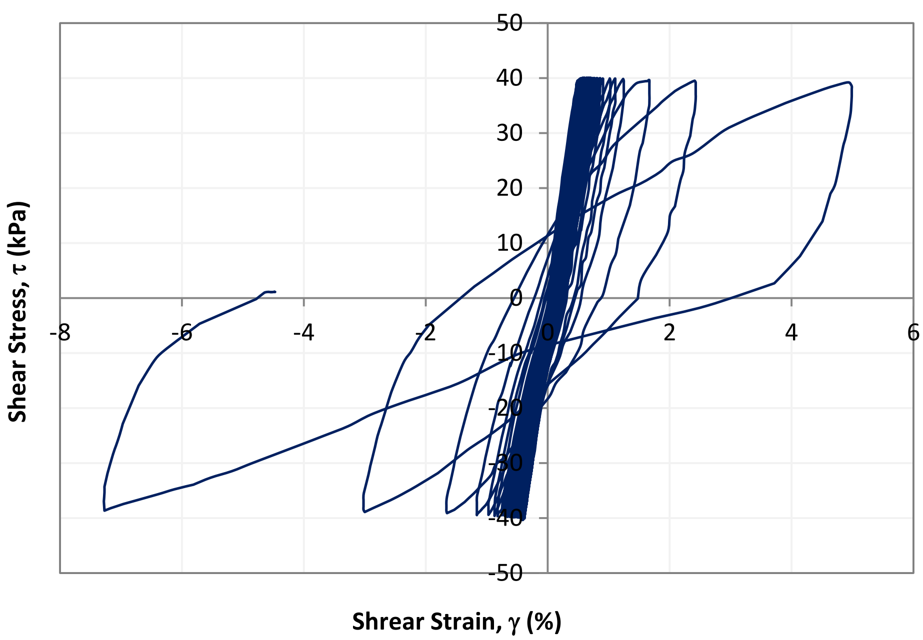
Figure 33. CYCLIC LOADING PHASE - TEST ID. KPL-A2-400-01

Sample ID : A2 -R6

σ'_{vc} : 397.99 kPa

τ_{cyc}/σ'_{vc} : 0.100



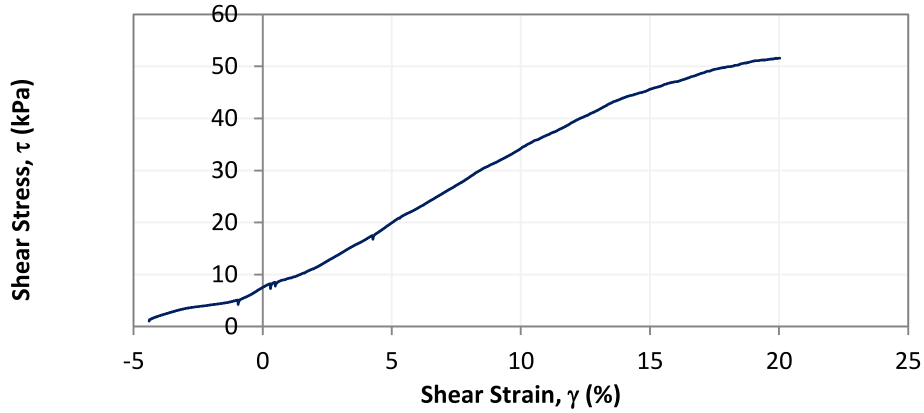


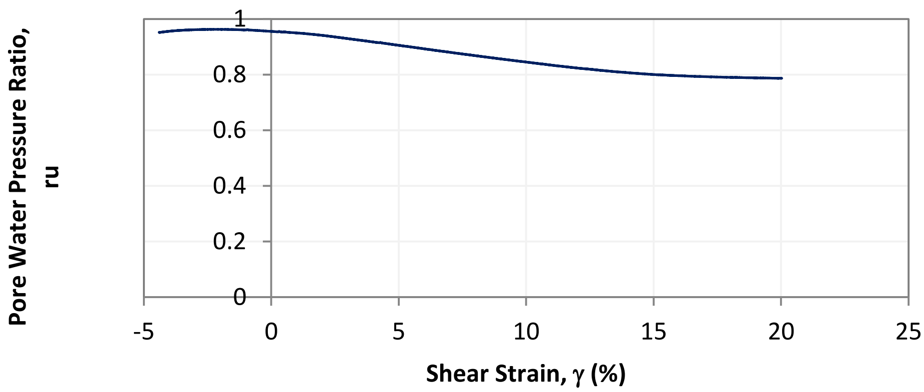
October 10, 2014

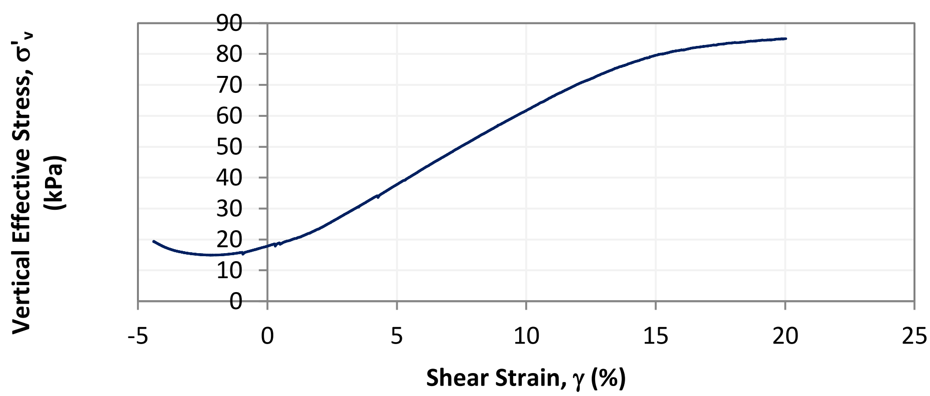
Our Project No : 14-KPL-001

Figure 34. MONOTONIC LOADING PHASE - TEST ID. KPL-A2-400-01

Sample ID : A2 -R6 σ'_{vc} : 397.99 kPa





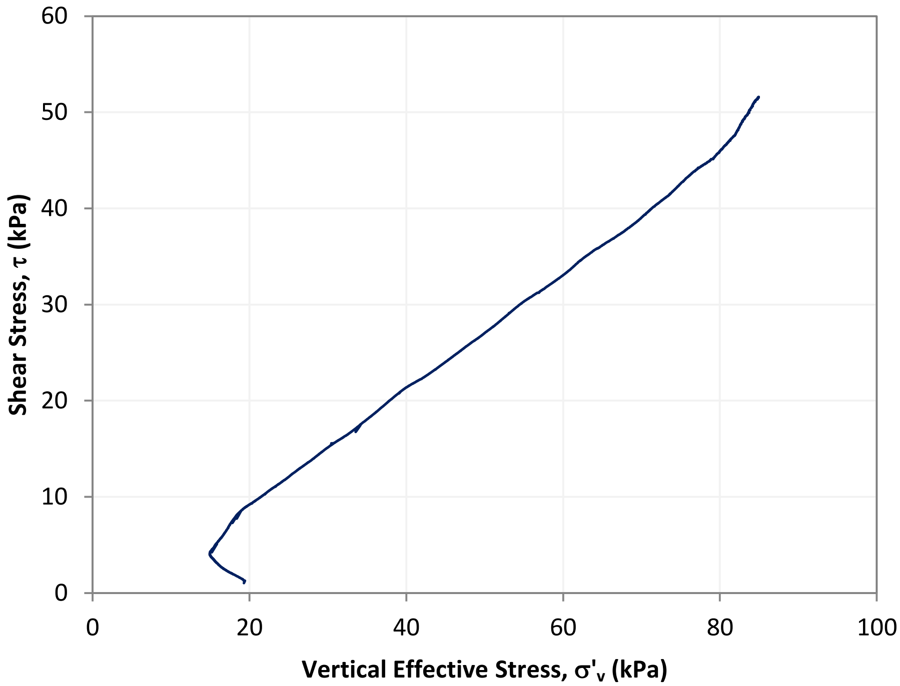


October 10, 2014 Our Project No : 14-KPL-001

Figure 35. MONOTONIC LOADING PHASE - TEST ID. KPL-A2-400-01

Sample ID : A2 -R6

σ'_{vc} : 397.99 kPa

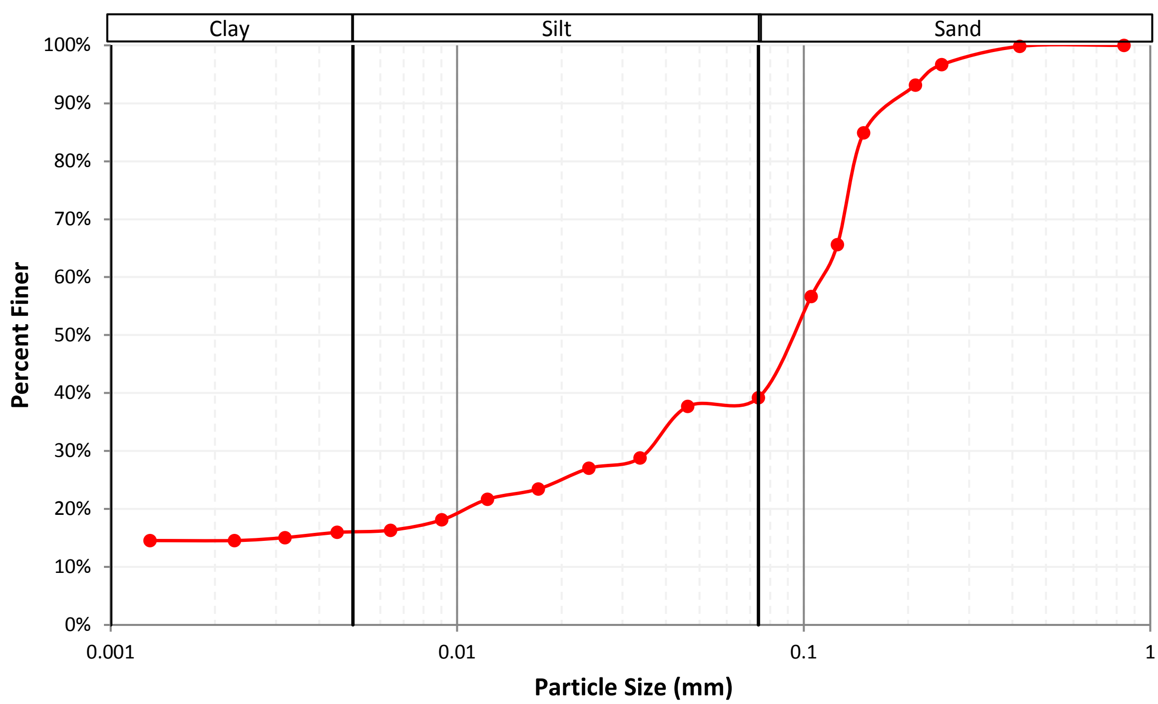


Project No	14-KPL-001
Test Date	10-Jul-14
Material	Dried, greyish, sandy silt
Sample ID	Area 2 - S#1
Test Method	ASTM D-422

Table 2 : Particle Size Distribution Analysis : Area 2 - S#1

Sieve Analysis			Hydrometer Analysis			
Sieve No.	Open (mm)	Percent Finer	Size (mm)	Percent Finer	Size (mm)	Percent Finer
20	0.840	100.0	0.0462	37.7	0.0032	15.1
40	0.420	99.8	0.0337	28.8	0.0023	14.6
60	0.250	96.7	0.0240	27.0	0.0013	14.6
70	0.210	93.1	0.0172	23.5		
100	0.149	84.9	0.0122	21.7		
120	0.125	65.6	0.0090	18.1		
140	0.105	56.7	0.0064	16.3		
200	0.074	39.2	0.0045	16.0		

Figure 36 : Particle Size Distribution Area 2 - S#1

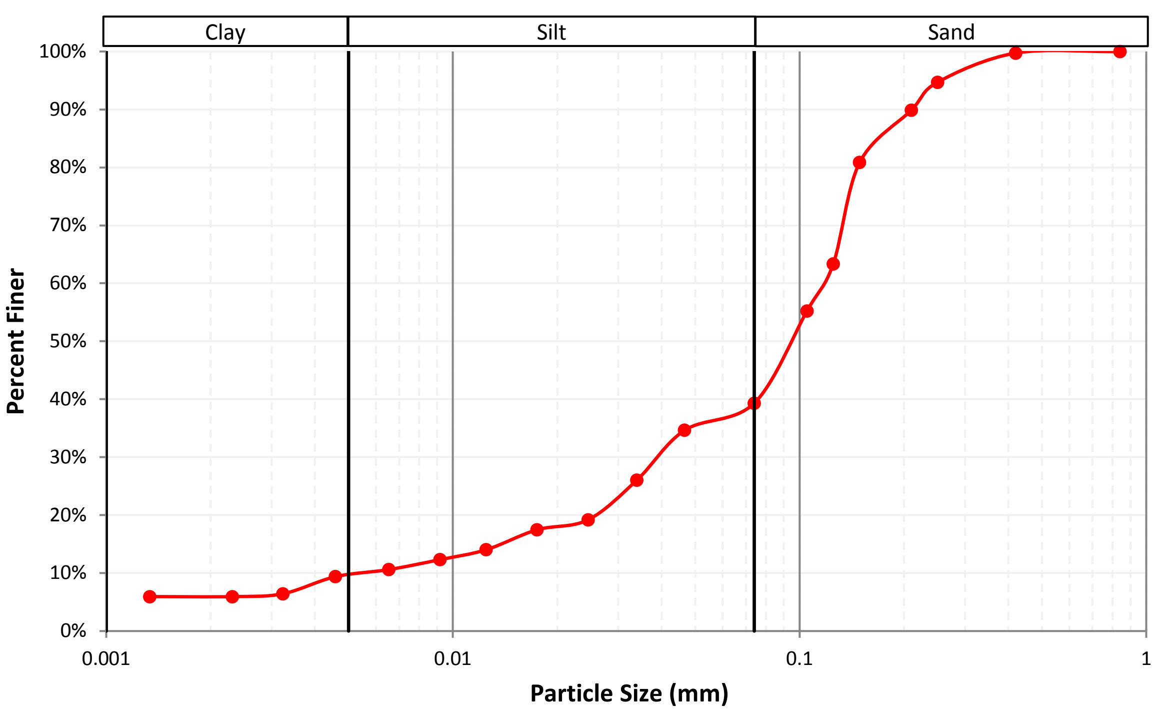


Project No	14-KPL-001
Test Date	10-Jul-14
Material	Dried, greyish, sandy silt
Sample ID	Area 2 - S#2
Test Method	ASTM D-422

Table 3 : Particle Size Distribution Analysis : Area 2 - S#2

Sieve Analysis			Hydrometer Analysis			
Sieve No.	Open (mm)	Percent Finer	Size (mm)	Percent Finer	Size (mm)	Percent Finer
20	0.840	100.0	0.0466	34.6	0.0032	6.4
40	0.420	99.7	0.0339	26.1	0.0023	5.9
60	0.250	94.7	0.0245	19.2	0.0013	5.9
70	0.210	89.9	0.0175	17.5		
100	0.149	80.8	0.0125	14.0		
120	0.125	63.3	0.0092	12.3		
140	0.105	55.2	0.0065	10.6		
200	0.074	39.3	0.0046	9.4		

Figure 37 : Particle Size Distribution Area 2 - S#2

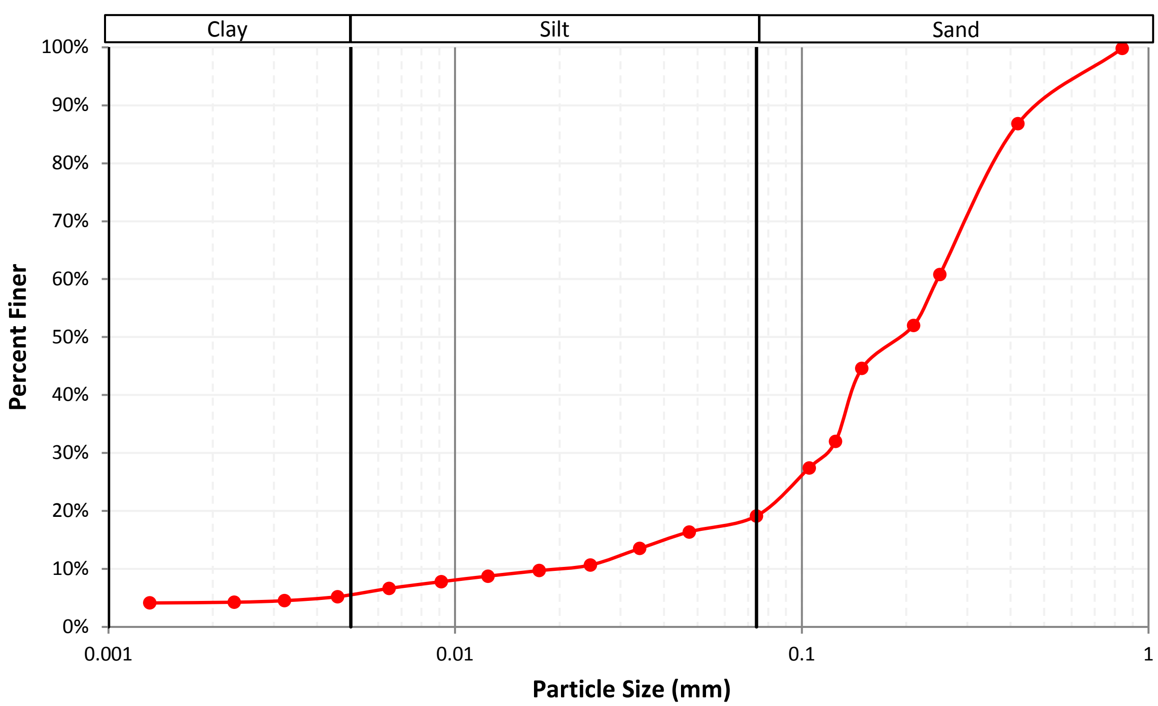


Project No	14-KPL-001
Test Date	10-Jul-14
Material	Dried, greyish, sand
Sample ID	Area 3 - S#1
Test Method	ASTM D-422

Table 4 : Particle Size Distribution Analysis : Area 3 - S#1

Sieve Analysis			Hydrometer Analysis			
Sieve No.	Open (mm)	Percent Finer	Size (mm)	Percent Finer	Size (mm)	Percent Finer
20	0.840	99.8	0.0473	16.4	0.0032	4.5
40	0.420	86.8	0.0341	13.5	0.0023	4.3
60	0.250	60.8	0.0245	10.7	0.0013	4.1
70	0.210	52.0	0.0175	9.7		
100	0.149	44.6	0.0124	8.8		
120	0.125	32.0	0.0091	7.8		
140	0.105	27.4	0.0065	6.6		
200	0.074	19.2	0.0046	5.2		

Figure 38 : Particle Size Distribution Area 3 - S#1



Project No	14-KPL-001
Test Date	10-Jul-14
Material	Dried, greyish, sand
Sample ID	Area 3 - S#2
Test Method	ASTM D-422

Table 5 : Particle Size Distribution Analysis : Area 3 - S#2

Sieve Analysis			Hydrometer Analysis			
Sieve No.	Open (mm)	Percent Finer	Size (mm)	Percent Finer	Size (mm)	Percent Finer
20	0.840	99.8	0.0468	19.9	0.0032	6.7
40	0.420	85.8	0.0337	16.8	0.0023	6.7
60	0.250	59.7	0.0243	13.7	0.0013	6.6
70	0.210	51.0	0.0173	11.6		
100	0.149	43.0	0.0123	10.6		
120	0.125	32.0	0.0090	9.8		
140	0.105	28.0	0.0064	8.8		
200	0.074	20.3	0.0045	7.7		

Figure 39 : Particle Size Distribution Area 3 - S#2

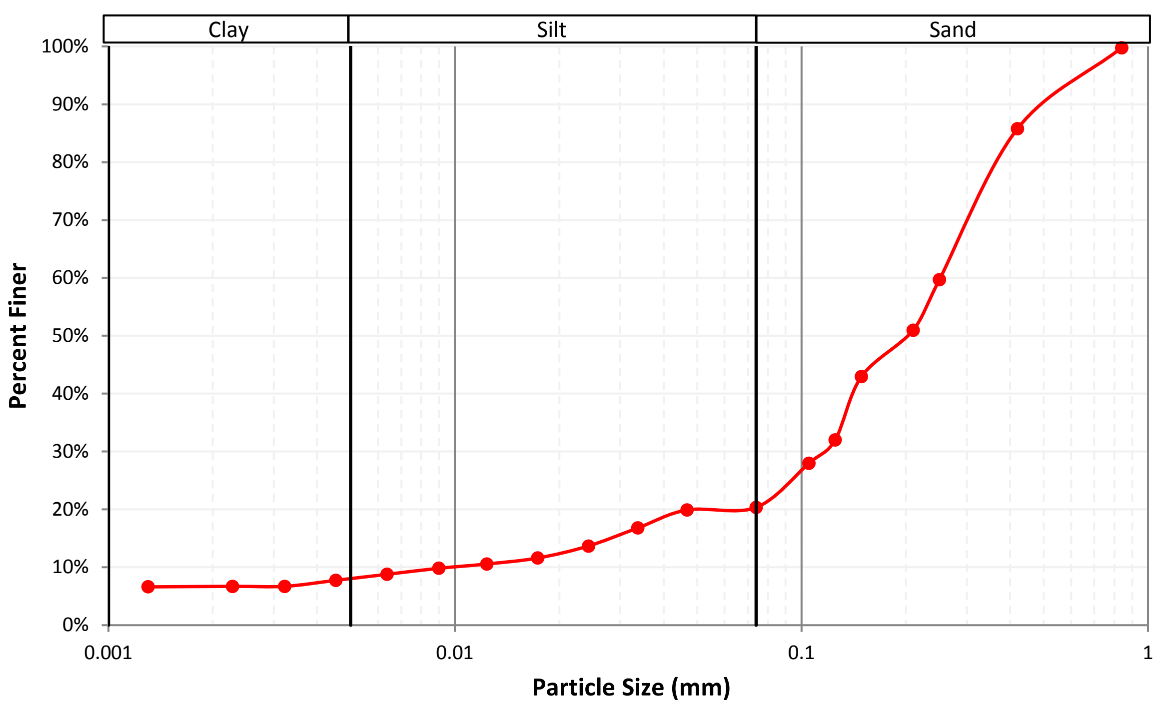


Table 6 : Specific Gravity Test Results

Sample Name	BT 4 Brass tube sample	BT 12 Brass tube sample
Sampling Location	Area 2	Area 3
Type of Material	Silty sand:fine tailings	Sand:course tailings
Initial visual description	Powder textured, greyish white oven dried sample	Gritty textured, greyish white oven dried sample
Average Specific Gravity of Soil Solids at 20 ^{0}C	2.71	2.7
Standard Deviation of the Specific Gravity of Soil Solids	0.004	0.018

Table 7 : Insitu Density and Moisture Content Test : Summary of test results

Visual description	Film of water seen over the top layer of grey, wet silty sand specimen		
Specimen No.	BT-04	BT-05	BT-06
Water Content (w) (%)	30.395	33.534	29.381
Density of total (moist) soil specimen ρ_m (g/cm^3)	1.731	1.713	1.641
Dry density of soil ρ_d (g/cm^3)	1.327	1.283	1.269
Moist/total unit weight of specimen γ_m (kN/m^3)	16.975	16.799	16.097
Dry unit weight of soil specimen γ_d (kN/m^3)	13.018	12.580	12.441
Visual description	Moist greyish sandy non uniform top surface. Clumps were visible.		
Specimen No.	BT-12	BT-13	BT-14
Water Content (w) (%)	12.240	12.883	10.929
Density of total (moist) soil specimen ρ_m (g/cm^3)	1.506	1.543	1.491
Dry density of soil ρ_d (g/cm^3)	1.341	1.367	1.344
Moist/total unit weight of specimen γ_m (kN/m^3)	14.764	15.134	14.622
Dry unit weight of soil specimen γ_d (kN/m^3)	13.154	13.407	13.181

Data Report on

Large-Diameter Simple Shear Testing

of Alluvial Soils at Montana Resources Site

By

Dimitrios Zekkos and Satuk Bugrahan Sari

Prepared for

Knight Piésold

750 W. Pender Street, Suite 1400

Vancouver, BC Canada V6C 2T8

Geotechnical Research Report No. UCB/GT/2023-02
Department of Civil and Environmental Engineering
University of California at Berkeley

December 12 2023

TABLE OF CONTENTS

1. INTRODUCTION

At the request of Mark Bancroft and Salina Yong of Knight Piésold, monotonic and cyclic simple shear tests were conducted on alluvial soils at the Montana Resources site. The tests were performed at the University of California at Berkeley (UCB) Geotechnical Laboratories by graduate student Mr. Satuk Bugrahan Sari under the direction of Professor Dimitrios Zekkos. This brief data report summarizes the testing conducted and includes the test results.

2. LABORATORY TESTING PROGRAM AND PROCEDURES

The testing program is presented in Table 1 and includes testing on six reconstituted specimens. Each specimen was reconstituted at a “loose” state and was first loaded at a vertical stress at 50 kPa. Then, the specimen was flooded with water that was raised from the bottom base cap all the way to the top. The specimen was then compressed to the target vertical stress (that varied depending on the test with values of 100 kPa, 300 kPa, and 550 kPa) and then shear testing was conducted. Reconstituted specimens were compressed at the target vertical consolidation stress for 18±2 hours.

Shear testing included constant volume stress-controlled cyclic testing at Cyclic Stress Ratios (CSR) specified by Knight Piésold and at a frequency of 0.033 Hz. Each cyclic test was cyclically sheared at the target CSR until “liquefaction” (defined as 3.75% single amplitude shear strain) and then sheared monotonically after “liquefaction” to shear strains of at least 10% strain. Shear wave velocity measurements were conducted using accelerometers immediately prior to the execution of the cyclic simple shear testing.

Specimen preparation, compression (and “consolidation”), shear-wave velocity measurement, and shearing followed the laboratory testing procedures that are included in Appendix A.

3. TESTING DEVICE

The testing device utilized for the laboratory testing program is a prototype large-diameter (d=300 mm) direct simple shear device developed in collaboration with a laboratory manufacturer. A detailed description of the device that was used for the execution of Direct Simple Shear (DSS) tests, along with validation testing can be found in an ASTM journal paper by Zekkos et al. (2018). Figure 1 shows a view of the device used for testing.

Fig. 1. View of large-diameter direct simple shear testing device with a specimen being submerged.

4. TESTED MATERIAL

In total 15 buckets of soil (each of them approximately 20-25 kg) were received. After inspection, 14 of these buckets with what appeared visually to be similar type of soil were mixed together thoroughly. The one remaining bucket had slightly different material based on texture and color and was not used. The mixed material was used to reconstitute specimens. The sieve analysis was also performed with this mixture.

The tested material consisted of alluvial soils from the Montana Resources site and is shown in Fig. 2. A grain size distribution of the tested material was developed using the wet sieving method and is shown in Fig. 3 with a thick blue line. The D_{10}, D_{30}, D_{50} and D_{60} values are determined as 0.0014 mm, 0.22 mm, 0.78 mm, and 1.38 mm, respectively, which resulted in a C_u value of 986. Atterberg limits were estimated for the #40 sieve passing material as follows: Plasticity Limit, PL = 19%; Liquid Limit, LL = 29% and Plasticity Index, PI = 10%. The gravel/boulder, sand and fines contents are estimated as 26.0%, 54.5% and 19.6%, respectively.

Fig. 2. View of material prior to specimen preparation (left) and upon specimen preparation (right)

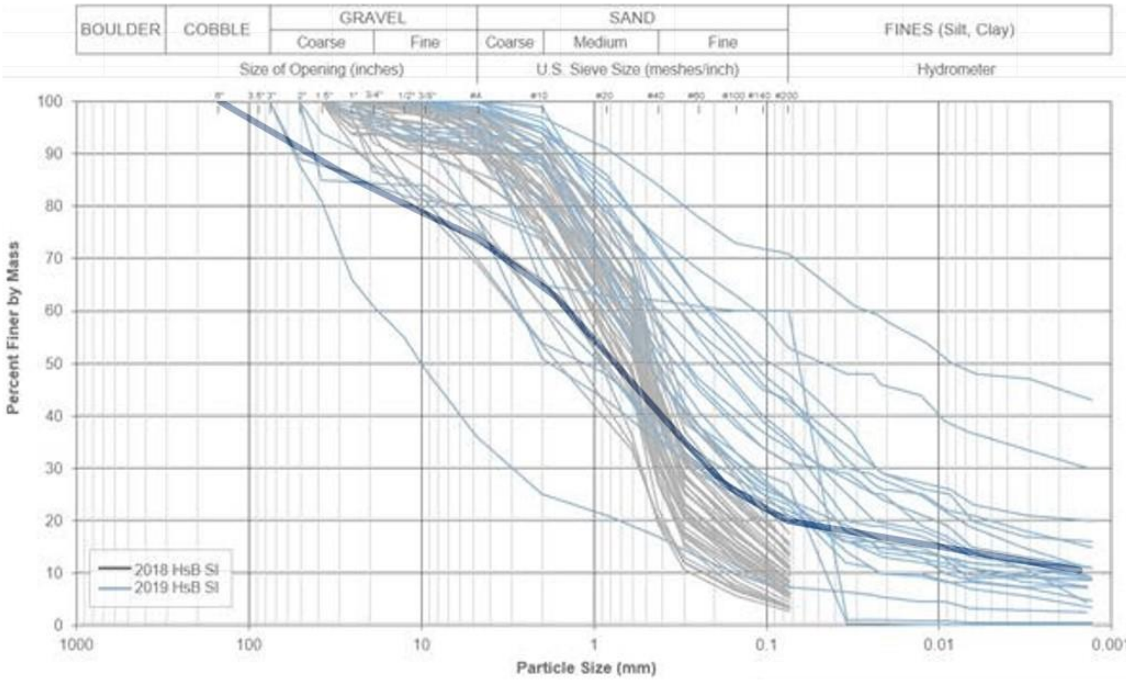


Fig. 3. Grain size distribution

The minimum and maximum void ratios (e_{min} and e_{max}) as well as the minimum and maximum dry densities ($\rho_{dry,min}$ and $\rho_{dry,max}$) were also evaluated for the tested material. For the evaluation of the minimum void ratio, the soil was placed in a cup (20.1 cm in diameter, 4.96 cm in height for a volume of 1574 cm^3) and was densified by tamping the cup on four sides 25-times with a plastic hammer. For the maximum void ratio, the loosest possible soil state was achieved by placing the soil in the cup with a sharp-headed spoon, with a zero falling height to minimize the compaction energy. The minimum and maximum void ratios were evaluated as 0.439 and 0.943, respectively. The corresponding maximum and minimum dry densities using an assumed specific gravity of 2.65 were estimated as 1840 and 1364 kg/m^3, respectively.

Specimens were prepared as loose-as-possible and the dry densities are shown in Table 1. The specimens compressed significantly following submersion and during vertical load application. As a result, during load application of the higher vertical stresses (300 kPa and 550 kPa), the vertical stroke length was exceeded (equivalent to vertical strains that are greater than 10%) and thus the specimens for these tests were prepared slightly denser, but still experienced significant compression during submersion and vertical load application.

5. TESTING RESULTS

Following vertical load application, horizontal shear (cyclic and monotonic) was applied. During shearing phase of each test, horizontal and vertical applied force and displacement were recorded with time. Subsequently, shear stress (τ) is calculated as the horizontal load divided by the cross-sectional area of the (upper) specimen, and vertical strain (ε_v) is calculated as the vertical displacement during shearing divided by the specimen height prior to shearing.

As-prepared and as-consolidated properties of each specimen along with measured shear wave velocities and number of cycles to liquefaction, are summarized in Table 1. The summary results for all specimens are presented in Appendix B using UC Berkeley’s standardized format for presenting direct simple shear data. The raw data in electronic format has been submitted electronically to Knight Piésold. Beyond the laboratory data analyses, no interpretations of test data are made in this report.

6. REFERENCES

ASTM (2011). "D3080-11 standard test method for direct shear test of soils under consolidated drained conditions." ASTM International, West Conshohocken, PA, USA.

Zekkos, D., Athanasopoulos-Zekkos, A., Hubler, J., Fei, X., Zehtab, K. H., & Marr, W. A. (2018). Development of a large-size cyclic direct simple shear device for characterization of ground materials with oversized particles. Geotechnical *Testing Journal*, (2), 263-279.

TABLES

Table 1. Testing program and summary of results

Test#	σ'_v (kPa)	CSR	Freq. (Hz)	Dry Density, ρ_{dry} (kg/m^3)		After consolidation V_s (m/s)	Number of cycles for liquefaction
				As-prepared	As-consolidated		
1	100	0.10	0.033	1452.6	1739.9	198 ± 8	34
2	100	0.20	0.033	1473.0	1677.3	177 ± 4	2
3	100	0.15	0.033	1466.4	1674.2	202 ± 5	13
4	550	0.15	0.033	1505.6	1808.1	292 ± 4	3
5	550	0.10	0.033	1515.7	1788.8	304 ± 1	29
6	300	0.125	0.033	1505.0	1734.7	246 ± 5	21

APPENDIX A

Specimen Preparation Procedures for DSS Testing

Geotechnical Engineering Laboratories

Testing protocols for Cyclic Shear Testing using the Cyclic Simple Shear Device on Soil Material

Testing for Knight Piesold

PROTOCOLS – WORKING DOCUMENT

November 18 2023, Version 2

1. TESTING DEVICE

A large-size Cyclic Simple Shear (CSS) device is used to perform cyclic shear tests followed by monotonic testing. The specimen is contained by stacked rings that are Teflon coated to minimize their frictional sliding resistance. In simple shear testing of soil materials, it is generally recommended that the specimen height does not exceed 0.4 of the diameter of the specimen for cylindrical specimens (ASTM D6528). The CSS apparatus uses 12-in. (307.5-mm) diameter by up to 4.87-in. (110-mm) height specimens thus having an as-prepared diameter to height ratio of approximately 0.40 before consolidation.

2. TEST PROCEDURES

A. Use a membrane (0.635 mm in thickness) is used to encapsulate the specimen to allow for specimen submergence. This is shown in Figure 1.

Figure 1 Placement of membrane

B. Next, stack each shear ring one by one as shown in Figure 2.

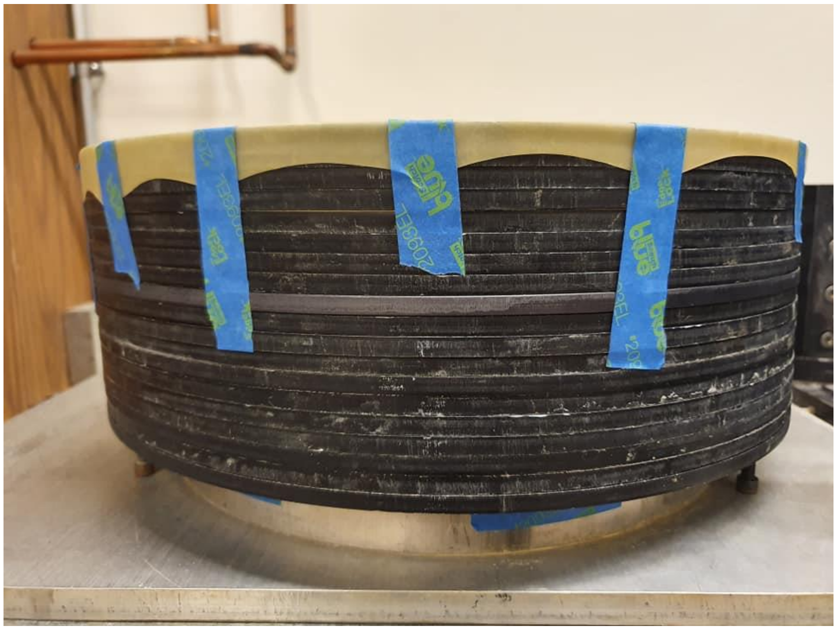


Figure 2 Placement of shear rings

C. Stretch the membrane against the top rings as shown in Figure 3. Make sure that the membrane is stretched smoothly and leaves no space between the shear rings and the membrane.

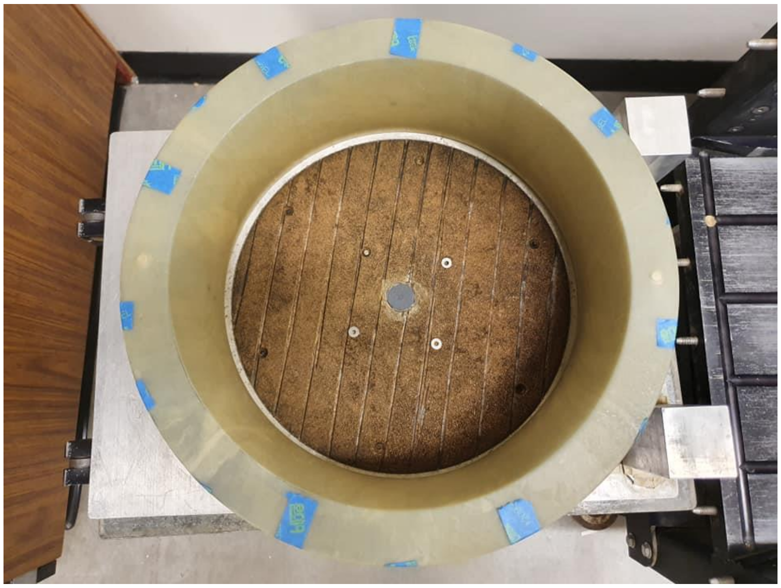
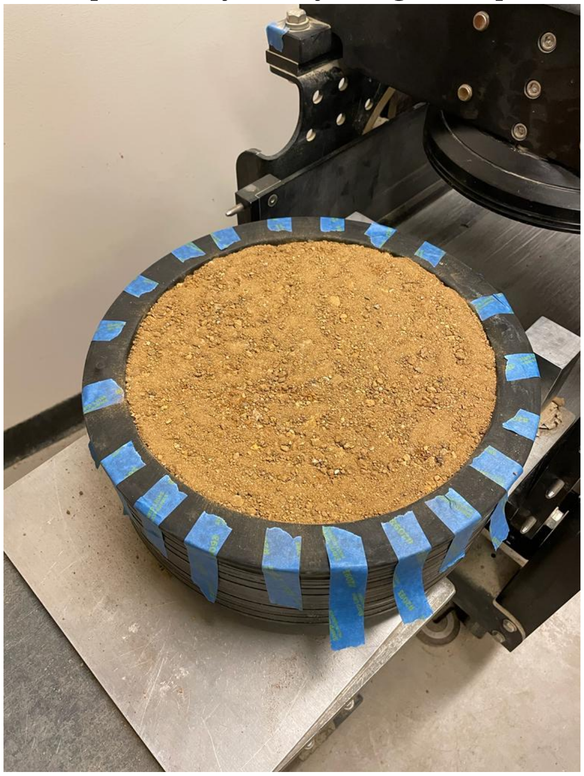


Figure 3 Fixed membrane prior to soil material placement

D. Material will be placed very slowly using a scoop to achieve the lowest density possible as shown in 

E. Figure *4*.

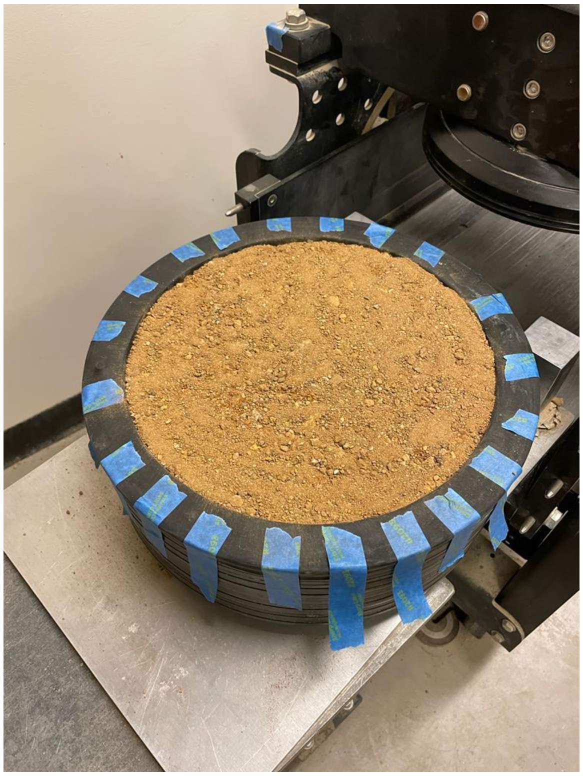


Figure 4 Material placed in as loose-as-possible state

F. Apply seating load of 50 kPa and submerge the specimen for around 2 hours as shown in Figure 5.

Figure 5 Submerge the specimen before the test

G. After submergence, the specimen is consolidated to 100 kPa, 300 kPa, and 550 kPa vertical stress for six different tests. Accelerometers are used to measure shear wave velocity prior to shearing.

H. Cyclic tests are conducted at a frequency ranging from 0.01 to 0.3 Hz, as needed to ensure constant volume testing. A cyclic shear stress (CSR) is applied. CSR for the first specimen is 0.1 followed by two other CSRs of 0.2 and 0.15 for two other specimens consolidated at 100 kPa vertical stress. For 550 kPa consolidation stress tests, the CSRs are applied as 0.15 and 0.1. For the last test with 300 kPa consolidation stress, the CSR value is given as 0.125.

Once the specimen liquefies, defined as a single amplitude shear strain of 3.75%, the cyclic testing is completed.

Figure 6 Inclined rings at the end of the cyclic test

I. After completion of the cyclic testing, the specimen is sheared monotonically to at least 10% shear strain at a target strain rate of ~0.1%/min.

APPENDIX B

Testing Results

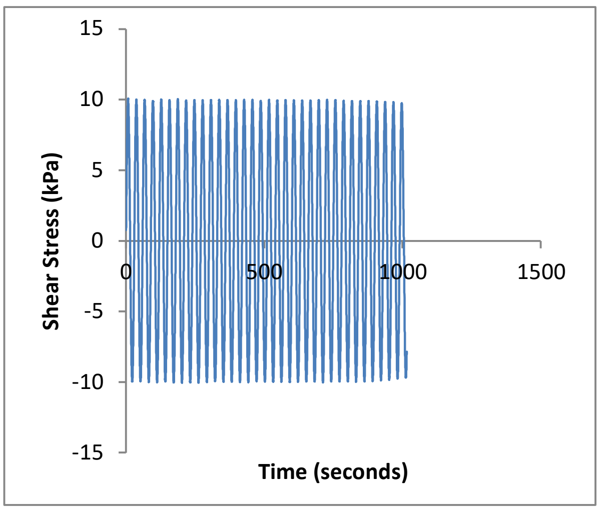
CSS Cyclic Shear Test Report
Geotechnical Engineering Laboratory

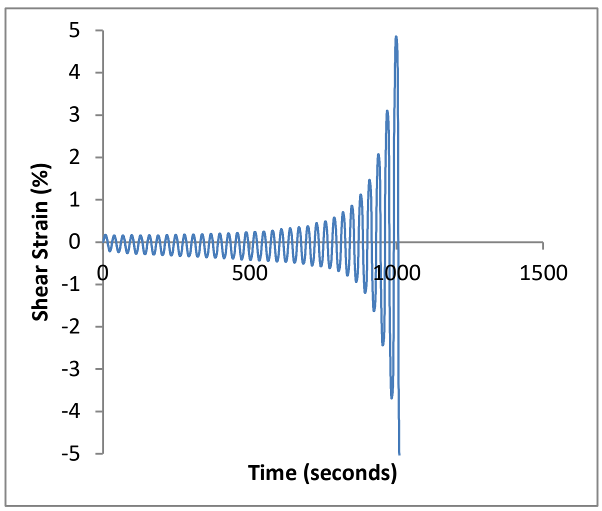
Berkeley UNIVERSITY OF CALIFORNIA

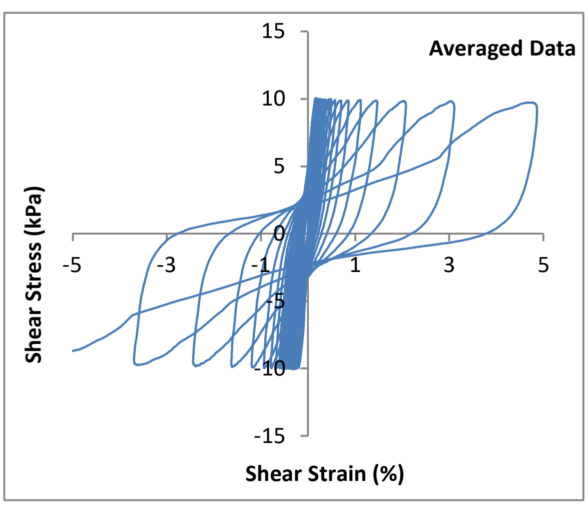
Cyclic Shear Test Summary

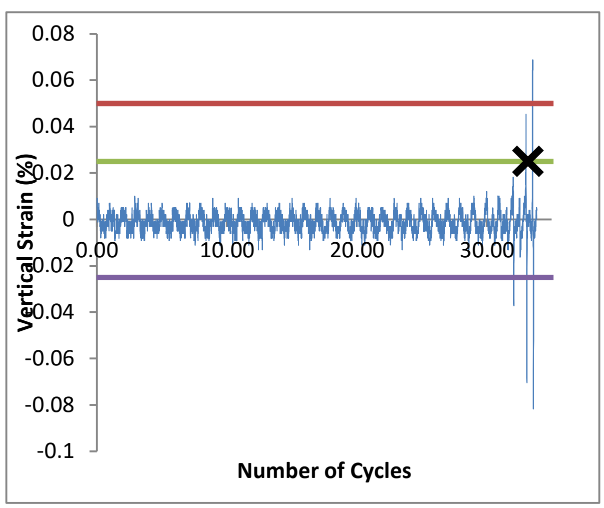
Device:	CSS	**Dry Density (kg/m3):**	1740
Specimen ID:	KPMT	**Relative Density (%):**	83%
Test ID:	Test1	**Void Ratio:**	0.523
Date of Test:	09/18/2023	**Vertical Stress (kPa):**	100
Test Performed:	Satuk	**Loading Frequency (Hz):**	0.033
Test Material:	KPMT	**Number of Cycles to Liq:**	34
Sample Preparation:	Submerged condition	**Cyclic Stress Ratio:**	0.1
		Shear Modulus (kPa):	
		Damping (%):	
Prepared by:	Satuk	**Shear Strain Single Amplitude (%):**	
Checked by:	Prof. Zekkos		

Additional Comments: Cyclic shear test is stopped at approximately 5% single amplitude shear strain. Post-cyclic monotonic shear test (PM) is performed after cyclic shearing.









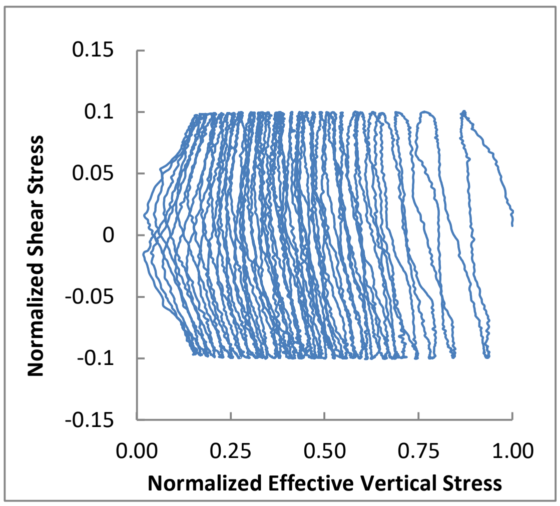
CSS Cyclic Shear Test Report

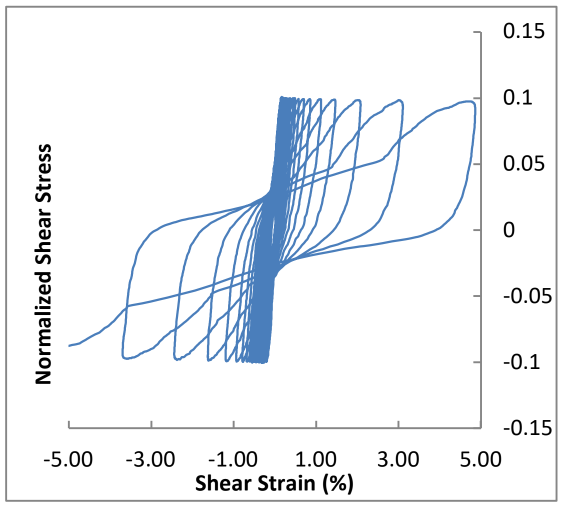
Geotechnical Engineering Laboratory

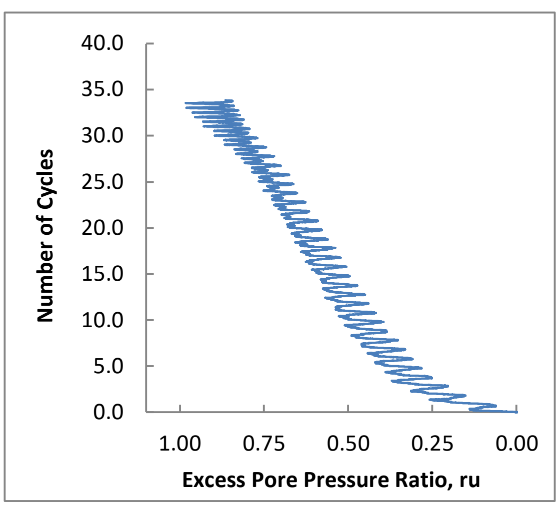
Berkeley UNIVERSITY OF CALIFORNIA

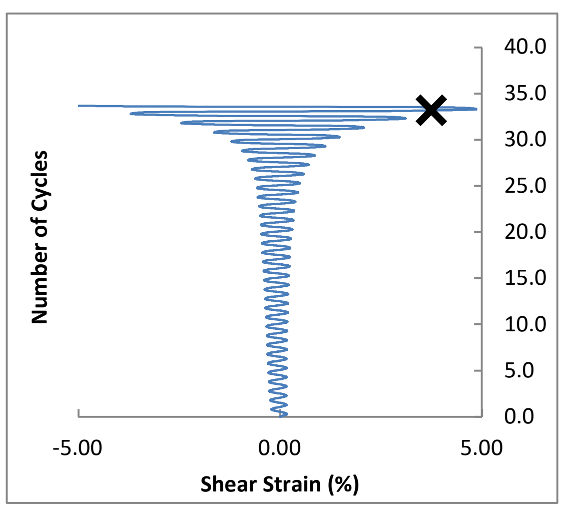
Cyclic Shear Test Summary			
Device:	CSS	**Dry Density (kg/m3):**	1740
Specimen ID:	KPMT	**Relative Density (%):**	83%
Test ID:	Test1	**Void Ratio:**	0.523
Date of Test:	09/18/2023	**Vertical Stress (kPa):**	100
Test Performed:	Satuk	**Loading Frequency (Hz):**	0.033
Test Material:	KPMT	**Number of Cycles to Liq:**	34
Sample Preparation:	Submerged condition	**Cyclic Stress Ratio:**	0.1
		Maximum ru:	0.98
Prepared by:	Satuk		
Checked by:	Prof. Zekkos		

Additional Comments: Cyclic shear test is stopped at approximately 5% single amplitude shear strain. Post-cyclic monotonic shear test (PM) is performed after cyclic shearing.









CSS Cyclic Shear Test Report

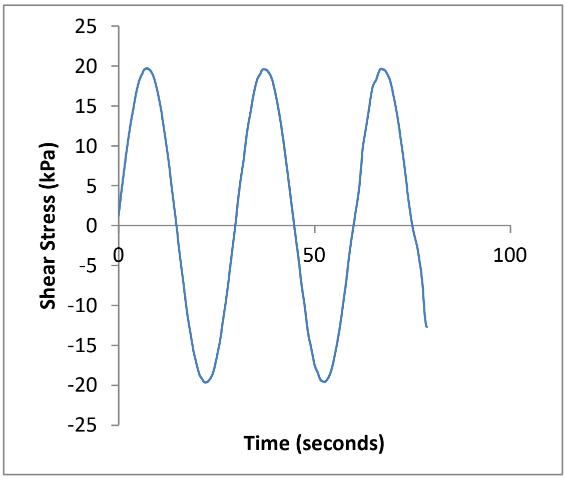
Geotechnical Engineering Laboratory

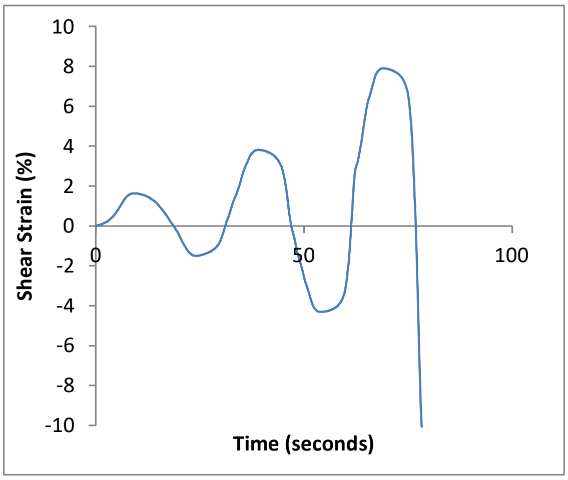
Berkeley
UNIVERSITY OF CALIFORNIA

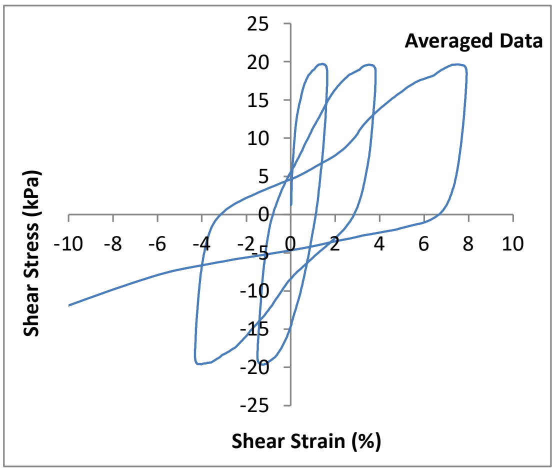
Cyclic Shear Test Summary

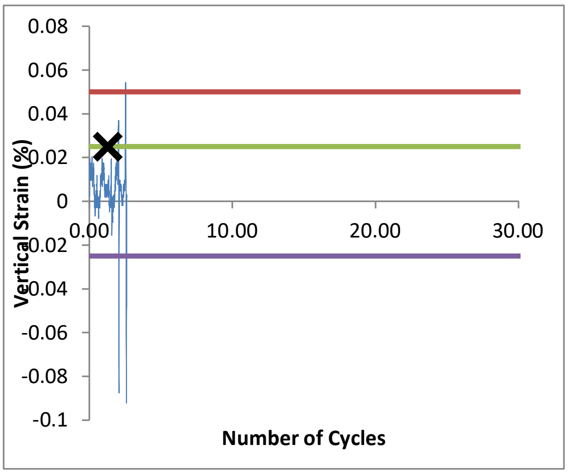
Device:	CSS	**Dry Density (kg/m3):**	1677
Specimen ID:	KPMT	**Relative Density (%):**	72%
Test ID:	Test2	**Void Ratio:**	0.580
Date of Test:	09/25/2023	**Vertical Stress (kPa):**	100
Test Performed:	Satuk	**Loading Frequency (Hz):**	0.033
Test Material:	KPMT	**Number of Cycles to Liq:**	2
Sample Preparation:	Submerged condition	**Cyclic Stress Ratio:**	0.2
		Shear Modulus (kPa):	
		Damping (%):	
Prepared by:	Satuk	**Shear Strain Single Amplitude (%):**	
Checked by:	Prof. Zekkos		

Additional Comments: Cyclic shear test is stopped at approximately 10% single amplitude shear strain. Post-cyclic monotonic test (PM) is performed after cyclic shearing.









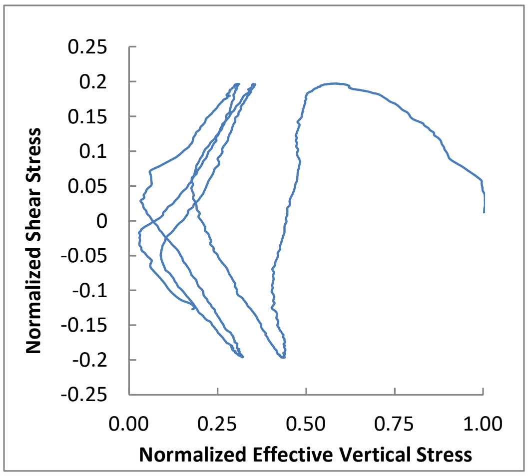
CSS Cyclic Shear Test Report

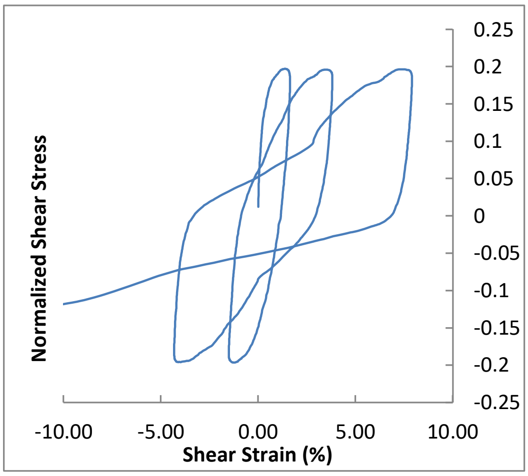
Geotechnical Engineering Laboratory

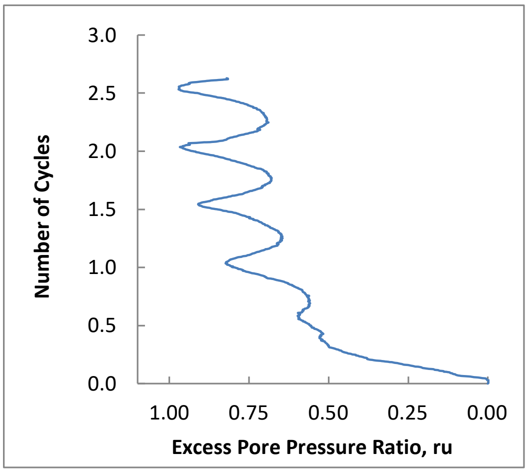
Berkeley UNIVERSITY OF CALIFORNIA

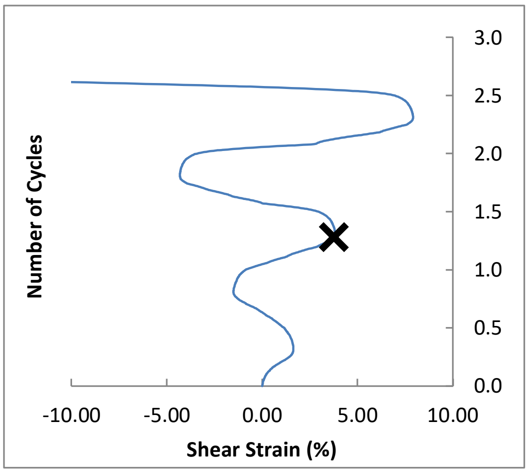
Cyclic Shear Test Summary			
Device:	CSS	**Dry Density (kg/m3):**	1677
Specimen ID:	KPMT	**Relative Density (%):**	72%
Test ID:	Test2	**Void Ratio:**	0.580
Date of Test:	09/25/2023	**Vertical Stress (kPa):**	100
Test Performed:	Satuk	**Loading Frequency (Hz):**	0.033
Test Material:	KPMT	**Number of Cycles to Liq:**	2
Sample Preparation:	Submerged condition	**Cyclic Stress Ratio:**	0.2
		Maximum ru:	0.97
Prepared by:	Satuk		
Checked by:	Prof. Zekkos		

Additional Comments: Cyclic shear test is stopped at approximately 10% single amplitude shear strain. Post-cyclic monotonic test (PM) is performed after cyclic shearing.









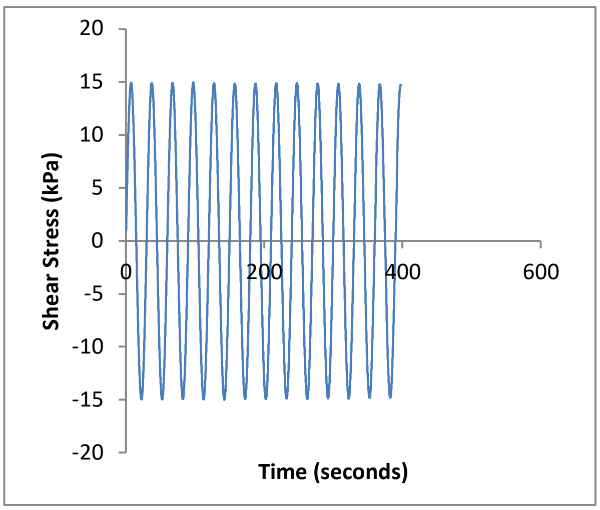
CSS Cyclic Shear Test Report

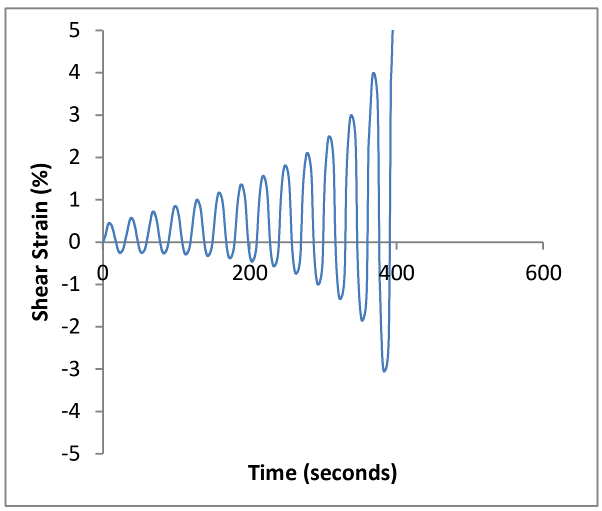
Geotechnical Engineering Laboratory

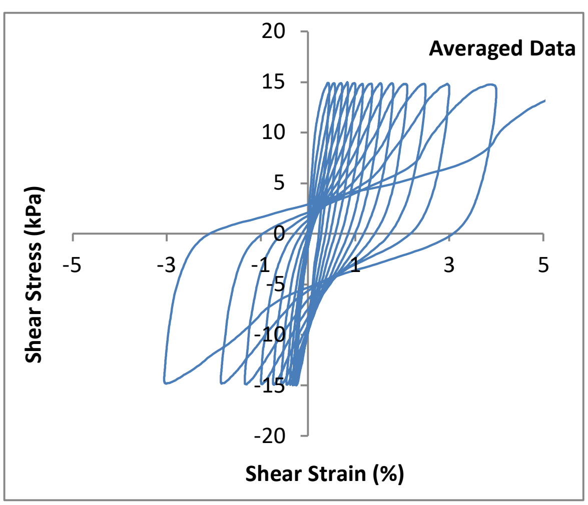
Berkeley UNIVERSITY OF CALIFORNIA

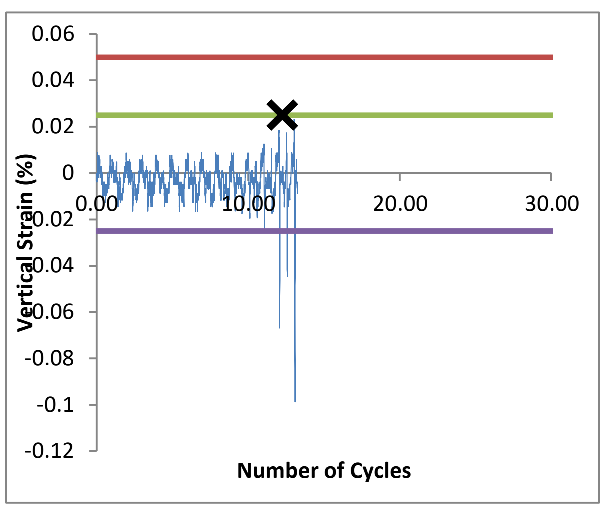
Cyclic Shear Test Summary			
Device:	CSS	**Dry Density (kg/m3):**	1674
Specimen ID:	KPMT	**Relative Density (%):**	72%
Test ID:	Test3	**Void Ratio:**	0.583
Date of Test:	09/29/2023	**Vertical Stress (kPa):**	100
Test Performed:	Satuk	**Loading Frequency (Hz):**	0.033
Test Material:	KPMT	**Number of Cycles to Liq:**	13
Sample Preparation:	Submerged condition	**Cyclic Stress Ratio:**	0.15
		Shear Modulus (kPa):	
		Damping (%):	
Prepared by:	Satuk	**Shear Strain Single Amplitude (%):**	
Checked by:	Prof. Zekkos		

Additional Comments: Cyclic shear test is stopped at approximately 5% single amplitude shear strain. Post-cyclic monotonic test (PM) is performed after cyclic shearing.









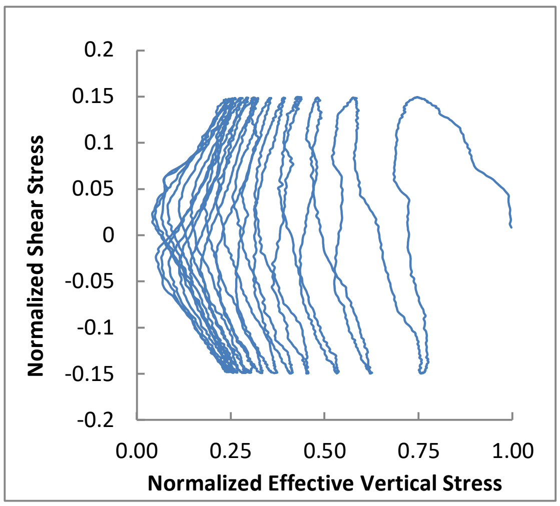
CSS Cyclic Shear Test Report

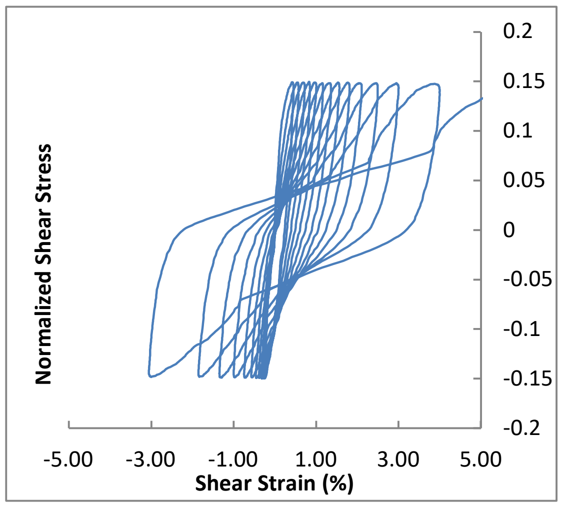
Geotechnical Engineering Laboratory

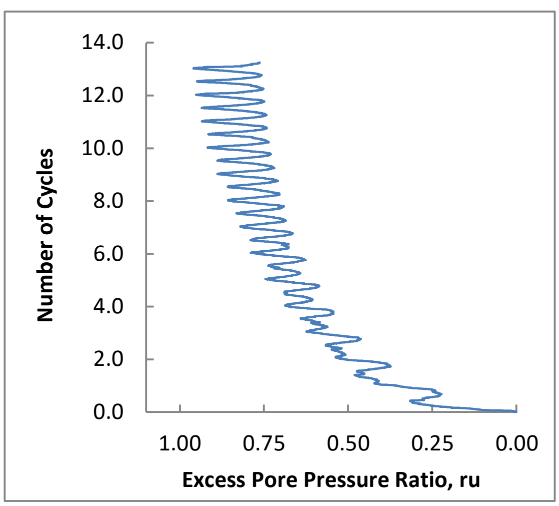
Berkeley UNIVERSITY OF CALIFORNIA

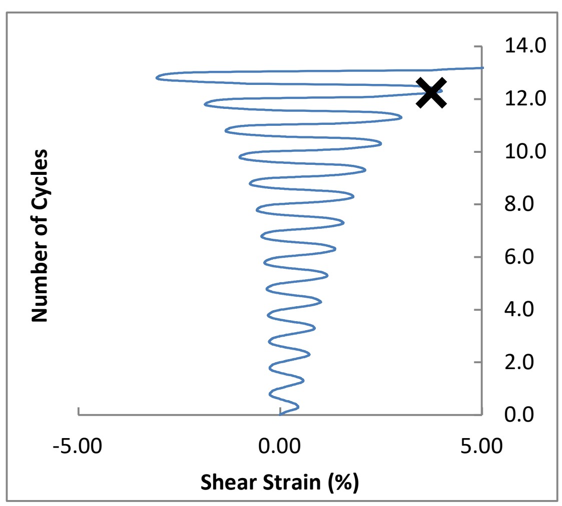
Cyclic Shear Test Summary			
Device:	CSS	**Dry Density (kg/m3):**	1674
Specimen ID:	KPMT	**Relative Density (%):**	72%
Test ID:	Test3	**Void Ratio:**	0.583
Date of Test:	09/29/2023	**Vertical Stress (kPa):**	100
Test Performed:	Satuk	**Loading Frequency (Hz):**	0.033
Test Material:	KPMT	**Number of Cycles to Liq:**	13
Sample Preparation:	Submerged condition	**Cyclic Stress Ratio:**	0.15
		Maximum ru:	0.96
Prepared by:	Satuk		
Checked by:	Prof. Zekkos		

Additional Comments: Cyclic shear test is stopped at approximately 5% single amplitude shear strain. Post-cyclic monotonic test (PM) is performed after cyclic shearing.









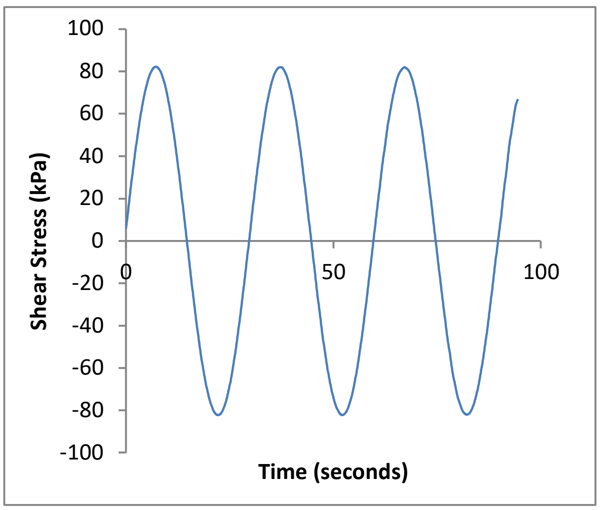
CSS Cyclic Shear Test Report

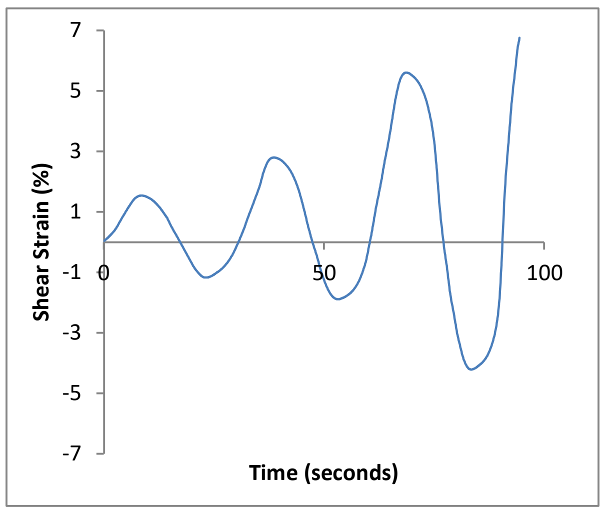
Geotechnical Engineering Laboratory

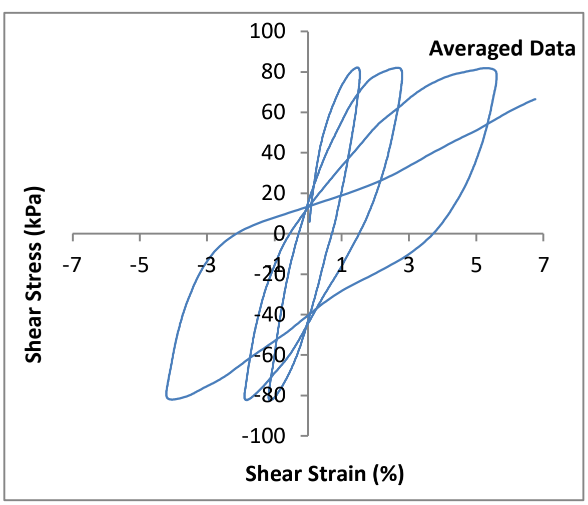
Berkeley UNIVERSITY OF CALIFORNIA

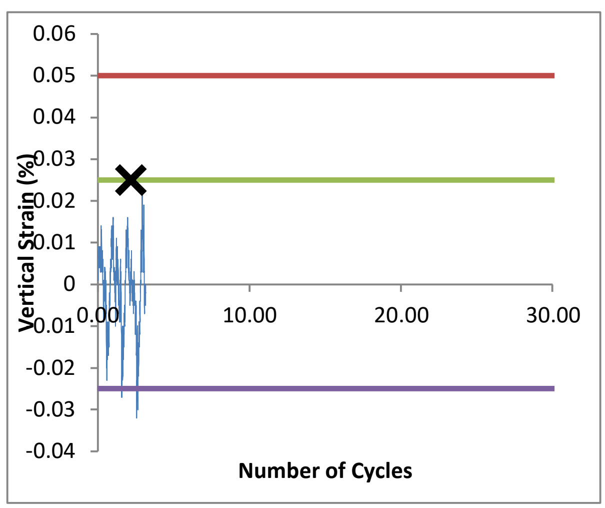
Cyclic Shear Test Summary			
Device:	CSS	**Dry Density (kg/m3):**	1808
Specimen ID:	KPMT	**Relative Density (%):**	95%
Test ID:	Test4	**Void Ratio:**	0.466
Date of Test:	10/09/2023	**Vertical Stress (kPa):**	550
Test Performed:	Satuk	**Loading Frequency (Hz):**	0.033
Test Material:	KPMT	**Number of Cycles to Liq:**	3
Sample Preparation:	Submerged condition	**Cyclic Stress Ratio:**	0.15
		Shear Modulus (kPa):	
		Damping (%):	
Prepared by:	Satuk	**Shear Strain Single Amplitude (%):**	
Checked by:	Prof. Zekkos		

Additional Comments: Cyclic shear test is stopped at approximately 7% single amplitude shear strain. Post-cyclic monotonic test (PM) is performed after cyclic shearing.









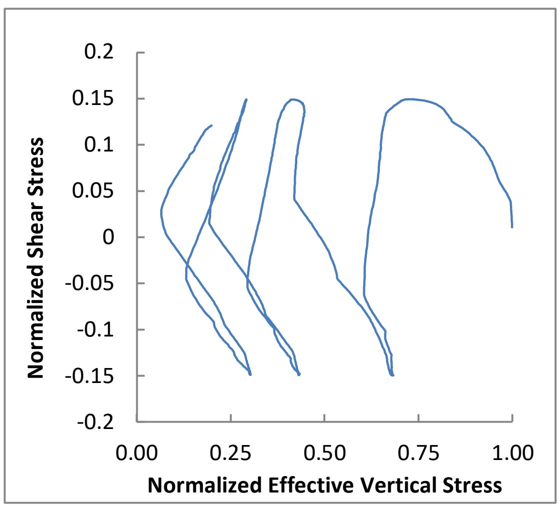
CSS Cyclic Shear Test Report

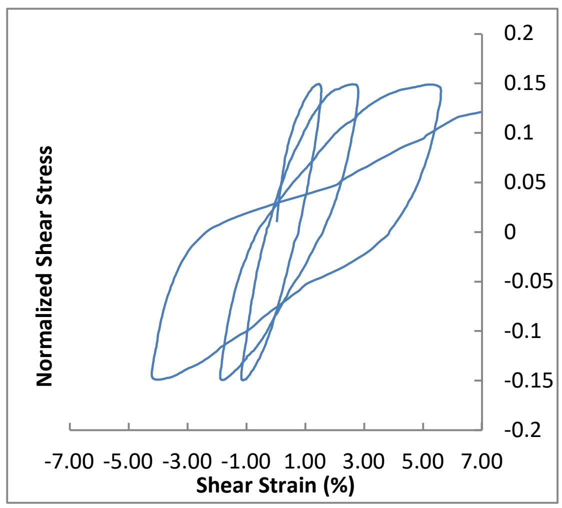
Geotechnical Engineering Laboratory

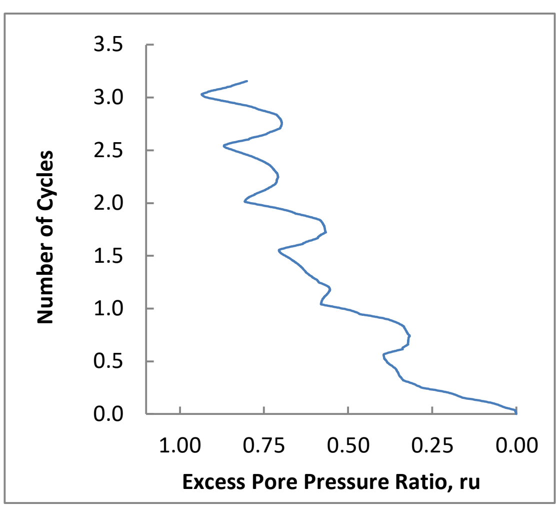
Berkeley
UNIVERSITY OF CALIFORNIA

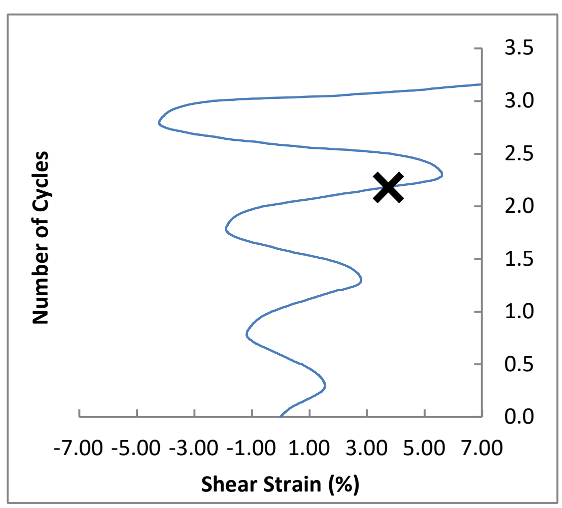
Cyclic Shear Test Summary			
Device:	CSS	**Dry Density (kg/m3):**	1808
Specimen ID:	KPMT	**Relative Density (%):**	95%
Test ID:	Test4	**Void Ratio:**	0.466
Date of Test:	10/09/2023	**Vertical Stress (kPa):**	550
Test Performed:	Satuk	**Loading Frequency (Hz):**	0.033
Test Material:	KPMT	**Number of Cycles to Liq:**	3
Sample Preparation:	Submerged condition	**Cyclic Stress Ratio:**	0.15
		Maximum ru:	0.93
Prepared by:	Satuk		
Checked by:	Prof. Zekkos		

Additional Comments: Cyclic shear test is stopped at approximately 7% single amplitude shear strain. Post-cyclic monotonic test (PM) is performed after cyclic shearing.









CSS Cyclic Shear Test Report

Geotechnical Engineering Laboratory

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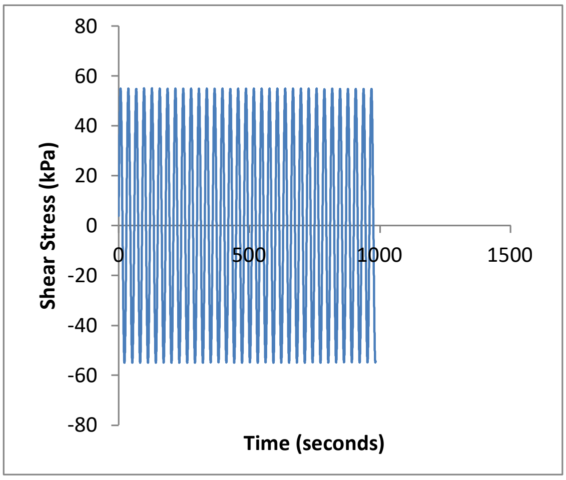
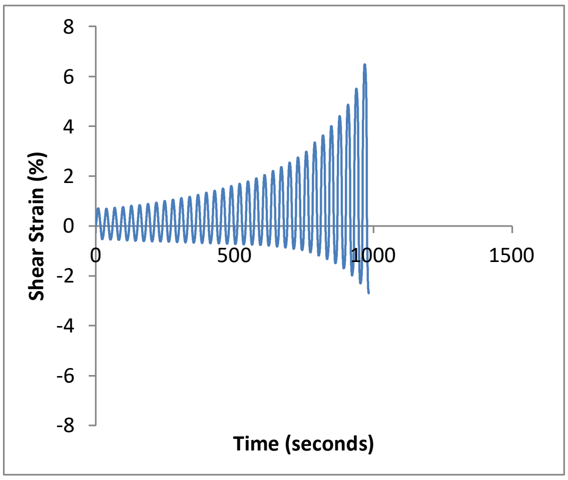
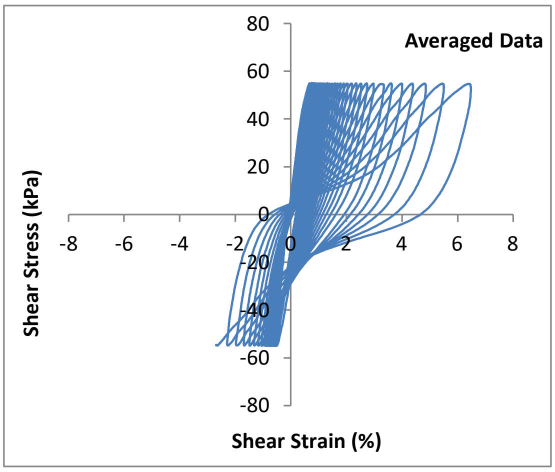
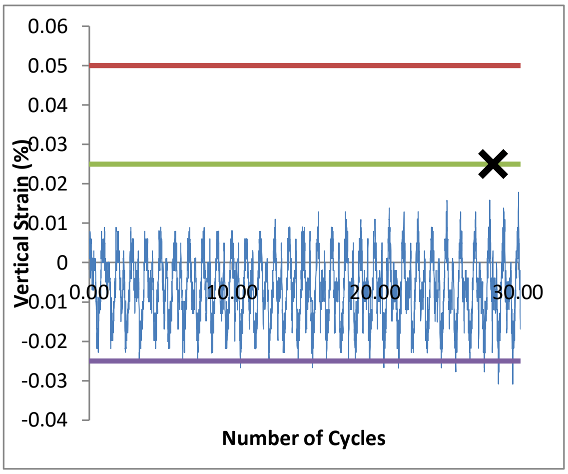
Cyclic Shear Test Summary			
Device:	CSS	**Dry Density (kg/m3):**	1788
Specimen ID:	KPMT	**Relative Density (%):**	92%
Test ID:	Test5	**Void Ratio:**	0.482
Date of Test:	10/11/2023	**Vertical Stress (kPa):**	550
Test Performed:	Satuk	**Loading Frequency (Hz):**	0.033
Test Material:	KPMT	**Number of Cycles to Liq:**	29
Sample Preparation:	Submerged condition	**Cyclic Stress Ratio:**	0.1
		Shear Modulus (kPa):	
		Damping (%):	
Prepared by:	Satuk	**Shear Strain Single Amplitude (%):**	
Checked by:	Prof. Zekkos		

Additional Comments: Cyclic shear test is stopped at approximately 6% single amplitude shear strain. Post-cyclic monotonic test (PM) is performed after cyclic shearing.









CSS Cyclic Shear Test Report

Geotechnical Engineering Laboratory

Berkeley
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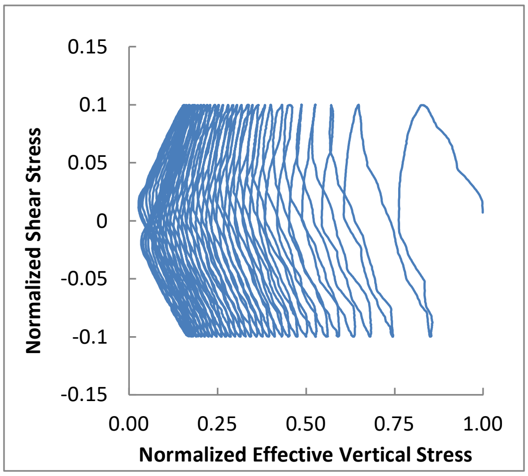
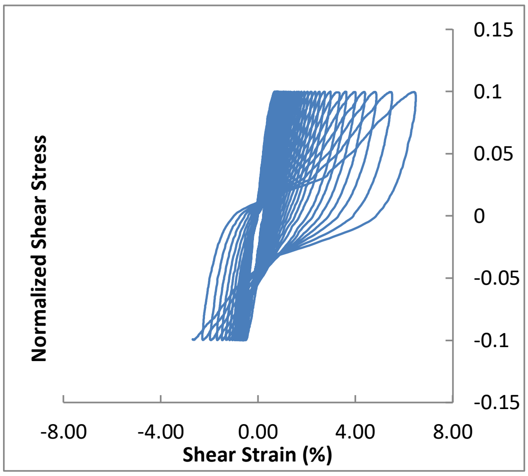
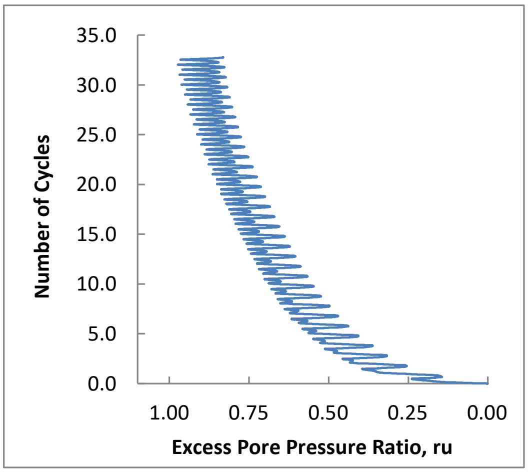
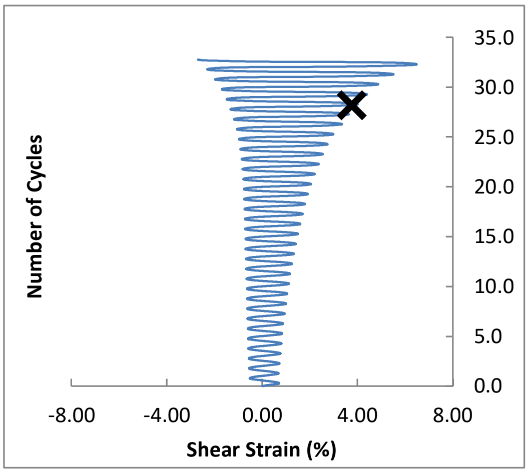
Cyclic Shear Test Summary			
Device:	CSS	**Dry Density (kg/m3):**	1788
Specimen ID:	KPMT	**Relative Density (%):**	92%
Test ID:	Test5	**Void Ratio:**	0.482
Date of Test:	10/11/2023	**Vertical Stress (kPa):**	550
Test Performed:	Satuk	**Loading Frequency (Hz):**	0.033
Test Material:	KPMT	**Number of Cycles to Liq:**	29
Sample Preparation:	Submerged condition	**Cyclic Stress Ratio:**	0.1
		Maximum ru:	0.97
Prepared by:	Satuk		
Checked by:	Prof. Zekkos		

Additional Comments: Cyclic shear test is stopped at approximately 6% single amplitude shear strain. Post-cyclic monotonic test (PM) is performed after cyclic shearing.









CSS Cyclic Shear Test Report

Geotechnical Engineering Laboratory

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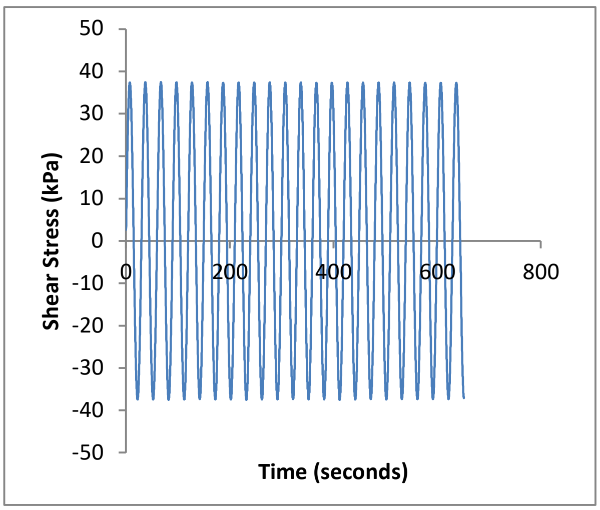
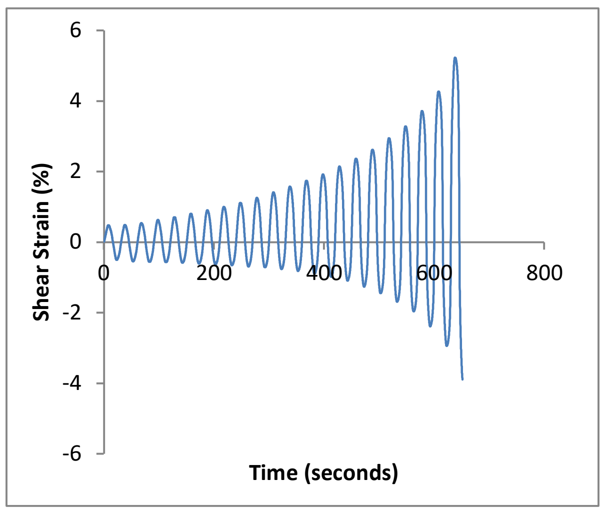
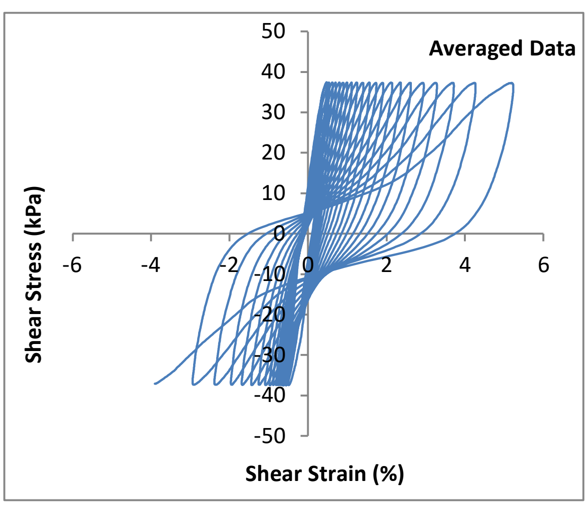
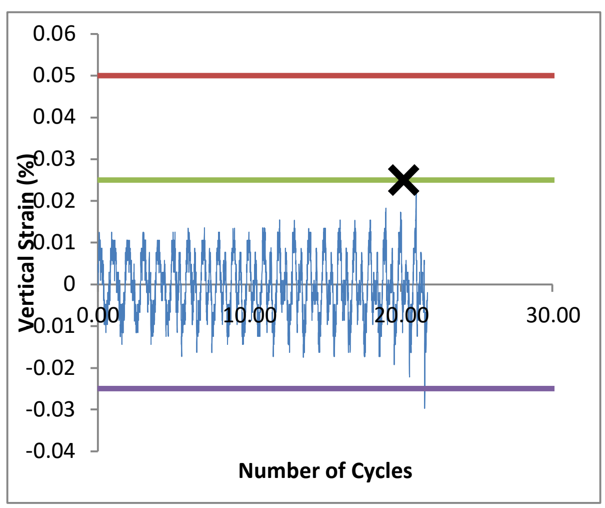
Cyclic Shear Test Summary			
Device:	CSS	**Dry Density (kg/m3):**	1735
Specimen ID:	KPMT	**Relative Density (%):**	83%
Test ID:	Test6	**Void Ratio:**	0.528
Date of Test:	10/20/2023	**Vertical Stress (kPa):**	300
Test Performed:	Satuk	**Loading Frequency (Hz):**	0.033
Test Material:	KPMT	**Number of Cycles to Liq:**	21
Sample Preparation:	Submerged condition	**Cyclic Stress Ratio:**	0.125
		Shear Modulus (kPa):	
		Damping (%):	
Prepared by:	Satuk	**Shear Strain Single Amplitude (%):**	
Checked by:	Prof. Zekkos		

Additional Comments: Cyclic shear test is stopped at approximately 5% single amplitude shear strain. Post-cyclic monotonic test (PM) is performed after cyclic shearing.









CSS Cyclic Shear Test Report

Geotechnical Engineering Laboratory

Berkeley
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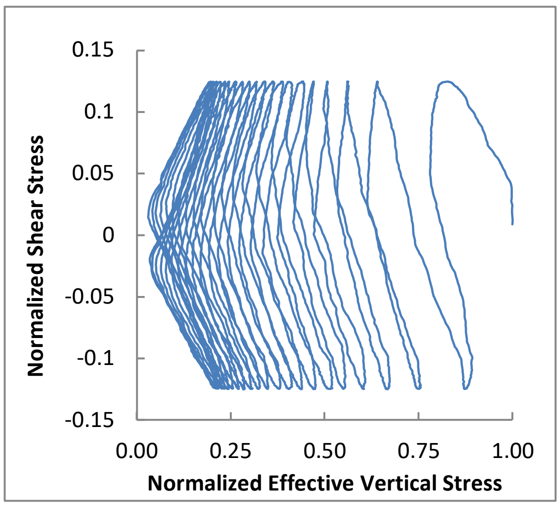
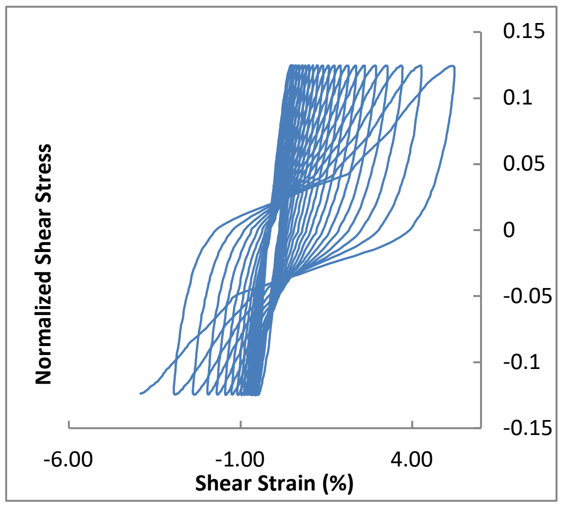
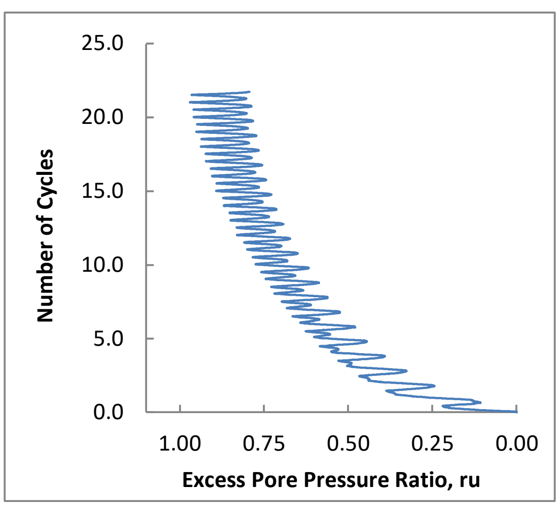
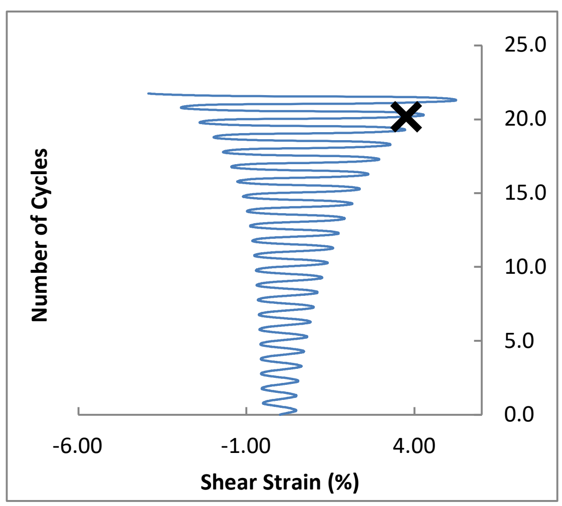
Cyclic Shear Test Summary			
Device:	CSS	**Dry Density (kg/m3):**	1735
Specimen ID:	KPMT	**Relative Density (%):**	83%
Test ID:	Test6	**Void Ratio:**	0.528
Date of Test:	10/20/2023	**Vertical Stress (kPa):**	300
Test Performed:	Satuk	**Loading Frequency (Hz):**	0.033
Test Material:	KPMT	**Number of Cycles to Liq:**	21
Sample Preparation:	Submerged condition	**Cyclic Stress Ratio:**	0.125
		Maximum ru:	0.97
Prepared by:	Satuk		
Checked by:	Prof. Zekkos		

Additional Comments: Cyclic shear test is stopped at approximately 5% single amplitude shear strain. Post-cyclic monotonic test (PM) is performed after cyclic shearing.









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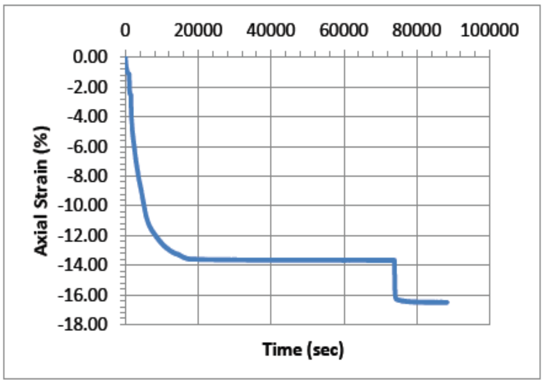
CSS Monotonic Shear Test Report

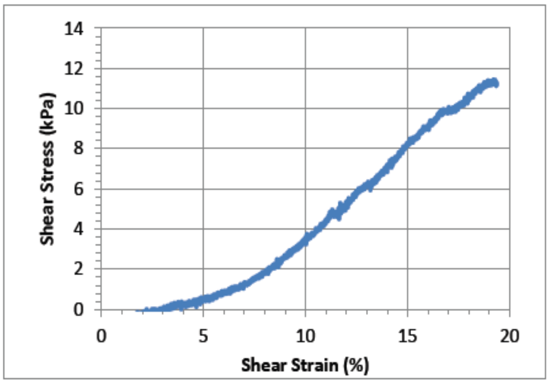
Geotechnical Engineering Laboratory

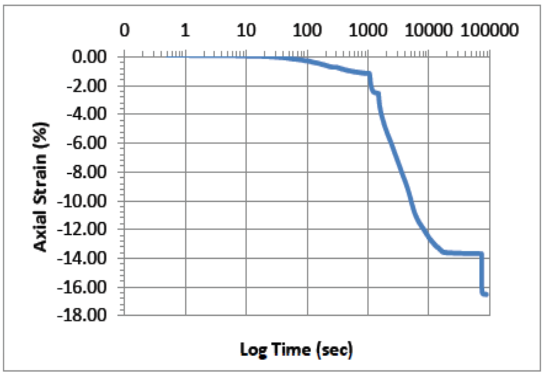
Berkeley UNIVERSITY OF CALIFORNIA

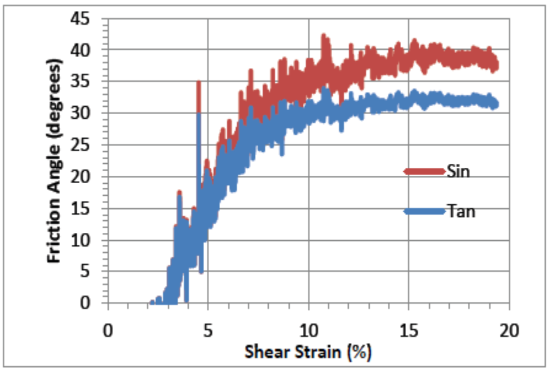
General Test Info and Sample Preparation			
Device:	CSS	**Relative Density (%):**	24%
Specimen ID:	Test1	**Void Ratio:**	0.825
Test ID:	Monotonic	**Height (mm):**	119.1
Date of Test:	9/18/2023	**Soil-Only Specimen Diameter (mm):**	306.20
Test Performed:	Monotonic Shear	**Dry Weight (kg):**	12.737
Test Material:	KPMT	**Dry Density (kg/m^3):**	1452.6
Sample Preparation:	Post-cyclic monotonic (PM)	**Membrane Thickness (mm):**	0.635
		Moisture Content (%):	4.4%
		Submerged (Y/N):	Y
		Prepared by:	Satuk
		Checked by:	Prof. Zekkos

Consolidation Stage		Shear Stage	
Vertical Stress (kPa):	100	**Type of Test:**	Constant Volume
Time to Compression (min):	Not Calculated	**Stress or Strain Controlled:**	Strain Controlled
Relative Density (%):	83%	**Shear Strain Rate (%/min):**	0.30
Void Ratio:	0.523	**Peak Shear Strength (kPa):**	11.4
Height (mm):	99.4	**Comments**	
Diameter (mm):	306.20		
Dry Weight (kg):	12.737		
Dry Density (kg/m^3):	1739.9		

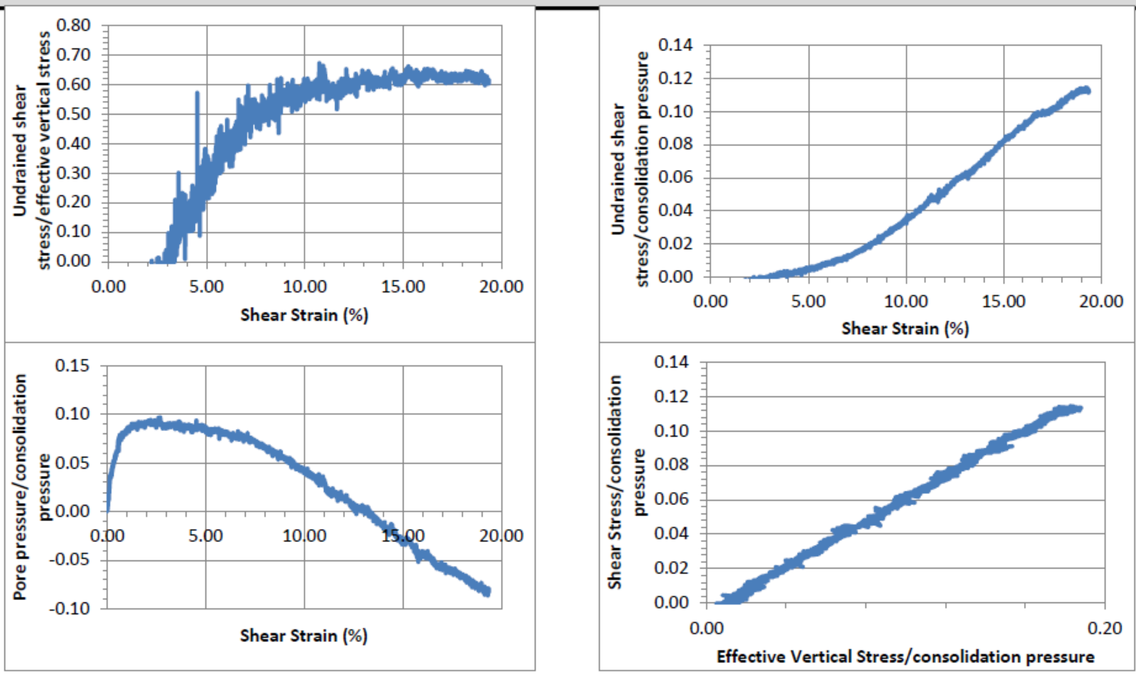








Undrained Shear Information



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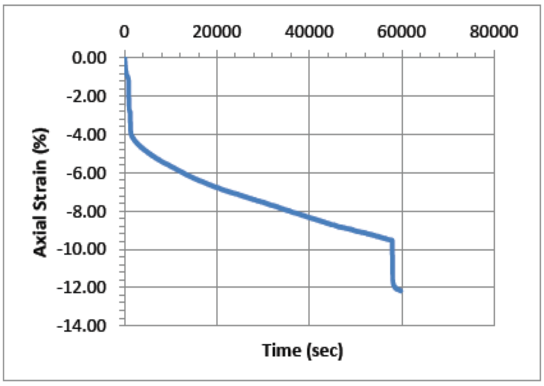
CSS Monotonic Shear Test Report

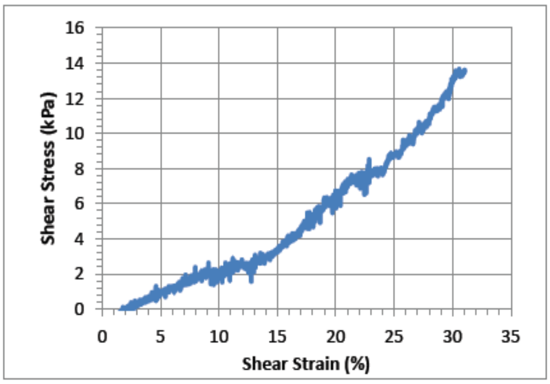
Geotechnical Engineering Laboratory

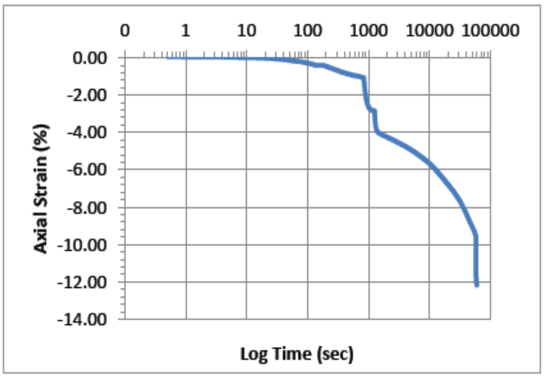
Berkeley UNIVERSITY OF CALIFORNIA

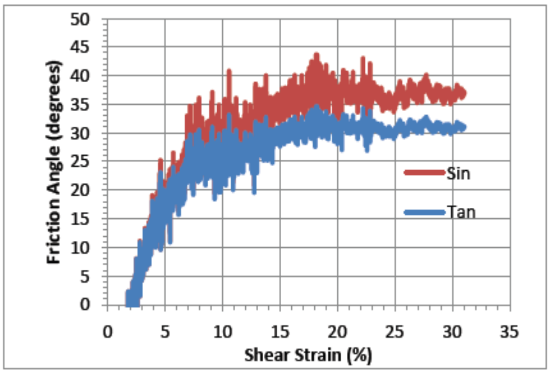
General Test Info and Sample Preparation			
Device:	CSS	Relative Density (%):	29%
Specimen ID:	Test2	Void Ratio:	0.799
Test ID:	Monotonic	Height (mm):	117.4
Date of Test:	25.09.2023	Soil-Only Specimen Diameter (mm):	306.20
Test Performed:	Monotonic Shear	Dry Weight (kg):	12.737
Test Material:	KPMT	Dry Density (kg/m^3):	1473.0
Sample Preparation:	Post-cyclic monotonic (PM)	Membrane Thickness (mm):	0.635
		Moisture Content (%):	4.4%
		Submerged (Y/N):	Y
		Prepared by:	Satuk
		Checked by:	Proz. Zekkos

Consolidation Stage		Shear Stage	
Vertical Stress (kPa):	100	Type of Test:	Constant Volume
Time to Compression (min):	Not Calculated	Stress or Strain Controlled:	Strain Controlled
Relative Density (%):	72%	Shear Strain Rate (%/min):	0.29
Void Ratio:	0.580	Peak Shear Strength (kPa):	13.6
Height (mm):	103.1	**Comments**	
Diameter (mm):	306.20		
Dry Weight (kg):	12.737		
Dry Density (kg/m^3):	1677.3		

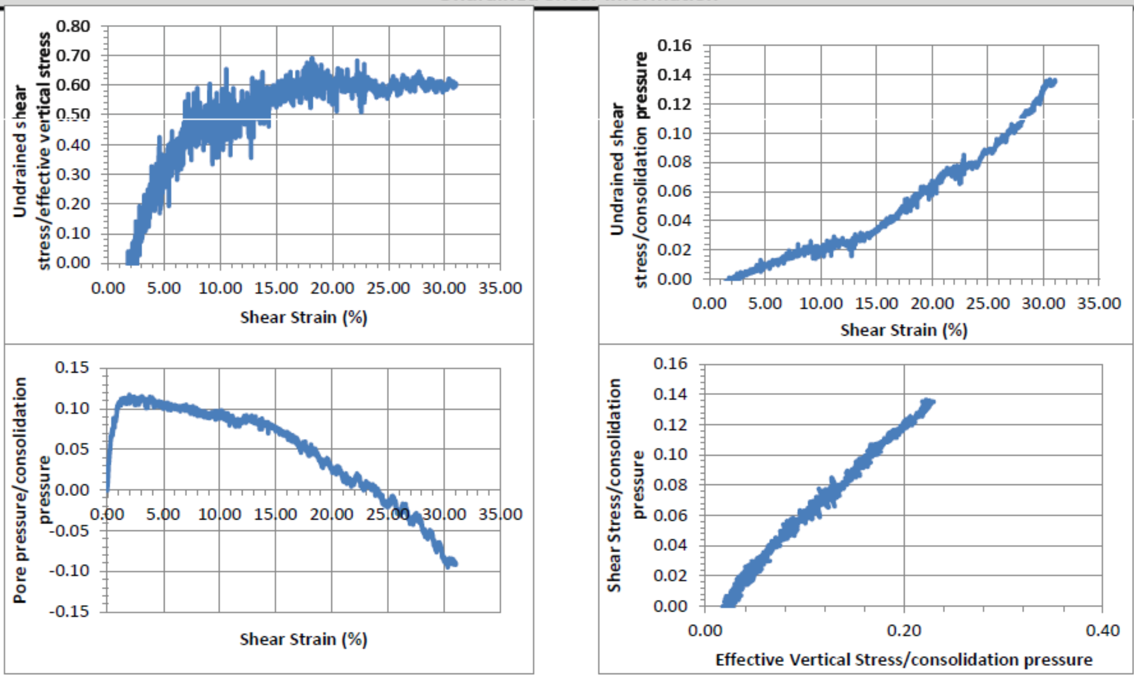








Undrained Shear Information



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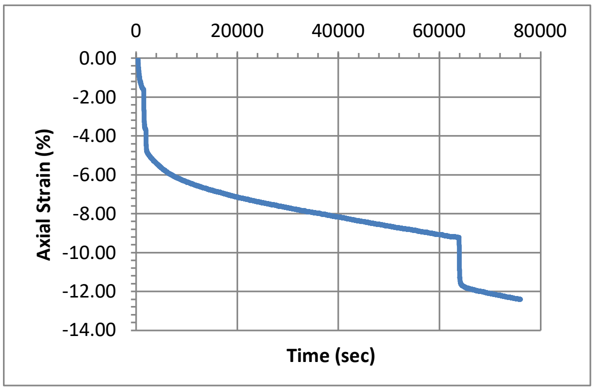
CSS Monotonic Shear Test Report

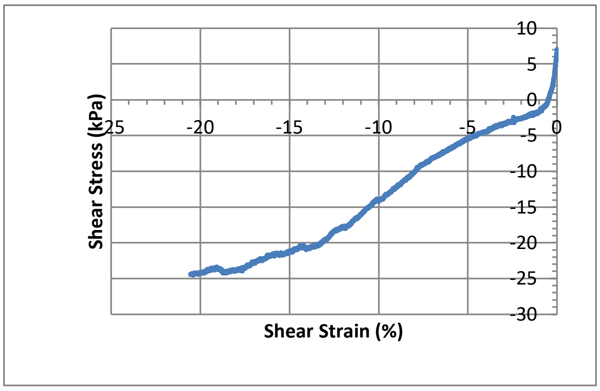
Geotechnical Engineering Laboratory

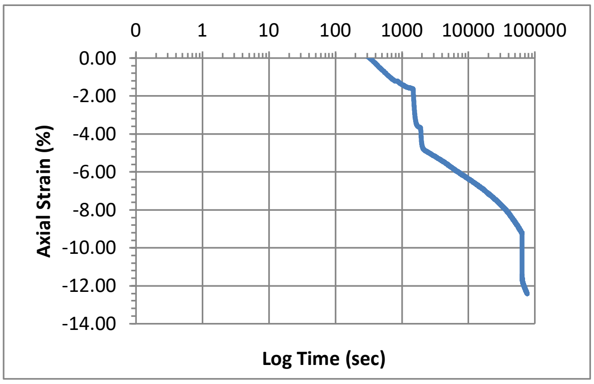
Berkeley UNIVERSITY OF CALIFORNIA

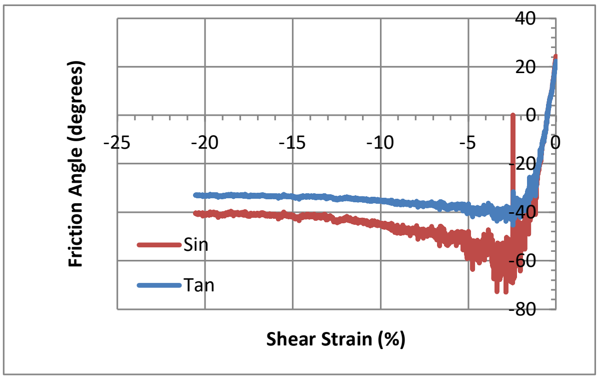
General Test Info and Sample Preparation			
Device:	CSS	**Relative Density (%):**	27%
Specimen ID:	Test3	**Void Ratio:**	0.808
Test ID:	Monotonic	**Height (mm):**	118.0
Date of Test:	29.09.2023	**Soil-Only Specimen Diameter (mm):**	306.20
Test Performed:	Monotonic Shear	**Dry Weight (kg):**	12.737
Test Material:	KPMT	**Dry Density (kg/m^3):**	1466.4
Sample Preparation:	Post-cyclic monotonic (PM)	**Membrane Thickness (mm):**	0.635
		Moisture Content (%):	4.4%
		Submerged (Y/N):	Y
		Prepared by:	Satuk
		Checked by:	Prof. Zekkos

Consolidation Stage		Shear Stage	
Vertical Stress (kPa):	100	**Type of Test:**	Constant Volume
Time to Compression (min):	Not Calculated	**Stress or Strain Controlled:**	Strain Controlled
Relative Density (%):	72%	**Shear Strain Rate (%/min):**	0.29
Void Ratio:	0.583	**Peak Shear Strength (kPa):**	7.0
Height (mm):	103.3	**Comments**	
Diameter (mm):	306.20		
Dry Weight (kg):	12.737		
Dry Density (kg/m^3):	1674.2		









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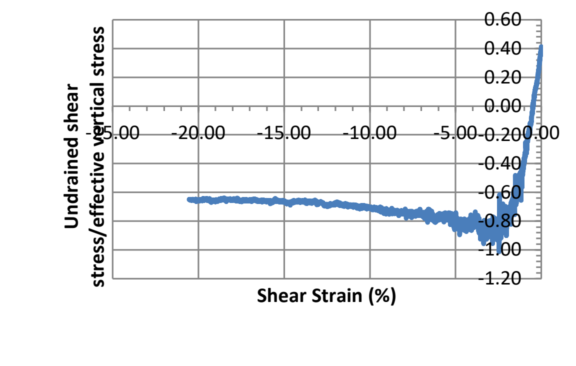
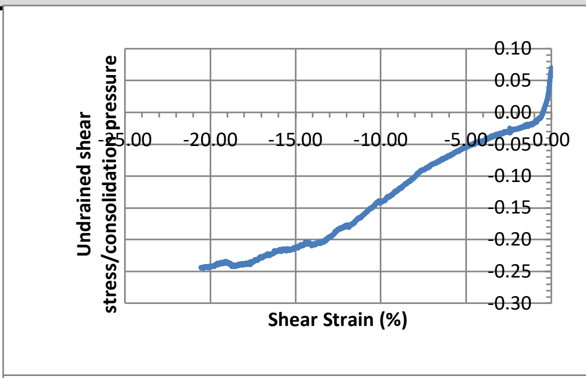
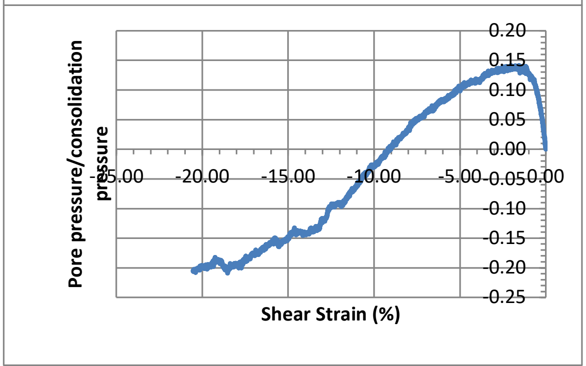
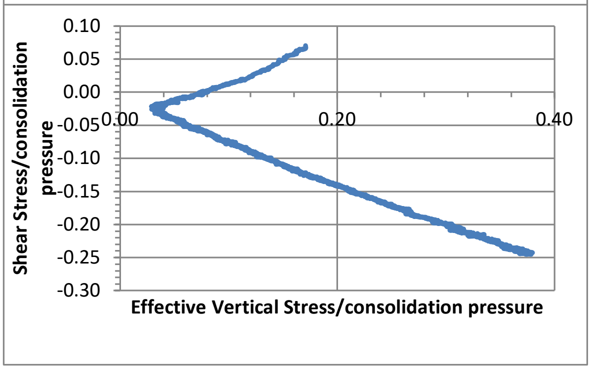








July 2 2020_Version 10.0

CSS Monotonic Shear Test Report

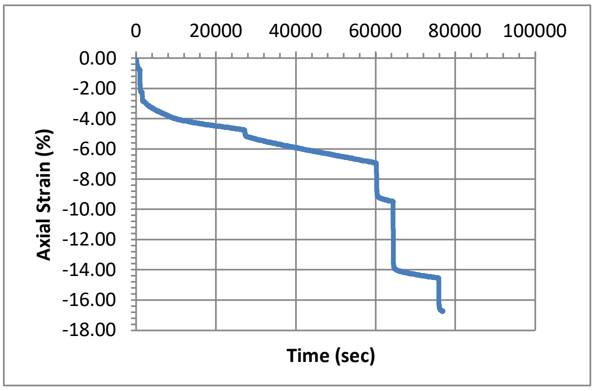
Geotechnical Engineering Laboratory

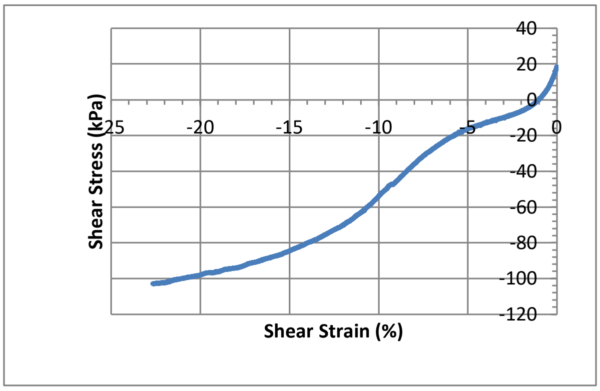
Berkeley UNIVERSITY OF CALIFORNIA

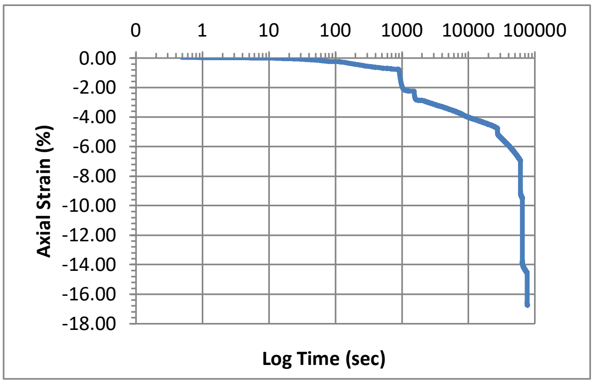
General Test Info and Sample Preparation

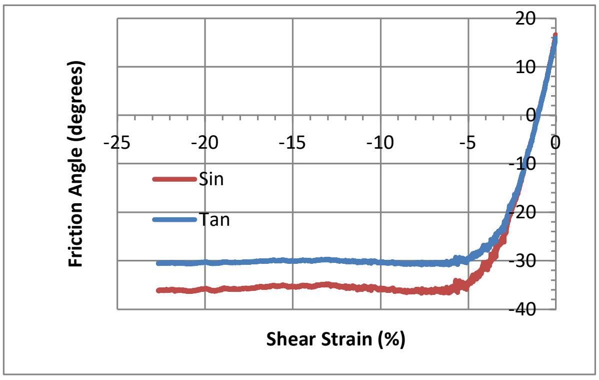
Device:	CSS	**Relative Density (%):**	36%
Specimen ID:	Test4	**Void Ratio:**	0.760
Test ID:	Monotonic	**Height (mm):**	120.1
Date of Test:	10.10.2023	**Soil-Only Specimen Diameter (mm):**	306.20
Test Performed:	Monotonic Shear	**Dry Weight (kg):**	13.312
Test Material:	KPMT	**Dry Density (kg/m^3):**	1505.6
Sample Preparation:	Post-cyclic monotonic (PM)	**Membrane Thickness (mm):**	0.635
		Moisture Content (%):	4.4%
		Submerged (Y/N):	Y
		Prepared by:	Satuk
		Checked by:	Prof. Zekkos

Consolidation Stage		Shear Stage	
Vertical Stress (kPa):	550	**Type of Test:**	Constant Volume
Time to Compression (min):	Not Calculated	**Stress or Strain Controlled:**	Strain Controlled
Relative Density (%):	95%	**Shear Strain Rate (%/min):**	0.30
Void Ratio:	0.466	**Peak Shear Strength (kPa):**	18.3
Height (mm):	100.0	**Comments**	
Diameter (mm):	306.20		
Dry Weight (kg):	13.312		
Dry Density (kg/m^3):	1808.1		









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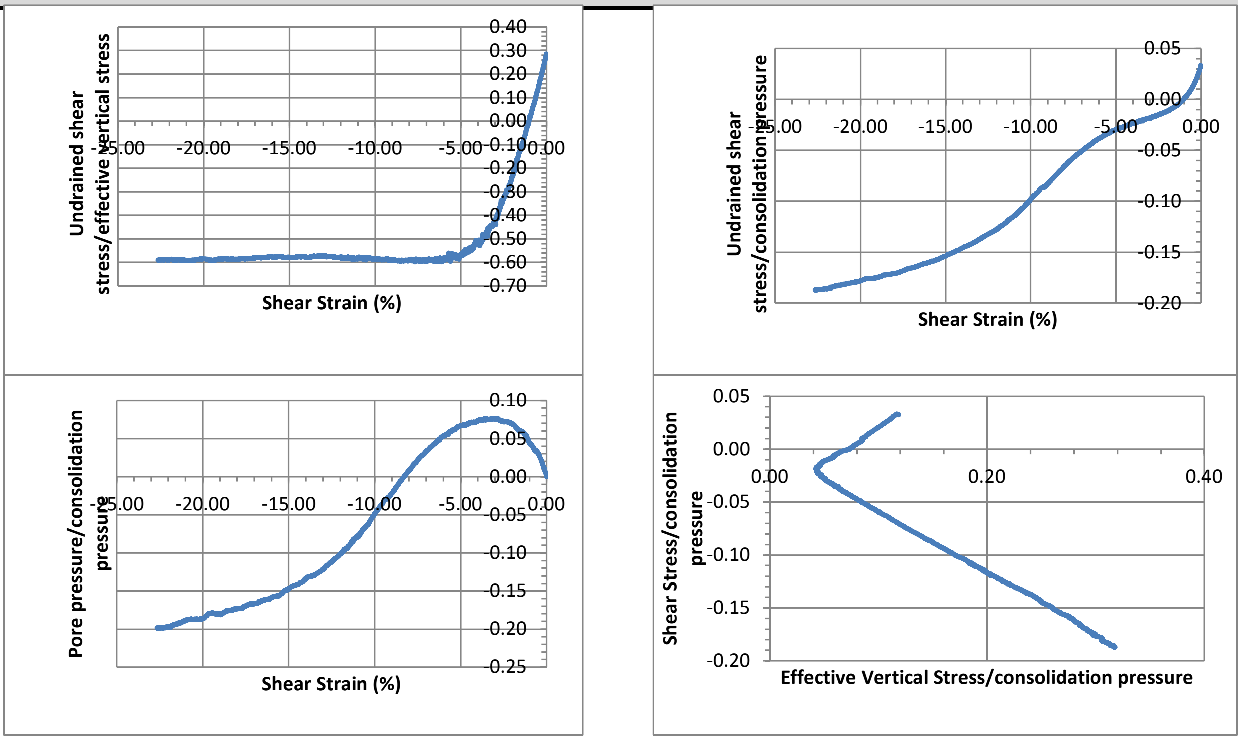


July 2 2020_Version 10.0

CSS Monotonic Shear Test Report

Geotechnical Engineering Laboratory

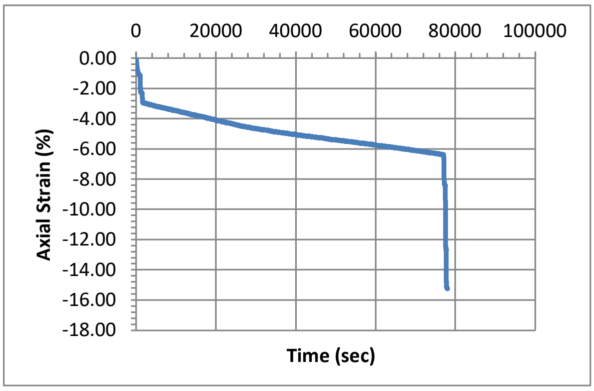
Berkeley UNIVERSITY OF CALIFORNIA

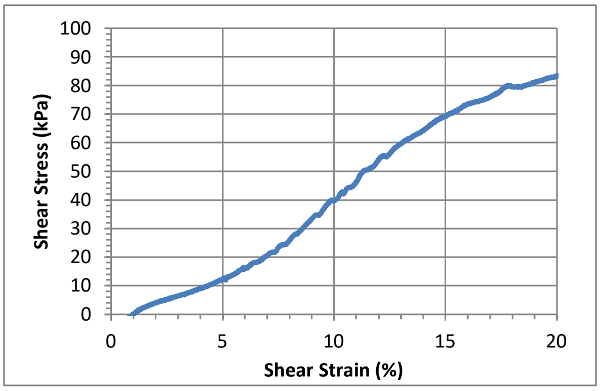
General Test Info and Sample Preparation			
Device:	CSS	**Relative Density (%):**	39%
Specimen ID:	Test5	**Void Ratio:**	0.749
Test ID:	Monotonic	**Height (mm):**	119.3
Date of Test:	10.11.2023	**Soil-Only Specimen Diameter (mm):**	306.20
Test Performed:	Monotonic Shear	**Dry Weight (kg):**	13.312
Test Material:	KPMT	**Dry Density (kg/m^3):**	1515.7
Sample Preparation:	Post-cyclic monotonic (PM)	**Membrane Thickness (mm):**	0.635
		Moisture Content (%):	4.4%
		Submerged (Y/N):	Y
		Prepared by:	Satuk
		Checked by:	Prof. Zekkos

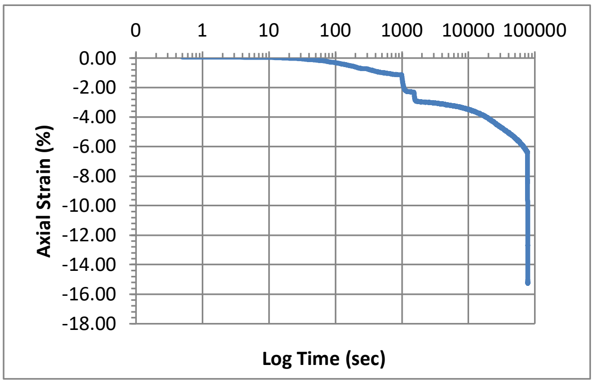
Consolidation Stage	
Vertical Stress (kPa):	550
Time to Compression (min):	Not Calculated
Relative Density (%):	92%
Void Ratio:	0.482
Height (mm):	101.1
Diameter (mm):	306.20
Dry Weight (kg):	13.312
Dry Density (kg/m^3):	1788.8

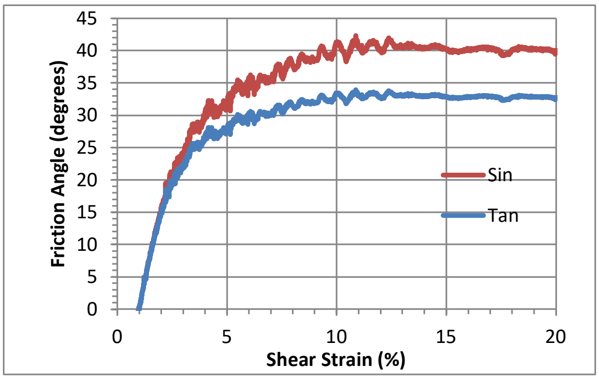
Shear Stage	
Type of Test:	Constant Volume
Stress or Strain Controlled:	Strain Controlled
Shear Strain Rate (%/min):	0.29
Peak Shear Strength (kPa):	87.1

Comments

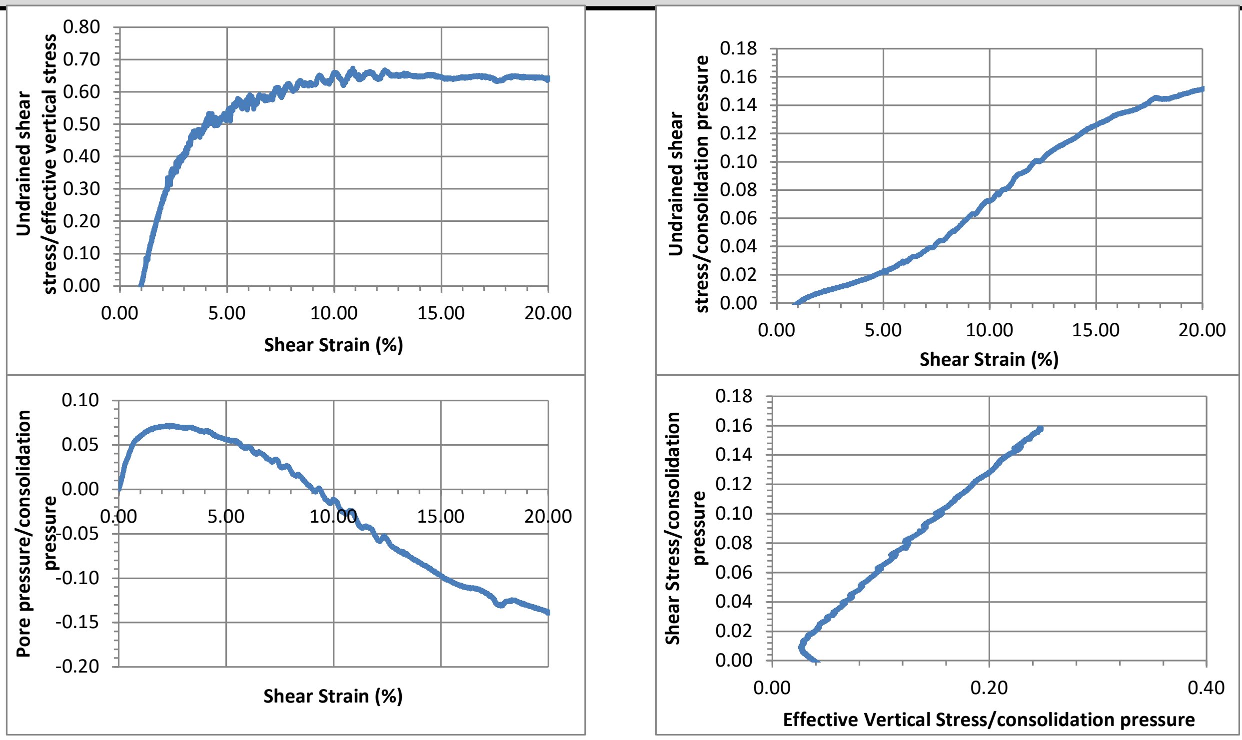








Undrained Shear Information



July 2 2020_Version 10.0

CSS Monotonic Shear Test Report

Geotechnical Engineering Laboratory

Berkeley
UNIVERSITY OF CALIFORNIA

General Test Info and Sample Preparation

Device:	CSS	**Relative Density (%):**	36%
Specimen ID:	Test6	**Void Ratio:**	0.761
Test ID:	Monotonic	**Height (mm):**	120.1
Date of Test:	10/20/2023	**Soil-Only Specimen Diameter (mm):**	306.20
Test Performed:	Monotonic Shear	**Dry Weight (kg):**	13.312
Test Material:	KPMT	**Dry Density (kg/m^3):**	1505.3
Sample Preparation:	Post-cyclic monotonic (PM)	**Membrane Thickness (mm):**	0.635
		Moisture Content (%):	4.4%
		Submerged (Y/N):	Y
		Prepared by:	Satuk
		Checked by:	Prof. Zekkos

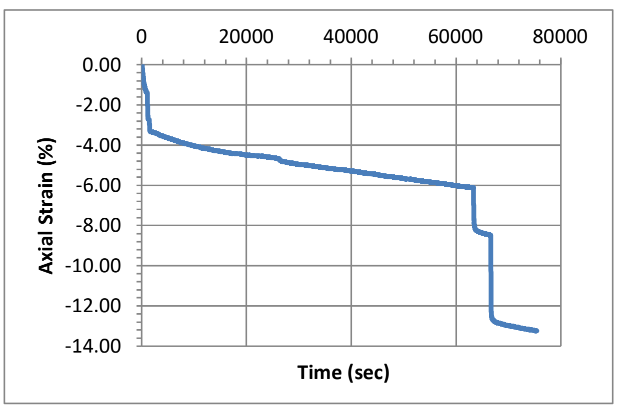
Consolidation Stage

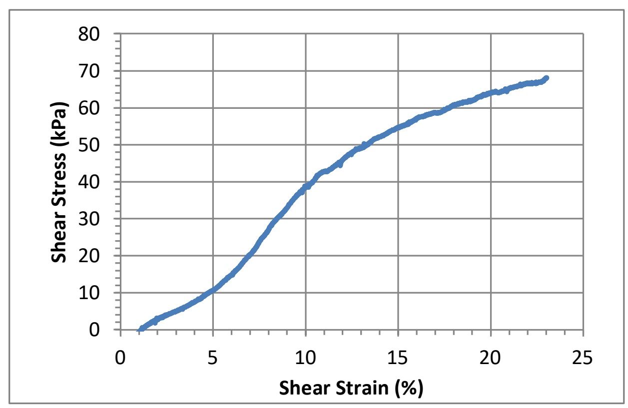
Vertical Stress (kPa):	300
Time to Compression (min):	Not Calculated
Relative Density (%):	83%
Void Ratio:	0.528
Height (mm):	104.2
Diameter (mm):	306.20
Dry Weight (kg):	13.312
Dry Density (kg/m^3):	1735.0

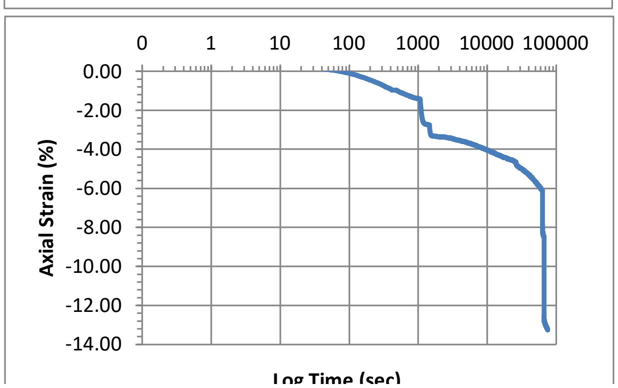
Shear Stage

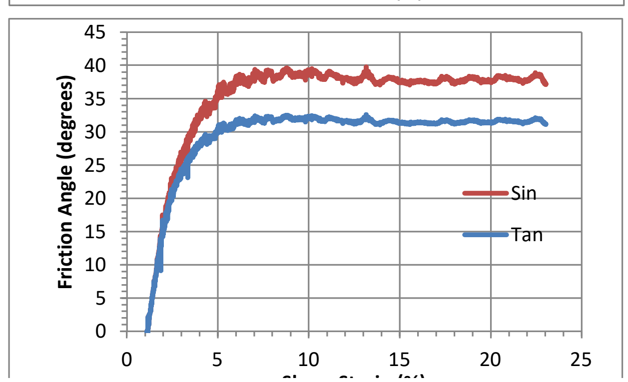
Type of Test:	Constant Volume
Stress or Strain Controlled:	Strain Controlled
Shear Strain Rate (%/min):	0.28
Peak Shear Strength (kPa):	68.1

Comments

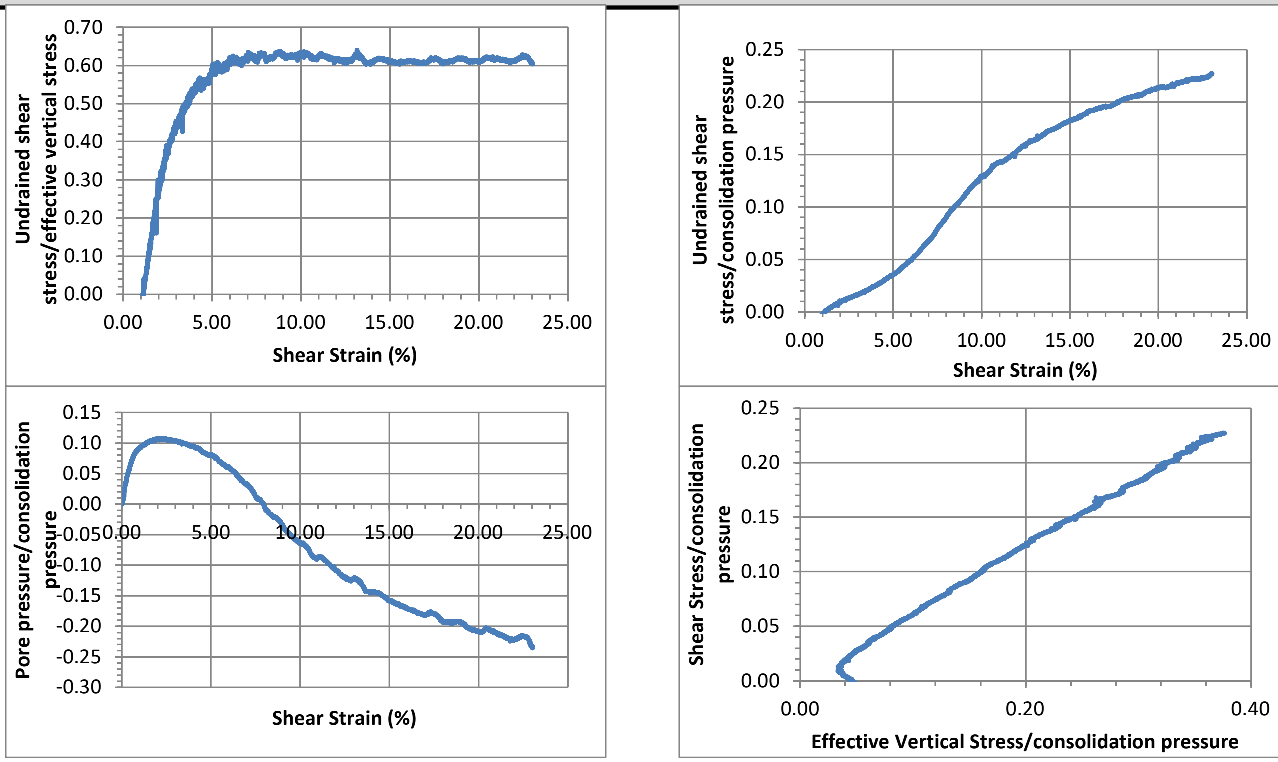








Undrained Shear Information



APPENDIX C

Piezometric Definition

(Pages C-1 to C-9)

APPENDIX C
PIEZOMETRIC DEFINITION

1.0 INTRODUCTION

The stability assessment of the Yankee Doodle Tailings Impoundment (YDTI) considers three primary soil units: overburden, embankment rockfill, and tailings. The overburden unit overlies the bedrock beneath the YDTI. The rockfill unit forms the embankment dam and the tailings unit is impounded by the rockfill embankment.

Piezometric conditions at the YDTI are monitored with multiple lines of instrumentation installed along several dam cross-sections (KP, 2022). The definition of piezometric conditions for the stability assessment was established through review of the following data sources:

- Instrumentation monitoring data
- Historical drill core logs
- In-situ testing (e.g. pore pressure dissipation tests)
- Surface observations of seepage and ponding (e.g. seeps within the Horseshoe Bend (HsB) area; ponding in the Berkeley Pit and YDTI supernatant pond)
- Facility operations (change to multi-point discharge of tailings)
- The embankment construction history (e.g. starter dams, historical lift-tops, Seep 10 Bench)

The data review indicated that three-dimensional (3D) considerations were required for defining steady-state conditions for stability analysis. The review identified the importance of two data sets, the piezometric sensors and surface observations, for defining the shape (spatial distribution) and elevation (temporal trends) of the phreatic surface to inform its construction.

2.0 FRAMEWORK AND APPROACH

The YDTI has been operational for many decades with monitoring playing an important role for supporting operations, construction, and design. This long history has led to the creation of multiple data sets with variable timespans. The instrumentation network is also actively augmented, annually and as needed. A detailed description of the monitoring network is provided in an annual Data Analysis Report (e.g., KP, 2022). The current plans for further development of the instrumentation monitoring network are described in the 5-Year Site Investigation, Instrumentation and Monitoring Plan (KP, 2021).

Three data sets from the monitoring network were utilized for developing a 3D representation of steady-state piezometric conditions that is reflective of data trends and is conceptually consistent with the hydrogeological regime of the facility. These data sets were selected due to the length of their monitoring histories, spatial distributions, and/or data resolution (vertical spacing). The three key data sets include the following:

- Vibrating wire piezometers (VWPs) – Single and multiple sensors have been installed in drillholes since 2015. Most historical standpipe piezometers prior to 2015 were retrofitted for automated monitoring by suspending a VWP within the standpipe. A majority of the drillhole installations involve multiple sensors, which have enabled the evaluation of gradients, in addition to estimating pore pressures. The VWP network monitors the pressure changes in the tailings, embankment, dam foundation, and the HsB area. The VWP data set is the most extensive in terms of sensor density, spatial distribution, data resolution, and period of monitoring.

- Geo4Sight pore pressure markers – These pore pressure sensors (resistive strain gauge type sensors) are installed at two drillholes (DH20-S2 and DH21-S4) that are located near the maximum height of the dam along Stations (Sta.) 8+00W and 0+00, respectively. Both installations involve multiple sensors at approximately 6 ft vertical spacing over the full length of the drillholes that provide the greatest data resolution along drillhole axes.
- Surface observations – Seepage and ponding have been observed and documented in the HsB area for many years. The supernatant pond and ponding in the Berkeley Pit are surveyed regularly. These surface observations provide important boundary controls for extrapolating the phreatic surface beyond the subsurface sensor network.

The conceptual development of the hydrogeological regime also considered other data sets, in addition to the three key data sets. The other data sets included the following:

- Pore pressure dissipation tests completed during cone penetration testing.
- Historical monitoring wells and standpipe piezometers that are no longer functioning. Some of which have been replaced with VWPs.
- Moisture conditions observed during logging of drill core.
- Saturation conditions inferred from nuclear magnetic resonance tests completed at select locations within the embankment rockfill and foundation materials.

The time histories of the sensors were reviewed in relation to facility operations to identify asymptotic values for defining steady-state piezometric elevations. The phreatic surface was constructed by triangulating between the irregular grid of data points (drillhole locations) and simplified based on a high-level conceptual model of the prevailing hydrogeological regime suggested by the monitoring data.

3.0 KEY CONTROLS

The data review identified two prevailing hydrogeological regimes and indicated that the phreatic surface could be simplified to three segments to integrate the two regimes, as described in the following:

- **Piezometric conditions in the tailings** – The phreatic elevation is controlled by proximity to the nearest tailings depositional point near the dam and the elevation of the supernatant pond at distance. Sensors nearest the upstream face of the dam indicate that phreatic conditions range in depth from approximately 100 ft to 200 ft.
- **Piezometric conditions at the base of the rockfill embankment** – The embankment dam is unzoned and constructed of free-draining pit run rockfill. Sensors installed in and near the base of the dam suggest a basal saturated zone with a thickness of approximately 100 ft to 150 ft at the upstream toe that thins towards the ground surface in the HsB area at the downstream toe. Surface observations and sensors in the HsB area indicate near-surface phreatic conditions downstream of the toe. Data trends along drillhole axes generally indicate hydrostatic conditions in the HsB area and an overall downward gradient within the saturated zone at the base of the embankment.

- **Piezometric conditions near the upstream face of the embankment** – This transitional zone connects the higher elevations in the tailings with the lower elevations in the embankment rockfill. The shape and dimensions of this zone are uncertain and is an identified area of interest for additional monitoring. The transition was simplified to a vertical step down near the upstream face, which is a reasonable approximation of the recently available monitoring data (i.e., from the Geo4Sight installations) and slightly more conservative than previous representations (KP, 2018).

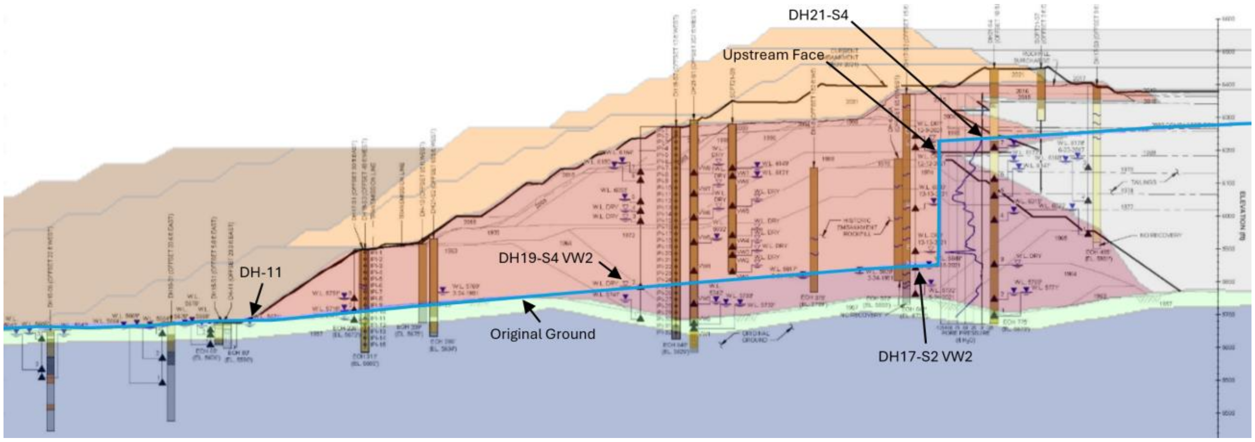
The three-segment piezometric representations along Sta. 0+00 and 8+00W are shown on Figure 3.1 and Figure 3.2, respectively. The sections along Sta. 0+00 and 8+00W are located in the central pedestal area, which coincide with the maximum dam height. The dam toe in this area bounds the northern extent of the concave HsB area, which is an important area of risk for evaluating potential for slope instability. As a result, the phreatic surface definition prioritized the data evaluation from the central pedestal area monitoring locations. Key data were selected to control the shape of the phreatic surface and the same key controls, where relevant, were used to form the 3D surface, in addition to the sensor grid, northeast and northwest of the central pedestal area.

The key control locations are indicated by black arrows, shown on Figure 3.1 and Figure 3.2, and include the following:

- The tailings piezometric line segment:
  - Curves towards the dam based on the readings from the nearest VWP sensors.
  - Transitions near the tailings-rockfill interface of the upstream face of the embankment, under the surcharge load.
- The transition from the tailings to the rockfill is a vertical step, based on the continuous profile of sensor readings in drillholes (DH21-S4 at Sta. 0+00 and DH20-S2 at Sta. 8+00W) closest to the upstream face.
- The slope of the embankment basal saturation was defined by:
  - The location of the closest hole drilled wholly in rockfill to the upstream face (e.g., DH17-S2 at Sta. 0+00 and DH15-S5 at Sta. 8+00W)
  - Pre-dam topography (DH19-S4 was used at Sta. 0+00 to ensure the line sloped towards the topographical high downstream of its location)
  - The location of hole drilled closest to the toe near Sta. 8+00W (MW94-8)
  - The ground topography where the dam toes into the HsB area

The piezometric elevations are based on those reported at the end of 2021 (KP, 2022) since data from subsequent years are influenced by construction activities for raising the dam crest to elevation 6,450 ft. However, data collected more recently is generally consistent with and supportive of this piezometric representation.

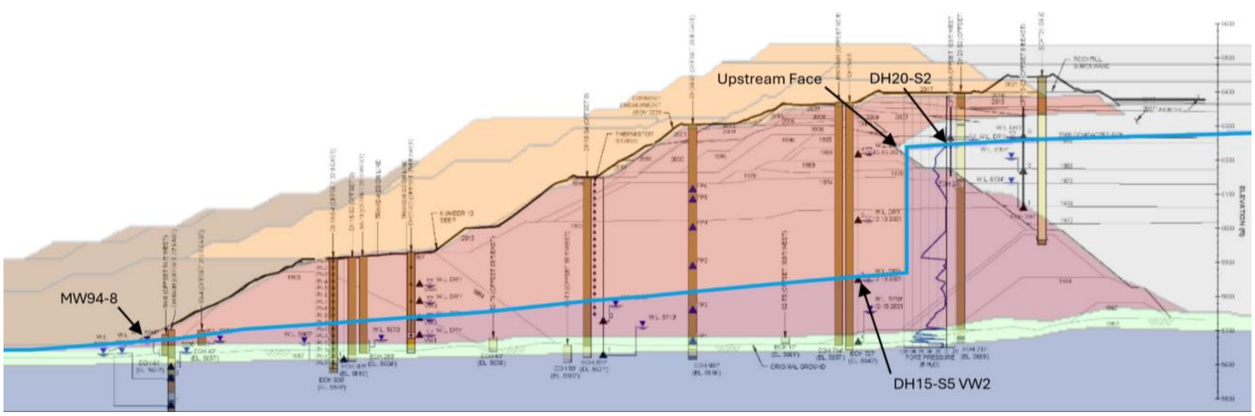
Also notable in the figures is the indication of perched zones within the embankment. However, these transient conditions appear to be of limited extent and are not considered in the steady-state assessment for the overall stability of the proposed El. 6,560 embankment crest and interim conditions evaluated in the stability assessment.



Note(s):

1. Image background showing instrumentation and piezometric readings from the 2021 Data Analysis Report (KP, 2022). See attached Figure C.1.
2. Filled polygons in the background show the stability analysis model of the EL. 6,560 ft embankment raise.
3. Annotated black arrows indicate key control locations.

Figure 3.1 Two-Dimensional Definition of Phreatic Conditions at Sta. 0+00



Note(s):

1. Image background showing instrumentation and piezometric readings from the 2021 Data Analysis Report (KP, 2022). See attached Figure C.2.
2. Filled polygons in the background show the stability analysis model of the EL. 6,560 ft embankment raise.
3. Annotated black arrows indicate key control locations.

Figure 3.2 Two-Dimensional Definition of Phreatic Conditions at Sta. 8+00W

4.0 PHREATIC SURFACE CONSTRUCTION

The phreatic surface was constructed by combining the three segments to form a continuous surface that spans from the supernatant pond to the Berkeley Pit. The upper tailings segment was created by incorporating the surveyed limit of the supernatant pond (georeferenced aerial image acquired in 2021) and available piezometric data from the tailings beach. The lower embankment base and HsB segment was likewise created by incorporating the surveyed surface of the water contained within the Berkeley Pit, available piezometric data, and the topography of the HsB area. The upper and lower segments are shown on Figure 4.1.

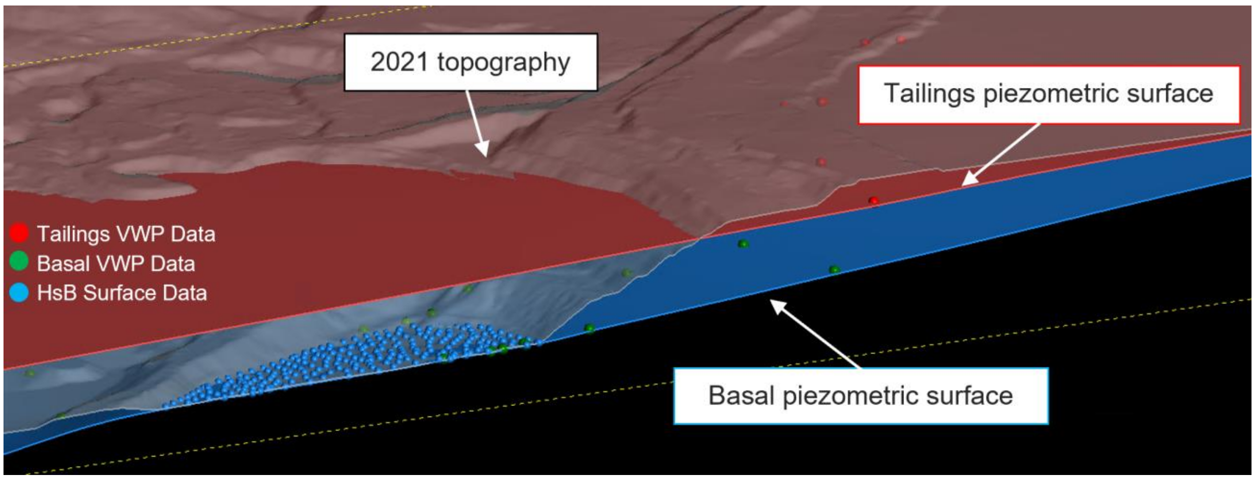
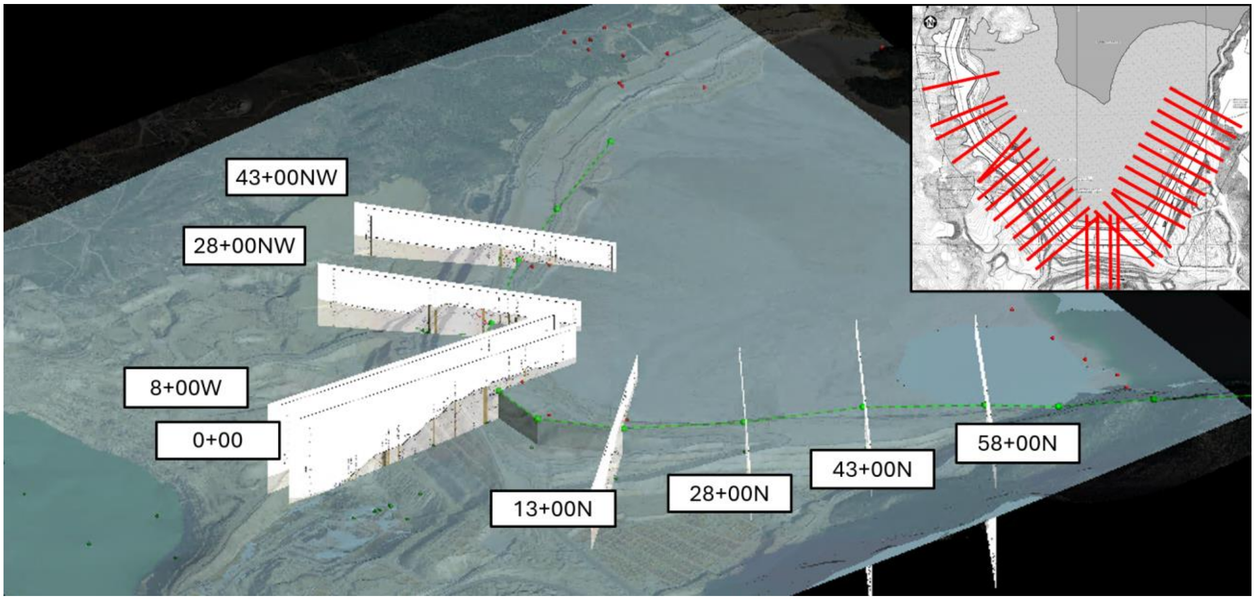


Figure 4.1 Tailings and basal phreatic surfaces at Section 0+00

The connecting vertical segment was created by first approximating the upstream face of the embankment from digitizing the various instrumentation sections from the Data Analysis Report (KP, 2022) and available embankment construction sections, as shown on Figure 4.2. The intersection of the upper segment with the upstream face at each section was joined with a polyline and extruded vertically to intersect the lower segment. A detailed view of the phreatic surface transition through the embankment at Sta. 0+00 is shown on Figure 4.3. The integrated 3D phreatic surface was incorporated into the model constructed for the 3D limit equilibrium analysis and model sections were created at analysis locations to complete the required two-dimensional (2D) limit equilibrium analyses.



Note(s):

1. The inset indicates the locations of embankment sections developed and provided by the mine (Montana Resources, LLC).
2. The phreatic surface is the transparent blue surface, showing the vertical step down in the central pedestal area.

Figure 4.2 Phreatic Surface with Instrumentation and Construction History Sections

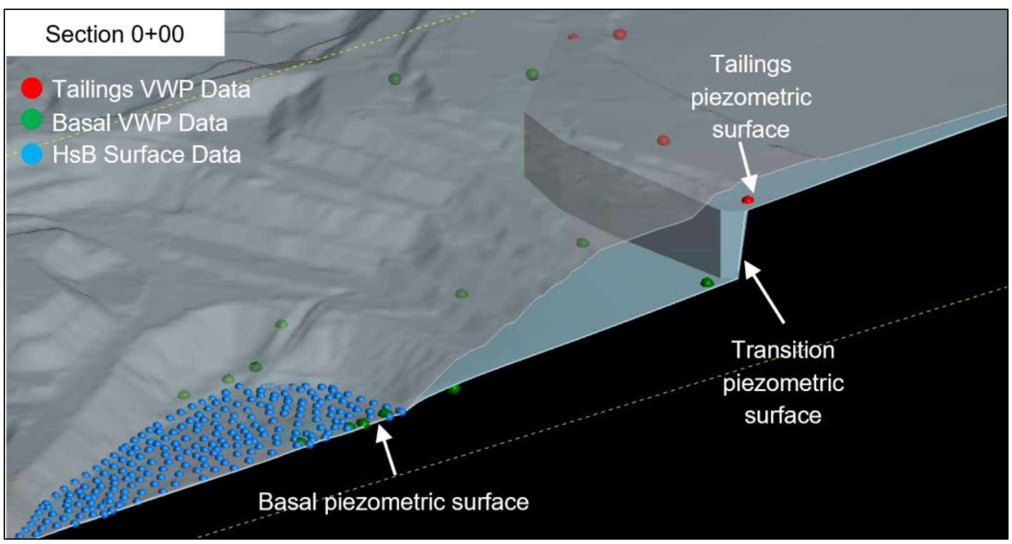


Figure 4.3 Central Pedestal Area Transition of the Phreatic Surface

5.0 RECOMMENDATIONS

The data review identified the key area of uncertainty lies in the definition of the piezometric transition from the upper tailings regime to the lower embankment regime. This is a known data gap that has been investigated extensively since 2015 and continues to be incorporated into the phased site investigation and instrumentation programs (KP, 2021). Future updates to the phreatic surface would benefit from additional high-resolution (e.g., Geo4Sight, multi-point VWPs) pore pressure monitoring through the upstream face and overlying tailings and surcharge rockfill. The instruments should be installed to capture both the tailings and rockfill response along a continuous vertical profile, where practicable. The additional data could also inform further sensitivity evaluation of the piezometric conditions on embankment stability.

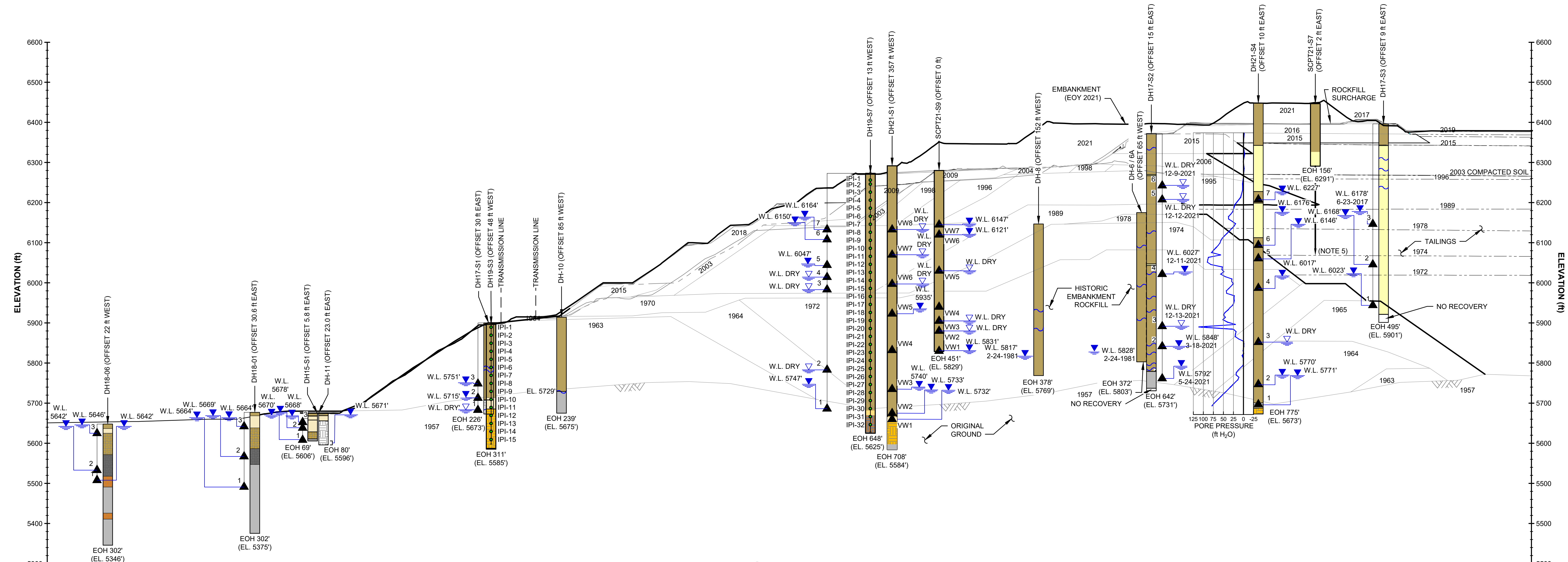
Additional improvements for the stability assessment in the future could include completing an updated piezometric characterization and a calibrated seepage analysis, both may provide greater rigour with which to evaluate the embankment response for evolving conditions as the TSF ages through to the life of mine and into closure. A seepage analysis may also help better define the piezometric conditions and governing characteristics of the isolated perched zones suggested in the current monitoring data. If required, evaluating the influence of such transient conditions on the embankment stability would benefit from a more refined approach for defining this important analysis input.

6.0 REFERENCE

Knight Piésold Ltd. (KP), 2018. Yankee Doodle Tailings Impoundment – Stability Assessment Report. March 13. Vancouver, BC. Ref. No. VA101-126/12-2, Rev 3.

Knight Piésold Ltd. (KP), 2021. 5-Year Site Investigation, Instrumentation and Monitoring Plan for Yankee Doodle Tailings Impoundment. December 22. Vancouver, BC. File No. VA101-126/25-A.01, Cont. No. VA21-02063.

Knight Piésold Ltd. (KP), 2022. Yankee Doodle Tailings Impoundment – 2021 Data Analysis Report. May 20. Vancouver, BC. Ref. No. VA101-126/25-6, Rev 0.



1 SECTION
STATION 0+00
SCALE A

LEGEND:

(pattern)	TAILINGS
(pattern)	FILL
(pattern)	OLDER ALLUVIUM
(pattern)	RECENT ALLUVIUM
(pattern)	HIGHLY ALTERED BEDROCK
(pattern)	HIGHLY WEATHERED BEDROCK
(pattern)	MODERATELY WEATHERED BEDROCK
(pattern)	COMPETENT BEDROCK
W.L. XXX	PIEZOMETRIC ELEVATION (FEET)
▲	VIBRATING WIRE PIEZOMETER (VWP)
1972 (dashed line)	HISTORIC TAILINGS SURFACE
1972 (line)	DATE OF EMBANKMENT RAISE
~	DISCONTINUOUS PERCHED WET ZONE OBSERVED DURING DRILLING
(heavy line)	EMBANKMENT TOPOGRAPHY AS OF DECEMBER 2021
(symbol)	IN-PLACE INCLINOMETER (IPI) SENSOR

NOTES:

1. COORDINATE SYSTEM AND ELEVATIONS ARE RELATIVE TO ANACONDA MINE GRID.
2. DIMENSIONS AND ELEVATIONS ARE IN FEET, UNLESS NOTED OTHERWISE.
3. PIEZOMETRIC ELEVATIONS (W.L.) SHOWN USING DECEMBER 31, 2021 READINGS UNLESS OTHERWISE INDICATED.
4. DRILLHOLE DH21-S4 CONTAINS 128 MARKERS, 93 OF WHICH INCLUDE PORE PRESSURE INSTRUMENTATION.

SCALE A: 125 0 125 250 375 500 625 ft

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END OF 2021 PIEZOMETRIC CONDITIONS ALONG EAST-WEST EMBANKMENT SECTION 0+00 (LOOKING WEST)

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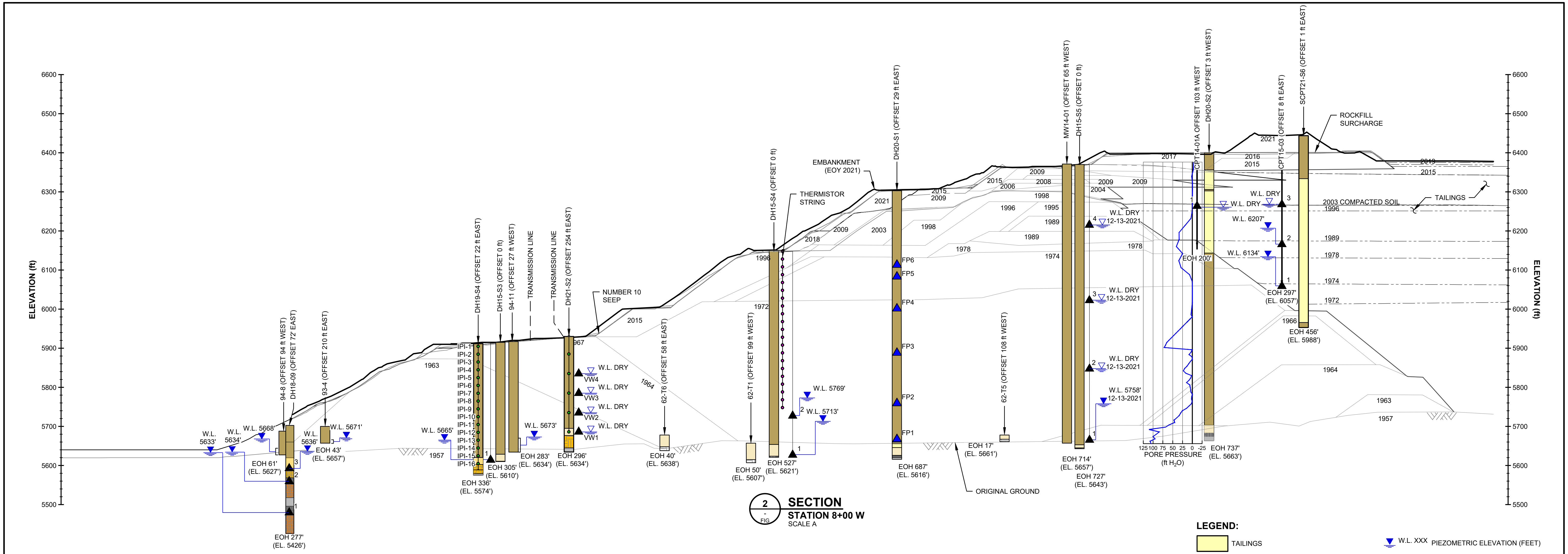
P/A NO.	REF NO.
VA101-126/24	5

FIGURE C.1 REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	19SEP'24	ISSUED WITH REPORT	SY3	MJC	DDF

SAVED: M:\1\01\00126\24\A\Acad\FIGS\B11, 12/20/2023 9:44:29 AM , RMCLELLAN PRINTED: 9/19/2024 1:47:52 PM, FIG C.1, RMCLELLAN
XREF FILE(S): Sections IMAGE FILE(S):



2 SECTION
STATION 8+00 W
SCALE A

LEGEND:

- TAILINGS
- FILL
- OLDER ALLUVIUM
- RECENT ALLUVIUM
- HIGHLY ALTERED BEDROCK
- HIGHLY WEATHERED BEDROCK
- MODERATELY WEATHERED BEDROCK
- COMPETENT BEDROCK
- W.L. XXX — PIEZOMETRIC ELEVATION (FEET)
- VIBRATING WIRE PIEZOMETER (VWP)
- 1972 — HISTORIC TAILINGS SURFACE
- 1972 — DATE OF EMBANKMENT RAISE
- DISCONTINUOUS PERCHED WET ZONE OBSERVED DURING DRILLING
- EMBANKMENT TOPOGRAPHY AS OF DECEMBER 2021
- IN-PLACE INCLINOMETER (IPI) SENSOR

NOTES:

1. COORDINATE SYSTEM AND ELEVATIONS ARE RELATIVE TO ANACONDA MINE GRID.
2. DIMENSIONS AND ELEVATIONS ARE IN FEET, UNLESS NOTED OTHERWISE.
3. PIEZOMETRIC ELEVATIONS (W.L.) SHOWN USING DECEMBER 31, 2020 READINGS UNLESS OTHERWISE INDICATED.
4. NO PORE WATER PRESSURE DATA ARE AVAILABLE FROM DH20-S1 AND DH20-S2 AS THE INSTRUMENTATION IS NOT FUNCTIONAL.
5. GEO4SIGHT MARKERS ARE MULTI-NODE WIRELESS DEFORMATION AND PORE WATER PRESSURE MONITORING INSTRUMENTS. DRILLHOLE DH20-S2 CONTAINS 123 MARKERS, 78 OF WHICH INCLUDE PORE PRESSURE INSTRUMENTATION. PORE PRESSURE DATA ARE AVAILABLE AT 6 FT AND 18 FT VERTICAL INTERVALS WITHIN ROCKFILL AND TAILINGS, RESPECTIVELY.

SCALE A: 125 0 125 250 375 500 625 ft

MONTANA RESOURCES, LLC

MONTANA RESOURCES

END OF 2021 PIEZOMETRIC CONDITIONS ALONG EAST-WEST EMBANKMENT SECTION 8+00W (LOOKING WEST)

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA101-126/24	5

FIGURE C.2 REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
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SAVED: M:\1\01\00126\24\A\Acad\FIGS\B12, 12/20/2023 9:45:07 AM , RMCLELLAN PRINTED: 9/19/2024 1:49:42 PM, FIG C.2, RMCLELLAN
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APPENDIX D

Liquefaction Assessment

(Pages D-1 to D-15)

APPENDIX D
LIQUEFACTION ASSESSMENT

1.0 INTRODUCTION

The stability assessment of the Yankee Doodle Tailings Impoundment (YDTI) considers three primary soil units: overburden, embankment rockfill, and tailings. The overburden unit overlies the bedrock beneath the YDTI. The rockfill unit forms the embankment dam and the tailings unit is impounded by the rockfill embankment.

An assessment of the liquefaction potential was carried out to evaluate if the key soil units are susceptible to cyclic liquefaction. The liquefaction assessment focused on the potential response to the maximum credible earthquake (MCE). A screening level assessment was initially conducted based on material index properties and seismic cone penetration testing (SCPT) data, and a one-dimensional (1D) total stress analysis was completed for materials that were screened as potentially susceptible. This appendix summarizes the liquefaction assessment.

Data availability for the assessment was not the same for all three soil units. Sufficient data was available for assessing the tailings and overburden units in isolation. A limited quantity of data was available for the saturated rockfill due to the difficulty of advancing penetration equipment through the stiff and coarse-grained material to reach the saturated zone at the base of the 800 ft high embankment dam. SCPT was successful at a few locations to depths of up to approximately 170 ft but resulted in near immediate refusal at deeper depths. The collection of downhole seismic data also proved challenging due to drilling and installation conditions. However, velocity data of the saturated rockfill was collected at three drillholes (DH17-S1, DH17-S2, DH17-S3) during the 2017 site investigation (KP, 2018). The resulting high shear-wave velocities (V_s) exceeded the applicability of the correlation equations (Kayen et al., 2013) for evaluating liquefaction potential, which corroborated the stiff nature of the saturated rockfill.

2.0 MATERIAL SUSCEPTIBILITY

2.1 ROCKFILL

Weathering, alteration, and gradation of the embankment rockfill has been observed to be highly variable during the various site investigation programs. This variability is inferred to result from the construction methodology used at the YDTI and differences in weathering and geological alteration in the Butte Quartz Monzonite (BQM) source material used to construct the embankment. A considerable portion of the embankment rockfill recovered during sonic drilling is typically gravel to sand sized and is moderately to highly weathered. It is surmised that some degradation of the original larger sized rockfill has occurred since initial placement, as much of the recovered rockfill core consists of friable, weathered gravels, cobbles and boulders within a silty sand or sandy-silt matrix. Some slightly weathered to fresh cobbles and gravel-sized materials are commonly interspersed throughout the drill core. The sonic drilling process introduces vibratory and rotational forces that can alter grain size distribution of the recovered samples and can reduce coarse rockfill and weathered bedrock to a soil-like consistency in the recovered core.

Gradation curves from the particle size distributions (PSD) testing on rockfill samples collected during select sonic drilling programs are shown Figure 2.1. The rockfill sampled during the site investigation programs has a typical fines content of less than 30%, and case histories indicate that material with similar gradations are potentially susceptible to liquefaction (Youd et al., 2001).

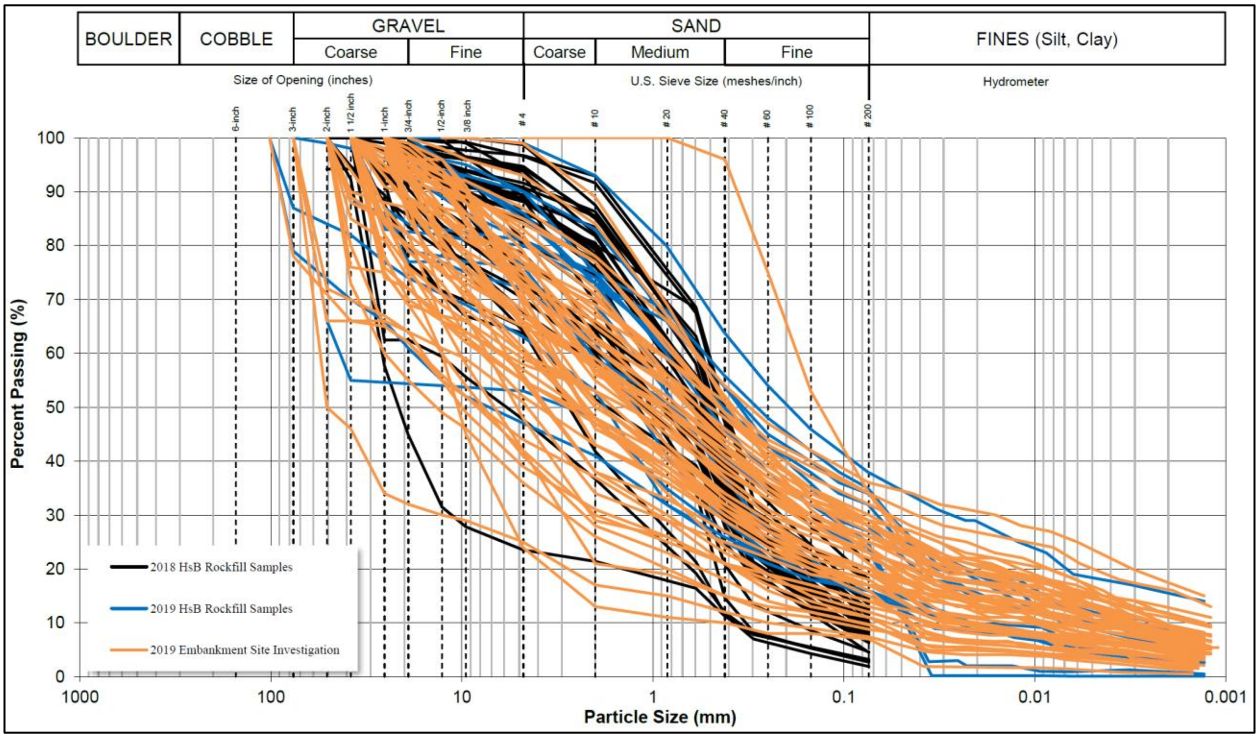

Figure 2.1 Rockfill Particle Size Distribution (2018 and 2019 Site Investigations)

SCPT data was collected in mine-derived rockfill during the 2019 and 2021 embankment site investigation programs at six drillholes (KP, 2020a, 2023a). Additional data was also collected for mine-derived fill in the Horseshoe Bend (HsB) area (KP, 2020b). Cone penetration testing in embankment rockfill generally encountered dense rockfill in which it was difficult to advance SCPT below a depth of approximately 100 ft below ground surface. SCPT was achievable within near-surface rockfill, particularly in targeted locations where historical leaching activities appear to have enhanced chemical weathering. Sonic drilling was used for pre-drilling and drillouts as needed to advance SCPT soundings past refusal.

The in-situ state of rockfill was evaluated using three methods as follows:

- the normalized soil behavior type (SBTn) using charts developed by Robertson (2016)
- an evaluation of pore pressure response during cone advancement and pore pressure dissipation (PPD) testing
- an assessment of microstructure after Robertson (2016)

The SBTn classification for mine-derived rockfill generally indicated the material was dilative. This finding contradicted some observations of contractive behavior in the pore pressure assessment (e.g. PPDs and dynamic pore pressures indicate slow dissipation and potential for contractive behavior at some locations/depths). The results of the microstructure assessment suggested that the rockfill material was structured. The presence of microstructure may be increasing the tip resistance and friction ratio measurements resulting in the data plotting higher up and slightly to the right in the SBTn plots. This results in SBTn values suggestive of dilative properties; however, the material may behave in a contractive manner if the material is/becomes saturated and the microstructure is reduced or removed (KP, 2023a) and is therefore potentially susceptible to liquefaction.

2.2 OVERBURDEN

Two sources of overburden are generally recognized in the YDTI area: recent stream deposits (referred to as recent alluvium) and older outwash deposits (referred to as older alluvium). Recent alluvium deposits are mapped to exist along the historical Silver Bow Creek channel, which approximately aligns with Section 8+00W along the East-West Embankment, and minor tributaries existing within the embankment footprint. Recent alluvium material encountered during the drilling programs was dark brown, poorly graded, and compact to very dense sand with some silt, some gravel, and is generally non-plastic. Older alluvium is located directly east of the historical Silver Bow Creek channel and forms a moderately sloping plain rising to the east, towards the East Ridge. The older alluvium unit is generally poorly sorted, unconsolidated to moderately indurated, silt, sand, gravel and cobble detritus locally derived from granitic and volcanic rocks. Locally it may include talus deposits comprised of unsorted cobble and boulder rock fragments and debris flow deposits. A substantial accumulation of these deposits exists on-site, and the older alluvium deposits within the YDTI embankment footprint are now extensively overlain by rockfill hundreds of feet thick.

Gradation curves from the PSD testing on overburden from HsB area are shown on Figure 2.2. The overburden typically has a fines content of less than 20%; however, a few recent alluvium samples had a higher fines content. Case histories indicate that material with similar gradations is potentially susceptible to liquefaction (Youd et al., 2001).

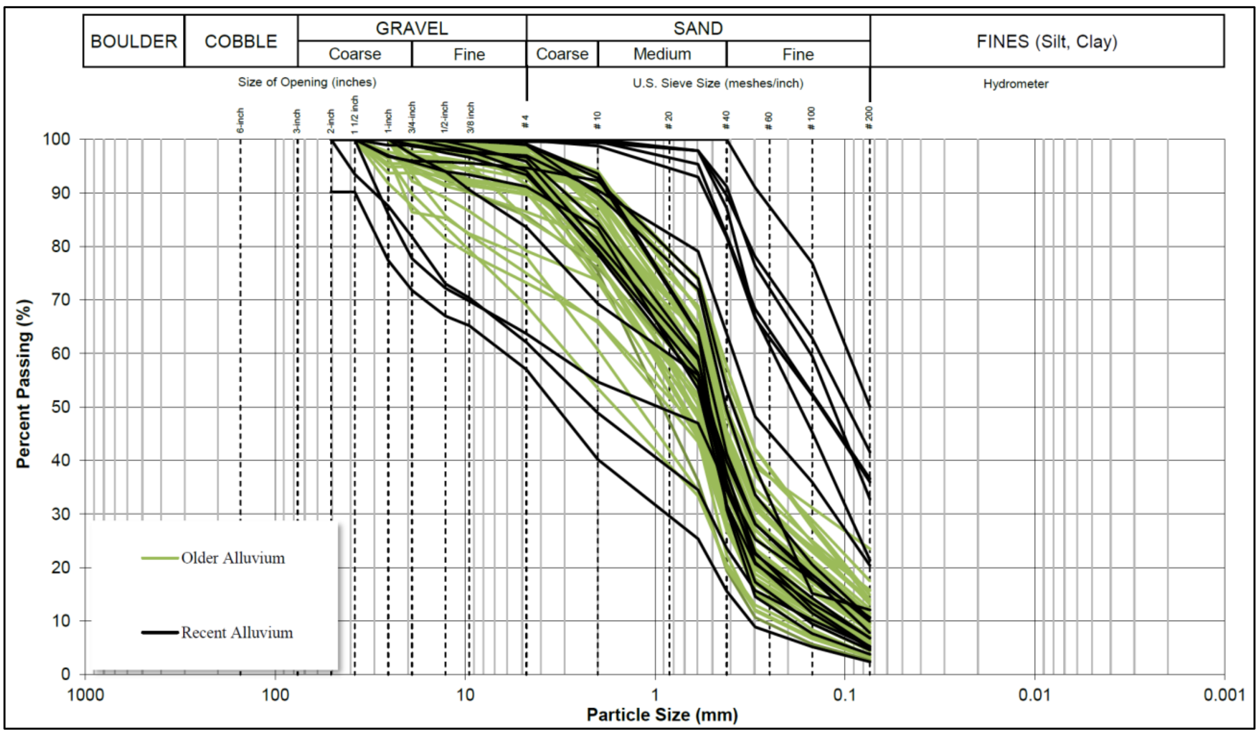

Figure 2.2 Overburden Particle Size Distribution (2018 HsB Site Investigation)

SCPT data was collected in overburden materials during the 2019 HsB area site investigation program (KP, 2020b). SCPT soundings were also attempted within older alluvium at several depths approximately 200 ft below ground surface (with drilling situated from the Seep 10 Bench) during the 2019 embankment investigation program (KP, 2020a). These attempted soundings achieved limited penetration (< 1.2 ft) before refusal indicating the alluvium situated below the embankment rockfill is dense, as expected. The in-situ state of the overburden in the HsB area was evaluated with similar methods to those described above. The SBTn-based classification of recent and older alluvium materials generally indicated dilative behavior with some locations/depths indicating potential for contractive behavior. PPDs at several locations/depths indicated a contractive response, and the microstructure assessment indicated layering and varying degrees of microstructure in most HsB area soils encountered. Recent alluvium appeared to have limited microstructure influence, while older alluvium exhibited more structure.

Similar to the rockfill unit, it is inferred that saturated overburden materials present in the embankment foundation may behave in a contractive manner if the microstructure is reduced or removed and is therefore potentially susceptible to liquefaction.

2.3 TAILINGS

The tailings material in close proximity to the embankments predominantly comprises sand with some silt and traces of clay. Atterberg limits testing was completed on tailings samples during the various site investigation programs was completed during several site investigation programs between 2013 and 2021. The tailings samples were typically non-plastic with a few samples showing low to medium plasticity. Non-plastic sands and silts are generally considered potentially susceptible to liquefaction if in a loose, saturated state.

The liquefaction susceptibility of tailings samples showing low to medium plasticity was further assessed using data from index testing. Laboratory data are plotted on Figure 2.3, superimposed on the Bray and Sancio (2006) liquefaction susceptibility chart. Figure 2.3 includes data collected from site investigations spanning 2013 through 2021 (KP, 2014, 2016a, 2016b, 2019, 2020a, 2020b, 2021, 2023a, 2023b). The results of this screening-level assessment indicate that the tailings are potentially susceptible to liquefaction, if saturated, consistent with expectations for low-plasticity sands and silts with relatively high water content to liquid limit ratio.

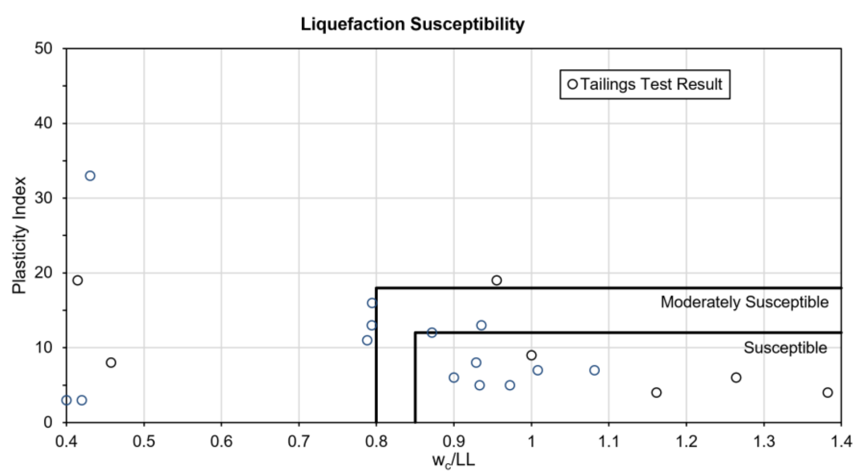

Figure 2.3 Tailings Liquefaction Susceptibility (modified from Bray and Sancio, 2006)

A second screening-level assessment was completed for the tailings using SCPT data collected at the YDTI in 2021 (KP, 2023b). The in-situ state of the tailings was analyzed using state parameter and soil behaviour type charts (Robertson, 2016, 2022), and further assessed using the PPD test results and seismic shear wave velocity measurements. The key findings from this investigation are summarized below, and additional information is available in the associated site investigation report (KP, 2023b). The key findings from the 2021 tailings SCPT site investigation were as follows:

- The tailings along the North-South Embankment (non-loaded tailings) are generally potentially contractive, as supported by SBTn plots and state parameters. The tailings under the East-West Embankment (surcharged tailings) are generally less contractive than the North-South Embankment tailings. Contractive behaviour is observed in the central pedestal area below approximately El. 6,230 ft near where the inferred saturated tailings zone is located.
- Comparison of surcharged and historically non-loaded tailings at approximately the same location (between 2015 and 2021) shows increased dilative properties after the phreatic surface elevation reduction over time in conjunction with natural consolidation with time and surcharge loading particularly within the upper 120 ft of tailings. This is consistent with expectations.
- The phreatic surface within the tailings mass generally occurs at shallower depths with increased proximity to the supernatant pond, as expected. The tailings abutting the central pedestal area monitored generally unsaturated tailings above the inferred phreatic surface at approximately El. 6,230 ft.
- Comparing SCPT data (between 2015 and 2021) from twinned sites indicates that surcharging the tailings generally results in material property improvements, particularly within the upper 120 ft of tailings. These improvements include lower (i.e. more dilative) state parameters and higher estimated peak and residual strengths.

3.0 TOTAL STRESS ANALYSIS

A 1D total stress analysis was conducted to evaluate the liquefaction potential of selected tailings and overburden in columns at the YDTI. The analysis columns coincide with the locations of cone penetration testing (CPT) data (KP, 2017, 2018, 2020, 2023), as summarized in Table 3.1. The locations of the analysis columns are shown on Figure 3.1. Four locations were selected to assess the spatial variability in terms of confinement and foundation conditions. The liquefaction assessment estimates and compares the predicted Cyclic Stress Ratio (CSR) with the estimated Cyclic Resistance Ratio (CRR) for each column. Where the CSR is greater than the CRR and the materials are saturated, liquefaction is predicted to occur in response to the MCE.

Table 3.1 Descriptions of the Analysis Columns

Profile	Description	Corresponding CPT Sounding
Tailings 1	East-West Embankment	SCPT21-S6
Tailings 2	Unconfined tailings beach	SCPT15-05
Tailings 3	East-West Embankment confined tailings	SCPT21-S3, SCPT21-S5
Tailings 4	North-South Embankment unconfined tailings	SCPT21-S2, SCPT21-S4, SCPT21-S1
Overburden 1	Older alluvium	SCPT19-02
Overburden 2	Recent alluvium overlying older alluvium	SCPT19-11

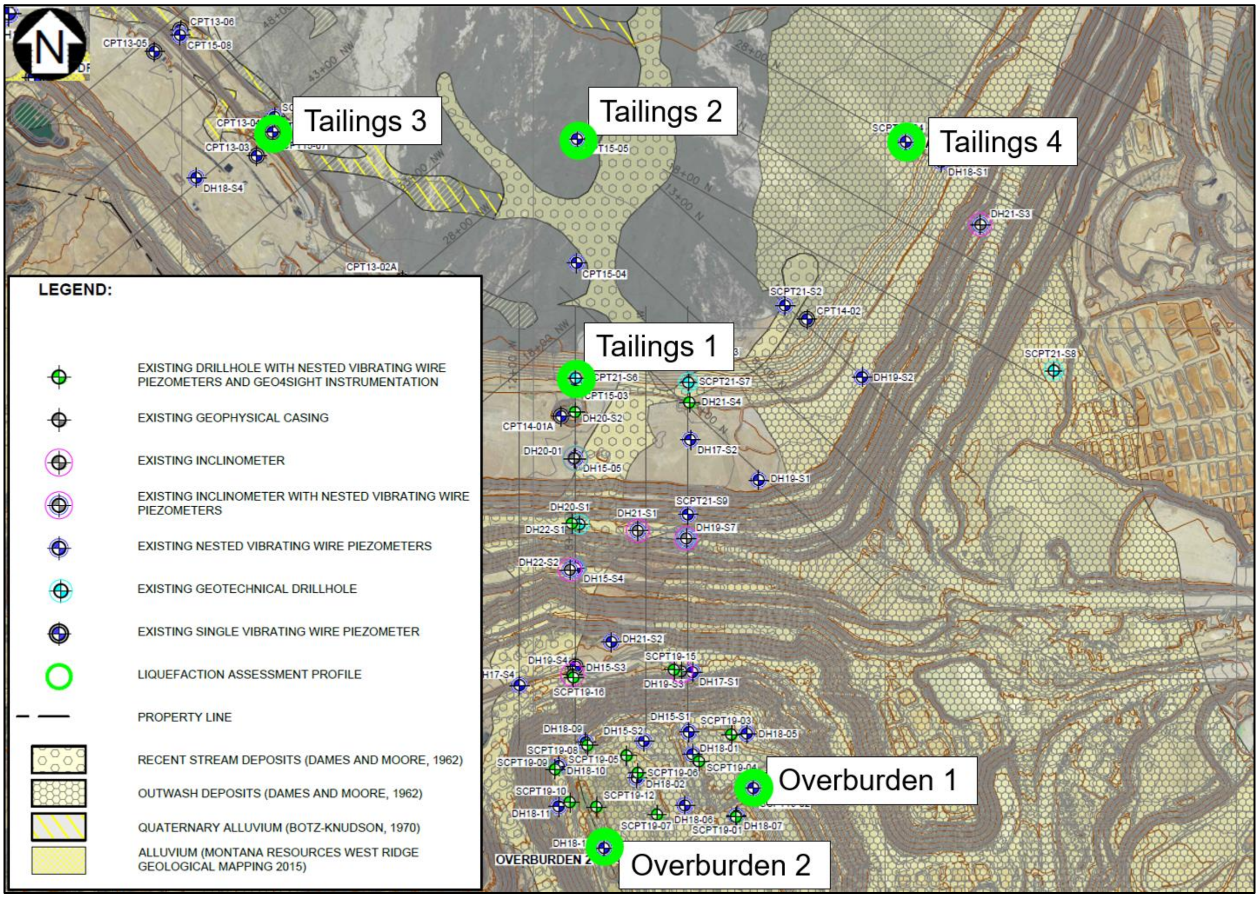

Figure 3.1 Total Stress Analysis Column Locations

The CSR profiles were calculated for each column by performing equivalent linear and non-linear site response analyses (SRA). The equivalent linear SRA was performed with Pro-Shake (EduPro, 2023), while the non-linear SRA was performed with DEEPSOIL (Hashash et al., 2020). The five MCE time histories were deconvoluted to ground conditions at the base of the analysis columns. Deconvolution for the overburden columns with a bedrock base was performed using a time-averaged shear wave velocity in the 30 m (100 ft) below a specified reference point (V_{s30}) of 1670 ft/sec or 510 m/sec. Deconvolution for the tailings columns with overburden at the base was performed using a V_{s30} of 1380 ft/sec or 420 m/sec. The columns were discretized into layers with stiffness and strength profiles that varied with depth. The stiffness profiles were developed from seismic testing and engineering experience of typical stiffness relationships for the different material types. The strength profiles were developed from material properties of each unit. Modulus reduction and damping curves were assigned to each layer using the stress-dependent Darendeli (2001) family of curves for a plasticity index of zero (non-plastic). The SRA input parameters and results are provided in Figures D.1 to D.4. The shear stress profiles from the SRA were used to calculate the CSR, according to the equation below:

$$\mathrm{CSR} = 0.65\frac{\tau}{\sigma'_v}$$

where τ is the calculated shear stress and σ'_v is the effective vertical stress in the layer. The CRR profiles for each column were calculated from the corresponding CPT data. The CRR was calculated using the

Updated NCEER (Robertson, 2009) and Boulanger and Idriss (2014) correlations. The reference CRR for a moment magnitude (M) earthquake of 7.5 and vertical effective stress of 1 atm ($CRR_{M=7.5,\sigma'_v=1}$) was converted to the MCE CRR (CRR_{M,σ'_v}) by applying a magnitude scaling factor (MSF) and effective overburden stress (K_σ) factor.

The CSR and CRR profiles for the four tailings columns are presented on Figure 3.2. The range of CRR values calculated from the CPT data suggests a large variability in the tailings with CRR data points scattered above and below the CSR lines. A lower bound of the estimated CRR values was chosen for the analysis; however, the full results indicate there is uncertainty in the anticipated response. The CRR determined from the cyclic direct simple shear (CDSS) tests are also plotted on Figure 3.2 and show consistency with the lower bound CRR values calculated from the CPT data. The CRR from the CDSS tests was determined for a confining pressure of 100 kPa (2,090 psf), which corresponds to shallow depths where confinement is minimal in the tailings. The CSR values calculated from the equivalent linear and non-linear SRA values range from approximately 0.1 to 0.2. The relatively small difference between the CSR values calculated with the equivalent-linear and nonlinear method are likely related to the lower stiffness of the tailings.

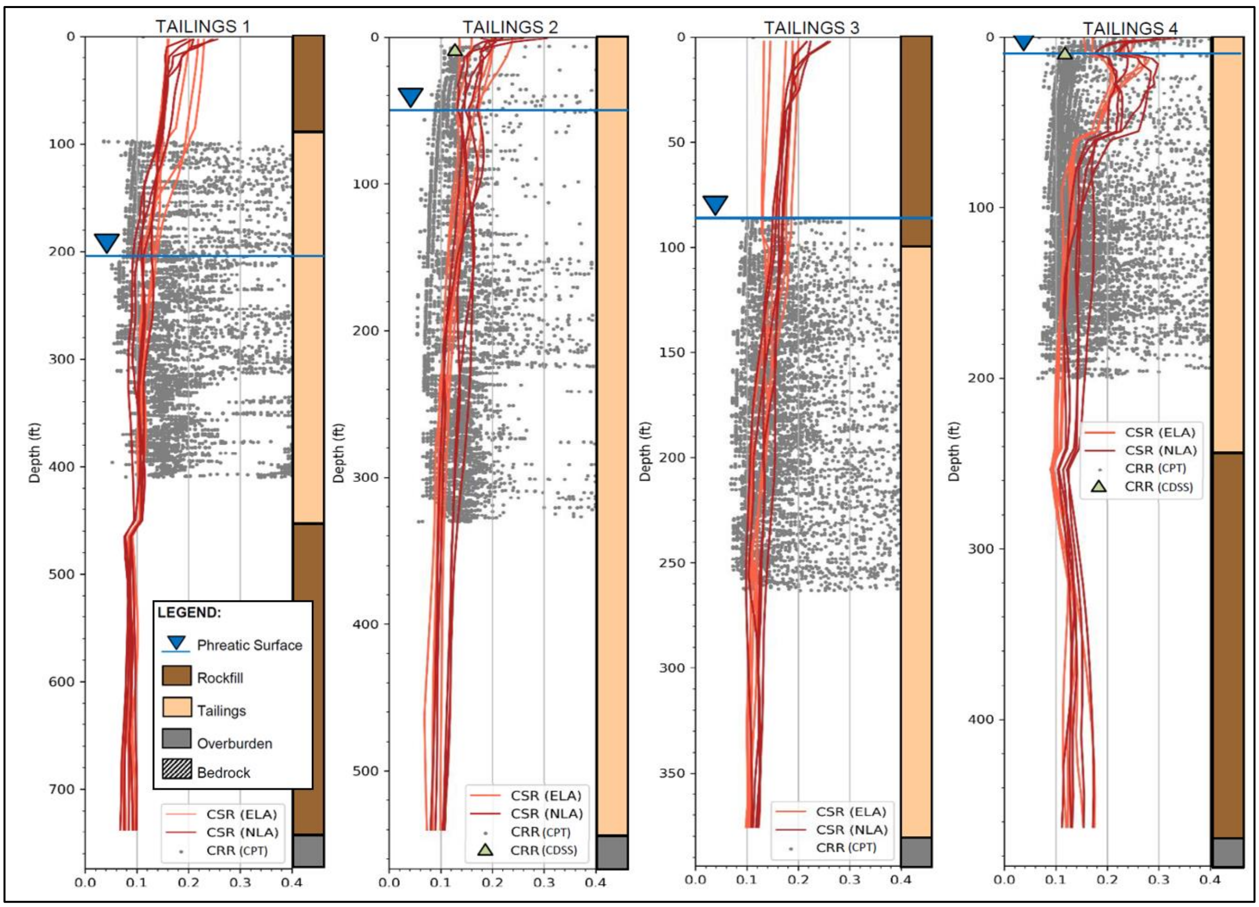

Figure 3.2 Total Stress Liquefaction Assessment – Tailings Columns

The CSR range of the tailings generally exceed the lower bound CRR values below the phreatic surface, particularly at shallow depths, indicating liquefaction susceptibility. However, the results also indicate that the liquefaction potential generally decreases with depth. The rockfill surcharge, where present, has resulted in lower potential for liquefaction for tailings in the central pedestal area, which also demonstrates the effect of increasing confinement. Tailings 1, which is in the central pedestal area, shows the smallest difference between the CSR and the lower bound CRR in the saturated tailings when comparing the four columns. The findings suggest saturated tailings have higher susceptibility to strength loss with proximity to the supernatant pond. Unsaturated tailings are not expected to liquefy. The tailings beach is extensive and the unsaturated zone in the tailings increases in thickness with proximity to the dam.

The CSR and CRR profiles of the overburden columns are presented on Figure 3.3. A continuous CRR profile is not available due to the drill outs required to push the cone to depth. CRRs calculated from the stress-normalized shear wave velocity, V_{s1}, were considered but they are not plotted because they exceed the bounds of this chart. Approximately 75% of the V_{s1} data from the seismic CPT are greater than 984 ft/sec (300 m/sec), as shown on Figure D.5, which exceeds the liquefiable bounds of the Kayen et al. (2013) triggering chart. The CRR determined from CDSS tests are also plotted on Figure 3.3, which show consistency with the lower bound CRR values calculated from the CPT data. Therefore, a lower bound CRR was selected for analysis based on the CPT and CDSS results. The comparison of the equivalent linear and non-linear CSRs shows the equivalent-linear SRA overpredicts shear stresses likely because of the inability of the equivalent-linear SRA to capture the non-linear response at high strains.

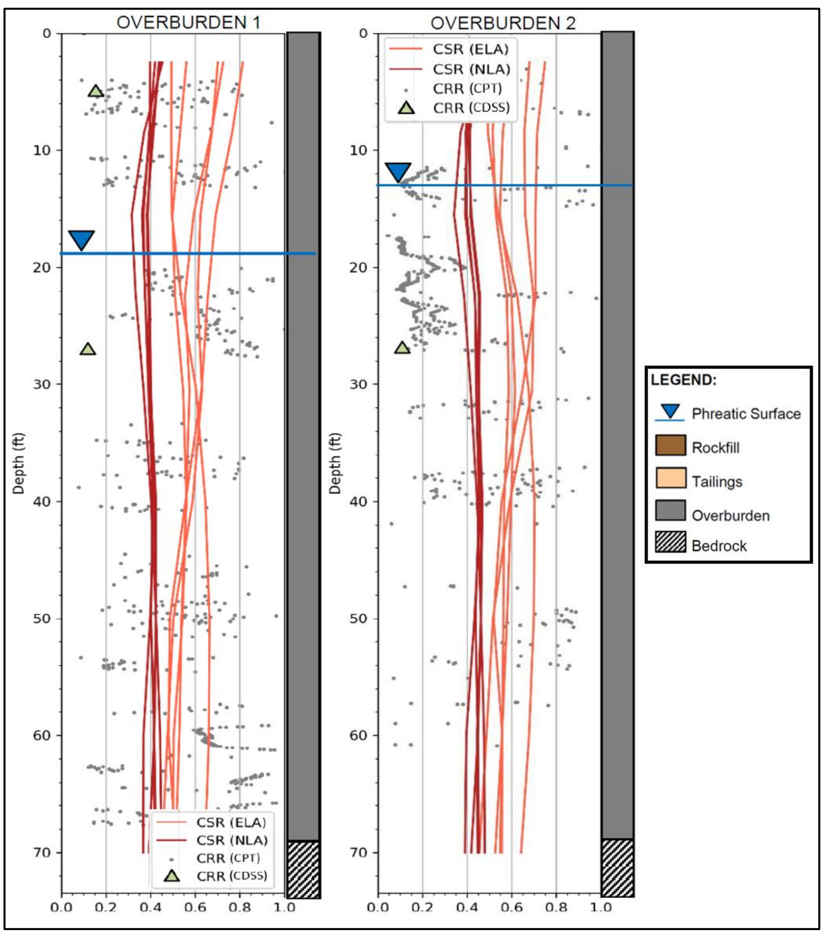

Figure 3.3 Total Stress Liquefaction Assessment – Overburden Columns

The CSR profiles of the overburden columns exceed the lower bound CRR values at shallow depths of the saturated zone at Overburden 2, where a continuous CPT profile is evident. The remaining discontinuous CPT data exhibits scatter in the CRR values, which suggests more data is required. However, the number of drill outs required to push the cone to depth limits the use of penetration methods but also suggests stiff, and possibly dense, conditions in the overburden. The available CPT data suggests susceptibility to liquefaction for the saturated overburden at shallow depths with uncertainty related to liquefaction potential extending to greater depths. With shallow piezometric conditions observed in the HsB area, the saturated overburden may be susceptible to liquefaction.

4.0 CONCLUSIONS AND RECOMMENDATIONS

The screening-level and 1D site response analysis (total stress) indicate the saturated tailings unit is potentially liquefiable. A similar conclusion can be drawn for the saturated overburden but with less confidence due to data availability. Regardless, a conservative approach is recommended for evaluating the seismic response of the YDTI. A two-dimensional dynamic site response analysis should be completed to assess the liquefaction potential and extent, as well as to estimate the earthquake-induced deformations by considering that the saturated materials of the three units (overburden, rockfill, tailings) are potentially susceptible to liquefaction.

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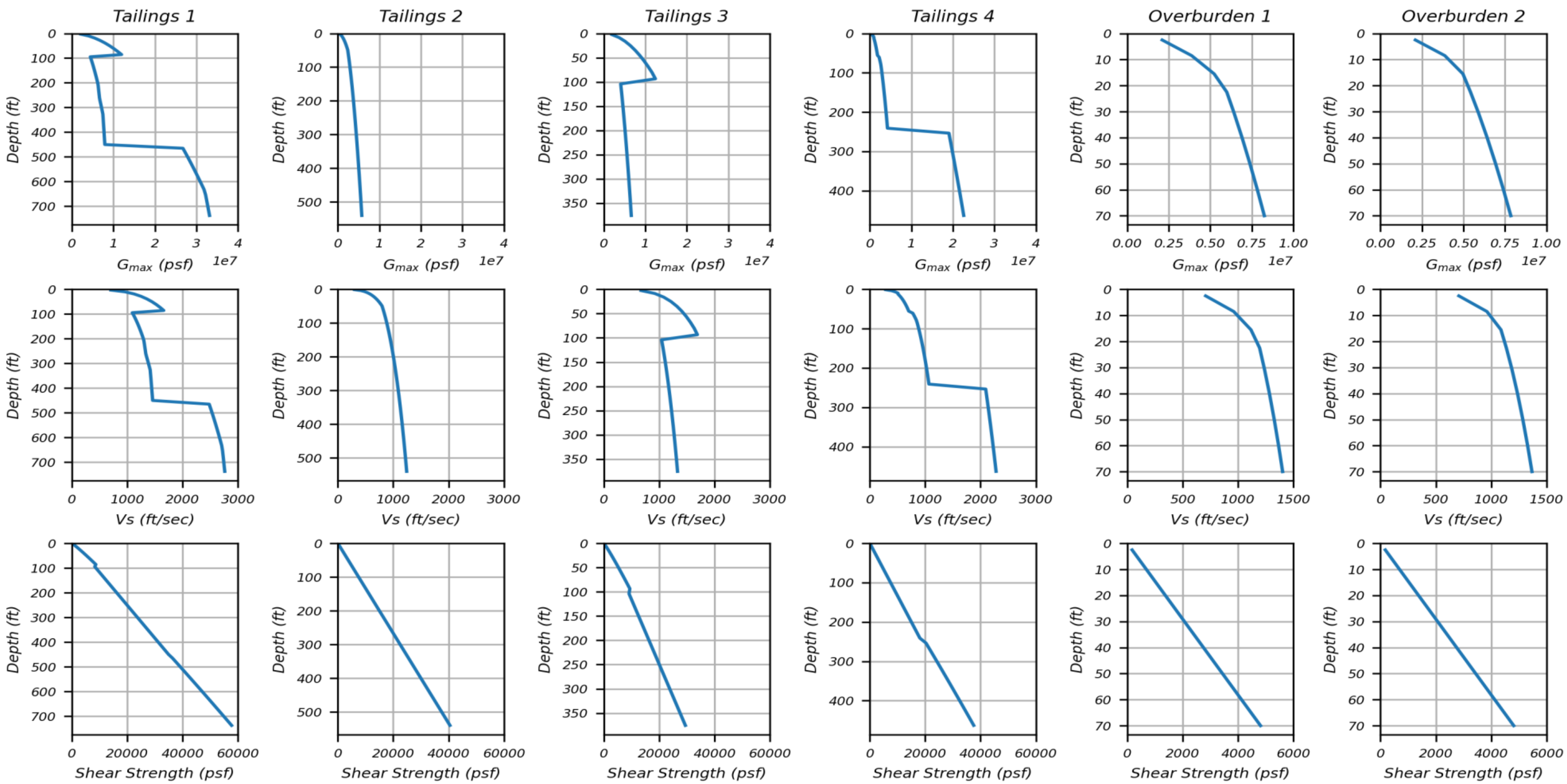

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MONTANA RESOURCES, LLC

MONTANA RESOURCES

MATERIAL SUSCPEPTIBILITY
SITE RESPONSE ANALYSIS
INPUT VALUES

Knight Piésold CONSULTING

P/A NO. VA101-126/24

REF. NO. 5

FIGURE D.1

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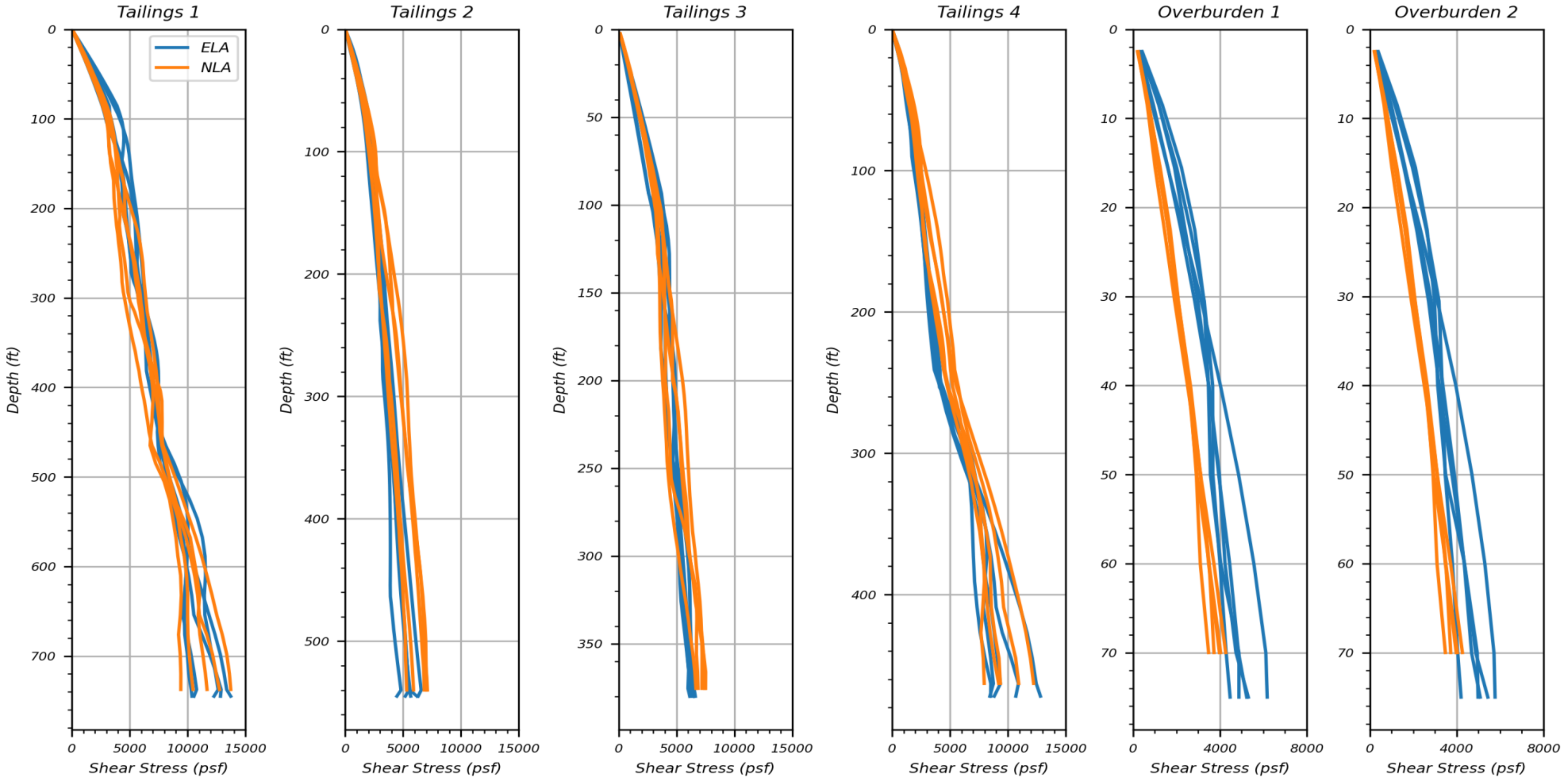


NOTES:

1. ELA IS EQUIVALENT LINEAR ANALYSIS. NLA IS NONLINEAR ANALYSIS.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	MJB2	GRG

MONTANA RESOURCES, LLC

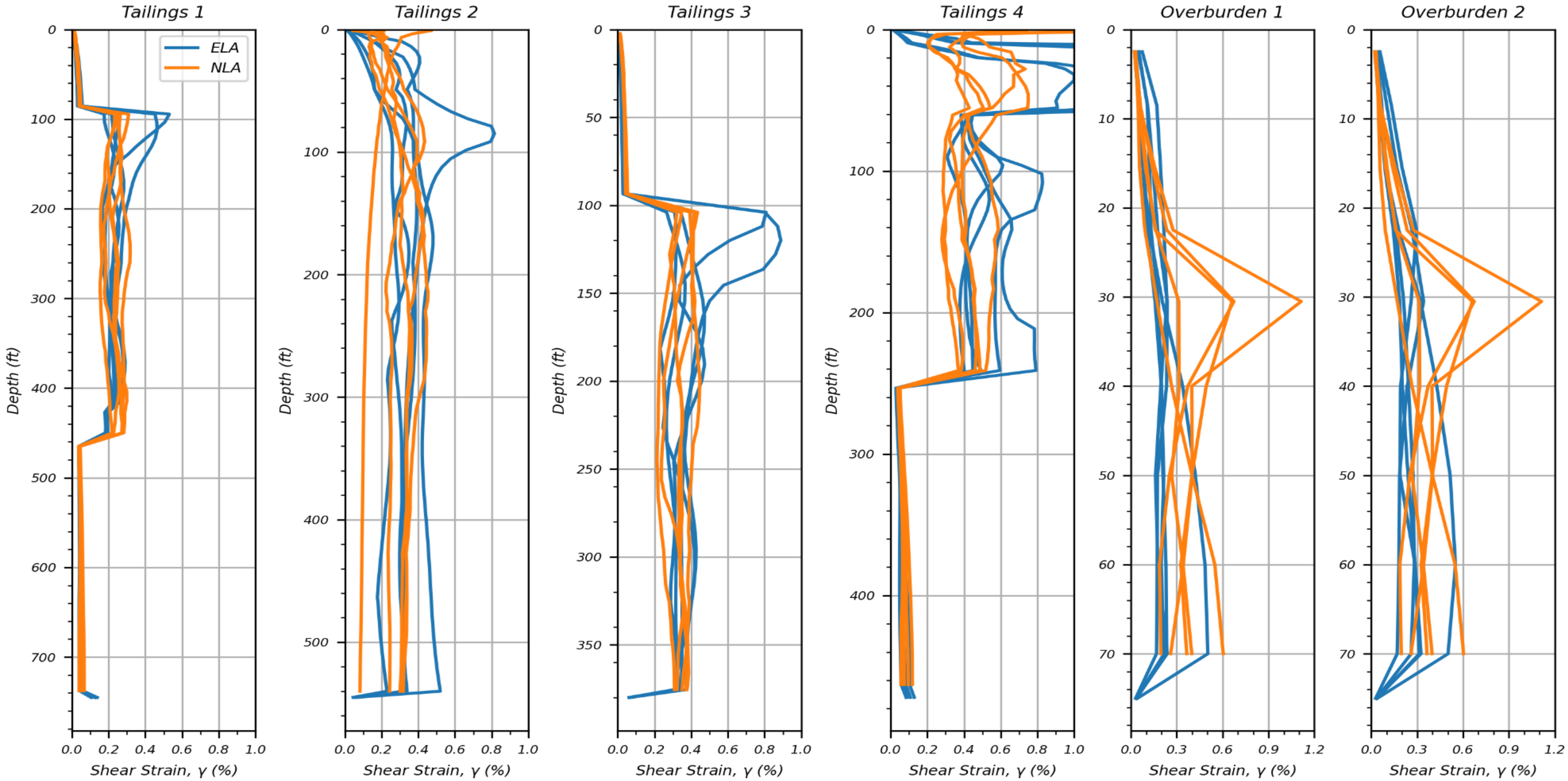
MONTANA RESOURCES

MATERIAL SUSCPEPTIBILITY
SITE RESPONSE ANALYSIS
SHEAR STRESS

Knight Piésold CONSULTING

P/A NO.	REF. NO.
VA101-126/24	5

FIGURE D.2 REV 0



NOTES:

1. ELA IS EQUIVALENT LINEAR ANALYSIS. NLA IS NONLINEAR ANALYSIS.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	MJB2	GRG

MONTANA RESOURCES, LLC

MONTANA RESOURCES

MATERIAL SUSCPEPTIBILITY SITE RESPONSE ANALYSIS SHEAR STRAIN

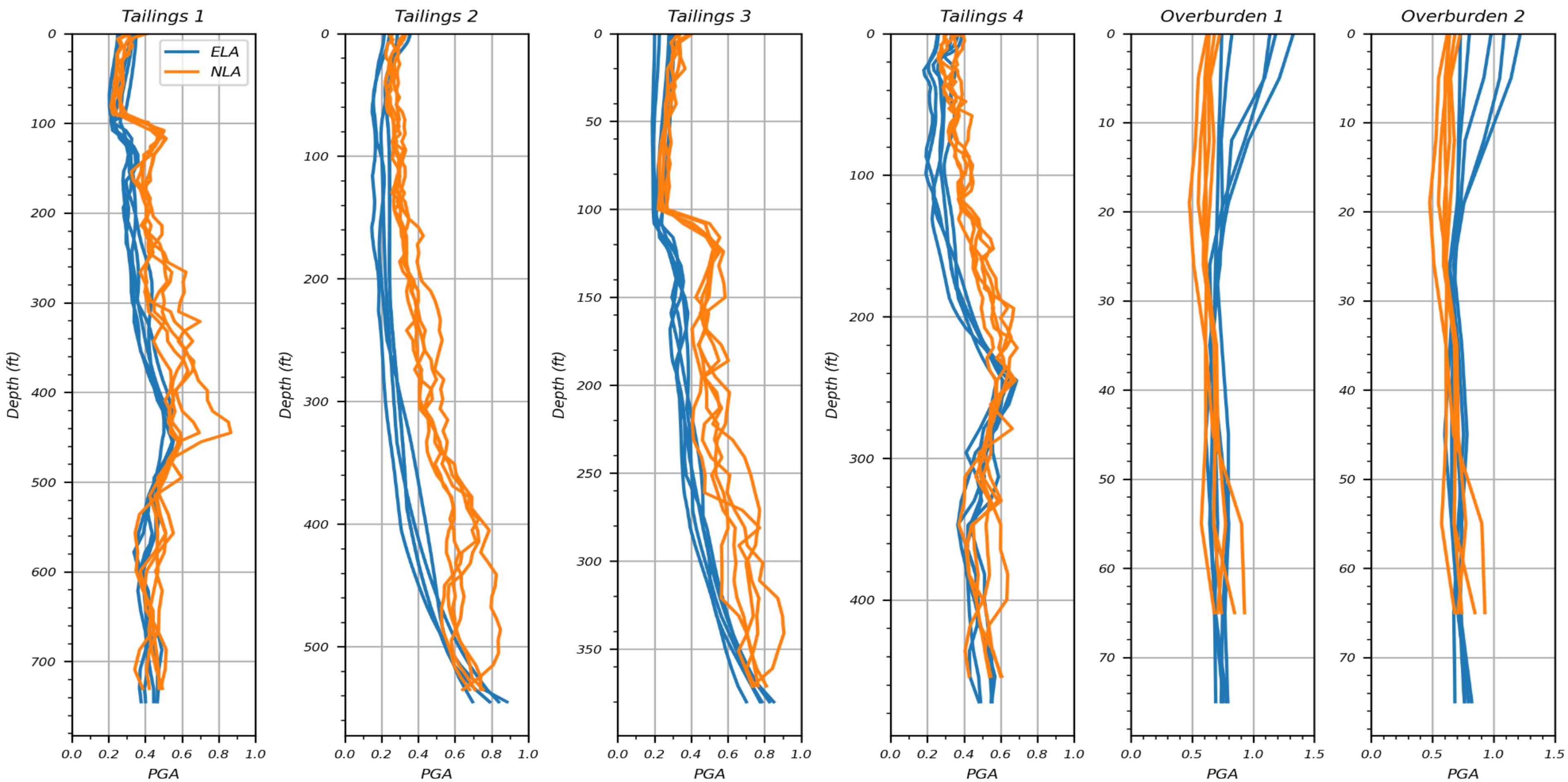
Knight Piésold CONSULTING

P/A NO. VA101-126/24

REF. NO. 5

FIGURE D.3

REV 0



NOTES:

1. ELA IS EQUIVALENT LINEAR ANALYSIS. NLA IS NONLINEAR ANALYSIS.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	MJB2	GRG

MONTANA RESOURCES, LLC

MONTANA RESOURCES

**MATERIAL SUSCPEPTIBILITY
SITE RESPONSE ANALYSIS
PEAK GROUND ACCELERATION**

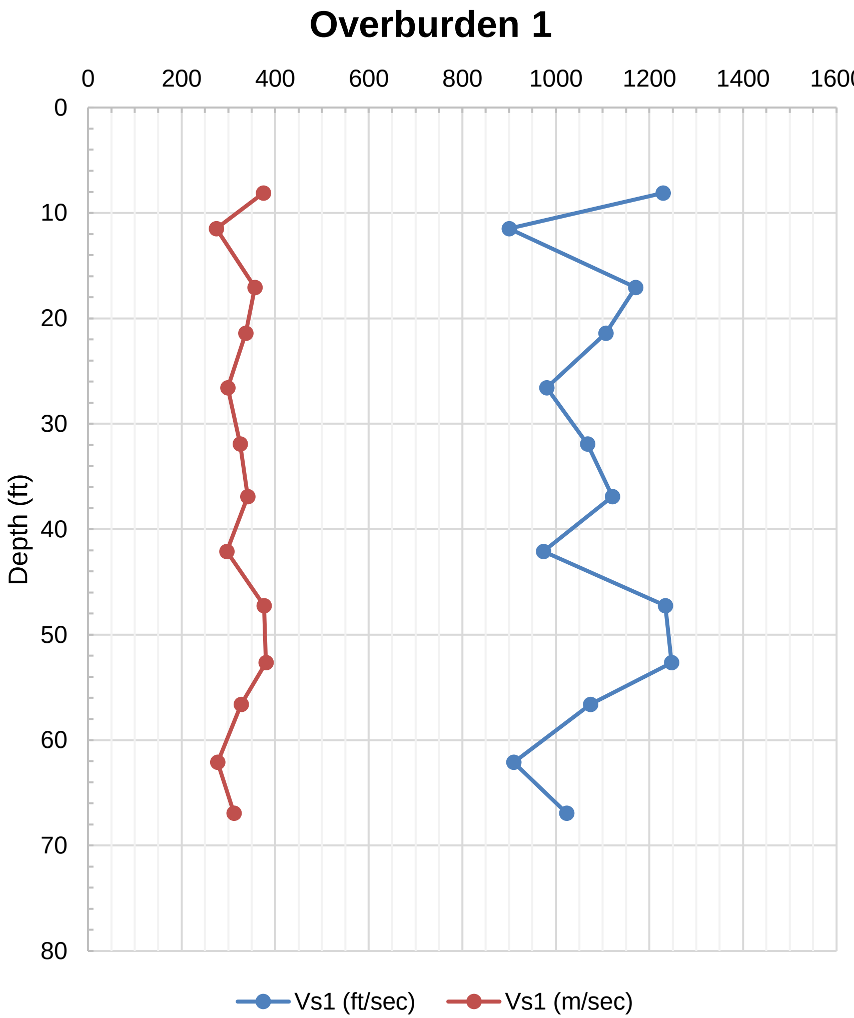
Knight Piésold CONSULTING

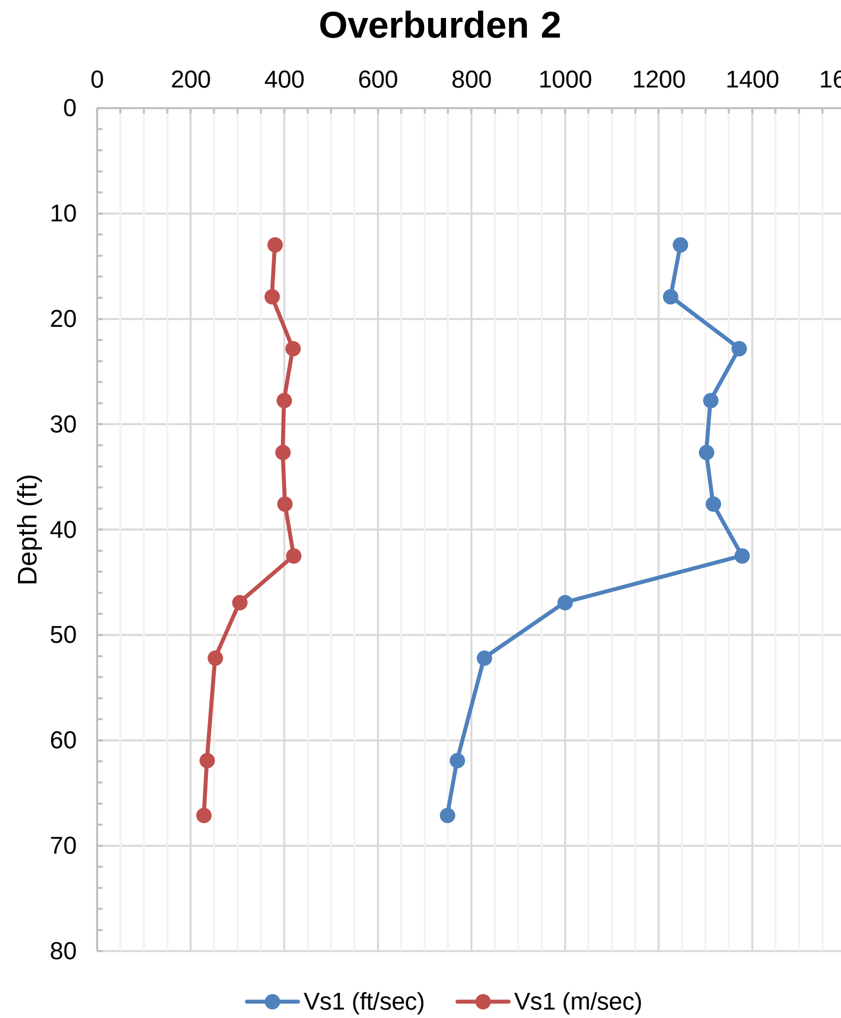
P/A NO. VA101-126/24

REF. NO. 5

FIGURE D.4

REV 0





NOTES:

1. V_{s1} MEASUREMENTS FROM SCPT DATA. OVERBURDEN 1 FROM SCPT19-02 AND OVERBURDEN 2 FROM SCPT19-09.

0	19SEP'24	ISSUED WITH REPORT	MJB2	GRG
REV	DATE	DESCRIPTION	PREP'D	RVW'D

MONTANA RESOURCES, LLC

MONTANA RESOURCES

**OVERBURDEN
STRESS-NORMALIZED SHEAR WAVE VELOCITY PROFILE**

Knight Piésold CONSULTING

P/A NO. VA101-126/24

REF. NO. 5

FIGURE D.5

REV 0

APPENDIX E

Limit Equilibrium Analysis Results

Appendix E1
2D Limit Equilibrium Analysis for Normal Operating Conditions

Appendix E2
2D Limit Equilibrium Analysis for Post-Earthquake Conditions

Appendix E3
2D Limit Equilibrium Sensitivity Analysis for Normal Operating Conditions at Station 0+00

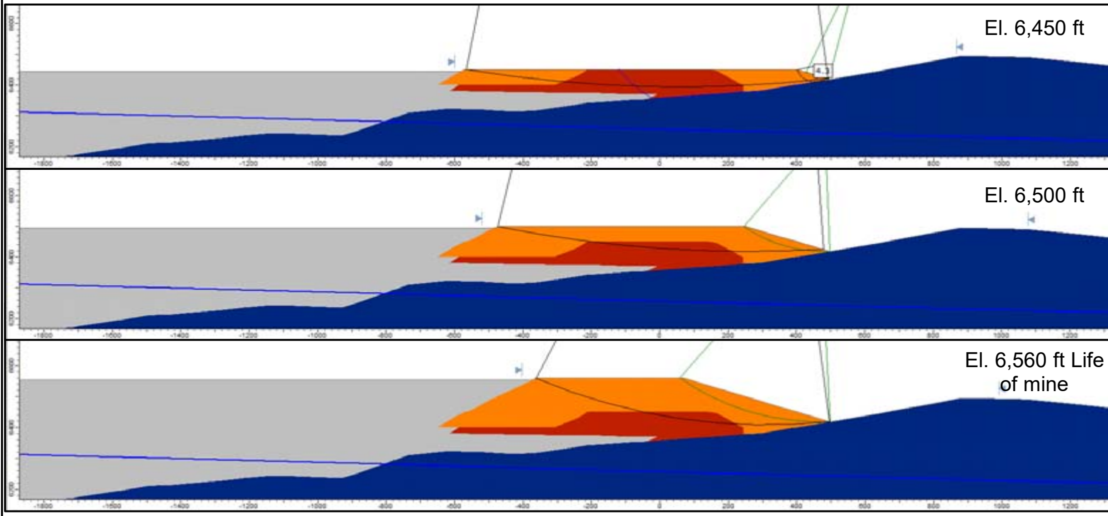
Appendix E4
3D Limit Equilibrium Analysis for Normal Operating Conditions

Appendix E5
3D Limit Equilibrium Analysis for Post-Earthquake Conditions

APPENDIX E1

2D Limit Equilibrium Analysis for Normal Operating Conditions

(Figures E1.1 to E1.10)



El. 6,450 ft

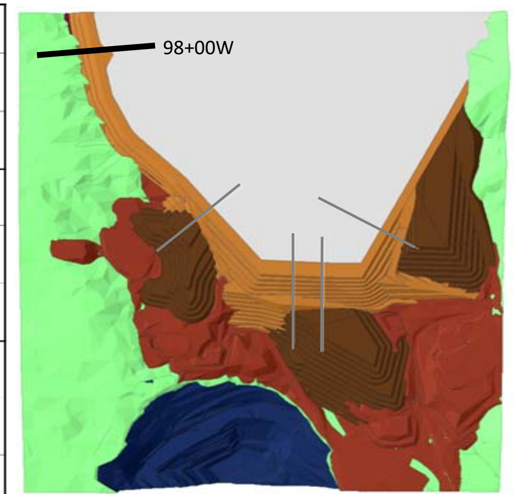
Location	FS
Upstream Crest	>5
Downstream Crest	>3

El. 6,500 ft

Location	FS
Upstream Crest	>5
Downstream Crest	2.8

El. 6,560 ft Life of mine

Location	FS
Upstream Crest	>3
Downstream Crest	2.7



NOTES:
1. SEE INSET FOR LOCATION OF ANALYSIS SECTION.
2. INSET IS PERSPECTIVE VIEW OF PLAN OF El. 6,560 ft GEOMETRY.
3. BLACK SLIPS ARE MINIMUM FACTOR OF SAFETY (FS) THROUGH UPSTREAM OR DOWNSTREAM CRESTS AND DAM TOE, AS TABULATED.
4. GREEN SLIP IS LOWEST FS GENERATED BY SEARCH ALGORITHM OR "GLOBAL MINIMUM".
5. El. 5,900 ft (STAGE 1 RDS) ANALYSIS RESULTS ARE THE SAME AS El. 6,450 ft SINCE GEOMETRY DOES NOT CHANGE.
6. El. 6,500 ft INTERIM ANALYSIS RESULTS ARE THE SAME AS El. 6,500 ft SINCE GEOMETRY DOES NOT CHANGE.

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)	Shear/Normal Function	Vertical Stress Ratio	Water Surface
Bedrock		165	Infinite Strength					Piezometric Line 1
Historical Rockfill		140	Vertical Stress Ratio				0.31	Piezometric Line 1
Historical Rockfill (drained)		140	Shear/Normal Function			Leps Angular Sand		Piezometric Line 1
Overburden		135	Vertical Stress Ratio				0.34	Piezometric Line 1
Tailings Sand (base)		120	Mohr-Coulomb	0	32			Piezometric Line 1
Zone U Rockfill Disposal		140	Shear/Normal Function			Leps Lower Bound		Piezometric Line 1
Zone U Embankment Fill		140	Shear/Normal Function			Leps Lower Bound		Piezometric Line 1

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	18JUL'24	ISSUED WITH REPORT	SRS	SY

MONTANA RESOURCES, LLC

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2D LIMIT EQUILIBRIUM ANALYSIS RESULTS
NORMAL OPERATING
SECTION 98+00W

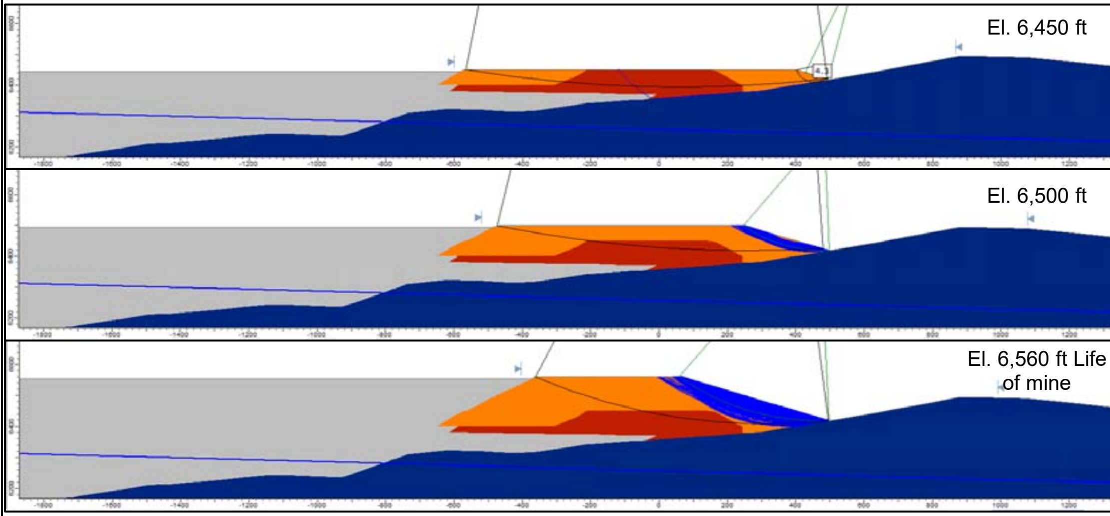
Knight Piésold CONSULTING

P/A NO. VA101-126/24

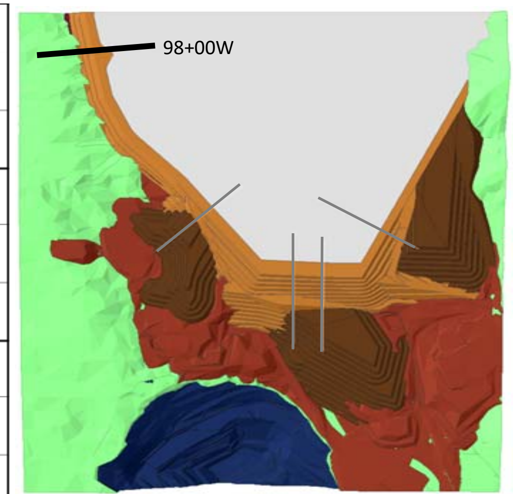
REF. NO. 5

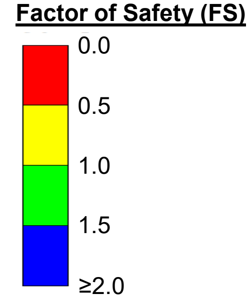
FIGURE E1.1

REV 0



Location	FS
El. 6,450 ft	
Upstream Crest	>5
Downstream Crest	>3
El. 6,500 ft	
Upstream Crest	>5
Downstream Crest	2.8
El. 6,560 ft Life of mine	
Upstream Crest	>3
Downstream Crest	2.7





NOTES:
1. SEE INSET FOR LOCATION OF ANALYSIS SECTION.
2. INSET IS PERSPECTIVE VIEW OF PLAN OF El. 6,560 ft GEOMETRY.
3. COLOR SLIPS SHOWN ON SAFETY MAPS HAVE FS BELOW 3.0.
4. BLACK SLIPS ARE MINIMUM FS THROUGH UPSTREAM OR DOWNSTREAM CRESTS AND DAM TOE, AS TABULATED.
4. GREEN SLIP IS LOWEST FS GENERATED BY SEARCH ALGORITHM OR "GLOBAL MINIMUM".
5. El. 5,900 ft (STAGE 1 RDS) ANALYSIS RESULTS ARE THE SAME AS El. 6,450 ft SINCE GEOMETRY DOES NOT CHANGE.
6. El. 6,500 ft INTERIM ANALYSIS RESULTS ARE THE SAME AS El. 6,500 ft SINCE GEOMETRY DOES NOT CHANGE.

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)	Shear/Normal Function	Vertical Stress Ratio	Water Surface
Bedrock		165	Infinite Strength					Piezometric Line 1
Historical Rockfill		140	Vertical Stress Ratio				0.31	Piezometric Line 1
Historical Rockfill (drained)		140	Shear/Normal Function			Leps Angular Sand		Piezometric Line 1
Overburden		135	Vertical Stress Ratio				0.34	Piezometric Line 1
Tailings Sand (base)		120	Mohr-Coulomb	0	32			Piezometric Line 1
Zone U Rockfill Disposal		140	Shear/Normal Function			Leps Lower Bound		Piezometric Line 1
Zone U Embankment Fill		140	Shear/Normal Function			Leps Lower Bound		Piezometric Line 1

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	18JUL'24	ISSUED WITH REPORT	SRS	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

2D LIMIT EQUILIBRIUM ANALYSIS RESULTS
NORMAL OPERATING
SECTION 98+00W - SAFETY MAP

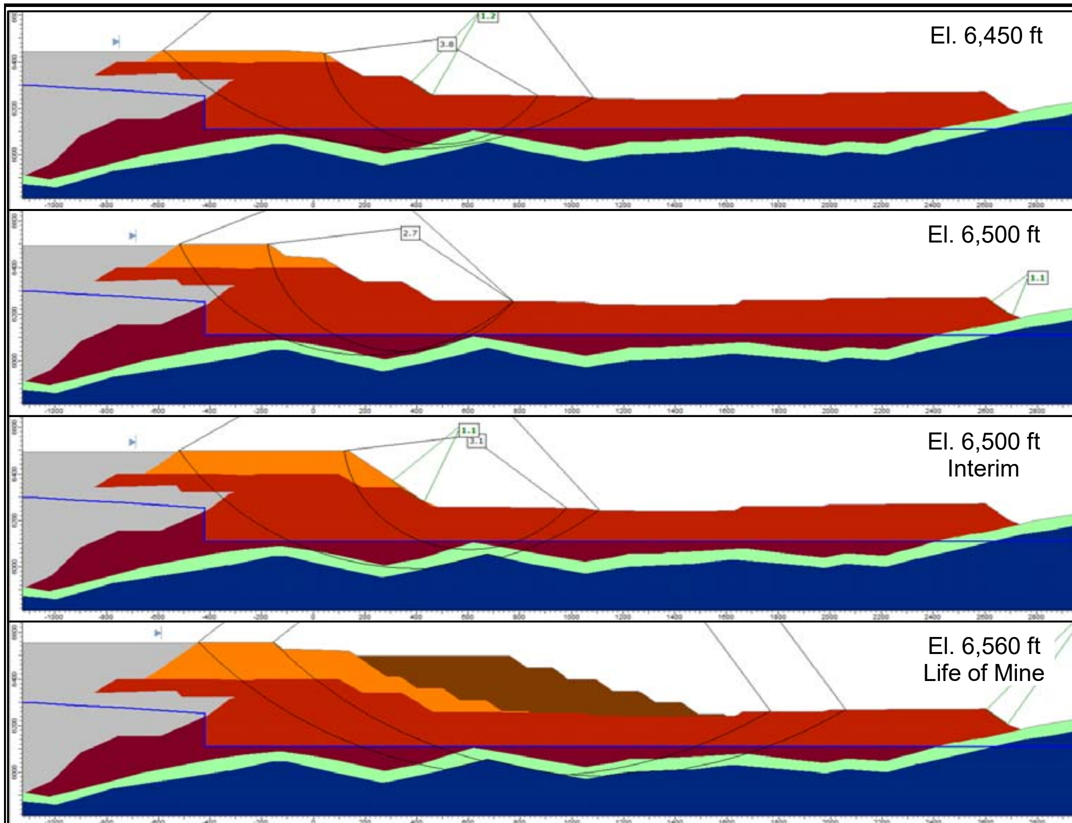
Knight Piésold CONSULTING

P/A NO. VA101-126/24

REF. NO. 5

FIGURE E1.2

REV 0

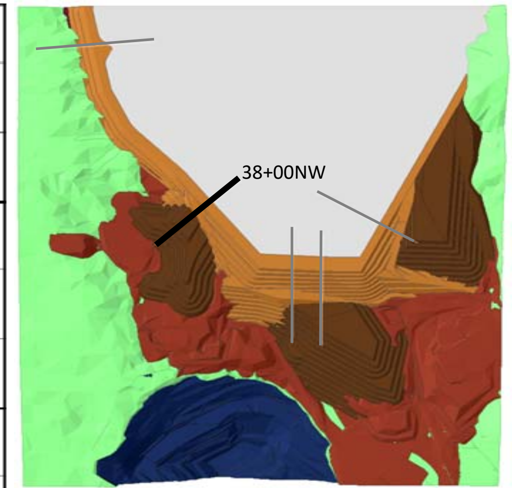


Location	FS
Upstream Crest	>3
Downstream Crest	>3

Location	FS
Upstream Crest	2.5
Downstream Crest	2.7

Location	FS
Upstream Crest	2.4
Downstream Crest	>3

Location	FS
Upstream Crest	>3
Downstream Crest	>3



NOTES:
1. SEE INSET FOR LOCATION OF ANALYSIS SECTION.
2. INSET IS PERSPECTIVE VIEW OF PLAN OF El. 6,560 ft GEOMETRY.
3. BLACK SLIPS ARE MINIMUM FACTOR OF SAFETY (FS) THROUGH UPSTREAM OR DOWNSTREAM CRESTS AND OVERBURDEN, AS TABULATED.
4. GREEN SLIP IS LOWEST FS GENERATED BY SEARCH ALGORITHM OR "GLOBAL MINIMUM".
5. El. 5,900 ft (STAGE 1 RDS) ANALYSIS RESULTS ARE THE SAME AS El. 6,450 ft SINCE GEOMETRY DOES NOT CHANGE.

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)	Shear/Normal Function	Vertical Stress Ratio	Water Surface
Bedrock		165	Infinite Strength					Piezometric Line 1
Historical Rockfill		140	Vertical Stress Ratio				0.31	Piezometric Line 1
Historical Rockfill (drained)		140	Shear/Normal Function			Leps Angular Sand		Piezometric Line 1
Overburden		135	Vertical Stress Ratio				0.34	Piezometric Line 1
Tailings Sand (base)		120	Mohr-Coulomb	0	32			Piezometric Line 1
Zone U Rockfill Disposal		140	Shear/Normal Function			Leps Lower Bound		Piezometric Line 1
Zone U Embankment Fill		140	Shear/Normal Function			Leps Lower Bound		Piezometric Line 1

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	18JUL'24	ISSUED WITH REPORT	SRS	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

2D LIMIT EQUILIBRIUM ANALYSIS RESULTS
NORMAL OPERATING
SECTION 38+00NW

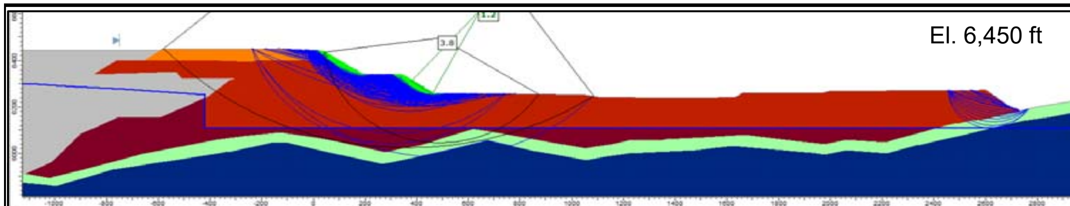
Knight Piésold CONSULTING

P/A NO. VA101-126/24

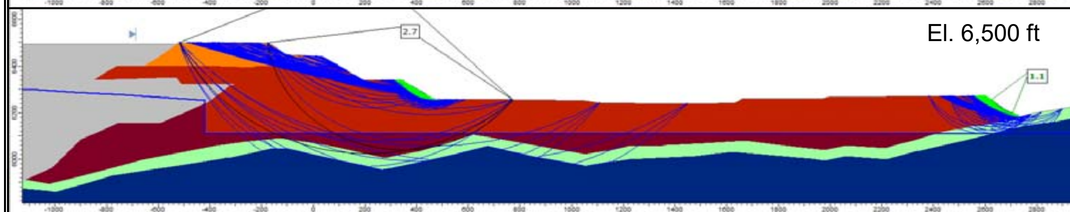
REF. NO. 5

FIGURE E1.3

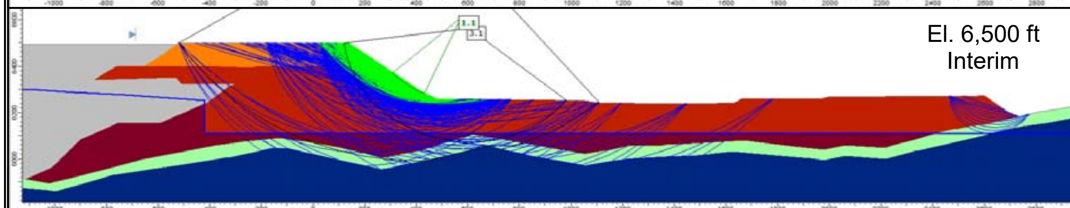
REV 0



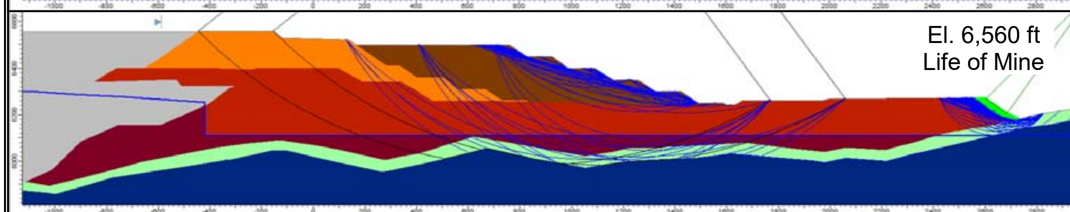
Location	FS
Upstream Crest	>3
Downstream Crest	>3



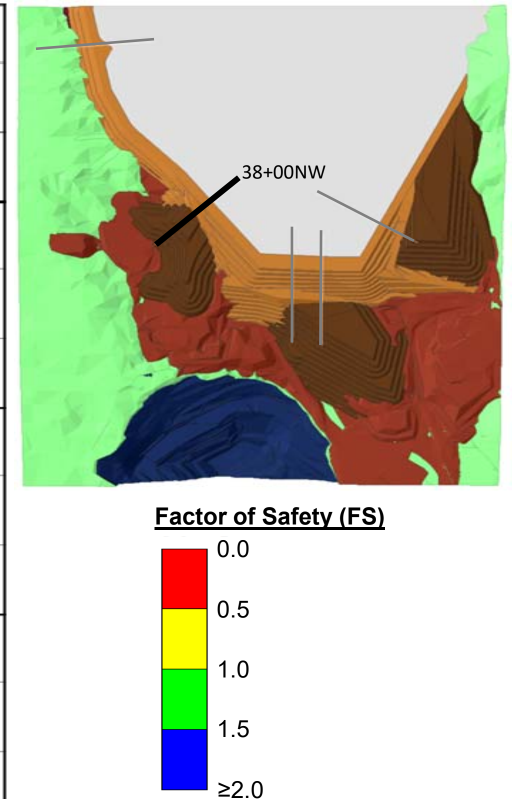
Location	FS
Upstream Crest	2.5
Downstream Crest	2.7



Location	FS
Upstream Crest	2.4
Downstream Crest	>3



Location	FS
Upstream Crest	>3
Downstream Crest	>3



NOTES:
1. SEE INSET FOR LOCATION OF ANALYSIS SECTION.
2. INSET IS PERSPECTIVE VIEW OF PLAN OF El. 6,560 ft GEOMETRY.
3. COLOR SLIPS SHOWN ON SAFETY MAPS HAVE FS BELOW 3.0.
4. BLACK SLIPS ARE MINIMUM FS THROUGH UPSTREAM OR DOWNSTREAM CRESTS AND OVERBURDEN, AS TABULATED.
5. GREEN SLIP IS LOWEST FS GENERATED BY SEARCH ALGORITHM OR "GLOBAL MINIMUM".
6. El. 5,900 ft (STAGE 1 RDS) ANALYSIS RESULTS ARE THE SAME AS El. 6,450 ft SINCE GEOMETRY DOES NOT CHANGE.

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Bedrock		165	Infinite Strength					Piezometric Line 1
Historical Rockfill		140	Vertical Stress Ratio				0.31	Piezometric Line 1
Historical Rockfill (drained)		140	Shear/Normal Function			Leps Angular Sand		Piezometric Line 1
Overburden		135	Vertical Stress Ratio				0.34	Piezometric Line 1
Tailings Sand (base)		120	Mohr-Coulomb	0	32			Piezometric Line 1
Zone U Rockfill Disposal		140	Shear/Normal Function			Leps Lower Bound		Piezometric Line 1
Zone U Embankment Fill		140	Shear/Normal Function			Leps Lower Bound		Piezometric Line 1

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	18JUL'24	ISSUED WITH REPORT	SRS	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

2D LIMIT EQUILIBRIUM ANALYSIS RESULTS
NORMAL OPERATING
SECTION 38+00NW - SAFETY MAP

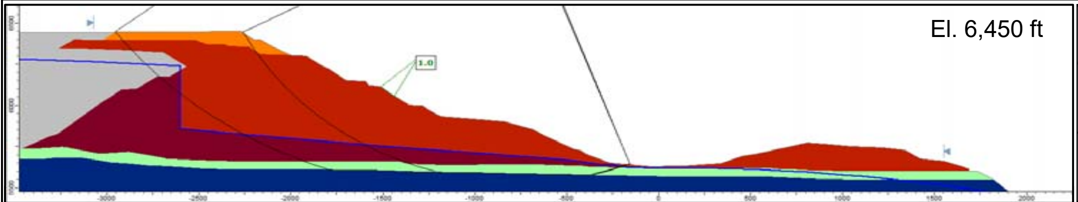
Knight Piésold CONSULTING

P/A NO. VA101-126/24

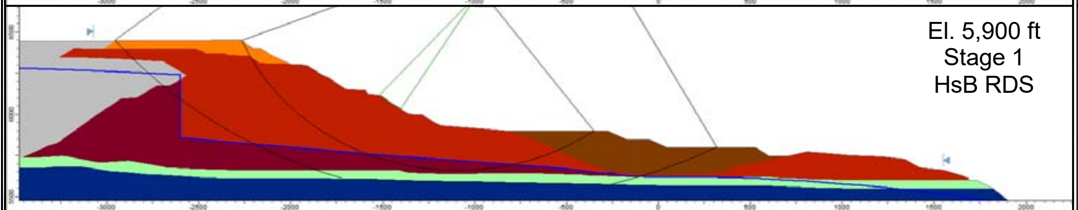
REF. NO. 5

FIGURE E1.4

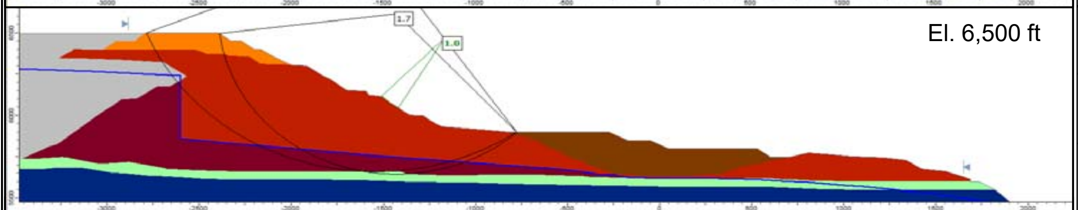
REV 0



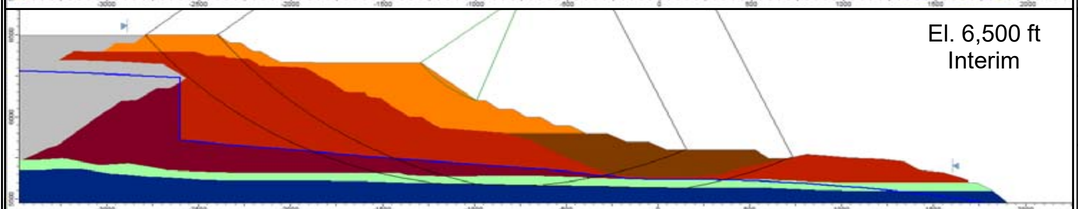
Location	FS
Upstream Crest	1.5
Downstream Crest	1.4



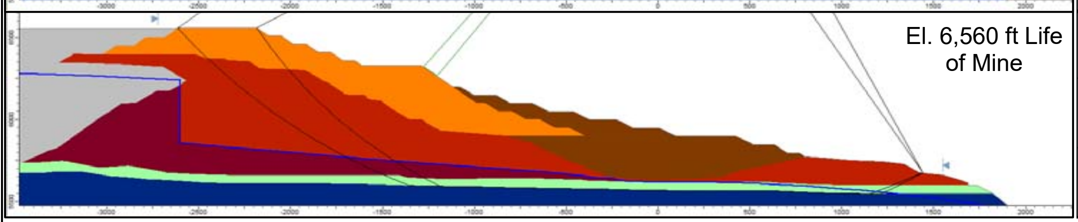
Location	FS
Upstream Crest	1.9
Downstream Crest	2.1



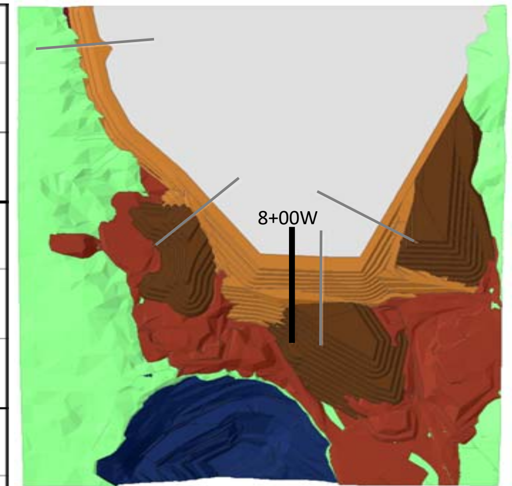
Location	FS
Upstream Crest	1.6
Downstream Crest	1.7



Location	FS
Upstream Crest	2.0
Downstream Crest	1.9



Location	FS
Upstream Crest	2.0
Downstream Crest	2.0



NOTES:
1. SEE INSET FOR LOCATION OF ANALYSIS SECTION.
2. INSET IS PERSPECTIVE VIEW OF PLAN OF El. 6,560 ft GEOMETRY.
3. BLACK SLIPS ARE MINIMUM FACTOR OF SAFETY (FS) THROUGH UPSTREAM OR DOWNSTREAM CRESTS AND OVERBURDEN, AS TABULATED.
4. GREEN SLIP IS LOWEST FS GENERATED BY SEARCH ALGORITHM OR "GLOBAL MINIMUM".

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)	Shear/Normal Function	Vertical Stress Ratio	Water Surface
Bedrock		165	Infinite Strength					Piezometric Line 1
Historical Rockfill		140	Vertical Stress Ratio				0.31	Piezometric Line 1
Historical Rockfill (drained)		140	Shear/Normal Function			Leps Angular Sand		Piezometric Line 1
Overburden		135	Vertical Stress Ratio				0.34	Piezometric Line 1
Tailings Sand (base)		120	Mohr-Coulomb	0	32			Piezometric Line 1
Zone U Rockfill Disposal		140	Shear/Normal Function			Leps Lower Bound		Piezometric Line 1
Zone U Embankment Fill		140	Shear/Normal Function			Leps Lower Bound		Piezometric Line 1

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	18JUL'24	ISSUED WITH REPORT	SRS	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

2D LIMIT EQUILIBRIUM ANALYSIS RESULTS
NORMAL OPERATING
SECTION 8+00W

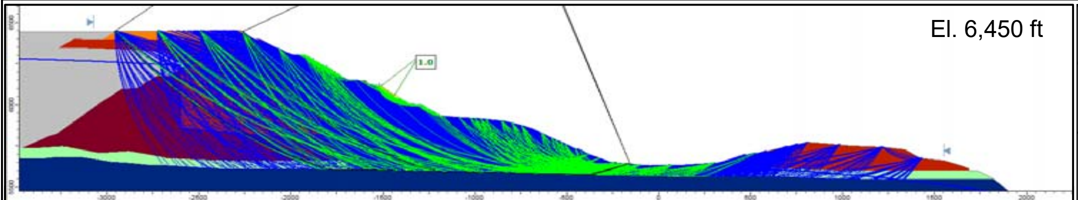
Knight Piésold CONSULTING

P/A NO. VA101-126/24

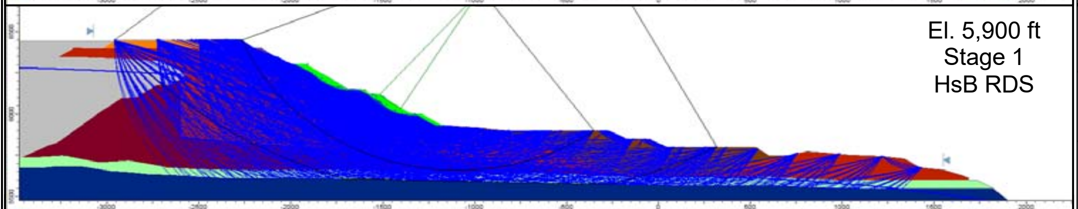
REF. NO. 5

FIGURE E1.5

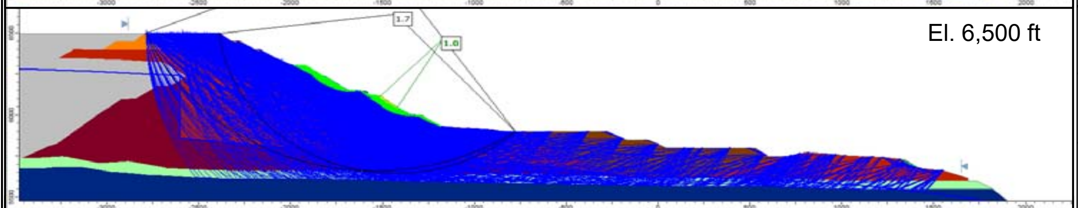
REV 0



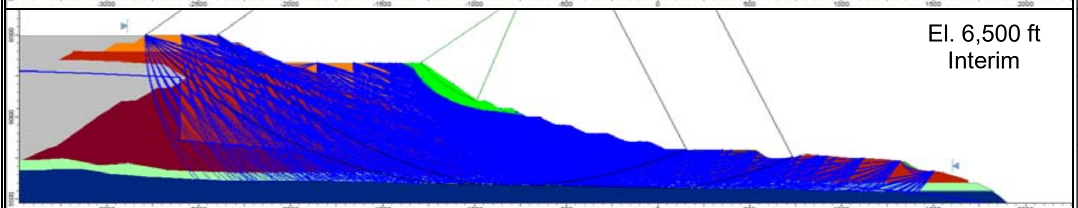
Location	FS
Upstream Crest	1.5
Downstream Crest	1.4



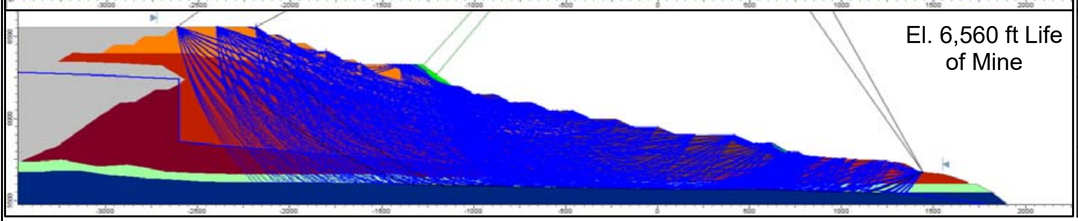
Location	FS
Upstream Crest	1.9
Downstream Crest	2.1



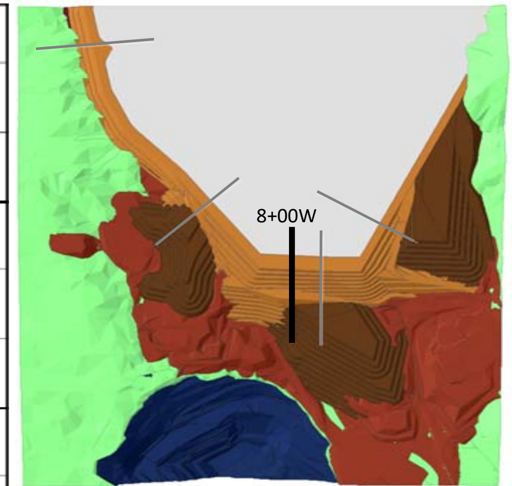
Location	FS
Upstream Crest	1.6
Downstream Crest	1.7



Location	FS
Upstream Crest	2.0
Downstream Crest	1.9



Location	FS
Upstream Crest	2.0
Downstream Crest	2.0



Factor of Safety (FS)

- 0.0
- 0.5
- 1.0
- 1.5
- ≥2.0

NOTES:
1. SEE INSET FOR LOCATION OF ANALYSIS SECTION.
2. INSET IS PERSPECTIVE VIEW OF PLAN OF EI. 6,560 ft GEOMETRY.
3. COLOR SLIPS SHOWN ON SAFETY MAPS HAVE FS BELOW 3.0.
4. BLACK SLIPS ARE MINIMUM FS THROUGH UPSTREAM OR DOWNSTREAM CRESTS AND OVERBURDEN, AS TABULATED.
5. GREEN SLIP IS LOWEST FS GENERATED BY SEARCH ALGORITHM OR "GLOBAL MINIMUM".

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)	Shear/Normal Function	Vertical Stress Ratio	Water Surface
Bedrock		165	Infinite Strength					Piezometric Line 1
Historical Rockfill		140	Vertical Stress Ratio				0.31	Piezometric Line 1
Historical Rockfill (drained)		140	Shear/Normal Function			Leps Angular Sand		Piezometric Line 1
Overburden		135	Vertical Stress Ratio				0.34	Piezometric Line 1
Tailings Sand (base)		120	Mohr-Coulomb	0	32			Piezometric Line 1
Zone U Rockfill Disposal		140	Shear/Normal Function			Leps Lower Bound		Piezometric Line 1
Zone U Embankment Fill		140	Shear/Normal Function			Leps Lower Bound		Piezometric Line 1

MONTANA RESOURCES, LLC

MONTANA RESOURCES

2D LIMIT EQUILIBRIUM ANALYSIS RESULTS
NORMAL OPERATING
SECTION 8+00W - SAFETY MAP

0	18JUL'24	ISSUED WITH REPORT	SRS	SY
REV	DATE	DESCRIPTION	PREP'D	RVW'D

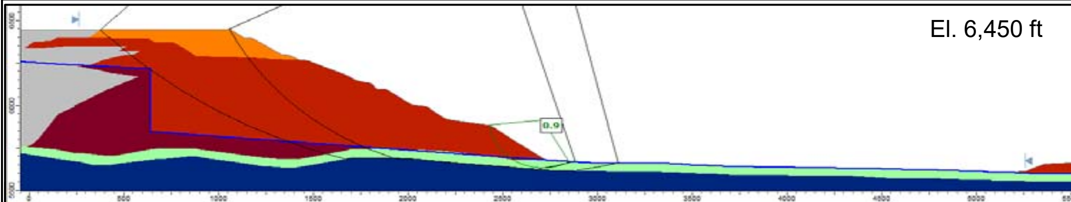
Knight Piésold CONSULTING

P/A NO. VA101-126/24

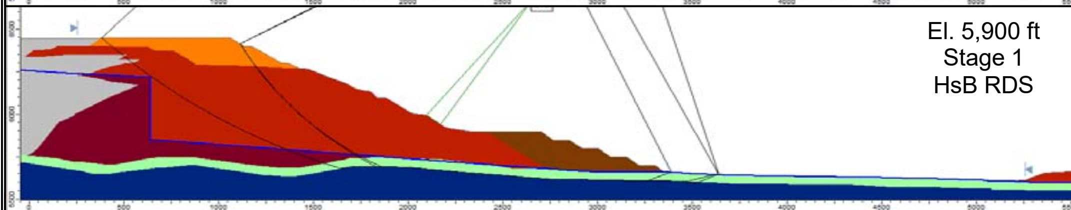
REF. NO. 5

FIGURE E1.6

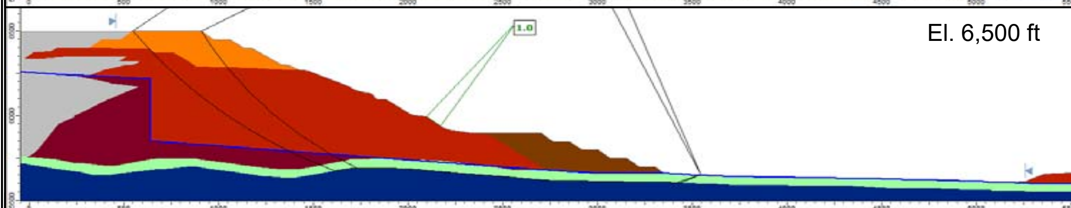
REV 0



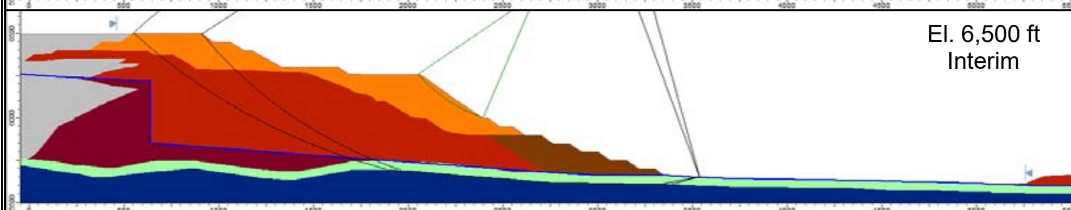
Location	FS
Upstream Crest	1.5
Downstream Crest	1.2



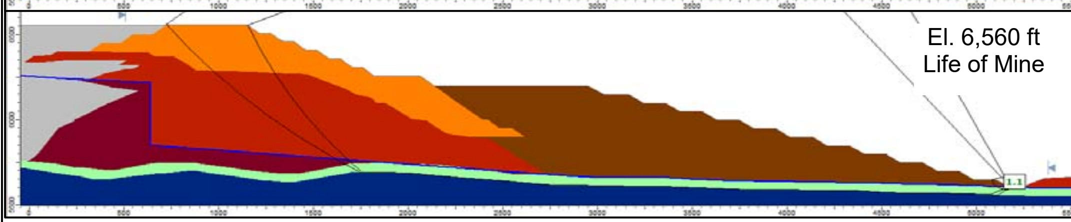
Location	FS
Upstream Crest	1.6
Downstream Crest	1.5



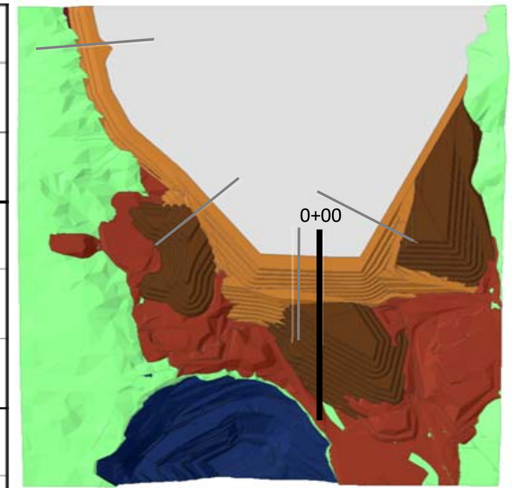
Location	FS
Upstream Crest	1.5
Downstream Crest	1.4



Location	FS
Upstream Crest	1.6
Downstream Crest	1.5



Location	FS
Upstream Crest	2.1
Downstream Crest	2.2



NOTES:
1. SEE INSET FOR LOCATION OF ANALYSIS SECTION.
2. INSET IS PERSPECTIVE VIEW OF PLAN OF El. 6,560 ft GEOMETRY.
3. BLACK SLIPS ARE MINIMUM FACTOR OF SAFETY (FS) THROUGH UPSTREAM OR DOWNSTREAM CRESTS AND OVERBURDEN, AS TABULATED.
4. GREEN SLIP IS LOWEST FS GENERATED BY SEARCH ALGORITHM OR "GLOBAL MINIMUM".

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)	Shear/Normal Function	Vertical Stress Ratio	Water Surface
Bedrock		165	Infinite Strength					Piezometric Line 1
Historical Rockfill		140	Vertical Stress Ratio				0.31	Piezometric Line 1
Historical Rockfill (drained)		140	Shear/Normal Function			Leps Angular Sand		Piezometric Line 1
Overburden		135	Vertical Stress Ratio				0.34	Piezometric Line 1
Tailings Sand (base)		120	Mohr-Coulomb	0	32			Piezometric Line 1
Zone U Rockfill Disposal		140	Shear/Normal Function			Leps Lower Bound		Piezometric Line 1
Zone U Embankment Fill		140	Shear/Normal Function			Leps Lower Bound		Piezometric Line 1

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	18JUL'24	ISSUED WITH REPORT	SRS	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

2D LIMIT EQUILIBRIUM ANALYSIS RESULTS
NORMAL OPERATING
SECTION 0+00

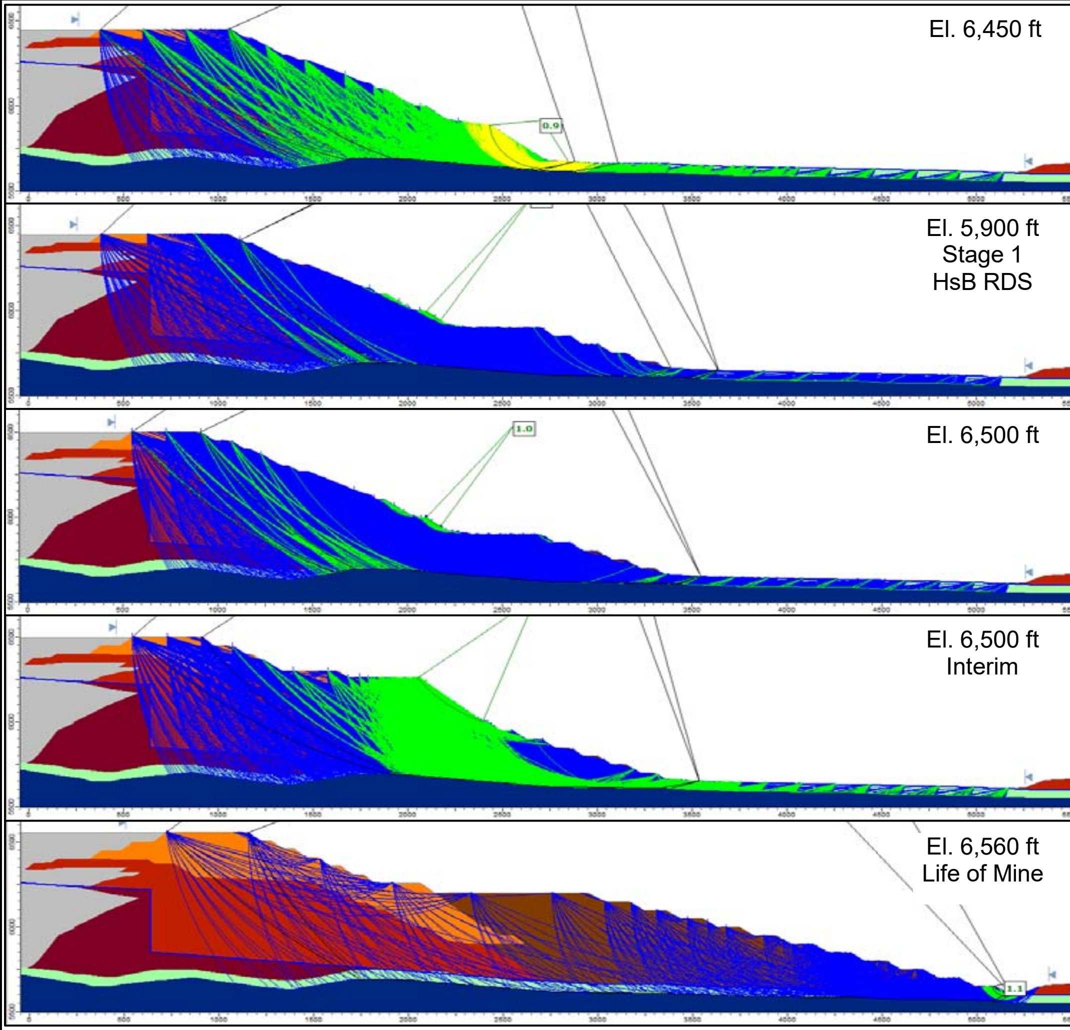
Knight Piésold CONSULTING

P/A NO. VA101-126/24

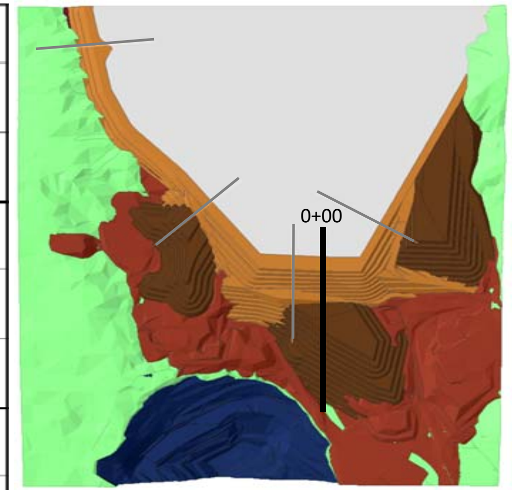
REF. NO. 5

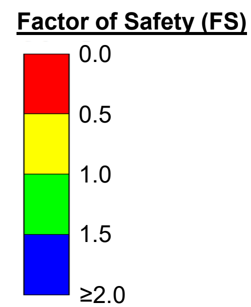
FIGURE E1.7

REV 0



Location	FS
El. 6,450 ft	
Upstream Crest	1.5
Downstream Crest	1.2
El. 5,900 ft Stage 1 HsB RDS	
Upstream Crest	1.6
Downstream Crest	1.5
El. 6,500 ft	
Upstream Crest	1.5
Downstream Crest	1.4
El. 6,500 ft Interim	
Upstream Crest	1.6
Downstream Crest	1.5
El. 6,560 ft Life of Mine	
Upstream Crest	2.1
Downstream Crest	2.2





NOTES:
1. SEE INSET FOR LOCATION OF ANALYSIS SECTION.
2. INSET IS PERSPECTIVE VIEW OF PLAN OF El. 6,560 ft GEOMETRY.
3. COLOR SLIPS SHOWN ON SAFETY MAPS HAVE FS BELOW 3.0.
4. BLACK SLIPS ARE MINIMUM FS THROUGH UPSTREAM OR DOWNSTREAM CRESTS AND OVERBURDEN, AS TABULATED.
5. GREEN SLIP IS LOWEST FS GENERATED BY SEARCH ALGORITHM OR "GLOBAL MINIMUM".

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)	Shear/Normal Function	Vertical Stress Ratio	Water Surface
Bedrock		165	Infinite Strength					Piezometric Line 1
Historical Rockfill		140	Vertical Stress Ratio				0.31	Piezometric Line 1
Historical Rockfill (drained)		140	Shear/Normal Function			Leps Angular Sand		Piezometric Line 1
Overburden		135	Vertical Stress Ratio				0.34	Piezometric Line 1
Tailings Sand (base)		120	Mohr-Coulomb	0	32			Piezometric Line 1
Zone U Rockfill Disposal		140	Shear/Normal Function			Leps Lower Bound		Piezometric Line 1
Zone U Embankment Fill		140	Shear/Normal Function			Leps Lower Bound		Piezometric Line 1

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	18JUL'24	ISSUED WITH REPORT	SRS	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

2D LIMIT EQUILIBRIUM ANALYSIS RESULTS
NORMAL OPERATING
SECTION 0+00 - SAFETY MAP

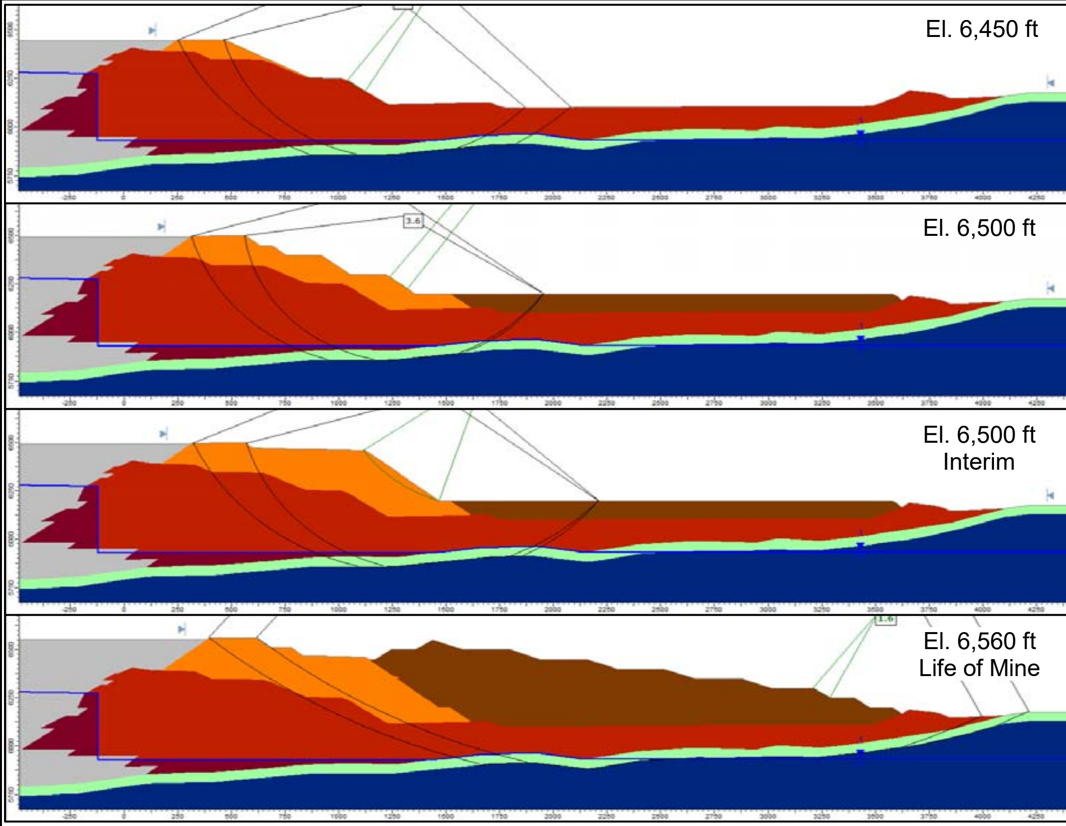
Knight Piésold CONSULTING

P/A NO. VA101-126/24

REF. NO. 5

FIGURE E1.8

REV 0

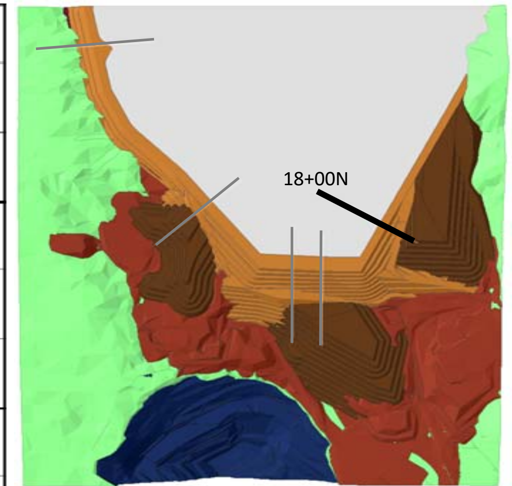


Location	FS
Upstream Crest	2.3
Downstream Crest	2.6

Location	FS
Upstream Crest	>3
Downstream Crest	>3

Location	FS
Upstream Crest	>3
Downstream Crest	>3

Location	FS
Upstream Crest	>3
Downstream Crest	>3



NOTES:
1. SEE INSET FOR LOCATION OF ANALYSIS SECTION.
2. INSET IS PERSPECTIVE VIEW OF PLAN OF El. 6,560 ft GEOMETRY.
3. BLACK SLIPS ARE MINIMUM FACTOR OF SAFETY (FS) THROUGH UPSTREAM OR DOWNSTREAM CRESTS AND OVERBURDEN, AS TABULATED.
4. GREEN SLIP IS LOWEST FS GENERATED BY SEARCH ALGORITHM OR "GLOBAL MINIMUM".
5. El. 5,900 ft (STAGE 1 RDS) ANALYSIS RESULTS ARE THE SAME AS El. 6,450 ft SINCE GEOMETRY DOES NOT CHANGE.

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)	Shear/Normal Function	Vertical Stress Ratio	Water Surface
Bedrock		165	Infinite Strength					Piezometric Line 1
Historical Rockfill		140	Vertical Stress Ratio				0.31	Piezometric Line 1
Historical Rockfill (drained)		140	Shear/Normal Function			Leps Angular Sand		Piezometric Line 1
Overburden		135	Vertical Stress Ratio				0.34	Piezometric Line 1
Tailings Sand (base)		120	Mohr-Coulomb	0	32			Piezometric Line 1
Zone U Rockfill Disposal		140	Shear/Normal Function			Leps Lower Bound		Piezometric Line 1
Zone U Embankment Fill		140	Shear/Normal Function			Leps Lower Bound		Piezometric Line 1

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	18JUL'24	ISSUED WITH REPORT	SRS	SY

MONTANA RESOURCES, LLC

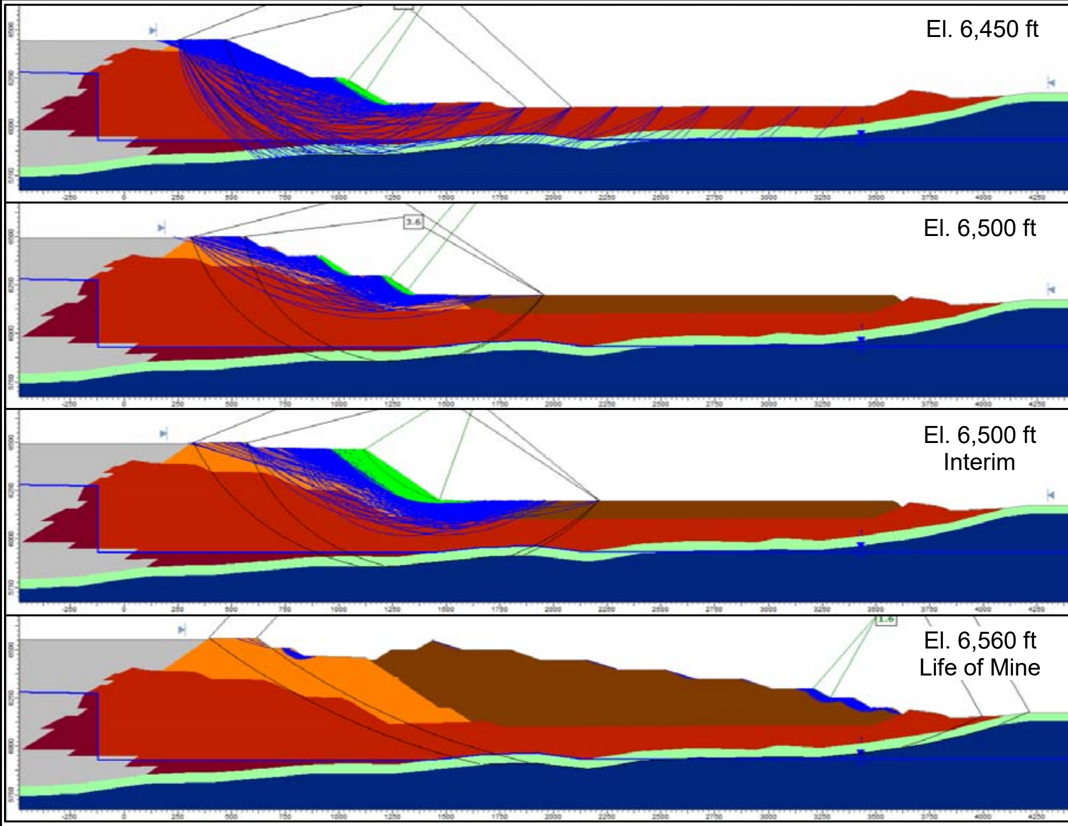
MONTANA RESOURCES

2D LIMIT EQUILIBRIUM ANALYSIS RESULTS
NORMAL OPERATING
SECTION 18+00N

Knight Piésold CONSULTING

P/A NO. VA101-126/24 REF. NO. 5

FIGURE E1.9 REV 0

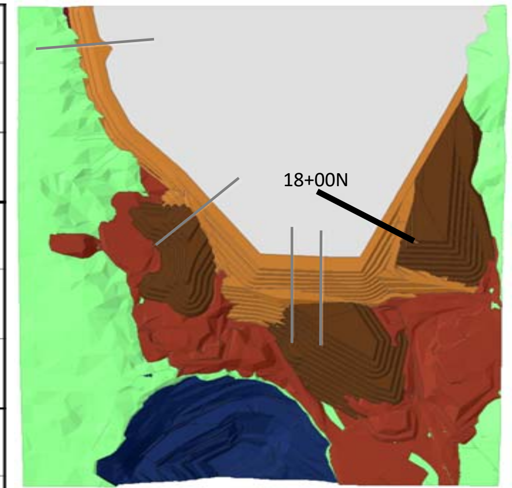


Location	FS
Upstream Crest	2.3
Downstream Crest	2.6

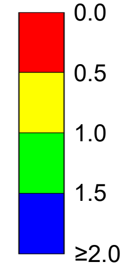
Location	FS
Upstream Crest	>3
Downstream Crest	>3

Location	FS
Upstream Crest	>3
Downstream Crest	3.0

Location	FS
Upstream Crest	>3
Downstream Crest	>3



Factor of Safety (FS)



NOTES:
1. SEE INSET FOR LOCATION OF ANALYSIS SECTION.
2. INSET IS PERSPECTIVE VIEW OF PLAN OF El. 6,560 ft GEOMETRY.
3. COLOR SLIPS SHOWN ON SAFETY MAPS HAVE FS BELOW 3.0.
4. BLACK SLIPS ARE MINIMUM FS THROUGH UPSTREAM OR DOWNSTREAM CRESTS AND OVERURDEN, AS TABULATED.
5. GREEN SLIP IS LOWEST FS GENERATED BY SEARCH ALGORITHM OR "GLOBAL MINIMUM".
6. El. 5,900 ft (STAGE 1 RDS) ANALYSIS RESULTS ARE THE SAME AS El. 6,450 ft SINCE GEOMETRY DOES NOT CHANGE.

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)	Shear/Normal Function	Vertical Stress Ratio	Water Surface
Bedrock		165	Infinite Strength					Piezometric Line 1
Historical Rockfill		140	Vertical Stress Ratio				0.31	Piezometric Line 1
Historical Rockfill (drained)		140	Shear/Normal Function			Leps Angular Sand		Piezometric Line 1
Overburden		135	Vertical Stress Ratio				0.34	Piezometric Line 1
Tailings Sand (base)		120	Mohr-Coulomb	0	32			Piezometric Line 1
Zone U Rockfill Disposal		140	Shear/Normal Function			Leps Lower Bound		Piezometric Line 1
Zone U Embankment Fill		140	Shear/Normal Function			Leps Lower Bound		Piezometric Line 1

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	18JUL'24	ISSUED WITH REPORT	SRS	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

2D LIMIT EQUILIBRIUM ANALYSIS RESULTS
NORMAL OPERATING
SECTION 18+00N - SAFETY MAP

Knight Piésold CONSULTING

P/A NO. VA101-126/24

REF. NO. 5

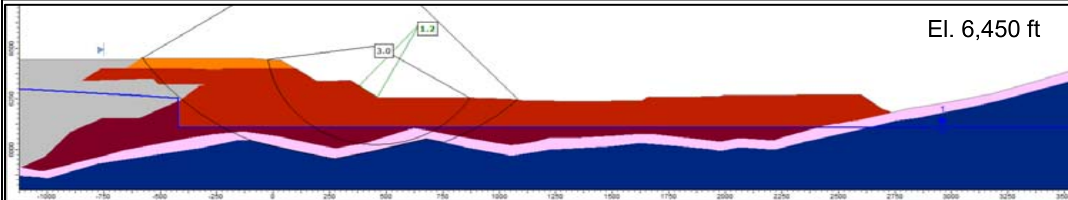
FIGURE E1.10

REV 0

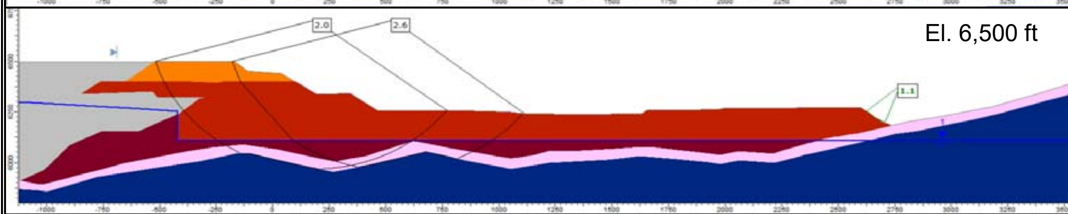
APPENDIX E2

2D Limit Equilibrium Analysis for Post-Earthquake Conditions

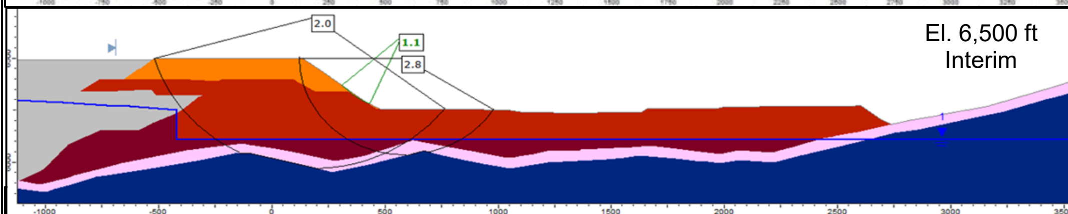
(Figures E2.1 to E2.8)



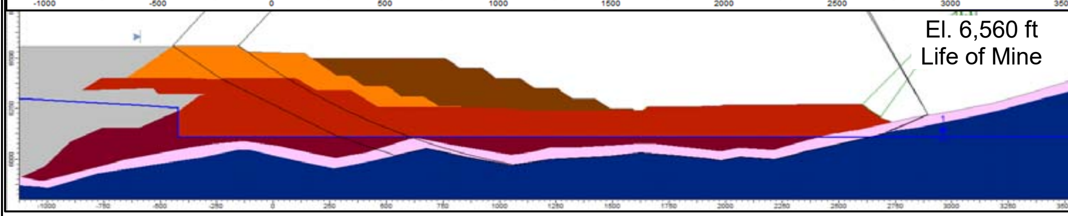
Location	FS
Upstream Crest	2.3
Downstream Crest	3.0



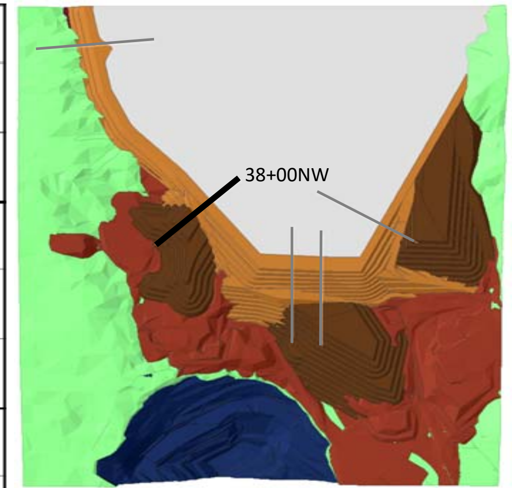
Location	FS
Upstream Crest	2.0
Downstream Crest	2.6



Location	FS
Upstream Crest	2.0
Downstream Crest	2.8



Location	FS
Upstream Crest	2.7
Downstream Crest	2.5



NOTES:
1. SEE INSET FOR LOCATION OF ANALYSIS SECTION.
2. INSET IS PERSPECTIVE VIEW OF PLAN OF El. 6,560 ft GEOMETRY.
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Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Shear/Normal Function	Vertical Stress Ratio	Water Surface
Bedrock		165	Infinite Strength			Piezometric Line 1
Historical Rockfill		140	Vertical Stress Ratio		0.31	Piezometric Line 1
Historical Rockfill (drained)		140	Shear/Normal Function	Leps Angular Sand		Piezometric Line 1
Zone U Rockfill Disposal		140	Shear/Normal Function	Leps Lower Bound		Piezometric Line 1
Zone U Embankment Fill		140	Shear/Normal Function	Leps Lower Bound		Piezometric Line 1
Overburden (PQ)		135	Vertical Stress Ratio		0.22	Piezometric Line 1
Tailings (post-Earthquake)		120	Vertical Stress Ratio		0.05	Piezometric Line 1

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	18SEP'24	ISSUED WITH REPORT	SRS	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

2D LIMIT EQUILIBRIUM ANALYSIS RESULTS POST-EARTHQUAKE SECTION 38+00NW

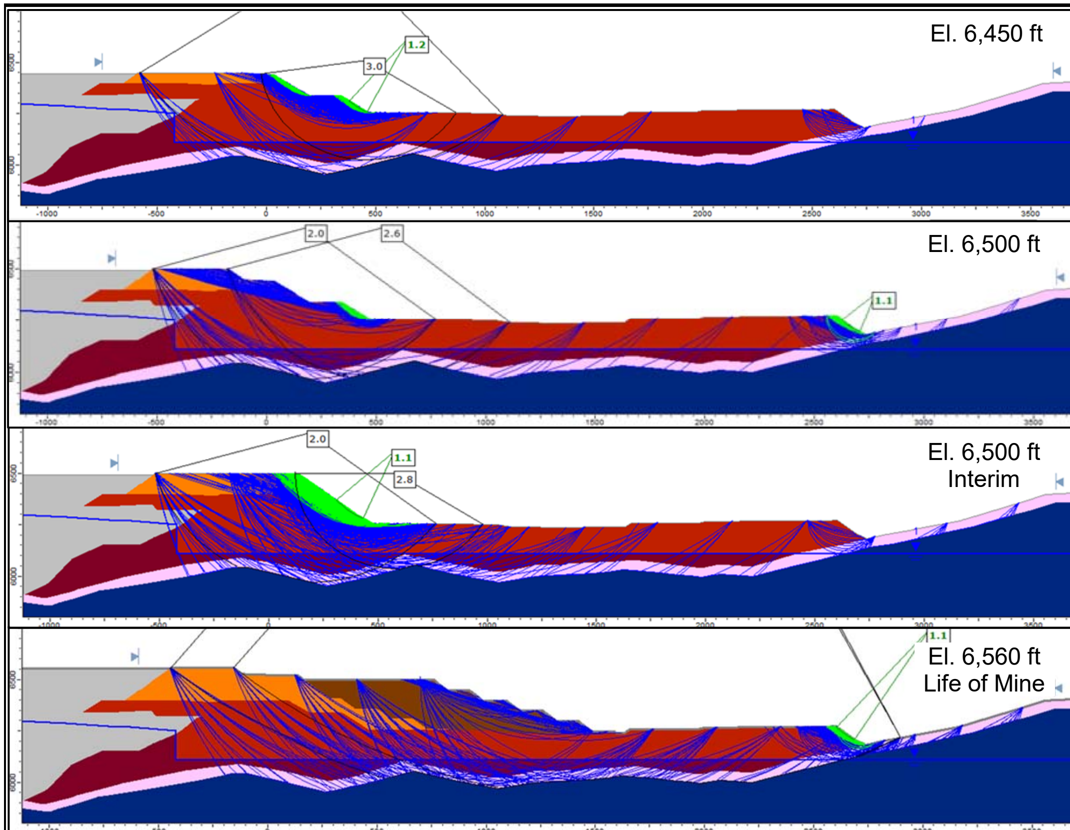
Knight Piésold CONSULTING

P/A NO. VA101-126/24

REF. NO. 5

FIGURE E2.1

REV 0

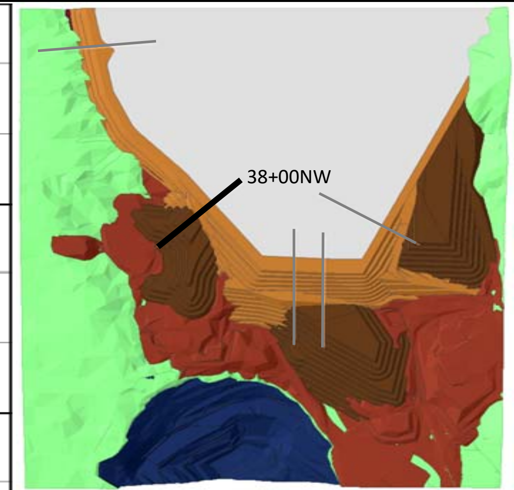


Location	FS
Upstream Crest	2.3
Downstream Crest	3.0

Location	FS
Upstream Crest	2.0
Downstream Crest	2.6

Location	FS
Upstream Crest	2.0
Downstream Crest	2.8

Location	FS
Upstream Crest	2.7
Downstream Crest	2.5



Factor of Safety (FS)

- 0.0
- 0.5
- 1.0
- 1.5
- ≥2.0

NOTES:

1. SEE INSET FOR LOCATION OF ANALYSIS SECTION.
2. INSET IS PERSPECTIVE VIEW OF PLAN OF El. 6,560 ft GEOMETRY.
3. COLOR SLIPS SHOWN ON SAFETY MAPS HAVE FS BELOW 3.0.
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6. El. 5,900 ft (STAGE 1 RDS) ANALYSIS RESULTS ARE THE SAME AS El. 6,450 ft SINCE GEOMETRY DOES NOT CHANGE.

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Shear/Normal Function	Vertical Stress Ratio	Water Surface
Bedrock		165	Infinite Strength			Piezometric Line 1
Historical Rockfill		140	Vertical Stress Ratio		0.31	Piezometric Line 1
Historical Rockfill (drained)		140	Shear/Normal Function	Leps Angular Sand		Piezometric Line 1
Zone U Rockfill Disposal		140	Shear/Normal Function	Leps Lower Bound		Piezometric Line 1
Zone U Embankment Fill		140	Shear/Normal Function	Leps Lower Bound		Piezometric Line 1
Overburden (PQ)		135	Vertical Stress Ratio		0.22	Piezometric Line 1
Tailings (post-Earthquake)		120	Vertical Stress Ratio		0.05	Piezometric Line 1

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	18SEP'24	ISSUED WITH REPORT	SRS	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

2D LIMIT EQUILIBRIUM ANALYSIS RESULTS POST-EARTHQUAKE SECTION 38+00NW - SAFETY MAP

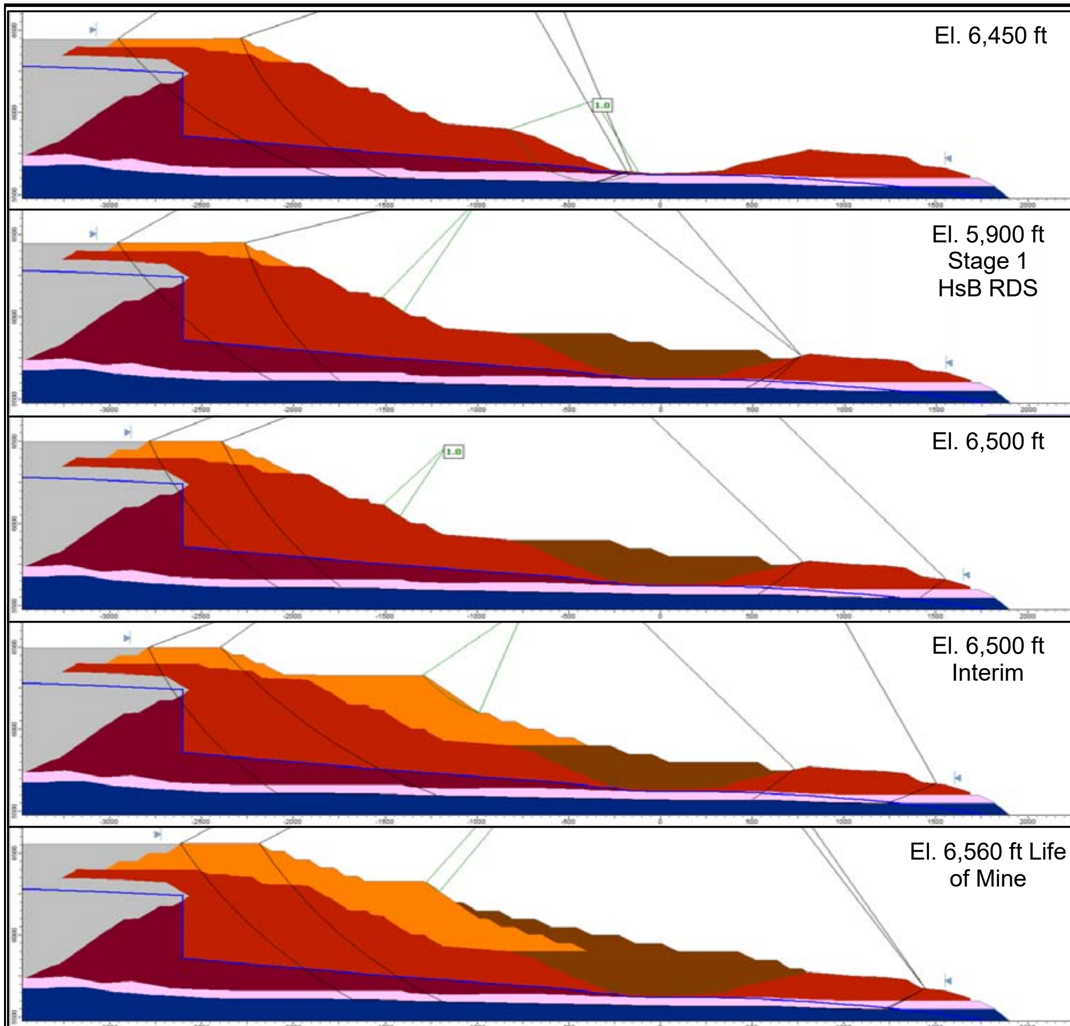
Knight Piésold CONSULTING

P/A NO. VA101-126/24

REF. NO. 5

FIGURE E2.2

REV 0



El. 6,450 ft

Location	FS
Upstream Crest	1.1
Downstream Crest	1.1

El. 5,900 ft Stage 1 HsB RDS

Location	FS
Upstream Crest	1.4
Downstream Crest	1.6

El. 6,500 ft

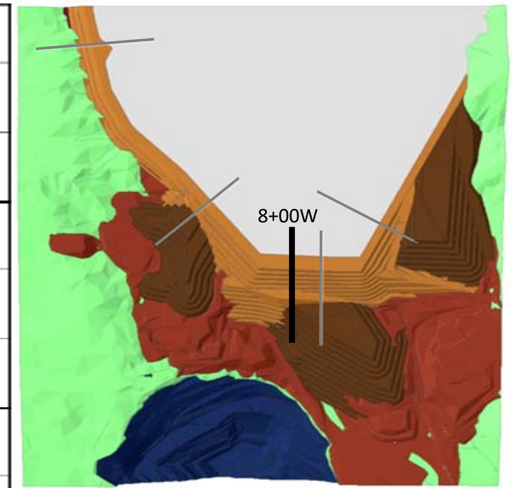
Location	FS
Upstream Crest	1.4
Downstream Crest	1.5

El. 6,500 ft Interim

Location	FS
Upstream Crest	1.6
Downstream Crest	1.6

El. 6,560 ft Life of Mine

Location	FS
Upstream Crest	1.5
Downstream Crest	1.6



NOTES:

1. SEE INSET FOR LOCATION OF ANALYSIS SECTION.
2. INSET IS PERSPECTIVE VIEW OF PLAN OF El. 6,560 ft GEOMETRY.
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4. GREEN SLIP IS LOWEST FS GENERATED BY SEARCH ALGORITHM OR "GLOBAL MINIMUM".

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Shear/Normal Function	Vertical Stress Ratio	Water Surface
Bedrock		165	Infinite Strength			Piezometric Line 1
Historical Rockfill		140	Vertical Stress Ratio		0.31	Piezometric Line 1
Historical Rockfill (drained)		140	Shear/Normal Function	Leps Angular Sand		Piezometric Line 1
Zone U Rockfill Disposal		140	Shear/Normal Function	Leps Lower Bound		Piezometric Line 1
Zone U Embankment Fill		140	Shear/Normal Function	Leps Lower Bound		Piezometric Line 1
Overburden (PQ)		135	Vertical Stress Ratio		0.22	Piezometric Line 1
Tailings (post-Earthquake)		120	Vertical Stress Ratio		0.05	Piezometric Line 1

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	18SEP'24	ISSUED WITH REPORT	SRS	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

2D LIMIT EQUILIBRIUM ANALYSIS RESULTS
POST-EARTHQUAKE
SECTION 8+00W

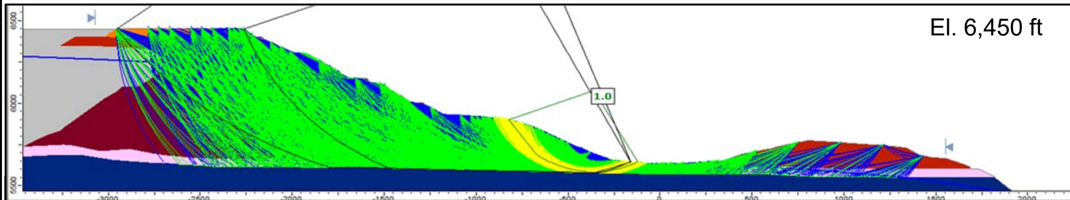
Knight Piésold CONSULTING

P/A NO. VA101-126/24

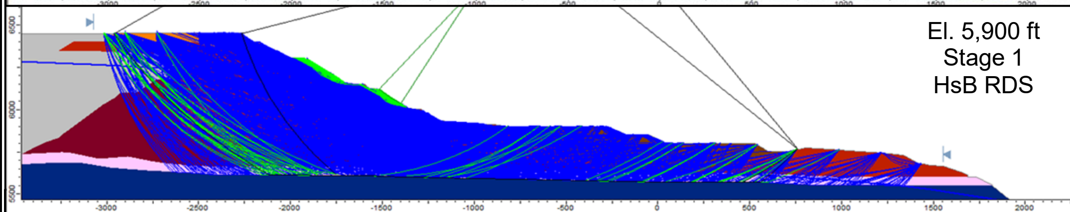
REF. NO. 5

FIGURE E2.3

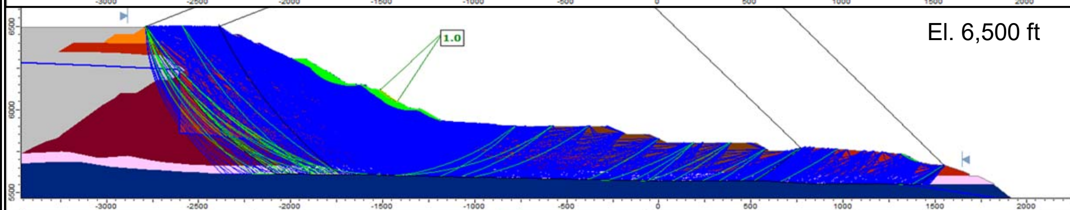
REV 0



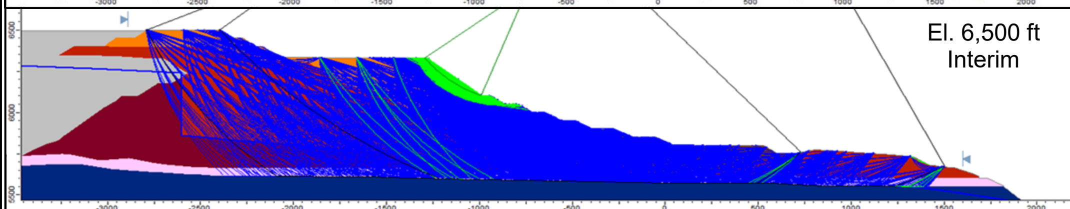
Location	FS
Upstream Crest	1.1
Downstream Crest	1.1



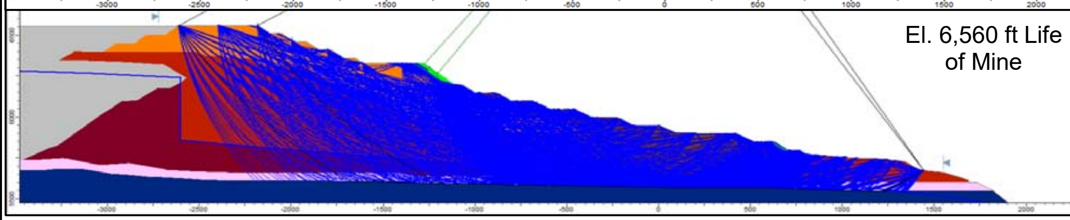
Location	FS
Upstream Crest	1.4
Downstream Crest	1.6



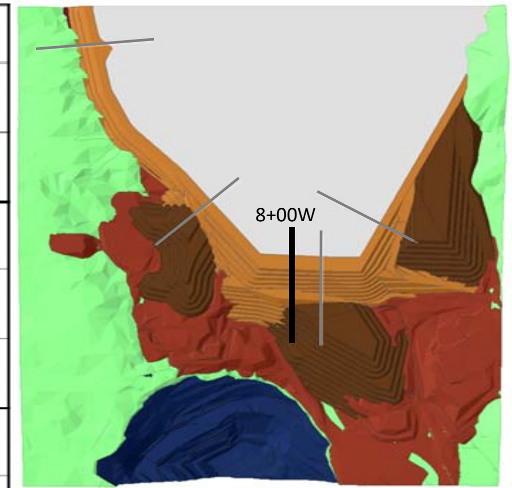
Location	FS
Upstream Crest	1.4
Downstream Crest	1.5



Location	FS
Upstream Crest	1.6
Downstream Crest	1.6



Location	FS
Upstream Crest	1.5
Downstream Crest	1.6



Factor of Safety (FS)

0.0
0.5
1.0
1.5
≥2.0

NOTES:
1. SEE INSET FOR LOCATION OF ANALYSIS SECTION.
2. INSET IS PERSPECTIVE VIEW OF PLAN OF El. 6,560 ft GEOMETRY.
3. COLOR SLIPS SHOWN ON SAFETY MAPS HAVE FS BELOW 3.0.
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5. GREEN SLIP IS LOWEST FS GENERATED BY SEARCH ALGORITHM OR "GLOBAL MINIMUM".

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Shear/Normal Function	Vertical Stress Ratio	Water Surface
Bedrock		165	Infinite Strength			Piezometric Line 1
Historical Rockfill		140	Vertical Stress Ratio		0.31	Piezometric Line 1
Historical Rockfill (drained)		140	Shear/Normal Function	Leps Angular Sand		Piezometric Line 1
Zone U Rockfill Disposal		140	Shear/Normal Function	Leps Lower Bound		Piezometric Line 1
Zone U Embankment Fill		140	Shear/Normal Function	Leps Lower Bound		Piezometric Line 1
Overburden (PQ)		135	Vertical Stress Ratio		0.22	Piezometric Line 1
Tailings (post-Earthquake)		120	Vertical Stress Ratio		0.05	Piezometric Line 1

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	18SEP'24	ISSUED WITH REPORT	SRS	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

2D LIMIT EQUILIBRIUM ANALYSIS RESULTS POST-EARTHQUAKE SECTION 8+00W - SAFETY MAP

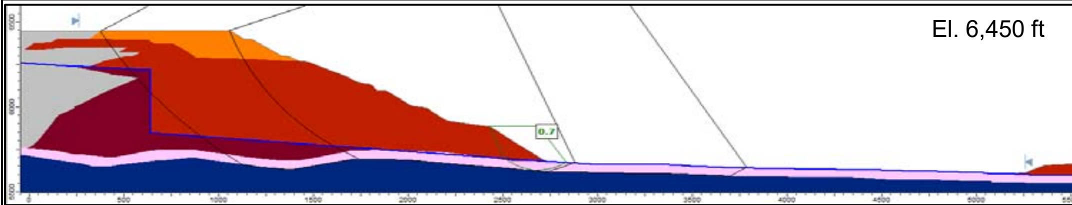
Knight Piésold CONSULTING

P/A NO. VA101-126/24

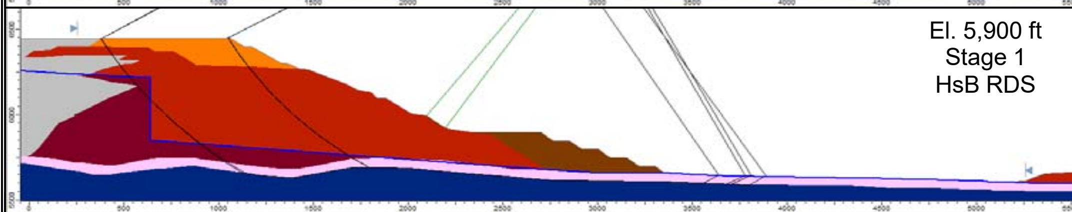
REF. NO. 5

FIGURE E2.4

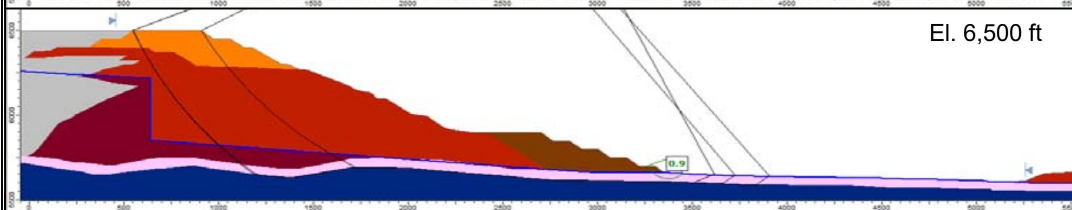
REV 0



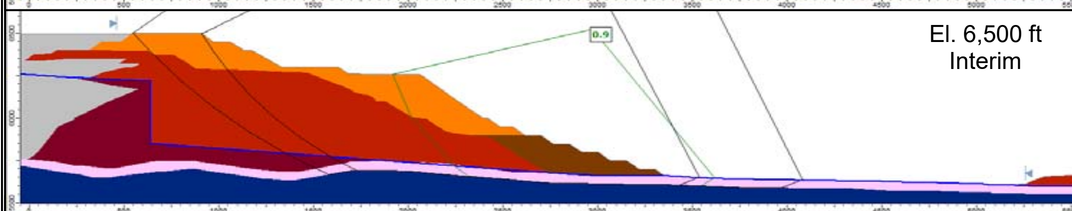
Location	FS
Upstream Crest	1.2
Downstream Crest	1.0



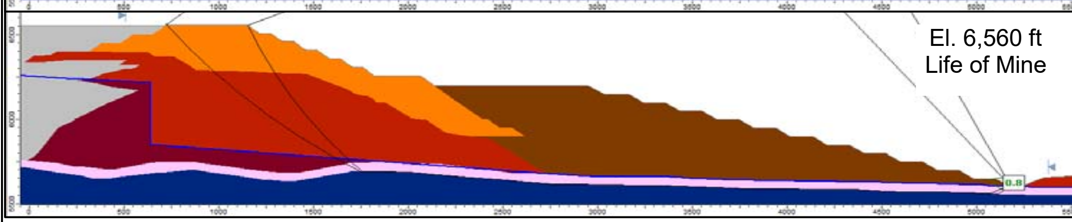
Location	FS
Upstream Crest	1.3
Downstream Crest	1.1



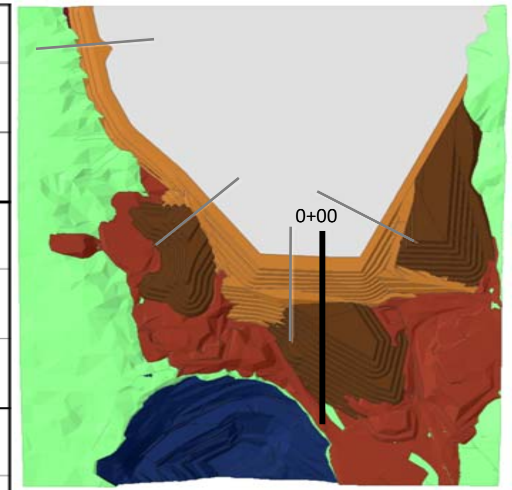
Location	FS
Upstream Crest	1.2
Downstream Crest	1.1



Location	FS
Upstream Crest	1.3
Downstream Crest	1.2



Location	FS
Upstream Crest	1.6
Downstream Crest	1.6



NOTES:
1. SEE INSET FOR LOCATION OF ANALYSIS SECTION.
2. INSET IS PERSPECTIVE VIEW OF PLAN OF El. 6,560 ft GEOMETRY.
3. BLACK SLIPS ARE MINIMUM FACTOR OF SAFETY (FS) THROUGH UPSTREAM OR DOWNSTREAM CRESTS AND OVERBURDEN, AS TABULATED.
4. GREEN SLIP IS LOWEST FS GENERATED BY SEARCH ALGORITHM OR "GLOBAL MINIMUM".

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Shear/Normal Function	Vertical Stress Ratio	Water Surface
Bedrock		165	Infinite Strength			Piezometric Line 1
Historical Rockfill		140	Vertical Stress Ratio		0.31	Piezometric Line 1
Historical Rockfill (drained)		140	Shear/Normal Function	Leps Angular Sand		Piezometric Line 1
Zone U Rockfill Disposal		140	Shear/Normal Function	Leps Lower Bound		Piezometric Line 1
Zone U Embankment Fill		140	Shear/Normal Function	Leps Lower Bound		Piezometric Line 1
Overburden (PQ)		135	Vertical Stress Ratio		0.22	Piezometric Line 1
Tailings (post-Earthquake)		120	Vertical Stress Ratio		0.05	Piezometric Line 1

0	18SEP'24	ISSUED WITH REPORT	SRS	SY
REV	DATE	DESCRIPTION	PREP'D	RVW'D

MONTANA RESOURCES, LLC

MONTANA RESOURCES

2D LIMIT EQUILIBRIUM ANALYSIS RESULTS
POST-EARTHQUAKE
SECTION 0+00

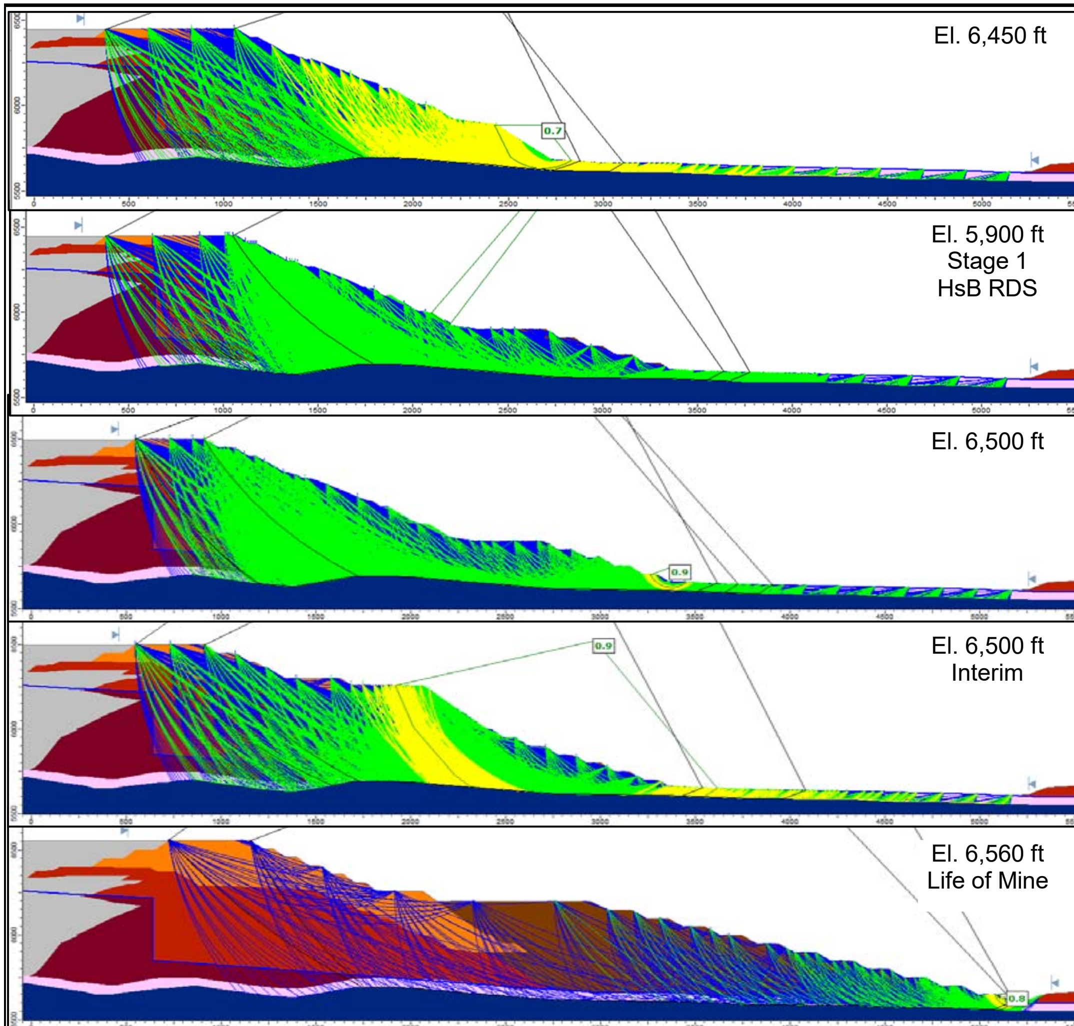
Knight Piésold CONSULTING

P/A NO. VA101-126/24

REF. NO. 5

FIGURE E2.5

REV 0



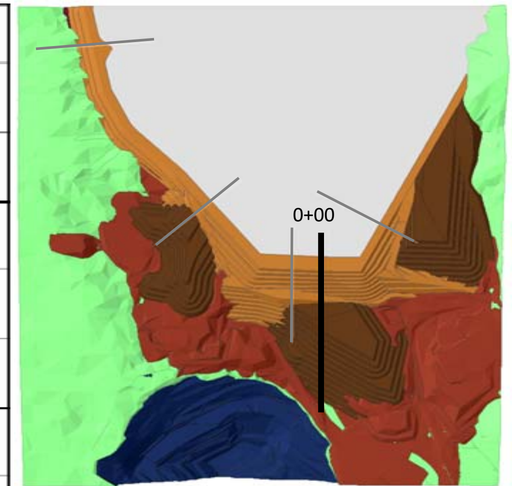
Location	FS
Upstream Crest	1.2
Downstream Crest	1.0

Location	FS
Upstream Crest	1.3
Downstream Crest	1.1

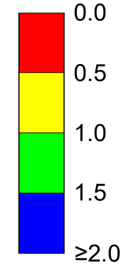
Location	FS
Upstream Crest	1.2
Downstream Crest	1.1

Location	FS
Upstream Crest	1.3
Downstream Crest	1.2

Location	FS
Upstream Crest	1.6
Downstream Crest	1.6



Factor of Safety (FS)



NOTES:
1. SEE INSET FOR LOCATION OF ANALYSIS SECTION.
2. INSET IS PERSPECTIVE VIEW OF PLAN OF El. 6,560 ft GEOMETRY.
3. COLOR SLIPS SHOWN ON SAFETY MAPS HAVE FS BELOW 3.0.
4. BLACK SLIPS ARE MINIMUM FS THROUGH UPSTREAM OR DOWNSTREAM CRESTS AND OVERBURDEN, AS TABULATED.
5. GREEN SLIP IS LOWEST FS GENERATED BY SEARCH ALGORITHM OR "GLOBAL MINIMUM".

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Shear/Normal Function	Vertical Stress Ratio	Water Surface
Bedrock		165	Infinite Strength			Piezometric Line 1
Historical Rockfill		140	Vertical Stress Ratio		0.31	Piezometric Line 1
Historical Rockfill (drained)		140	Shear/Normal Function	Leps Angular Sand		Piezometric Line 1
Zone U Rockfill Disposal		140	Shear/Normal Function	Leps Lower Bound		Piezometric Line 1
Zone U Embankment Fill		140	Shear/Normal Function	Leps Lower Bound		Piezometric Line 1
Overburden (PQ)		135	Vertical Stress Ratio		0.22	Piezometric Line 1
Tailings (post-Earthquake)		120	Vertical Stress Ratio		0.05	Piezometric Line 1

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	18SEP'24	ISSUED WITH REPORT	SRS	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

2D LIMIT EQUILIBRIUM ANALYSIS RESULTS POST-EARTHQUAKE SECTION 0+00 - SAFETY MAP

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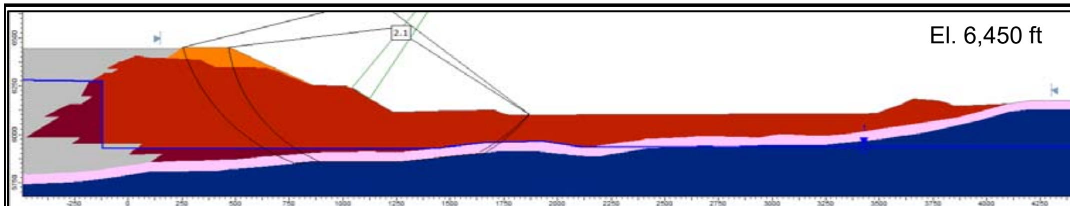
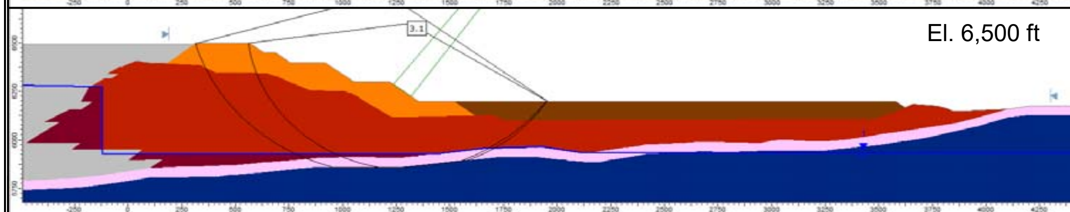
REF. NO. 5

FIGURE E2.6

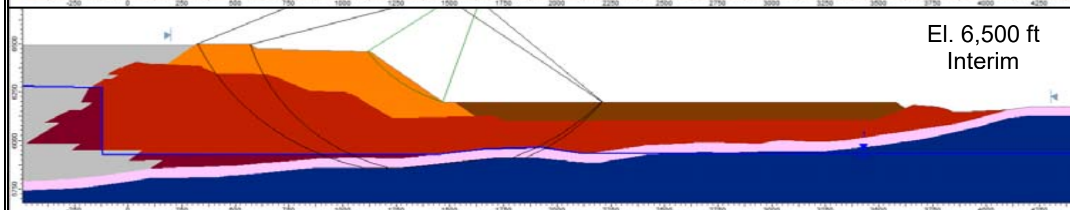
REV 0



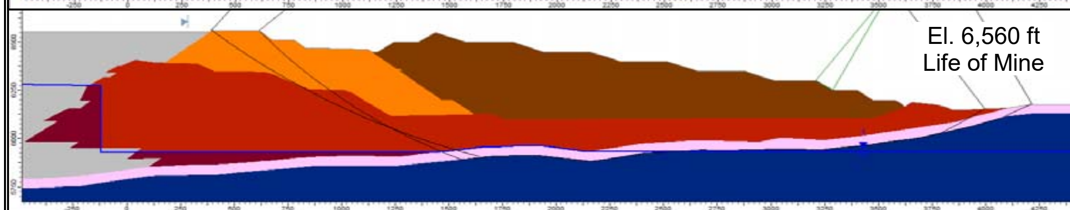
Location	FS
Upstream Crest	1.9
Downstream Crest	2.1



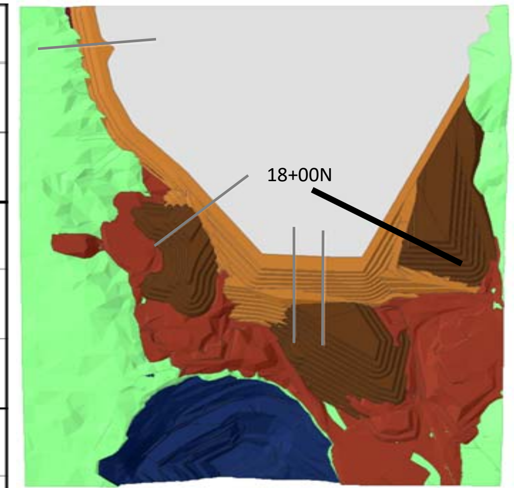
Location	FS
Upstream Crest	2.6
Downstream Crest	>3



Location	FS
Upstream Crest	2.6
Downstream Crest	2.6



Location	FS
Upstream Crest	>3
Downstream Crest	>3



NOTES:
1. SEE INSET FOR LOCATION OF ANALYSIS SECTION.
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3. BLACK SLIPS ARE MINIMUM FACTOR OF SAFETY (FS) THROUGH UPSTREAM OR DOWNSTREAM CRESTS AND OVERBURDEN, AS TABULATED.
4. GREEN SLIP IS LOWEST FS GENERATED BY SEARCH ALGORITHM OR "GLOBAL MINIMUM".
5. El. 5,900 ft (STAGE 1 RDS) ANALYSIS RESULTS ARE THE SAME AS El. 6,450 ft SINCE GEOMETRY DOES NOT CHANGE.

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Shear/Normal Function	Vertical Stress Ratio	Water Surface
Bedrock		165	Infinite Strength			Piezometric Line 1
Historical Rockfill		140	Vertical Stress Ratio		0.31	Piezometric Line 1
Historical Rockfill (drained)		140	Shear/Normal Function	Leps Angular Sand		Piezometric Line 1
Zone U Rockfill Disposal		140	Shear/Normal Function	Leps Lower Bound		Piezometric Line 1
Zone U Embankment Fill		140	Shear/Normal Function	Leps Lower Bound		Piezometric Line 1
Overburden (PQ)		135	Vertical Stress Ratio		0.22	Piezometric Line 1
Tailings (post-Earthquake)		120	Vertical Stress Ratio		0.05	Piezometric Line 1

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	18SEP'24	ISSUED WITH REPORT	SRS	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

2D LIMIT EQUILIBRIUM ANALYSIS RESULTS POST-EARTHQUAKE SECTION 18+00N

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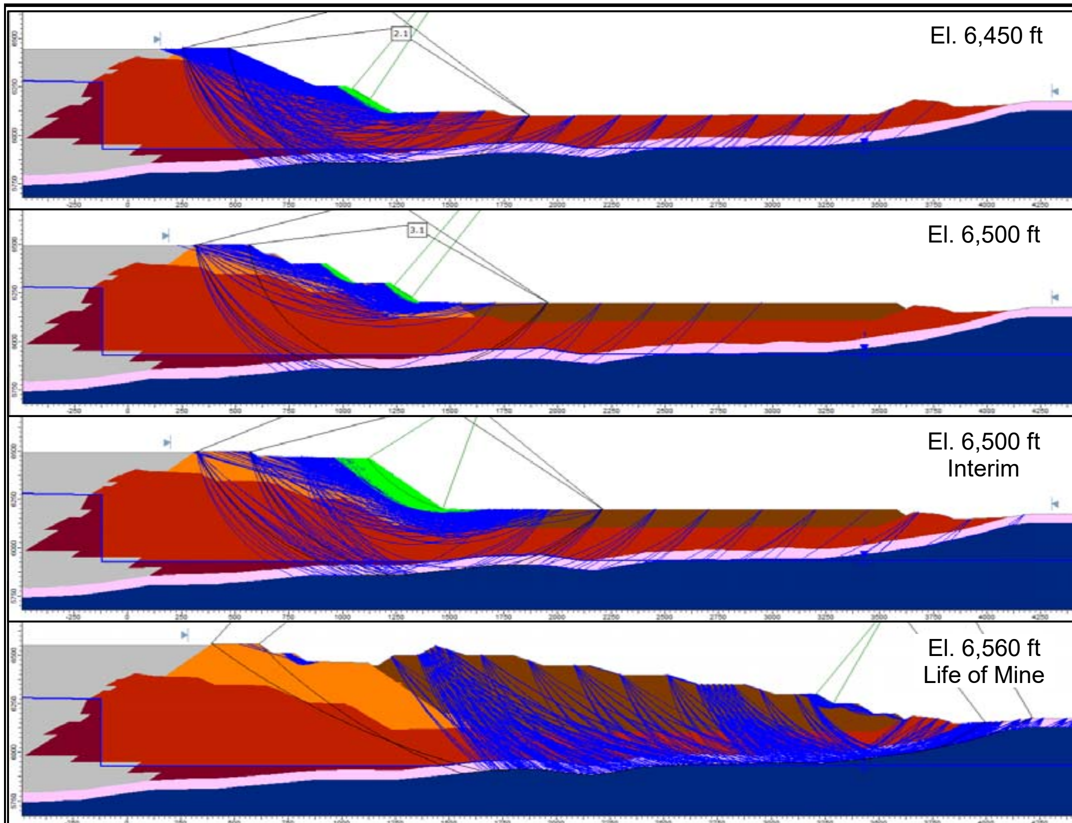
P/A NO. VA101-126/24

REF. NO. 5

FIGURE E2.7

REV 0

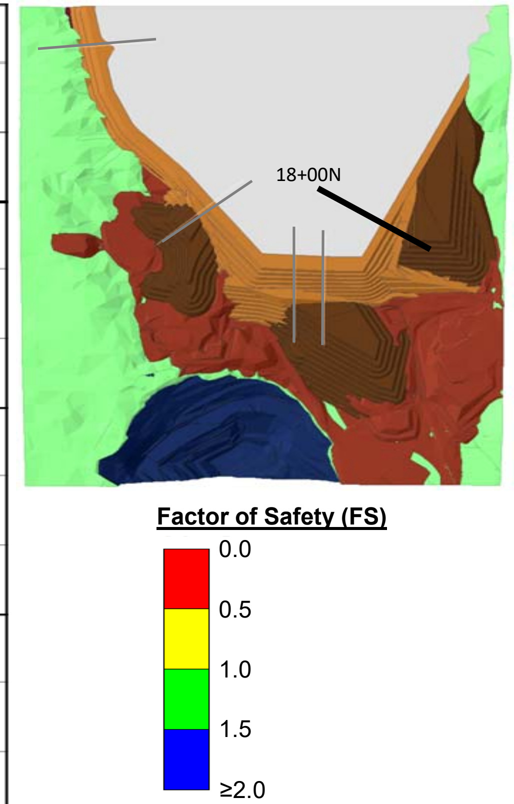


Location	FS
Upstream Crest	1.9
Downstream Crest	2.1

Location	FS
Upstream Crest	2.6
Downstream Crest	>3

Location	FS
Upstream Crest	2.6
Downstream Crest	2.6

Location	FS
Upstream Crest	>3
Downstream Crest	>3



NOTES:
1. SEE INSET FOR LOCATION OF ANALYSIS SECTION.
2. INSET IS PERSPECTIVE VIEW OF PLAN OF El. 6,560 ft GEOMETRY.
3. COLOR SLIPS SHOWN ON SAFETY MAPS HAVE FS BELOW 3.0.
4. BLACK SLIPS ARE MINIMUM FS THROUGH UPSTREAM OR DOWNSTREAM CRESTS AND OVERBURDEN, AS TABULATED.
5. GREEN SLIP IS LOWEST FS GENERATED BY SEARCH ALGORITHM OR "GLOBAL MINIMUM".
6. El. 5,900 ft (STAGE 1 RDS) ANALYSIS RESULTS ARE THE SAME AS El. 6,450 ft SINCE GEOMETRY DOES NOT CHANGE.

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Shear/Normal Function	Vertical Stress Ratio	Water Surface
Bedrock		165	Infinite Strength			Piezometric Line 1
Historical Rockfill		140	Vertical Stress Ratio		0.31	Piezometric Line 1
Historical Rockfill (drained)		140	Shear/Normal Function	Leps Angular Sand		Piezometric Line 1
Zone U Rockfill Disposal		140	Shear/Normal Function	Leps Lower Bound		Piezometric Line 1
Zone U Embankment Fill		140	Shear/Normal Function	Leps Lower Bound		Piezometric Line 1
Overburden (PQ)		135	Vertical Stress Ratio		0.22	Piezometric Line 1
Tailings (post-Earthquake)		120	Vertical Stress Ratio		0.05	Piezometric Line 1

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	18SEP'24	ISSUED WITH REPORT	SRS	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

2D LIMIT EQUILIBRIUM ANALYSIS RESULTS
POST-EARTHQUAKE
SECTION 18+00N - SAFETY MAP

Knight Piésold CONSULTING

P/A NO. VA101-126/24

REF. NO. 5

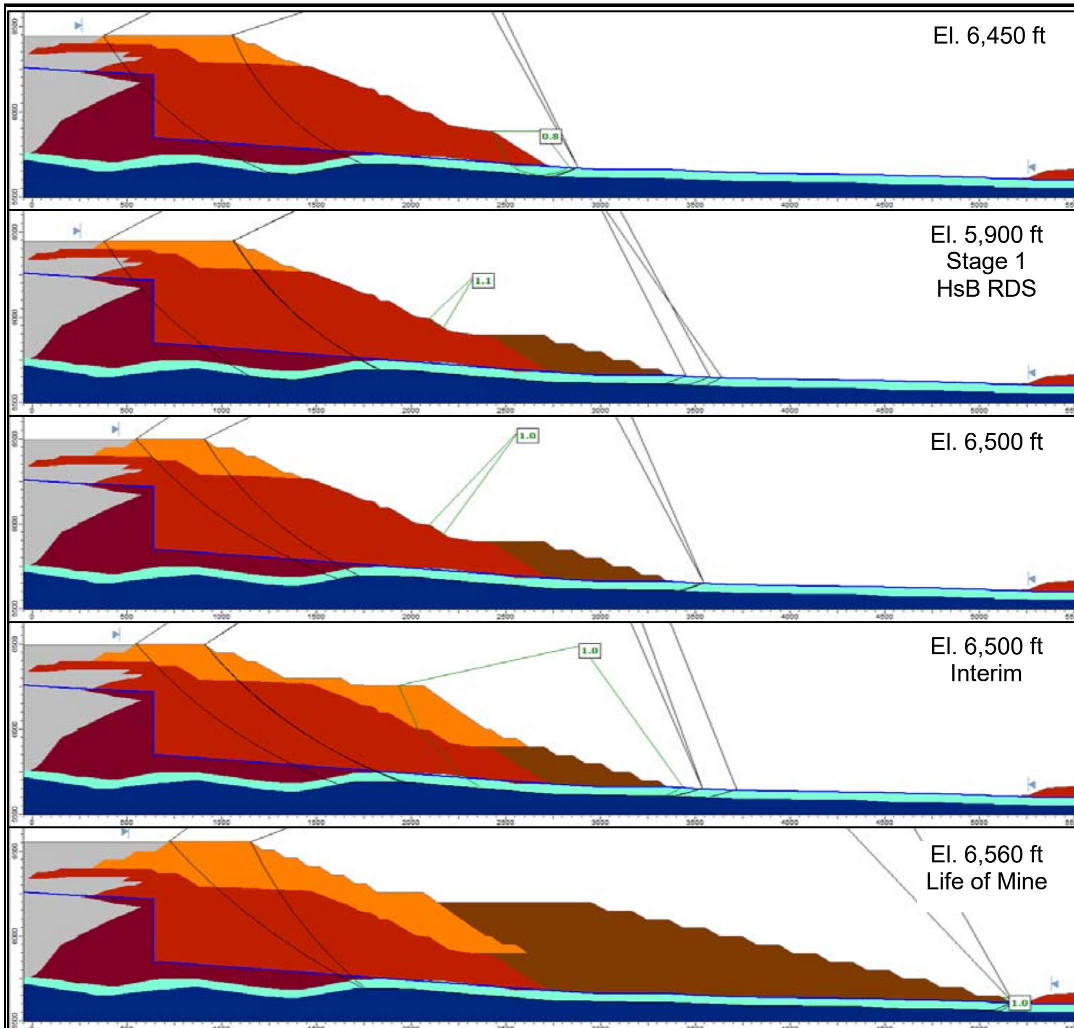
FIGURE E2.8

REV 0

APPENDIX E3

2D Limit Equilibrium Sensitivity Analysis for Normal Operating Conditions at Station 0+00

(Figures E3.1 to E3.4)



El. 6,450 ft

Location	FS
Upstream Crest	1.3
Downstream Crest	1.1

El. 5,900 ft Stage 1 HsB RDS

Location	FS
Upstream Crest	1.4
Downstream Crest	1.2

El. 6,500 ft

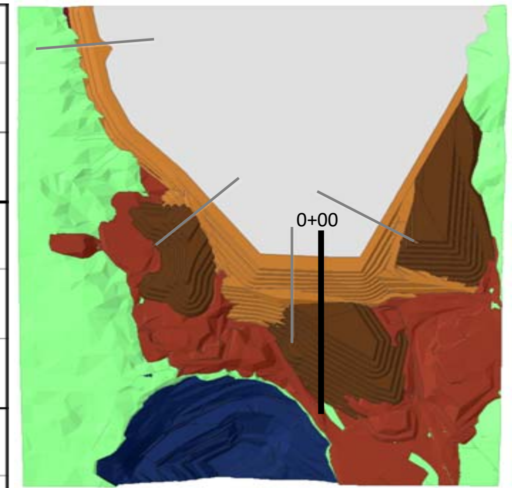
Location	FS
Upstream Crest	1.3
Downstream Crest	1.2

El. 6,500 ft Interim

Location	FS
Upstream Crest	1.4
Downstream Crest	1.3

El. 6,560 ft Life of Mine

Location	FS
Upstream Crest	1.8
Downstream Crest	1.8



NOTES:
1. SEE INSET FOR LOCATION OF ANALYSIS SECTION.
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4. GREEN SLIP IS LOWEST FS GENERATED BY SEARCH ALGORITHM OR "GLOBAL MINIMUM".

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)	Shear/Normal Function	Vertical Stress Ratio	Water Surface
Bedrock		165	Infinite Strength					Piezometric Line 1
Historical Rockfill (undrained)		140	Vertical Stress Ratio				0.31	Piezometric Line 1
Historical Rockfill		140	Shear/Normal Function			Leps Angular Sand		Piezometric Line 1
Overburden (Sensitivity)		135	Vertical Stress Ratio				0.26	Piezometric Line 1
Tailings Sand		120	Mohr-Coulomb	0	32			Piezometric Line 1
Zone U Rockfill Disposal		140	Shear/Normal Function			Leps Lower Bound		Piezometric Line 1
Zone U Embankment Fill		140	Shear/Normal Function			Leps Lower Bound		Piezometric Line 1

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	18JUL'24	ISSUED WITH REPORT	SRS	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

2D LIMIT EQUILIBRIUM ANALYSIS RESULTS
NORMAL OPERATING - SENSITIVITY
SECTION 0+00

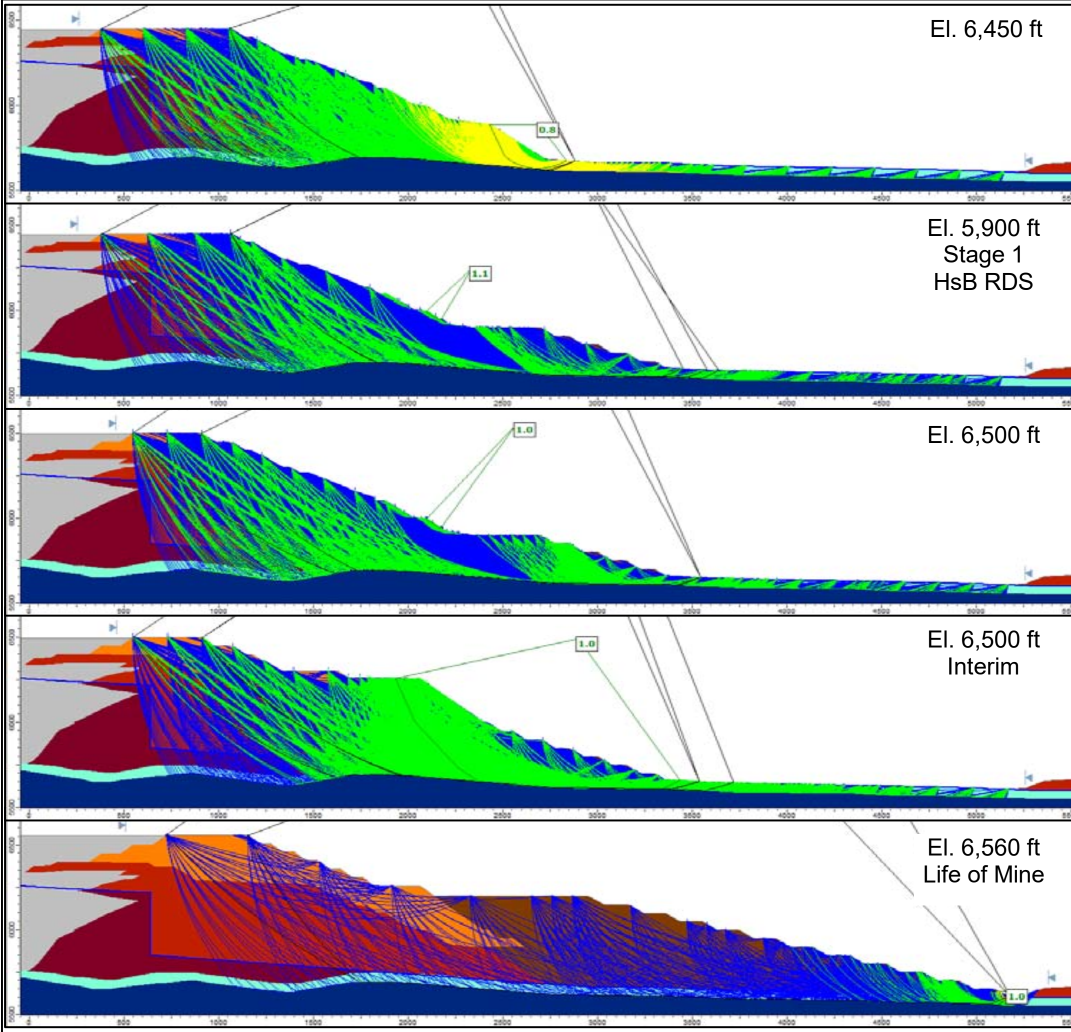
Knight Piésold CONSULTING

P/A NO. VA101-126/24

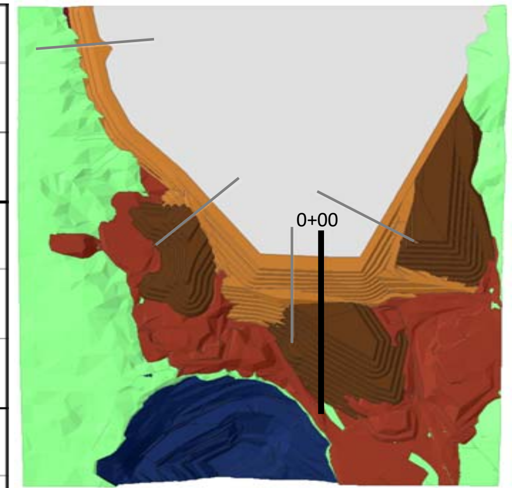
REF. NO. 5

FIGURE E3.1

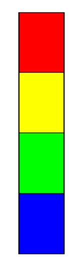
REV 0



Location	FS
El. 6,450 ft	
Upstream Crest	1.3
Downstream Crest	1.1
El. 5,900 ft Stage 1 HsB RDS	
Upstream Crest	1.4
Downstream Crest	1.2
El. 6,500 ft	
Upstream Crest	1.3
Downstream Crest	1.2
El. 6,500 ft Interim	
Upstream Crest	1.4
Downstream Crest	1.3
El. 6,560 ft Life of Mine	
Upstream Crest	1.8
Downstream Crest	1.8



Factor of Safety (FS)



NOTES:
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4. BLACK SLIPS ARE MINIMUM FS THROUGH UPSTREAM OR DOWNSTREAM CRESTS AND OVERBURDEN, AS TABULATED.
5. GREEN SLIP IS LOWEST FS GENERATED BY SEARCH ALGORITHM OR "GLOBAL MINIMUM".

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)	Shear/Normal Function	Vertical Stress Ratio	Water Surface
Bedrock		165	Infinite Strength					Piezometric Line 1
Historical Rockfill (undrained)		140	Vertical Stress Ratio				0.31	Piezometric Line 1
Historical Rockfill		140	Shear/Normal Function			Leps Angular Sand		Piezometric Line 1
Overburden (Sensitivity)		135	Vertical Stress Ratio				0.26	Piezometric Line 1
Tailings Sand		120	Mohr-Coulomb	0	32			Piezometric Line 1
Zone U Rockfill Disposal		140	Shear/Normal Function			Leps Lower Bound		Piezometric Line 1
Zone U Embankment Fill		140	Shear/Normal Function			Leps Lower Bound		Piezometric Line 1

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	18JUL'24	ISSUED WITH REPORT	SRS	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

2D LIMIT EQUILIBRIUM ANALYSIS RESULTS
NORMAL OPERATING - SENSITIVITY
SECTION 0+00 - SAFETY MAP

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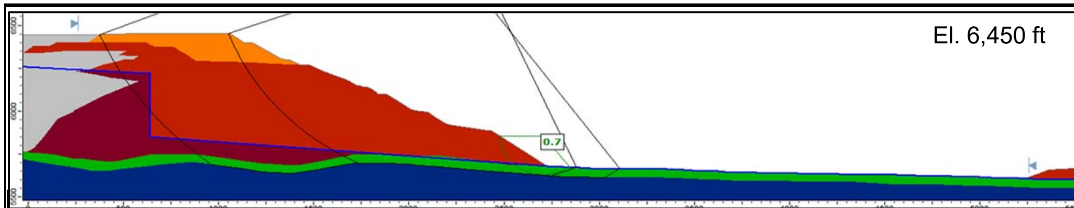
P/A NO. VA101-126/24

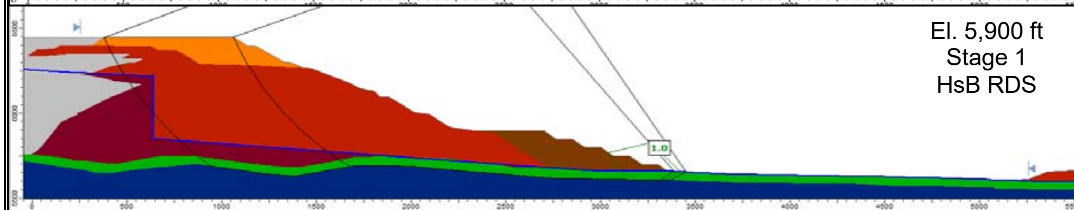
REF. NO. 5

FIGURE E3.2

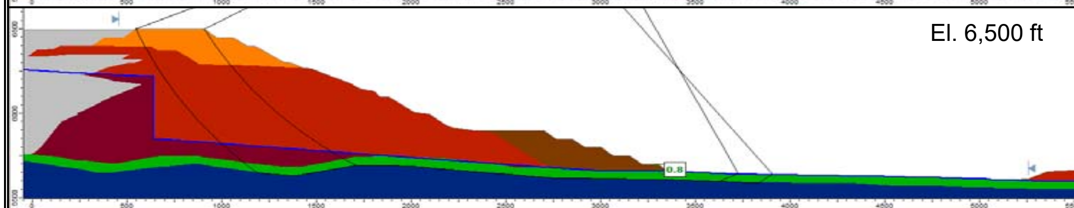
REV 0



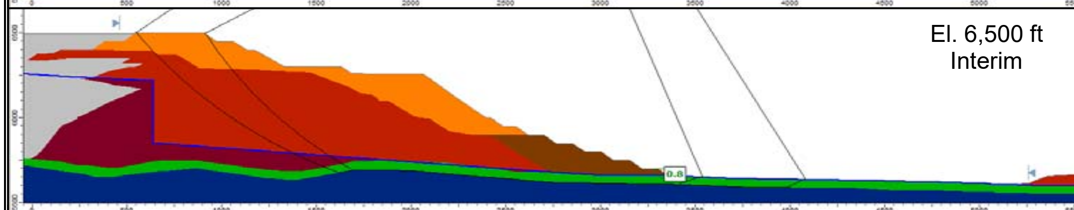
Location	FS
Upstream Crest	1.1
Downstream Crest	<1.0



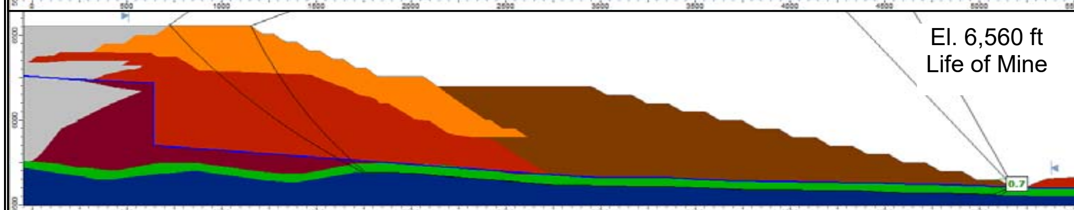
Location	FS
Upstream Crest	1.2
Downstream Crest	1.1



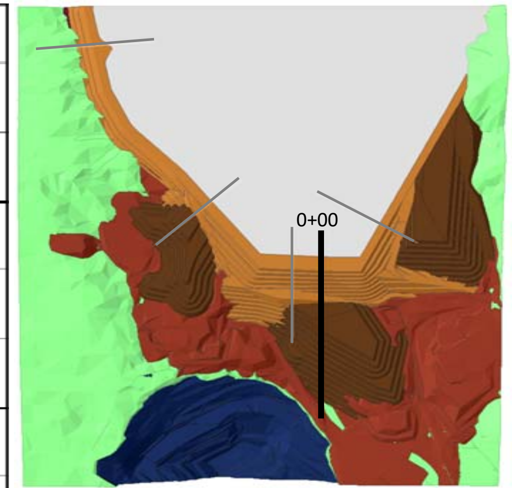
Location	FS
Upstream Crest	1.2
Downstream Crest	1.1



Location	FS
Upstream Crest	1.3
Downstream Crest	1.2



Location	FS
Upstream Crest	1.5
Downstream Crest	1.5



NOTES:
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4. GREEN SLIP IS LOWEST FS GENERATED BY SEARCH ALGORITHM OR "GLOBAL MINIMUM".

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Shear/Normal Function	Vertical Stress Ratio	Water Surface
Bedrock		165	Infinite Strength			Piezometric Line 1
Historical Rockfill (undrained)		140	Vertical Stress Ratio		0.31	Piezometric Line 1
Historical Rockfill		140	Shear/Normal Function	Leps Angular Sand		Piezometric Line 1
Overburden (Post-Earthquake, Sensitivity)		135	Vertical Stress Ratio		0.2	Piezometric Line 1
Zone U Rockfill Disposal		140	Shear/Normal Function	Leps Lower Bound		Piezometric Line 1
Zone U Embankment Fill		140	Shear/Normal Function	Leps Lower Bound		Piezometric Line 1
Tailings (Post-Earthquake)		120	Vertical Stress Ratio		0.05	Piezometric Line 1

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	18SEP'24	ISSUED WITH REPORT	SRS	SY

MONTANA RESOURCES, LLC

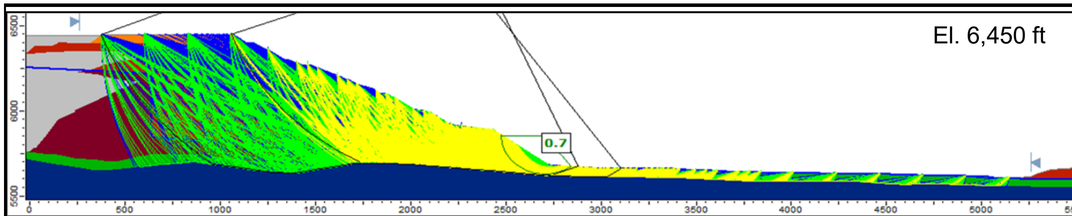
MONTANA RESOURCES

2D LIMIT EQUILIBRIUM ANALYSIS RESULTS
POST-EARTHQUAKE - SENSITIVITY
SECTION 0+00

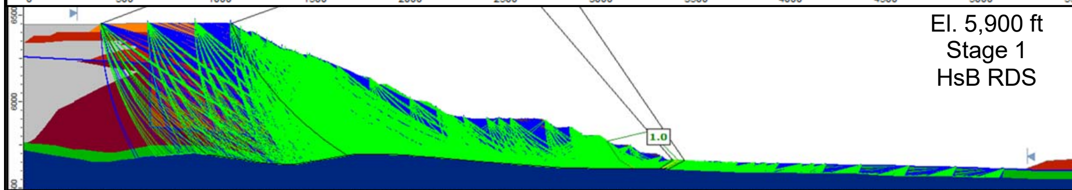
Knight Piésold CONSULTING

P/A NO. VA101-126/24 | REF. NO. 5

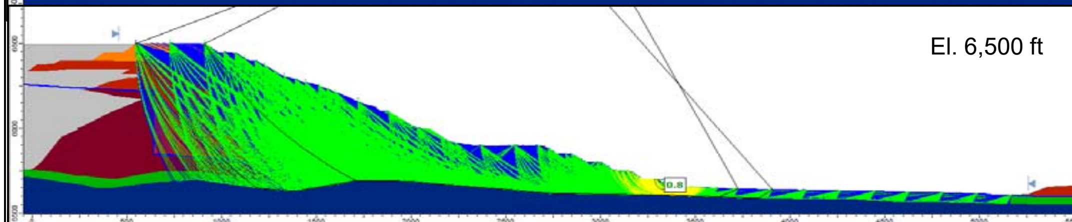
FIGURE E3.3 | REV 0



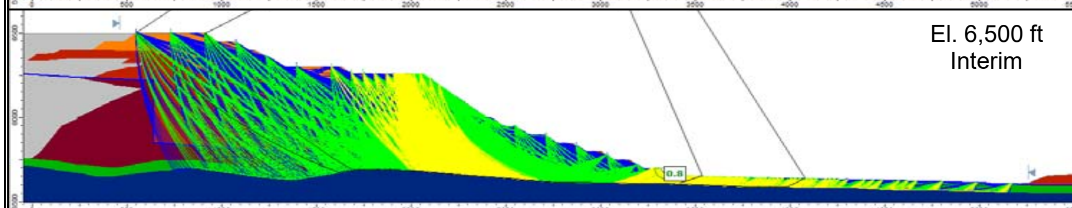
Location	FS
Upstream Crest	1.1
Downstream Crest	<1.0



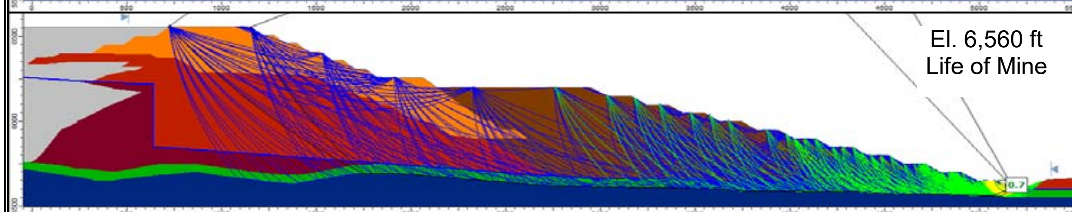
Location	FS
Upstream Crest	1.2
Downstream Crest	1.1



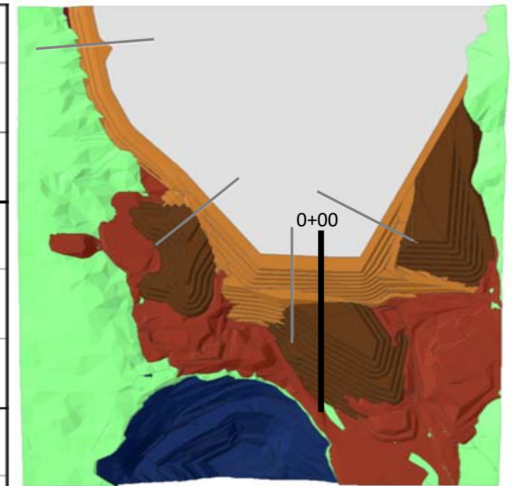
Location	FS
Upstream Crest	1.2
Downstream Crest	1.1



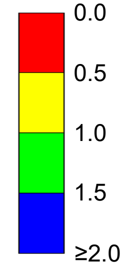
Location	FS
Upstream Crest	1.3
Downstream Crest	1.2



Location	FS
Upstream Crest	1.5
Downstream Crest	1.5



Factor of Safety (FS)



NOTES:
1. SEE INSET FOR LOCATION OF ANALYSIS SECTION.
2. INSET IS PERSPECTIVE VIEW OF PLAN OF El. 6,560 ft GEOMETRY.
3. COLOR SLIPS SHOWN ON SAFETY MAPS HAVE FS BELOW 3.0.
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5. GREEN SLIP IS LOWEST FS GENERATED BY SEARCH ALGORITHM OR "GLOBAL MINIMUM".

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Shear/Normal Function	Vertical Stress Ratio	Water Surface
Bedrock		165	Infinite Strength			Piezometric Line 1
Historical Rockfill (undrained)		140	Vertical Stress Ratio		0.31	Piezometric Line 1
Historical Rockfill		140	Shear/Normal Function	Leps Angular Sand		Piezometric Line 1
Overburden (Post-Earthquake, Sensitivity)		135	Vertical Stress Ratio		0.2	Piezometric Line 1
Zone U Rockfill Disposal		140	Shear/Normal Function	Leps Lower Bound		Piezometric Line 1
Zone U Embankment Fill		140	Shear/Normal Function	Leps Lower Bound		Piezometric Line 1
Tailings (Post-Earthquake)		120	Vertical Stress Ratio		0.05	Piezometric Line 1

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	18SEP'24	ISSUED WITH REPORT	SRS	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

2D LIMIT EQUILIBRIUM ANALYSIS RESULTS
POST-EARTHQUAKE - SENSITIVITY
SECTION 0+00 - SAFETY MAP

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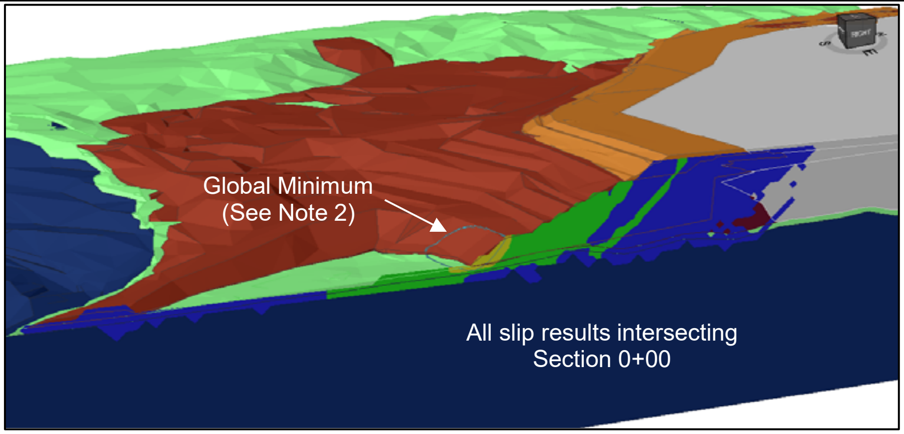
P/A NO.	REF. NO.
VA101-126/24	5

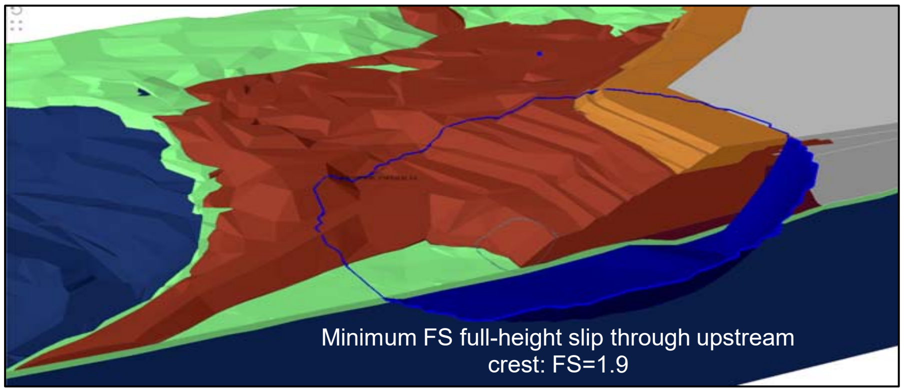
FIGURE E3.4 REV 0

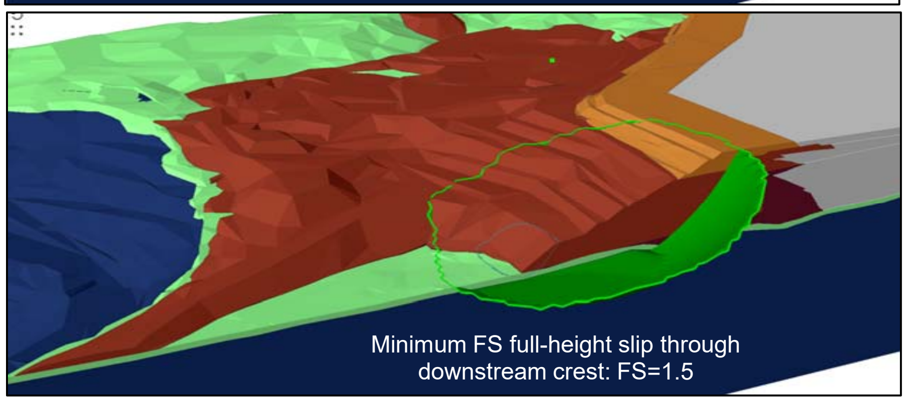
APPENDIX E4

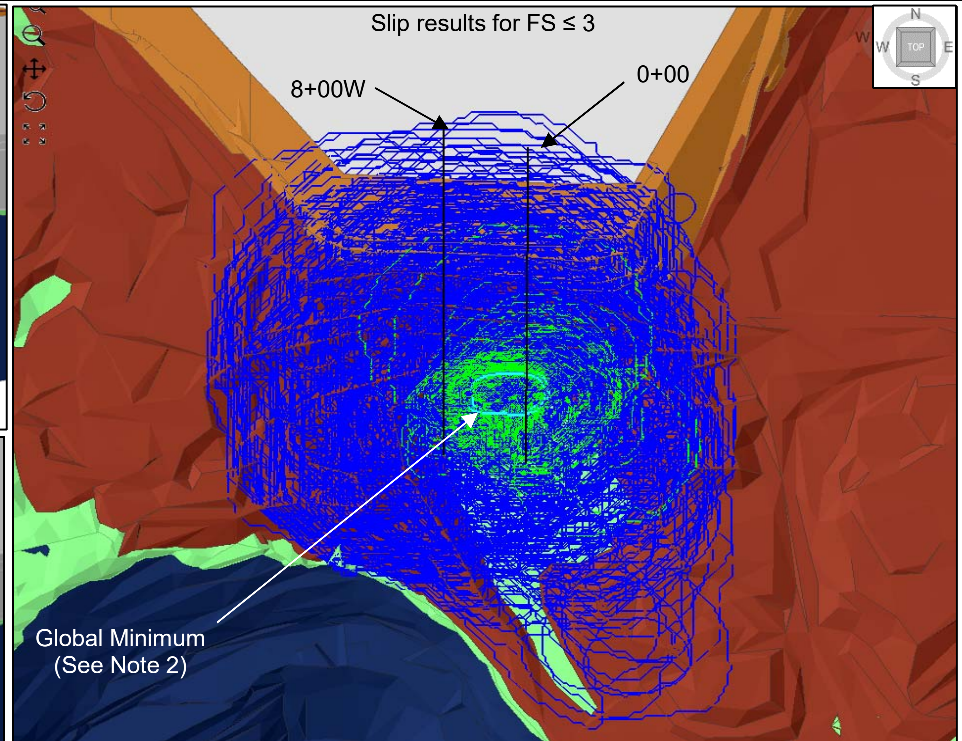
3D Limit Equilibrium Analysis for Normal Operating Conditions

(Figures E4.1 to E4.4)









Name	Colour	Unit Weight (lbs/ft3)	Water Surface	Failure Criterion	Vertical Stress Ratio	Cohesion (psf)	Phi (°)
Bedrock		165	Piezometric Surface	Infinite Strength			
Historic Rockfill (Undrained)		140	Piezometric Surface	Vertical Stress Ratio	0.31		
Historical Rockfill (Drained)		140	Piezometric Surface	Shear/Normal Function			
Overburden		135	Piezometric Surface	Vertical Stress Ratio	0.34		
Tailings Sand (base)		120	Piezometric Surface	Mohr Coulomb		0	32
Zone U Structural Rockfill		140	Piezometric Surface	Shear/Normal Function			
Zone U Surcharge		140	Piezometric Surface	Shear/Normal Function			

Factor of Safety (FS)

0.0
0.50
1.0
1.5
≥2.0

NOTES:
1. PHREATIC SURFACE NOT SHOWN FOR CLARITY. SEE FIGURE 4.7 FOR DETAILS.
2. GLOBAL MINIMUM IS MINIMUM FS GENERATED BY SEARCH ALGORITHM. SLIP SURFACE REPRESENTS LOCALIZED FS < 1.0 BETWEEN SEEP 10 BENCH AND HsB AREA.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	18JUL'24	ISSUED WITH REPORT	SY3	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

3D LIMIT EQUILIBRIUM ANALYSIS RESULTS NORMAL OPERATING El. 6,450 ft CONFIGURATION

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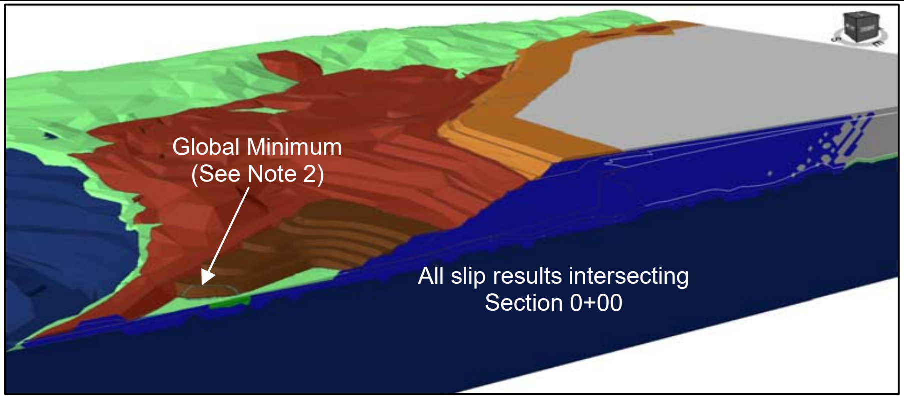
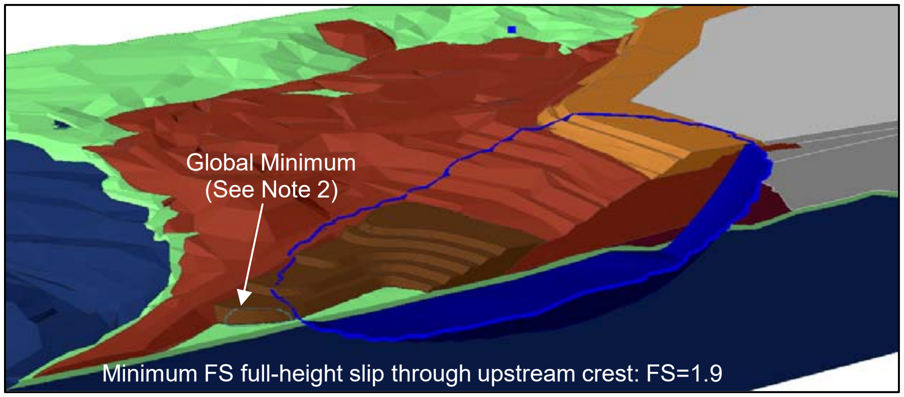
P/A NO. VA101-126/24

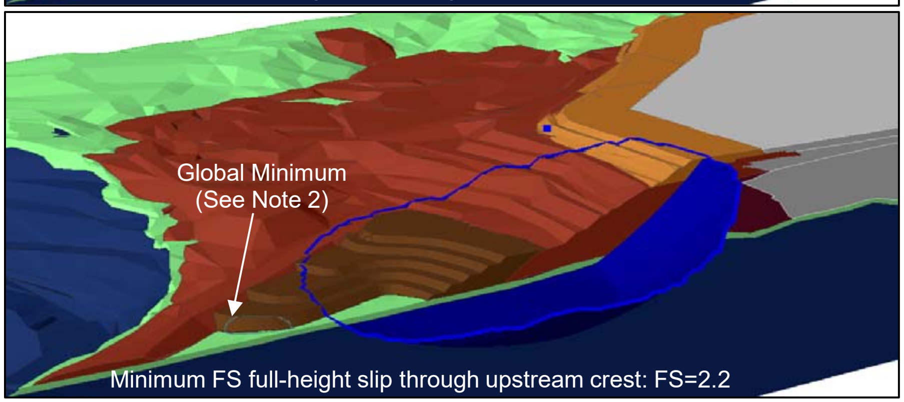
REF. NO. 5

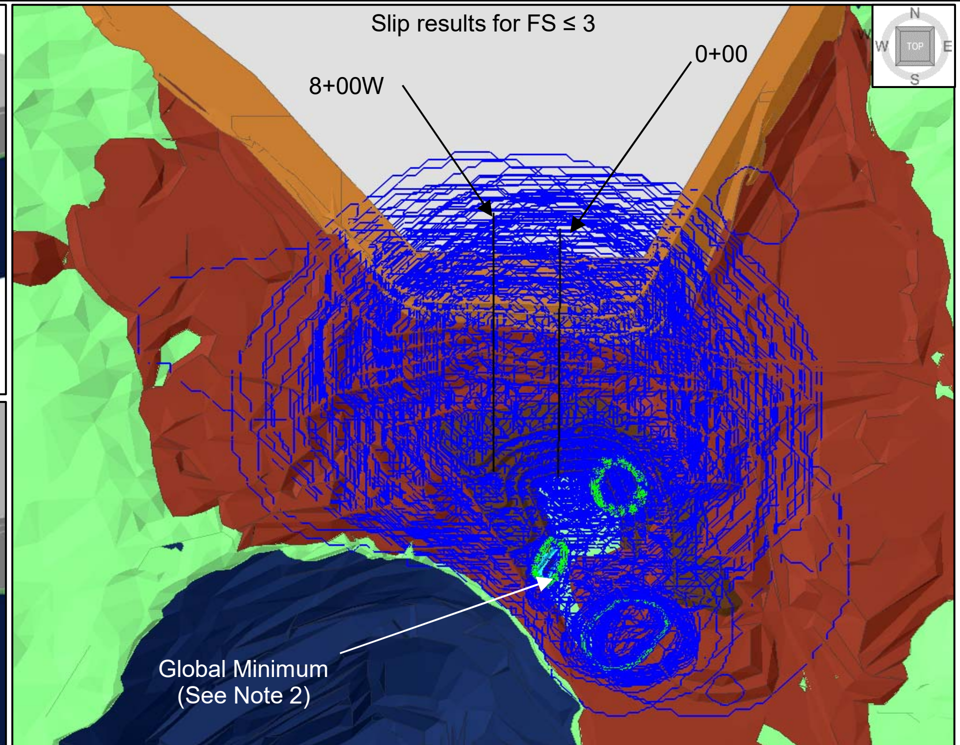
FIGURE E4.1

REV 0









Name	Colour	Unit Weight (lbs/ft3)	Water Surface	Failure Criterion	Vertical Stress Ratio	Cohesion (psf)	Phi (°)
Bedrock		165	Piezometric Surface	Infinite Strength			
Historic Rockfill (Undrained)		140	Piezometric Surface	Vertical Stress Ratio	0.31		
Historical Rockfill (Drained)		140	Piezometric Surface	Shear/Normal Function			
Overburden		135	Piezometric Surface	Vertical Stress Ratio	0.34		
Tailings Sand (base)		120	Piezometric Surface	Mohr Coulomb		0	32
Zone U Structural Rockfill		140	Piezometric Surface	Shear/Normal Function			
Zone U Surcharge		140	Piezometric Surface	Shear/Normal Function			

Factor of Safety (FS)

0.0
0.50
1.0
1.5
≥2.0

NOTES:
1. PHREATIC SURFACE NOT SHOWN FOR CLARITY. SEE FIGURE 4.7 FOR DETAILS.
2. GLOBAL MINIMUM IS MINIMUM FS GENERATED BY SEARCH ALGORITHM. SLIP SURFACE REPRESENTS LOCALIZED FS < 1.0 ALONG BOTTOM BENCH OF STAGE 1 RDS. SECOND AREA OF INTEREST IDENTIFIED IN THE EASTERN SLOPE OF STAGE 1 RDS WITH A SIMILAR SCALE OF SLIP

0	18JUL'24	ISSUED WITH REPORT	SY3	SY
REV	DATE	DESCRIPTION	PREP'D	RVW'D

MONTANA RESOURCES, LLC

MONTANA RESOURCES

3D LIMIT EQUILIBRIUM ANALYSIS RESULTS
NORMAL OPERATING
STAGE 1 RDS (El. 5,900 ft) CONFIGURATION

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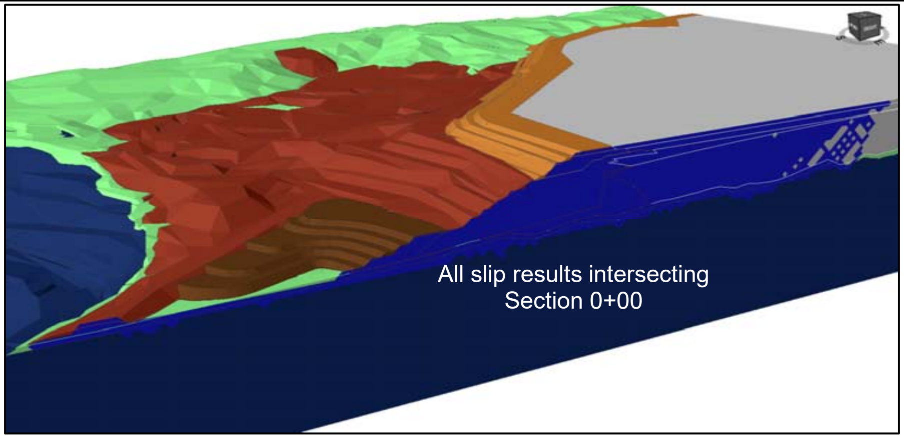
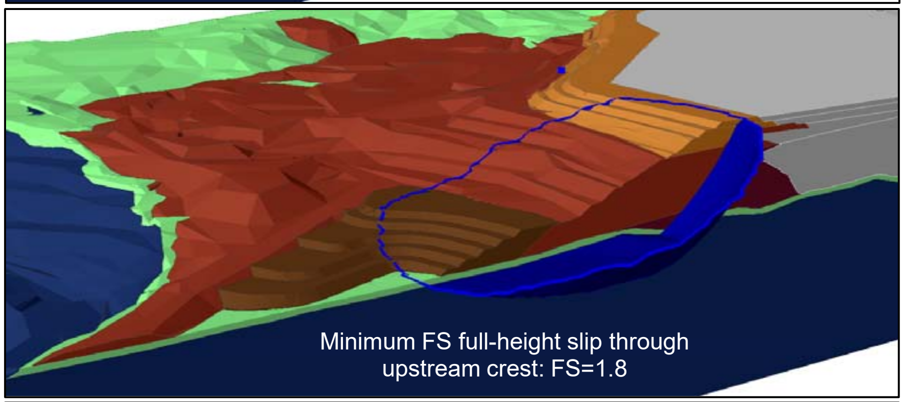
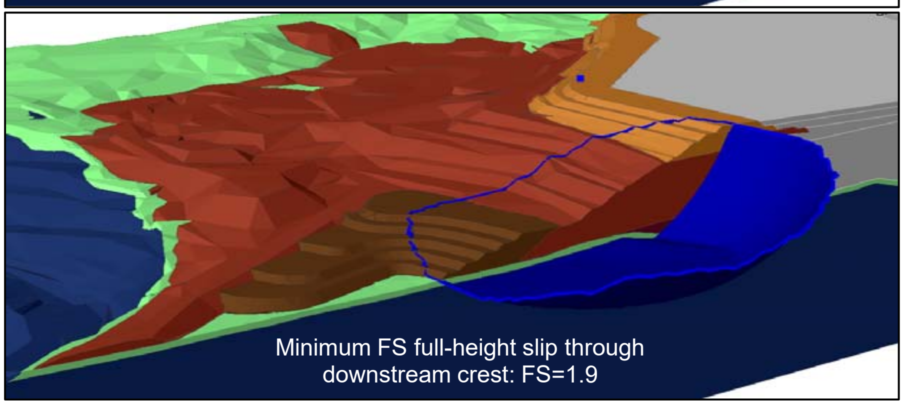
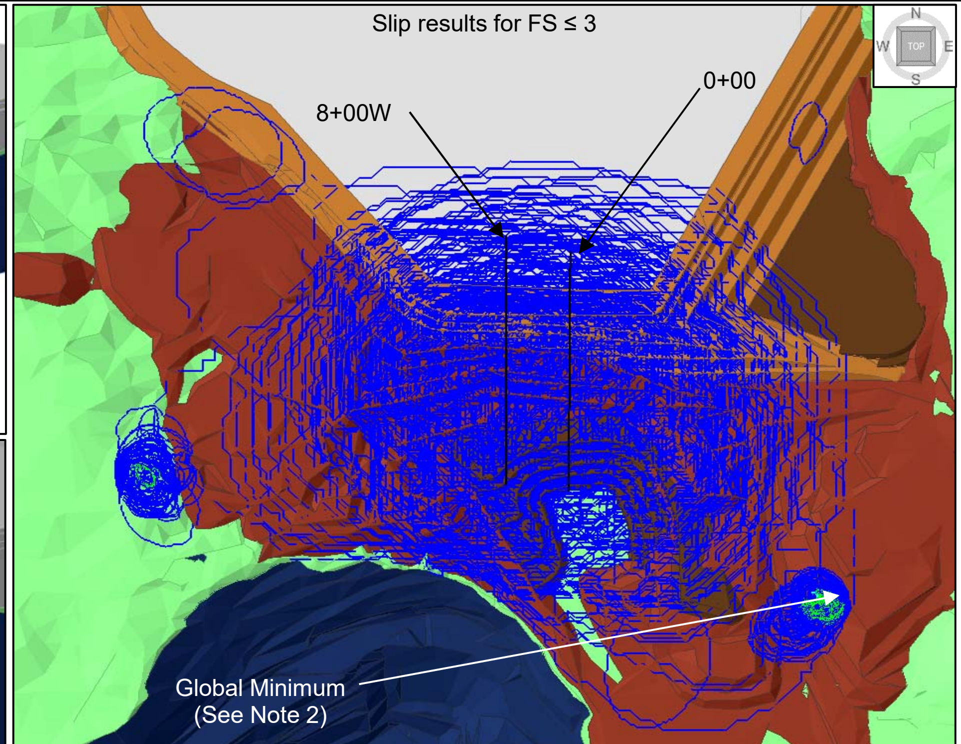
FIGURE E4.2 | REV 0









Name	Colour	Unit Weight (lbs/ft3)	Water Surface	Failure Criterion	Vertical Stress Ratio	Cohesion (psf)	Phi (°)
Bedrock		165	Piezometric Surface	Infinite Strength			
Historic Rockfill (Undrained)		140	Piezometric Surface	Vertical Stress Ratio	0.31		
Historical Rockfill (Drained)		140	Piezometric Surface	Shear/Normal Function			
Overburden		135	Piezometric Surface	Vertical Stress Ratio	0.34		
Tailings Sand (base)		120	Piezometric Surface	Mohr Coulomb		0	32
Zone U Structural Rockfill		140	Piezometric Surface	Shear/Normal Function			
Zone U Surcharge		140	Piezometric Surface	Shear/Normal Function			

Factor of Safety (FS)

0.0
0.50
1.0
1.5
≥2.0

NOTES:
1. PHREATIC SURFACE NOT SHOWN FOR CLARITY. SEE FIGURE 4.7 FOR DETAILS.
2. GLOBAL MINIMUM IS MINIMUM FS GENERATED BY SEARCH ALGORITHM. SLIP SURFACE REPRESENTS LOCALIZED FS < 1.0 ALONG DUMP SLOPE TO SOUTHEAST OF THE HsB AREA.

0	18JUL'24	ISSUED WITH REPORT	SY3	SY
REV	DATE	DESCRIPTION	PREP'D	RVW'D

MONTANA RESOURCES, LLC

MONTANA RESOURCES

3D LIMIT EQUILIBRIUM ANALYSIS RESULTS
NORMAL OPERATING
El. 6,500 ft CONFIGURATION

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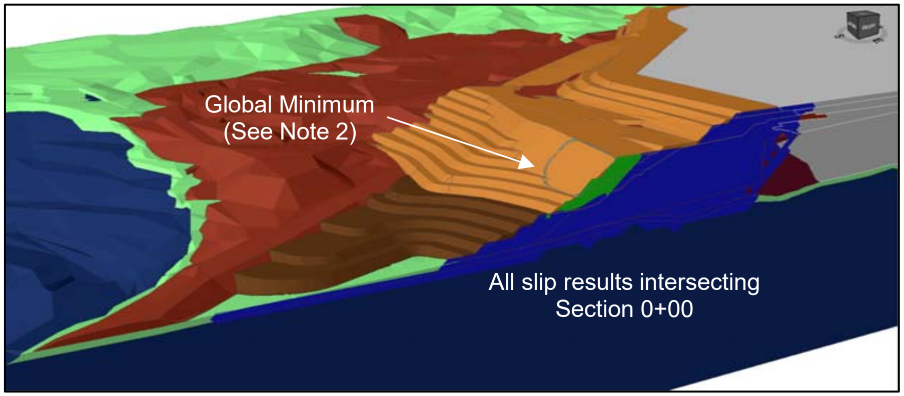
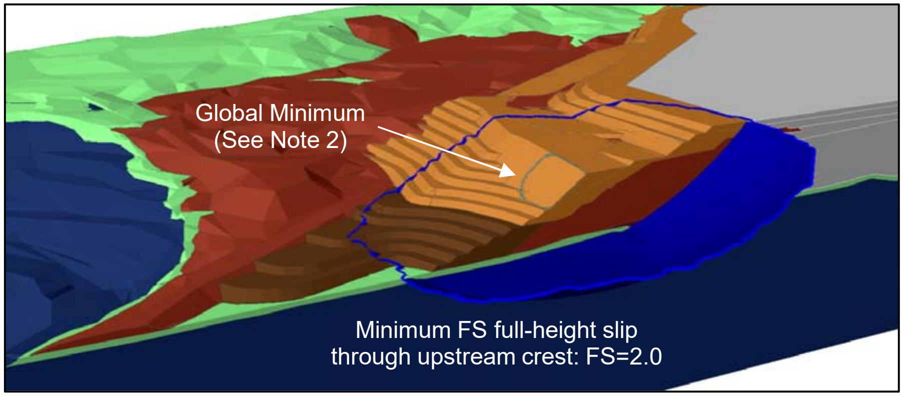
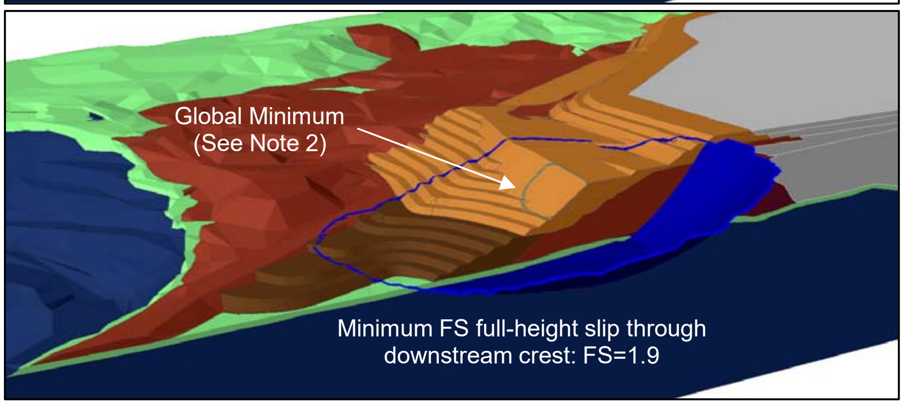
REF. NO. 5

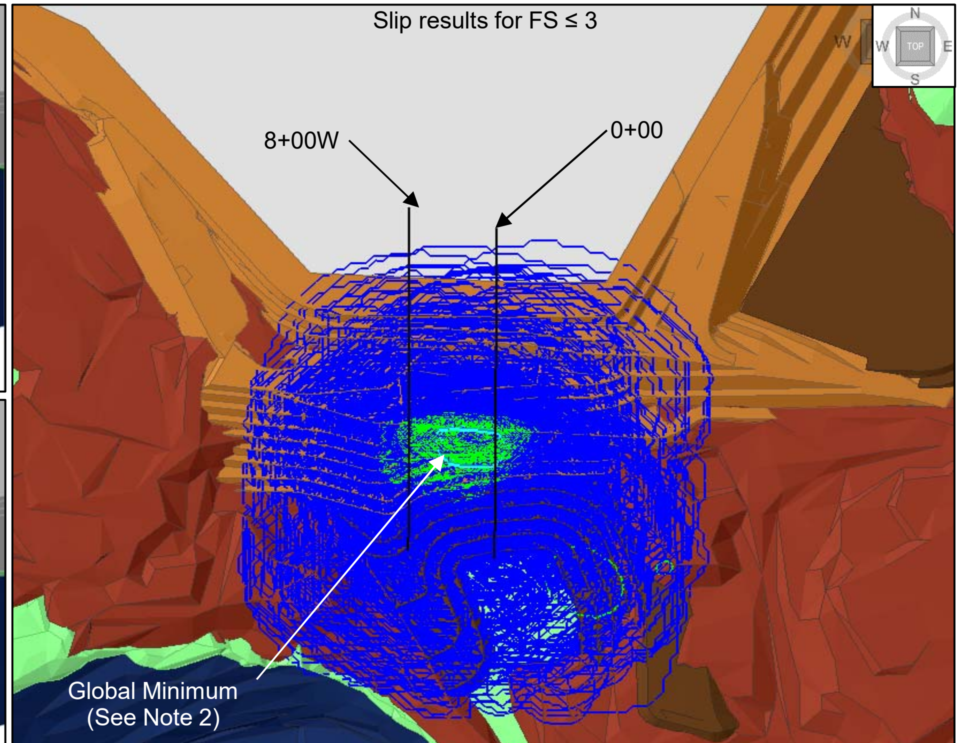
FIGURE E4.3

REV 0









Name	Colour	Unit Weight (lbs/ft3)	Water Surface	Failure Criterion	Vertical Stress Ratio	Cohesion (psf)	Phi (°)
Bedrock		165	Piezometric Surface	Infinite Strength			
Historic Rockfill (Undrained)		140	Piezometric Surface	Vertical Stress Ratio	0.31		
Historical Rockfill (Drained)		140	Piezometric Surface	Shear/Normal Function			
Overburden		135	Piezometric Surface	Vertical Stress Ratio	0.34		
Tailings Sand (base)		120	Piezometric Surface	Mohr Coulomb		0	32
Zone U Structural Rockfill		140	Piezometric Surface	Shear/Normal Function			
Zone U Surcharge		140	Piezometric Surface	Shear/Normal Function			

Factor of Safety (FS)

0.0
0.50
1.0
1.5
≥2.0

NOTES:
1. PHREATIC SURFACE NOT SHOWN FOR CLARITY. SEE FIGURE 4.7 FOR DETAILS.
2. GLOBAL MINIMUM IS MINIMUM FS GENERATED BY SEARCH ALGORITHM. SLIP SURFACE REPRESENTS LOCALIZED FS = 1.2 ALONG ANGLE OF REPOSE PIPELINE RAMP SLOPE.

0	18JUL'24	ISSUED WITH REPORT	SY3	SY
REV	DATE	DESCRIPTION	PREP'D	RVW'D

MONTANA RESOURCES, LLC

MONTANA RESOURCES

3D LIMIT EQUILIBRIUM ANALYSIS RESULTS
NORMAL OPERATING
El. 6,500 ft INTERIM CONFIGURATION

Knight Piésold CONSULTING

P/A NO. VA101-126/24

REF. NO. 5

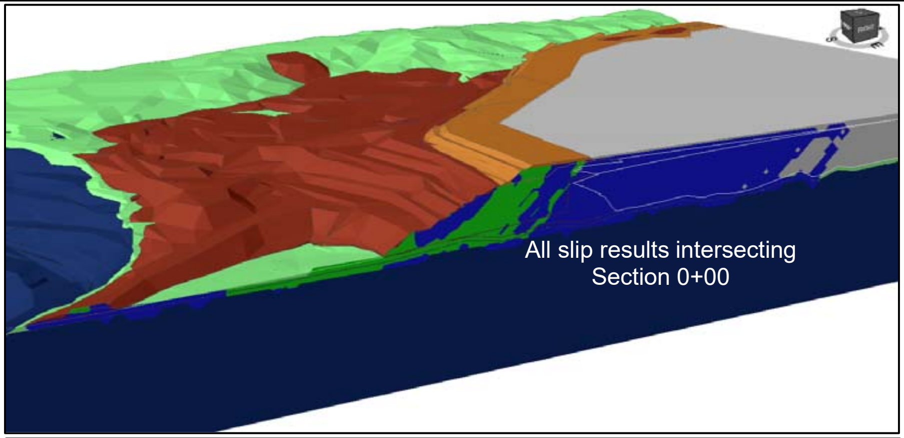
FIGURE E4.4

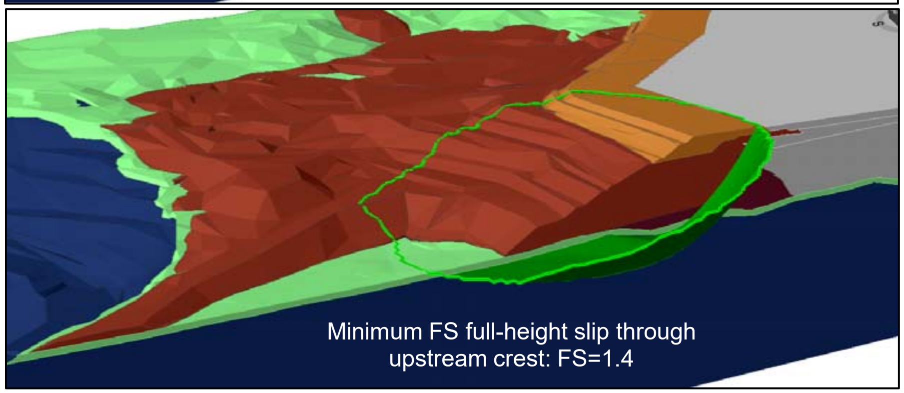
REV 0

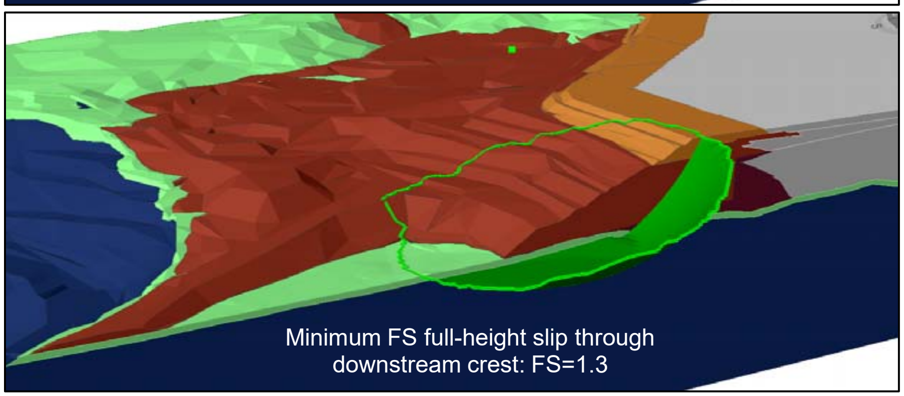
APPENDIX E5

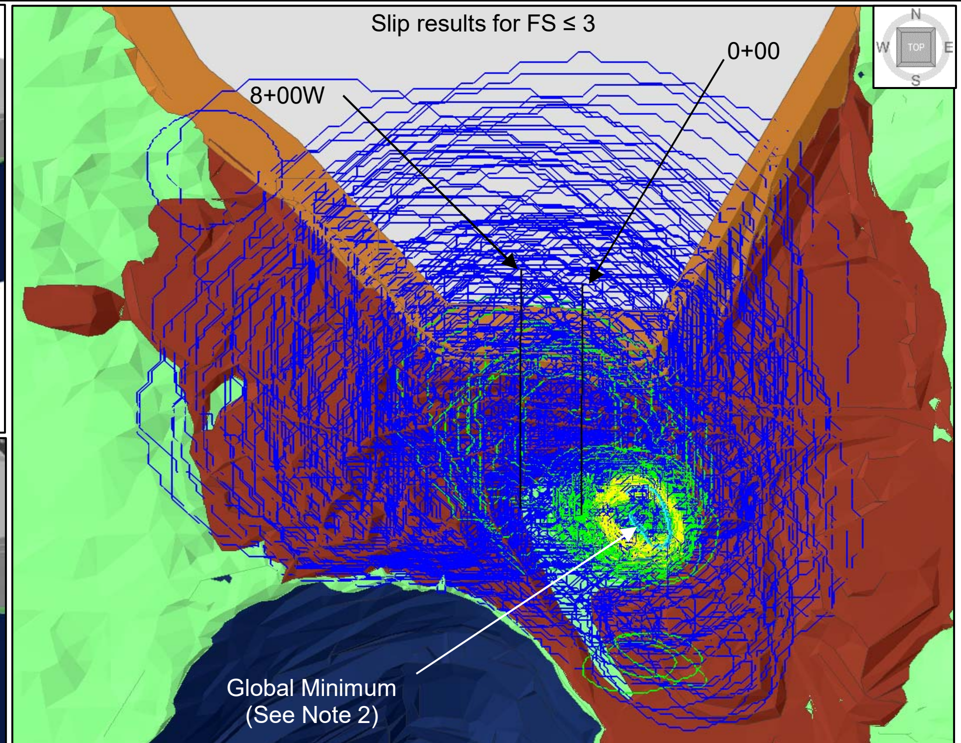
3D Limit Equilibrium Analysis for Post-Earthquake Conditions

(Figures E5.1 to E5.4)









Name	Colour	Unit Weight (lbs/ft3)	Water Surface	Failure Criterion	Vertical Stress Ratio
Bedrock		165	Piezometric Surface	Infinite Strength	
Historic Rockfill (Undrained)		140	Piezometric Surface	Vertical Stress Ratio	0.31
Historical Rockfill (Drained)		140	Piezometric Surface	Shear/Normal Function	
Overburden		135	Piezometric Surface	Vertical Stress Ratio	0.22
Tailings		120	Piezometric Surface	Vertical Stress Ratio	0.05
Zone U Structural Rockfill		140	Piezometric Surface	Shear/Normal Function	
Zone U Surcharge		140	Piezometric Surface	Shear/Normal Function	

Factor of Safety (FS)

0.0
0.50
1.0
1.5
≥2.0

NOTES:
1. PHREATIC SURFACE NOT SHOWN FOR CLARITY. SEE FIGURE 4.7 FOR DETAILS.
2. GLOBAL MINIMUM IS MINIMUM FS GENERATED BY SEARCH ALGORITHM. SLIP SURFACES REPRESENT LOCALIZED FS < 1.0 AT HsB AREA PONDS, WHICH WERE DECOMMISSIONED DURING

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	18JUL'24	ISSUED WITH REPORT	SY3	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

3D LIMIT EQUILIBRIUM ANALYSIS RESULTS
POST-EARTHQUAKE
El. 6,450 ft CONFIGURATION

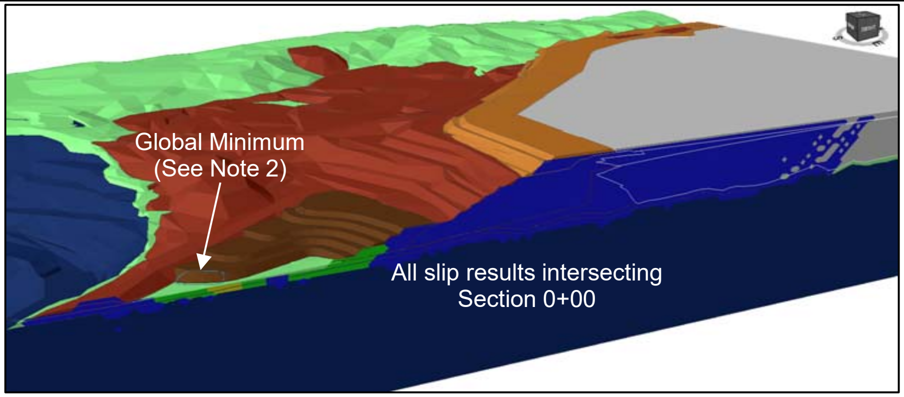
Knight Piésold CONSULTING

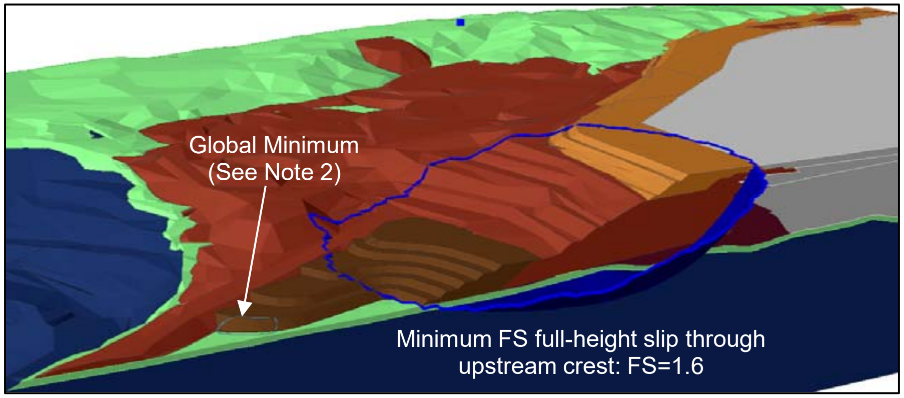
P/A NO. VA101-126/24

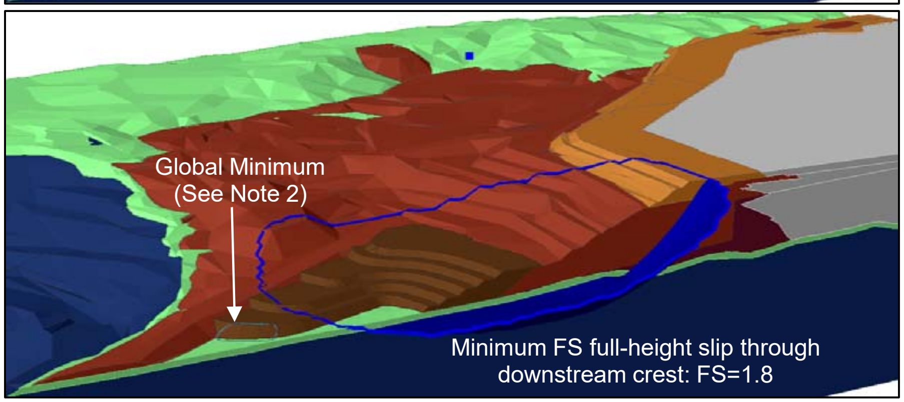
REF. NO. 5

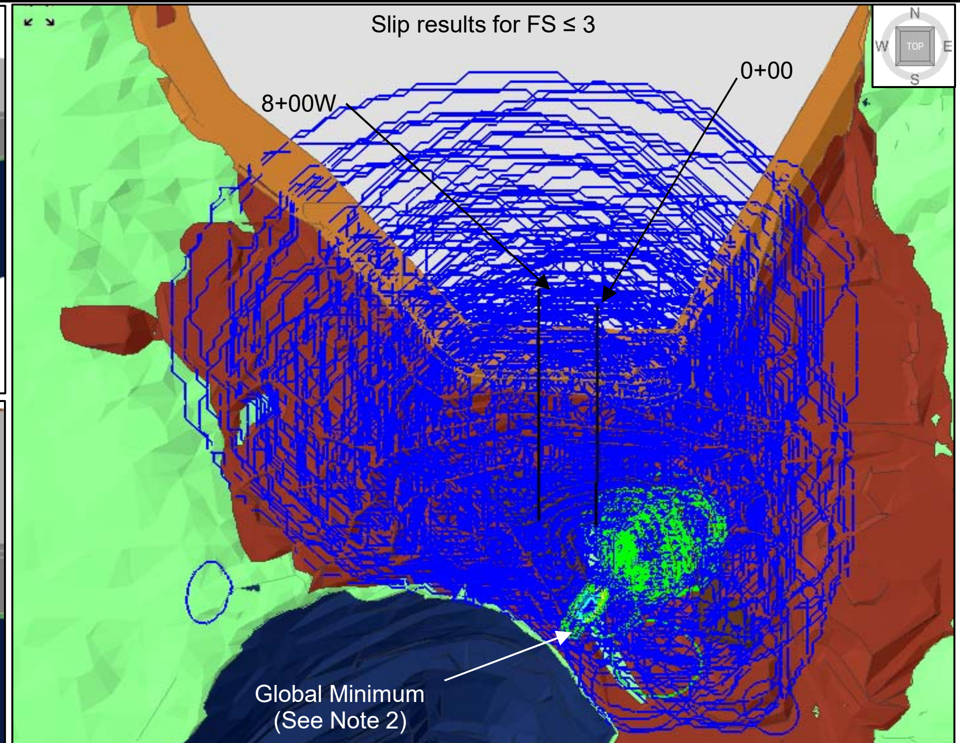
FIGURE E5.1

REV 0









Name	Colour	Unit Weight (lbs/ft3)	Water Surface	Failure Criterion	Vertical Stress Ratio
Bedrock		165	Piezometric Surface	Infinite Strength	
Historic Rockfill (Undrained)		140	Piezometric Surface	Vertical Stress Ratio	0.31
Historical Rockfill (Drained)		140	Piezometric Surface	Shear/Normal Function	
Overburden		135	Piezometric Surface	Vertical Stress Ratio	0.22
Tailings		120	Piezometric Surface	Vertical Stress Ratio	0.05
Zone U Structural Rockfill		140	Piezometric Surface	Shear/Normal Function	
Zone U Surcharge		140	Piezometric Surface	Shear/Normal Function	

Factor of Safety (FS)

0.0
0.50
1.0
1.5
≥2.0

NOTES:
1. PHREATIC SURFACE NOT SHOWN FOR CLARITY. SEE FIGURE 4.7 FOR DETAILS.
2. GLOBAL MINIMUM IS MINIMUM FS GENERATED BY SEARCH ALGORITHM. SLIP SURFACE REPRESENTS LOCALIZED FS < 1.0 ALONG BOTTOM BENCH OF STAGE 1 HsB RDS.

MONTANA RESOURCES, LLC

MONTANA RESOURCES

3D LIMIT EQUILIBRIUM ANALYSIS RESULTS
POST-EARTHQUAKE
STAGE 1 RDS (El. 5,900 ft) CONFIGURATION

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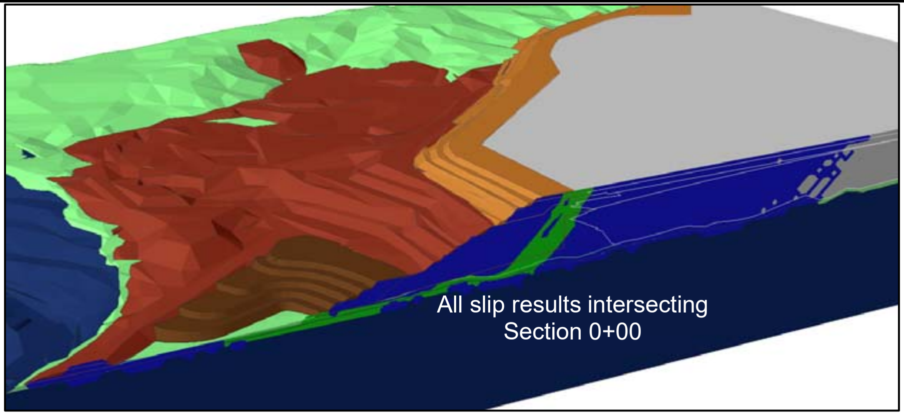
P/A NO. VA101-126/24

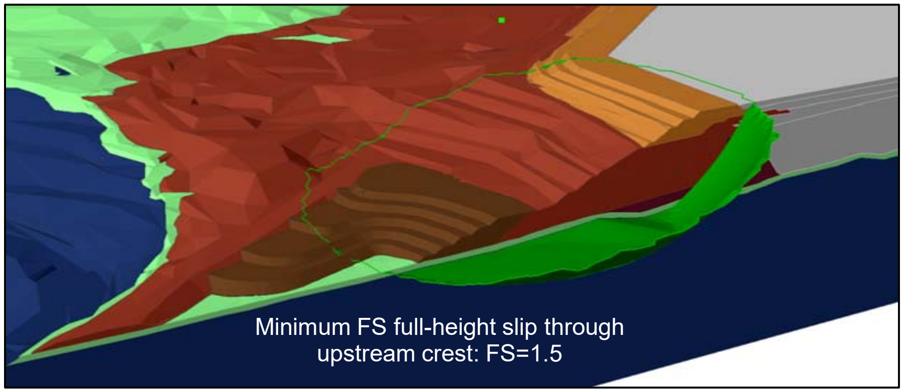
REF. NO. 5

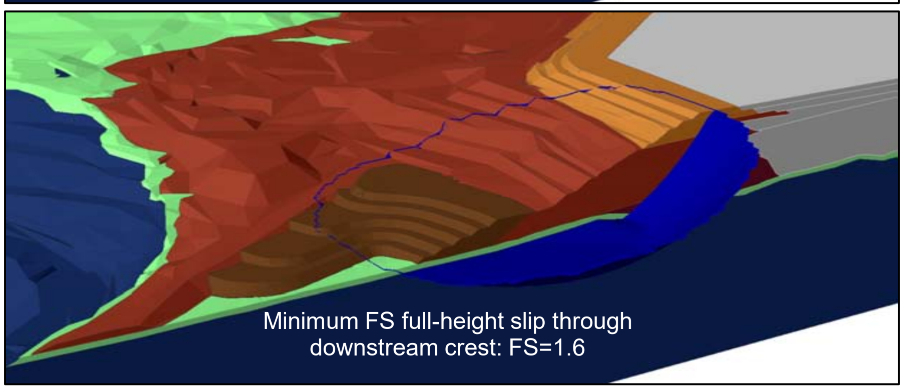
FIGURE E5.2

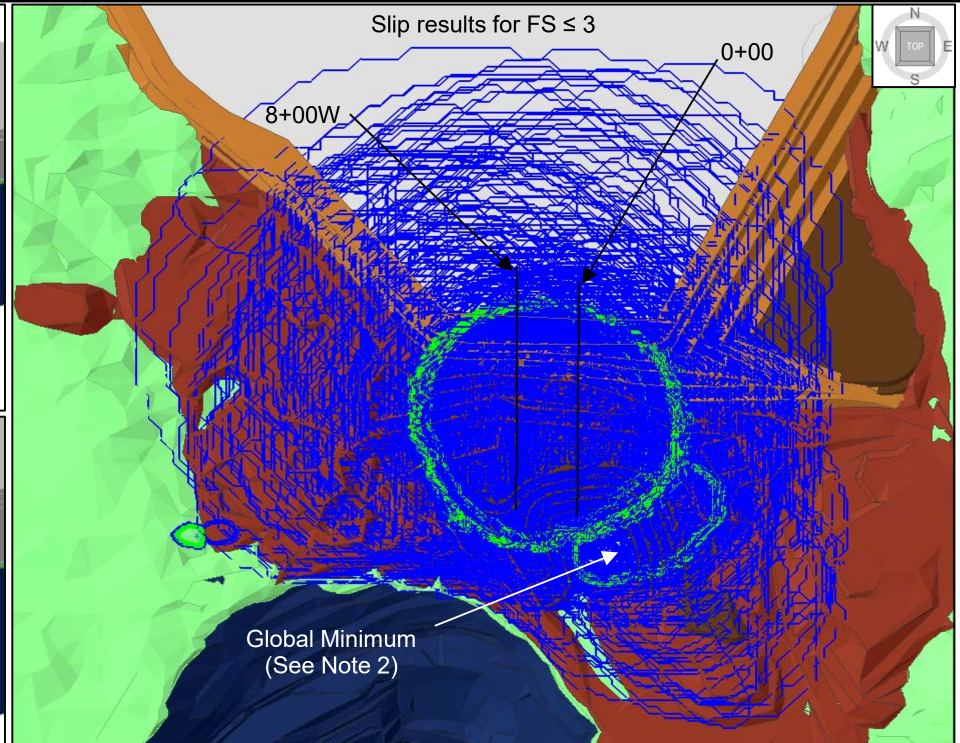
REV 0

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	18JUL'24	ISSUED WITH REPORT	SY3	SY









Name	Colour	Unit Weight (lbs/ft3)	Water Surface	Failure Criterion	Vertical Stress Ratio
Bedrock		165	Piezometric Surface	Infinite Strength	
Historic Rockfill (Undrained)		140	Piezometric Surface	Vertical Stress Ratio	0.31
Historical Rockfill (Drained)		140	Piezometric Surface	Shear/Normal Function	
Overburden		135	Piezometric Surface	Vertical Stress Ratio	0.22
Tailings		120	Piezometric Surface	Vertical Stress Ratio	0.05
Zone U Structural Rockfill		140	Piezometric Surface	Shear/Normal Function	
Zone U Surcharge		140	Piezometric Surface	Shear/Normal Function	

Factor of Safety (FS)

0.0
0.50
1.0
1.5
≥2.0

NOTES:
1. PHREATIC SURFACE NOT SHOWN FOR CLARITY. SEE FIGURE 4.7 FOR DETAILS.
2. GLOBAL MINIMUM IS MINIMUM FS GENERATED BY SEARCH ALGORITHM. SLIP SURFACE NOT VISIBLE BUT REPRESENTS LOCALIZED FS = 1.0 AT EASTERN SLOPE OF STAGE 1 RDS.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	18JUL'24	ISSUED WITH REPORT	SY3	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

3D LIMIT EQUILIBRIUM ANALYSIS RESULTS
POST-EARTHQUAKE
El. 6,500 ft CONFIGURATION

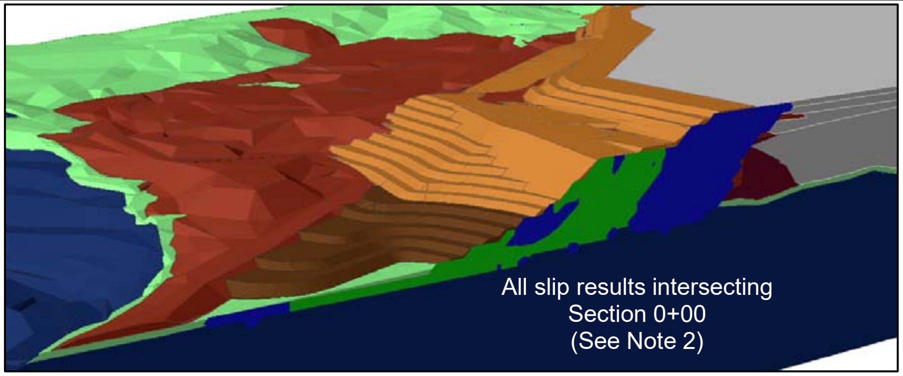
Knight Piésold CONSULTING

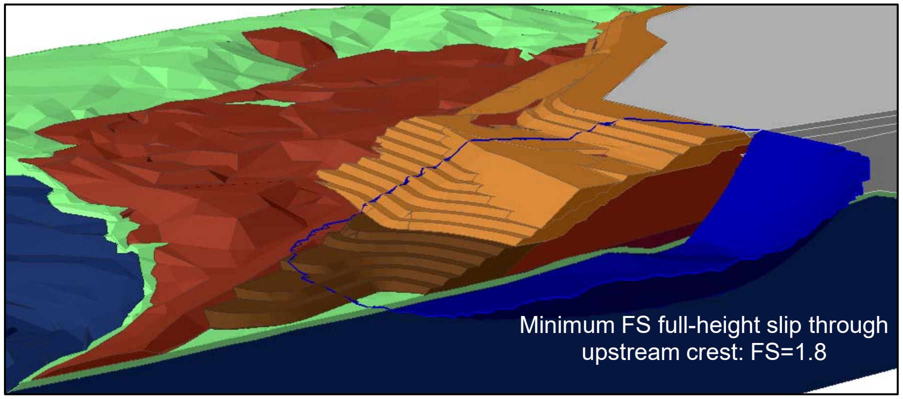
P/A NO. VA101-126/24

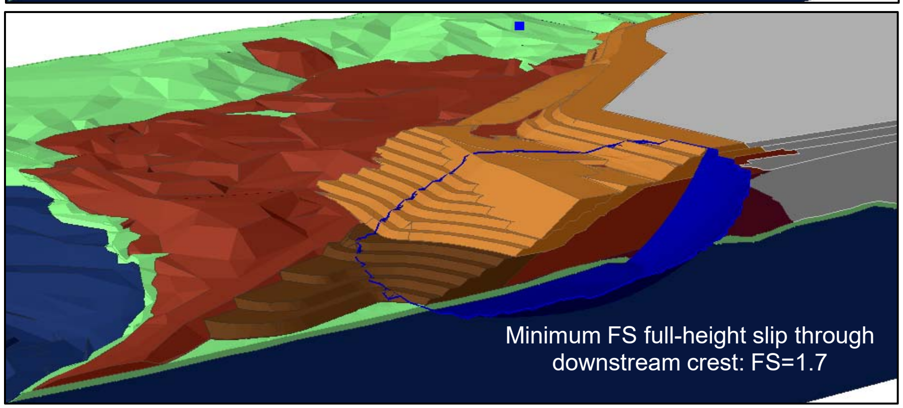
REF. NO. 5

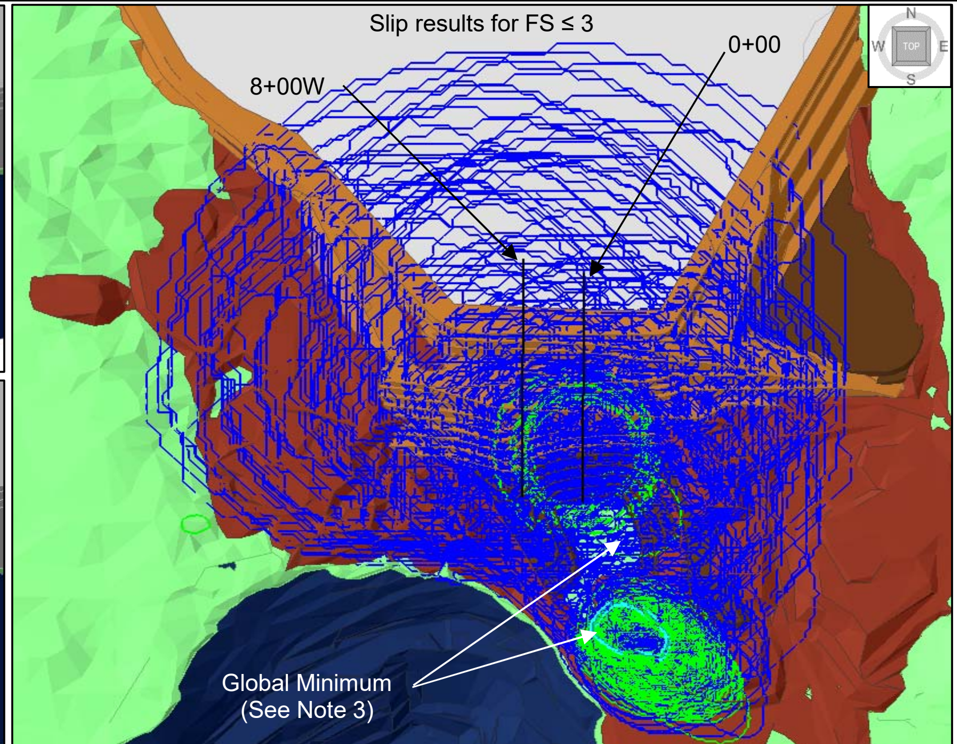
FIGURE E5.3

REV 0



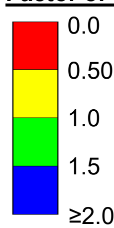






Name	Colour	Unit Weight (lbs/ft3)	Water Surface	Failure Criterion	Vertical Stress Ratio
Bedrock		165	Piezometric Surface	Infinite Strength	
Historic Rockfill (Undrained)		140	Piezometric Surface	Vertical Stress Ratio	0.31
Historical Rockfill (Drained)		140	Piezometric Surface	Shear/Normal Function	
Overburden		135	Piezometric Surface	Vertical Stress Ratio	0.22
Tailings		120	Piezometric Surface	Vertical Stress Ratio	0.05
Zone U Structural Rockfill		140	Piezometric Surface	Shear/Normal Function	
Zone U Surcharge		140	Piezometric Surface	Shear/Normal Function	

Factor of Safety (FS)



NOTES:
1. PHREATIC SURFACE NOT SHOWN FOR CLARITY. SEE FIGURE 4.7 FOR DETAILS.
2. TWO ANALYSES WITH DIFFERENT SEARCH VOLUMES REQUIRED TO LOCATE FULL RANGE OF DEEP-SEATED AND SHALLOW SLIPS.
3. GLOBAL MINIMUM IS MINIMUM FS GENERATED BY SEARCH ALGORITHM. SLIP SURFACE

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	18JUL'24	ISSUED WITH REPORT	SY3	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

3D LIMIT EQUILIBRIUM ANALYSIS RESULTS
POST-EARTHQUAKE
El. 6,500 ft INTERIM CONFIGURATION

Knight Piésold CONSULTING

P/A NO. VA101-126/24

REF. NO. 5

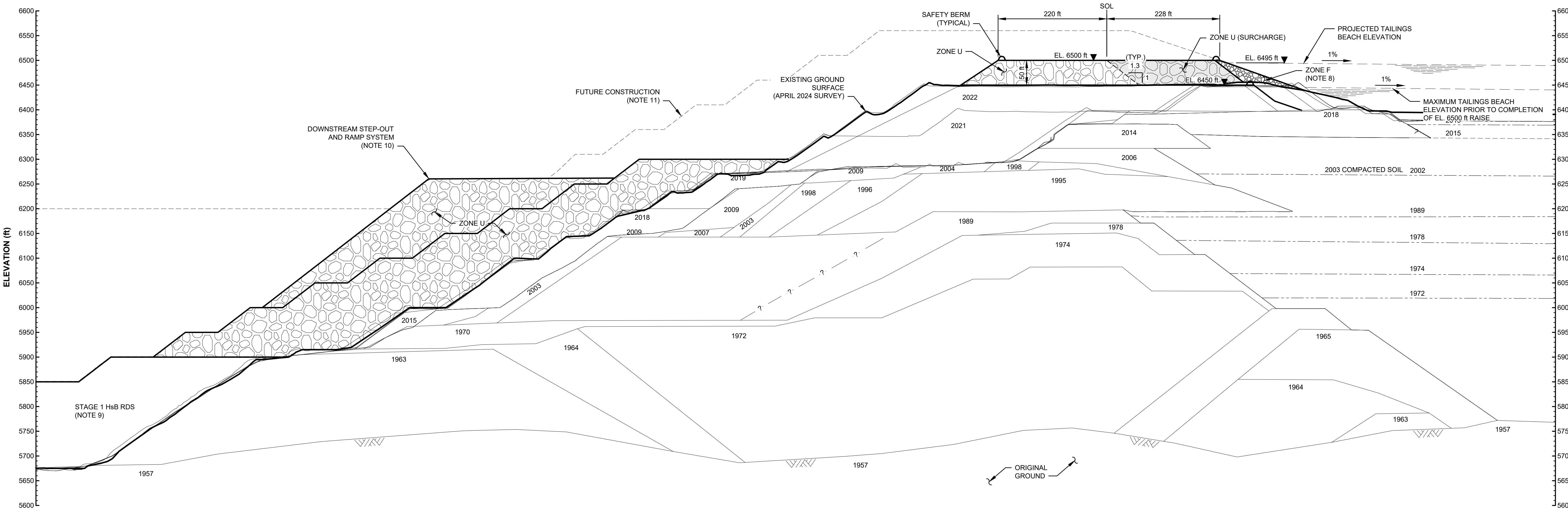
FIGURE E5.4

REV 0

APPENDIX F

Station 0+00 6500 Crest Geometry

(Figure F.1)



SECTION
STATION 0+00
SCALE A

LEGEND:

- ZONE F - EARTHFILL
- ZONE U - ROCKFILL (SURCHARGE)
- ZONE U - ROCKFILL
- SOL — SETTING OUT LINE (NOTE 7)
- 1972 — HISTORICAL TAILINGS SURFACE
- 1972 — DATE OF EMBANKMENT RAISE

NOTES:

1. EMBANKMENT STAGING IS BASED ON PRELIMINARY LIFE OF MINE DESIGN. NOT FOR CONSTRUCTION.
2. THE EL. 6,500 ft INTERIM CONFIGURATION PRESENTED ON THIS FIGURE WAS SELECTED FOR MODELING AS IT REPRESENTS A CRITICAL DESIGN CASE FOR EVALUATION. FURTHER EXPANSION OF THE HsB RDS MAY BE REQUIRED TO ENHANCE STABILITY CONCURRENTLY WITH RAMP SYSTEM DEVELOPMENT. FINAL DESIGN GEOMETRY TO BE DETERMINED AT ISSUED FOR CONSTRUCTION STAGE.
3. SAFETY BERMS SHALL BE MID AXLE HEIGHT OF THE LARGEST WHEELED VEHICLE.
4. COORDINATE GRID IS ANACONDA MINE GRID.
5. APRIL 2024 END OF MONTH TOPOGRAPHY (EXISTING GROUND) PROVIDED BY MONTANA RESOURCES, LLC IN MAY 2024.
6. GROUND CONTOUR INTERVAL IS 5 FEET.
7. THE DOWNSTREAM SIDE OF THE EMBANKMENT CREST IS LAID OUT 220 FT FROM THE SETTING OUT LINE AND ROUGHLY DELINEATES THE INTERFACE BETWEEN ZONE U EMBANKMENT AND ZONE U SURCHARGE.
8. ZONE F TO BE PLACED ALONG THE UPSTREAM FACE OF ZONE U AS REQUIRED TO MAINTAIN SEPARATION ZONE BETWEEN THE TAILINGS AND THE ROCKFILL, AND TO CREATE A CONTINUOUS ZONE WITH PRECEDING ZONE F MATERIALS. ZONE F TO BE PLACED AT 2H:1V OR FLATTER WITH A MINIMUM NOMINAL THICKNESS OF 3 FT.
9. STAGE 1 HsB RDS ASSUMED TO BE COMPLETED PRIOR TO EL. 6500 FT CREST RAISE.
10. DOWNSTREAM STEP-OUT AND RAMP SYSTEM TO BE PROGRESSIVELY CONSTRUCTED FOLLOWING EL. 6500 FT CREST RAISE.
11. OUTLINE FOR CONCEPTUAL FUTURE CONSTRUCTION AREAS.

SCALE A: 100 0 100 200 300 400 500 ft

MONTANA RESOURCES, LLC

MONTANA RESOURCES

YANKEE DOODLE TAILINGS IMPOUNDMENT
EAST-WEST EMBANKMENT - 6500 CREST
SECTION 0+00

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA101-126/24	5

FIGURE F.1 REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	19SEP'24	ISSUED WITH REPORT	JRG	RMM	DDF

SAVED: M:\1\01\00126\24\A\Acad\FIGS\B13, 7/10/2024 8:05:40 AM , RMCLELLAN PRINTED: 9/19/2024 1:52:21 PM, FIG F.1, RMCLELLAN
XREF FILE(S): Sections IMAGE FILE(S):

APPENDIX G

Dynamic Analysis Material Inputs

Appendix G1
Material Properties and Supporting Data

Appendix G2
Constitutive Model Calibration

APPENDIX G1

Material Properties and Supporting Data

(Tables G1.1 to G1.4, Figures G1.1 to G1.2)

TABLE G1.1

MONTANA RESOURCES, LLC
MONTANA RESOURCES

FLAC MATERIAL PROPERTIES
PROPERTIES FOR STATIC ANALYSIS

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Unit	Unit Weight (pcf)	Shear Modulus (psf)	Bulk Modulus (psf)	Friction Angle (°)	Cohesion (psf)
Bedrock	169	$G = G_{max}$ $G_{max} = \rho Vs^2$ Vs = 4921 ft/sec	v = 0.25 K(G, v)	-	-
Overburden	127	$G = 0.5G_{max}$ G_{max} = 5.0E6	v = 0.3 K(G, v)	27	0
Rockfill	143	$G = 0.5G_{max}$ $G_{max}(k_{2,max}, p')$ $k_{2,max} = 140$	v = 0.3 K(G, v)	Leps Angular Sand Function (capped at 38.5°)	105
Tailings	129	$G = 0.5G_{max}$ $G_{max}(k_{2,max}, p')$ $k_{2,max} = 36$	v = 0.3 K(G, v)	32	0

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NOTES:

1. PROPERTIES FROM LABORATORY AND DOWNHOLE SEISMIC TESTS.
2. G_{max} DENOTES SMALL STRAIN SHEAR MODULUS. $k_{2,max}$ DENOTES SMALL STRAIN SHEAR MODULUS COEFFICIENT.
3. SMALL STRAIN SHEAR MODULUS, $G_{max} = \rho Vs^2 = 21.7k_{2,max}\left(\frac{p'}{p_{atm}}\right)^{0.5}$
4. MEAN CONFINING STRESS, $p' = \frac{\sigma'_x - \sigma'_y}{2}$
5. POISSON'S RATIO OF 0.3 ASSUMED.
6. BULK MODULUS, $K = \frac{2G(1+\nu)}{3(1-2\nu))}$
7. LEPS (1970) ANGULAR SAND FUNCTION IS DEFINED BY *φ' = -2.447LN(p') + 59.815* , WHERE φ' IS FRICTION ANGLE (°) AND p' IS MEAN EFFECTIVE STRESS IN PSF. φ' IS CAPPED AT 38.5°.
8. A NOMINAL AMOUNT OF COEHSION (105 psf) IS USED TO ASSIST WITH NUMERICAL STABILITY IN THE ROCKFILL.

0	19SEP'24	ISSUED WITH REPORT VA101-126/24-5	MJB2	SY
REV	DATE	DESCRIPTION	PREP'D	RVW'D

TABLE G1.2

MONTANA RESOURCES, LLC
MONTANA RESOURCES

FLAC MATERIAL PROPERTIES
CALIBRATED UBCHYST MATERIAL PROPERTIES

Print Sep/20/24 11:21:26

Property	Unit	
	Unsaturated Rockfill	Unsaturated Tailings
Small-strain shear modulus, G_{max} (psf)	$k_{2,max}$ = 140 [2] v = 0.3	$k_{2,max}$ = 36 [2] v = 0.3
Bulk modulus, K (psf)	G_{max} = ($k_{2,max}$, p', p_{atm}) [3] K = (G_{max}, v) [4]	G_{max} = ($k_{2,max}$, p', p_{atm}) [3] K = (G_{max}, v) [4]
Friction Angle, φ	Leps Angular Sand [5]	32
Cohesion, c (psf) [6]	10	10
Tension, σ^t	0	0
Dilation, ψ	0	0
Stiffness exponent, n	2.0	3.5
Failure ratio, R_f	0.5	0.98
Virgin loading reduction factor, Mod_1	0.8	0.8
Permanent large strain modulus reduction factor, Mod_2	1.0	1.0
Reference atmospheric pressure, p_{atm} (psf)	2116	2116

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NOTES:

1. MATERIAL DENSITY THE SAME AS USED IN THE STATIC ANALYSES.
2. $k_{2,max}$ FROM IN SITU SEISMIC TESTING.
3. $G_{max} = 21.7 * k_{2,max} * p_{atm} * (p' / p_{atm})^{0.5}$, where $p' = (\sigma'_1 + \sigma'_3) / 2$.
4. $K = [2 * G_{max}(1 + v)] / [3 * (1 - 2 * v)]$
5. LEPS ANGULAR SAND FUNCTION CAPPED AT 38.5°: $\varphi = -2.447 * LN(p') + 59.815$, where $p' = (\sigma'_1 + \sigma'_3) / 2$ in psf.
6. APPLIED FOR NUMERICAL STABILITY.

0	19SEP'24	ISSUED WITH REPORT VA101-126/24-5	MJB2	SY
REV	DATE	DESCRIPTION	PREP'D	RVW'D

Knight Piésold CONSULTING

TABLE G1.3

MONTANA RESOURCES, LLC
MONTANA RESOURCES

FLAC MATERIAL PROPERTIES
CALIBRATED PM4SAND MATERIAL PROPERTIES

Print Sep/20/24 11:21:26

Type	Property	Unit		
		Saturated Rockfill	Saturated Tailings	Overburden
Primary Input Parameter	Apparent relative density, D_R	0.65	0.4	0.5
	Shear modulus coefficient, G_o	3040	785	1800
	Contraction rate parameter, h_{po}	1.5	= 0.2846 * EXP(3.105E-4 * σ'_{vc}) [3] Capped at 4.0	=2.447E-5 * σ'_{vc} + 0.1689 [3] Capped at 1.0
	Atmospheric pressure, p_{atm} (psf)	2116	2116	2116
	FirstCall	[4]	[4]	[4]
	PostShake	[5]	[5]	[5]
Secondary Input Parameter [6]	h_o	Default	Default	Default
	e_{max} and e_{min}	Default	Default	Default
	n^b	0.125	0.25	0.15
	n^d	Default	Default	Default
	A_{do}	Default	Default	Default
	z_{max}	Default	Default	Default
	C_Z	Default	Default	Default
	C_ε	Default	Default	Default
	φ'_{cv}	Default	Default	35 [7]
	v_o	Default	Default	Default
	C_{GD}	Default	Default	Default
	C_{Dr}	Default	Default	Default
	$C_{K\alpha f}$	Default	Default	Default
	Q	Default	Default	Default
	R	Default	Default	Default
	m	Default	Default	Default
	$F_{sed,min}$	Default	Default	Default
	$p'_{sed,o}$	Default	Default	Default
	cr_{hg}	Default	Default	Default
	c_{hg}	Default	Default	Default

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NOTES:

1. MATERIAL DENSITY THE SAME AS USED IN THE STATIC ANALYSES.
2. SHEAR MODULUS COEFFICIENT SELECTED USING IN SITU SEISMIC TEST RESULTS.
3. σ'_{vc} IS INITIAL VERTICAL EFFECTIVE STRESS.
4. FIRSTCALL FLAG SET TO 0.0 AT MODEL INITIATION AND RESET TO 0.0 PRIOR TO INITIATING DYNAMIC EARTHQUAKE LOADING.
5. POSTSHAKE FLAG SET TO 1.0 AT THE END OF STRONG SHAKING.
6. REFER TO BOULANGER AND ZIOTOPOULOU (2023) FOR DEFAULT PARAMETER VALUES.
7. SELECTED FROM TRIAXIAL TESTING OF DH15-S5 SAMPLES 25 AND 27 (IN 2015) AND DH18-01 (IN 2022).

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT VA101-126/24-5	MJB2	SY

Knight Piésold CONSULTING

TABLE G1.4

MONTANA RESOURCES, LLC
MONTANA RESOURCES

FLAC MATERIAL PROPERTIES
PROPERTIES FOR POST-EARTHQUAKE ANALYSIS

Print Sep/20/24 11:21:26

Unit	Residual Shear Strength Ratio S_r/σ'_{vc}
Overburden	0.22
Rockfill	0.31
Tailings	0.05

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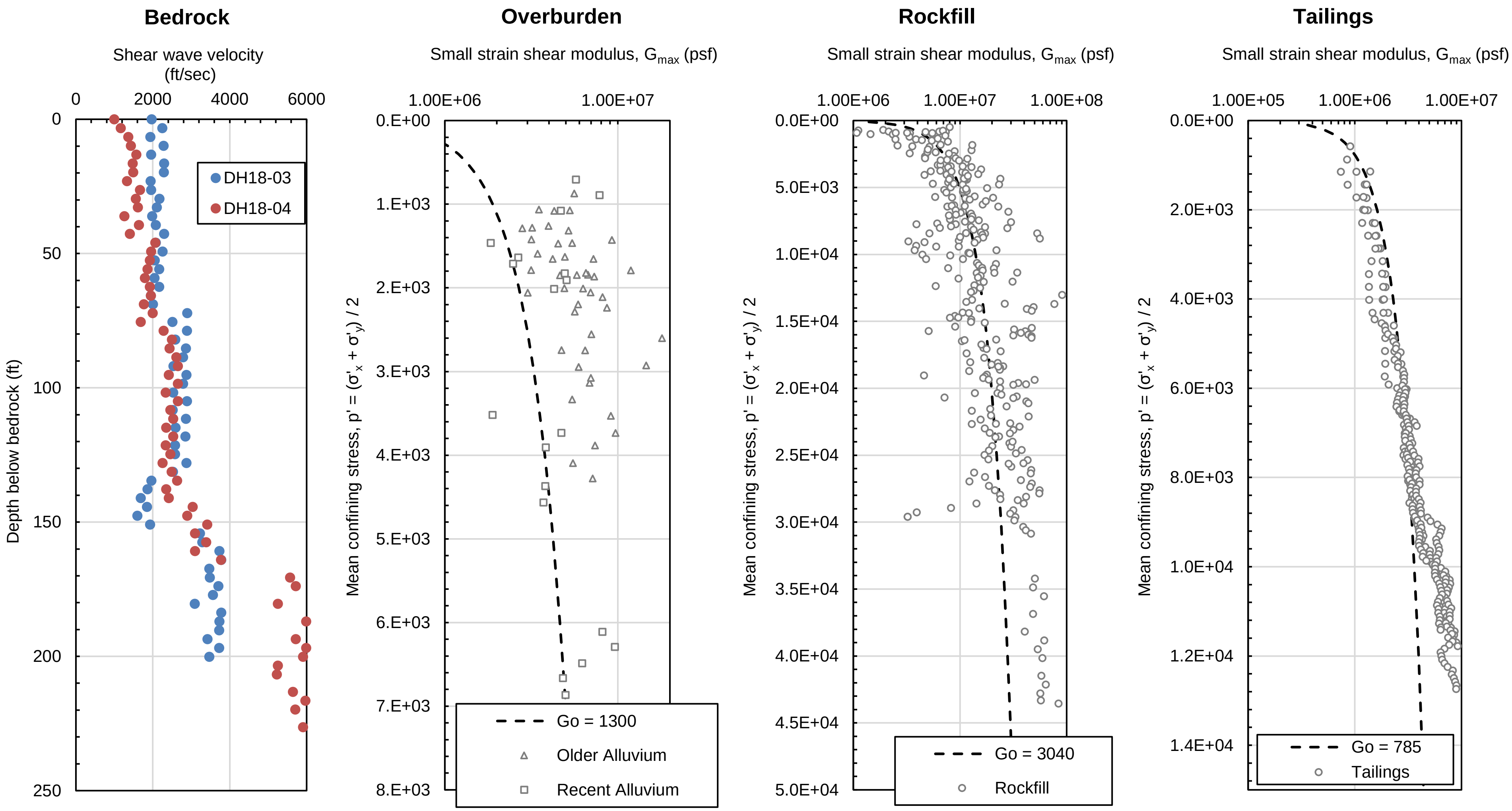
NOTES:

1. TAILINGS RESIDUAL STRENGTH RATIO ESTIMATED LOWER BOUND VALUE.

0	19SEP'24	ISSUED WITH REPORT VA101-126/24-5	MJB2	SY
REV	DATE	DESCRIPTION	PREP'D	RVW'D



NOTES:

1. POINTS FROM IN SITU (SCPT OR DOWNHOLE SEISMIC) TESTING DATA.
2. SMALL STRAIN SHEAR MODULUS, $G_{max} = G_o * p_{atm} * (p' / p_{atm})^{0.5}$.
3. $G_o = 21.7 * k_{2,max}$.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	MJB2	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

FLAC MATERIAL PROPERTIES
STIFFNESS PROFILES

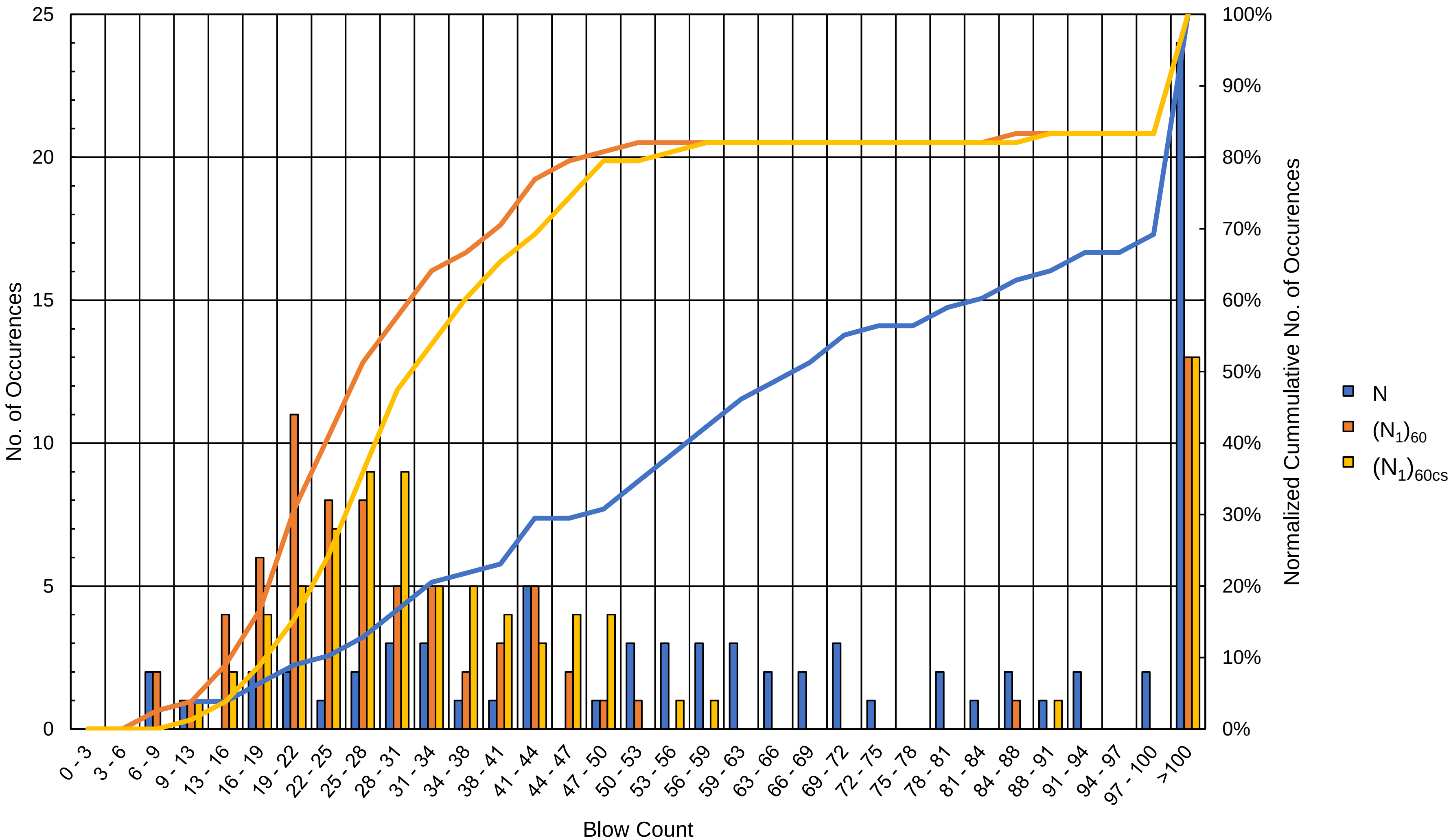
Knight Piésold CONSULTING

P/A NO. VA101-126/24

REF. NO. 5

FIGURE G1.1

REV 0



NOTES:

1. DATA FROM DH15-S3, DH15-S4, DH15-S5, AND DH15-09.
2. FINES CONTENT ADJUSTMENT PERFORMED WITH A FINES CONTENT OF 20%.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SRS	MJB2

MONTANA RESOURCES, LLC

MONTANA RESOURCES

MATERIAL PROPERTIES
ROCKFILL BLOWCOUNTS

Knight Piésold CONSULTING

P/A NO. VA101-00126/24

REF. NO. 5

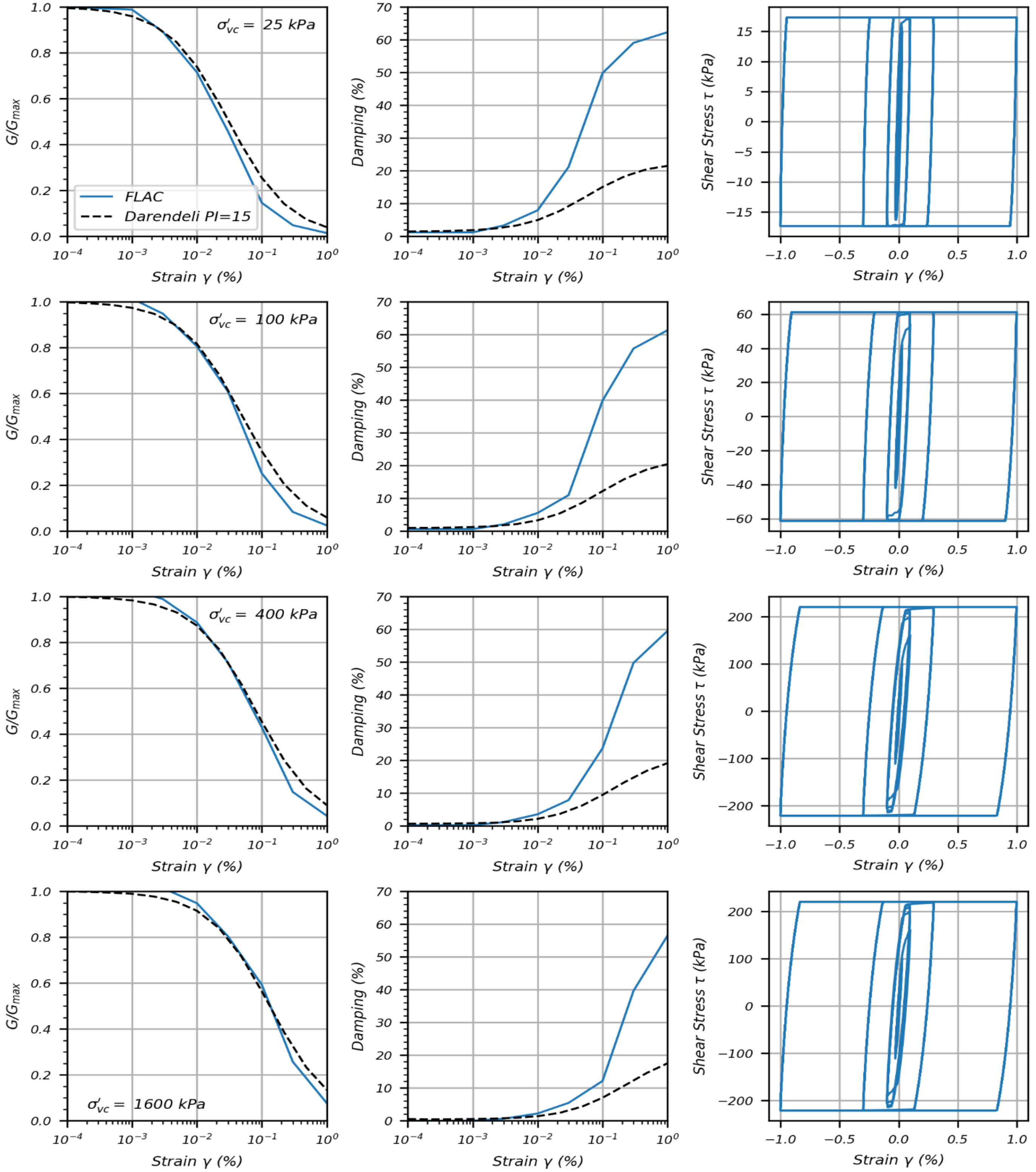
FIGURE G1.2

REV 0

APPENDIX G2

Constitutive Model Calibration

(Pages G2.1 to G2.17)



NOTES:

1. UNSATURATED ROCKFILL MODELED WITH UBCHYST.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	MJB2	GRG

MONTANA RESOURCES, LLC

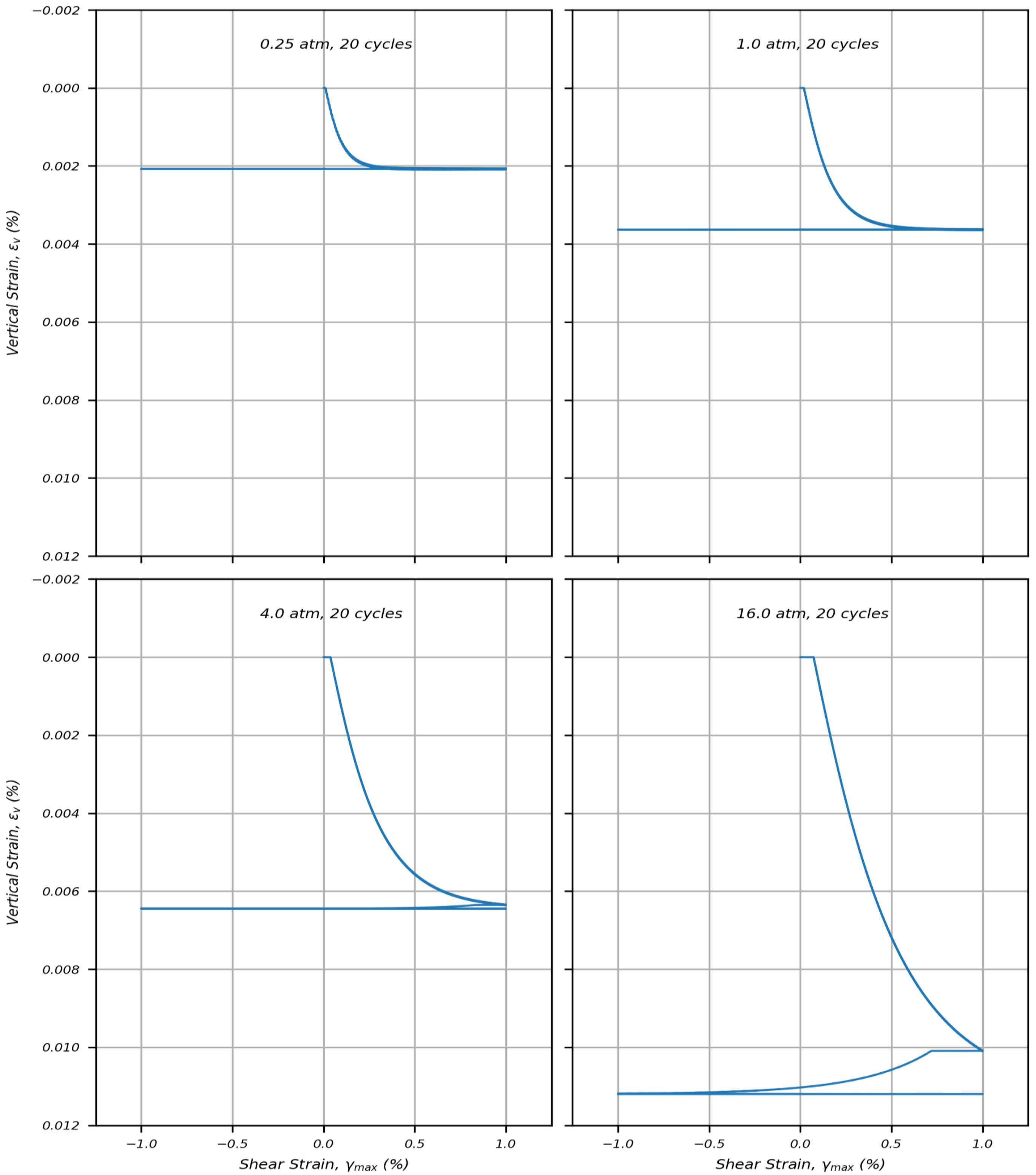
MONTANA RESOURCES

CONSTITUTIVE MODEL CALIBRATION
UNSATURATED ROCKFILL
STRAIN CONTROLLED CDSS

Knight Piésold CONSULTING

P/A NO.	REF. NO.
VA101-126/24	5

FIGURE G2.1 REV 0



NOTES:

1. UNSATURATED ROCKFILL MODELLED WITH UBCHYST.
2. CONDUCTED AT 1% SHEAR STRAIN.

MONTANA RESOURCES, LLC

MONTANA RESOURCES

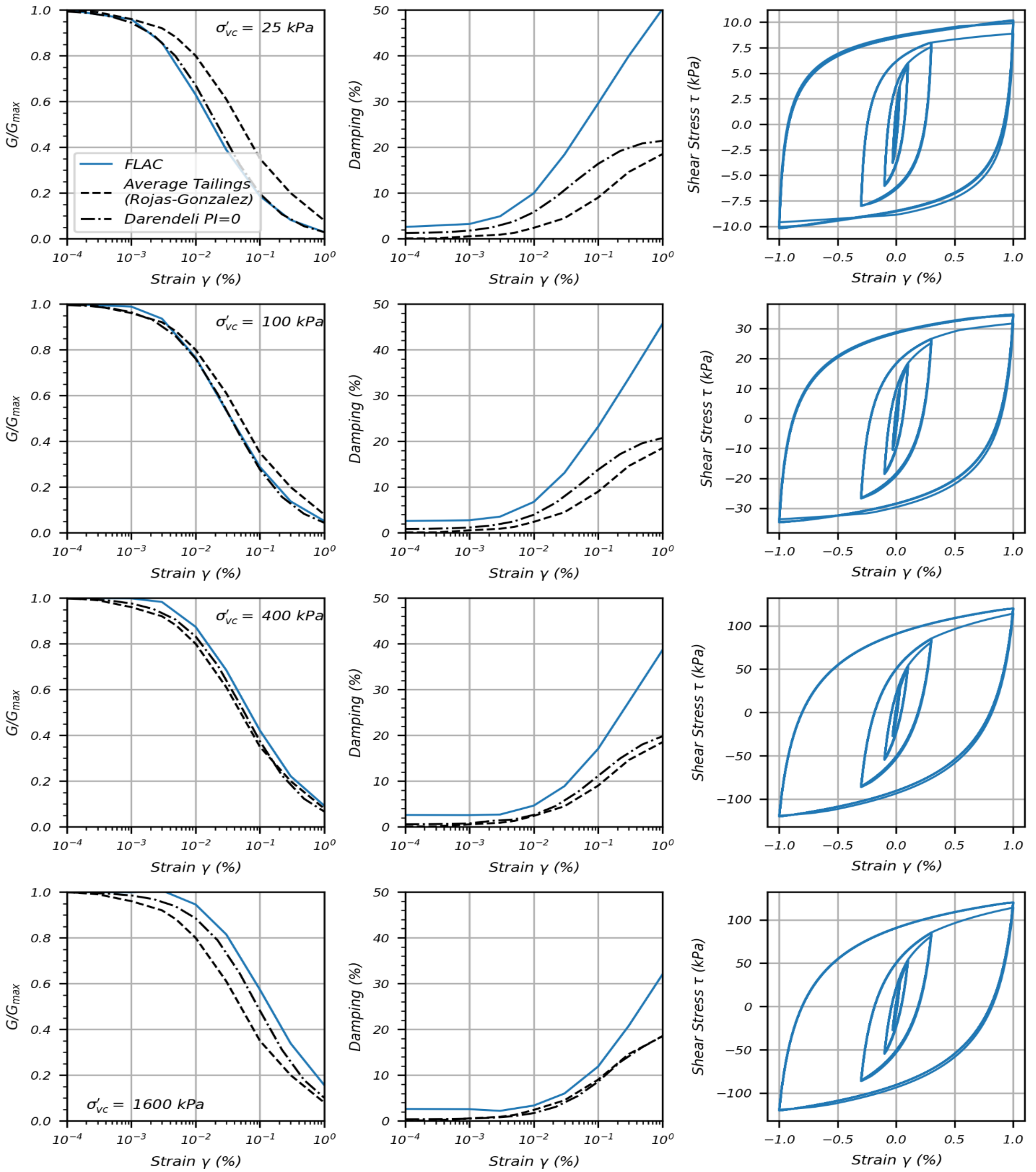
CONSTITUTIVE MODEL CALIBRATION
UNSATURATED ROCKFILL
STRAIN CONTROLLED CDSS

Knight Piésold CONSULTING

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	MJB2	GRG

P/A NO. VA101-126/24 | REF. NO. 5

FIGURE G2.2 | REV 0



NOTES:

1. UNSATURATED TAILINGS MODELED WITH UBCHYST.

MONTANA RESOURCES, LLC

MONTANA RESOURCES

CONSTITUTIVE MODEL CALIBRATION
UNSATURATED TAILINGS
STRAIN CONTROLLED CDSS

Knight Piésold CONSULTING

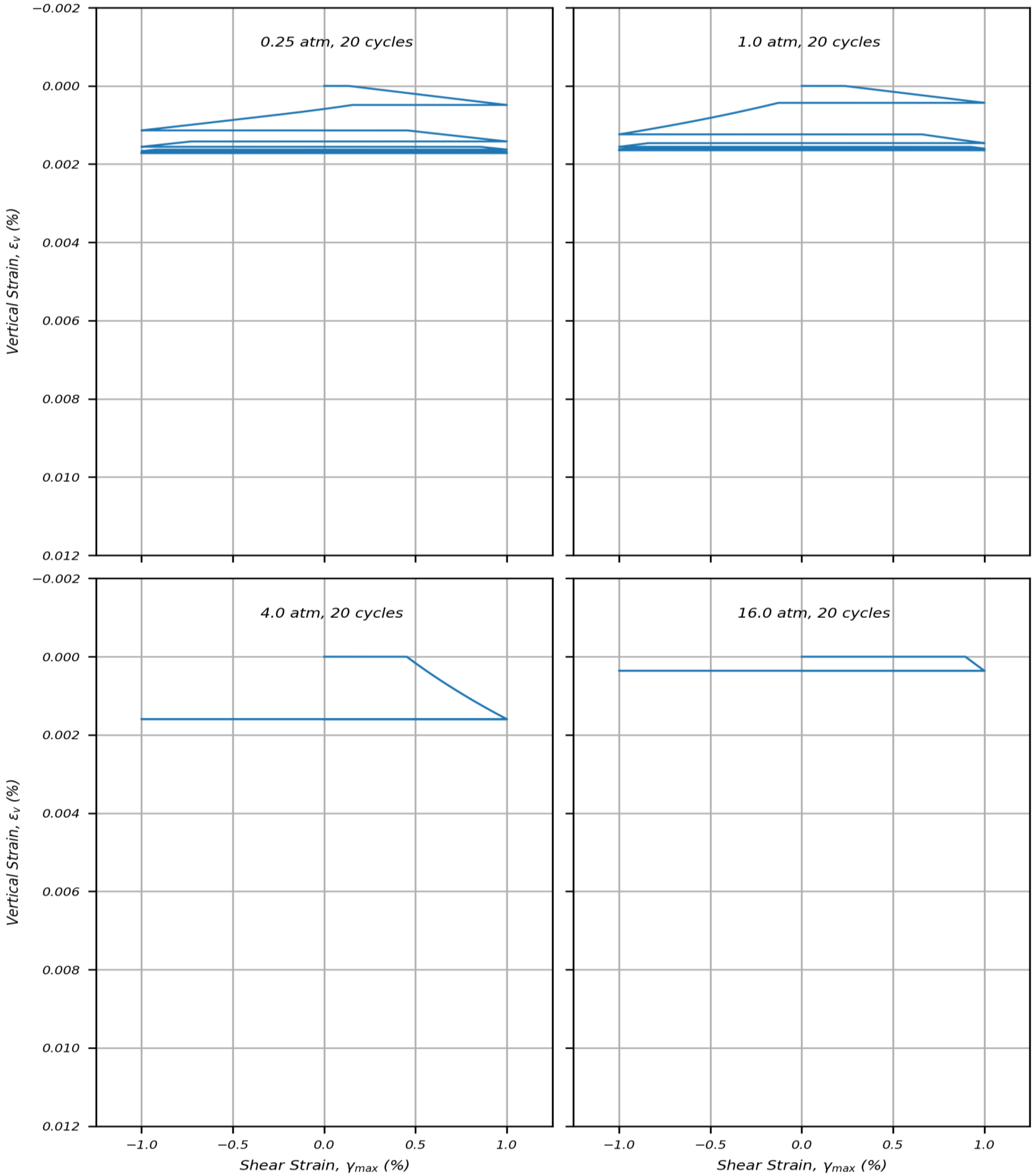
REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	MJB2	GRG

P/A NO. VA101-126/24

REF. NO. 5

FIGURE G2.3

REV 0



NOTES:

1. UNSATURATED ROCKFILL MODELLED WITH UBCHYST.
2. CONDUCTED AT 1% SHEAR STRAIN.

MONTANA RESOURCES, LLC

MONTANA RESOURCES

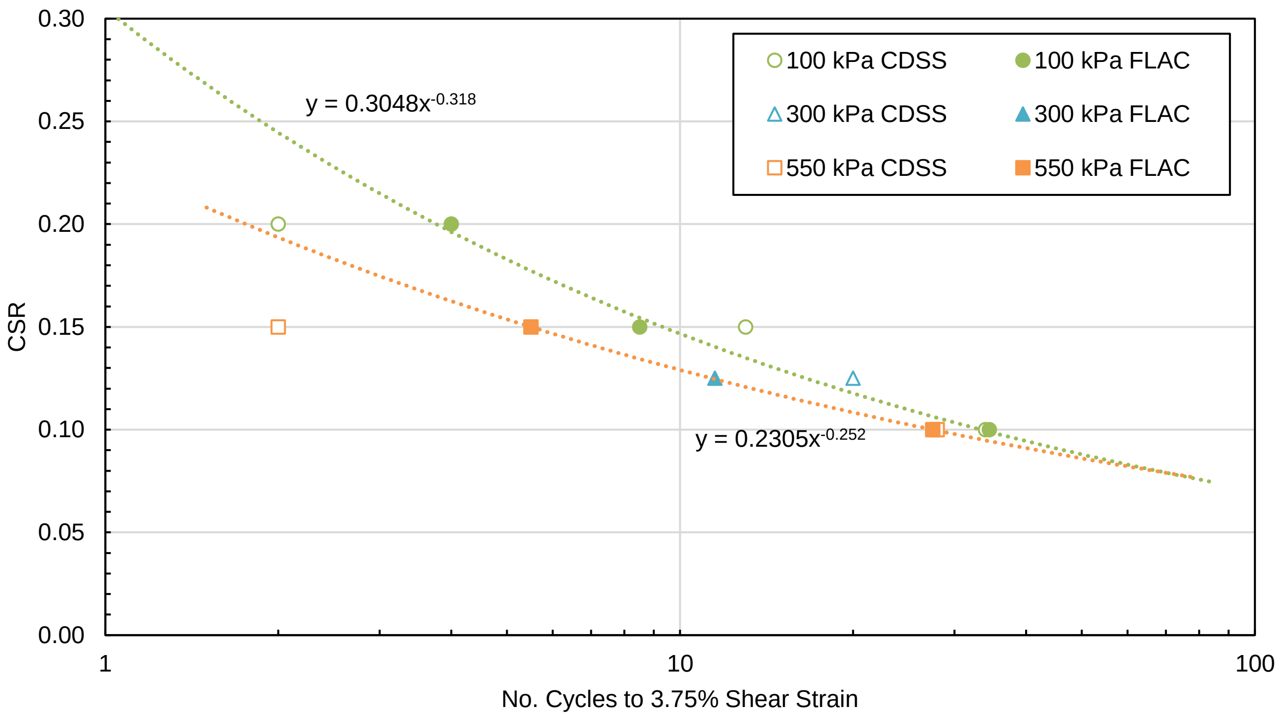
CONSTITUTIVE MODEL CALIBRATION
UNSATURATED TAILINGS
STRAIN CONTROLLED CDSS

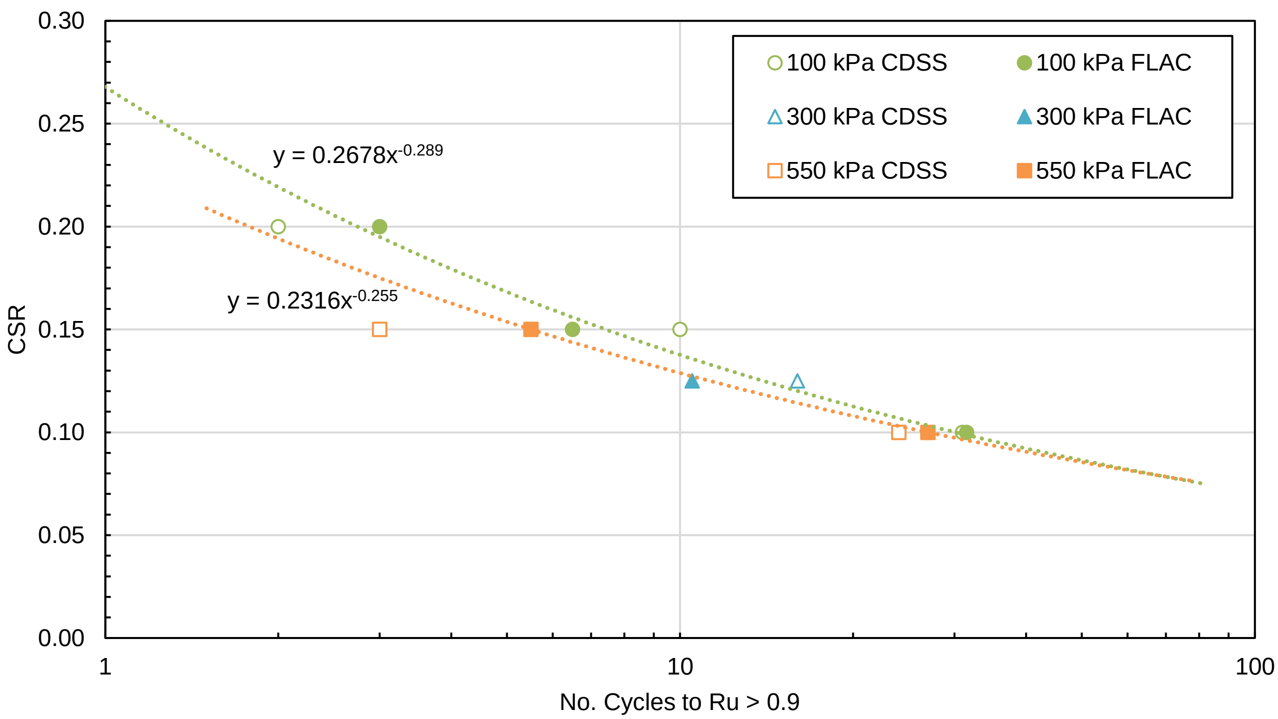
Knight Piésold CONSULTING

P/A NO.	REF. NO.
VA101-126/24	5

FIGURE G2.4 REV 0

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	MJB2	GRG





NOTES:

1. SATURATED OVERBURDEN MODELED WITH PM4SAND.

MONTANA RESOURCES, LLC

MONTANA RESOURCES

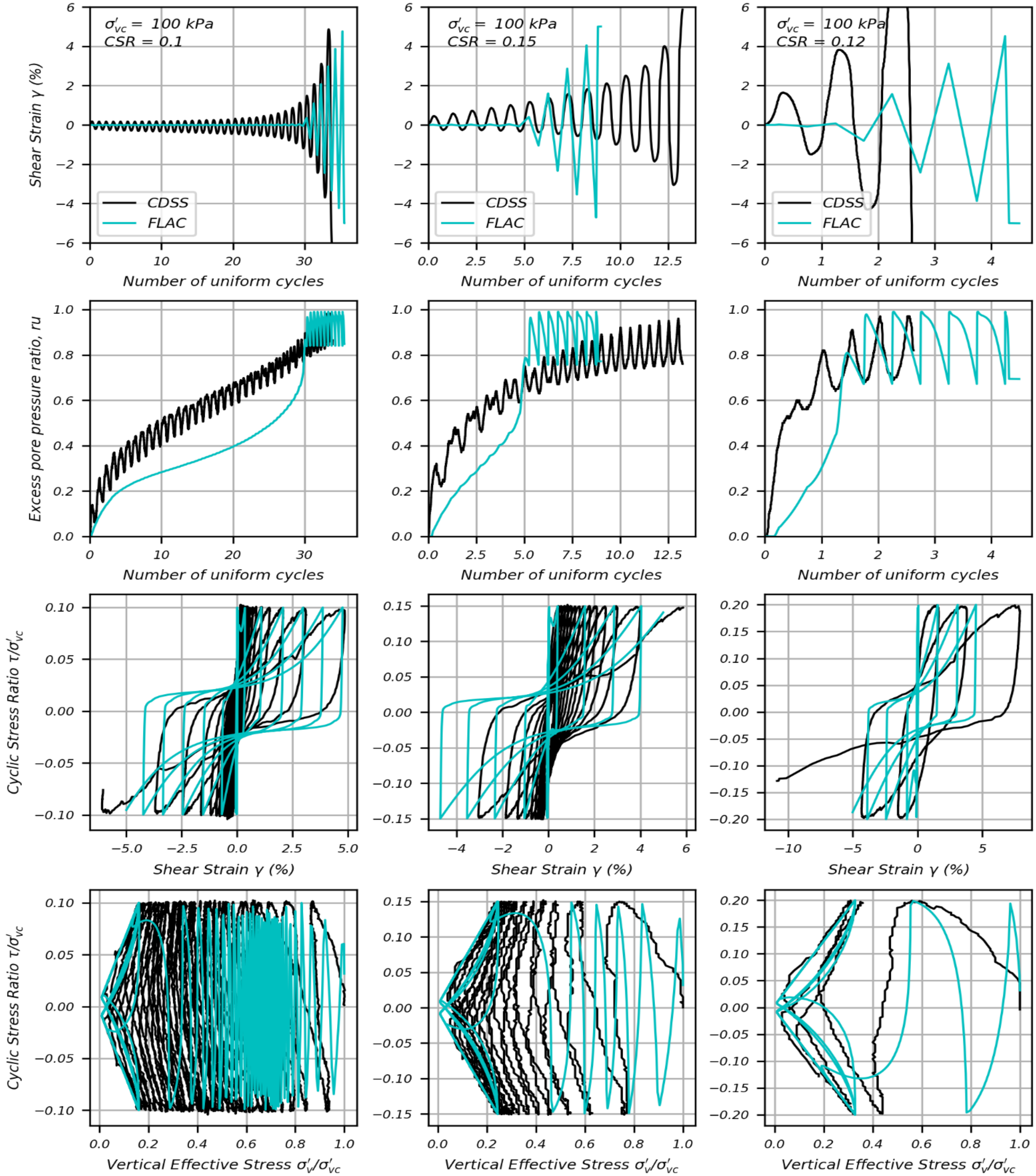
CONSTITUTIVE MODEL CALIBRATION
SATURATED OVERBURDEN
CYCLES TO LIQUEFACTION

Knight Piésold CONSULTING

P/A NO.	REF. NO.
VA101-126/24	5

FIGURE G2.5 REV 0

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	MJB2	GRG



NOTES:

1. SATURATED OVERBURDEN MODELED WITH PM4SAND.

0	19SEP'24	ISSUED WITH REPORT	MJB2	GRG
REV	DATE	DESCRIPTION	PREP'D	RVW'D

MONTANA RESOURCES, LLC

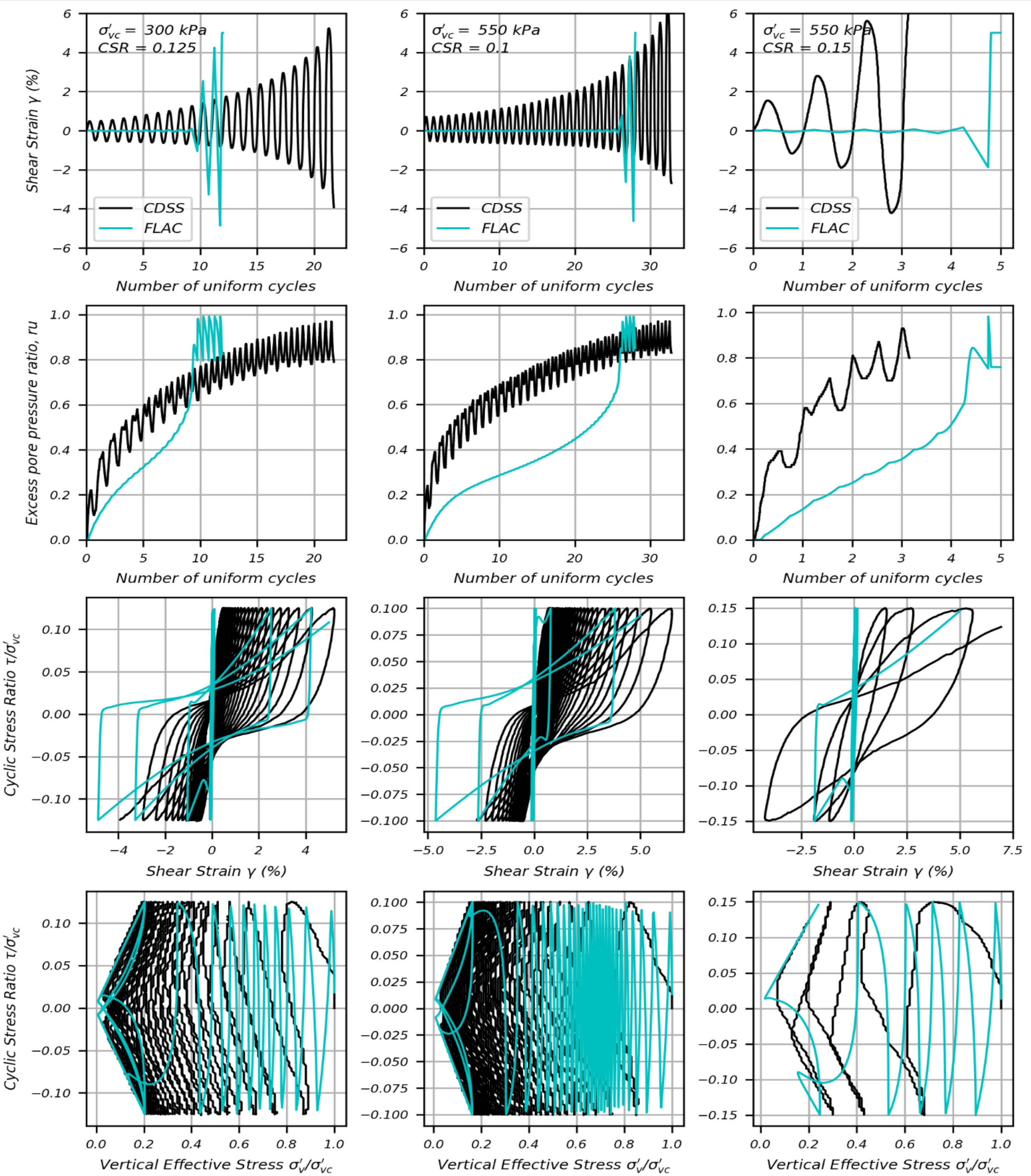
MONTANA RESOURCES

CONSTITUTIVE MODEL CALIBRATION
SATURATED OVERBURDEN
STRESS CONTROLLED CDSS (100 kPa)

Knight Piésold CONSULTING

P/A NO.	REF. NO.
VA101-126/24	5

FIGURE G2.6 REV 0



NOTES:

1. SATURATED OVERBURDEN MODELED WITH PM4SAND.

MONTANA RESOURCES, LLC

MONTANA RESOURCES

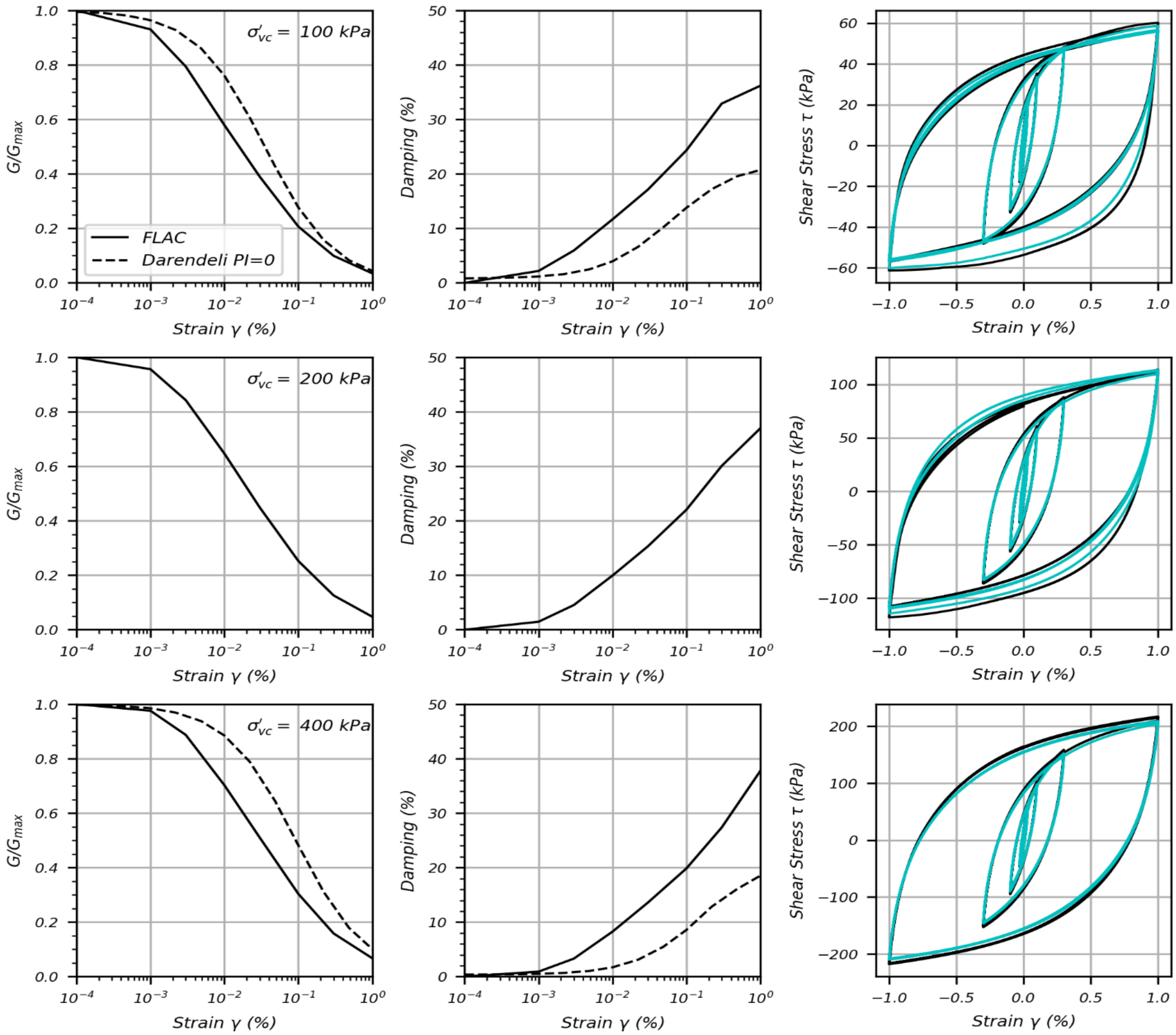
CONSTITUTIVE MODEL CALIBRATION
SATURATED OVERBURDEN
STRESS CONTROLLED CDSS (300 & 550 kPa)

Knight Piésold CONSULTING

P/A NO.	REF. NO.
VA101-126/24	5

FIGURE G2.7 REV 0

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	MJB2	GRG



NOTES:

1. SATURATED OVERBURDEN MODELED WITH PM4SAND.

MONTANA RESOURCES, LLC

MONTANA RESOURCES

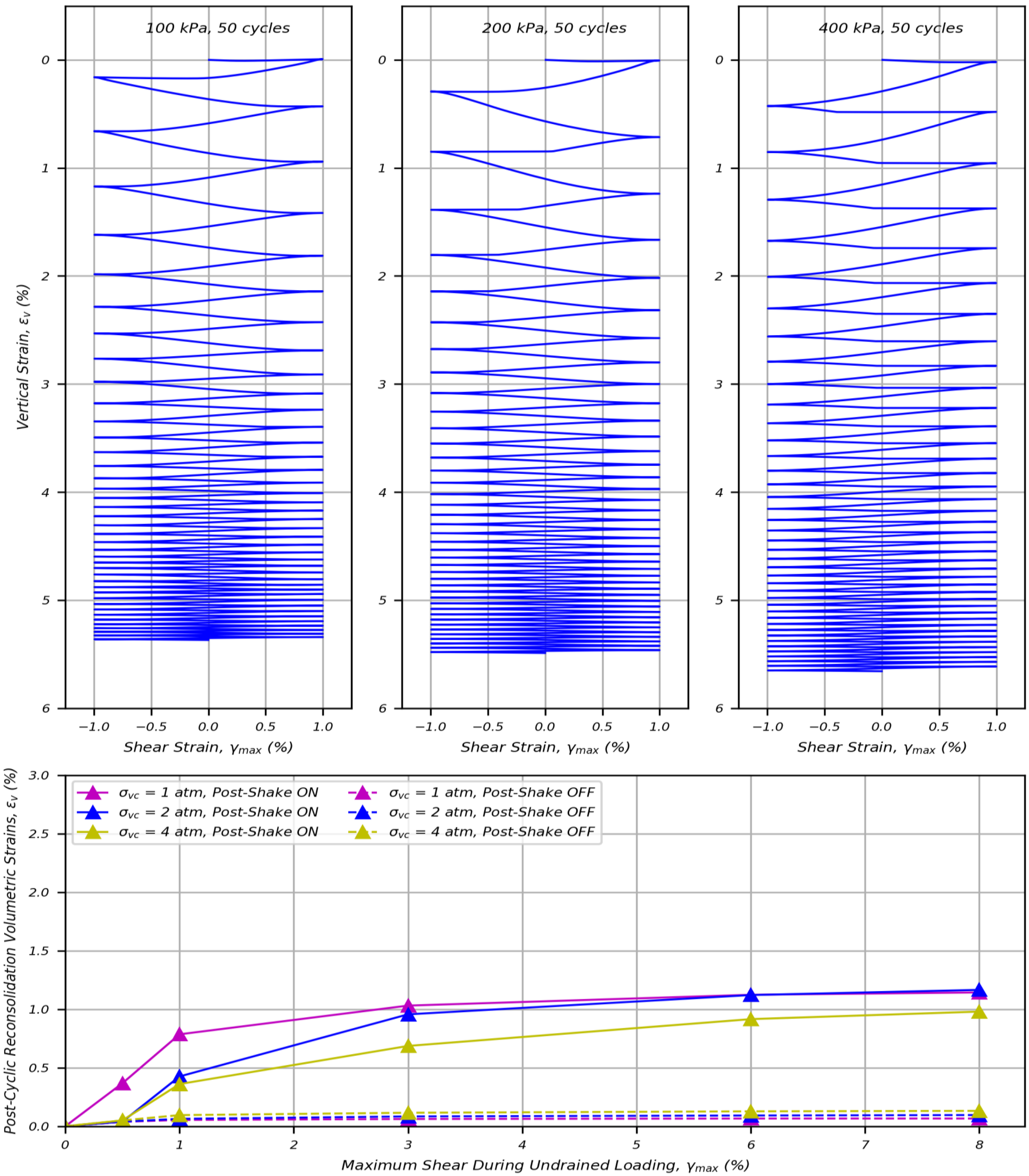
CONSTITUTIVE MODEL CALIBRATION
SATURATED OVERBURDEN
STRAIN CONTROLLED CDSS

Knight Piésold CONSULTING

P/A NO.	REF. NO.
VA101-126/24	5

FIGURE G2.8 REV 0

0	19SEP'24	ISSUED WITH REPORT	MJB2	GRG
REV	DATE	DESCRIPTION	PREP'D	RVW'D



NOTES:

1. SATURATED OVERBURDEN MODELED WITH PM4SAND.

MONTANA RESOURCES, LLC

MONTANA RESOURCES

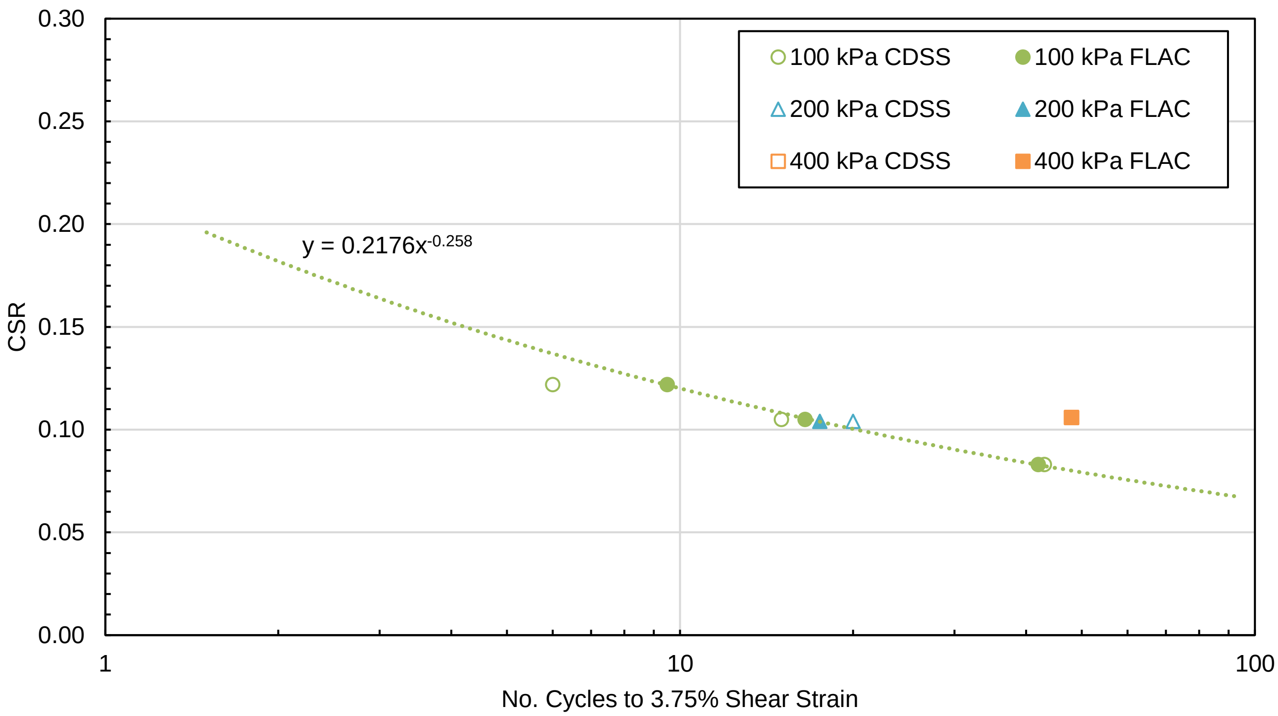
CONSTITUTIVE MODEL CALIBRATION
SATURATED OVERBURDEN
VERTICAL STRAIN AND RECONSOLIDATION

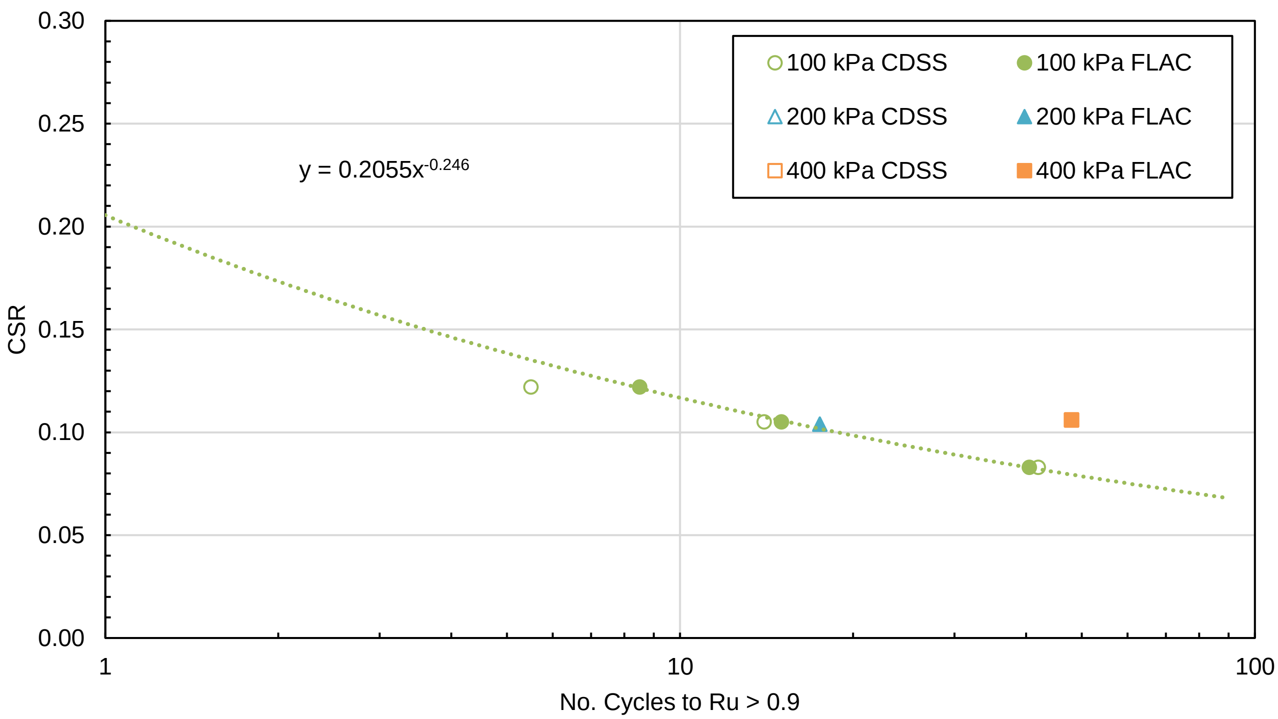
Knight Piésold CONSULTING

P/A NO.	REF. NO.
VA101-126/24	5

FIGURE G2.9 REV 0

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	MJB2	GRG





NOTES:

1. SATURATED TAILINGS MODELED WITH PM4SAND.

MONTANA RESOURCES, LLC

MONTANA RESOURCES

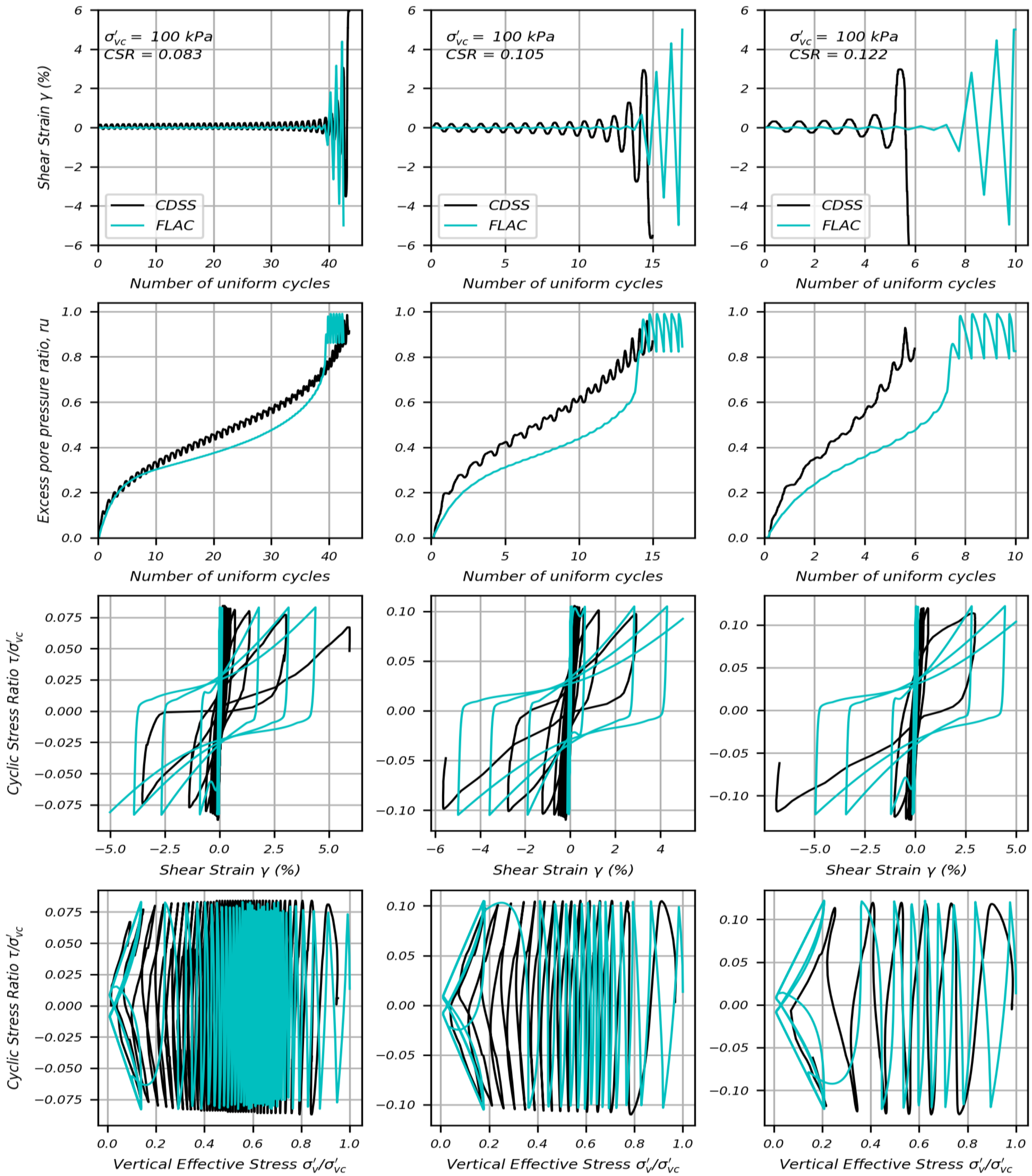
CONSTITUTIVE MODEL CALIBRATION
SATURATED TAILINGS
CYCLES TO LIQUEFACTION

Knight Piésold CONSULTING

P/A NO.	REF. NO.
VA101-126/24	5

FIGURE G2.10 REV 0

0	19SEP'24	ISSUED WITH REPORT	MJB2	GRG
REV	DATE	DESCRIPTION	PREP'D	RVW'D



NOTES:

1. SATURATED TAILINGS MODELED WITH PM4SAND.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	MJB2	GRG

MONTANA RESOURCES, LLC

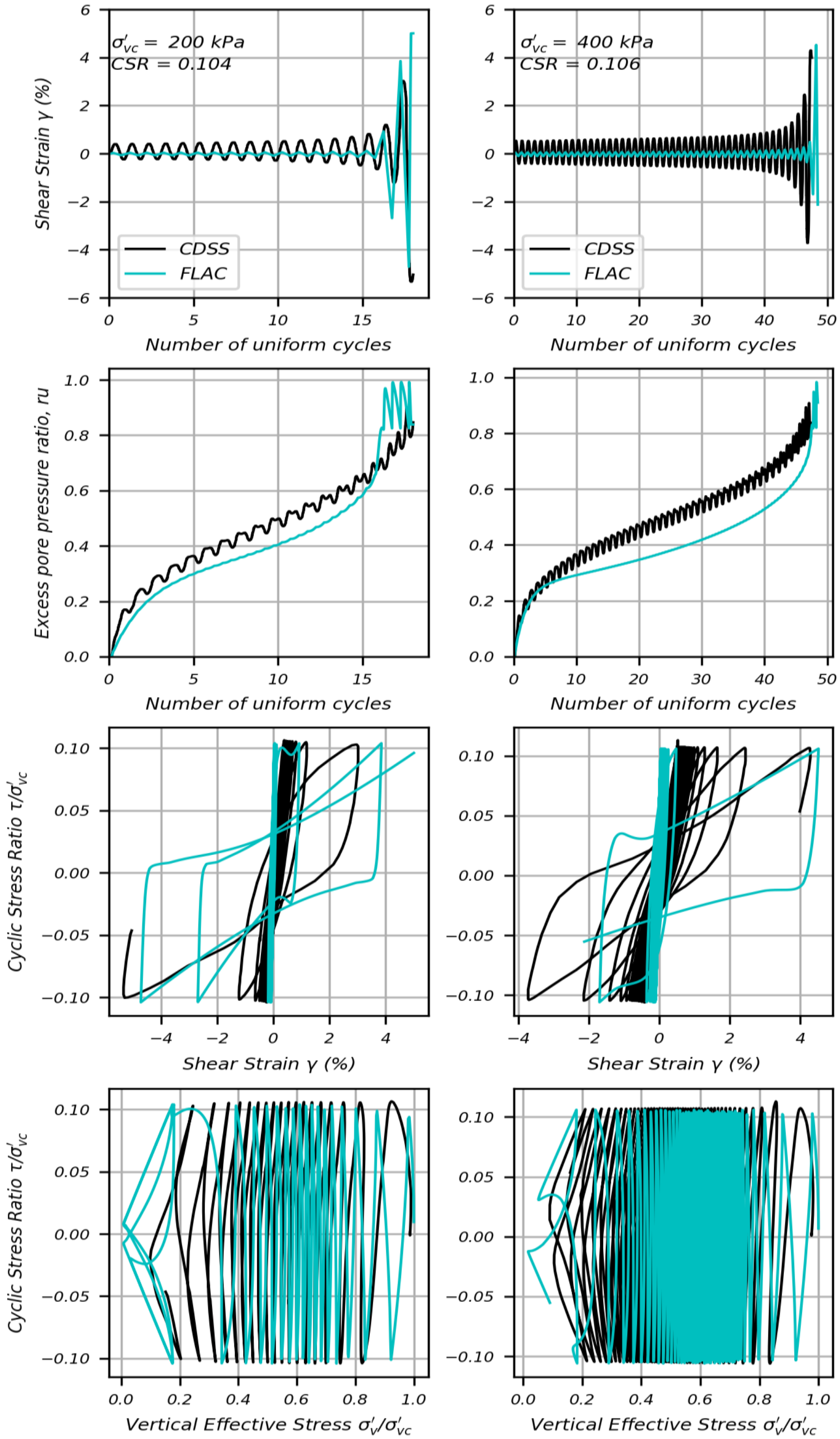
MONTANA RESOURCES

CONSTITUTIVE MODEL CALIBRATION
SATURATED TAILINGS
STRESS CONTROLLED CDSS (100 kPa)

Knight Piésold CONSULTING

P/A NO.	REF. NO.
VA101-126/24	5

FIGURE G2.11 REV 0



NOTES:

1. SATURATED TAILINGS MODELED WITH PM4SAND.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	MJB2	GRG

MONTANA RESOURCES, LLC

MONTANA RESOURCES

CONSTITUTIVE MODEL CALIBRATION
SATURATED TAILINGS
STRESS CONTROLLED CDSS (200 & 400 kPa)

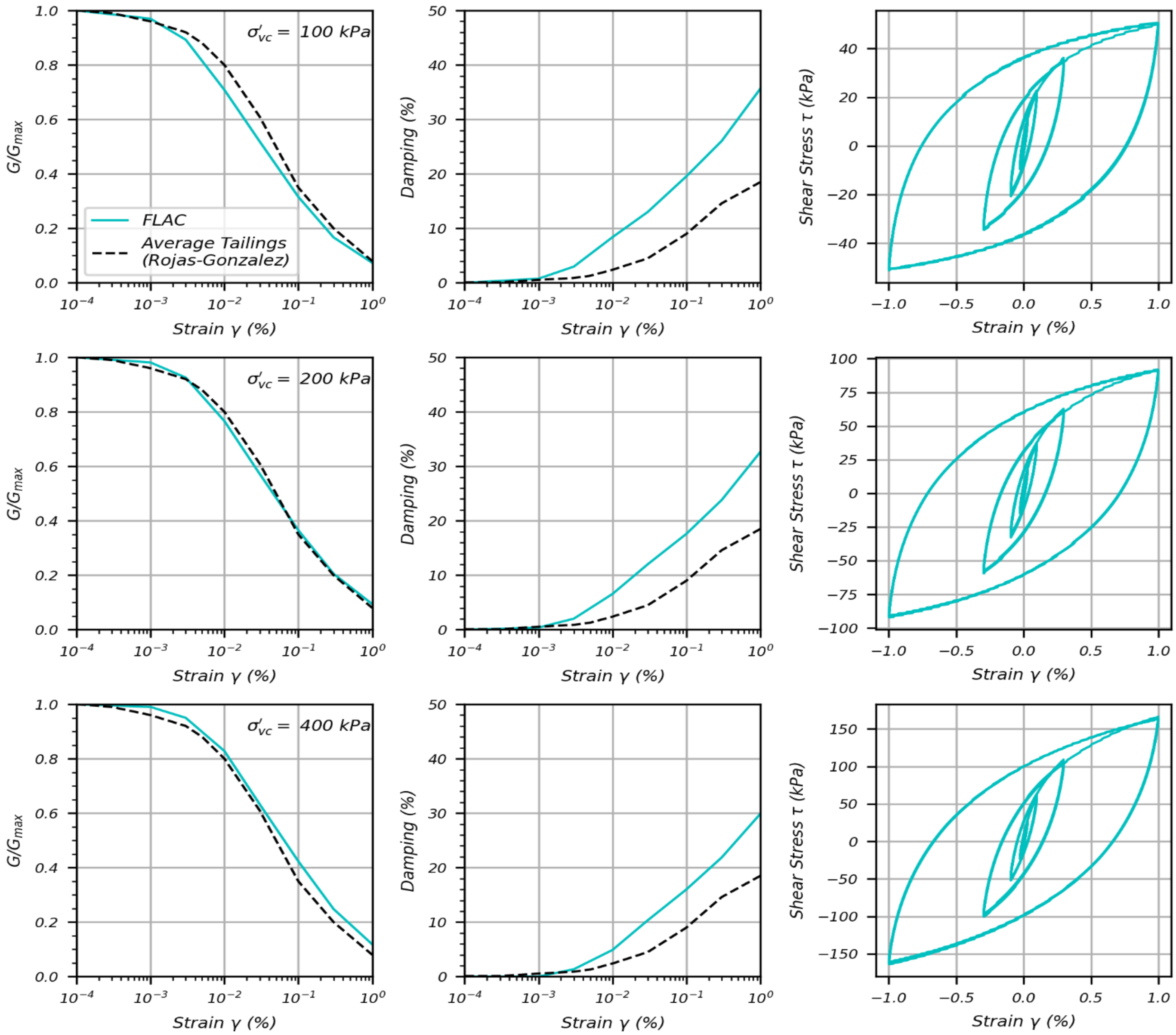
Knight Piésold CONSULTING

P/A NO. VA101-126/24

REF. NO. 5

FIGURE G2.12

REV 0



NOTES:

1. SATURATED TAILINGS MODELED WITH PM4SAND.

0	19SEP'24	ISSUED WITH REPORT	MJB2	GRG	
REV	DATE	DESCRIPTION	PREP'D	RVW'D	

MONTANA RESOURCES, LLC

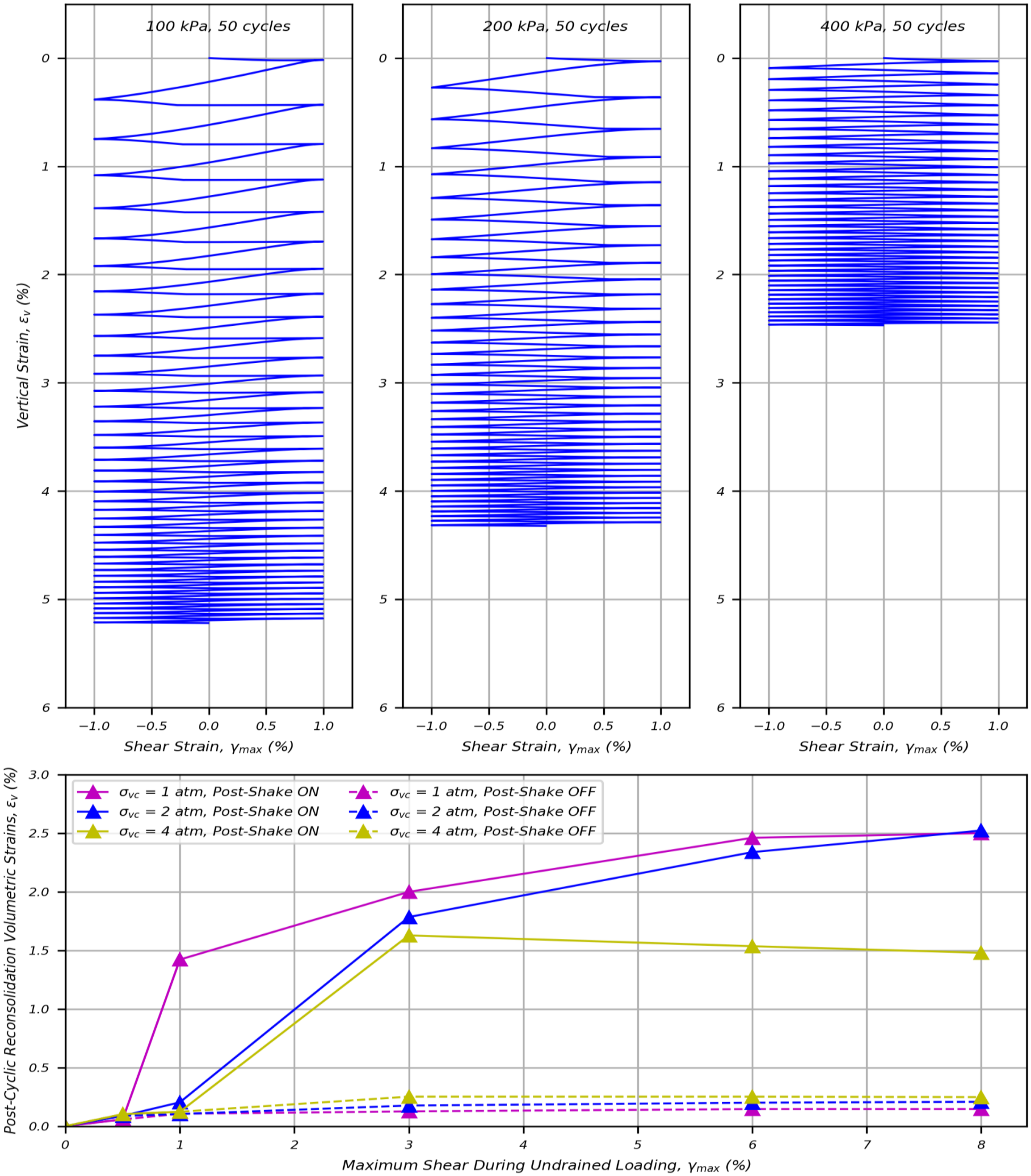
MONTANA RESOURCES

CONSTITUTIVE MODEL CALIBRATION
SATURATED TAILINGS
STRAIN CONTROLLED CDSS

Knight Piésold CONSULTING

P/A NO.	REF. NO.
VA101-126/24	5

FIGURE G2.13 REV 0



NOTES:

1. SATURATED TAILINGS MODELED WITH PM4SAND.

MONTANA RESOURCES, LLC

MONTANA RESOURCES

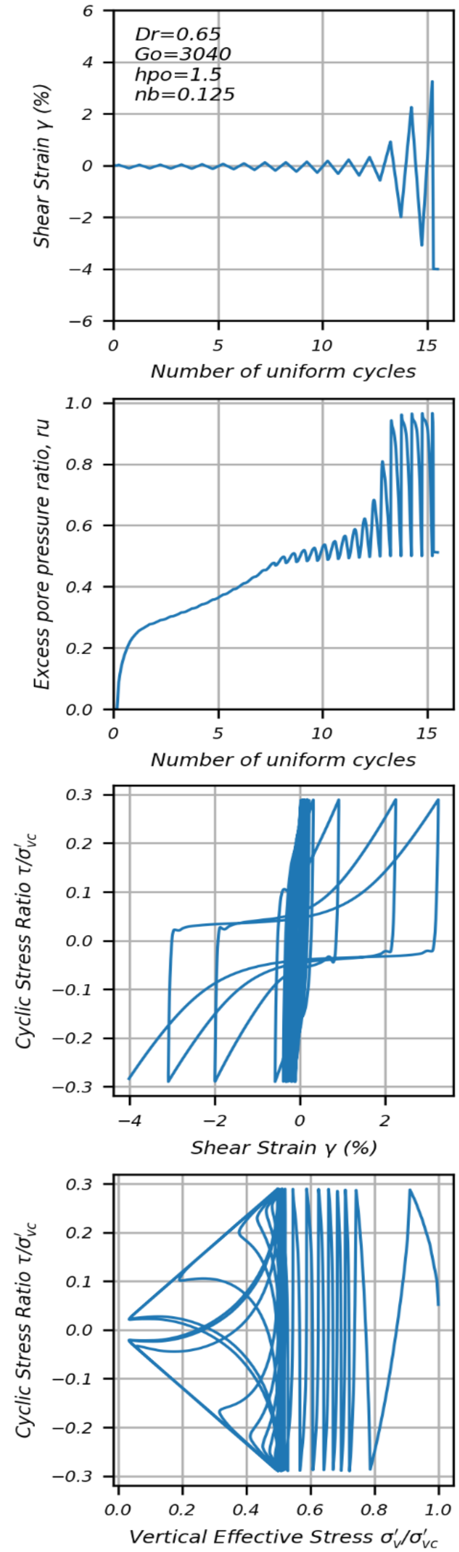
CONSTITUTIVE MODEL CALIBRATION
SATURATED TAILINGS
VERTICAL STRAIN AND RECONSOLIDATION

Knight Piésold CONSULTING

P/A NO.	REF. NO.
VA101-126/24	5

FIGURE G2.14 REV 0

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	MJB2	GRG



NOTES:

1. SATURATED ROCKFILL MODELED WITH PM4SAND.

MONTANA RESOURCES, LLC

MONTANA RESOURCES

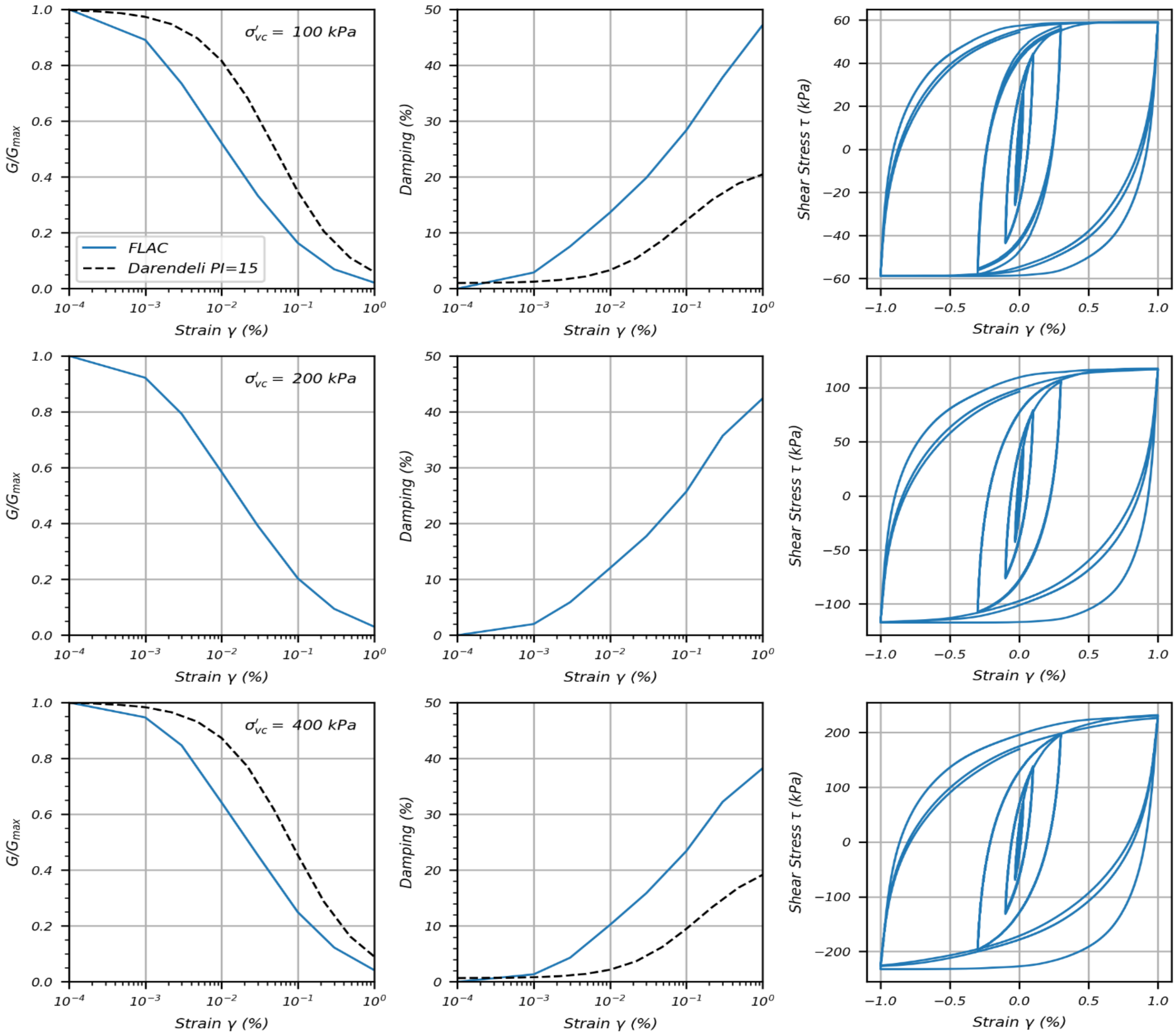
CONSTITUTIVE MODEL CALIBRATION
SATURATED ROCKFILL
STRESS CONTROLLED CDSS (100 kPa)

Knight Piésold CONSULTING

P/A NO.	REF. NO.
VA101-126/24	5

FIGURE G2.15 REV 0

0	19SEP'24	ISSUED WITH REPORT	MJB2	GRG
REV	DATE	DESCRIPTION	PREP'D	RVW'D



NOTES:

1. SATURATED ROCKFILL MODELED WITH PM4SAND.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	MJB2	GRG

MONTANA RESOURCES, LLC

MONTANA RESOURCES

CONSTITUTIVE MODEL CALIBRATION
SATURATED ROCKFILL
STRAIN CONTROLLED CDSS

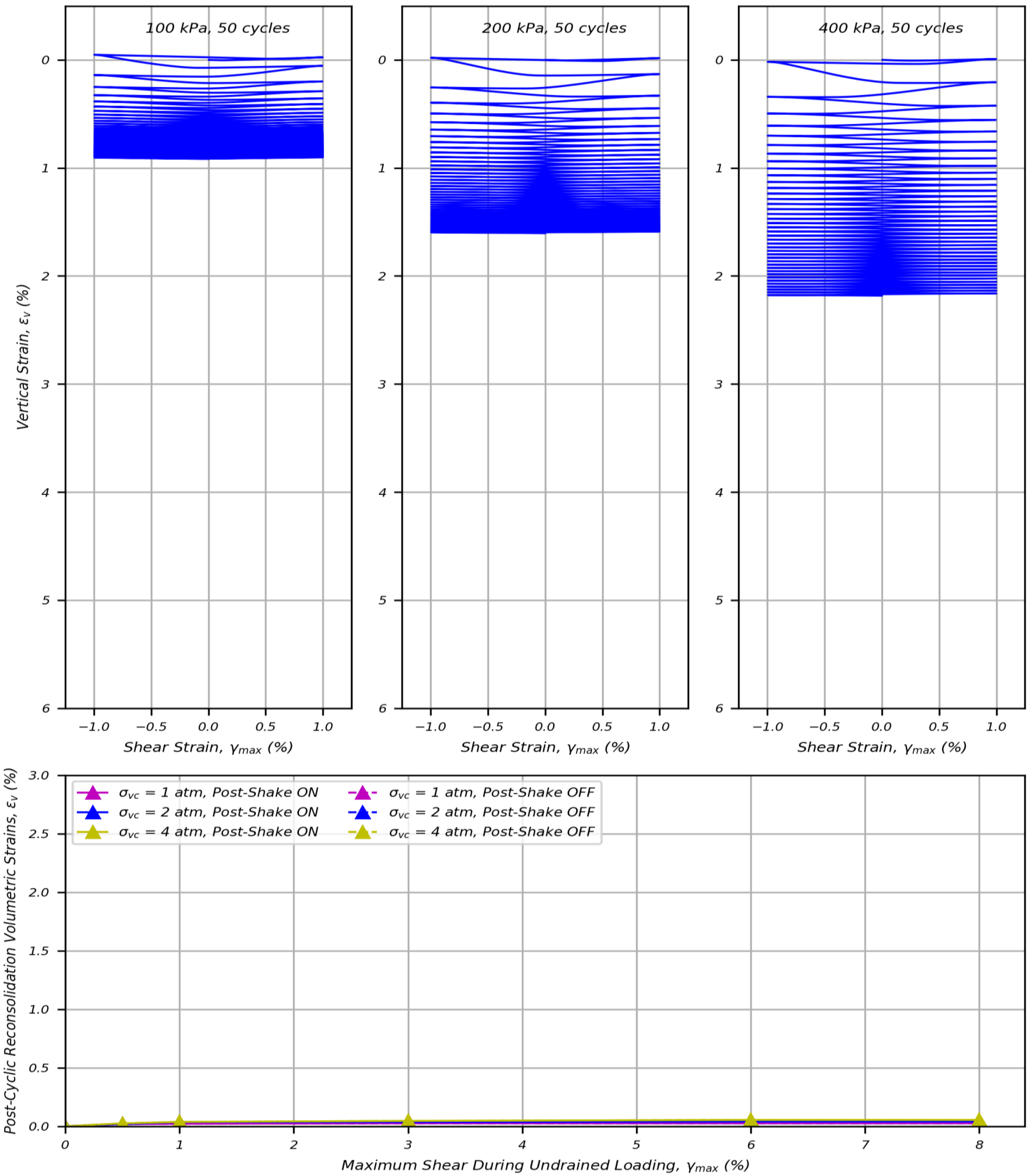
Knight Piésold CONSULTING

P/A NO. VA101-126/24

REF. NO. 5

FIGURE G2.16

REV 0



NOTES:

1. SATURATED ROCKFILL MODELED WITH PM4SAND.

MONTANA RESOURCES, LLC

MONTANA RESOURCES

CONSTITUTIVE MODEL CALIBRATION
SATURATED ROCKFILL
VERTICAL STRAIN AND RECONSOLIDATION

Knight Piésold CONSULTING

P/A NO.	REF. NO.
VA101-126/24	5

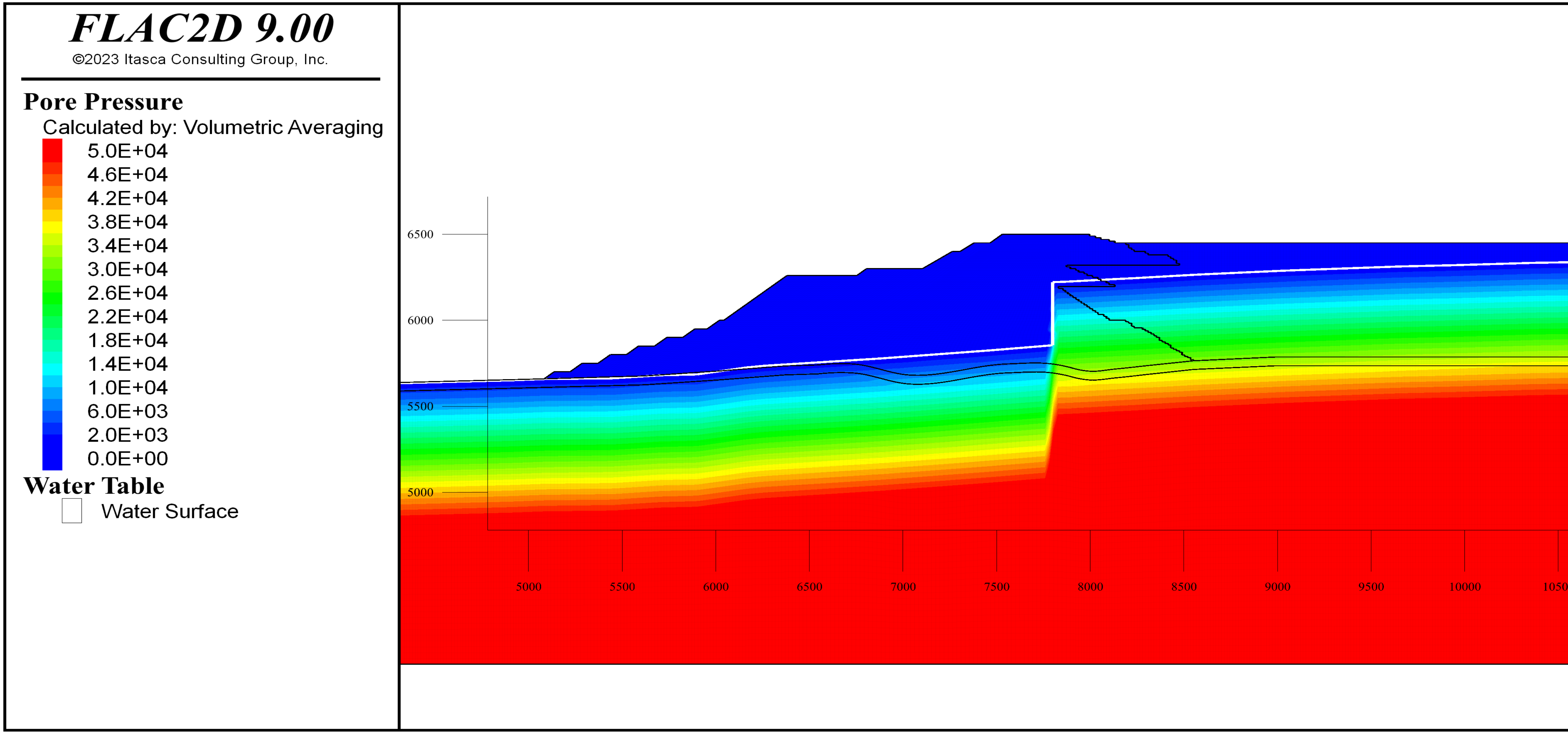
FIGURE G2.17 REV 0

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	MJB2	GRG

APPENDIX H

Dynamic Analysis Pore Pressure Conditions

(Figure H.1)



NOTES:

1. SCALE BAR UNITS ARE IN FEET.
2. PORE PRESSURE UNITS IN POUNDS PER SQUARE FEET (lb/ft^2).
3. CONTOUR RANGE SELECTED TO DISPLAY PORE PRESSURES WITHIN EMBANKMENT AND OVERBURDEN.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	MJB2

MONTANA RESOURCES, LLC

MONTANA RESOURCES

DYNAMIC DEFORMATION ANALYSIS
PORE PRESSURE CONDITIONS

Knight Piésold CONSULTING

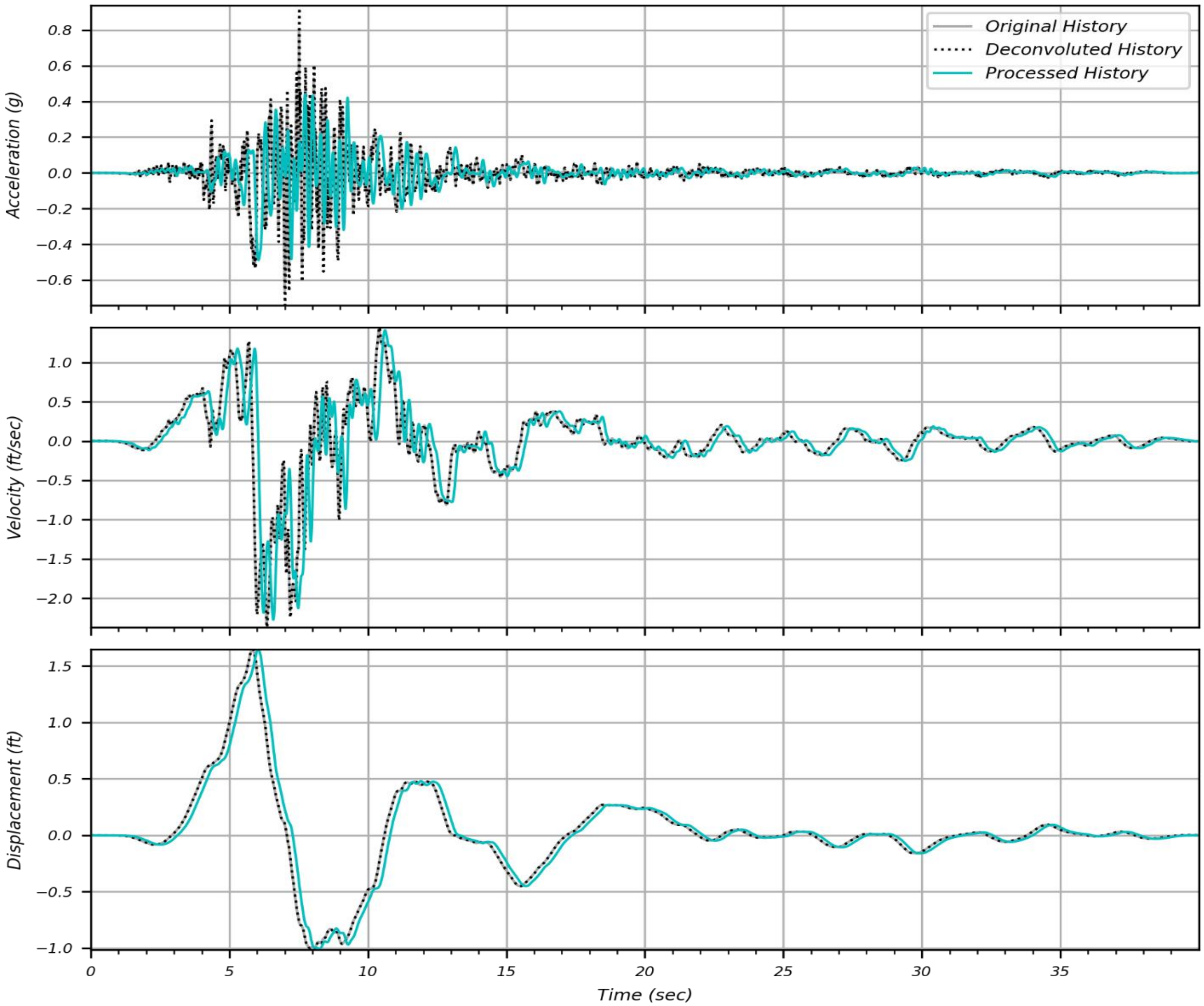
P/A NO.	REF. NO.
VA101-00126/24	5

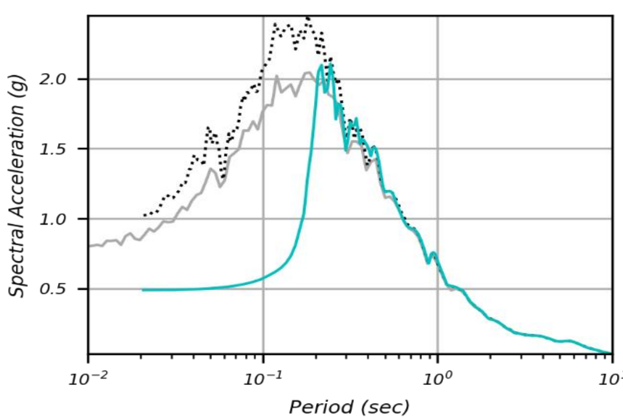
FIGURE H.1 REV 0

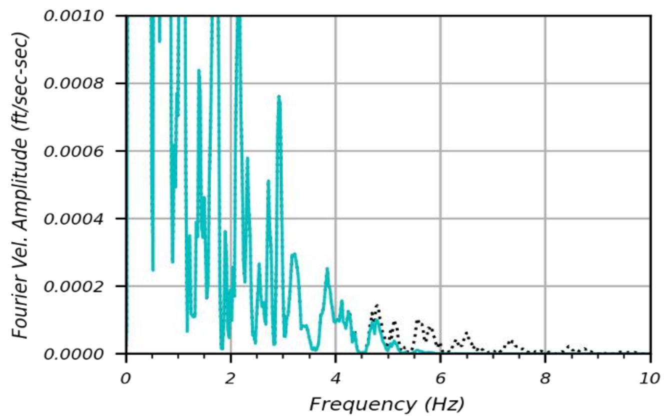
APPENDIX I

Earthquake Time Histories

(Figures I.1 to I.5)







NOTES:

1. ORIGINAL TIME HISTORY FROM AL ATIK AND GREGOR (2022).
2. HISTORY DECONVOLUTED TO THE BASE OF A BEDROCK WITH Vs = 4921 ft/sec.
3. PROCESSED HISTORY BY APPLYING BASELINE CORRECTION AND HIGH FREQUENCY FILTER.

MONTANA RESOURCES, LLC

MONTANA RESOURCES

TIME HISTORY PROCESSING
MCE 1

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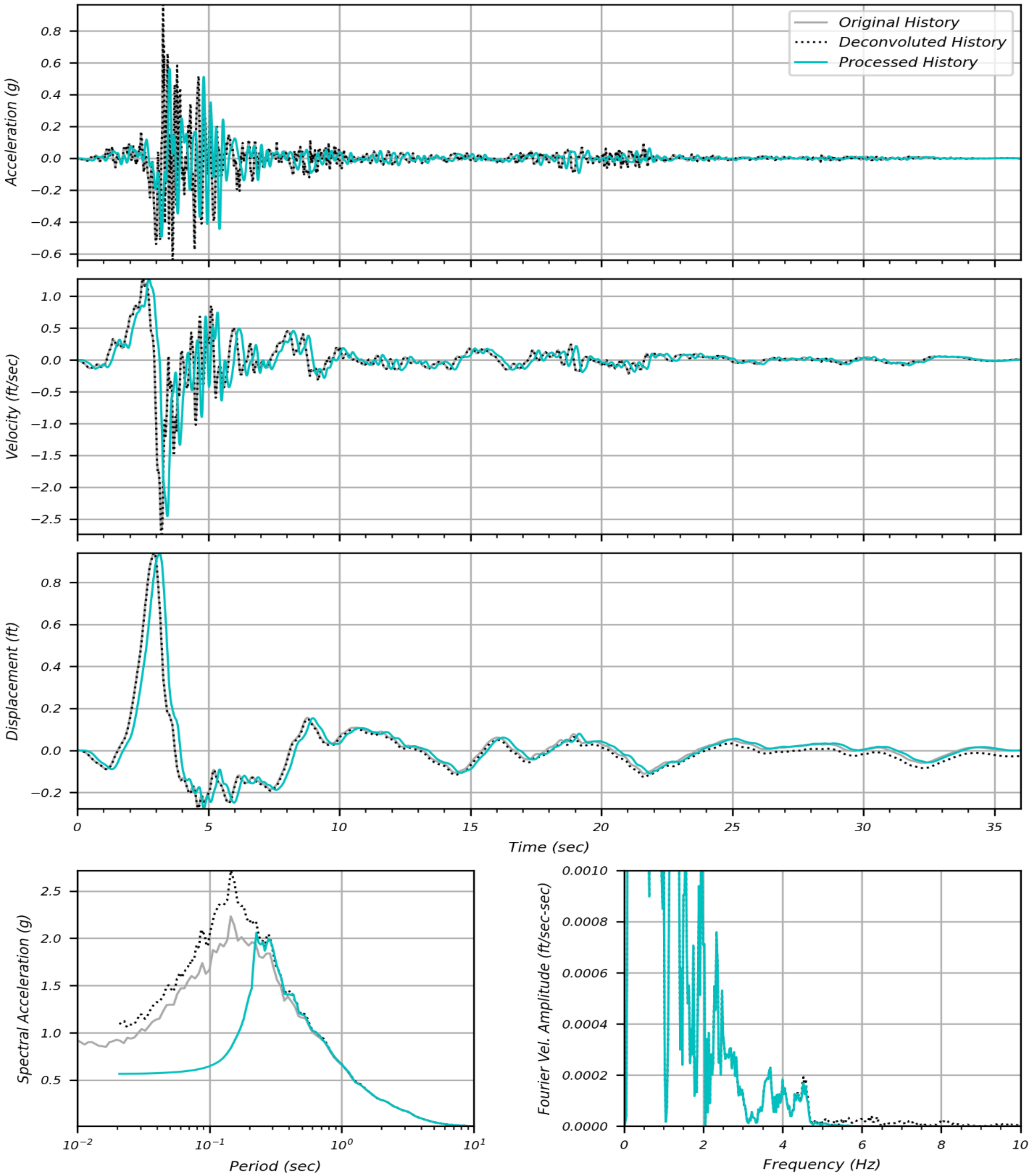
P/A NO.	REF. NO.
VA101-126/24	5

FIGURE I.1 REV 0

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	MJB2	GRG



NOTES:

1. ORIGINAL TIME HISTORY FROM AL ATIK AND GREGOR (2022).
2. HISTORY DECONVOLUTED TO THE BASE OF A BEDROCK WITH Vs = 4921 ft/sec.
3. PROCESSED HISTORY BY APPLYING BASELINE CORRECTION AND HIGH FREQUENCY FILTER.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	MJB2	GRG

MONTANA RESOURCES, LLC

MONTANA RESOURCES

TIME HISTORY PROCESSING
MCE 2

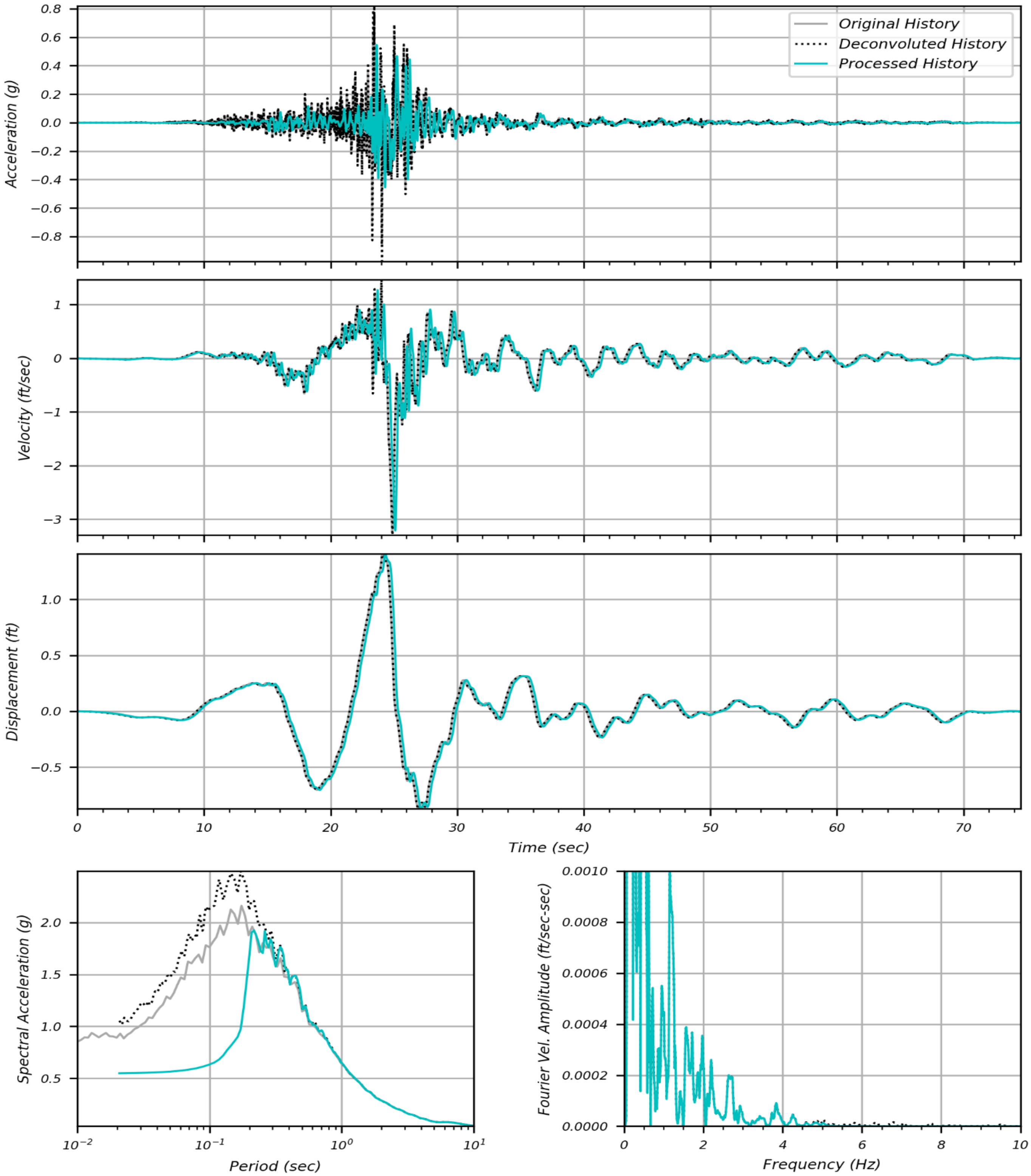
Knight Piésold CONSULTING

P/A NO. VA101-126/24

REF. NO. 5

FIGURE I.2

REV 0



NOTES:

1. ORIGINAL TIME HISTORY FROM AL ATIK AND GREGOR (2022).
2. HISTORY DECONVOLUTED TO THE BASE OF A BEDROCK WITH Vs = 4921 ft/sec.
3. PROCESSED HISTORY BY APPLYING BASELINE CORRECTION AND HIGH FREQUENCY FILTER.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	MJB2	GRG

MONTANA RESOURCES, LLC

MONTANA RESOURCES

TIME HISTORY PROCESSING
MCE 3

Knight Piésold CONSULTING

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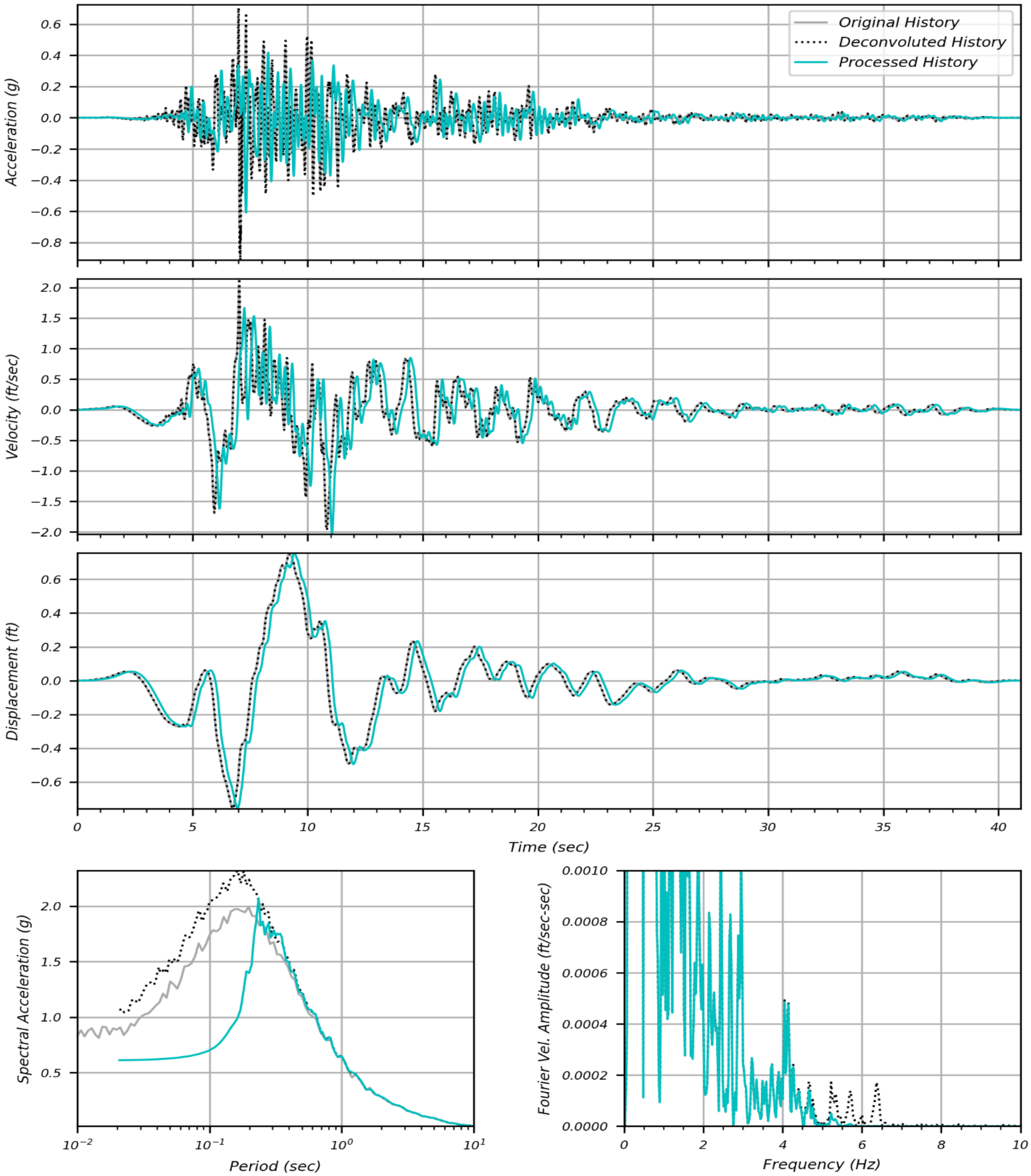
REF. NO. 5

FIGURE I.3

REV 0



NOTES:

1. ORIGINAL TIME HISTORY FROM AL ATIK AND GREGOR (2022).
2. HISTORY DECONVOLUTED TO THE BASE OF A BEDROCK WITH Vs = 4921 ft/sec.
3. PROCESSED HISTORY BY APPLYING BASELINE CORRECTION AND HIGH FREQUENCY FILTER.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	MJB2	GRG

MONTANA RESOURCES, LLC

MONTANA RESOURCES

TIME HISTORY PROCESSING
MCE 4

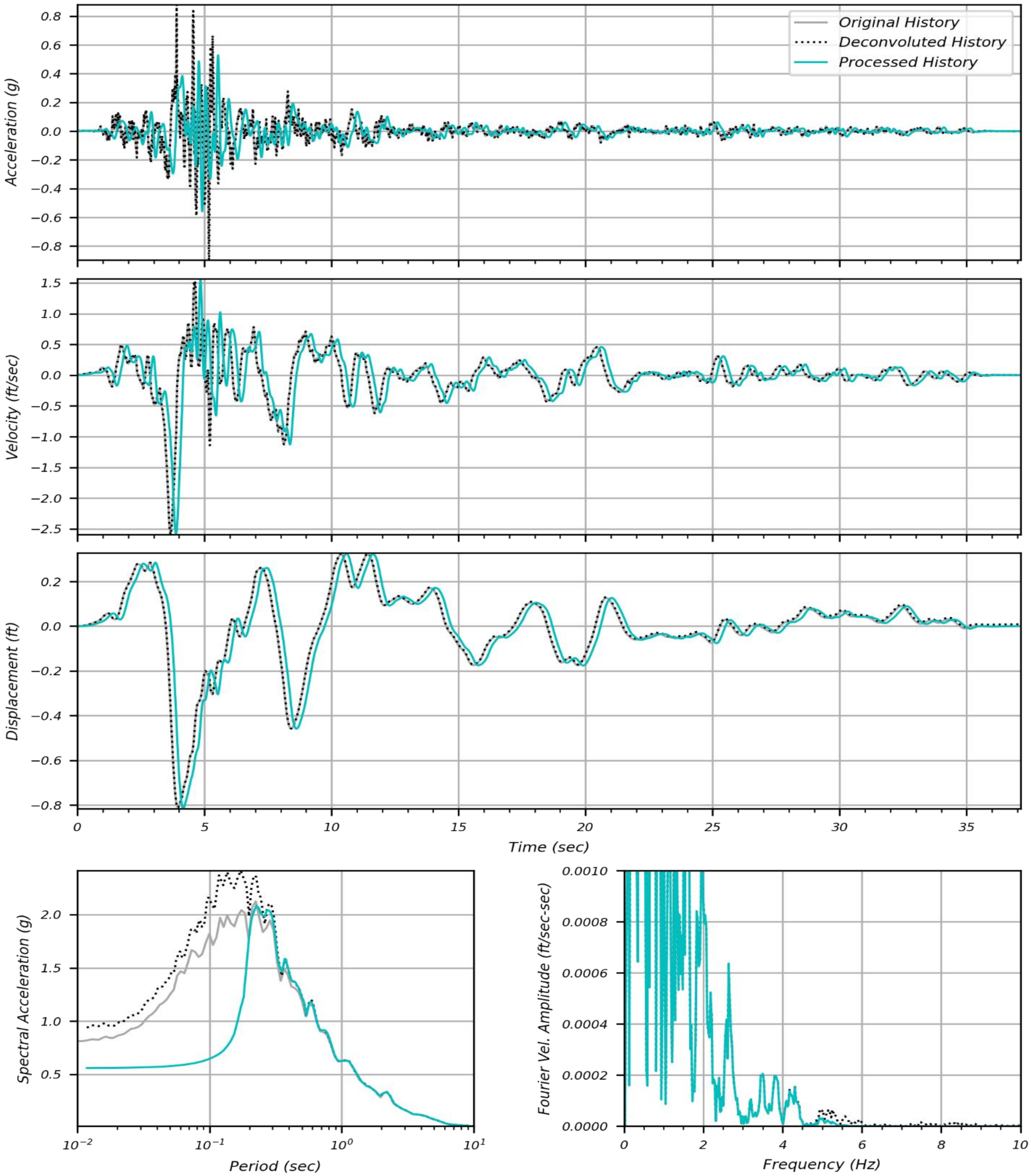
Knight Piésold CONSULTING

P/A NO. VA101-126/24

REF. NO. 5

FIGURE I.4

REV 0



NOTES:

1. ORIGINAL TIME HISTORY FROM AL ATIK AND GREGOR (2022).
2. HISTORY DECONVOLUTED TO THE BASE OF A BEDROCK WITH Vs = 4921 ft/sec.
3. PROCESSED HISTORY BY APPLYING BASELINE CORRECTION AND HIGH FREQUENCY FILTER.

MONTANA RESOURCES, LLC

MONTANA RESOURCES

TIME HISTORY PROCESSING
MCE 5

Knight Piésold CONSULTING

P/A NO.	REF. NO.
VA101-126/24	5

FIGURE I.5 REV 0

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	MJB2	GRG

APPENDIX J

Dynamic Analysis Results

Appendix J1
Static Analysis (Pre-Dynamic Condition)

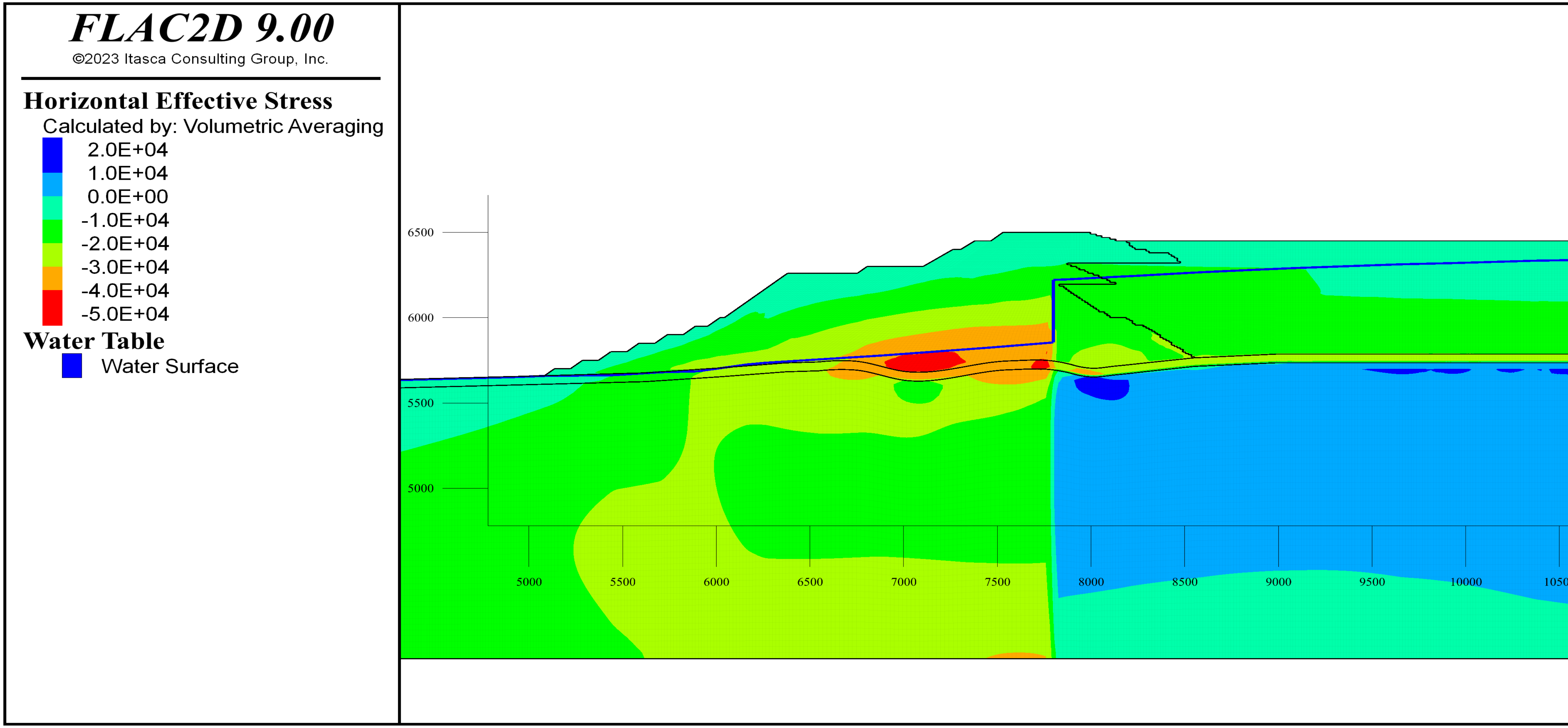
Appendix J2
Dynamic Analysis

Appendix J3
Post-Earthquake Analysis

APPENDIX J1

Static Analysis (Pre-Dynamic Condition)

(Figures J1.1 to J1.5)



NOTES:

1. SCALE BAR UNITS ARE IN FEET.
2. EFFECTIVE STRESS UNITS IN POUNDS PER SQUARE FEET (lb/ft^2).

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

DYNAMIC DEFORMATION ANALYSIS
STATIC (PRE-DYNAMIC) CONDITIONS
HORIZONTAL EFFECTIVE STRESS

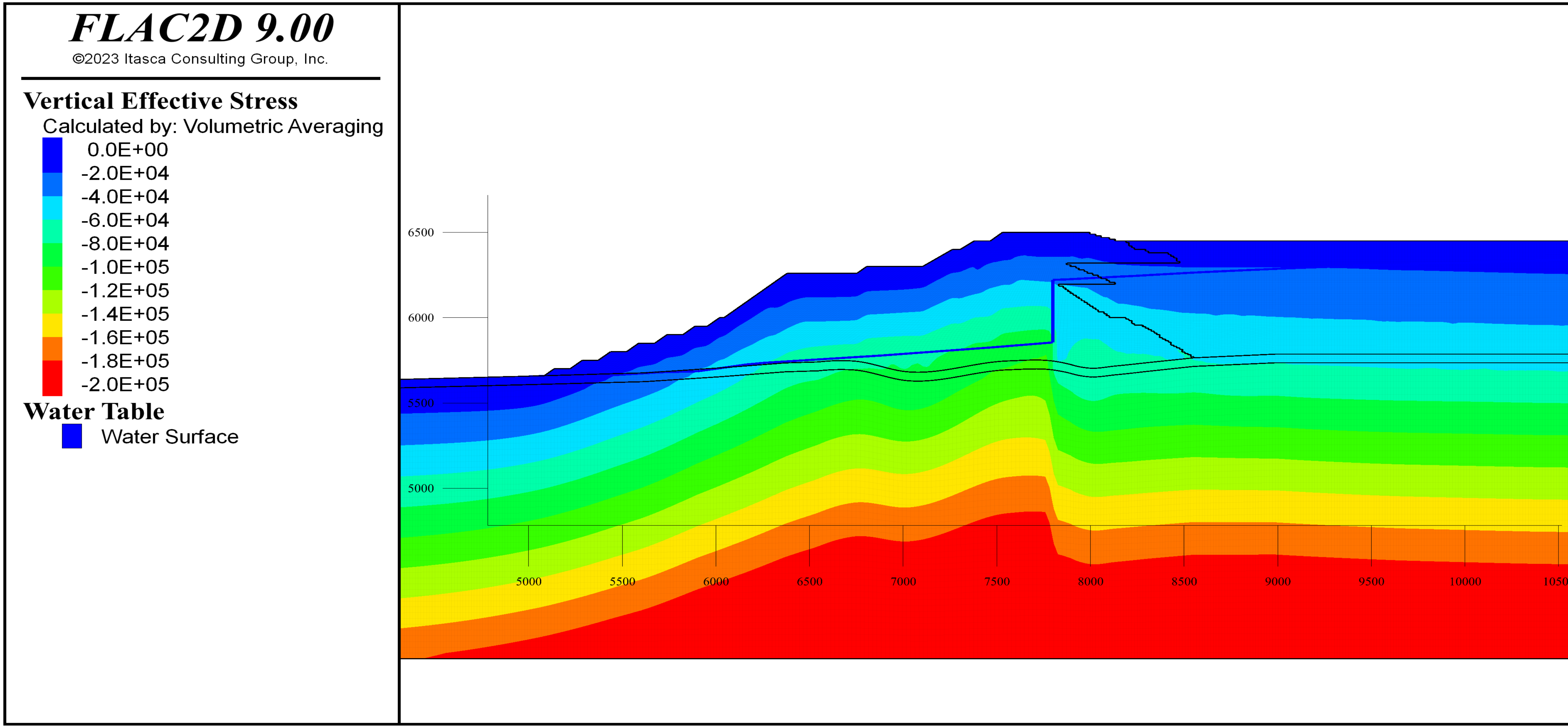
Knight Piésold CONSULTING

P/A NO. VA101-00126/24

REF. NO. 5

FIGURE J1.1

REV 0



NOTES:

1. SCALE BAR UNITS ARE IN FEET.
2. EFFECTIVE STRESS UNITS IN POUNDS PER SQUARE FEET (lb/ft^2).

MONTANA RESOURCES, LLC

MONTANA RESOURCES

DYNAMIC DEFORMATION ANALYSIS
STATIC (PRE-DYNAMIC) CONDITIONS
VERTICAL EFFECTIVE STRESS

Knight Piésold CONSULTING

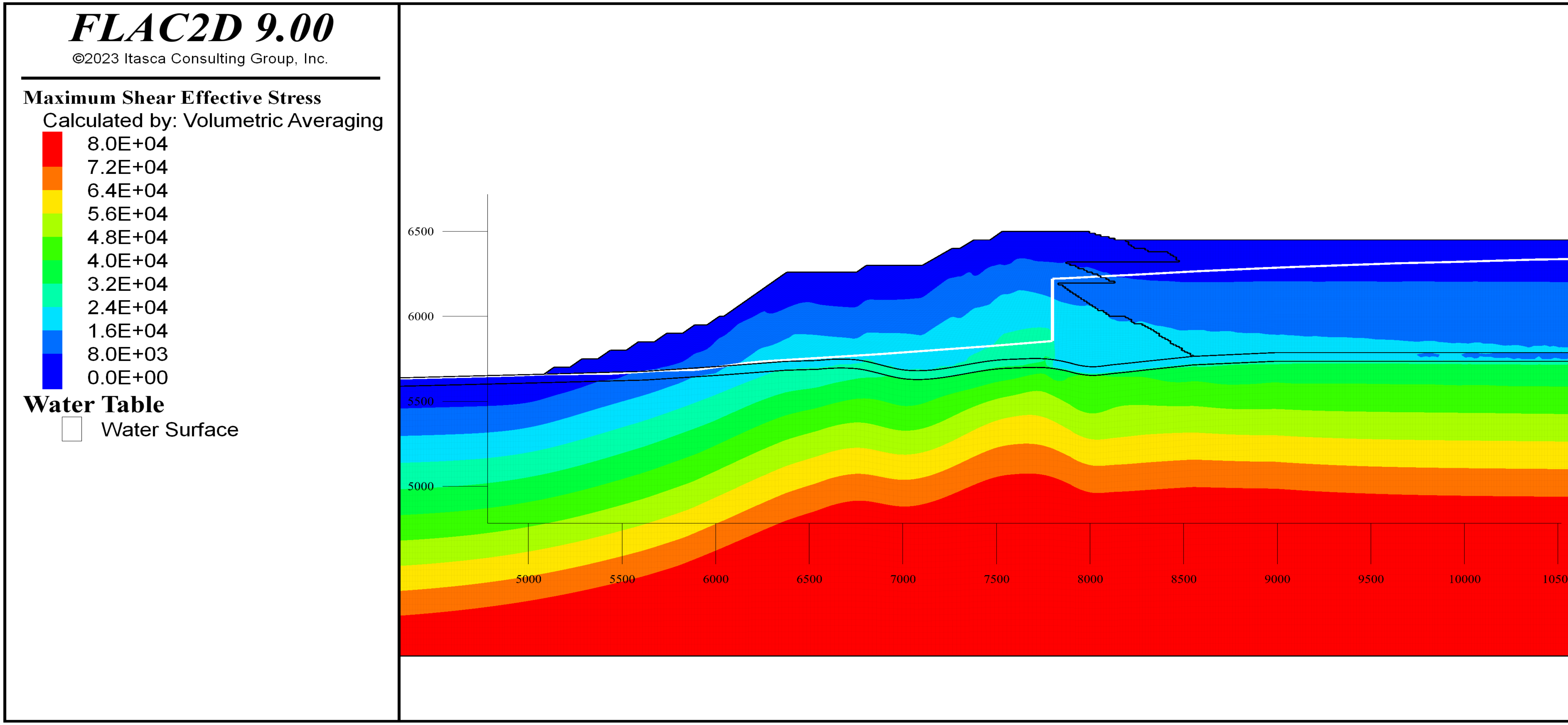
P/A NO. VA101-00126/24

REF. NO. 5

FIGURE J1.2

REV 0

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY



NOTES:

1. SCALE BAR UNITS ARE IN FEET.
2. EFFECTIVE STRESS UNITS IN POUNDS PER SQUARE FEET (lb/ft^2).

MONTANA RESOURCES, LLC

MONTANA RESOURCES

DYNAMIC DEFORMATION ANALYSIS
STATIC (PRE-DYNAMIC) CONDITIONS
EFFECTIVE SHEAR STRESS

Knight Piésold CONSULTING

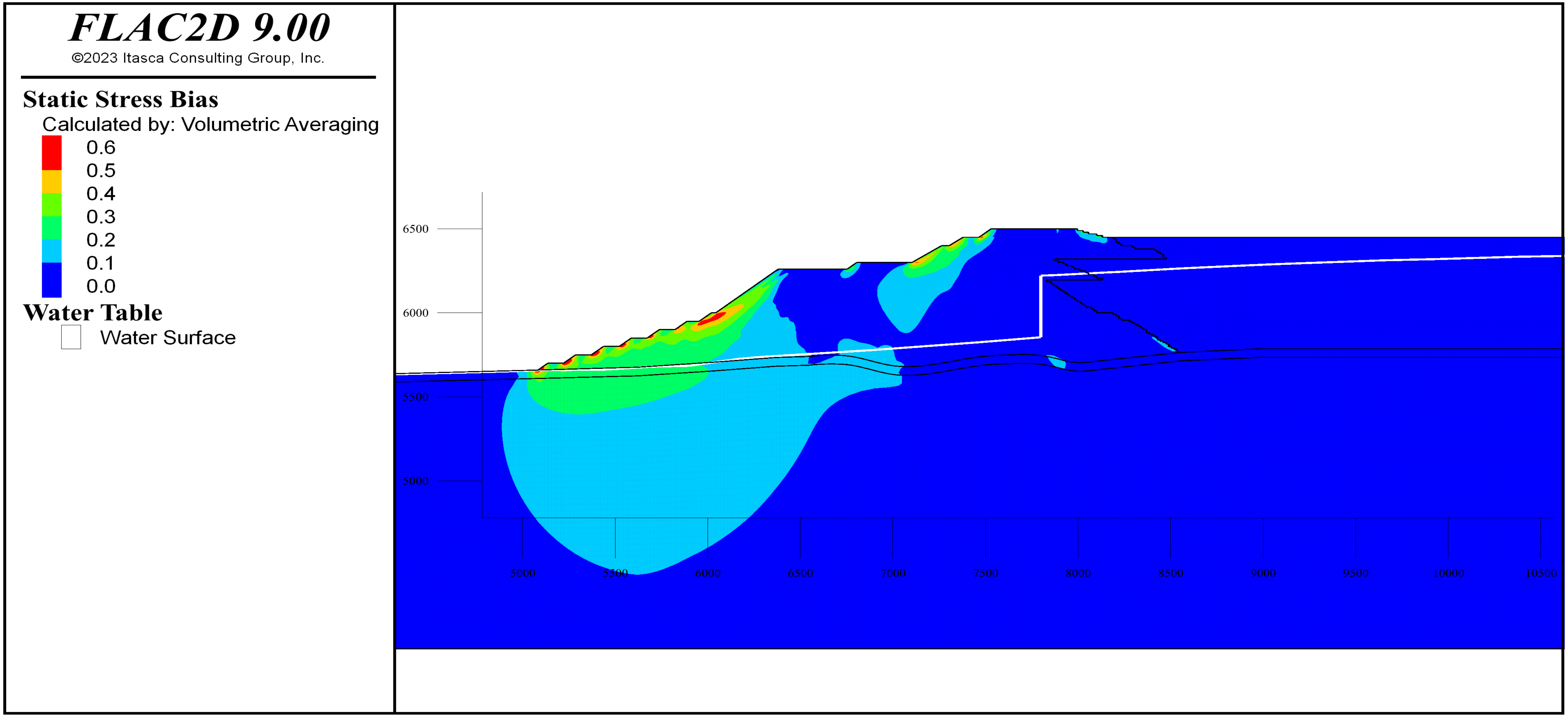
P/A NO. VA101-00126/24

REF. NO. 5

FIGURE J1.3

REV 0

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY



NOTES:

1. SCALE BAR UNITS ARE IN FEET.
2. STATIC STRESS BIAS, τ_{xy} / σ'_{vo} .

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

DYNAMIC DEFORMATION ANALYSIS
STATIC (PRE-DYNAMIC) CONDITIONS
STATIC STRESS BIAS

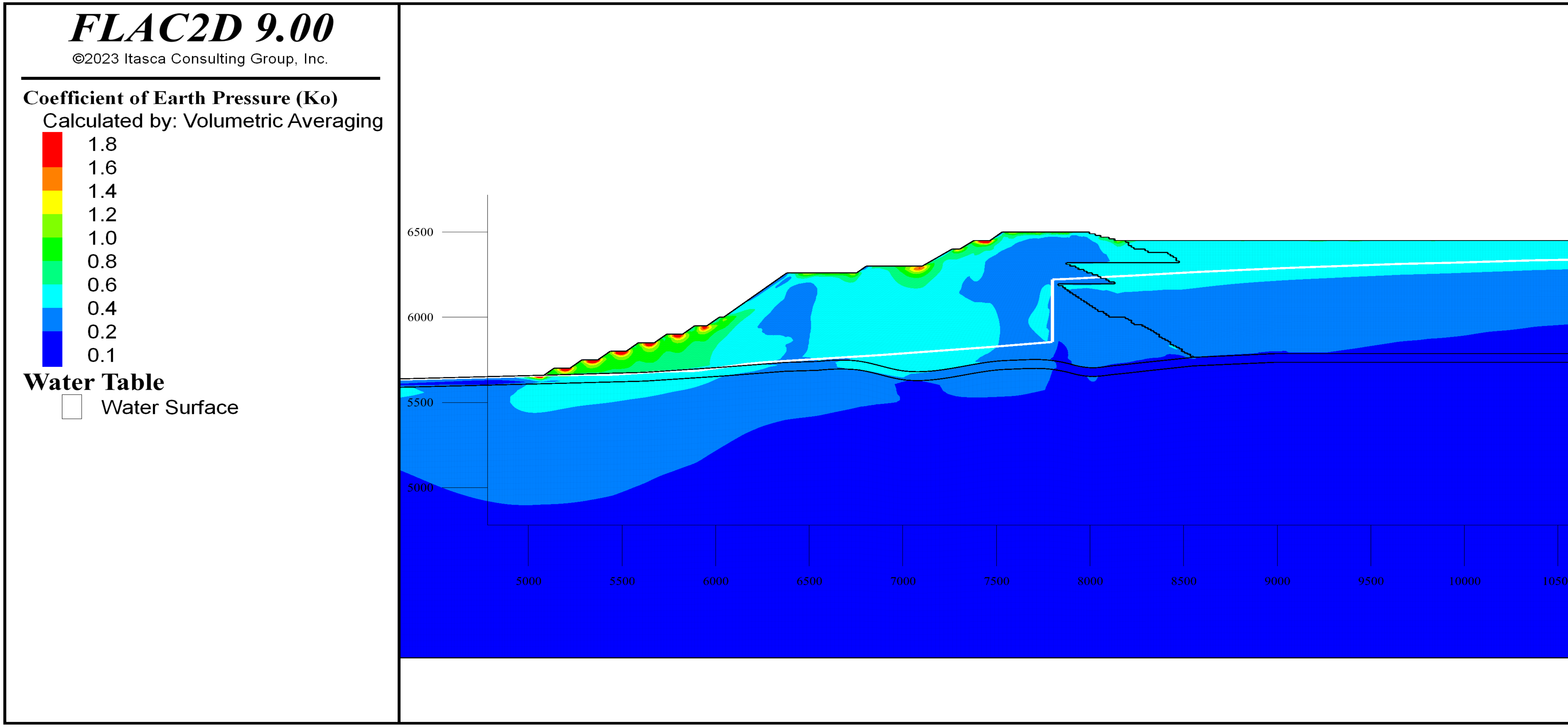
Knight Piésold CONSULTING

P/A NO. VA101-00126/24

REF. NO. 5

FIGURE J1.4

REV 0



NOTES:

1. SCALE BAR UNITS ARE IN FEET.
2. COEFFICIENT OF LATERAL EARTH PRESSURE, $K_{0=}\sigma'_h / \sigma'_v$.

MONTANA RESOURCES, LLC
MONTANA RESOURCES
DYNAMIC DEFORMATION ANALYSIS **STATIC (PRE-DYNAMIC) CONDITIONS** **COEFFICIENT OF EARTH PRESSURE**

Knight Piésold CONSULTING

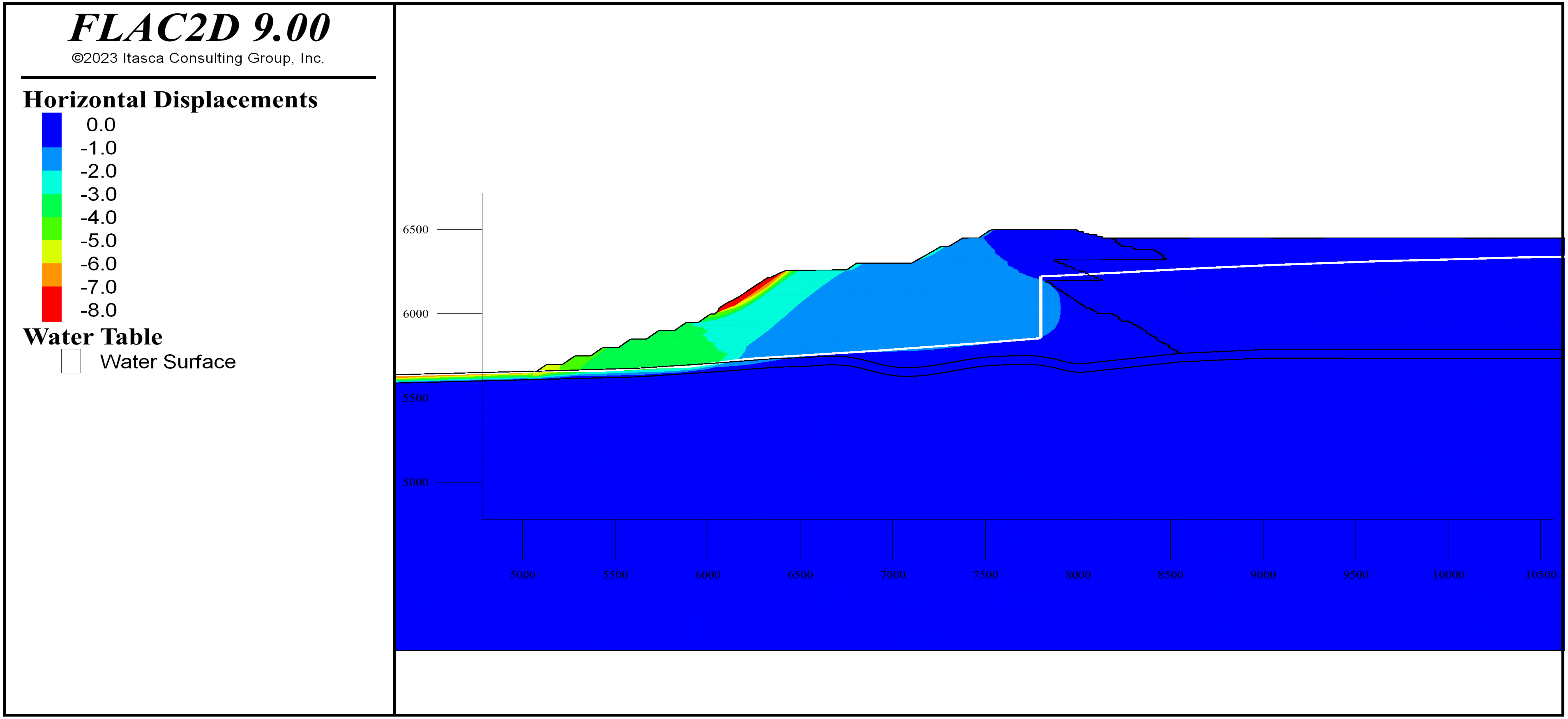
P/A NO.	REF. NO.
VA101-00126/24	5
FIGURE J1.5	REV 0

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

APPENDIX J2

Dynamic Analysis

(Figures J2.1 to J2.25)



NOTES:

1. AXIS LABEL AND LEGEND UNITS ARE FEET.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

DYNAMIC DEFORMATION ANALYSIS
HORIZONTAL DISPLACEMENTS
MCE-1

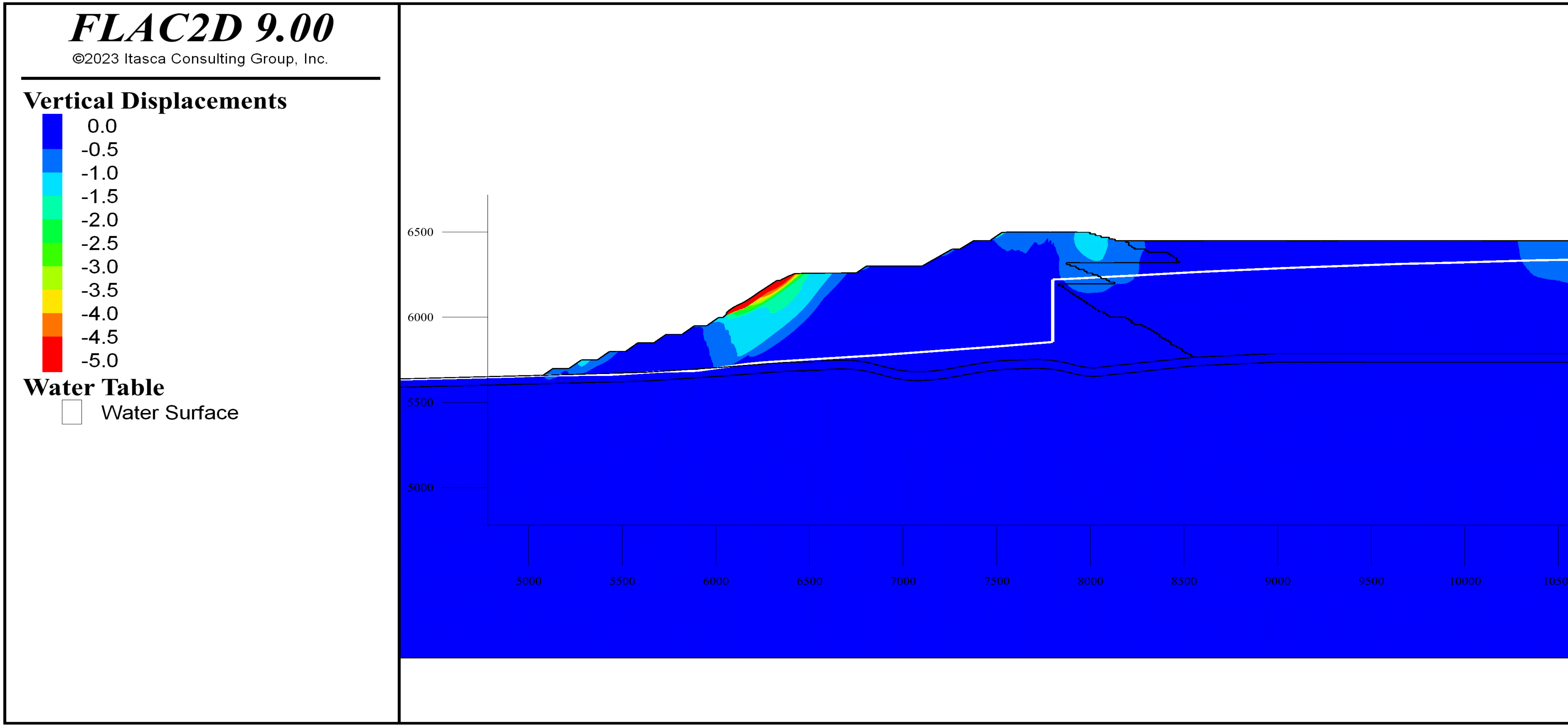
Knight Piésold CONSULTING

P/A NO. VA101-00126/24

REF. NO. 5

FIGURE J2.1

REV 0



NOTES:

1. AXIS LABEL AND LEGEND UNITS ARE FEET.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

DYNAMIC DEFORMATION ANALYSIS
VERTICAL DISPLACEMENTS
MCE-1

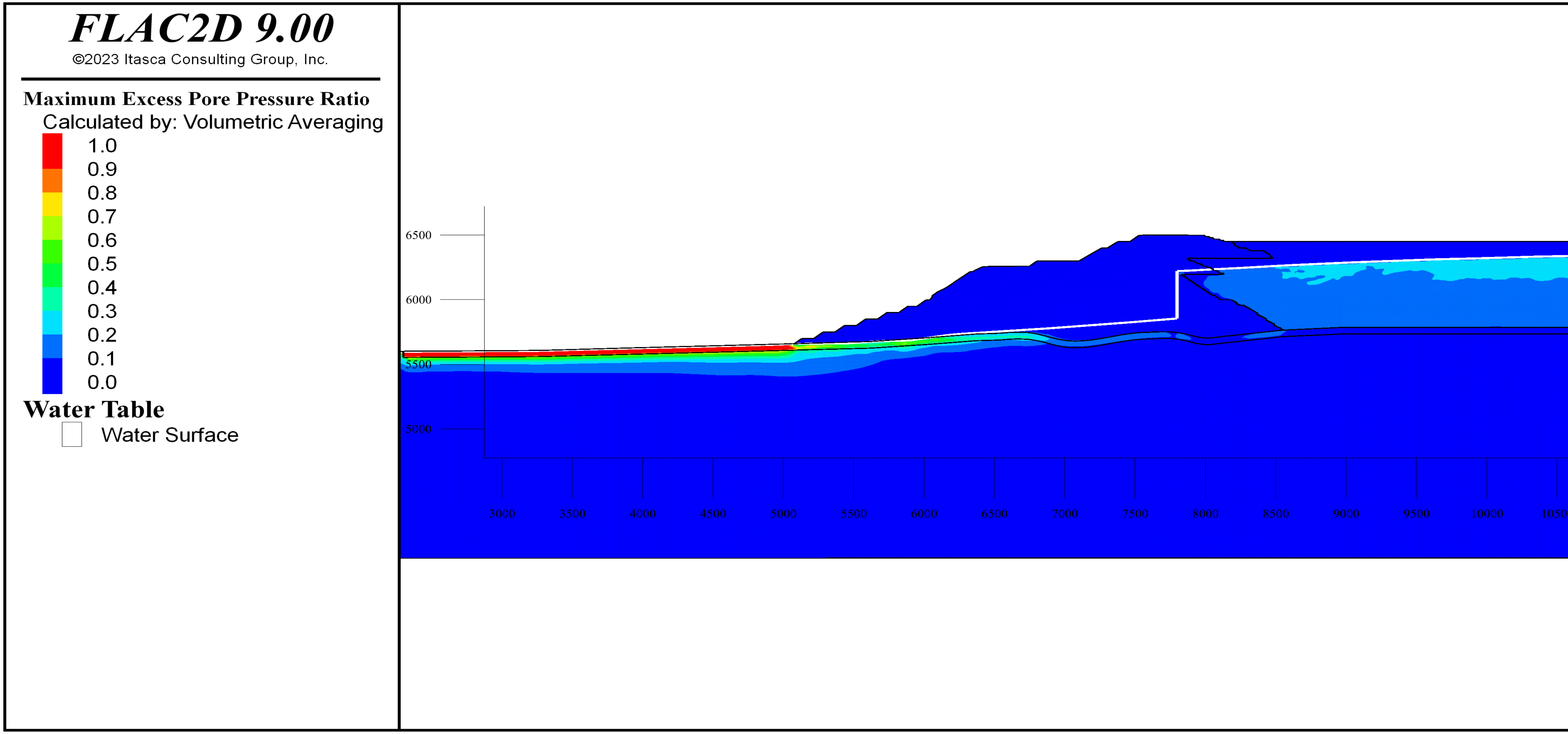
Knight Piésold CONSULTING

P/A NO. VA101-00126/24

REF. NO. 5

FIGURE J2.2

REV 0



NOTES:

1. AXIS LABEL UNITS ARE FEET.
2. EXCESS PORE PRESSURE RATIO, r_u, IS THE PORE PRESSURE CHANGE DIVIDED BY THE INITIAL OVERBRUDEN/VERTICAL STRESS.

0	19SEP'24	ISSUED WITH REPORT	SVW	SY
REV	DATE	DESCRIPTION	PREP'D	RVW'D

MONTANA RESOURCES, LLC

MONTANA RESOURCES

DYNAMIC DEFORMATION ANALYSIS
EXCESS PORE PRESSURE RATIO
MCE-1

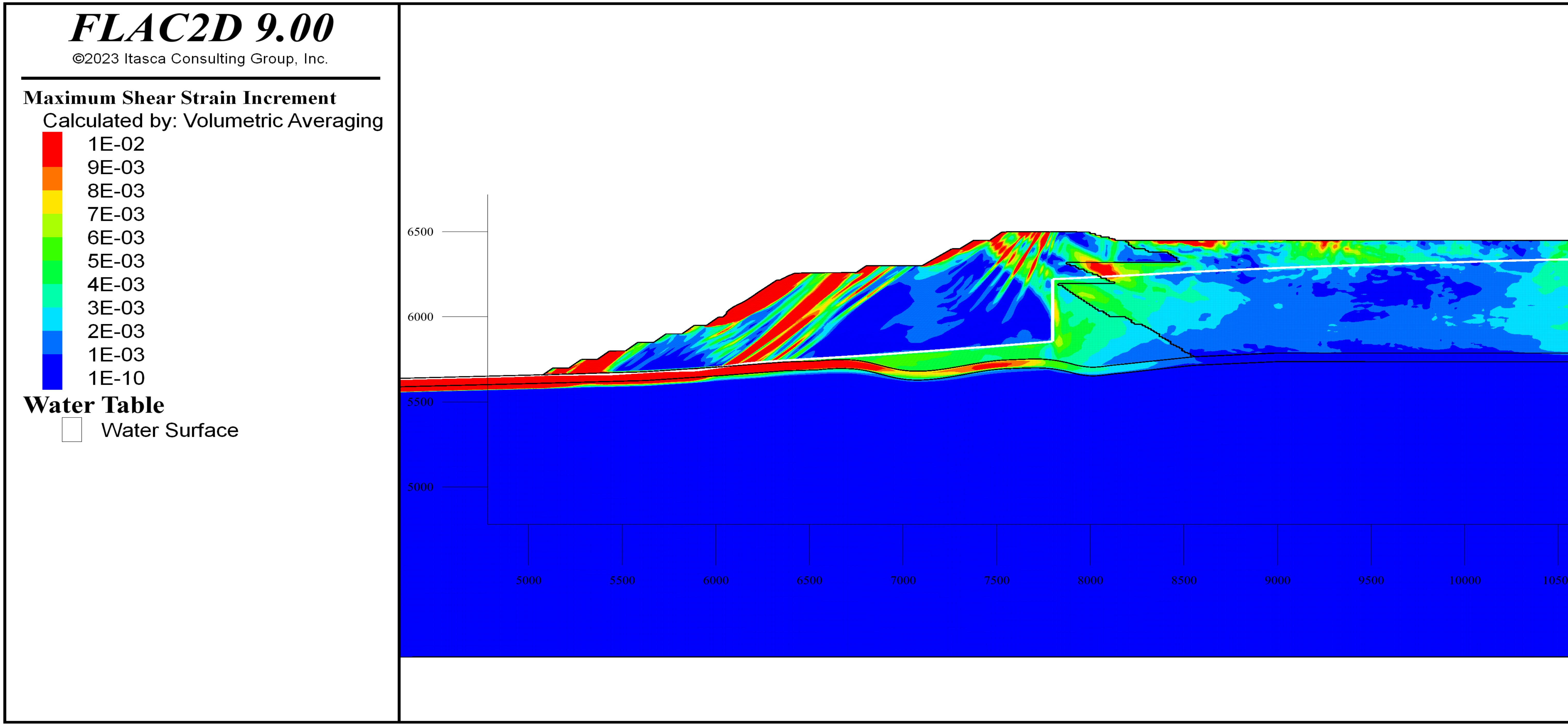
Knight Piésold CONSULTING

P/A NO. VA101-00126/24

REF. NO. 5

FIGURE J2.3

REV 0



NOTES:

1. AXIS LABEL UNITS ARE FEET.
2. SHEAR STRAIN INCREMENT ARE DECIMAL FRACTIONS.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

DYNAMIC DEFORMATION ANALYSIS
MAXIMUM SHEAR STRAIN
MCE-1

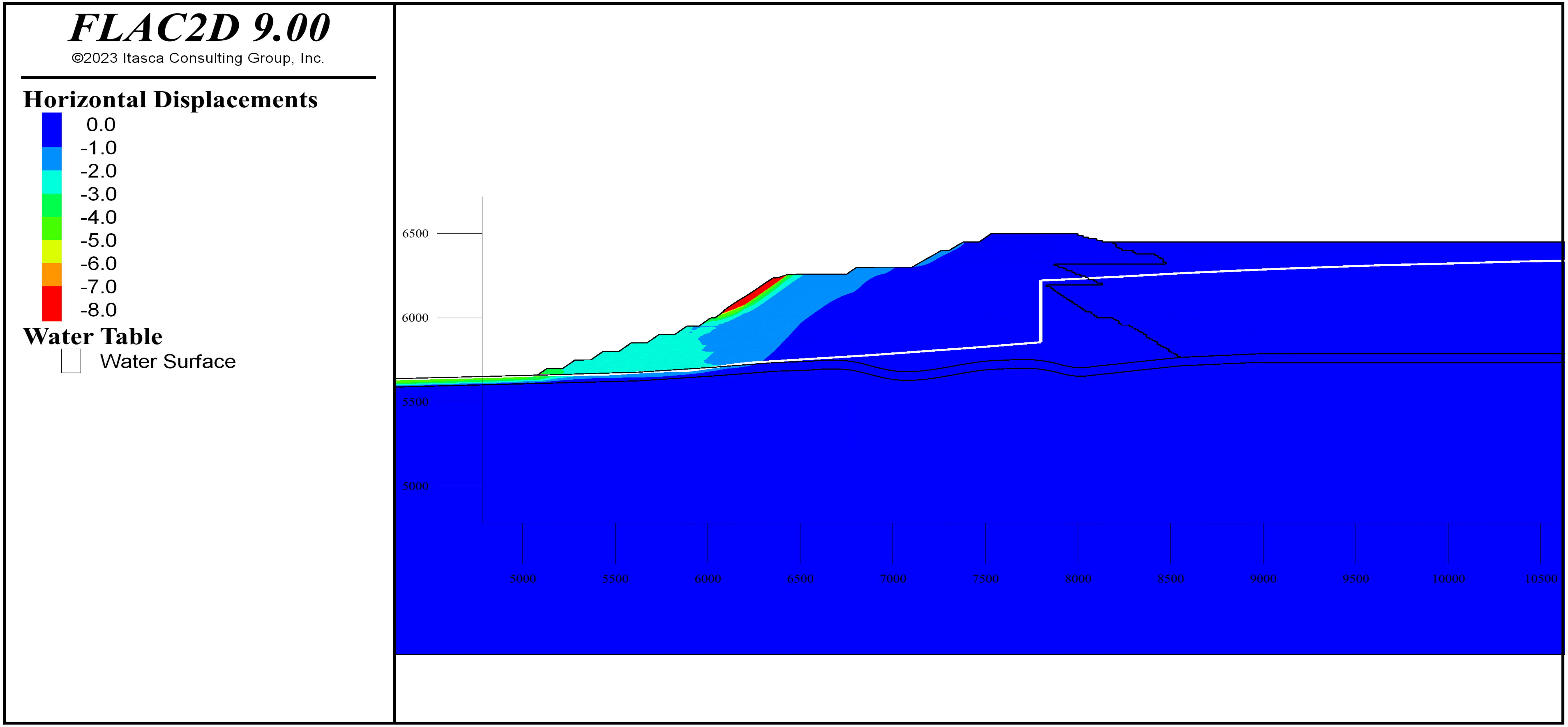
Knight Piésold CONSULTING

P/A NO. VA101-00126/24

REF. NO. 5

FIGURE J2.4

REV 0



NOTES:

1. AXIS LABEL AND LEGEND UNITS ARE FEET.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

DYNAMIC DEFORMATION ANALYSIS
HORIZONTAL DISPLACEMENTS
MCE-2

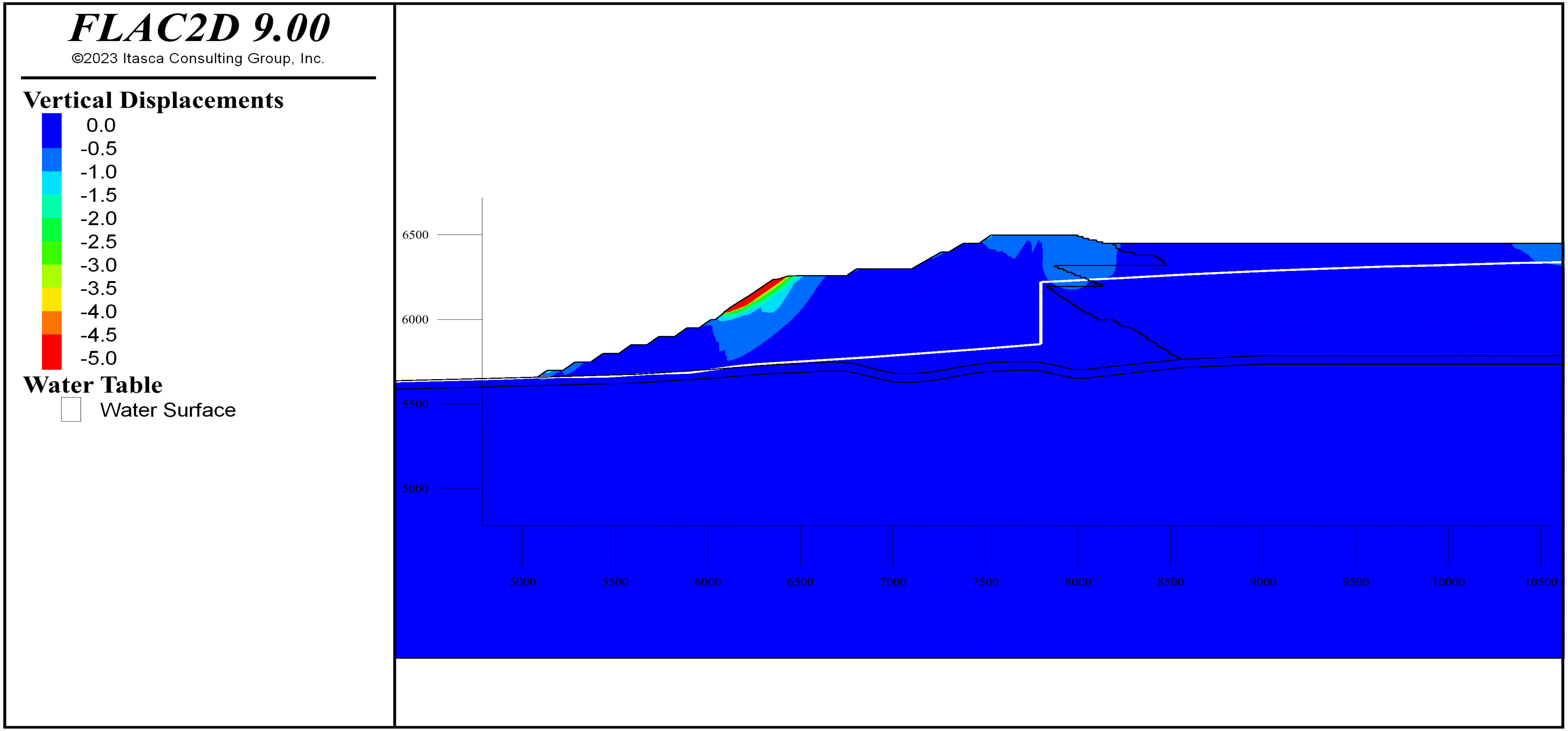
Knight Piésold CONSULTING

P/A NO. VA101-00126/24

REF. NO. 5

FIGURE J2.5

REV 0



NOTES:

1. AXIS LABEL AND LEGEND UNITS ARE FEET.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

MONTANA RESOURCES, LLC

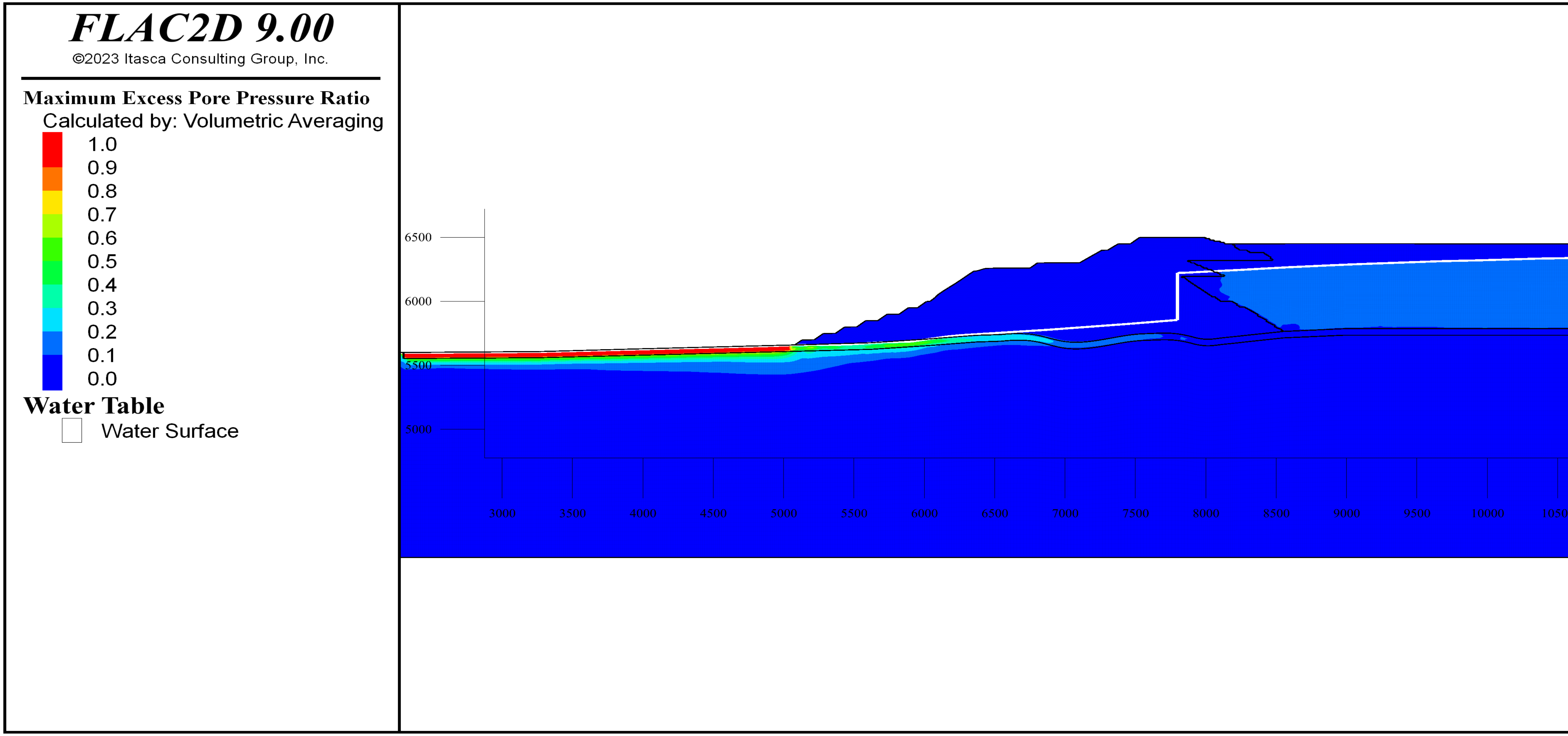
MONTANA RESOURCES

DYNAMIC DEFORMATION ANALYSIS
VERTICAL DISPLACEMENTS
MCE-2

Knight Piésold CONSULTING

P/A NO.	REF. NO.
VA101-00126/24	5

FIGURE J2.6 REV 0



NOTES:

1. AXIS LABEL UNITS ARE FEET.
2. EXCESS PORE PRESSURE RATIO, r_u, IS THE PORE PRESSURE CHANGE DIVIDED BY THE INITIAL OVERBRUDEN/VERTICAL STRESS.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

DYNAMIC DEFORMATION ANALYSIS
EXCESS PORE PRESSURE RATIO
MCE-2

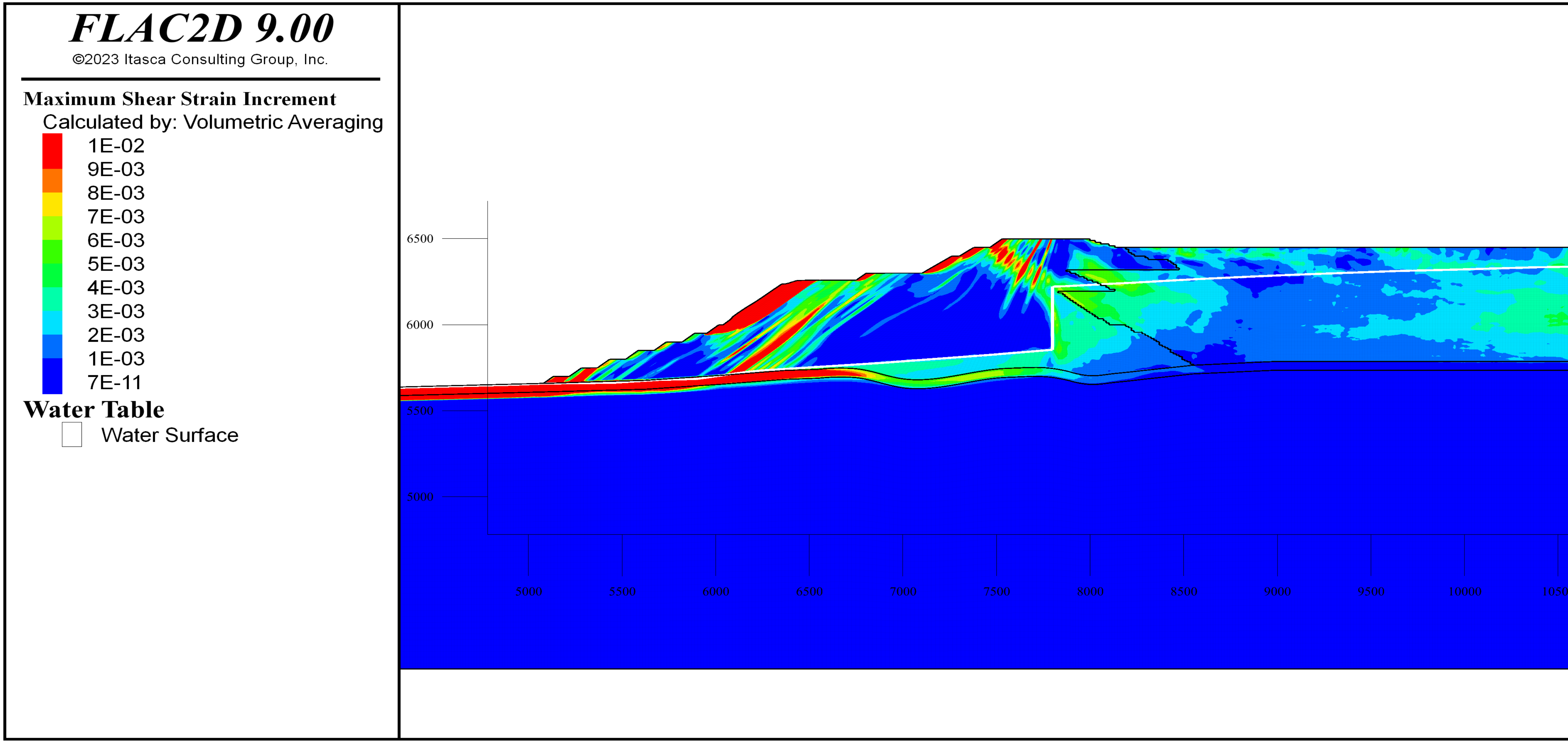
Knight Piésold CONSULTING

P/A NO. VA101-00126/24

REF. NO. 5

FIGURE J2.7

REV 0



NOTES:

1. AXIS LABEL UNITS ARE FEET.
2. SHEAR STRAIN INCREMENT ARE DECIMAL FRACTIONS.

0	19SEP'24	ISSUED WITH REPORT	SVW	SY
REV	DATE	DESCRIPTION	PREP'D	RVW'D

MONTANA RESOURCES, LLC

MONTANA RESOURCES

DYNAMIC DEFORMATION ANALYSIS
MAXIMUM SHEAR STRAIN
MCE-2

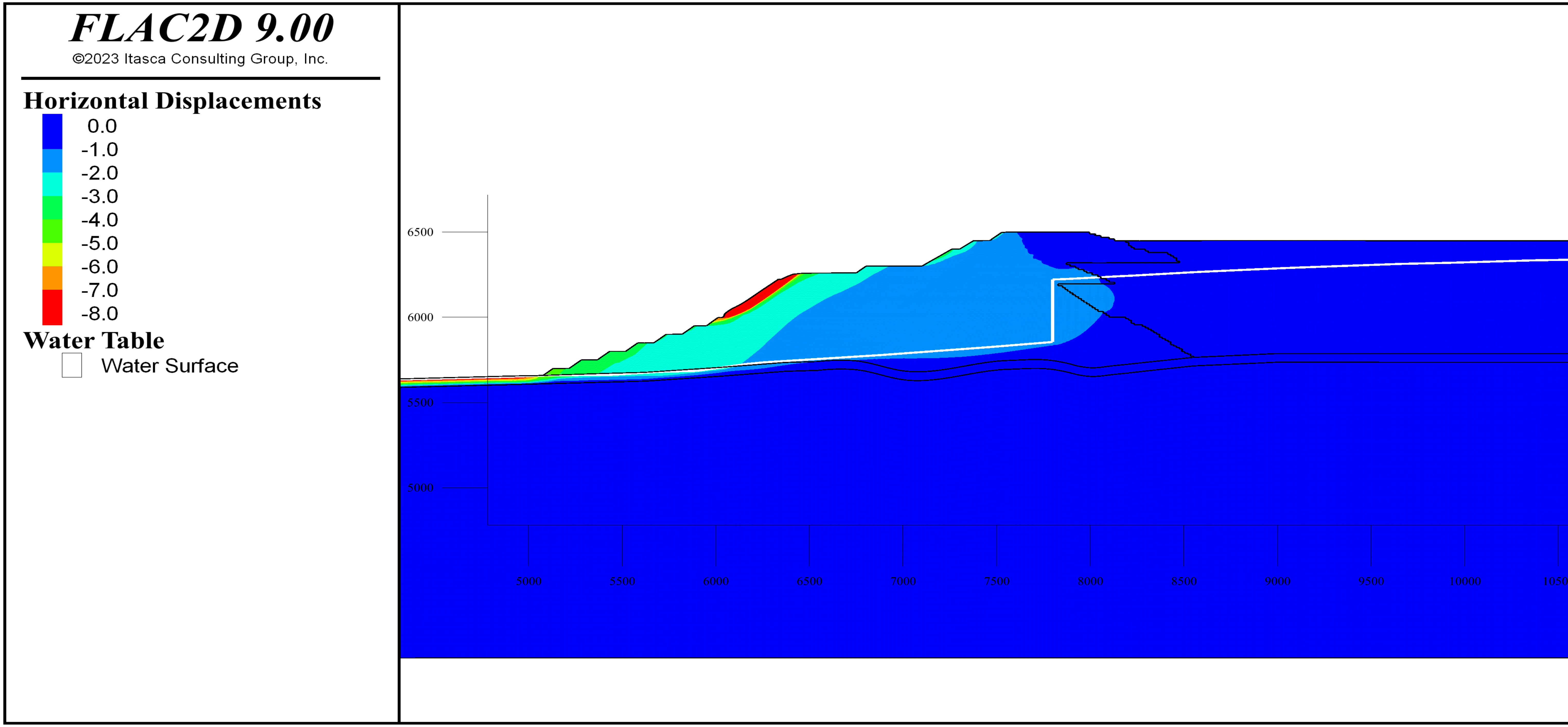
Knight Piésold CONSULTING

P/A NO. VA101-00126/24

REF. NO. 5

FIGURE J2.8

REV 0



NOTES:

1. AXIS LABEL AND LEGEND UNITS ARE FEET.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

DYNAMIC DEFORMATION ANALYSIS
HORIZONTAL DISPLACEMENTS
MCE-3

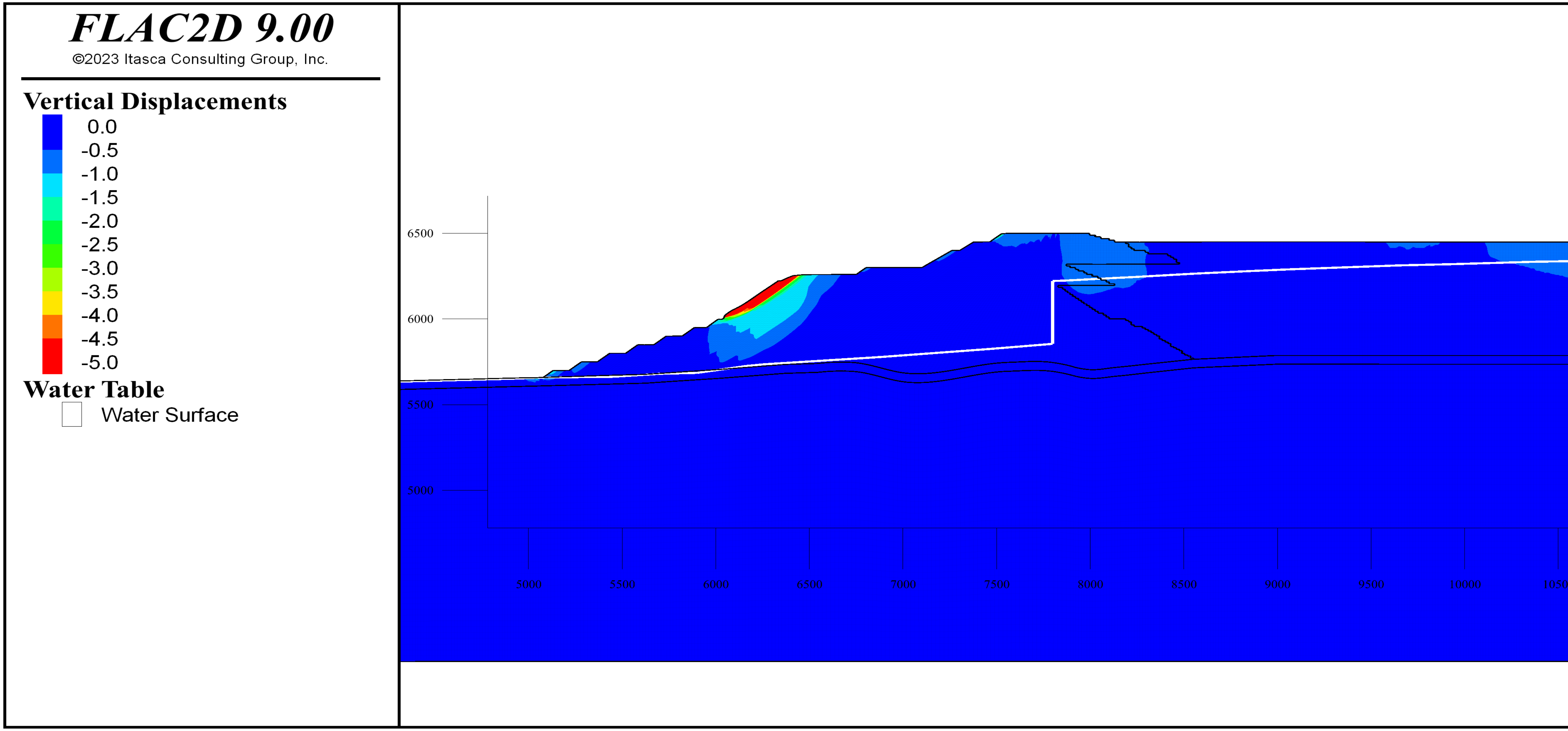
Knight Piésold CONSULTING

P/A NO. VA101-00126/24

REF. NO. 5

FIGURE J2.9

REV 0



NOTES:

1. AXIS LABEL AND LEGEND UNITS ARE FEET.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

DYNAMIC DEFORMATION ANALYSIS
VERTICAL DISPLACEMENTS
MCE-3

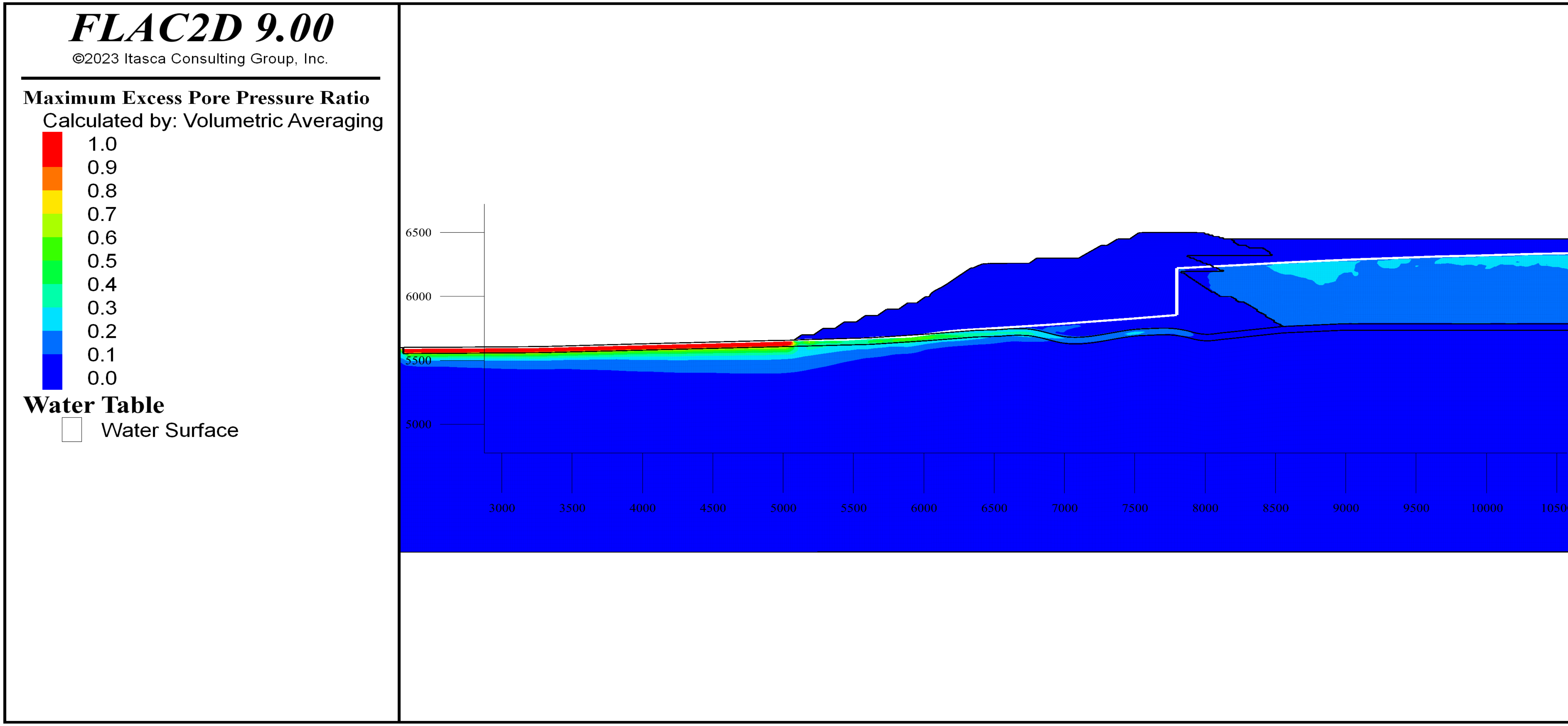
Knight Piésold CONSULTING

P/A NO. VA101-00126/24

REF. NO. 5

FIGURE J2.10

REV 0



NOTES:

1. AXIS LABEL UNITS ARE FEET.
2. EXCESS PORE PRESSURE RATIO, r_u, IS THE PORE PRESSURE CHANGE DIVIDED BY THE INITIAL OVERBRUDEN/VERTICAL STRESS.

0	19SEP'24	ISSUED WITH REPORT	SVW	SY
REV	DATE	DESCRIPTION	PREP'D	RVW'D

MONTANA RESOURCES, LLC

MONTANA RESOURCES

DYNAMIC DEFORMATION ANALYSIS
EXCESS PORE PRESSURE RATIO
MCE-3

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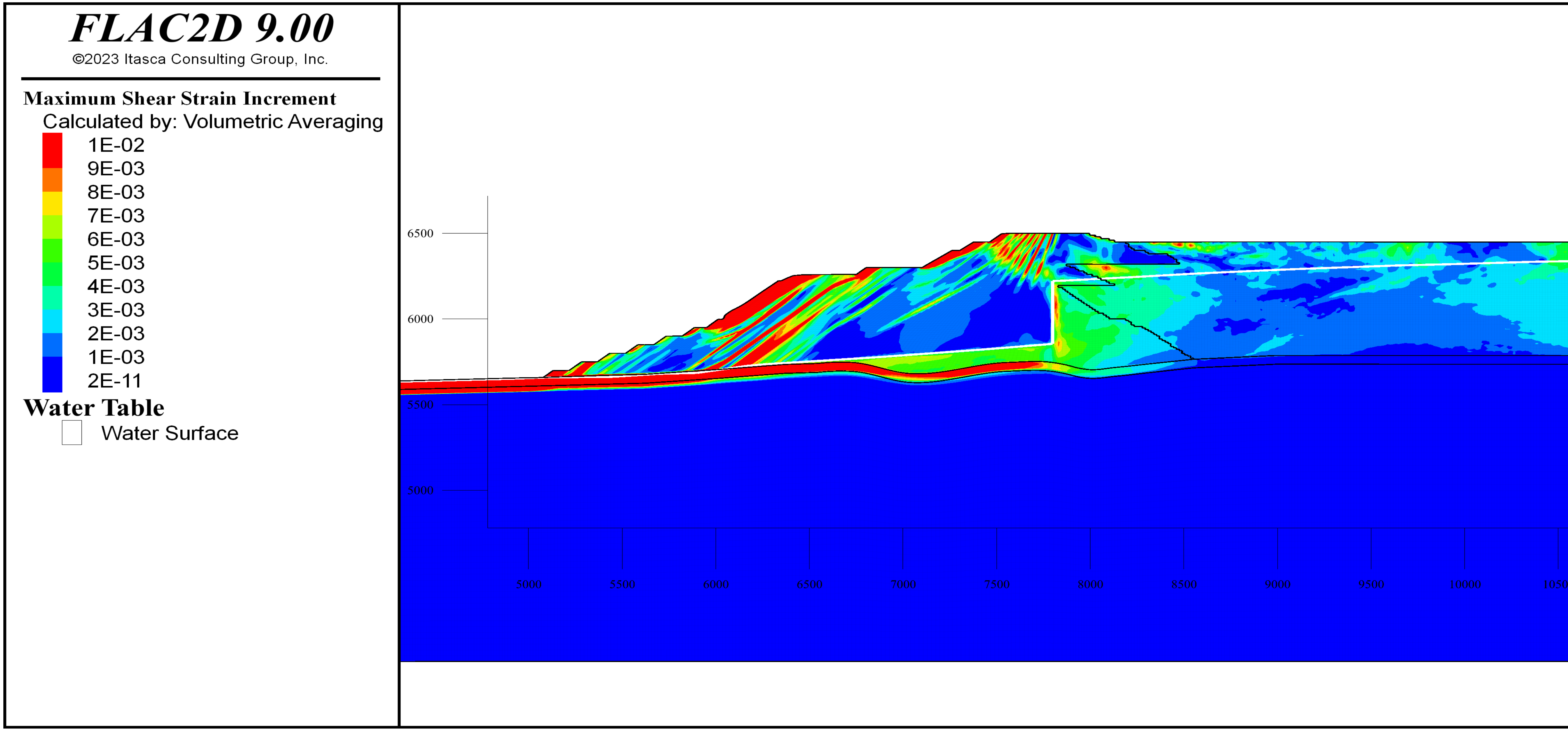
P/A NO. VA101-00126/24 | REF. NO. 5

FIGURE J2.11 REV 0



NOTES:

1. AXIS LABEL UNITS ARE FEET.
2. SHEAR STRAIN INCREMENT ARE DECIMAL FRACTIONS.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

DYNAMIC DEFORMATION ANALYSIS
MAXIMUM SHEAR STRAIN
MCE-3

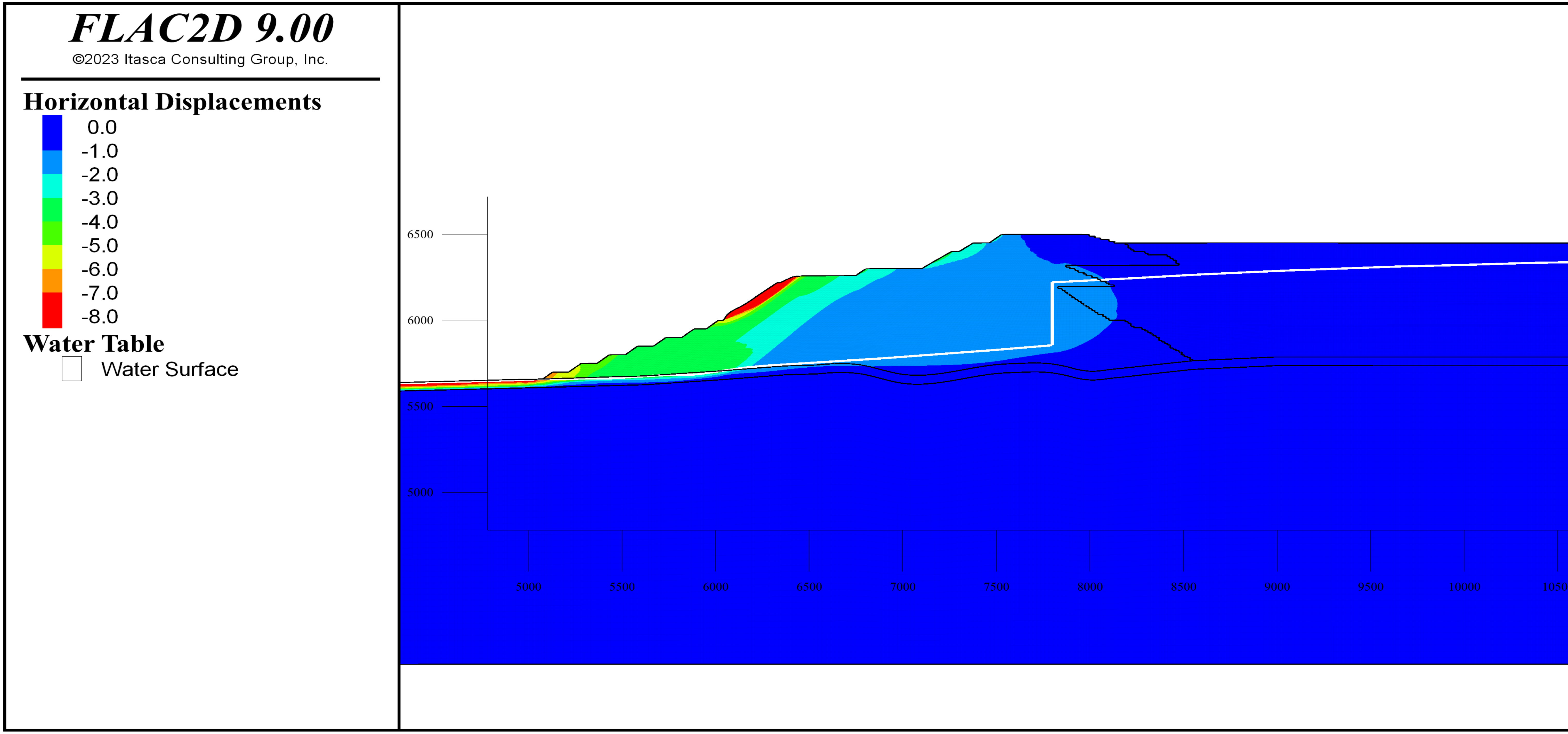
Knight Piésold CONSULTING

P/A NO. VA101-00126/24

REF. NO. 5

FIGURE J2.12

REV 0



NOTES:

1. AXIS LABEL AND LEGEND UNITS ARE FEET.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

DYNAMIC DEFORMATION ANALYSIS
HORIZONTAL DISPLACEMENTS
MCE-4

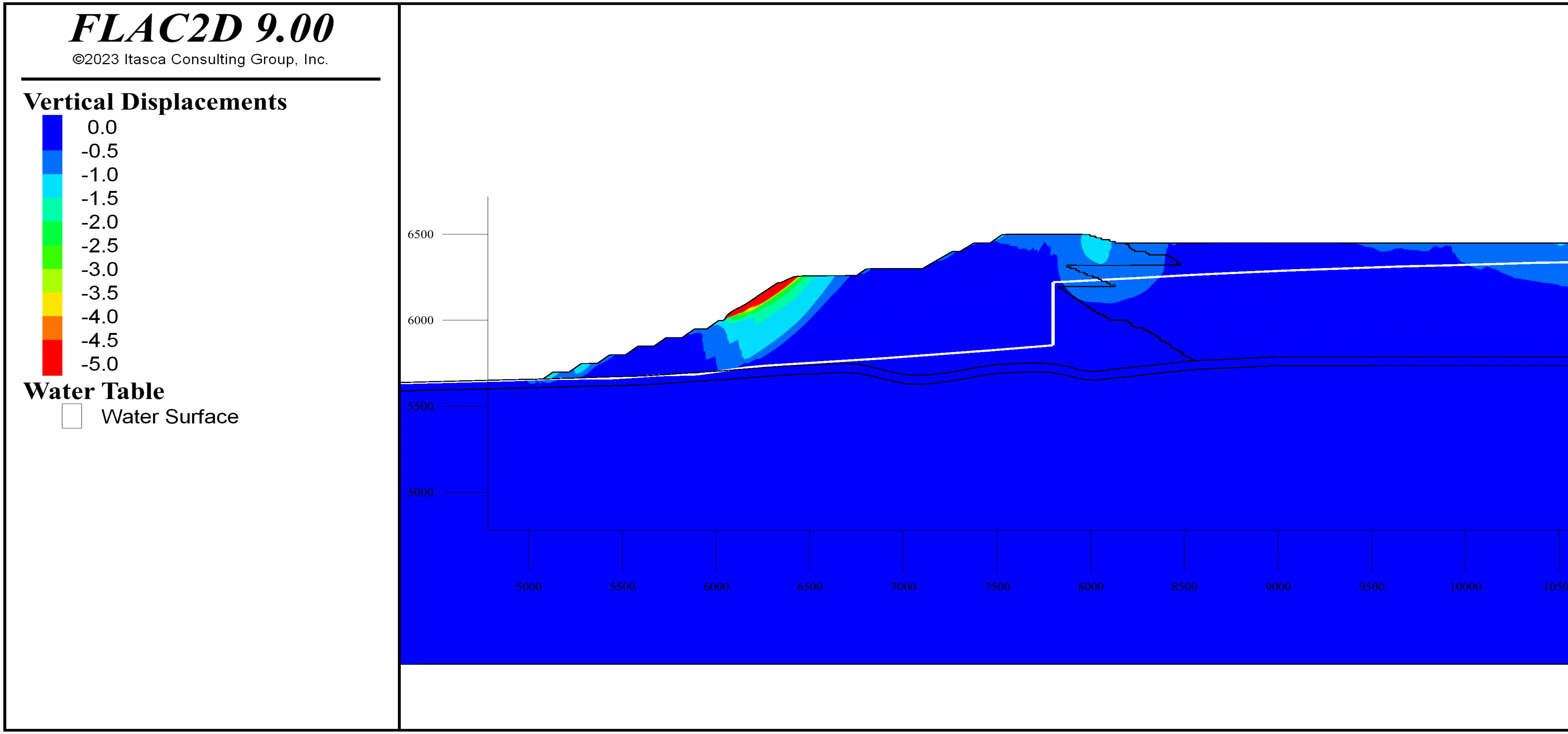
Knight Piésold CONSULTING

P/A NO. VA101-00126/24

REF. NO. 5

FIGURE J2.13

REV 0



NOTES:

1. AXIS LABEL AND LEGEND UNITS ARE FEET.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

DYNAMIC DEFORMATION ANALYSIS
VERTICAL DISPLACEMENTS
MCE-4

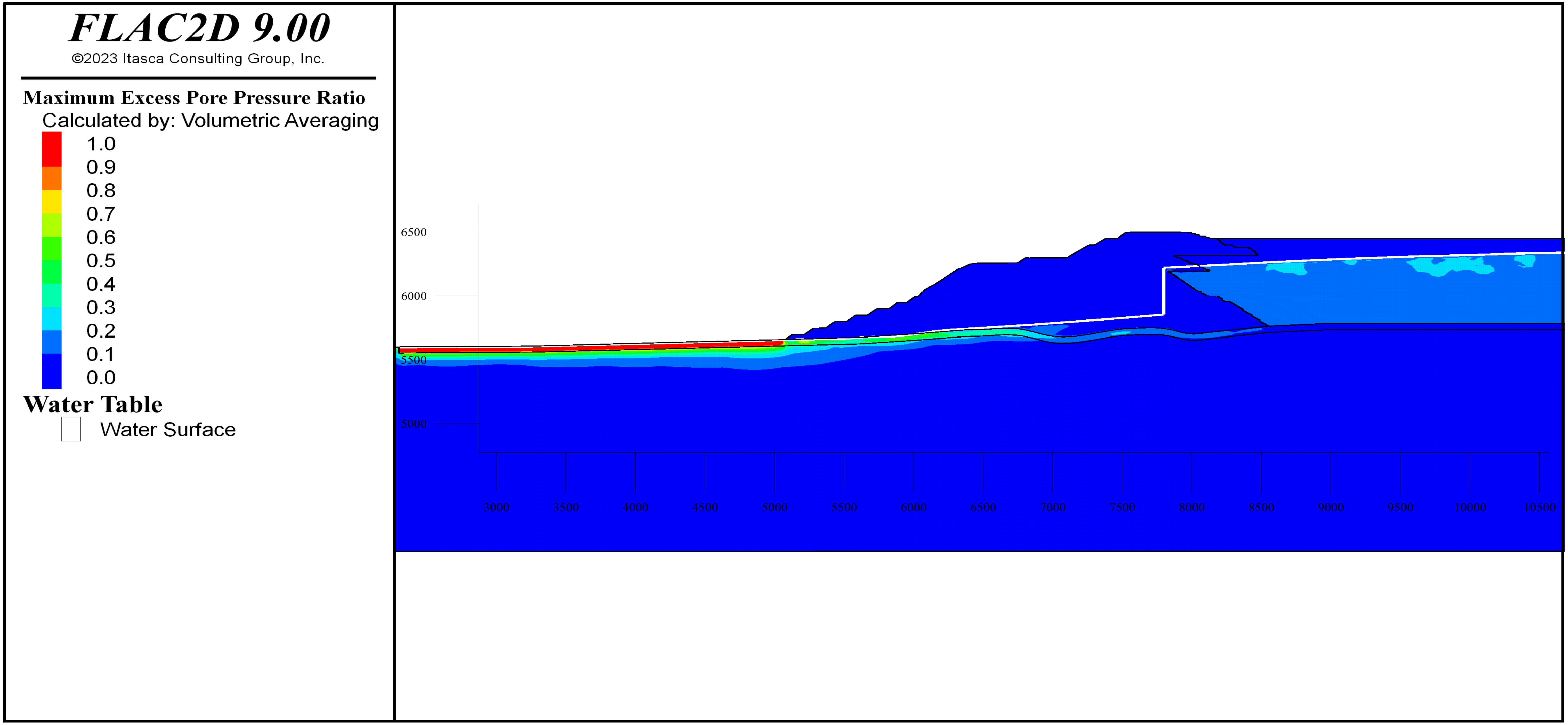
Knight Piésold CONSULTING

P/A NO. VA101-00126/24

REF. NO. 5

FIGURE J2.14

REV 0



NOTES:

1. AXIS LABEL UNITS ARE FEET.
2. EXCESS PORE PRESSURE RATIO, r_u, IS THE PORE PRESSURE CHANGE DIVIDED BY THE INITIAL OVERBRUDEN/VERTICAL STRESS.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

MONTANA RESOURCES, LLC

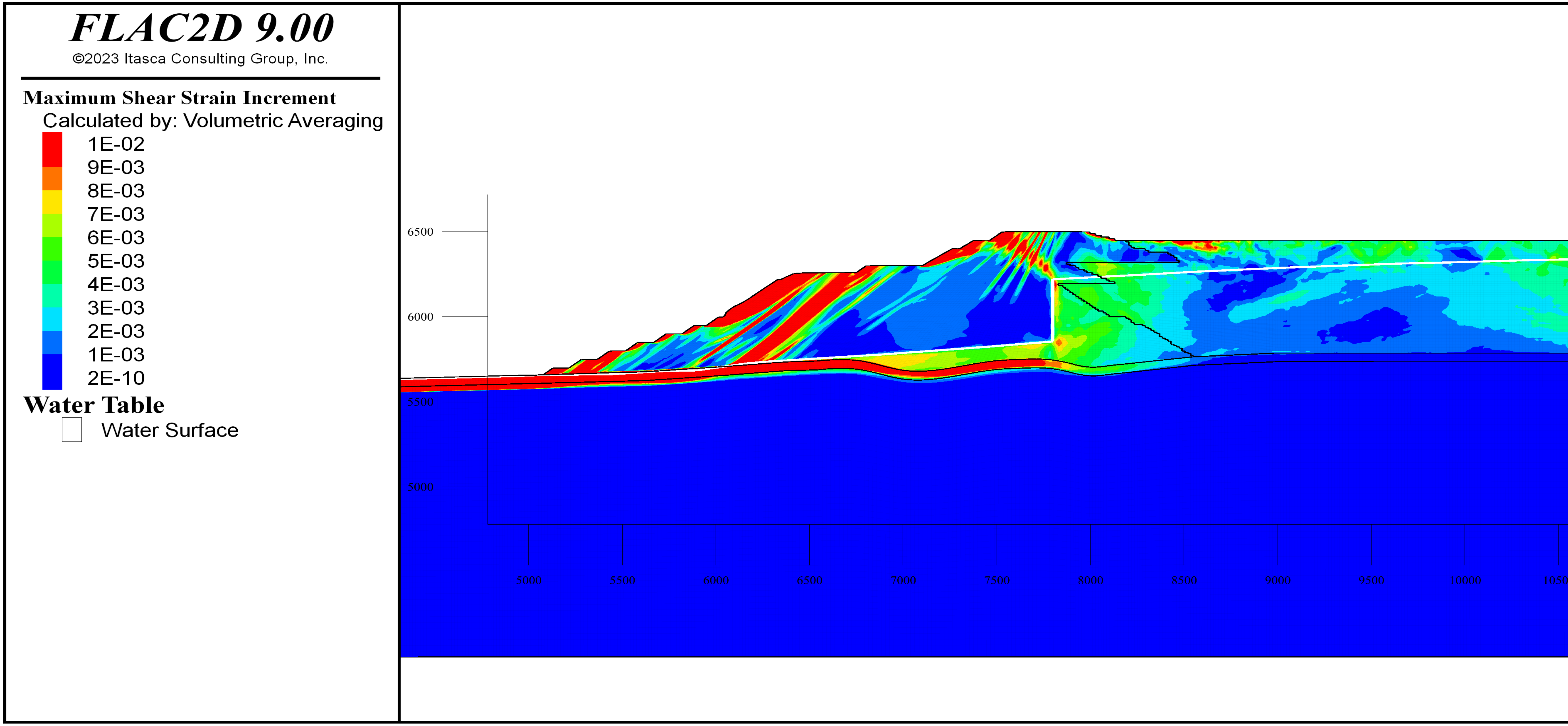
MONTANA RESOURCES

DYNAMIC DEFORMATION ANALYSIS
EXCESS PORE PRESSURE RATIO
MCE-4

Knight Piésold CONSULTING

P/A NO. VA101-00126/24 REF. NO. 5

FIGURE J2.15 REV 0



NOTES:

1. AXIS LABEL UNITS ARE FEET.
2. SHEAR STRAIN INCREMENT ARE DECIMAL FRACTIONS.

0	19SEP'24	ISSUED WITH REPORT	SVW	SY
REV	DATE	DESCRIPTION	PREP'D	RVW'D

MONTANA RESOURCES, LLC

MONTANA RESOURCES

DYNAMIC DEFORMATION ANALYSIS
MAXIMUM SHEAR STRAIN
MCE-4

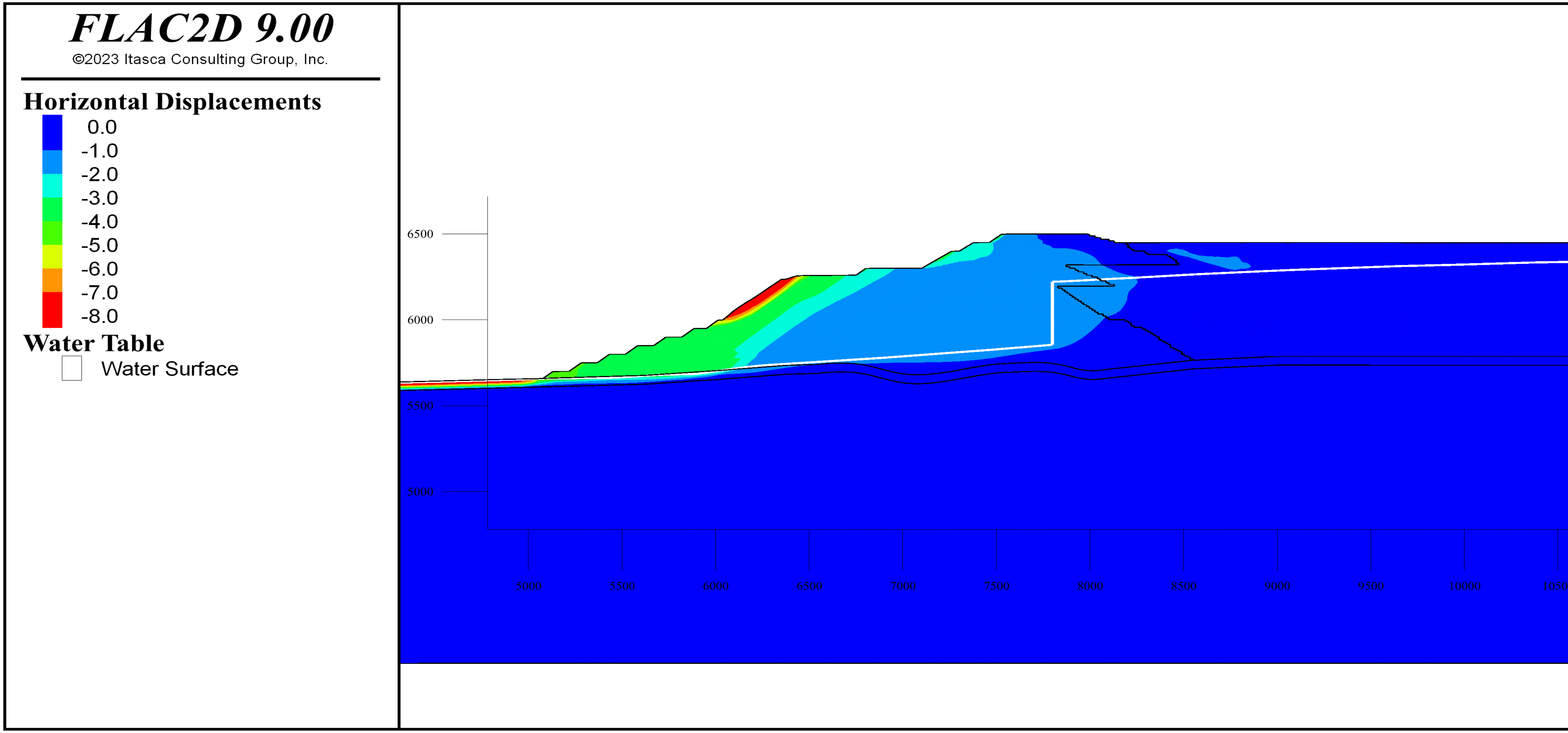
Knight Piésold CONSULTING

P/A NO. VA101-00126/24

REF. NO. 5

FIGURE J2.16

REV 0



NOTES:

1. AXIS LABEL AND LEGEND UNITS ARE FEET.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

DYNAMIC DEFORMATION ANALYSIS
HORIZONTAL DISPLACEMENTS
MCE-5

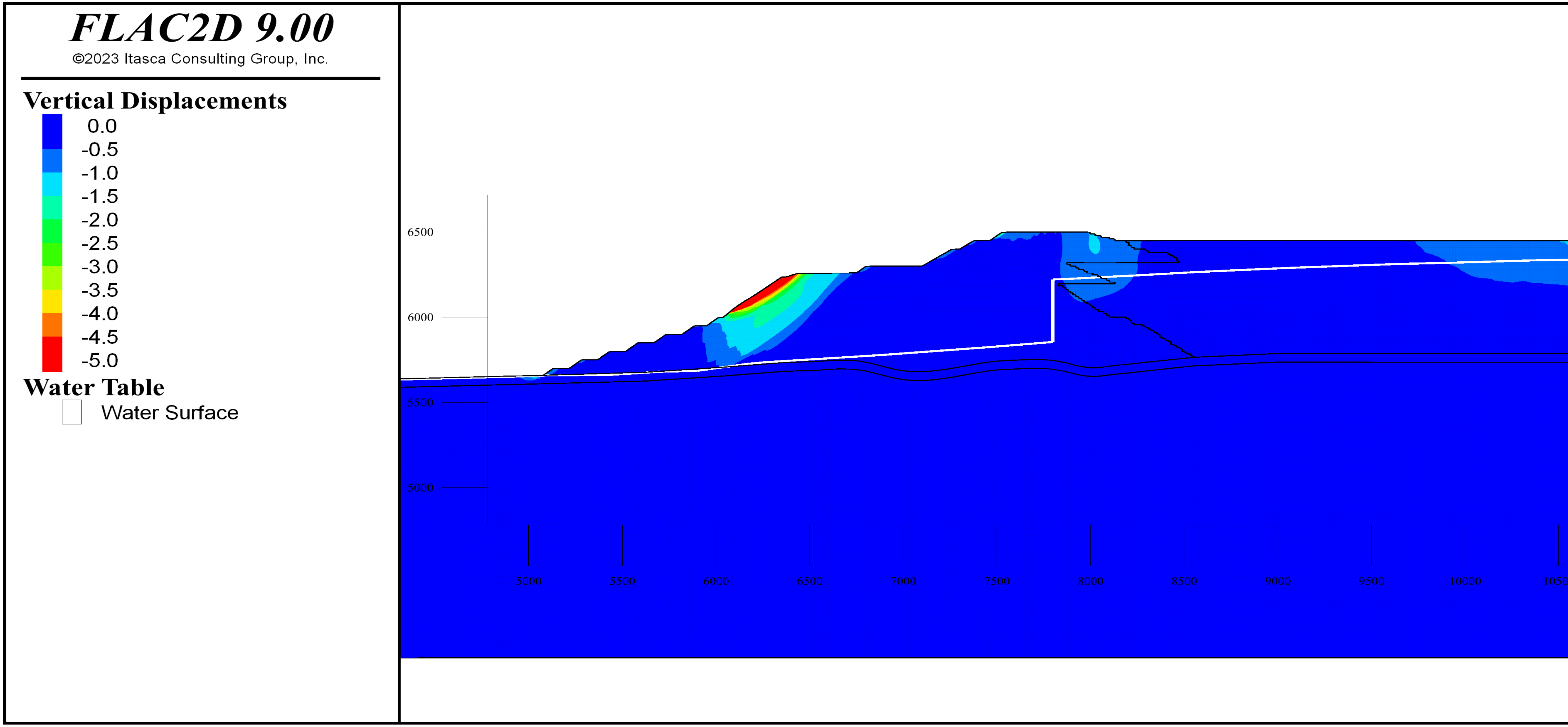
Knight Piésold CONSULTING

P/A NO. VA101-00126/24

REF. NO. 5

FIGURE J2.17

REV 0



NOTES:

1. AXIS LABEL AND LEGEND UNITS ARE FEET.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

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MONTANA RESOURCES

DYNAMIC DEFORMATION ANALYSIS
VERTICAL DISPLACEMENTS
MCE-5

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FIGURE J2.18

REV 0

FLAC2D 9.00

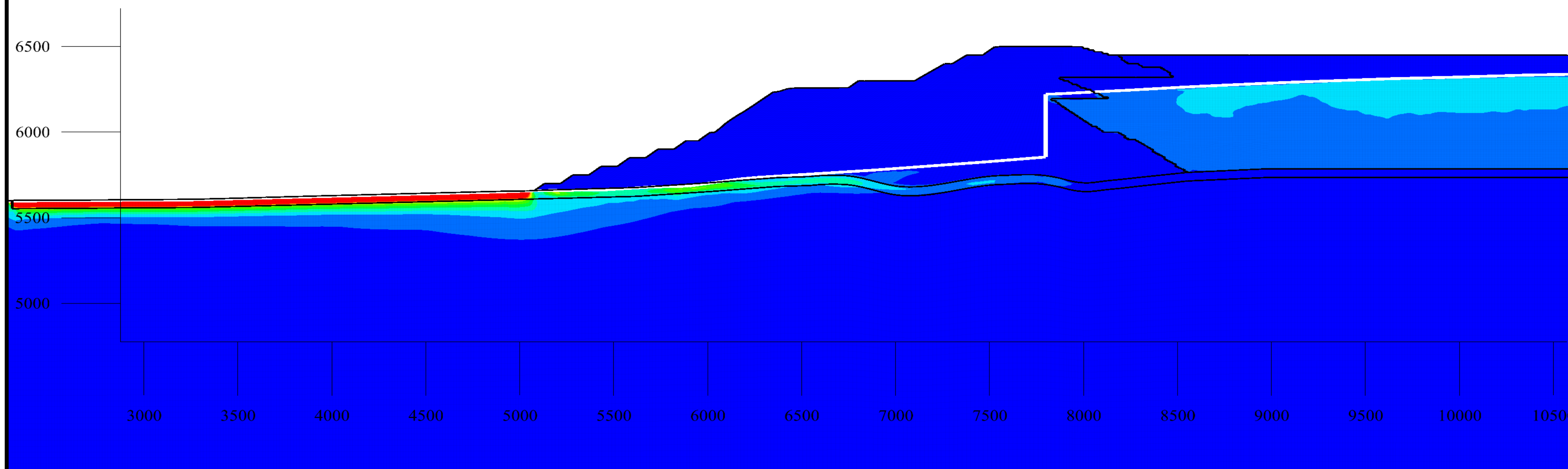
Maximum Excess Pore Pressure Ratio

Calculated by: Volumetric Averaging

1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0

Water Table

Water Surface



NOTES:

1. AXIS LABEL UNITS ARE FEET.
2. EXCESS PORE PRESSURE RATIO, r_u, IS THE PORE PRESSURE CHANGE DIVIDED BY THE INITIAL OVERBRUDEN/VERTICAL STRESS.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

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DYNAMIC DEFORMATION ANALYSIS
EXCESS PORE PRESSURE RATIO
MCE-5

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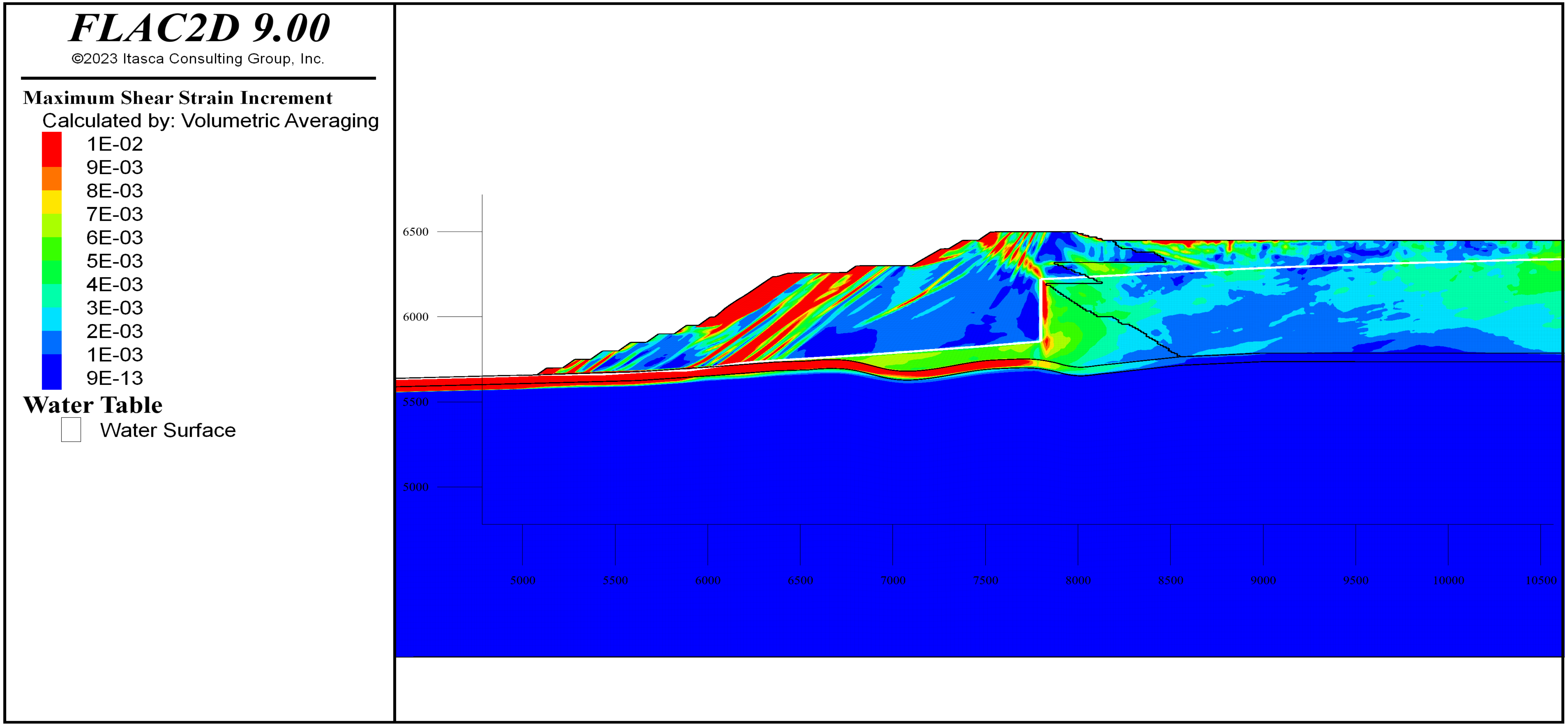
REF. NO. 5

FIGURE J2.19

REV 0



NOTES:

1. AXIS LABEL UNITS ARE FEET.
2. SHEAR STRAIN INCREMENT ARE DECIMAL FRACTIONS.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

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DYNAMIC DEFORMATION ANALYSIS
MAXIMUM SHEAR STRAIN
MCE-5

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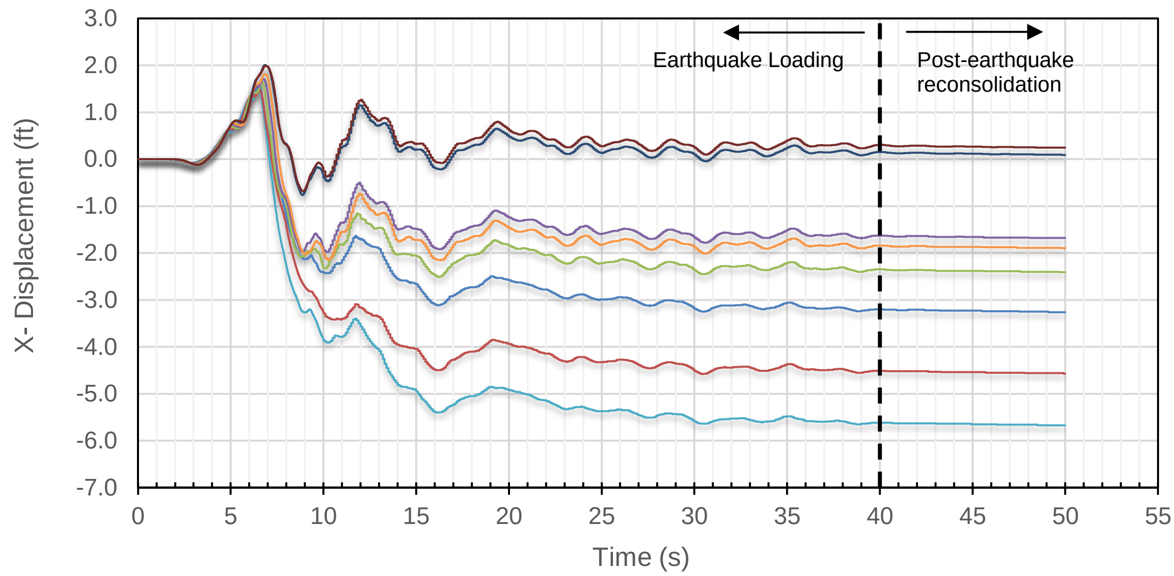
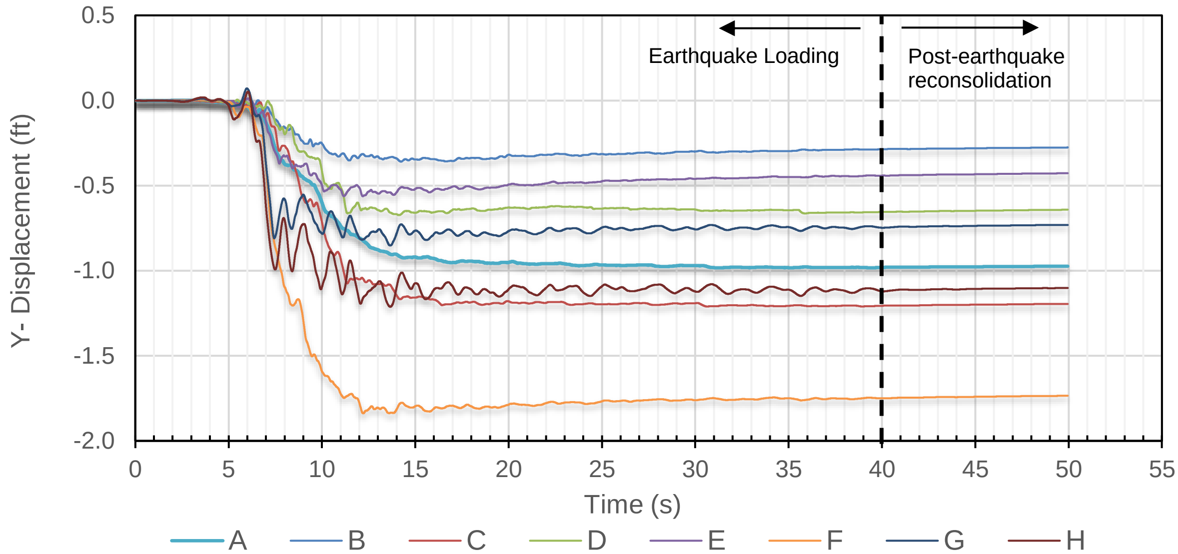
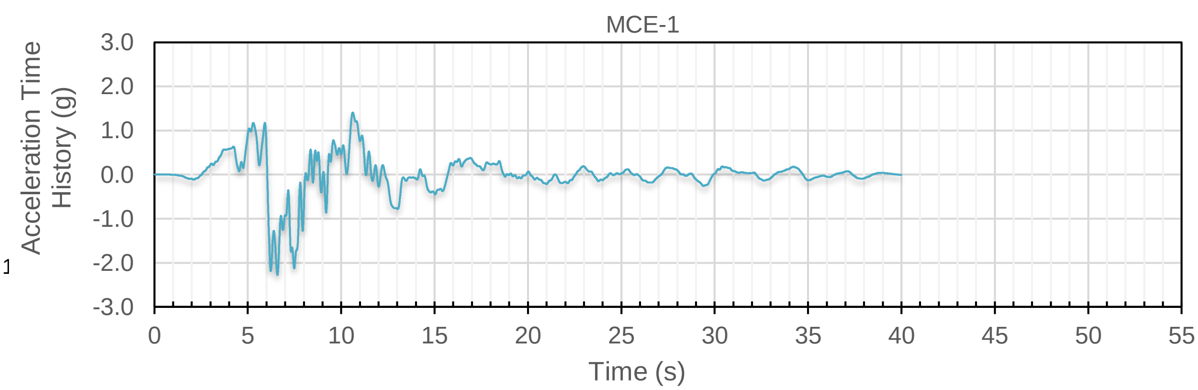
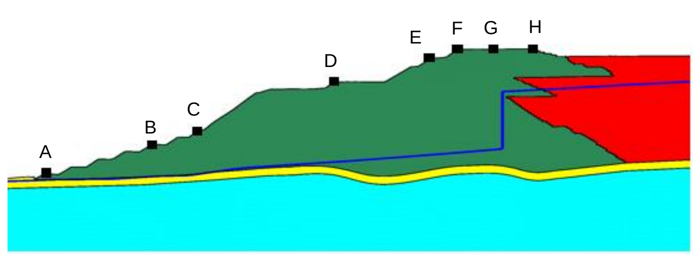
FIGURE J2.20 | REV 0









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DYNAMIC DEFORMATION ANALYSIS
DISPLACEMENT TIME HISTORIES
MCE-1

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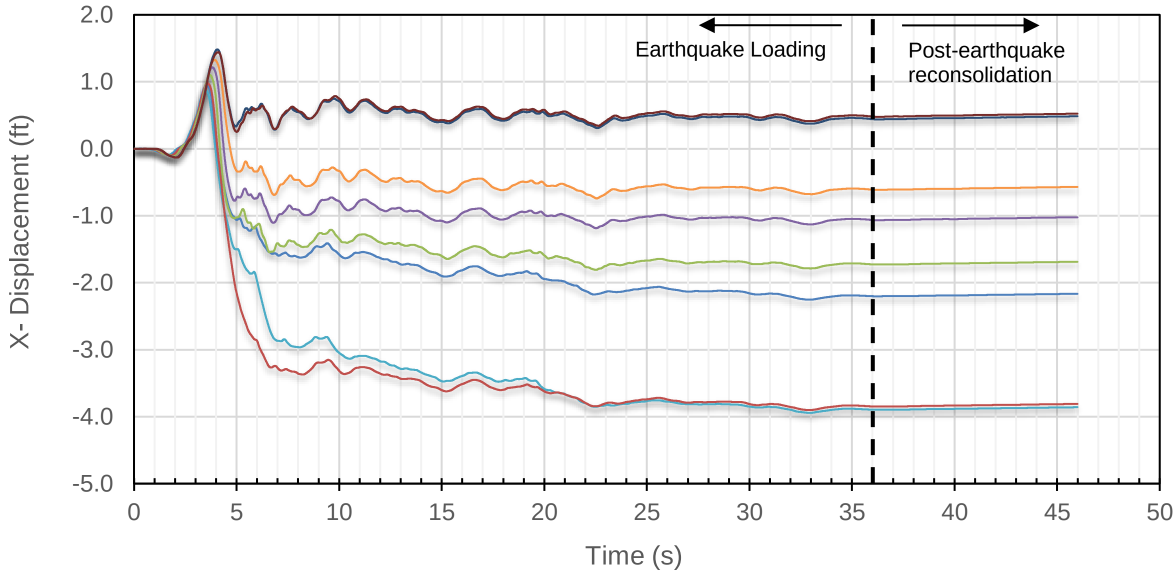
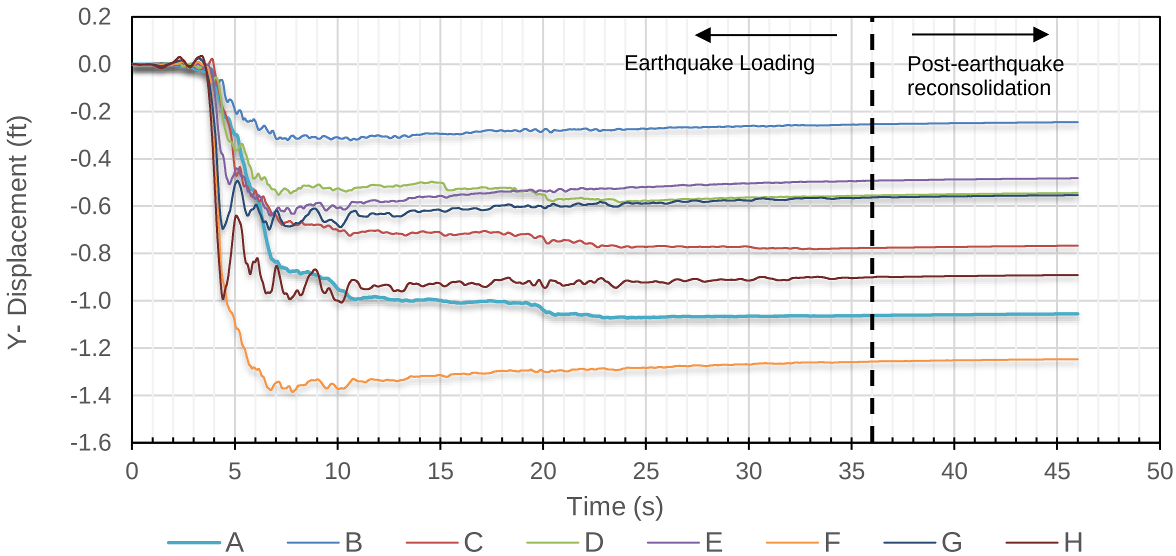
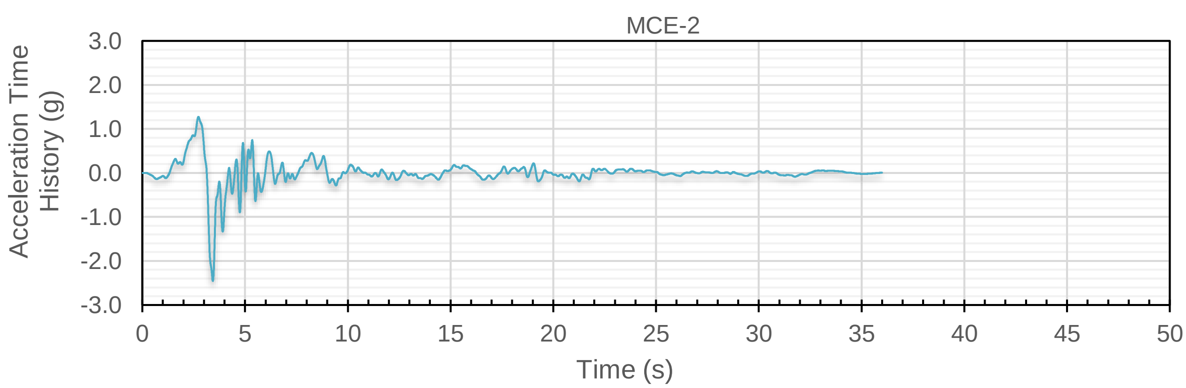
FIGURE J2.21

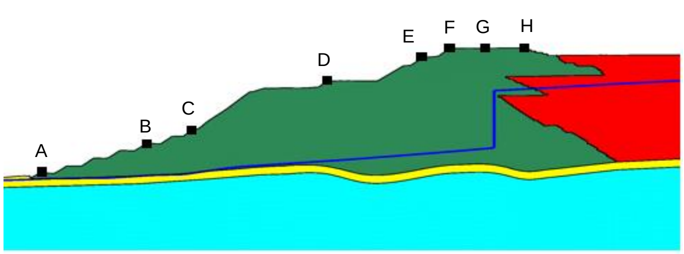
REV 0

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY









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MONTANA RESOURCES

DYNAMIC DEFORMATION ANALYSIS
DISPLACEMENT TIME HISTORIES
MCE-2

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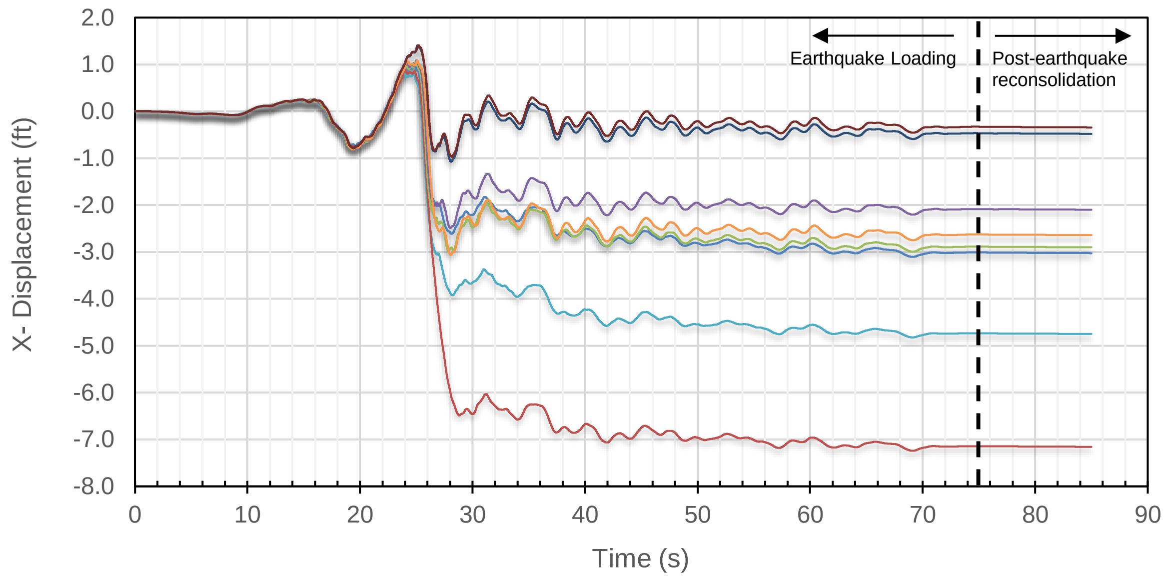
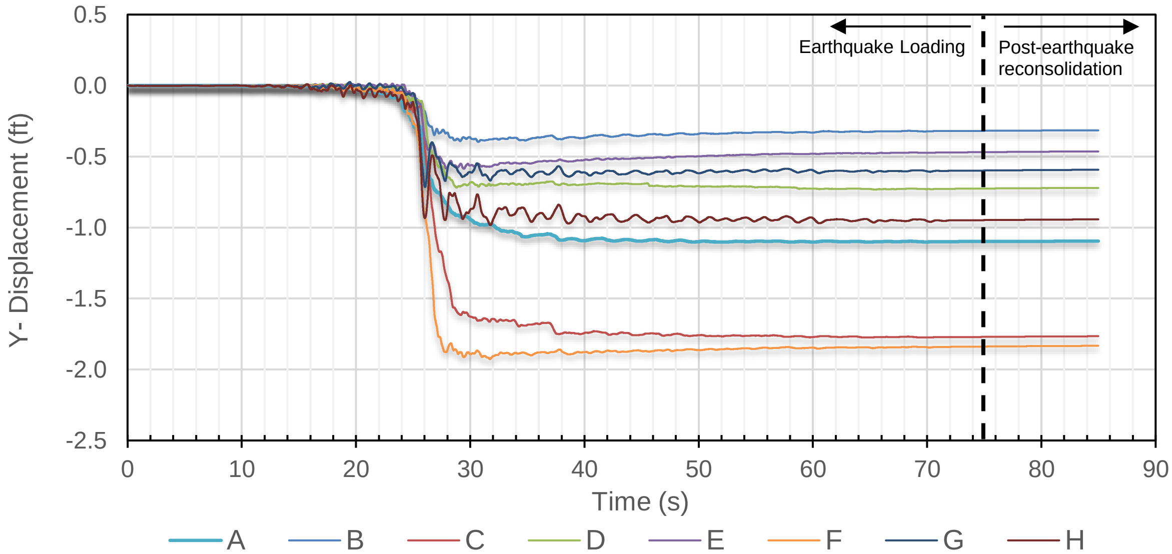
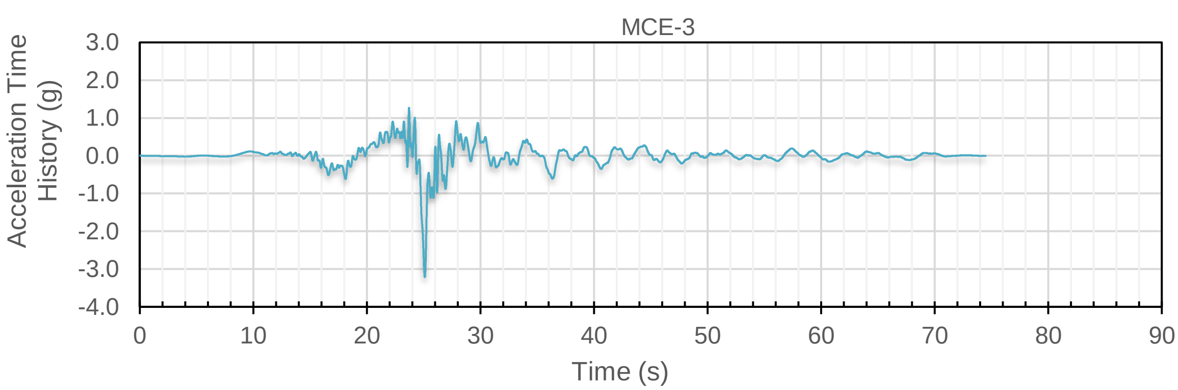
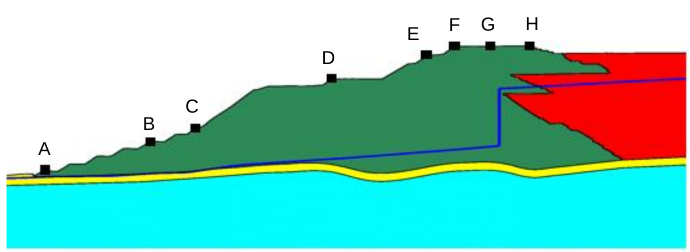
FIGURE J2.22 REV 0

0	19SEP'24	ISSUED WITH REPORT	SVW	SY
REV	DATE	DESCRIPTION	PREP'D	RVW'D









0	19SEP'24	ISSUED WITH REPORT	SVW	SY
REV	DATE	DESCRIPTION	PREP'D	RVW'D

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DYNAMIC DEFORMATION ANALYSIS
DISPLACEMENT TIME HISTORIES
MCE-3

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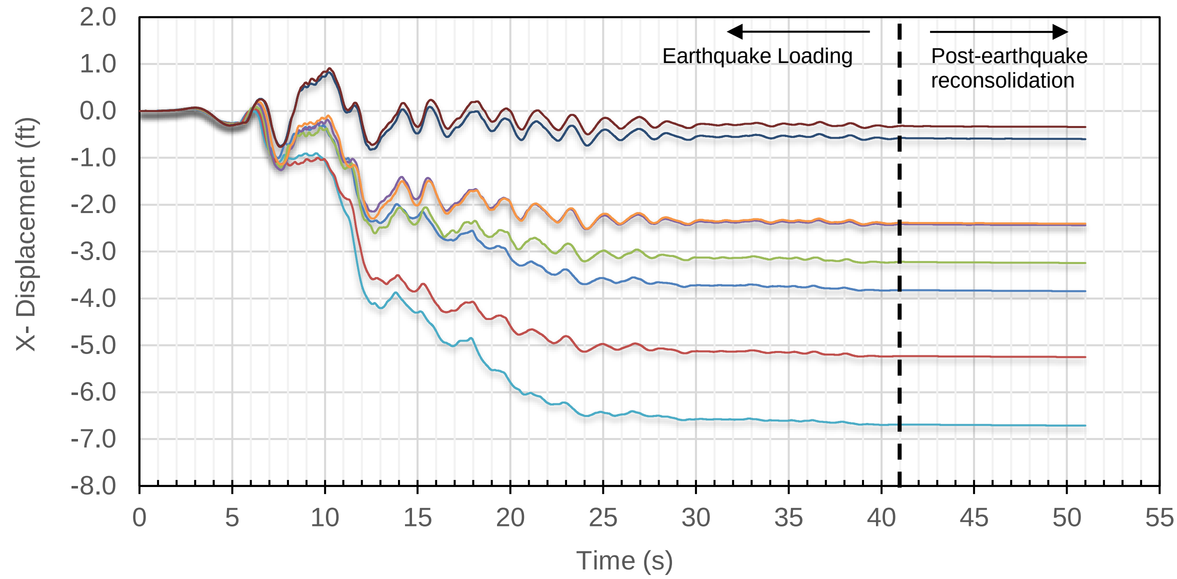
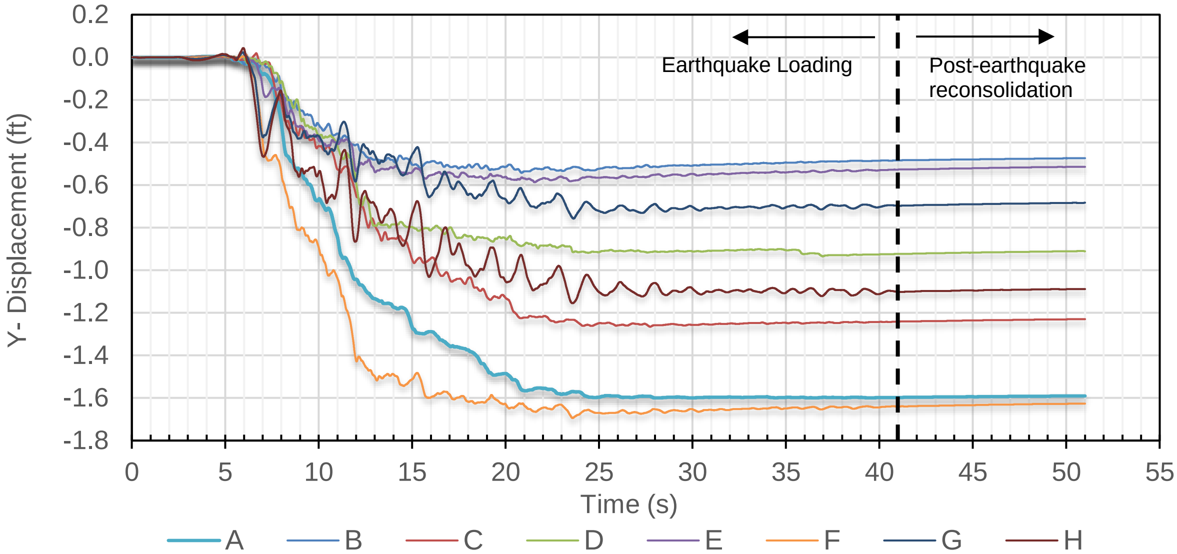
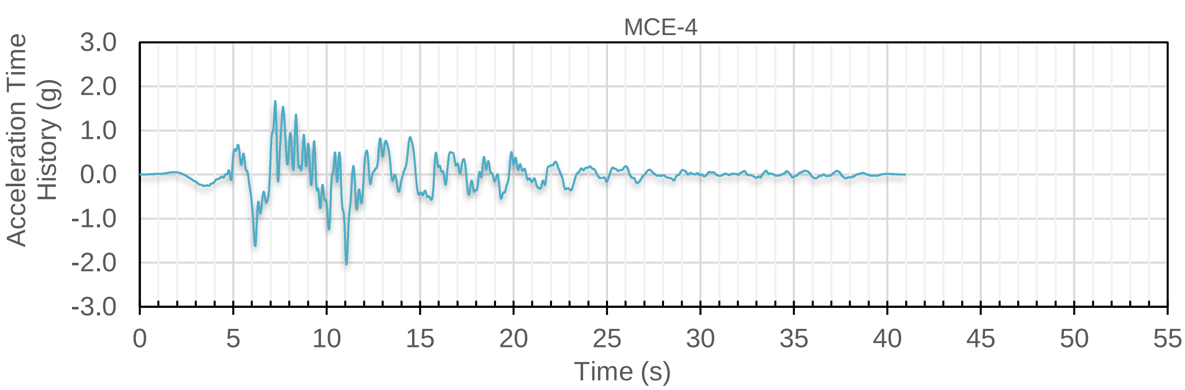
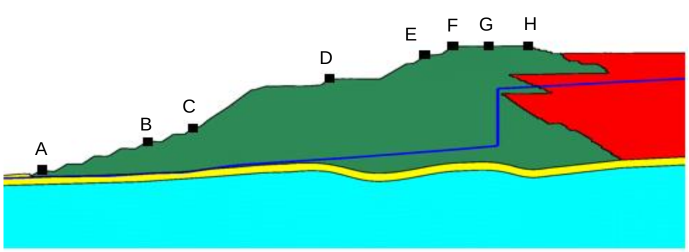
VA101-00126/24	5

FIGURE J2.23 REV 0









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DYNAMIC DEFORMATION ANALYSIS
DISPLACEMENT TIME HISTORIES
MCE-4

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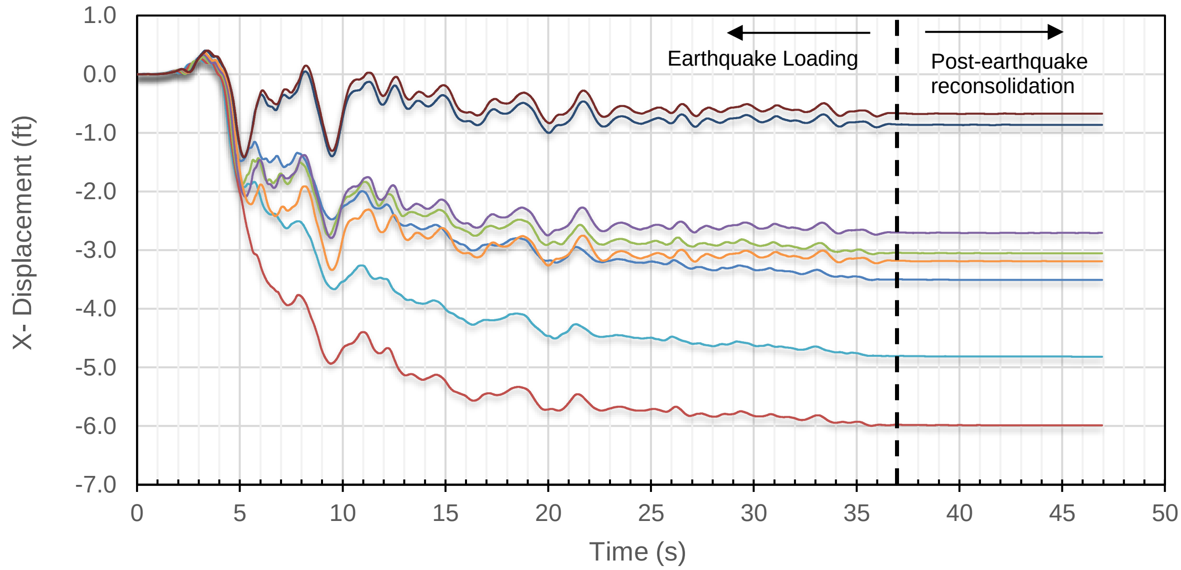
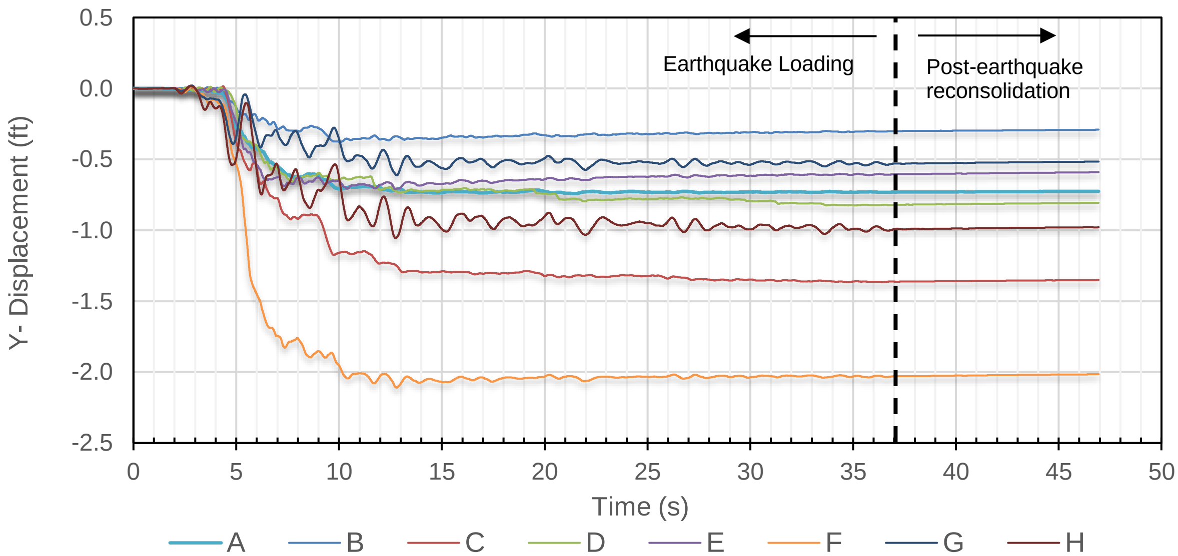
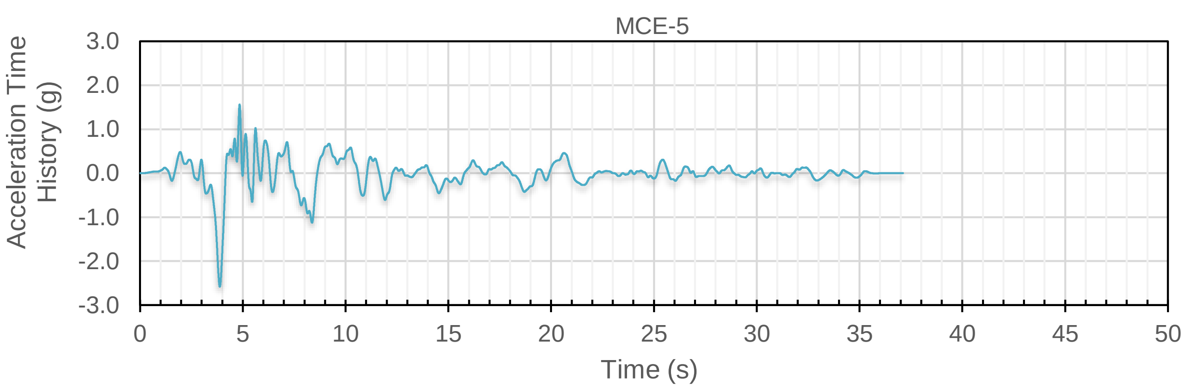
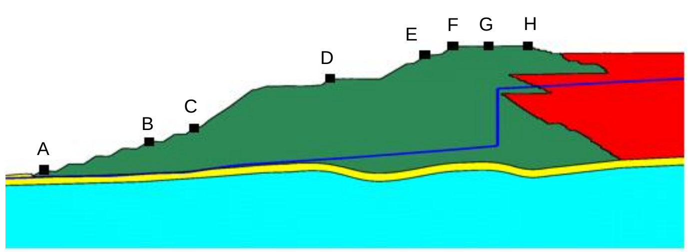
FIGURE J2.24 REV 0

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY









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MONTANA RESOURCES

DYNAMIC DEFORMATION ANALYSIS
DISPLACEMENT TIME HISTORIES
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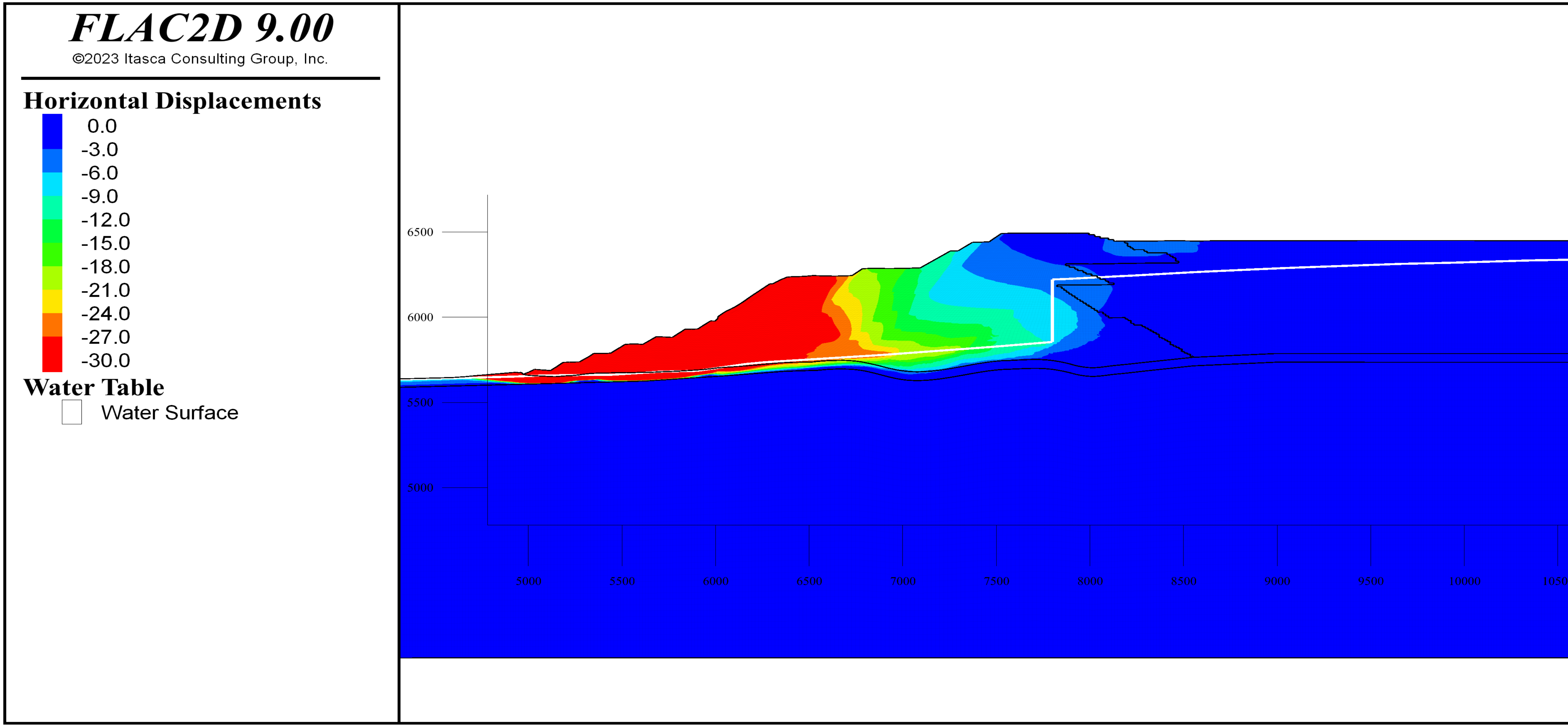
FIGURE J2.25 REV 0

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

APPENDIX J3

Post-Earthquake Analysis

(Pages J3.1 to J3.15)



NOTES:

1. AXIS LABEL AND LEGEND UNITS ARE FEET.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

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MONTANA RESOURCES

DYNAMIC DEFORMATION ANALYSIS
HORIZONTAL DISPLACEMENTS (POST-DYNAMIC)
MCE-1

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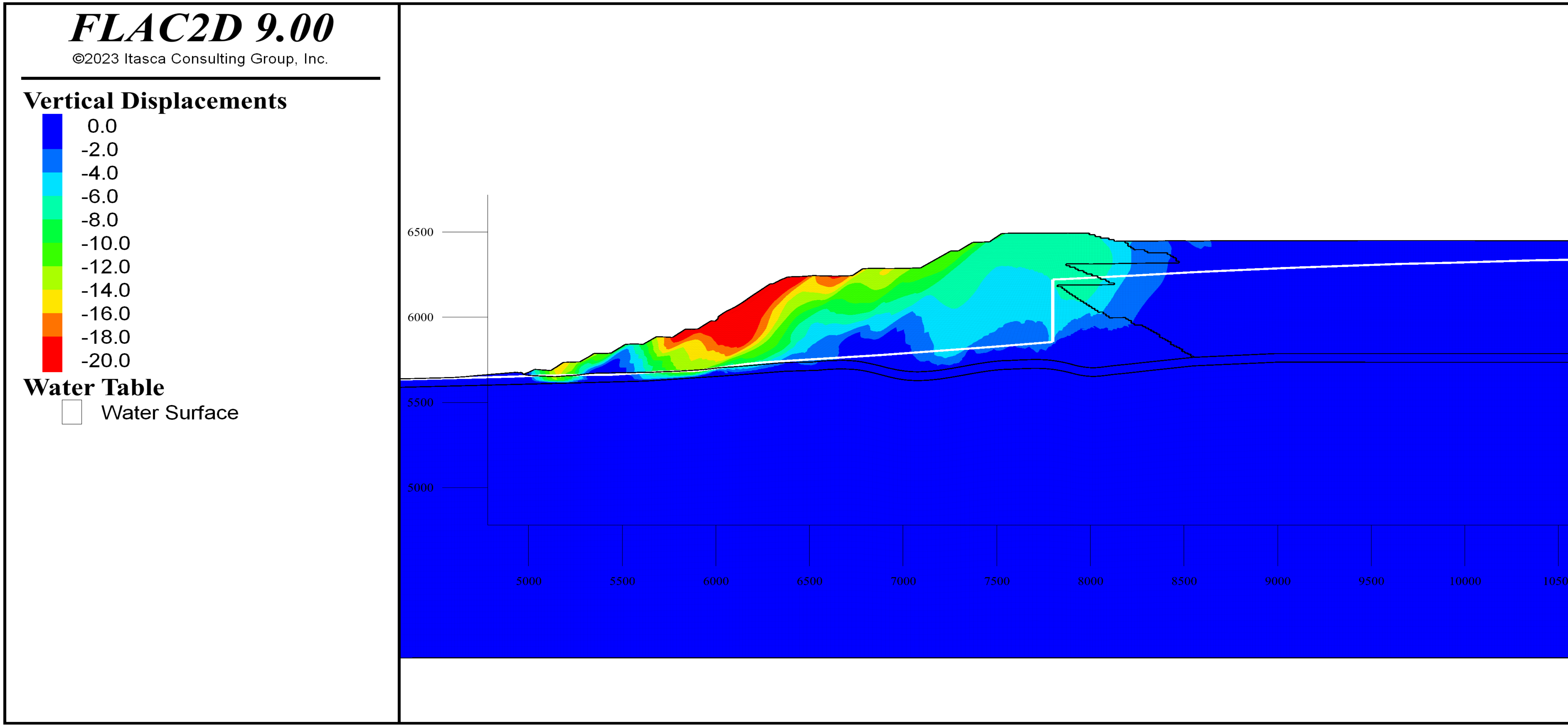
REF. NO. 5

FIGURE J3.1

REV 0



NOTES:

1. AXIS LABEL AND LEGEND UNITS ARE FEET.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

MONTANA RESOURCES, LLC

MONTANA RESOURCES

DYNAMIC DEFORMATION ANALYSIS
VERTICAL DISPLACEMENTS (POST-DYNAMIC)
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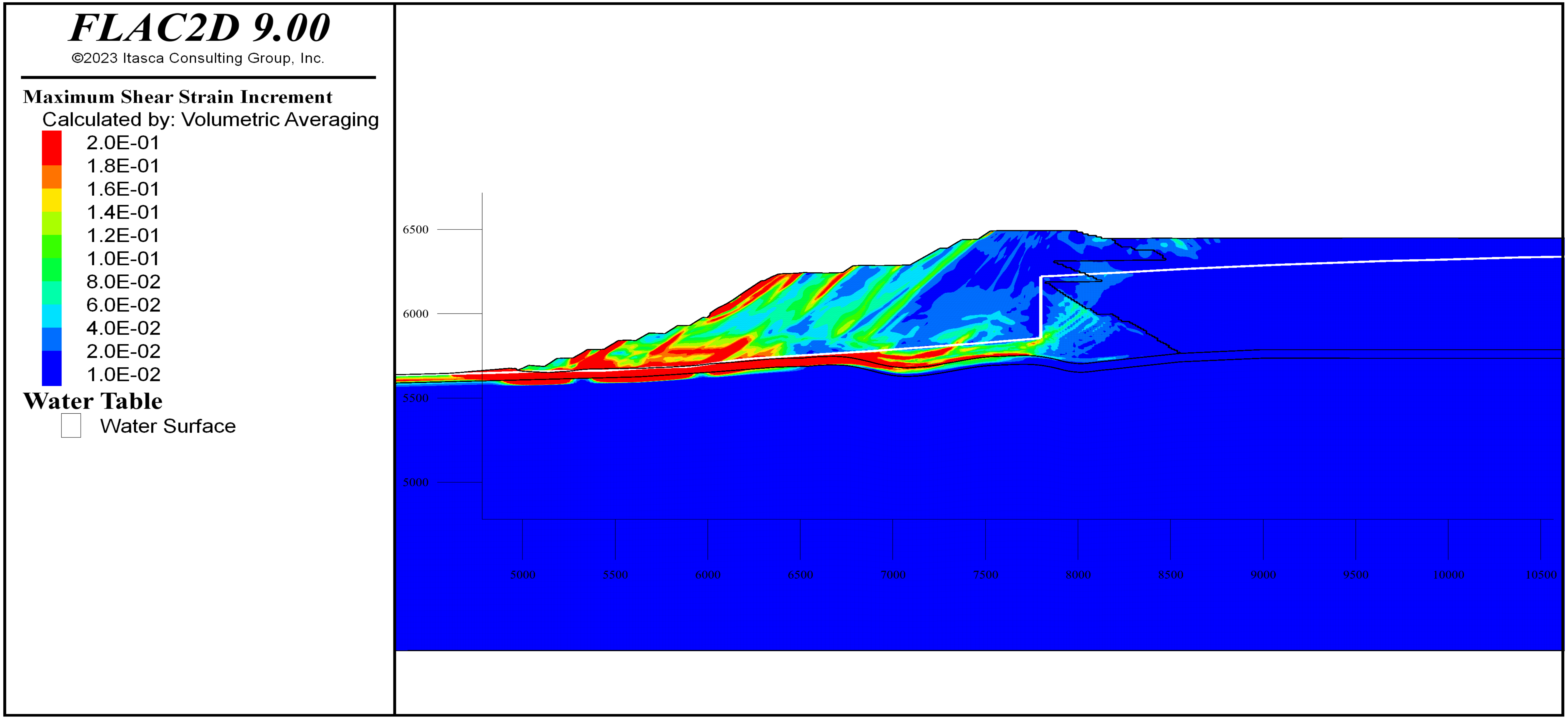
REF. NO. 5

FIGURE J3.2

REV 0



NOTES:

1. AXIS LABEL UNITS ARE FEET.
2. SHEAR STRAIN INCREMENT ARE DECIMAL FRACTIONS.

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DYNAMIC DEFORMATION ANALYSIS
SHEAR STRAIN (POST-DYNAMIC)
MCE-1

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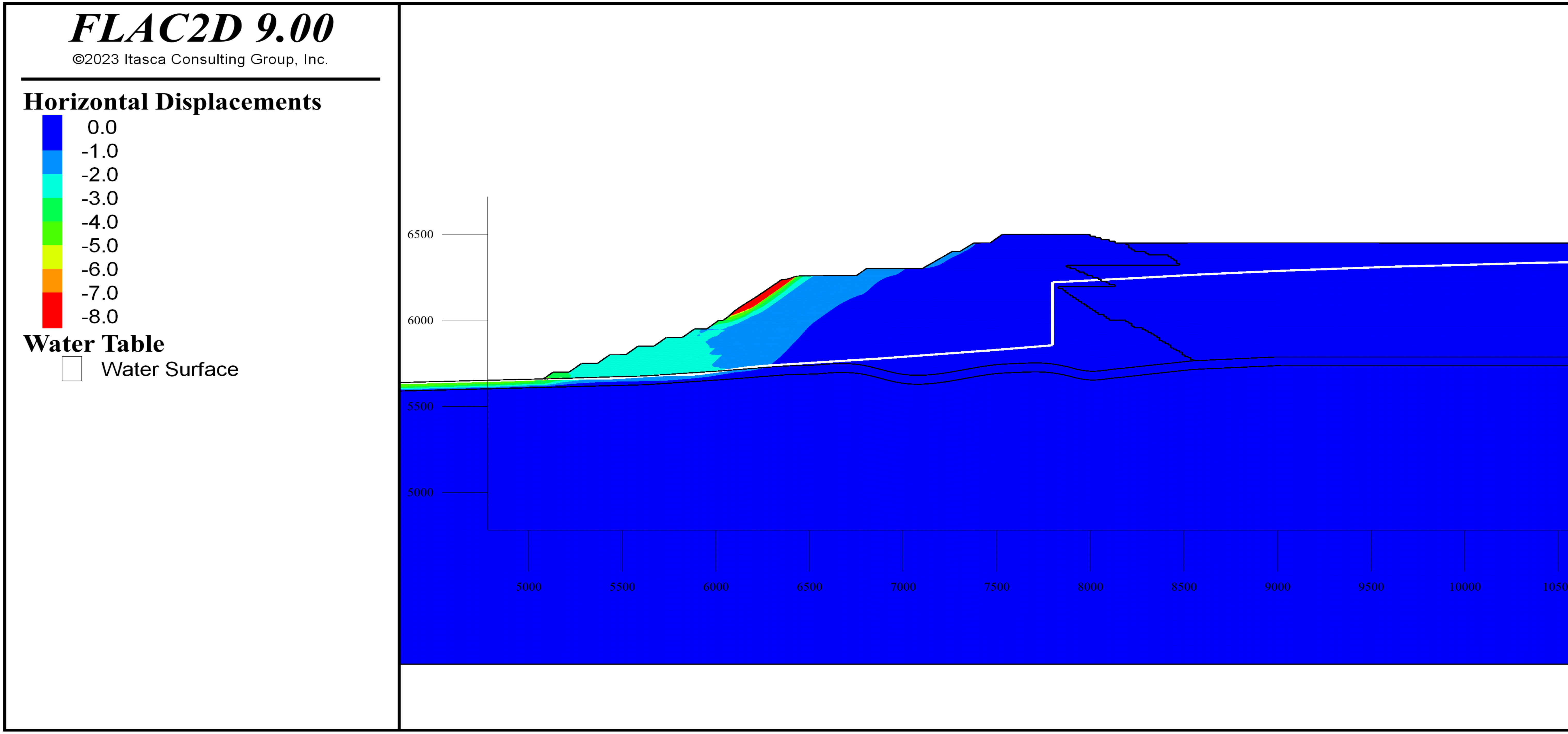
FIGURE J3.3 REV 0

0	19SEP'24	ISSUED WITH REPORT	SVW	SY
REV	DATE	DESCRIPTION	PREP'D	RVW'D



NOTES:

1. AXIS LABEL AND LEGEND UNITS ARE FEET.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

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DYNAMIC DEFORMATION ANALYSIS
HORIZONTAL DISPLACEMENTS (POST-DYNAMIC)
MCE-2

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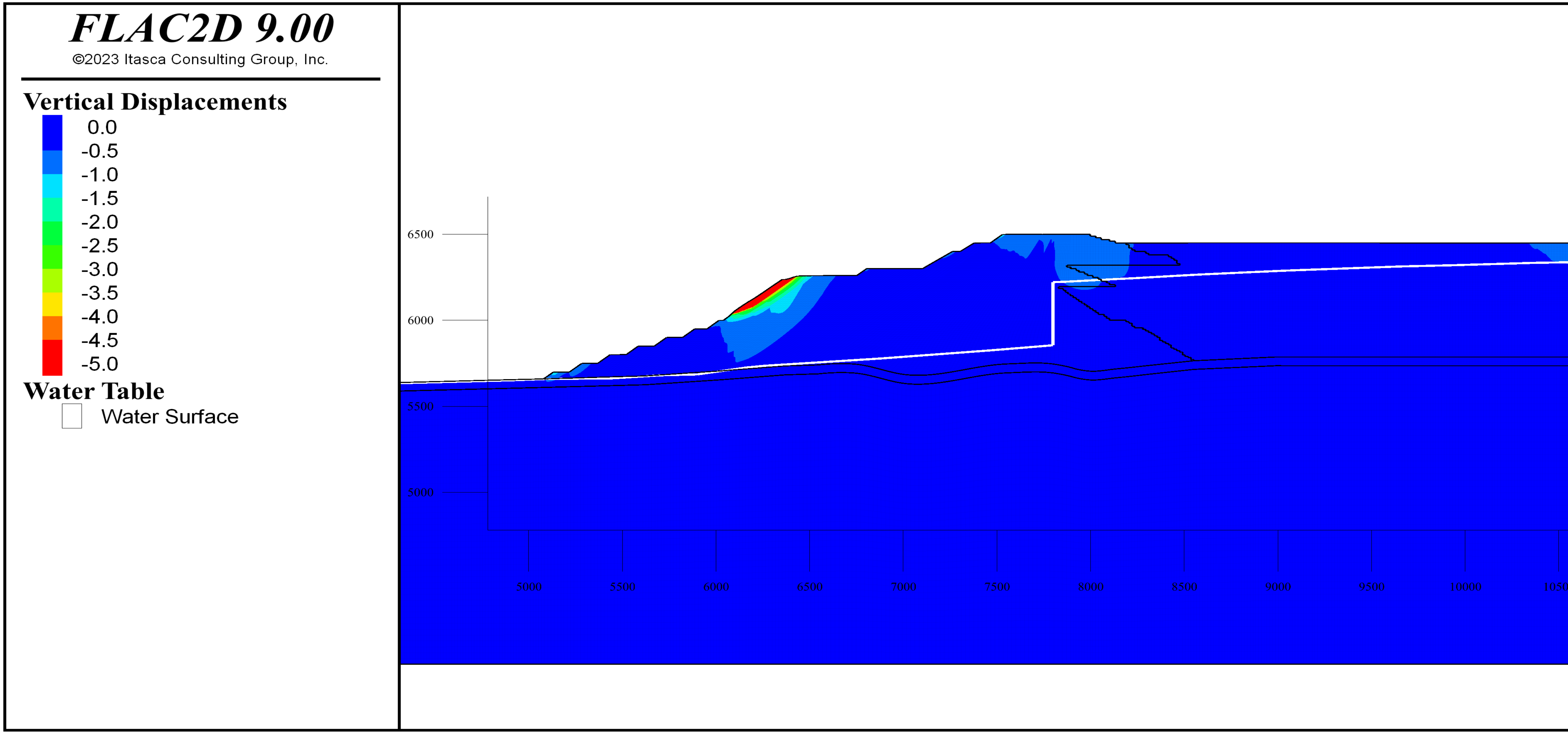
REF. NO. 5

FIGURE J3.4

REV 0



NOTES:

1. AXIS LABEL AND LEGEND UNITS ARE FEET.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

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DYNAMIC DEFORMATION ANALYSIS
VERTICAL DISPLACEMENTS (POST-DYNAMIC)
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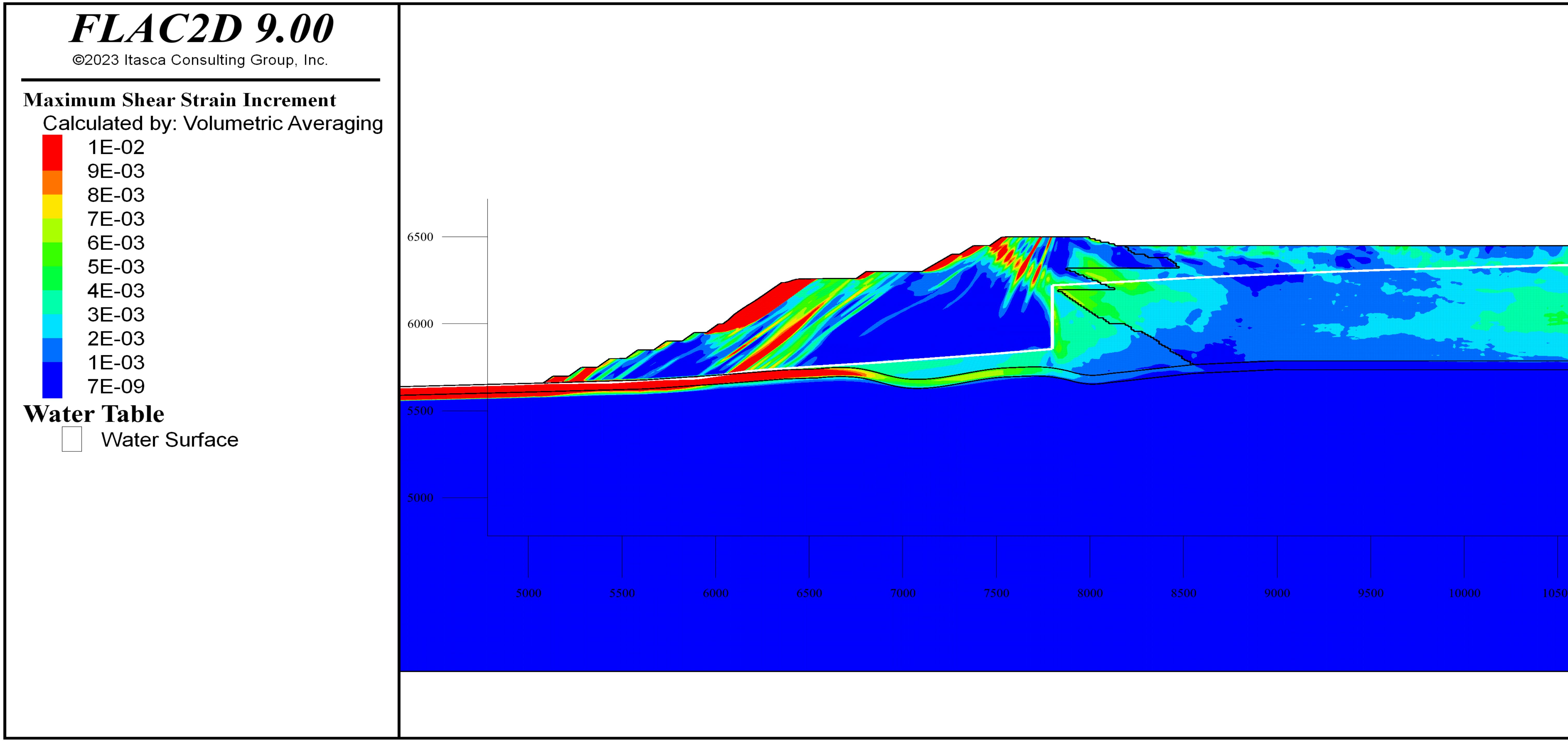
FIGURE J3.5

REV 0



NOTES:

1. AXIS LABEL UNITS ARE FEET.
2. SHEAR STRAIN INCREMENT ARE DECIMAL FRACTIONS.

0	19SEP'24	ISSUED WITH REPORT	SVW	SY
REV	DATE	DESCRIPTION	PREP'D	RVW'D

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DYNAMIC DEFORMATION ANALYSIS
SHEAR STRAIN (POST-DYNAMIC)
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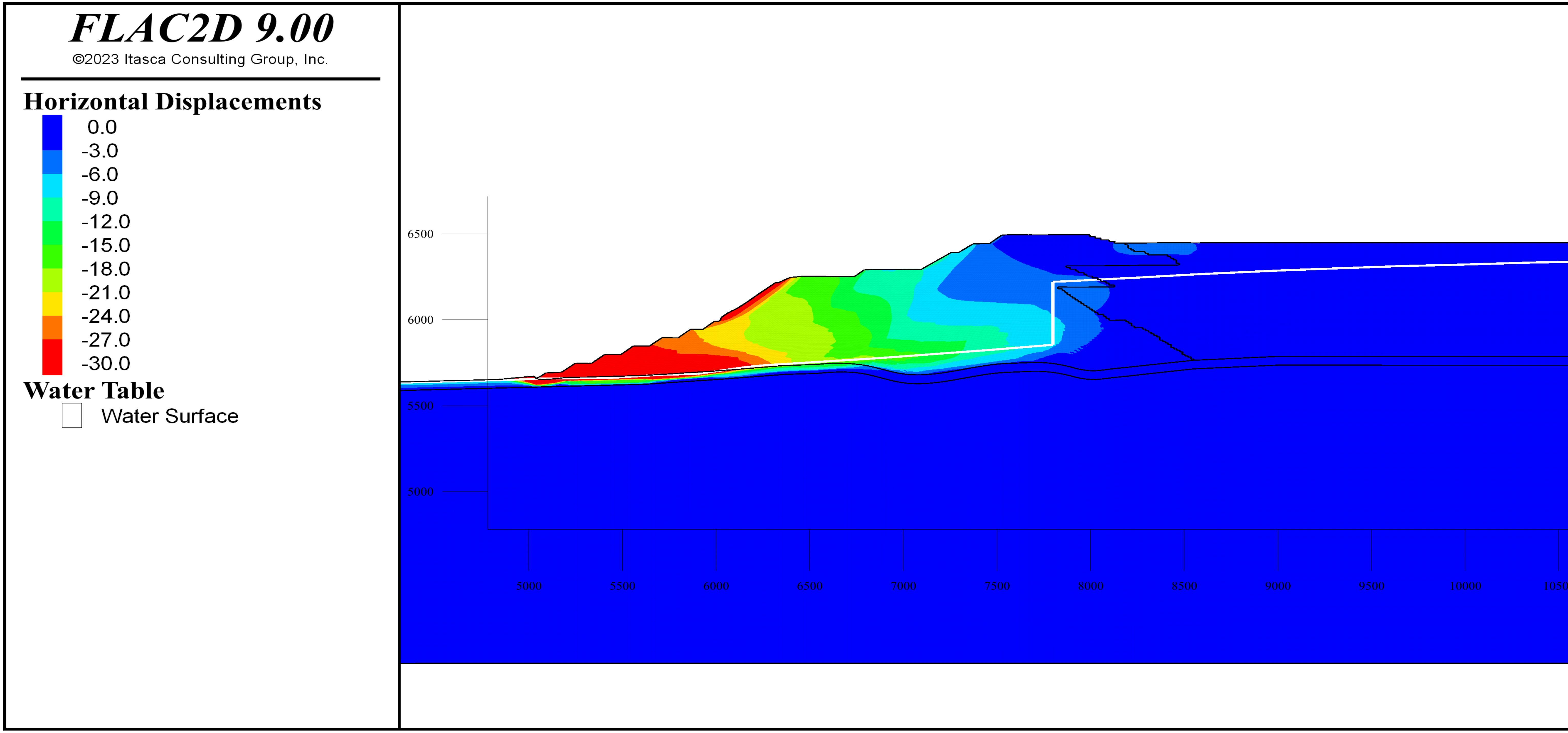
FIGURE J3.6 | REV 0



NOTES:

1. AXIS LABEL AND LEGEND UNITS ARE FEET.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

MONTANA RESOURCES, LLC

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DYNAMIC DEFORMATION ANALYSIS
HORIZONTAL DISPLACEMENTS (POST-DYNAMIC)
MCE-3

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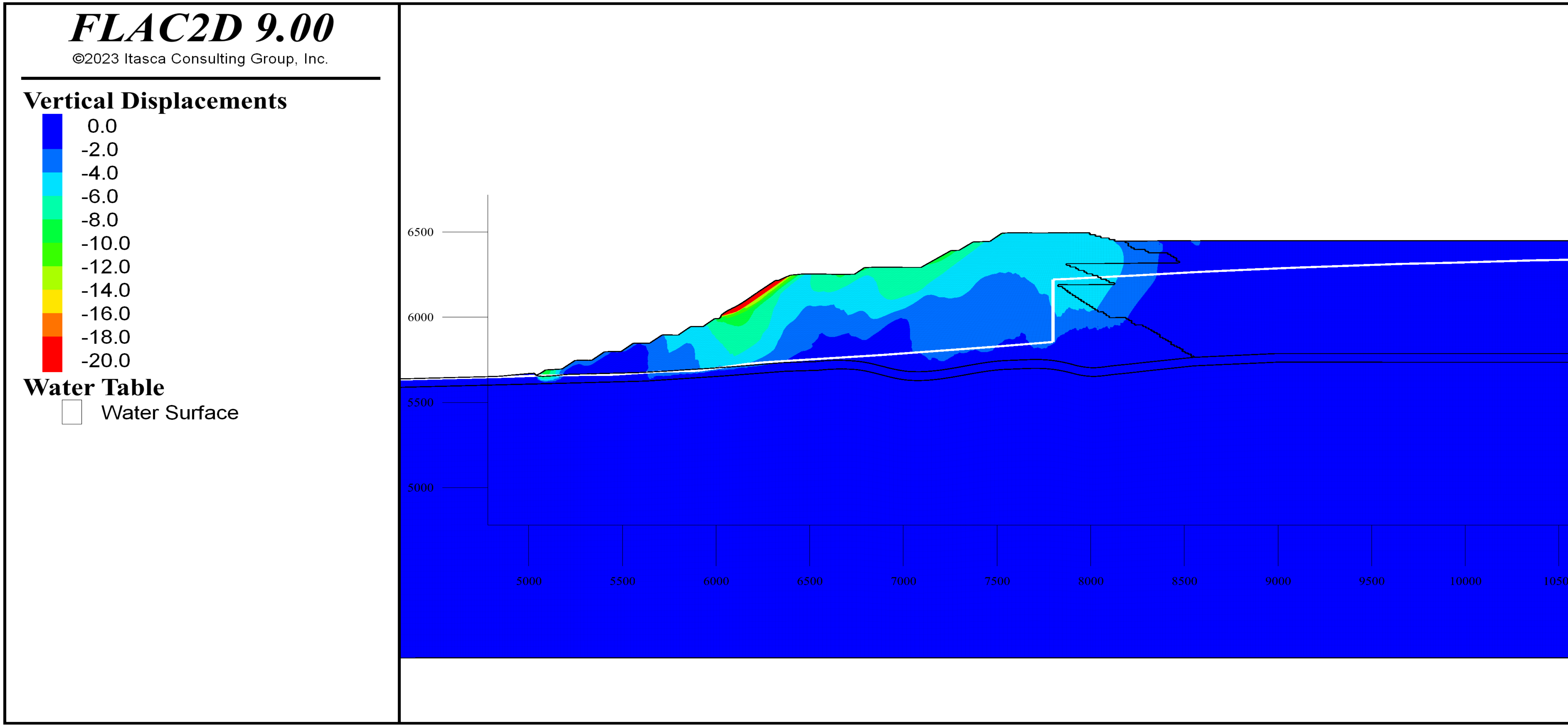
REF. NO. 5

FIGURE J3.7

REV 0



NOTES:

1. AXIS LABEL AND LEGEND UNITS ARE FEET.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

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DYNAMIC DEFORMATION ANALYSIS
VERTICAL DISPLACEMENTS (POST-DYNAMIC)
MCE-3

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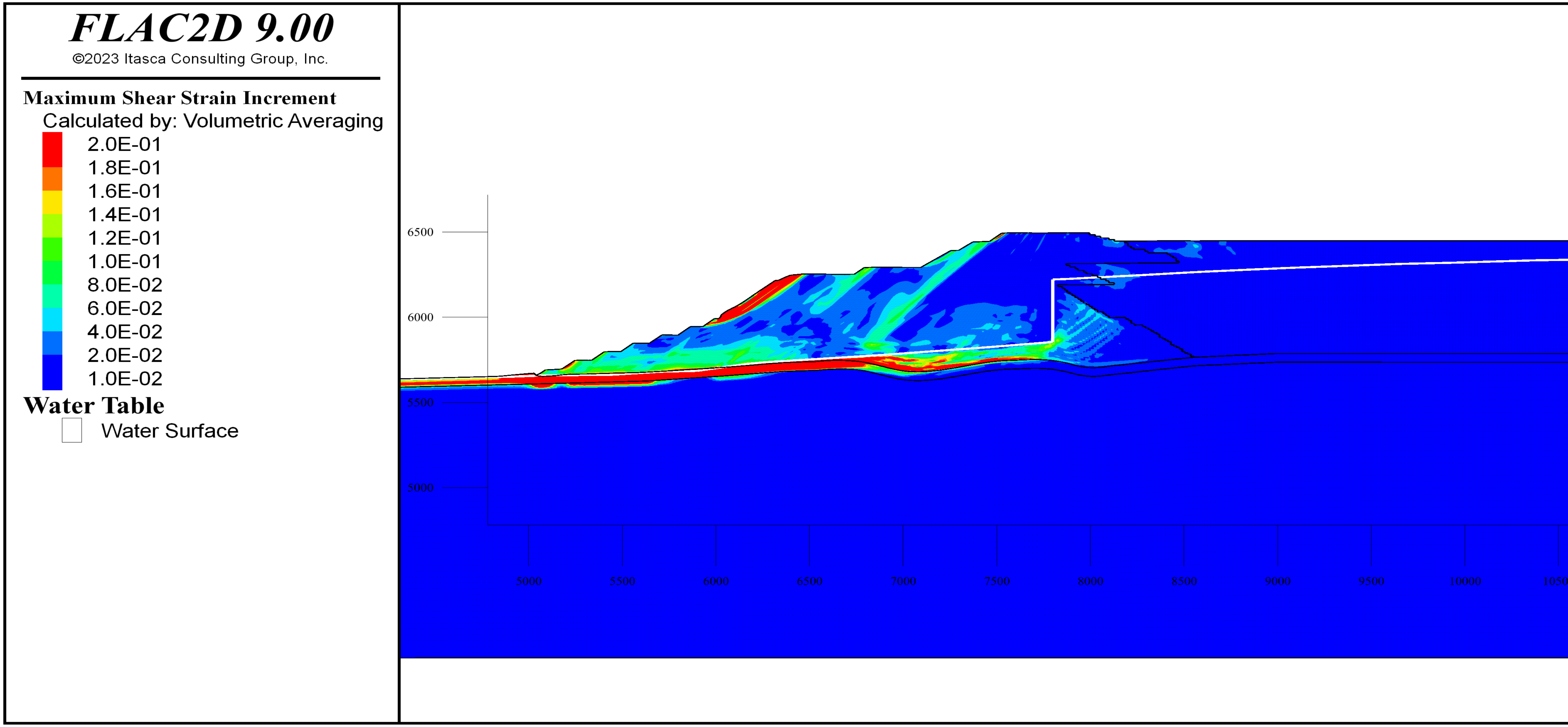
FIGURE J3.8

REV 0



NOTES:

1. AXIS LABEL UNITS ARE FEET.
2. SHEAR STRAIN INCREMENT ARE DECIMAL FRACTIONS.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

MONTANA RESOURCES, LLC

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DYNAMIC DEFORMATION ANALYSIS
SHEAR STRAIN (POST-DYNAMIC)
MCE-3

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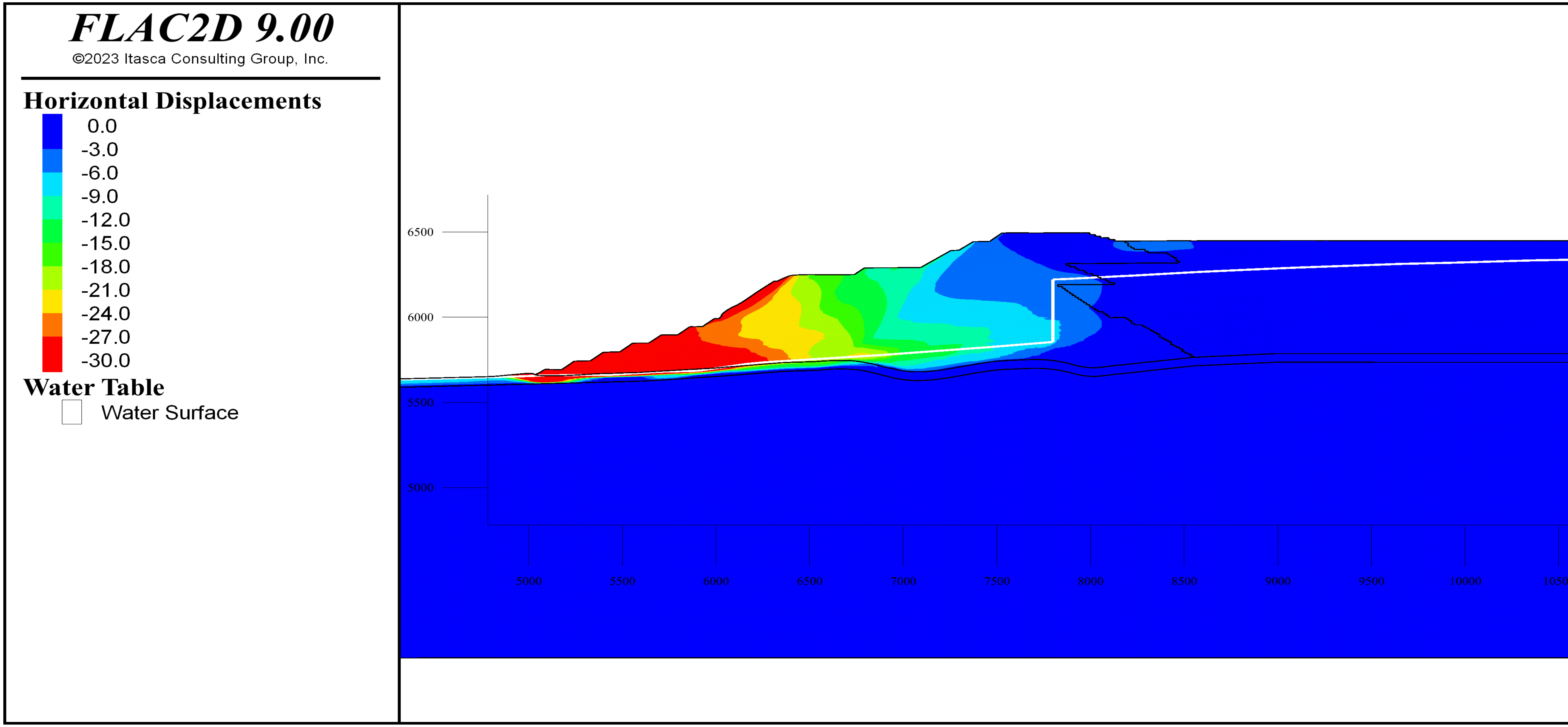
REF. NO. 5

FIGURE J3.9

REV 0



NOTES:

1. AXIS LABEL AND LEGEND UNITS ARE FEET.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

MONTANA RESOURCES, LLC

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DYNAMIC DEFORMATION ANALYSIS
HORIZONTAL DISPLACEMENTS (POST-DYNAMIC)
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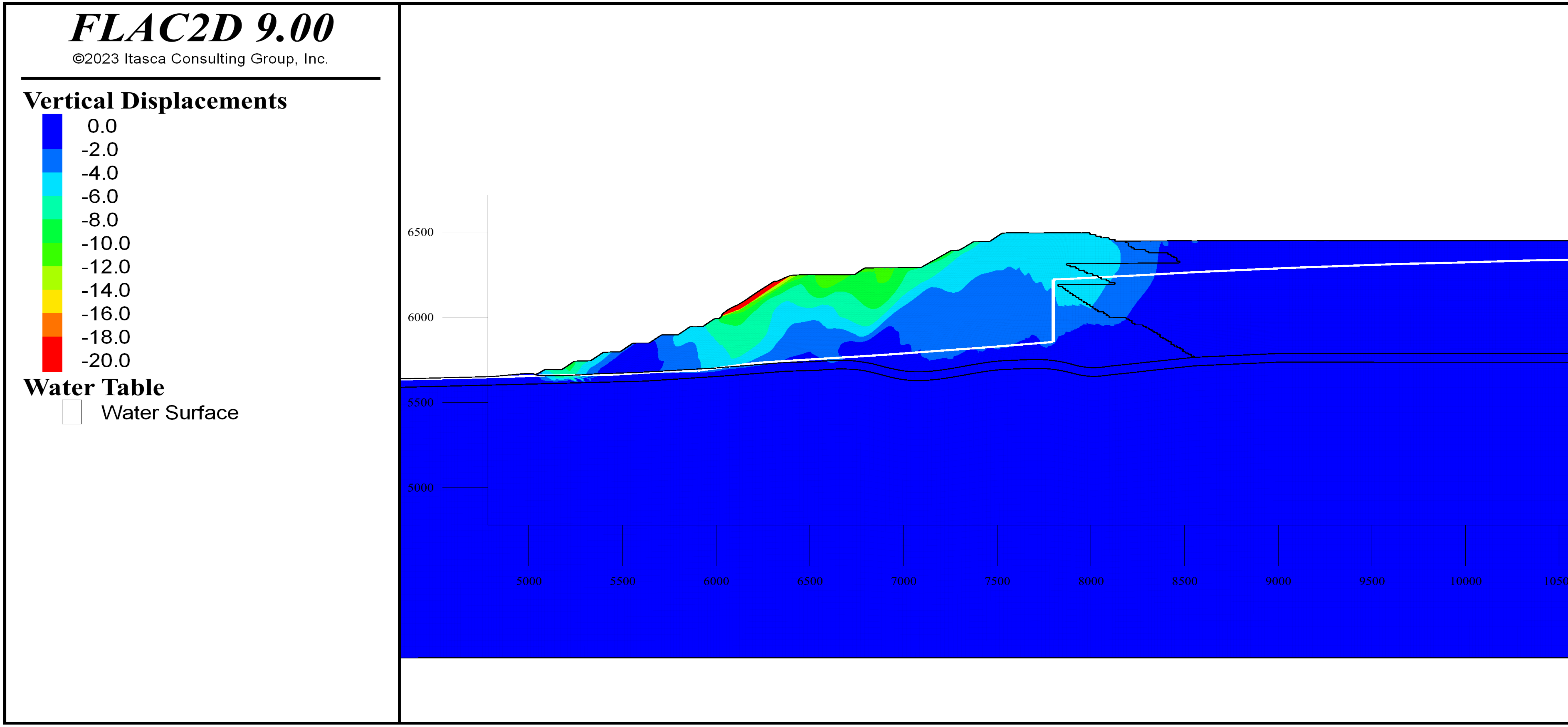
REF. NO. 5

FIGURE J3.10

REV 0



NOTES:

1. AXIS LABEL AND LEGEND UNITS ARE FEET.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

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VERTICAL DISPLACEMENTS (POST-DYNAMIC)
MCE-4

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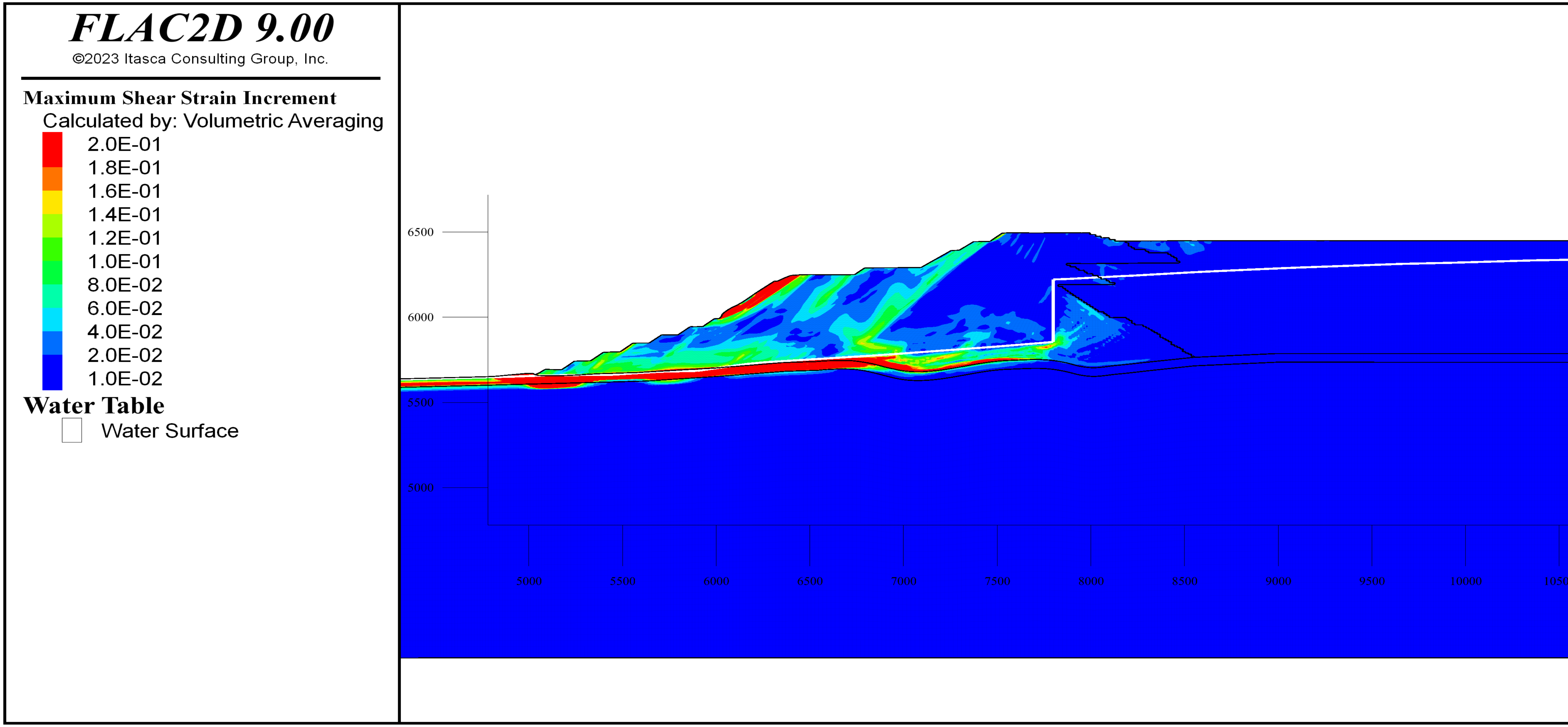
FIGURE J3.11

REV 0



NOTES:

1. AXIS LABEL UNITS ARE FEET.
2. SHEAR STRAIN INCREMENT ARE DECIMAL FRACTIONS.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

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DYNAMIC DEFORMATION ANALYSIS
SHEAR STRAIN (POST-DYNAMIC)
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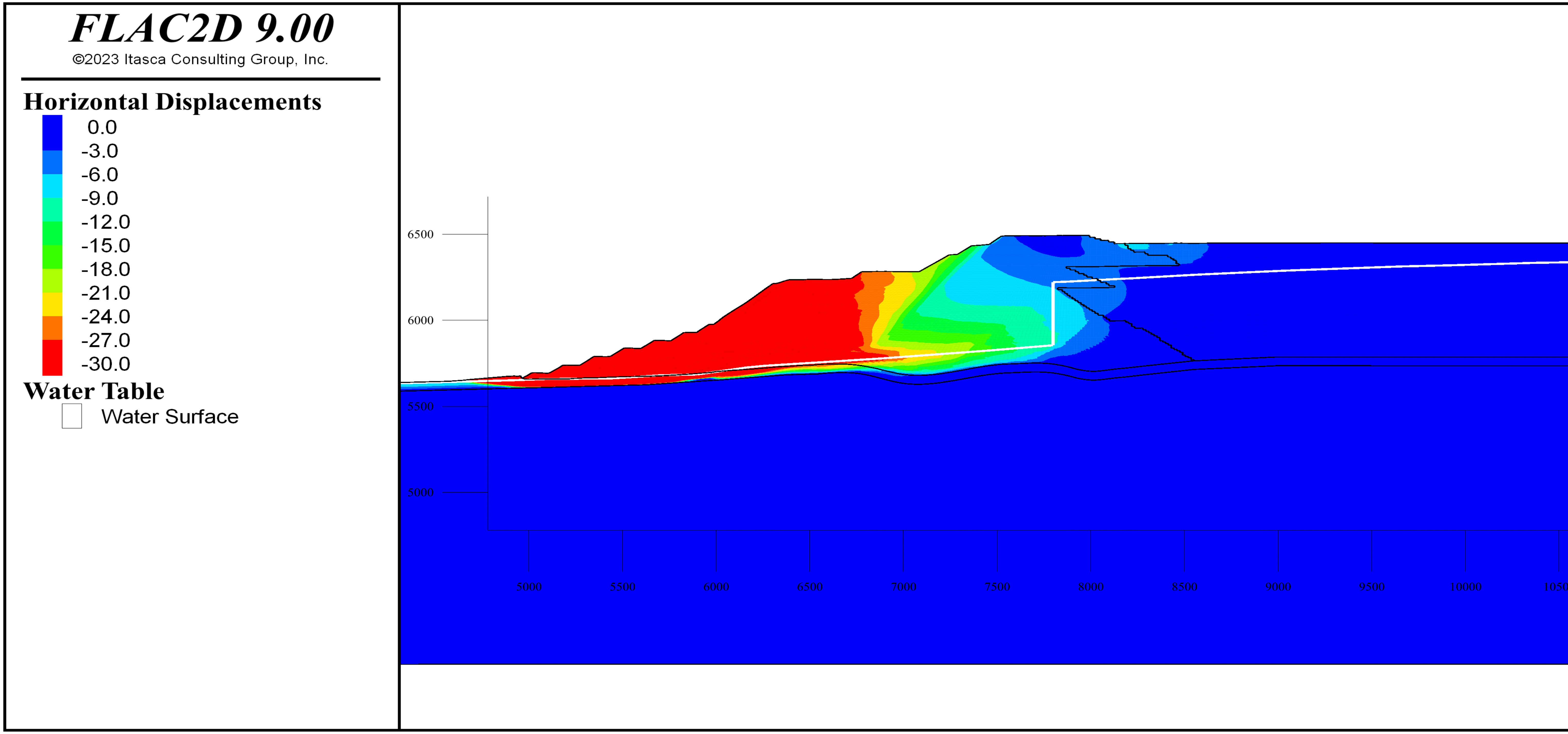
FIGURE J3.12 | REV 0



NOTES:

1. AXIS LABEL AND LEGEND UNITS ARE FEET.

0	19SEP'24	ISSUED WITH REPORT	SVW	SY
REV	DATE	DESCRIPTION	PREP'D	RVW'D

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DYNAMIC DEFORMATION ANALYSIS
HORIZONTAL DISPLACEMENTS (POST-DYNAMIC)
MCE-5

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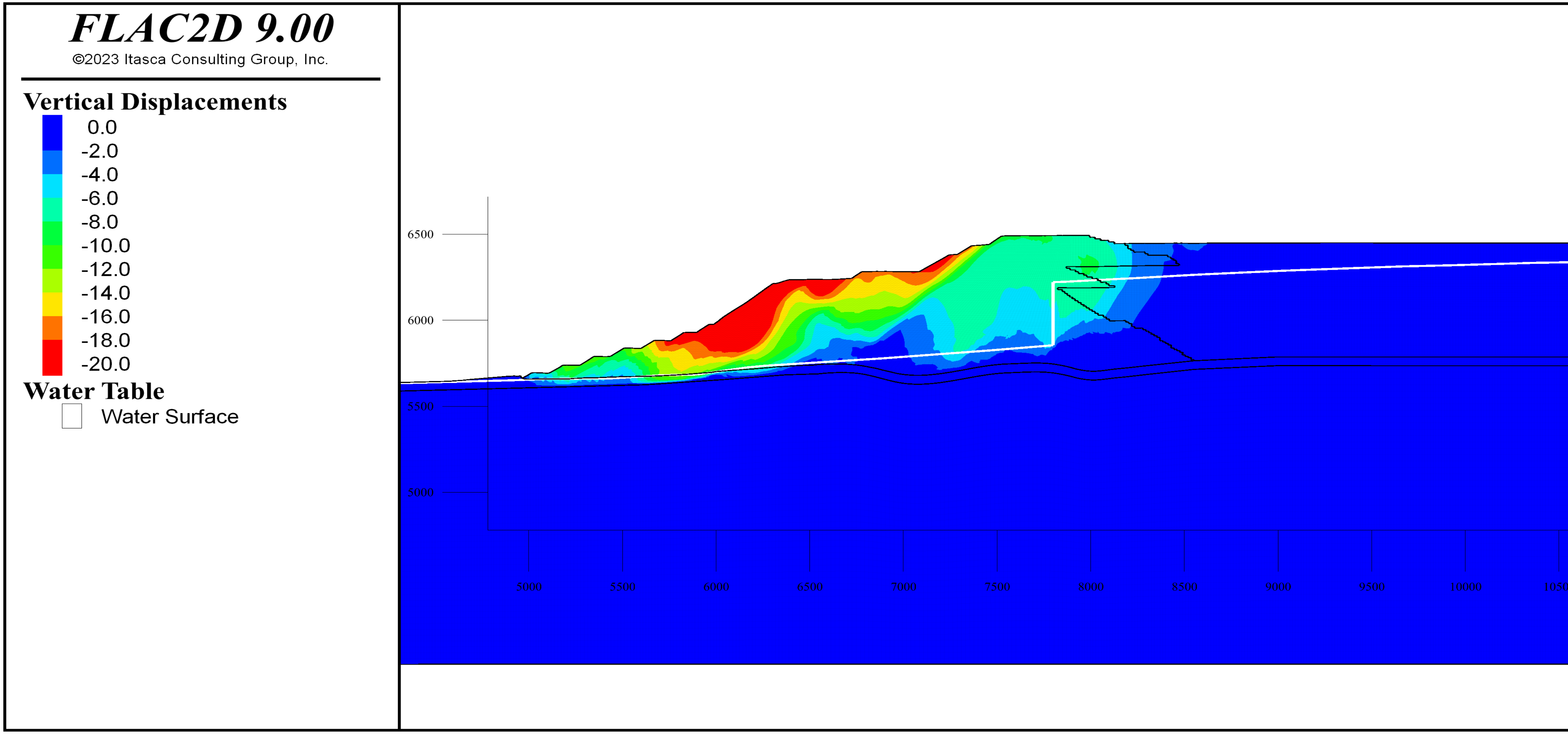
P/A NO.	REF. NO.
VA101-00126/24	5

FIGURE J3.13 REV 0



NOTES:

1. AXIS LABEL AND LEGEND UNITS ARE FEET.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

MONTANA RESOURCES, LLC

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DYNAMIC DEFORMATION ANALYSIS
VERTICAL DISPLACEMENTS (POST-DYNAMIC)
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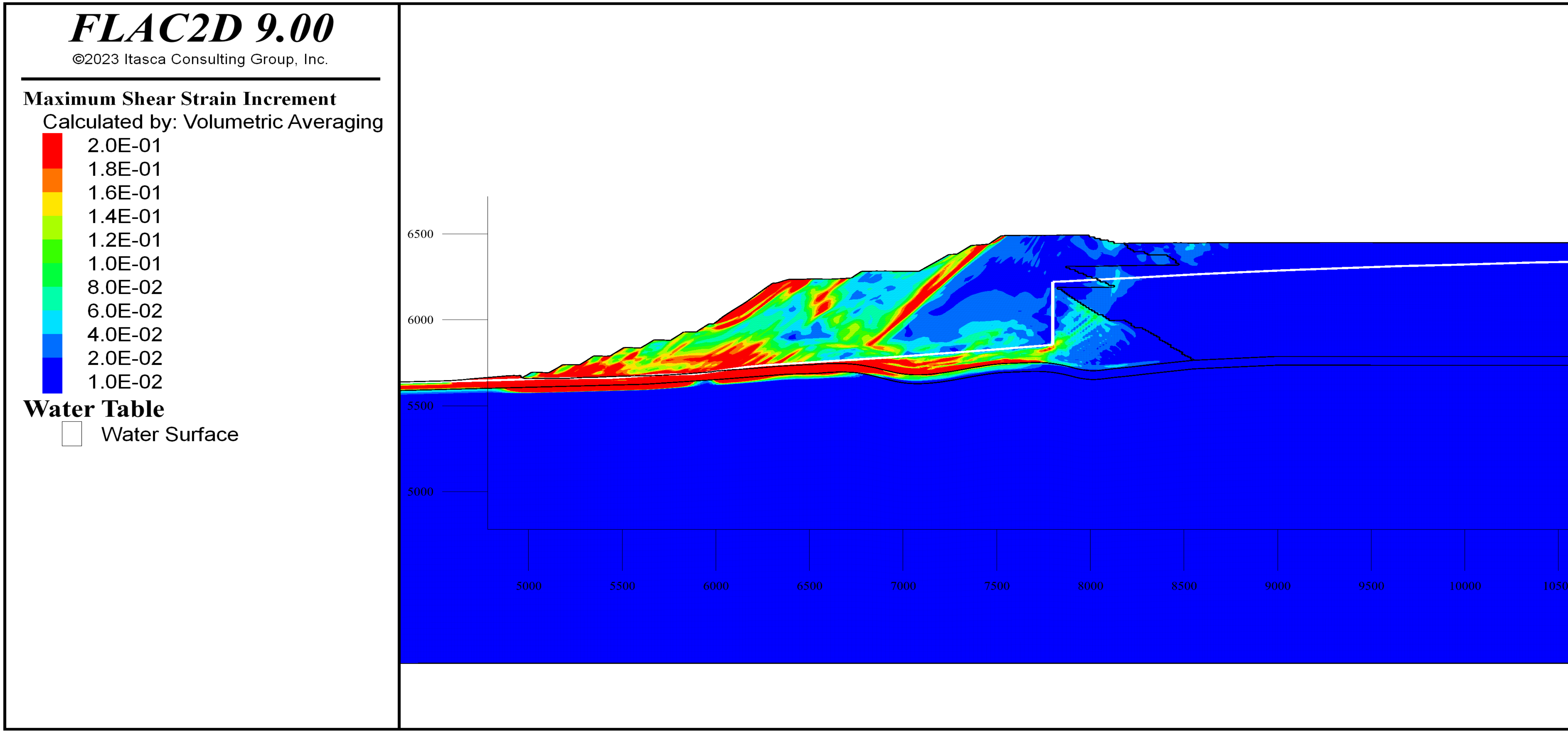
REF. NO. 5

FIGURE J3.14

REV 0



NOTES:

1. AXIS LABEL UNITS ARE FEET.
2. SHEAR STRAIN INCREMENT ARE DECIMAL FRACTIONS.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
0	19SEP'24	ISSUED WITH REPORT	SVW	SY

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REF. NO. 5

FIGURE J3.15

REV 0